Contribution à l'étude des mouvements forts en Iran : du catalogue aux lois d'atténuation

Mehdi Zare

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LABORATOIRE DE GÉOPHYSIQUE INTERNE ET TECTONOPHYSIQUE

THÈSE

présentée par

Mehdi ZARÉ

pour obtenir le titre de DOCTEUR de

L'UNIVERSITÉ JOSEPH FOURIER - GRENOBLE I

(Arrêtés ministériels du 5 juillet 1984 et du 30 mars 1992)

Specialité: **Géophysique - Géochimie - Géomécanique**

Contribution à l'étude des mouvements forts en Iran; du catalogue aux lois d'atténuation

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10204083

Quand la terre tremblera d'un violent tremblement,
et que la terre fera sortir ses fardeaux,
et que l'homme dira: Qu'a-t-elle?!

Le Saint Coran; Zelzaal (1 à 3)

A mon père; Mohammad
A ma mère; Fatemeh
A mon frère; Mehrdad

A l'esprit de mon oncle qui
est mort pour sa patrie; Radjab Nasiri (1965-1986)
et à l'esprit de son ami; Amir-Reza Keshmiri (1964-1987)

A la prospérité de l'Iran dans
21ème siècle... inshaallah!

CONTRIBUTION À L'ÉTUDE DE MOUVEMENTS FORTS EN IRAN; DU CATALOGUE AUX LOIS D'ATTÉNUATION

Les études de risque sismique en Iran sont dans leur phase initiale. Ainsi, il n'existait jusqu'à présent aucun catalogue d'enregistrements accélérométriques en Iran, et aucune étude sur l'ensemble des données iraniennes n'avait été réalisée. Ce mémoire présente donc la première étude d'ensemble sur les mouvements forts en Iran. Un premier objectif a été d'établir un catalogue des mouvements forts d'Iran en faisant correspondre à chaque enregistrement de qualité suffisante, un événement sismique de localisation et magnitude connues, pour 279 enregistrements accélérométriques, analogues et digitaux. Cette correspondance a pu se faire sur la base des catalogues sismologiques internationaux (ISC, NEIC,... etc.) ou nationaux. Pour 189 autres enregistrements numériques, pour lesquelles aucune information télésismique ou locale n'était disponible, les distance hypocentrales et les moments sismiques ont été estimés sur la base des enregistrements eux-mêmes. Une attention particuliere a été accordée aux effets de sites, en choisissant notamment 50 stations accélérométriques du réseau national où les enregistrements ont été nombreux. Une nouvelle classification pour les effets de sites est proposée -basée sur les rapports H/V - qui s'avère relativement simple dans son principe, et plus fiable que les classifications déjà utilisées. Finalement, les lois d'atténuation pour différents paramètres de mouvement fort (dont Arms, Intensité Arias, PGA, PGV, et PGD, énergie, durée et valeurs spectrales) sont obtenues et discutées sur la base d'un total de 468 enregistrements accélérométriques en 3 composantes.

CONTRIBUTION TO THE STRONG MOTION STUDIES IN IRAN; FROM THE CATALOG TO THE ATTENUATION LAWS

The seismic risk studies in Iran are in the first stages. Till now, no catalog of strong motion accelerograms was existing in Iran, and no study has been conducted on the entire of the strong motion data. This thesis presents therefore the first study on the whole strong motion data-set in Iran. A first objective in this work was to establish a catalog of strong motion assign to each record - of a satisfactory quality - a seismic event with known location and magnitude. Such correspondance was possible based on the international (NEIC, ISC, ...etc) or national seismologic catalogs, for 279 analog and digital accelerograms. For 189 other digital data, for which no teleseismic or local information was available, the hypocentral distance and the moment magnitude are estimated based on each record. A special attention was paid to site effects, choosing 50 strong motion stations of the national network, where there were a lot of records. A new classification for site effects is proposed - based on the H/V ratio - which is relatively simple, and more reliable than the previously proposed methods. Finally, the attenuation laws for different parameters of strong motion (such as Arms, Arias intensity, PGA, PGV, and PGD, energy, duration and the spectral ordinates) are obtained and discussed, based on the whole set of 468 three-component accelerometric records.

پژوهش و بررسی جنبش شدید زمین در ایران : از کاتالوگ تا قانونهای کاهندگی

پژوهشهای خطر زمینلرزه در ایران هنوز در گامهای نخستین می‌باشد.
پیش از مطالعات ارائه شده در این رساله هیچ کاتالوگی ازجنبش شدید زمین
در ایران وجود نداشته است. از سوی دیگر تاکنون مطالعه‌ای جامع بر روی
داده های شتابنگاری ایران صورت نگرفته است. بنابراین رساله حاضر
اولین مطالعه بر روی تمام داده های شتابنگاری ایران می باشد. یک هدف اولیه این
مطالعات تهیه کاتالوگ جنبش زمین ایران بود که در آن برای ۲۷۹ نگاشت ۳ مولفه ای
آنالوگ و دیجیتال - که کیفیتی مناسب داشتند - اطلاعات جنبش زمین و سرچشمه ارائه شد.
داده های سرچشمه بر اساس گزارش مرکز های جهانی و کشوری گردآوری شد. برای ۱۸۹
نگاشت دیجیتال که که گزارشی از سرچشمه آنها در دسترس نبود فاصله کانونی و بزرگای
گشتاوری آنها بر اساس خود نگاشتها محاسبه گردید . اثرهای ساختگاه با انتخاب ۵۰
ایستگاه شتابنگاری - جایی که بیشترین نگاشتها بدست آمده بود -
مطالعه گردید. یک روش جدید برای طبقه بندی ساختگاه پیشنهاد شد که اساسی ساده
و کارایی بیشتری از روشهای پیشین دارد. . در نهایت قانون های کاهندگی برای پارامترهای
مختلف جنبش زمین (بیشینه شتاب، سرعت و تغییرمکان ، انرژی، دوام ومقدار های طیفی)
بر اساس پایگاه داده هایی با ٤٦٨ نگاشت شتابنگاری بدست آمده و مورد بحث قرار گرفت .

Remerciements

Comment peut-on être persan!?
Montesquieu

La question posée par Montesquieu est celle que je me pose toujours!, surtout depuis le temps que je voulais faire mon doctorat en France... pour celui qui vient d'un pays avec un risque très important de séismes majeurs, la réponse pourrait être "Étudier le mouvement fort en Iran!". Un sujet qui n'avait jamais été étudié avant, et en même temps, un travail assez important...

Il y a 5 ans, dans mon mémoire de M.Sc., j'ai écrit "il faut continuer les études sur les mouvements forts en Iran, sur la base de l'ensemble des données de l'Iran, inshaallah...". Aujourd'hui, quand je vois que mon rêve de ce jour-là est devenu une réalité, il faut d'abord que je remercie le bon Dieu, qui m'ai fourni la possiblité de faire ce devoir.

Dans ce travail, qui m'a impose au départ et à la fin des difficultés majeures, après le bon Dieu qui m'a donné cet esprit amoureux pour travailler pour mon pays(!), il faut que je remercie mon directeur de thèse; M. Pierre-Yves Bard. Pierre-Yves était présent dans ce travail de la première jusqu'à la dernière minute pour m'assister (moralement, scientifiquement, ...etc.) et me montrer le chemin. Je remercie P.-Y. Bard, pas seulement pour diriger ce travail, mais aussi pour m'avoir montré "comment peut-on être humain?"!.

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Je remercie les membres de jury, M. Mohammadioun et M. Fukushima, qui ont accepté d'être rapporteurs de ma thèse, M. Campillo, M. Mouroux et M. Hatzefeld qui ont y assisté comme les examinateurs.

Un grand merci à ma famille: mon père; Mohammad, ma mère; Fatemeh, et mon frère,

Mehrdad qui ont été toujours avec moi pendant ce travail, malgré leur absence physique de France. Etre loin d'eux, était mon problème le plus important quand j'étais en France.

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Je remerci BHRC (Building and Housing Research Center), l'organisation qui nous a donné la permission d'utiliser les enregistrements accélérométriques de l'Iran.

Je remercie mes amis à Grenoble, et à Téhéran, pour leur soutien (de différents manière); A. Aboura, M. Abtahi, E. Akbari, M. Akbari-Jokar, A. Azadmanesh, A. Baboli, D. Baumont, R. Bousso, P. Buxton, S. Eshghi, M. Farsi, E. Farzanegan, M. Heydari, M.K. Jafari, A. Jalali, C. Lacombe, D. Maclean, G. Mahmoodi, N. Madjoudj, L. Margerin, H. Mirzaei-Alavijeh, K. Pashaei, S. Shakhesi, M. Shirazian, M. Tatar, M. Zaré (mon père!), M. Zolfaghari, F. Zoueshtiagh,... et les autres dont j'ai oublié les noms!...

Enfin, un grand remerciment à mes compatriotes, pour leur gentillesse et leur coopération avec notre équipe pendant notre manip (1996-1997) de 20000 km de voyage dans mon cher pays.

Que Dieu protége les iraniens et
les autres peuples des pays tributaires des
aléas sismiques... inshaallah!...

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Chapitre 1

Introduction Générale

1.1 Le Risque Sismique en Iran

Le plateau iranien (Figure 1.1) est situé entre les plaques Arabie et Eurasie. Le système structurel en Iran est compressif, et la plupart des failles importantes sont chevauchantes avec des composantes de cisaillement. Les régions sismotectoniques de l'Iran (les plus connues) sont le Zagros au sud-ouest du pays, l'Alborz au nord ; l'Iran Central; le Koppeh-Dagh au nord-est; le Makran au sud-est et la plaine du Khuzestan à l'extrême sud-ouest. Les études géologiques de l'Iran montrent que la situation en Azarbayjan (au Nord-Ouest du pays) est plus ou moins similaire aux caractéristiques géologiques de l'Iran-Central. Basé sur les données accélérométriques iraniennes actuellement disponibles, nous allons (au point de vue de la source sismique) distinguer la région de Zagros des autres régions iraniennes (avec des durée et des contenus fréquenciels différents).

La figure 1.2 montre la sismicité récente du plateau iranien. La plupart des séismes destructeurs (récents et historiques) en Iran se sont produits dans les régions de l'Iran-Central et d'Alborz ; tandis qu'au Zagros les séismes sont plus fréquents avec des magnitudes de niveau moyen ($M =< 6$). Les séismes les plus importants en Iran au cours des vingt dernières années sont le séisme de Sarkhun (Bandarabbas) du 7-3-1975 (Ms6.1, mb5.9); Vendik (Ghaen) du 7-11-1976 (Ms6.4, mb5.8); le séisme de Khurgu du 21-3-1977 (Ms7.0, mb6.2); le séisme de Naghan du 6-4-1977 (Ms6.1, mb5.6); le séisme de Tabas du 16-9-1978 (Ms7.3, mb6.7, Mw7.4); le séisme de Ghaen du 16-1-1979 (Ms6.8, mb6.0); le séisme de Korizan (Ghaen) du 14-11-1979 (Ms6.6, mb6.0); le séisme de Koli-Bonyabad (Ghaen) du 27-11-1979 (Ms7.1, mb6.1); le séisme de Golbaf (Kerman) du 11-6-1981 (Ms6.7, mb6.1); le séisme de Sirch (Kerman) du 28-7-1981 (Ms7.1, mb5.7); le séisme de Manjil du 20-6-1990 (Ms7.7, mb6.8, Mw7.3); et le séisme de Ebrahimabad (Firouzabad) du 20-6-1994 (Ms5.7, mb5.9, Mw5.9) [Les épicentres de ces séismes sont indiqués dans la figure 1.2]. La figure 1.3 montre bien que la plupart des épicentres des séismes en Iran sont concentrés dans la région de Zagros en sud-ouest, en Iran-Central (sur les frontières des montagnes et des plaines).

Actuellement, les études sur le risque sismique en Iran se concentrent sur les domaines suivants :

- études néotectoniques et connaissance des failles actives.

- installation d'un nouveau réseau (de sismomètres) [un réseau de stations du WWSSN est installé en Iran depuis fin des années 1950].

- Installation de plus en plus d'instruments de mouvements forts en Iran, et remplacement progressive des instruments analogiques anciens pour des instruments numériques.

- Etudes du mouvement fort en Iran; lois d'atténuation ; effets de sites.

- Etudes de microzonage sismique dans les grandes villes (Téhéran, Tabriz, ..etc).

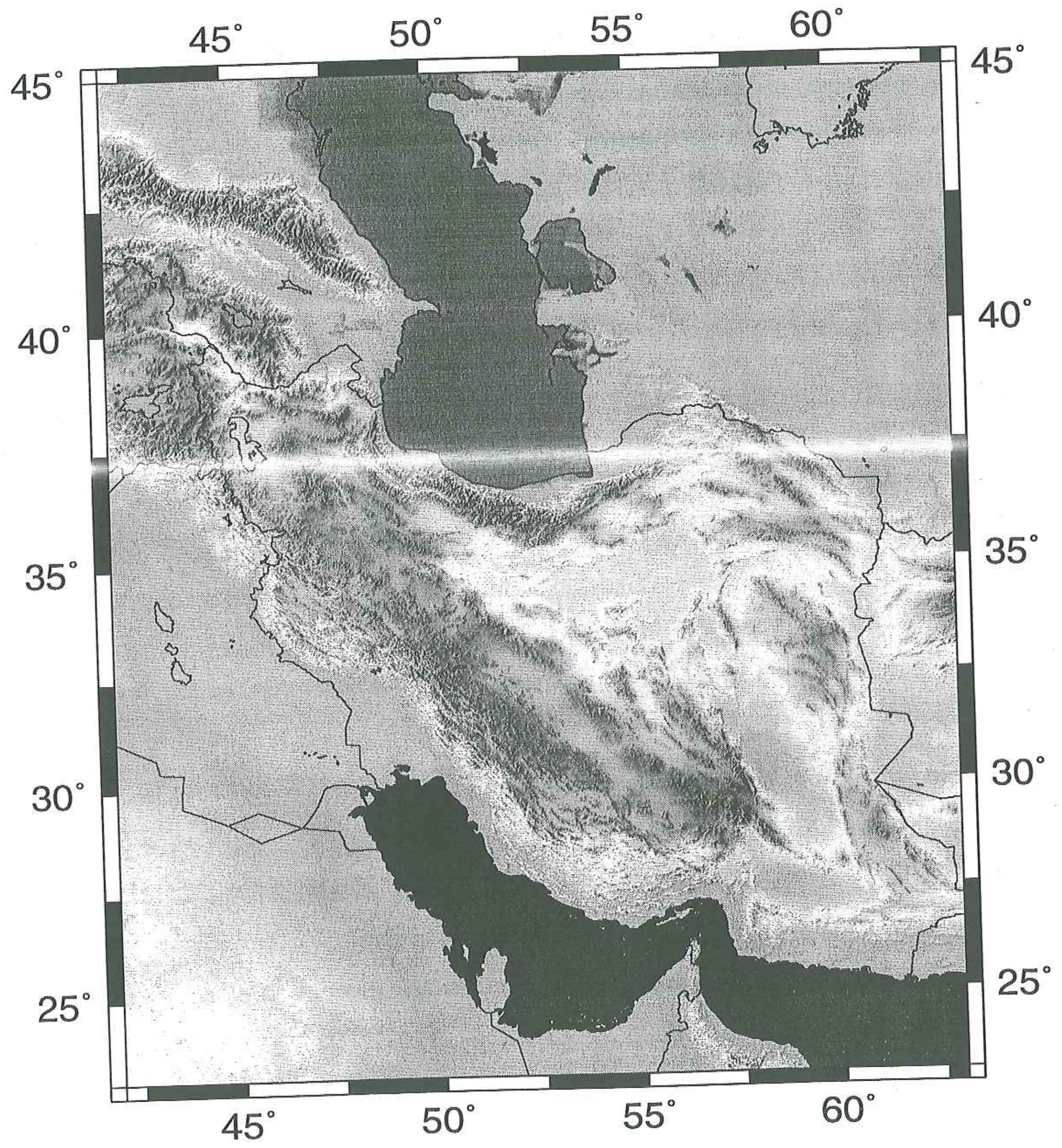

FIG. 1.1 – *La carte de la topographie du plateau iranien et des territoires voisins*

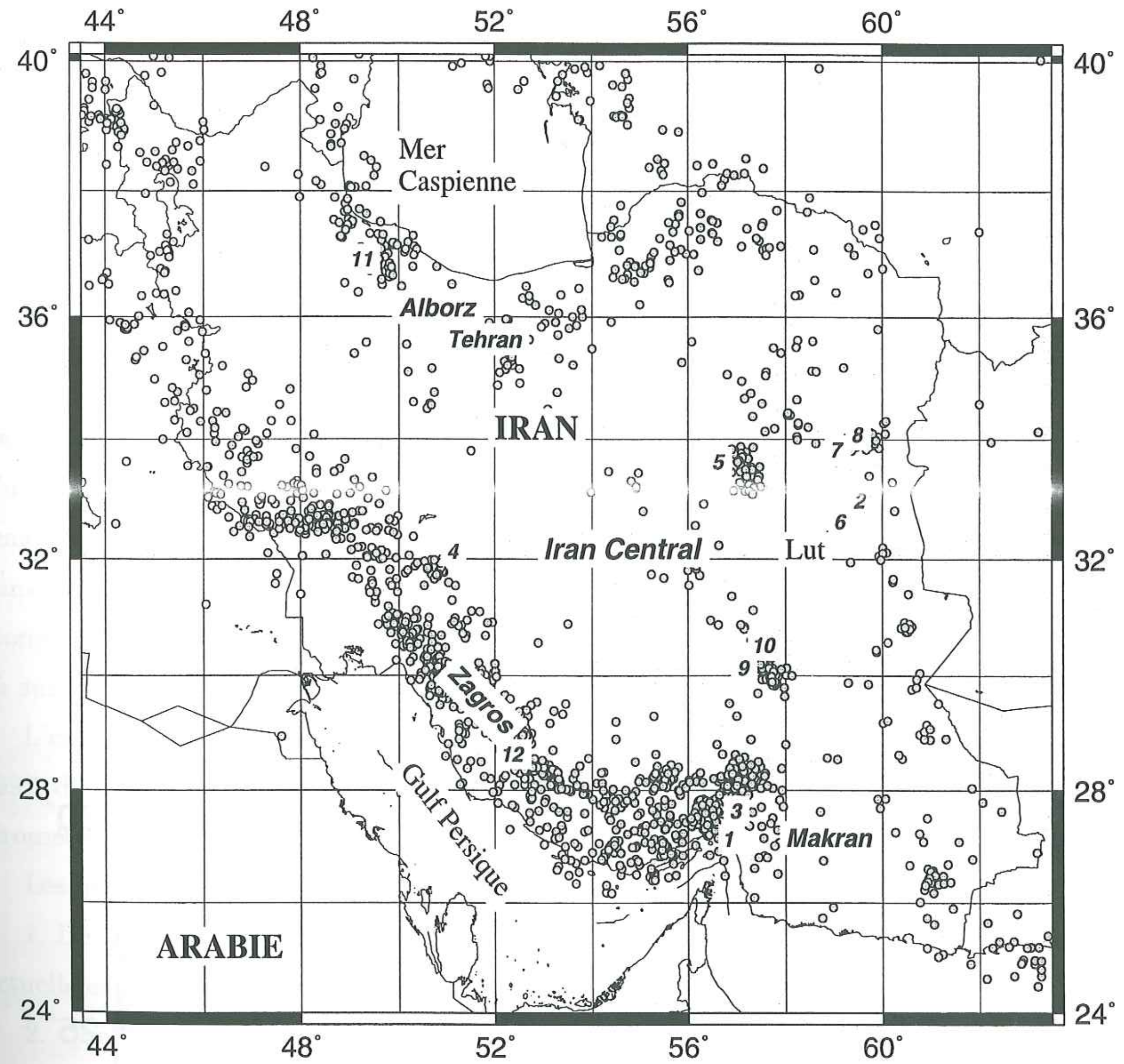

FIG. 1.2 – *Les séismes en Iran avec les magnitudes supérieurs à 4.5 de 1965 à 1998; les chiffres sur la carte montrent les épicentres des séismes de 1: Sarkhun, 2: Vendik, 3: Khurgu, 4: Naghan, 5:Tabas, 6:Ghaen, 7: Korizan, 8: Koli, 9:Golbaf, 10: Sirch, 11: Manjil, 12: Ebrahimabad; pour plus de détails regardez le texte.*

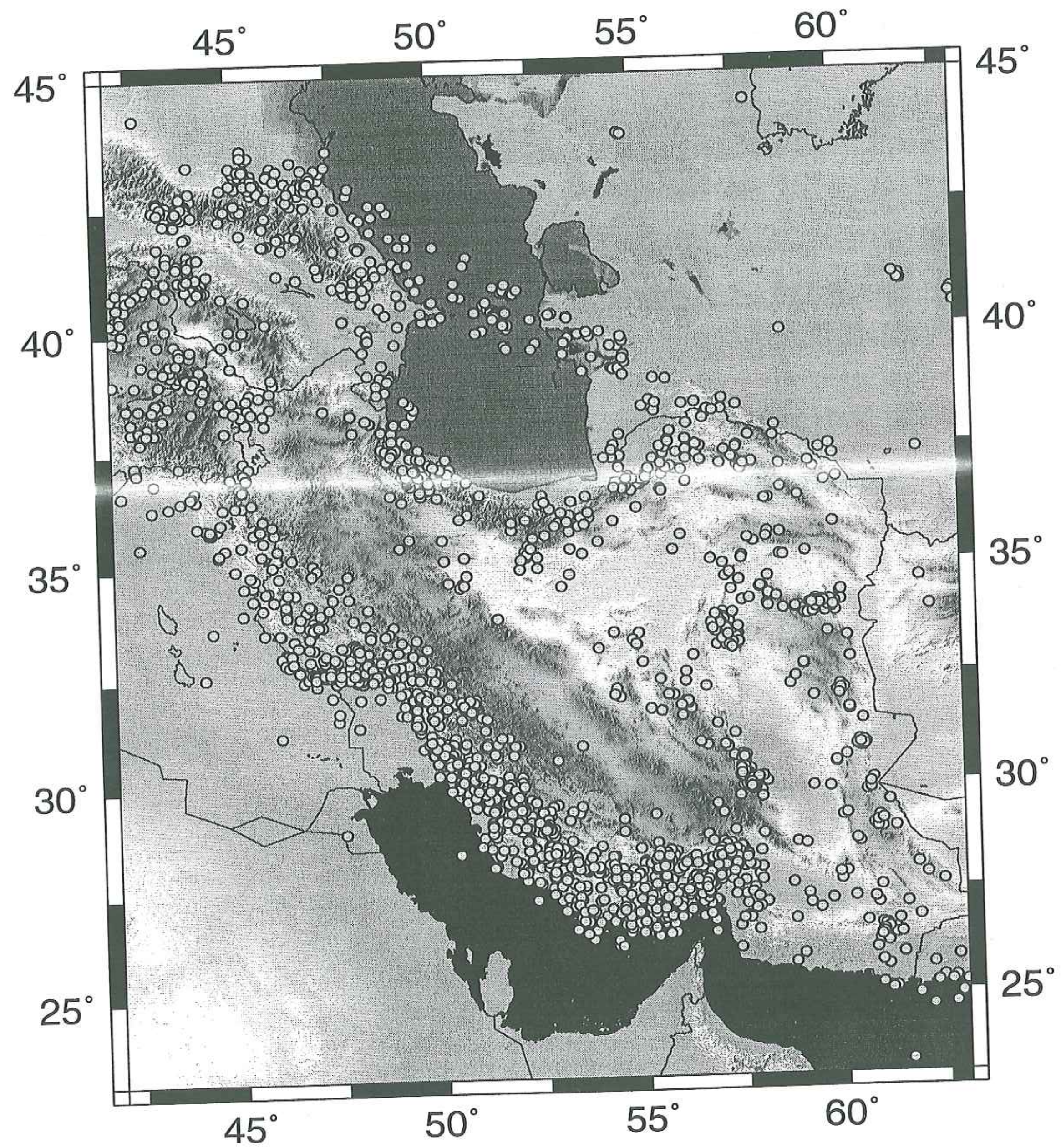

FIG. 1.3 – *Les séismes en Iran avec les magnitudes supérieurs à 4.5 de 1965 à 1998, sur fond topographique*

1.2 Problématique

Le risque sismique a du être pris en compte en Iran pour les nombreux projets de constructions d'ouvrages majeurs en Iran (barrages, ponts, villes nouvelles, tours, constructions souterraines comme les tunnels, le métro de Téhéran et des autres grands villes,... etc.) depuis une vingtaine d'années. Tout ces études se sont déroulées en estimant les sollicitations de dimensionnement sur la base d'enregistrements et/ou de modèles d'atténuations des mouvement forts développés dans d'autres régions du monde (Californie, Japon ou Europe) (Zaré 1995). Il y avait toujours cette discussion sur l'application des loi d'atténuations: est-il possible d'extrapoler une relation d'atténuation développée sur la base des données accélérométriques d'une certaine région? Les spécifications sismotectoniques et physiques différentes de la croûte de chaque région (épaisseur, facteur de qualité, contraintes principales, géologie ...etc) imposent certaine limites à de telles extrapolations. Ce type d'études du risque sismique, sans avoir utilisé les données iraniennes et des modèles basés sur ces données, n'arrivent jamais à manifester l'aléa sismique d'une façon optimum en Iran. Néanmoins, on pense que les analyses du risque sismique en Iran, tenant compte de ces résultats, peuvent être plus réalistes. Les études qui seront présentées dans ce mémoire sont donc d'un intérêt fondamental parce qu'un séisme destructeur, à toute moment ou l'autre, même quand quelqu'un lit ce texte!, peut se produire quasiment n'importe où sur le plateau iranien (l'Iran et ces régions voisins).

L'existence d'un réseau accélérométrique en Iran depuis 1975 (avec 1000 stations à la fin 1997, d'après un rapport du BHRC) permet une étude spécifique en utilisant les données accélérométriques iraniennes.

Les questions importantes auxquelles on voudrait répondre dans cette thèse sont:

1. De combien d'enregistrements accélérométriques de bonne qualité dispose-t-on à l'heure actuelle en Iran?

2. Quels sont les effets de site dans les données iraniennes? Combien de "classes de site" différentes doivent (ou peuvent) être prises en compte?

3. Quelles sont les caractéristiques de source des séismes destructeurs que l'on peut étudier à partir des enregistrements accélérométriques iraniens (moment sismique, chute de contrainte, processus ... etc.)?

4. Est-il possible de distinguer à l'intérieur de l'Iran différentes zones géographiques ou tectoniques, ayant des comportements différents en matière de mouvement forts?

5. Quelles sont les variations de l'énergie et de la durée des mouvements forts dans différentes régions de l'Iran?

6. Quels sont les paramètres d'atténuation en Iran, et quel est le meilleur modèle pour arriver aux résidus minima?

1.3 Les Chapitres de ce Mémoire

Ce mémoire comporte neuf chapitres différents :

- Le deuxième chapitre est consacré au catalogue des mouvement forts iraniens : 770 enregistrements accélérométriques iraniens ont été étudiés. Les rapports signal sur bruit ont été calculés pour tous les enregistrements iraniens disponibles. Un filtrage passe-haut et passe-bas est effectué pour éliminer les bruits et les signaux trop bruités. Les caractéristiques des sources sismiques (localisation, magnitude) ont été trouvées pour les enregistrements de qualité convenable, essentiellement à partir des billetins des organismes sismologiques internationaux, et aussi, chaque fois que c'était possible, des informations locales. Le catalogue présenté dans ce chapitre est composé de 279 données accélérométriques 3 composants, analogues et numériques.

- Le troisième chapitre est consacré à l'étude des effets de sites. Cinquante sites ont d'abord fait l'objet d'un examen attentif, avec la réalisation des mesures géotechniques ou géophysiques spécifiques. 25 sites ont été l'objet de plusieurs types de mesures simultanés: sismique réfraction de surface, profil géotechnique, bruit de fond sismique, tandis que les 25 autres sites faisaient l'objet exclusivement de mesure de bruit de fond sismique. Les résultats de ces mesures ont été comparés à ceux de l'analyse du rapport H/V des enregistrements accélérométriques, et ont conduit à proposer une nouvelle classification en 4 catégories, sur la base du seul rapport H/V. Cette classification s'avère être assez bien corrélée aux valeurs de Vs dans les 30 premiers mètres.

- Le quatrième chapitre se compose d'études sur le moment sismique, la chute de contrainte et la décroissance haute fréquence. Pour un nombre importants d'enregistrements numériques aucune information locale ou télésismiques ne permet de correspondance avec un événement dûment répertorié. Les magnitudes de moment (Mw) ont donc été calculées pour toutes les données (y compris les enregistrements figurant dans les bulletins des organisms int'ernationaux). Les distances hypocentrales ont été estimées par les différences entre les temps d'arrivée des ondes P et S (quand c'était possible). Le calcul de Mw a fourni un échelle de magnitude, homogène, pour toutes les données. La distance hypocentrale est la seule définition pour les données iraniennes qui peut être à peu prés contrôlée avec les données accélérométriques. Ce faisant, avec ces calculs de magnitudes et de distances hypocentrales, 189 données trois composantes ont pu être ajoutées aux 279 enregistrements précédents. D'un autre côté, un ordre de grandeur

pour les chutes des contraintes a pu être estimé, et on observe qu'elles sont représentatives de séismes intra-plaque.

- Le cinquième chapitre est consacré au calcul de l'énergie, de la durée des mouvements forts, et de l'accélération moyenne (Arms) et à l'etablissement de lois d'atténuation sur ces différents paramètres.

- Le sixième chapitre présente les lois d'atténuation sur les principales caractéristique des mouvements forts, à savoir les valeurs maximales et les valeurs spectrales. Plusieurs formes fonctionelles ont été analysées, et les régressions ont été établies aussi bien en 1 seule étape qu'en 2 étapes. Les paramètres de ces lois sont présentés pour deux régions du pays (qui semblent montrer des comportements accélérométriques différents) et pour l'ensemble les données iraniennes.

- Le septième chapitre présente un bilan général de ce mémoire. Des suggestions sont formulées pour continuer ce type d'études en Iran et dans les pays voisins.

- La bibliographie générale et l'annexe sont placées dans le huitième et le neuvième chapitres, respectivement.

Les études sur les mouvements forts en Iran présentś dans ce mémoire, constituent un premier pas pour établir en Iran les bases de la « sismologie de l'ingénieur » (Engineering Seismology), un des points très importants pour améliorer la conception parasismique dans ce pays. Cette amélioration sera à la base de toute mise-à-jour des codes parasismiques en Iran.

Chapitre 2

Le Catalogue des Mouvements forts en Iran

Résumé Les données accélérométriques en Iran seront étudiées dans ce chapitre et présentées dans un catalogue qui comprend les valeurs maximales des mouvements forts et les caractéristiques des sources pour chaque enregistrement. Les enregistrements sont les données pour lesquelles : 1) La qualité de l'enregistrement et de la numérisation (pour les données analogiques) est suffisamment bonne et 2) les caractéristiques de la source auront pu être déterminées à partir des enregistrements télésismiques. Les enregistrements de mouvements forts en Iran sont de deux types: les données analogiques qui sont obtenues par les instruments SMA-1 (Kinemetrics), et les données numériques enregistrées par les appareils SSA-2 (de même marque). D'après les rapports du BHRC (l'organisation qui s'occupe de réseau accélérométrique iranien) il y avait, à la fin de l'année 1997, 1000 stations installées un peu partout en Iran. Parmi environ 750 enregistrements disponibles (obtenu entre 1974 et 1997) , on a choisi 279 enregistrements (qui satisfont les conditions précédentes), dont 169 analogiques et 110 numériques (en trois composantes). Ces données proviennent des différentes régions du pays: 143 du Zagros (ouest et sud-ouest), 78 de l'Iran-Central, 48 de l'Alborz (au nord), 9 de l'Azarbayjan (au nord-ouest) et 1 enregistrement du Koppeh-Dagh (en nord-est). Nous allons donc présenter le premier catalogue de mouvement forts en Iran, qui contient les noms des stations, la catégorie du site, les fréquences de filtrage, les valeurs maximales de l'accélération, de la vitesse et du déplacement, les paramètres de la source [la magnitude (Ms, mb, Mw, ML)], les distances à la source (épicentrale, hypocentrale, et distance à l'épicentre macrosismique), l'intensité, le mécanisme au foyer quand celui-ci était disponible, et un indice de qualité pour chaque enregistrement présenté dans ce tableau.

The Iranian Accelerometric Data Bank, A Revision and Data Correction

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Abstract The Iranian strong motion records are studied in order to prepare a catalog to be used as a data base for further studies (for instance empirical attenuation laws). The network was installed in 1974, and now comprises 1000 stations. The instruments are SMA-1 analog (installed before the Manjil earthquake) and SSA-2 digital Kinemetrics types (after Manjil

earthquake). Out of a total of 450 records with a priori satisfactory quality (well recorded and correctly digitized in the case of the SMA-1 records), a set of 279 records was selected for which it was possible to associate correctly determined source parameters (source magnitudes and epicentral distances): 169 correspond to SMA-1 instruments, and the remaining 110 to SSA-2. The distribution of the records in the different geological/seismotectonics regions are; 143 in Zagros, 78 in Central-Iran/Lut, 48 in Alborz, 9 in Azarbayjan and one record in the Kopeh-Dagh region. The main outcome of this paper is to provide the first strong motion catalog of Iran, with the indication of the site conditions; the frequency band of the reliability of the records, the peak values of acceleration, velocity and displacements, the source parameters (magnitude, epicentral and macroseismic distances), the intensity and finally the fault plane solutions whenever possible.

2.1 Introduction

The first Iranian strong motion instruments were installed in 1974. The strong motion network has grown considerably since that time and by the end of 1997 comprises 1000 stations all over Iran, in different geologic conditions. The first instruments were of Kinemetrics SMA-1 type. The SMA-1 analog recorders have been in use from 1974 until 1991 (the great Manjil earthquake and its aftershocks provided the last important records on SMA-1 instruments). They have been progressively replaced by SSA-2 instruments after the Manjil (1990) earthquake in NW Iran. By the end of December 1997, 640 SSA-2 and 200 SMA-1 instruments were installed mostly in free-field conditions while 58 SSA-2 and 2 SMA-1 instruments were placed on dams all over the country. Several hundred of records have been obtained with this network.

The total number of records (three component accelerograms) which were available for this study were 770 (out of which about 550 SMA-1). These data were distributed by the Building and Housing Research Center of Iran (BHRC) as uncorrected but digitized records. The raw data set distributed by BHRC comprises a relatively complete data set of recordings obtained by the national accelerometric network of Iran since 1974, otherwise we have used some BHRC previously corrected data in order to complete some gaps in the recent data set. Recent records (most of them in the southern Iran; Zagros area) were obtained with the digital network. The digital records are obviously more reliable than the previous analog ones; they include the exact trigger time, and there is no more additional noise brought in by the handy digitalization process. Therefore the amount of reliable SSA-2 accelerograms selected here after about two years (1994-1995) almost equals the number of well-recorded SMA-1 records, although they relate to a much larger duration; about twenty years (1974-1993).

The previous publications on the Iranian accelerometric data are limited to some reconnaissance reports on the great earthquakes, comprising the uncorrected accelerograms or just the peak values (e.g. Moinfar and Eetemadi, 1982, Moinfar and Adib-Nazari, 1982, Moinfar and Naderzadeh, 1990, Niazi and Bozorgnia, 1992) and the reports presenting a list of the recorded uncorrected accelerograms (BHRC, 1992) or a preliminary processing of the records of one particular event (Moinfar and Shoja-Taheri 1988). The complete listing of the Iranian analog data has been published in 1993 by BHRC, and the SSA-2 accelerograms are published gradually. Some studies on some particular subsets have been already published by Niazi (1986), Shoja-Taheri and Anderson (1988), and Saikia (1994) on the Tabas earthquake of 1978 and in Zaré (1996) on Tabas (1978) and Manjil (1990) earthquakes. Preliminary attenuation studies in Iran have been already performed by Zaré (1995) who has presented the models, developed based on some accelerograms recorded during the great earthquakes in Iran. In another the Iranian data have been compared by the American models is performed by Niazi and Bozorgnia (1990).

The scope of this study was to sort and select accelerograms within this large data set, so as to propose a catalogue of strong motion data in Iran with appropriate and valuable source parameters and site conditions. This catalog (Appendix 1) is the first one to present the well recorded accelerograms in Iran. The catalogue comprises the source and site parameters as well as the maximum values of acceleration, velocity and the displacement for each record. A quality factor is defined as well in this table to indicate the level of reliability of each record.

It should be noticed that during the final stages of the present study, another great earthquake with a magnitude over 7 has shocked the eastern Iran region (Abiz - Ghaen - earthquake of 10 May 1997, Mw7.3) but the recent records from this earthquake were not yet accessible to be included in this study.

In this paper we will present, first, how we have determined the source parameters for each record. The method to select the best (best recorded, more reliable,...) records are explained afterward, and then our methodology to process the accelerograms are presented. The sources of the probable errors are discussed finally.

2.2 Determination of the Source Data for each Record

We have chosen a set of 279 records within which we could find minimum source parameters (source magnitudes and epicentral distances) and the best qualities. The selected SMA-1 and SSA-2 accelerographs are shown in Figure 2.1. Figures 2.2 to 2.5 show the distribution of

the accelerometric sites and the instrumental epicenters of the recorded events in the national network, in the northwest, northeast, southwest and southeast of Iran, respectively.

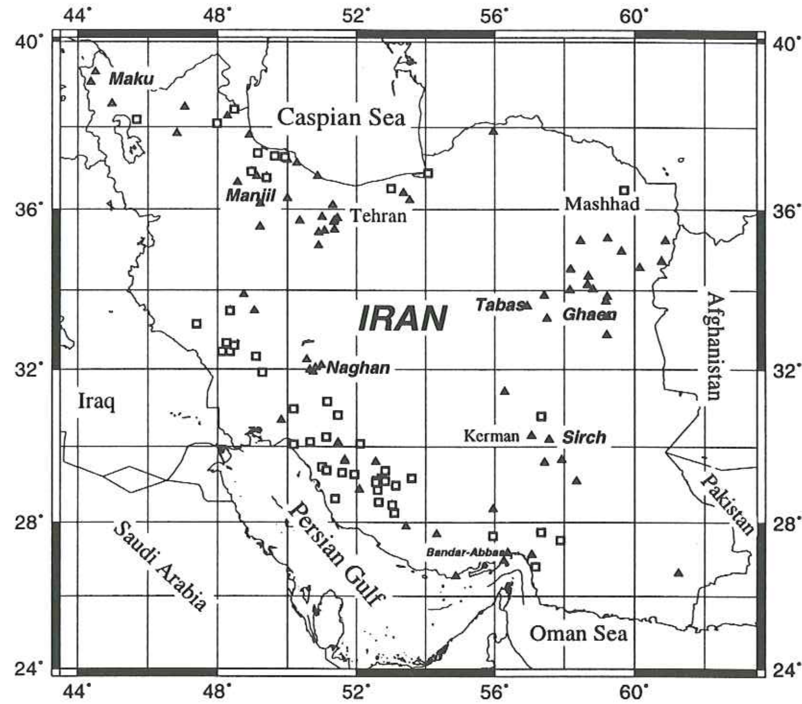


FIG. 2.1 – *The locations of the selected accelerometric sites in Iran in this study; the triangles show the analog SMA-1 and quadrangles show the digital SSA-2 instruments.*

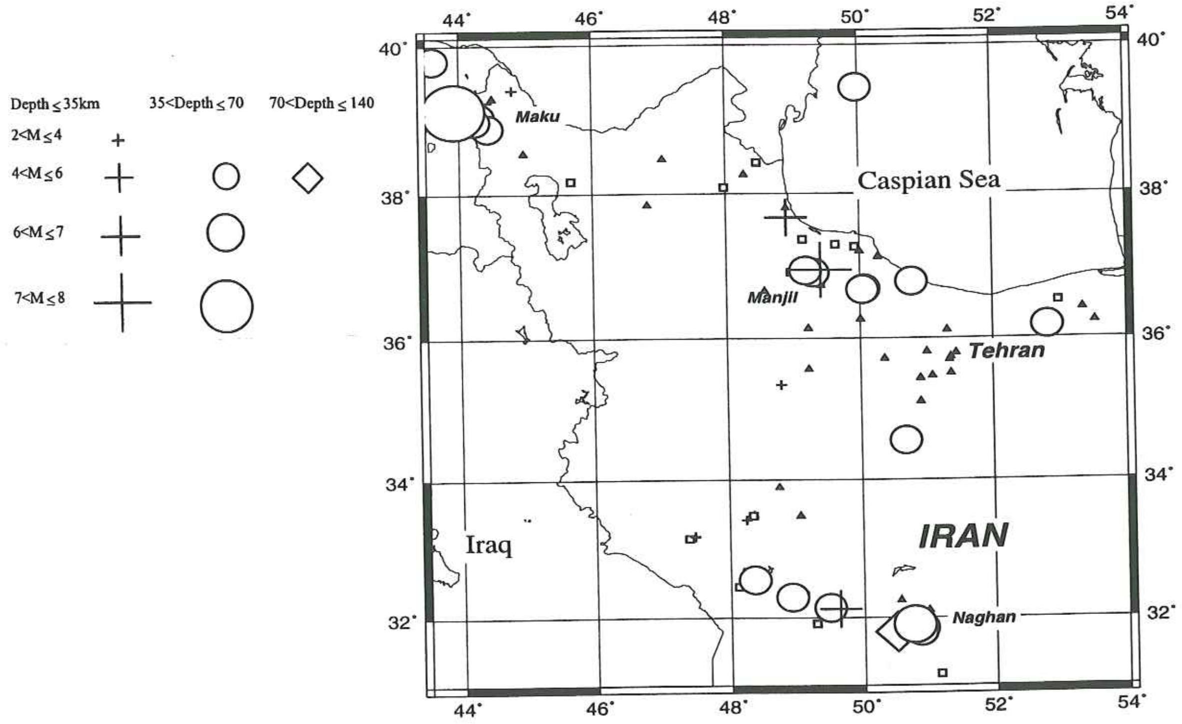


FIG. 2.2 – *The location of the strong motion station and the epicenter of the event which a re recorded in these stations in northwest of Iran.*

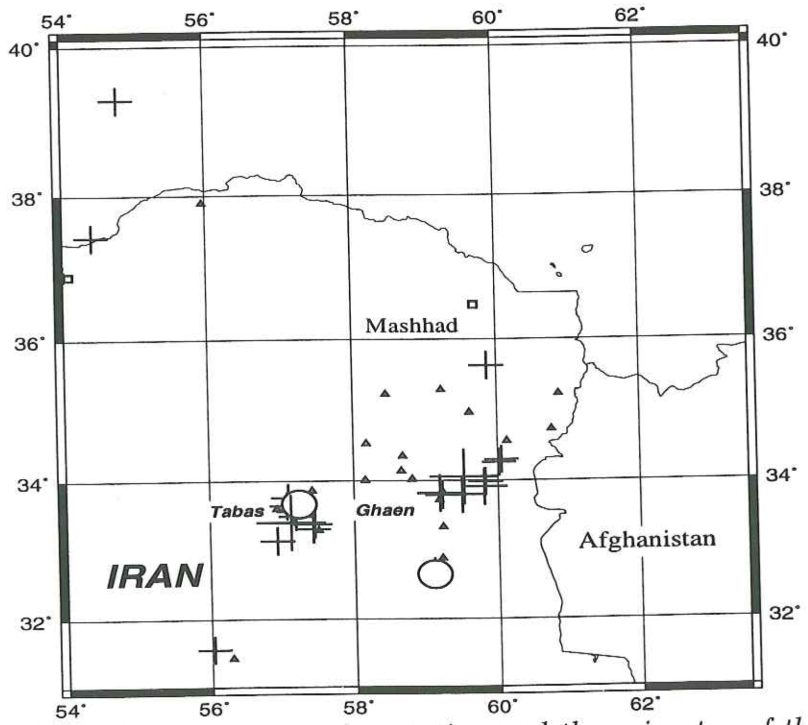


FIG. 2.3 – *The location of the strong motion station and the epicenter of the event which a re recorded in these stations in northeast of Iran.*

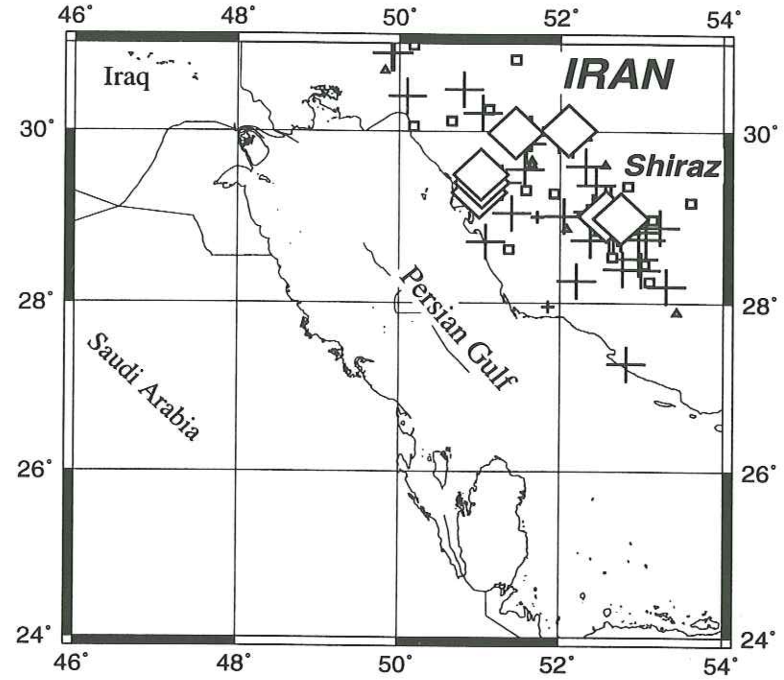


FIG. 2.4 – *The location of the strong motion station and the epicenter of the event which a re recorded in these stations in southwest of Iran.*

Most of the accelerometric data have been disseminated without corresponding earthquake characteristics (location and magnitude) for each record. Based on the existing data for each record (the peak accelerations, the date and arrival times of the SSA-2 records, or the date of the visit of the operators to change the analog films of the SMA-1 instruments) the causing earthquake is determined. The epicentral locations determined by NEIC and ISC are used in most of the cases. Meanwhile, reports by the national seismic network (Institute of Geophysics, Tehran university; IGTU) and earthquake reports published in the national dailies (if available) are analyzed to check the localitions of the macroseismic areas and therefore to have other criteria to check the epicentral distances. Whenever reports on macroseimic epicenters could be found (Ambraseys and Melville 1982; Zaré 1991; 1994; Zaré and Moinfar 1994; Heydari and Zaré 1995; or therefore detail of damage reports in the dailies, or in the NEIC or ISC monthly bulletins) it was possible to have an estimation of the epicentral distances (Appendix 1).

The magnitude of the events are presented as available; the body wave, surface wave and moment magnitudes (mb, Ms and Mw, reported by NEIC and ISC) are included, whilst the local magnitudes are given, when available, in the reports by the national seismic network (IGTU).

The focal depths show that most of the recorded events in the Iranian plateau were super-

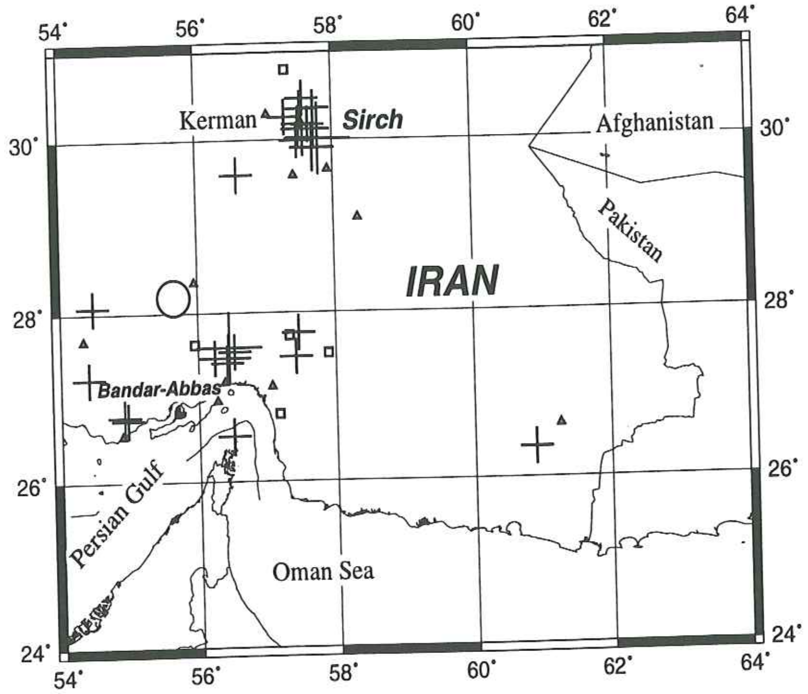


FIG. 2.5 – *The location of the strong motion station and the epicenter of the event which a re recorded in these stations in southeast of Iran.*

ficial. Most of the events had focal depths between 0 and 35 Km (218 records; comprising the depths which are reported '33km', that are the defaults to show the superficial events when it was not possible to determine an exact depth). Forty-one other events have a depth between 35 and 70 Km (in the Zagros area, Alborz, northern Lut, and Azarbayjan - NW Iran - region). Six have a depths between 70 and 140 Km (on the Zagros thrust zone, Southern Zagros and Alborz). There was no depth reported for 12 other events.

The earthquake intensities presented in this work are based on the reported isoseismal maps (Ambraseys and Melville, 1982; Ambraseys, 1988; Berberian et al, 1984; Eshghi et al, 1994; Moinfar and Naderzadeh 1990), but in some cases an estimated intensity was added based on detailed reports that were found in dailies. The intensity values are all presented in MSK scale: when they were reported in another scale, they were converted to this scale using a comparison chart for different intensity values (Japan Technical Committee 4, 1992). The intensity may give an idea of the damage or shaking of an event in an inhabited region. In some cases the landslide reports (as geotechnical evidence) are also used to estimate the intensity; a previous study on the Manjil earthquake (Zaré 1993) has shown that landslides in the form of rock-block slides occurred only in areas with intensities of at least VI MSK. The localities of the most important macroseismic regions, localized in this study, are shown in Figure 2.6. A summary

on these localities is given in Appendix 2.

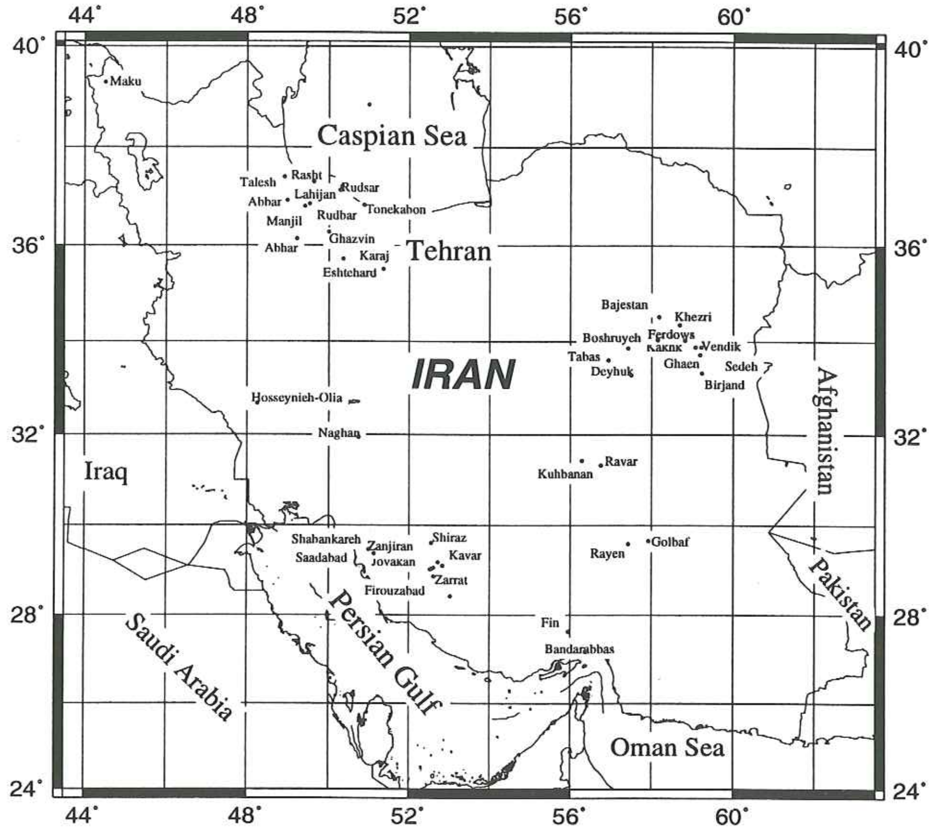


FIG. 2.6 – *The selected stations in this study.*

The focal mechanisms are reported in Appendix 1 based on the NEIC monthly publications 'Preliminary Determination of Epicenters' as well as the monthly bulletins of ISC. The data presented with reported focal mechanism number 100, of which 40 have strike-slip/reverse solutions, and 31 pure strike slip, 24 pure reverse, 4 pure vertical plane and just one with strike-slip/normal mechanism. Most of the events thus have a strike-slip/compressional mechanism, in agreement with the recent general tectonic activity in the Iranian plateau (by compression between the Arabian plate, in the southwest, and the Turan -Eurasian- plate in its northeast). The deformation is accommodated through the strike-slip and reverse/thrust faults in most of the cases in this plateau. Jackson and McKenzie (1984, 1988) have shown the details of such features of stress and deformation in the Iranian plateau.

2.3 Extracting the most Reliable Records

The criteria to select the records are presented below: . Knowledge of the magnitude and source location. The existence of the minimum required source parameters (magnitude and epicentral distance) was necessary to develop the attenuation laws. . Acceptable signal to noise ratio (for the SMA-1 data). Many SMA-1 records had long period noises. The magnitude of the noise was such that it was not possible to distinguish real signal from the noise (especially in the case of the records corresponding to the low magnitude events or the records that were obtained in the far distances from the epicenters).

The amount of low and high frequency noise was verified through the signal to noise ratios. This ratio was calculated for each records. The way to calculate this ratio is described further below.

2.4 Data Correction

The data correction (after base-line correction) is carried out through the following steps:

2.4.1 Determination of the appropriate frequency band

For each record, the Fourier transform of the signal is computed $S(f)$ over a length ts, as well as the Fourier transform of the noise, computed over a length of tn. The normalized signal to noise ratio $N(f)$ may be shown as :

$$R_{sn} = \frac{\frac{S(f)}{\sqrt{t_s}}}{\frac{N(f)}{\sqrt{t_n}}} \tag{2.1}$$

The threshold level of 3 for R_{sn} is selected to delimitate the frequency band where the information is meaningful. The example of Bandarabbas record during the Sarkhun earthquake of March 7, 1975 (Ms6.1, mb5.9) that is recorded at an epicentral distance of 28 km (Appendix 1, Figure 2.7) is selected to show the procedure of the correction. This three component accelerogram (raw data) is shown in Figure 2.7 as it results from the digitalization. The window of 30 to 45 sec is selected for noise window $N(f)$, and the window between 0 to 25 sec is chosen for signal window $S(f)$. The R_{sn} ratio for this record is presented in Figure 2.8. A part of this spectrum between 0.6 and 20 Hz may be selected as the proper signal frequencies. This

procedure may be too severe when there is no clear « noise » window over the whole record length.

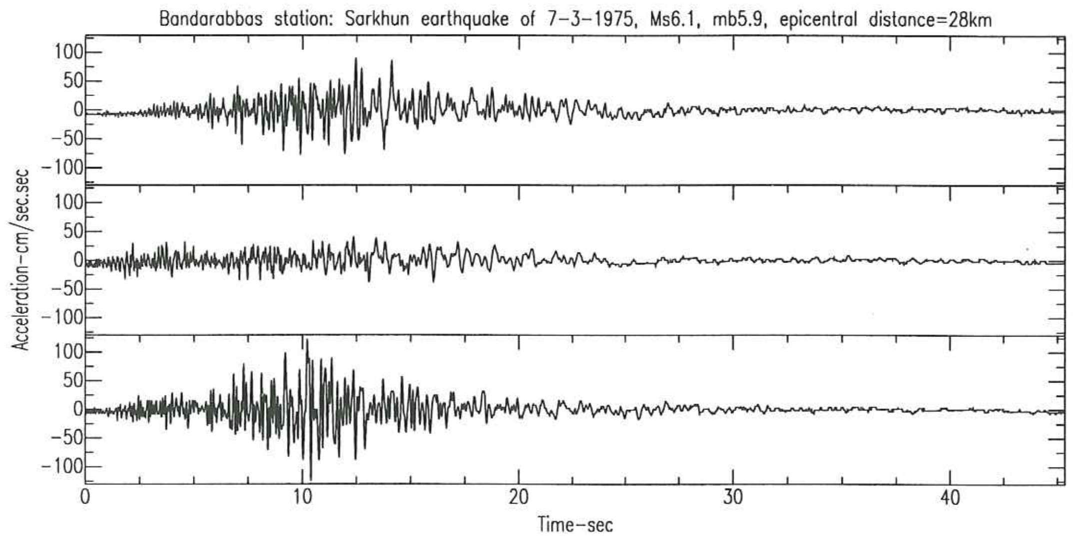


FIG. 2.7 – *Three component acceleration time history of Sarkhun earthquake (7-3-1975) recorded in Bandarabbas (before correction and filtering). The middle record is the vertical and the two others are the horizontal components.*

2.4.2 Spectrum shape

To be sure that the frequency band selected is the dominant signal band, the Fast Fourier Transform (FFT) is calculated for all the records. The FFT for the three components of the aformentioned record is presented in Figure 2.9. According to the ideal shape of the FFT for acceleration, an f^2 shape is expected in the area below the « corner frequency » f_c and a decaying shape at high frequencies beyond « maximum frequency » f_{max}. A more or less constant amplitude of the FFT spectrum (below f_c) or at high frequencies (beyond f_{max}) estimates some low or high frequency noises. In Figure 2.9, the part of the spectra before 0.6Hz and after 20Hz are abnormally high. However these trends might be continued and descend in the ideal slopes in these areas. Therefore these parts may be thought of as noises and the section between these two limits contains the reliable signal. As is shown in this example, the accuracy of the selected

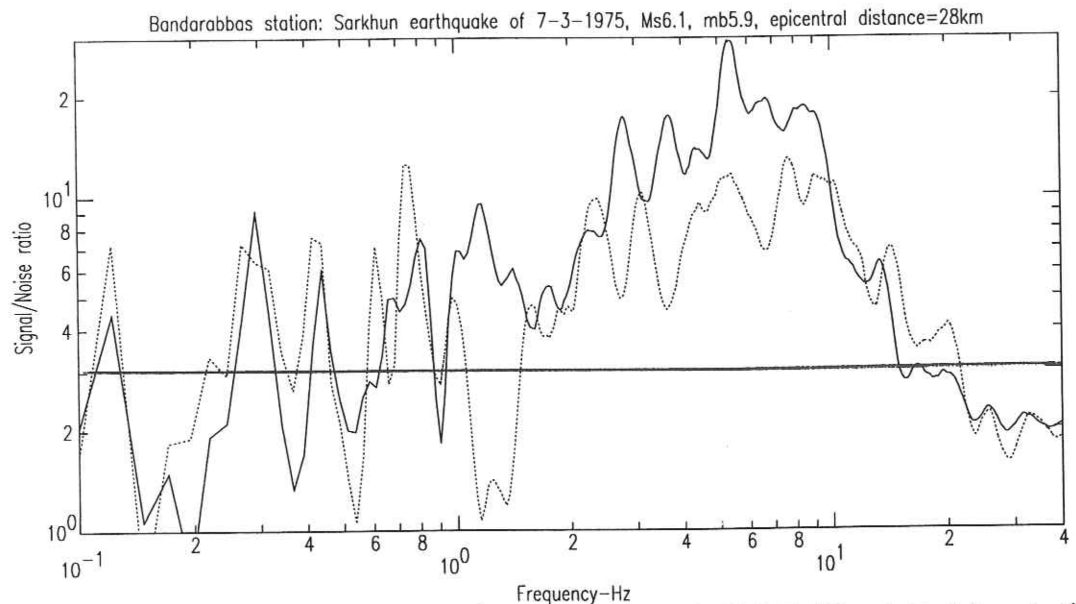


FIG. 2.8 – *The signal to noise ratio for the time history in fig2.7. The dotted line is the spectrum for the vertical and the continuous line is for the horizontal components.*

windows for the noise and signals, as well as the applied method of signal to noise ratio is verified by checking the spectral shape.

2.4.3 Filtering and Integration

Once the reliable frequency band is determined through both signal to noise ratio R_{sn} and checking of the spectrum shape, the SAC (Seismic Analysis Code) software is used to filter the records in those frequency bands with infinite impulsive response (IIR) filters. The butterworth filter is applied in the present study. This type of filters is a good choice since it has a fairly sharp transition from pass band to stop band, and it has a moderate group delay response. The result of the use of band-pass filtering is shown in Figure 2.10 in the case of Bandarabbas accelerograms during the Sarkhun earthquake. The FFT for this three component record after the filtering (using a band-pass filter with cutoff filters 0.6 and 20 Hz) is presented in Figure 2.11.

The high-pass filters have also been used to eliminate the low frequency (long period) noises from the digital (SSA-2 Kinemetrics) records although this filter is much less important than for SMA-1 records. For instance, Figure 2.12 shows the three components accelerograms in the

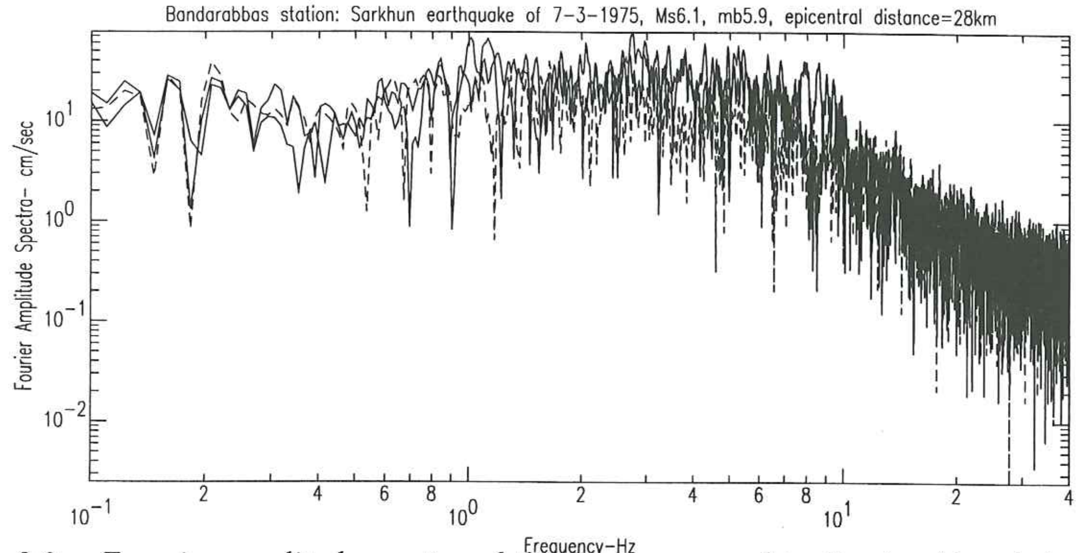


FIG. 2.9 – *Fourrier amplitude spectra of the Sarkhun record in Bandarabbas, before filterin g. The dotted line is the spectrum for the vertical component.*

Zanjiran station recorded during the Ebrahimabad earthquake of 20-6-1994. This is the record with the highest acceleration (among the digital records); peak acceleration exceeds 1g. In these cases there were no handy digitalization noises, therefore the filters were selected on the basis of the Fourier spectra to see in which part(s) the FFT spectra differed from the ideal forms before the corner frequency f_c and after the maximum frequency f_{max}. These digital recordings have only very small high frequency noise which does not affect significantly peak values (the high frequency noises are generally in the domain of 50 to 100 Hz). Therefore the main attention must be paid to the low frequency noises which are evident before the corner frequency f_c. The low frequency noises may cause the greatest divergence on the velocity time-histories after an integration on the acceleration time-history. The domain of the low frequency noises may be searched for the example of Figure 2.12 by taking a FFT (shown in Figure 2.13). Even in these transformations some low frequency noises may be seen below 0.3 Hz. Applying a high-pass butterworth filter of 0.3 Hz, one may get the FFT given in Figure 2.14. The filtered acceleration time history is shown in Figure 2.15. The integration on this record after filtering (Figure 2.16) indicates no divergence from the base-line and so a proper filter is selected. The same high-

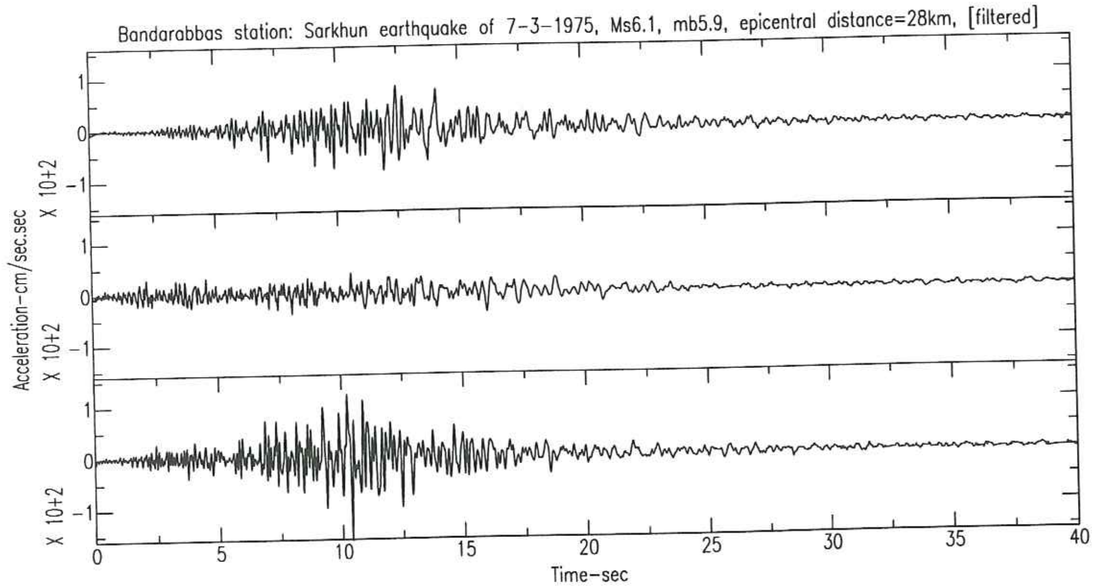


FIG. 2.10 – *The corrected and filtered three component acceleration time history in Bandara bbas. The middle record is the vertical and the two others are the horizontal components.*

pass filter (0.3 Hz) is applied before the second filtering (on the velocity time-history) and the resultant displacement time-history is shown in Figure 2.17.

The analog corrected record (after filtering) has been integrated to find the velocity and displacement time-histories (Figure 2.18 and 2.19, respectively). It is noteworthy to say that in the present case (Sarkhun earthquake record in Bandarabbas) there was no need to use another filtering before the second integration (to obtain the displacement time-history). As shown in Appendix 1, in most cases a second filtering was needed to obtain the displacement spectra starting and ending on the zero base-line, and with no sharp offset when the recorded samples meet the zero baseline. When these abnormal forms are observed, a second filtering is applied to eliminate these effects.

2.5 Site effects

The records are obtained under different soil conditions. As there are no downhole arrays in the country nor any pair of sites in one locality, in most cases there is no possiblity to compare

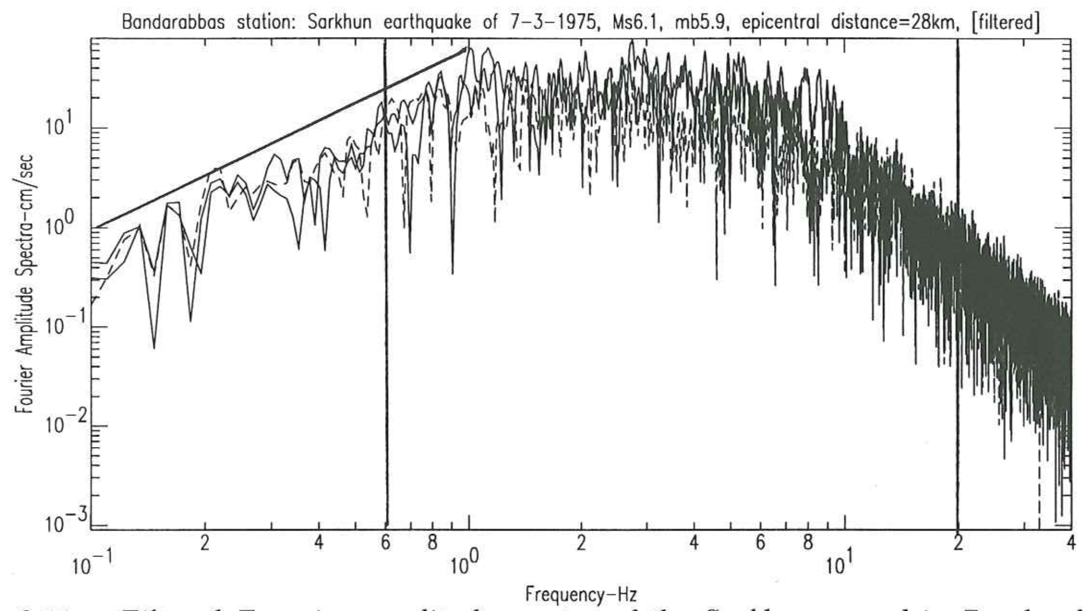


FIG. 2.11 – *Filtered Fourrier amplitude spectra of the Sarkhun record in Bandarabbas. The d otted line is the spectrum for the vertical component.*

empirically the records on soil and on nearby rock outcrops.

Soil conditions are also indicated in Appendix 1. These soil categories were defined after a comprehensive study of soil conditions which is detailed in another paper (Zaré et al 1999a). In brief, site category 1 corresponds to rock and hard alluvial sites, with Vs>800 m/s over 1st 30m depth and site amplifications (SAM) over 15 Hz. The site category 2 relates to alluvial sites; thin soft alluviums, with 500<Vs<700 over 1st 30m depth, and 5<SAM<15 Hz. The site category 3 corresponds to soft gravel and sandy sites, with 300<Vs<500 over 1st 30m depth and 2<SAM<5Hz. Finally the site category 4 relates to soft soil sites; thick soft alluviums with Vs<300m/s over 1st 30m depth and SAM<2Hz. This preliminary ranking is based both on the studies on 50 sites where geotechnical measurements were performed (compressional and shear wave velocity and microtremor measurements) and three component accelerograms were used to calculate the receiver function for the strong motions. The result of this classification is presented in table-I (Zaré et al 1999a):

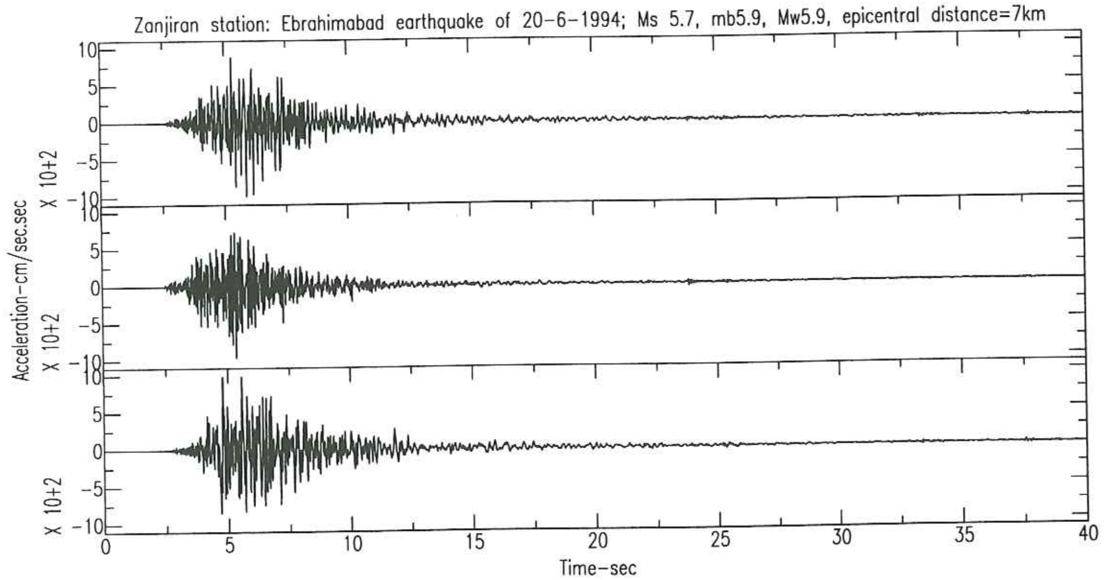


FIG. 2.12 – *Three component acceleration time history of the Ebrahimabad earthquake of 20-6 -1994 recorded at Zanjiran before filtering. The middle record is the vertical and the tw o others are the horizontal components.*

Table-I: The 4 class site categorization

Group	Frequency Band of the Amplification	Vs_{30} m/s	Sites
1	$F >= 15Hz$	$Vs_{30} >= 700$	Abbar, Deyhuk, Ghaen, Jovakan, Kakhk, Naghan, Saadabad, Tabas
2	$5 =< F < 15Hz$	$500 =< Vs_{30} < 700$	Kavar, Maku, Manjil,Vendik, Zanjiran
3	$2 =< F < 5Hz$	$300 =< Vs_{30} < 500$	Fin, Firouzabad, Ghazvin,Golbaf, Rudbar, Zarrat
4	$F < 2Hz$	$Vs_{30} < 300$	Abhar, Lahijan, Hosseinieh, Rudsar, Shabankareh,Tonkabon,Talesh

Among the methods that we have used to study the site conditions, the only method that may reveal the site response to ground motions is to study the three component strong motion records. The benefit gained from this method is that we had at least one record in each of the stations and this is the only method which may be applied at each location. The velocity profiles that we measure by the geoseismic methods are limited to the first 30-35 metres; the microtremors have shown important amplifications just in the soft soil sites, and the geoelectric

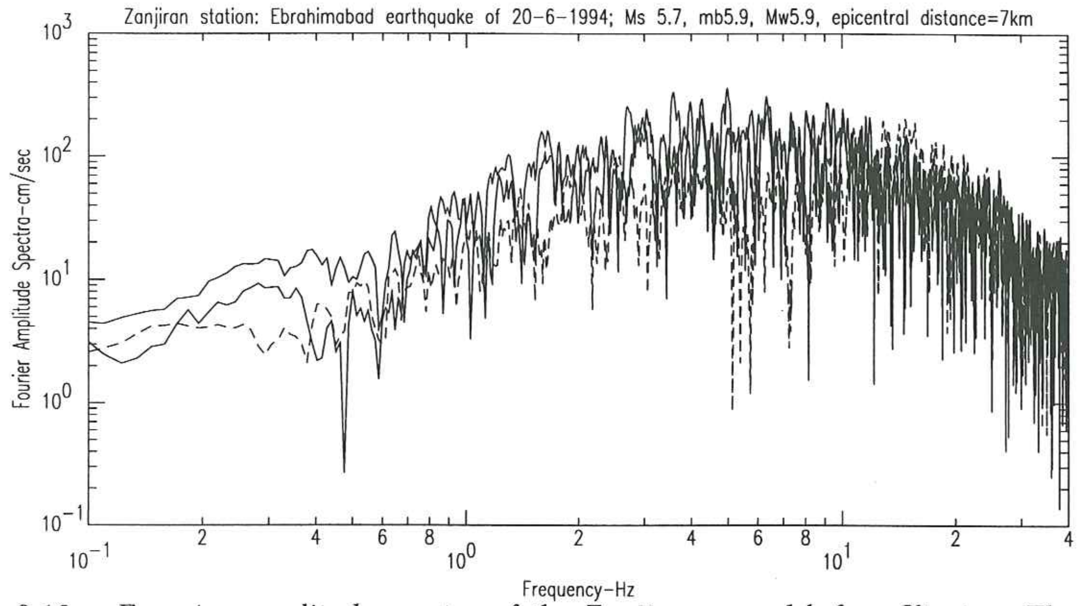


FIG. 2.13 – *Fourrier amplitude spectra of the Zanjiran record before filtering. The dotted line is the spectrum for the vertical component.*

tests do not give the precise measurements to distinguish the different sites. Meanwhile, if there are thick alluvial layers on the surface (with a thickness of more than 30 metres) on a very high velocity layer at greater depths, the H/V spectrum for the strong motion (the receiver function) is the only way to observe such an amplification in low frequencies. In this case the other methods will show just the high velocity alluvium with some amplifications in high to very high frequencies (more than 15Hz).

2.6 Assigning a Quality Label to each Record

A four class categorization is used to grade the quality of each record; « A » corresponds to the best quality and « D » to the worst. Four criteria are taken into account for this categorization; 1. The quality of digitalization of the analog records (corresponding generally to low PGA records). 2. The source focal depth (sould be unequal to 33 km). 3. The macroseismic epicentral distance. 4. The source mechanism. If these conditions are available for one record, then its label is assigned « A », and in the absence of each of these cases the qualify factor

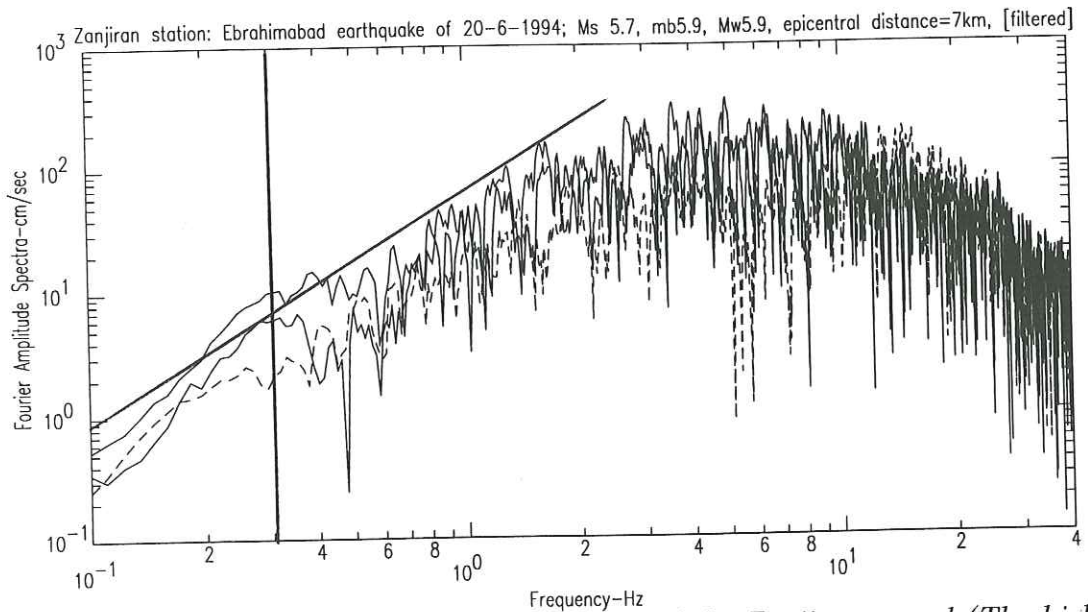


FIG. 2.14 – *The filtered Fourrier amplitude spectra of the Zanjiran record (The high-pass filter of 0.3Hz is used). The dotted line is the spectrum for the vertical component.*

diminishes to « B », « C »,... but the worst records which are chosen had at least the earthquake « magnitude » and the epicentral distance (instrumental) which are referred to as « D ».

2.7 Sources of Errors and Uncertainties

Some expected sources of uncertainties during this study may originate from:

2.7.1 Instrumental and macroseismic epicentral distances

As most of the source parameters are based on the teleseismic data, an uncertainty may originate from the lack of precision in the epicenters location, and the concequences on the estimates of epicentral distances. According to ISC monthly bulletin, the accuracy of the localization in the last 20 years has been different from about 0.01 (approximately about 1 km in a geographical coordinate such as Iran) for the great earthquakes with magnitudes more than $M7.0$, to about 0.15 (approximately about 15 km for such a region) for the earthquakes with magnitudes about $M4.0$. We have however the feeling that these precision estimates are very

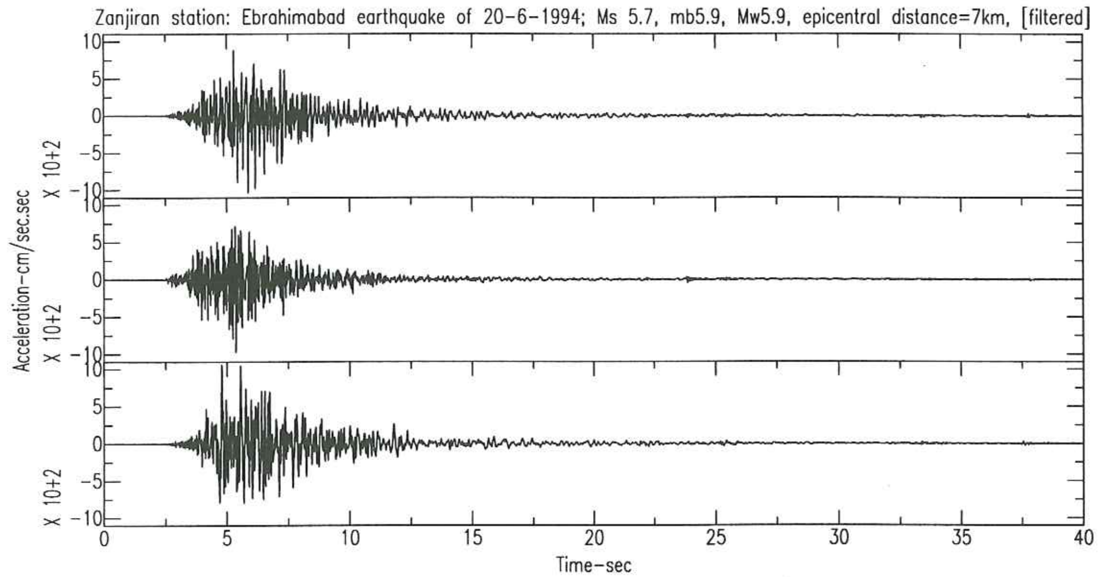


FIG. 2.15 – *The filtered three component acceleration time history of the Zanjiran record (The high-pass filter of 0.3Hz is used). The middle record is the vertical and the two othe rs are the horizontal components.*

optimistic and should be at least doubled.

The macroseismic epicenters are based on damage reports, whenever available (which is possible only in the inhabited areas), as well as the surface earthquake fault ruptures if there was evidence. Therefore the distances to macroseismic epicenters depend greatly on the presence (or absence) of damage reports, the geographic distribution of the inhabited regions and finally on the presence of the surface rupture. Each of these factors (especially this fact that in most of the cases, the causative fault had no new surface ruptures) may result in the distances to the macroseismic epicenter being uncertain. From this point of view, the great earthquakes are the exceptions (Vendik 1976, Naghan 1977, Ghaen 1978, Tabas 1978, Ghaen 1979, Korizan 1979, Koli-Bonyabad 1979, Golbaf 1981, Sirch 1981, Manjil 1990 and Ebrahimabad 1994), such that the damage reports on these cases are more precise and the causative faults are well known.

For part of the records (mainly SSA-2 which have a pre-event memory) it was possible to estimate the hypocentral distance using the well-known folmula: $D_{hypo} = 8 * (ts - tp)$ Where tp and ts are the first arrivals of the P and S waves, respectively. This formula was compared

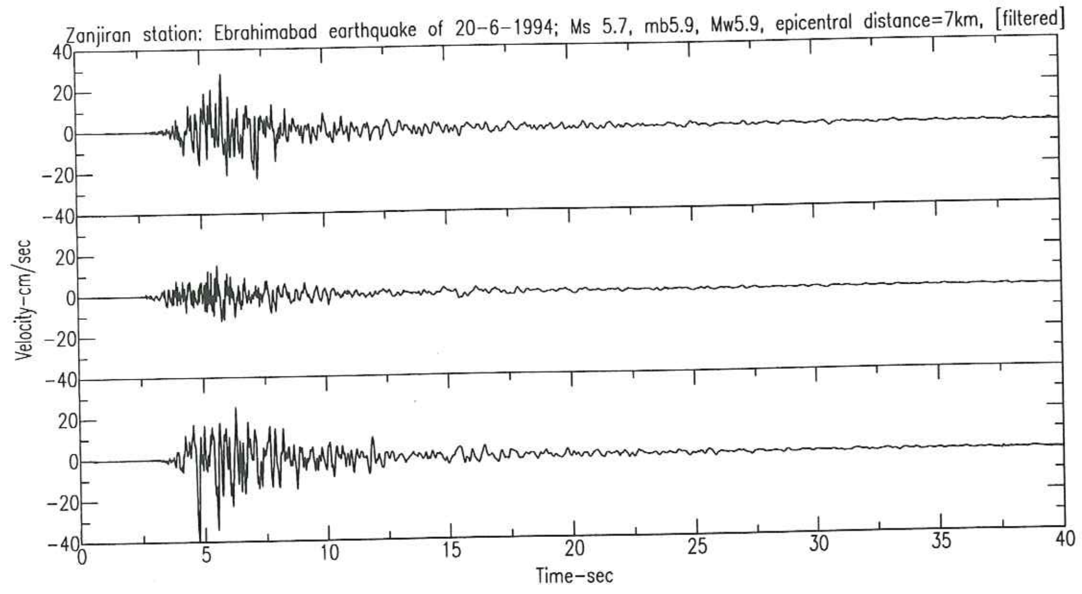


FIG. 2.16 – *Three component velocity time history of the Zanjiran record after the integrat ion of the acceleration. The middle record is the vertical and the two others are the hor izontal components.*

with the epicentral distances and focal depths as inferred for ISC and/or NEIC locations. This distance was not computed for the near-field records of large event, because it was not possible in many cases to identify clearly the P and S waves. As may be seen in Appendix 1, these values are not always consistent with one another. This is another hint that epicenter location in Iran is not very precise.

2.7.2 Focal depths

The earthquakes in the Iranian plateau are mostly of the crustal type origin and, as was shown before, most of those considered in this study were superficial (depths less than 35 km). According to the ISC monthly bulletins, the precision of focal depths is different by as much as +/-4 km for the well determined superficial earthquake (generally the events with the magnitudes more than M6) to +/-30km for the poorly determined events (generally the small earthquakes with the magnitudes less than about M4). Therefore, it may be concluded that precision of the focal depths is even less than the precision involved in the location of the

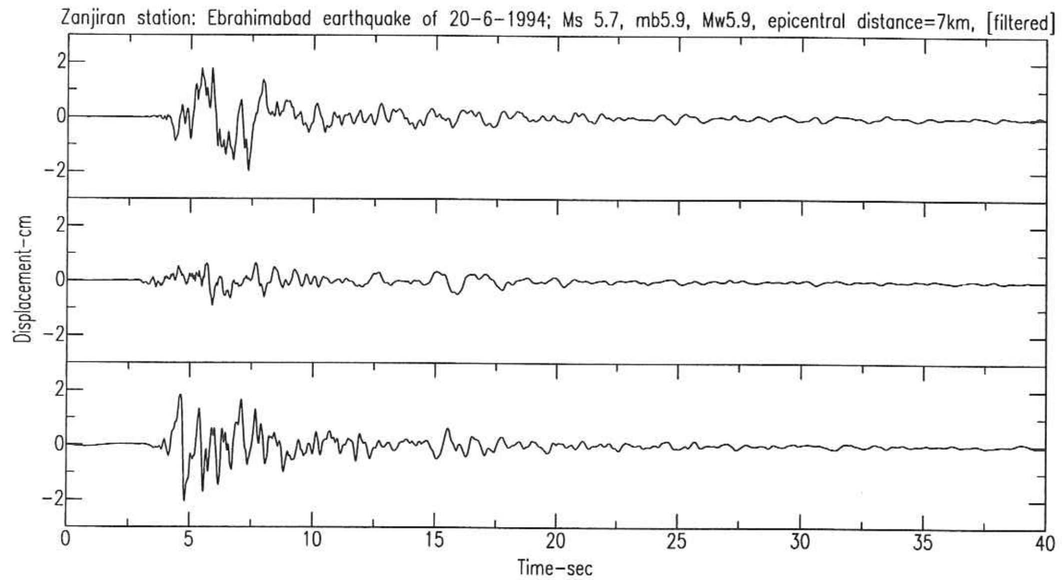


FIG. 2.17 – *Three component displacement time history of the Zanjiran record after the inte gration of the velocity. The middle record is the vertical and the two others are the hor izontal components.*

epicenter.

2.7.3 Integration of the filtered records

The integration to obtain the velocity and displacement time-histories may cause some uncertainties especially for the analog recordings, since the presence of even little high frequency or low frequency noises may cause some differences in the peak values. The high-pass filtering that we applied was intended to eliminate this low frequency noise. This low frequency cut off certainly cuts some signal so that the peak velocity and peak displacement values may be biased (underestimated) in some cases.

2.7.4 Earthquake intensities

It has been explained (to determine the macroseismic epicenters) that earthquake intensities are strictly based on observations and reports. According to the qualitative nature of

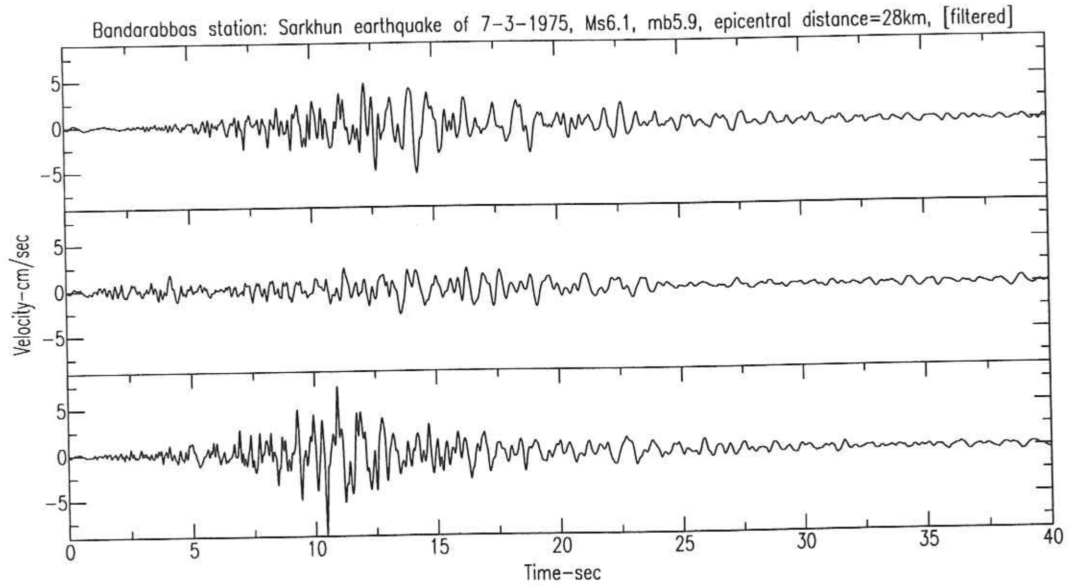


FIG. 2.18 – *Three component velocity time history of the Bandarabbas record after the inte gration of the acceleration. The middle record is the vertical and the two others are the horizontal components.*

intensity measurements, different intensities may be presented for one single earthquake by different investigators. On the other hand, in order to compare the different damaged areas with earthquakes with same magnitudes and epicentral distances, we have endeavored to present all the intensities on a single scale (MSK). In this regard, the previously reported intensities on other scales are converted to this scale using the comparison chart of Japan TC-4 (1992). The nature of the intensity measurements and the quality of the reports from the damages or shocked zones, as well as the conversion of the intensities to MSK scale, may be the origin of many uncertainties.

2.8 Conclusion

The first Iranian strong motion catalog (Appendix 1) was developed in this study. This catalog comprises the source and site information for each selected three-component record as well as the maximum values of the acceleration, velocity and displacements. The data-set

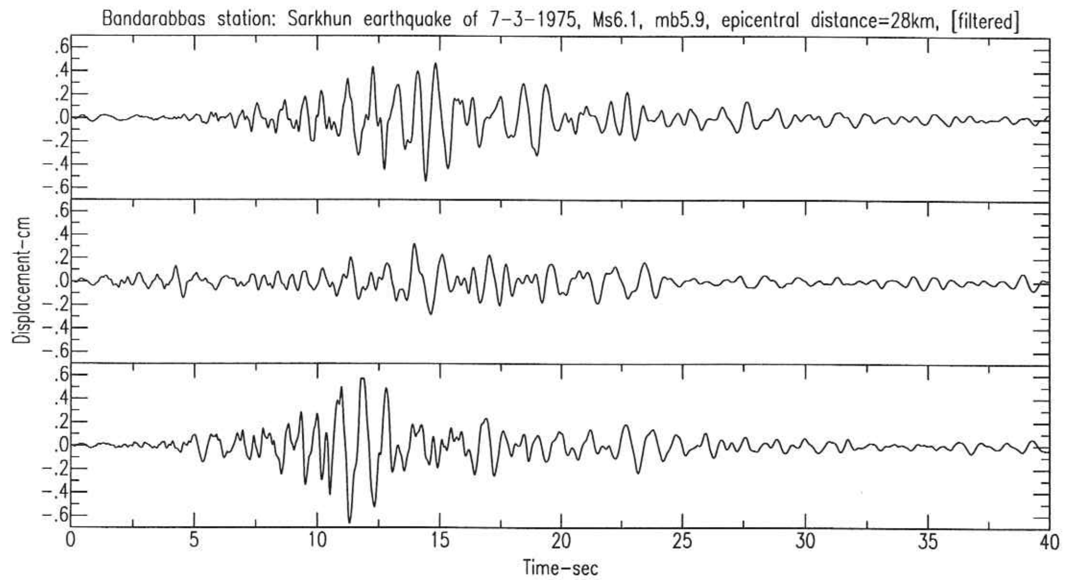


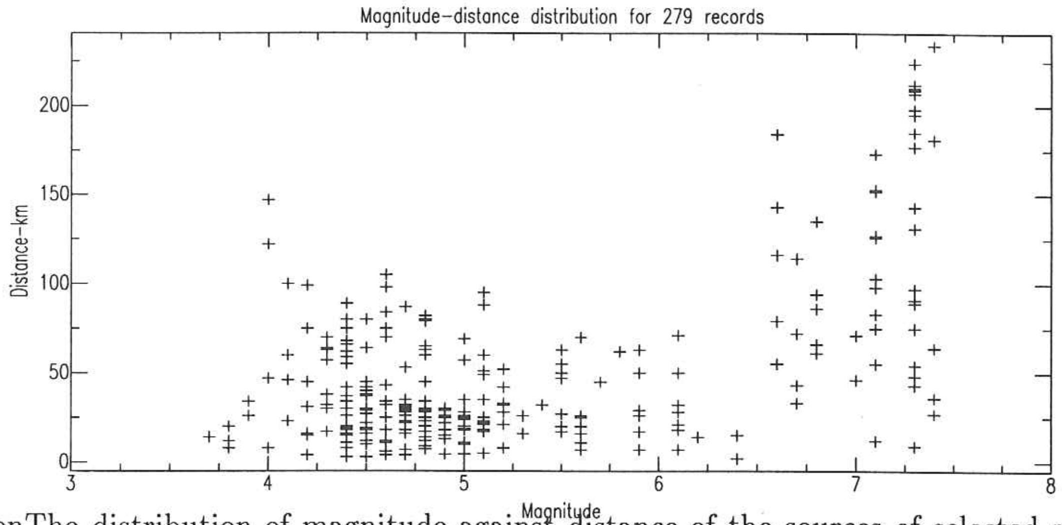
FIG. 2.19 – *Three component displacement time history of the Bandarabbas record after the i ntegration of the velocity. The middle record is the vertical and the two others are the horizontal components.*

contains the intensity and focal mechanism of the causative events (whenever available). This catalog provides a set of 279 three-component records, with a satisfactory quality and for which we could found their source parameters. There are 169 SMA-1 (analog) and 108 SSA-2 (digital) record in this set. According to the selected sources in this catalog, the geographical distribution of the epicenters indicates that the Zagros region was the most seismically active during the last twenty five years in the Iranian plateau. The most important earthquakes in this catalog are; Sarkhun (Bandarabbas) earthquake of 7-3-1975 (Ms6.1, mb5.9; 3 records for the mainshock and 2 for the aftershock); Vendik (Ghaen) earthquake of 7-11-1976 (Ms6.4, mb5.8; 4 records); Khurgu earthquake of 21-3-1977 (Ms7.0, mb6.2; 2 records); Naghan earthquake of 6-4-1977 (Ms6.1, mb5.6; 4 records for the mainshock and 3 for the aftershock); Tabas earthquake of 16-9-1978 (Ms7.3, mb6.7, Mw7.4; 5 records for the mainshock and 6 for the aftershocks); Ghaen earthquake of 16-1-1979 (Ms6.8, mb6.0; 5 records), Korizan (Ghaen) earthquake of 14-11-1979 (Ms6.6, mb6.0; 6 records) Koli-Bonyabad (Ghaen) 27-11-1979 (Ms7.1, mb6.1; 12 records), Golbaf (Kerman) earthquake of 11-6-1981 (Ms6.7, mb6.1; 3 records), Sirch (Kerman) earthquake of 28-7-1981 (Ms7.1, mb5.7, 2 records for the mainshock and 6 for the aftershocks), Manjil earthquake of 20-6-1990 (Ms7.7, mb6.8, Mw7.3; 18 records for the mainshocks and 20 for the aftershocks); Ebrahimabad (Firouzabad) earthquake of 20-6-1994 (Ms5.7, mb5.9, Mw5.9; 5 records for the mainshock and 6 for the aftershocks).

It must be noticed that there are other good quality recorded three component accelerograms in BHRC collection but they could not be selected in Appendix 1 because they could not be assigned to any particular earthquake [due to the lack of timing on SMA-1 instruments].

The Iranian strong motion data (Appendix 1) are recorded mostly in the Zagros mountains, western Alborz and northern Lut areas. The distribution of the records is shown in (Figure 2.8 in a diagram of the magnitudes against the distances. This figure shows that most of the records are obtained in the magnitude range of M4-5 and in the distance range of zero to 100 kilometers. The great earthquakes are recorded, as well, in this network (in the range of $6.5 < M < 8.0$ within a distance range of 5 to 230 km). Therefore, it seems that the attenuation relationships that will be developed on these data will be most reliable in the mentioned ranges of magnitudes and distances. The digital data which will be obtained in the future may fill the gaps between the mentioned ranges. On the other hand, it is still necessary to obtain more data in the near field especially in the range of great events (M6-8), in order to develop reliable analyses in the near field and to perform detailed studies on the source and/or site effects. Until that time, it seems difficult to perform detailed near field studies with the present (especially in the magnitude range of M6-8).

In the capital, Tehran, the strong motion records are mostly limited to the Manjil earthquake corresponding to a distance of about 200 km. No important records were obtained (with high acceleration values) in the regions of country similar to the situation of the Tehran plain. Meanwhile there is concern that a great event may shock the capital in an unpredictable time in the future. Therefore, we suggest strongly the installation of dense accelerometric arrays in Tehran and other major and most hazardous cities of Iran such as Ghazvin, Tabriz, Mashhad, Shiraz, Shahr-e Kord, Naein, Zahedan, Tabas, Kashmar, Gorgan, Kazerun, Birjand, Ardebil and Kerman which have situations comparable to Tehran considering site conditions and distances to the earthquake sources. This would be important to obtain meaningful data-sets for reliable microzonation and hazard studies in Tehran and in the mentioned cities. In general, the Iranian network may provide strong motion data not only for herself, but also to share these data with the other neighboring countries with similar seismic source conditions such as Turkey, Iraq, Afghanistan and Pakistan, as well as with the central Asian and Caucasus republics.



captionThe distribution of magnitude against distance of the sources of selected r ecords for the present study.

Acknowledgements

Many individuals have assisted us in this paper; most notably Mr. Mehdi Heydari (in IIEES) assisted this project to provide the source data. The BHRC (Building and Housing Research Center, Tehran) who have released the raw strong motion records is greatly acknowledged. The financial support in Iran was provided by IIEES, and in France (for the first author) was provided by a French scholarship (Ministère Français des Affaires Etrangères), which are both duly acknowledged. We thank Mr. Mohammad Zaré (the father of first author) who has provided the reports of the Persian dailies on the earthquake damages in Iran during the period of 1974-1996. Our thanks also go to Douglas McLean who has proof-read this text and has given comments to correct the orthography.

Appendix 1 The catalog of the accelerometric data of Iran (the published data since the beginning of its installation until the end of February 1996). The references are;

1: NEIC (PDE monthlies of the National Earthquake Information Center, USGS),

2: ISC (monthly bulletin of the International Seismological Center, UK),

3: Ambraseys and Melville, 1982 (Ref. No.2),

4: Newspapers (the Persian language newspapers published in Iran since 1974 untill the end of February 1996),

5: IGTU (the catalog of the Institute of Geophysics Tehran University),

6: Zaré (1994),

7: Eshghi et al (1994).

No	Code (BHRC)	Station	Site	Filters to process (1st filtering for acceleration & velocity)		Filters to process (2nd filtering for Displacement (if used))		Peak Ground Acceleration (cm/s²)			Peak Ground Velocity (cm/s)			Peak Ground Displacement (cm)			Macroseismic epicenter (Region)	Date	Ms	mb	ML	Mw	Focal Depth (km)	Epicentral Distance (km)	Hypocentral distance	Macroseismic epicenter distance (km)	Intensity (MSK)	Focal Mechanism	Q	Ref.
				HP	LP	HP	LP	H1	V	H2	H1	V	H2	H1	V	H2														
1	1012	Kiasar	2	2.5	15			41	14.5	30								11/5/74		4.5			88	84					C	1
2	1006-1	Bandarabbas (S)	2	0.8	20			79	39.5	184	7.2	4.0	8.2				Sarkhun	3/7/75	6.1	5.9			27	28	48	28	VII+	Rv	A	1,3,4
3	1006-2	Bandarabbas (S)	2	1.5	9			17	13	27							Sarkhun (Af. Shock)	3/7/75		5.2				28	40	28			D	1,3
4	1007	Minab	1	2.5	9			18.5	11.5	17.3							Sarkhun	3/7/75	6.1	5.9			27	71	80	71	VI	Rv	B	1,3
5	1008	Gheshm Island	1	2	7			15	14.2	14.2							Sarkhun	3/7/75	6.1	5.9			27	50	58	50	V	Rv	B	1,3
6	1013	Tonkabon	4	1	9			49	8.7	25								3/13/75	4.1	4.4				34					D	2
7	1009	Minab	1	1.5	5			34	7.8	17.3							Sarkhun (Af. Shock)	4/12/75		4.8				65	48				D	2
8	1026	Shiraz	4	1.5	33			64	46	44								8/2/75		4.1			52	60					C	1,2
9	1014-4	Hajiabad	3	1	15			77	52	82							Hajiabad	10/6/75	5.4	5.3			51	32					C	1
10	1024	Marayeh-Tappeh	3	1:H 4:V	40			372	186	397	7.5	2.72	10.6				Marayeh-Tappeh	12/27/75		4.8			33a	0					C	1,2
11	1034-1	Maku	2	1	20			47	36	61	1.2	0.88	1.5					2/27/76	3.9					26					C	2
12	1034-2	Maku	2	1.5	30			201	78	110								4/2/76		4.8			48	98	12				C	2
13	1040-3	Naghan-1	1	0.65	40	0.65	40	47	45	49	0.8	1.5	1.45	0.048	0.14	0.13		9/5/76	4.7	5.1			44	88					B	1
14	1043	Ghaen	1	0.4 BHRC	25			115	170	157	9.8	6.4	14.8				Vendik	11/7/76	6.4	5.8			13	15	10	14	VII	SS	A	1,2
15	1047-8	Vendik	2	0.5	40			490	115	550	11	2.8	6.5				Vendik	11/7/76	6.4	5.8			13	2		2	VIII	SS	A	1,2,3,4
16	1047-9	Vendik	2	1	40	1	40	188	66	182	2	0.63	1.8	0.037	0.021	0.058	Vendik	11/7/76		4.8			21	0	4			SS	A	2
17	1047-10	Vendik	2	0.4	40	1.3	40	205	67	182	1.8	0.55	2.5	0.027	0.019	0.088	Vendik	11/9/76		5.1			29	5				SS	A	1
18	1046-1	Maku	2	3	15			87	40	82							Chaldoran (Turkey)	11/24/76	7.3	6.1			36	48		81	VI+	SS	B	1,3
19	1046-2	Maku	2	3	15			88	18	49							Chaldoran (Turkey)	11/24/76	5.5	5.5			33a	47				SS	C	1,2
20	1049-1	Siah-Cheshmeh	1	1.5	10			41	18	28.5							Siah-Cheshmeh	12/6/76	4.2	4.4			48	3		5	V+		C	1,2,4
21	1049-2	Siah-Cheshmeh	1	3	7			12.4	6.9	15.3							Siah-Cheshmeh	12/6/76	4.3	4.4			67	19		15			C	1,2
22	1049-3	Siah-Cheshmeh	1	2	5			8.8	5.3	12.5							Siah-Cheshmeh	12/12/76	4.6	4.8			40	14					C	1,2
23	1050-1	Bandarabbas (S)	2	1	15			115	41	137	5.7	3.1	7.9				Khurgu	3/21/77	7.0	6.2			29	48	52	42	V+	Rv	A	1,2,3,4
24	1052	Gheshm-Island	1	1	7			29	15	21							Khurgu	3/21/77	7.0	6.2			29	71		70		Rv	B	1,2,3,4
25	1054-1	Naghan-1	1	0.2 BHRC	24	0.2	24	720	520	615	48	54	38	10	10.2	3.2	Naghan	4/6/77	6.1	5.8			43	7		2	VII+	Rv	A	1,2,3,4
26	1055	Farsan	1	2	8			18	10.1	18.5							Naghan	4/6/77	6.1	5.8			33a	32		38	VI	Rv	B	1,2,3,4
27	1058	Dastgerd	2	2	30			101	57	83							Naghan	4/6/77	6.1	5.8			33a	18		22	VI+	Rv	C	1,2,3,4
28	1059	Ardal	4	2.5	40			88	46.5	84							Naghan	4/6/77	6.1	5.8			33a	21		10	VI+	Rv	C	1,2,3,4
29	1056-5	Naghan-1	1	1	40			61	22	35	0.87	0.89	0.92				Naghan (a.shock)	4/12/77	4.3	4.9			33a	4.5					C	1,2
30	1080-2	Naghan-1	1	3	20			13	18.5	19							Naghan	5/4/77	4.2	4.8			48	20					C	1,2
31	1080-8	Naghan-1	1	1	40			94	78	137							Naghan	10/21/77		5.0			33a	18.6					D	1
32	1092-1	Aghajari	2	5	20			47	19	83	0.61	0.25	0.77					3/31/78		4.4			33a	30					C	2
33	1080-10	Naghan-1	1	1	40			72	119	110							Naghan	4/12/78	4.9	4.1			45	15					C	2
34	1080-11	Naghan-1	1	1.5	40			54	66	40							Naghan	5/20/78		5.0			113	28					C	2
35	1080-12	Naghan-1	1	3	40			118	54	113							Naghan	8/11/78		4.3			72	30					C	2
36	1094-1	Kazerun	2	2	30			44	21	80								8/29/78		4.9			34	18	12				C	1
37	1082-1	Deyhuk	1	0.2	40			309	176	377	18.5	14	30	3.7	4.8	5.7	Tabas	9/16/78	7.3	6.7		7.4	10	36	28	20	VII+	Rv	A	1,2,3,4
38	1083-1	Boshruyeh	1	0.3 BHRC	17			98	87	94	9.8	7.6	11.4	1.9	1.8	2.3	Tabas	9/16/78	7.3	6.7		7.4	10	64	84	46	VII+	Rv	A	1,2,3,4
39	1084-1	Tabas	1	0.1	40	0.1	40	1103	848	841	113	36	97	83.5	13.9	37.3	Tabas	9/16/78	7.3	6.7		7.4	10	27	28	6	X	Rv	A	1,2,3,4
40	1088	Bajestan	3	0.4	10			90	22	58	4.5	1.3	2.9				Tabas	9/16/78	7.3	6.7		7.4	10	181	140	144	VI	Rv	A	1,2,3,4
41	1090-2	Kashmar	3	0.4	6			35	24	44.5							Tabas	9/16/78	7.3	6.7		7.4	10	234		220	V	Rv	B	1,2,3,4
42	1082-6	Deyhuk	1	3	20			80	40	47							Tabas	9/17/78		4.7			33a	63				Rv	C	1
43	1103-1	Tabas	1	3	30			26	21	41	0.41	0.42	0.78					9/24/78	3.7	4.5			33a	22					C	1
44	1104-2	Deyhuk	1	1	20			64	35	42	1.8	0.55	1.15					9/24/78	3.7	4.5			33a	42					C	1
45	1093-2	Khorj	1	4	25			34.5	22.5	26.5								10/12/78		4.2			33a	75					D	2
46	1103-3	Tabas	1	2	20			79	39	132	1.45	0.77	3.3					10/12/78	3.7	4.9			15	30	20				B	1
47	1098-3	Talesh	3	2	20			56	28	58	1.5	0.75	1.7					11/4/78	6.0	6.2			34	14	20			VI	A	1,3
48	1096-1	Naghan-1	1	0.2 : H 0.6 : V	40			74	82	83	0.99	0.98	1.93					12/14/78	6.1	5.9			33a		5			VI	B	1,3
49	1096-2	Naghan-1	1	2	30			32	30	67	0.27	0.38	0.91					12/14/78		4.7			44		5			VI	A	1
50	1097-2	Naghan-2	1	2 : H 0.4 : V	40			67	41	40	0.93	0.97	0.57					12/14/78		4.7			44		5			VI	A	1
51	1103-9	Tabas	1	3	15			30	18	80	0.61	0.56	1.8					12/28/78		4.5			45	29	21				B	1
52	1102	Bajestan	3	1	6			39	18	31							Ghaen	1/16/79	6.8	6.0			33a	135		140		Rv	C	1,3,4
53	1108	Sedeh	3	5	11			32	37	44							Ghaen	1/16/79	6.8	6.0			33a	88	80	75		Rv	C	1,3,4
54	1107	Khezri	1	5	12			16	12.5	26							Ghaen	1/16/79	6.8	6.0			33a	61		65		Rv	C	1,3,4
55	1109	Gonabad	4	3	11			18	19.5	32.5							Ghaen	1/16/79	6.8	6.0			33a	88	84	85		Rv	C	1,3,4
56	1113	Khaf	2	3	20			69	30	69							Ghaen	1/16/79	6.8	6.0			33a	94	80	90		Rv	C	1,3,4
57	1103-11	Tabas	1	3	40			64	46	102								1/17/79		5.1			33a	23	16				D	1
58	1103-12	Tabas	1	2.5	25			98	38	109	2	0.91	3					2/13/79	4.8	5.5			33a	55				Rv	B	1
59	1125-2	Aghajari	2	1	40			71	49	119								3/28/79	4.6	5.1			33a	25					D	1
60	1117	Sedeh	3	3	11			26	12.5	21							Kortzan	11/14/79	6.6	6.0			33a	79	88	80	IV	Rv	C	1,2,3,4
61	1118	Ghaen	1	2	10			38	29.5	45							Kortzan	11/14/79	6.6	6.0			33a	55		60	IV	SS	C	1,2,3,4
62	1121	Khaf	2	2	25			100	41	81							Kortzan	11/14/79	6.6	6.0			33a	79	72	50	IV	SS	C	1,2,3,4
63	1124	Roshtkhar	1	2	6			21	13.5	14.7							Kortzan	11/14/79	6.6	6.0			33a	116		105	IV	SS	C	1,2,3,4
64	1130-2	Kashmar	3	4	11			19	10	20							Kortzan	11/14/79	6.6	6.0			33a	184		170	III?	SS	C	1,2,3,4
65	1132-1	Ferdows	1	4	11			16	14	22.5							Kortzan	11/14/79	6.6	6.0			33a	143	132	150	IV	SS	C	1,2,3,4
66	1143-1	Khaf	2	4	15			20	13	17.3								11/23/79	4.5	5.0			33a	69					D	1
67	1131	Torbat-Heydarieh (SH)	3	1	10			50	28	42.5							Kaf-Bonyabad	11/27/79	7.1	6.1			10	153	160	130	III	SS	B	1,2,3,4
68	1134-2	Bajestan	3	1.5	9			111	37	90							Kaf-Bonyabad	11/27/79	7.1	6.1			10	152		120	III?	SS	B	1,2,3,4
69	1135	Kakhk	1	3	15			49	26.5	33							Kaf-Bonyabad	11/27/79	7.1	6.1			10	98	88	80	V	SS	B	1,2,3,4
70	1137	Birjand	1	0.3	2			29	12.5	22	4.8	2.2	4.4				Kaf-Bonyabad	11/27/79	7.1	6.1			10	127	139	130	IV	SS	A	1,2,3,4
71	1138-1	Sedeh	3	2	15			67	39	61							Kaf-Bonyabad	11/27/79	7.1	6.1			10	83	80	75	V	SS	B	1,2,3,4
72	1139	Ghaen	1	0.4	40			228	136	132	9.5	9.7	9.3	1.5	1.0	1.35	Kaf-Bonyabad	11/27/79	7.1	6.1			10	55	44	40	V+	SS	A	1,2,3,4
73	1140-1	Khezri	1	1	20			69	58.5	80							Kaf-Bonyabad	11/27/79	7.1	6.1			10	83	80	65	V	SS	B	1,2,3,4
74	1141-1	Taybad	4	3	15			76	35.5	70.5							Kaf-Bonyabad	11/27/79	7.1	6.1			10	128	120	105	IV	SS	B	1,2,3,4
75	1142-1	Gonabad	4	2	25			81	61	88							Kaf-Bonyabad	11/27/79	7.1	6.1			10	103	92	80	V	SS	B	1,2,3,4

No	Code (BHRC)	Station	Site	Filters to procces (1st filtering for acceleration & velocity		Filters to procces (2nd filtering for Displacement (if used)		Peak Ground Acceleration (cm/s^2) *			Peak Ground Velocity (cm/s)			Peak Ground Displacement (cm)			Macroseismic epicenter (Region)	Date	Ms	mb	ML	Mw	Focal Depth (km)	Epicentral Distance (km)	Hypocentral distanc	Macroseismic epicenter distance (km)	Intensity (MSK)	Focal Mechanism	Q	Ref
				HP	LP	HP	LP	H1	V	H2	H1	V	H2	H1	V	H2														
76	1143-2	Khaf	2	2	30			145	86	146							Koli-Bonyabad	11/27/79	7.1	6.1			10	75	84	86	V	SS	B	1,2,3,4
77	1143-3	Khaf	2	0.4	15			35	20	32.3	1.38	1.23	1.43					11/27/79		4.8			10	34	40				B	1
78	1144-2	Roshtkhar	1	2	15: H 20:V			40.5	41.3	52.5							Koli-Bonyabad	11/27/79	7.1	6.1			10	75	108	105	IV?	SS	B	1,2,3,4
79	1145	Torbat-Jam	1	0.2	4			46	20.3	36	5.6	3.25	5.3				Koli-Bonyabad	11/27/79	7.1	6.1			10	173	180	165	III	SS	A	1,2,3,4
80	1143-4	Khaf	2	1.5	15			61	19.5	64								11/28/79	4.0	4.7			10	29					B	1
81	1136-2	Tabas	1	3	25			86	37	77								12/2/79		4.8			33s	12					C	1
82	1136-3	Tabas	1	2	40			182	47	271								1/12/80	5.9	5.4			33s	26				Rv	C	1
83	1151	Rudsar	4	1	40			78.5	96	139	4.1	2.3	4.0					1/13/80	4.8	5.0			33s	4.6	16				C	1
84	1149	Khorramabad	2	1	20			52.5	14.3	37.7								3/31/80		4.6			33s	4					D	1
85	1182	Sarbaz	2	2	30			72	35	50	2	1	1.3					8/11/80		4.6			33s	43	16	10	V		C	1,2,3
86	1180	Boroujerd	3	1	20			101	57	105								9/15/80	3.8	4.4			33s	11	20				D	1
87	1153-1	Kushk-Nosrat	1	3	6			13	10.5	10.7								12/19/80	5.6	5.6			33s	62				Rv/SS	C	1
88	1168	Kerman	4	2	20			36.5	19.5	26							Golbaf	8/11/81	6.7	6.1			33s	72		86	V	SS/Rv	C	1,2,3,4
89	1169	Rayen	1	0.3 BHRC	17	0.3	17	25	37	37	2.8	2.2	2.6	0.56	0.66	0.43	Golbaf	8/11/81	6.7	6.1			33s	43	40	40	VI	SS/Rv	B	1,2,3,4
90	1172-6	Golbaf	3	2	20			45	33	62							Golbaf	8/11/81	6.7	6.1			33s	33	20	1	VII	SS/Rv	C	1,2,3,4
91	1178	Bam	1	0.4 BHRC	17	0.4	17	33	21	22	2.7	1.7	2.35	0.46	0.29	0.43		8/11/81	6.7	6.1			33s	114		145	VI	SS/Rv	B	1,2,3,4
92	1174	Kerman	4	0.4	40			91	69	108	8.3	3.0	6.4				Sirch	7/28/81	7.1	5.7			11	65	48	55	VII	Rv/SS	A	1,2,3,4
93	1176-5	Golbaf	3	0.4 BHRC	25			198	204	218	13.5	8.4	17.5				Sirch	7/28/81	7.1	5.7			11	12		20	IX	Rv/SS	A	1,2,3,4
94	1176-25	Golbaf	3	3	25			20.5	19.5	27	0.42	0.23	0.7					7/29/81		4.4			33s	89	16				C	1
95	1183-6	Golbaf	3	8	20			9.7	10.5	12.2								8/10/81		4.1			33s	46					D	1
96	1183-6	Golbaf	3	3	25			71	34	108	1.7	0.45	0.27					8/20/81	4.2	4.6	5.5		27	63	16	20			B	1,4,5
97	1191-3	Golbaf	3	3	30			41	36.5	82.5	1.4	0.75	3.1					1/7/82		4.1			33s	100	12				C	2
98	1191-4	Golbaf	3	3	20			23.3	10	23.7								1/21/82		4.4			33s	62	18				D	1
99	1191-5	Golbaf	3	4	20			23.5	30	42	0.4	0.35	1.0					1/30/82		4.4			33s	60	16				C	1
100	1195	Doroud	4	1.5	20			28.5	34.5	29.5	1.25	0.65	.98	0.085	0.024	0.082		9/1/82	3.5	4.9			33s	25					C	1
101	1220-1	Farrashband	1	4	15			22.5	14.0	20.5								6/1/83		4.3			33s	63					D	1
102	1211-1	Gilvan	1	4	18			26.5	40	38.5							Chorzagh Tarom-Olya	7/22/83	5.0	5.6			41	16	20	18	VI	Rv	B	1,2,4
103	1211-2	Gilvan	1	3	12			22	12.5	19.5								7/23/83		4.4			33s	15					D	1
104	1214-1	Shalamzar	3	0.8	30			165	128.5	127	4.4	3.0	3.4	0.15	0.12	0.135		8/17/83		4.9			47	22	16				B	1
105	1216-1	Ardal	3	2	30			49	47	48	1.4	0.75	2.1	0.071	0.032	0.095		8/17/83		4.9			47	26					B	1
106	1216-2	Ardal	3	2	12			21	14.5	21.5								8/28/83		4.5			33s	29					D	2
107	1218	Tonkabon	4	2	20			42	36.5	67	1.4	0.75	0.32	0.044	0.024	0.16	Tonkabon	12/20/83		4.8	4.5		42	7.4	16	0-5	V		B	1,2,4
108	1224-3	Ardal	3	3	30			54	45	45							Ardal	6/1/84		5.0			33s	11	10	0-5	VII		D	1,2,4
109	1226-2	Shalamzar	3	0.8	40			318	276	3368	10	6.2	7.5	0.4	0.19	0.37		6/1/84		5.0			33s	26	16				C	1,2,4
110	12121233	Naghan-1	1	1	40			143	157	187	3.4	3.9	8.5	0.1	0.17	0.42	Ardal	6/1/84		5.0			33s	16	10	15	IV		C	1,2,4
111	1228-2	Khoy	3	1	4			7.9	3.0	8.1								8/29/84		4.6			33s	25	7				D	1
112	1240-4	Ghir	3	8	25			25	9.4	21								2/2/85		4.5			33s	16		15			D	1
113	1240-6	Ghir	3	4	40			185	79	185	2.1	1	1.6					2/2/85	5.3	5.2	5.6		37	25	7	5	VII+	SS/Nm	A	2,4,5
114	1247-1	Avaj	1	3	40			56	32	34	1	0.45	0.62					5/9/85			3.1				9	45	IV		C	4,5
115	1291-1	Kazerun	2	4	30			39	125.5	31								7/12/85	5.6	5.7			10	45		40		SS	B	1
116	1308	Bandar-lengeh	3	1.5	10			36	32	73	1.5	0.92	2.3					8/9/86	4.4	5.1			33s	23					C	1
117	1289-1	Noorabad-Mamassani	3	3	20			31	13.5	29							Darreh-Gorg (Nourabad- Ma	10/10/88		4.3			10	32		30			C	1
118	1289-3	Noorabad-Mamassani	3	3	30			108	47	74	2.7	1.1	2					10/10/88		4.9			16	29	32	32	VII		B	2,4
119	1289-2	Noorabad-Mamassani	3	3	30			80	31	44	1.7	0.51	1.1					10/18/88	3.9	4.9			54	13		15			B	1
120	1289-4	Noorabad-Mamassani	3	3	20			98	55	65	2.7	0.9	2.3					11/20/88	4.1	5.2			32	21	24	30			B	1
121	1289-5	Noorabad-Mamassani	3	5	15			34	15.5	14.5	0.9	0.28	0.29					12/20/88	5.0	5.5			28	20	24				B	1
122	1311-1	Old Lar	1	3	30			33.5.5	37.5	39	0.63	0.63	0.53				Fatavlyeh Village (Bastak)	1/16/87			4.5				16	39	III		C	4,5
123	1311-2	Old Lar	1	3	18			16.5	16	32.5							Fatavlyeh Village (Bastak)	1/19/87			4.0				24	39	III		D	4,5
124	1319-1	Naghan-2	1	0.8	40			129	88	65	1.55	1.45	1.7					1/20/87		4.6			33s	4					C	1
125	1320-2	Naghan-1	1	1.5	40			76	93	118	1.7	1.2	2.1	0.063	0.041	0.63		1/20/87		4.6			33s	4	6				C	1
126	1319-2	Naghan-2	1	0.4	40	0.8	40	1133	77	86	2.6	1.15	1.95	0.088	0.053	0.084		3/12/87		4.3			78	64					B	1
127	1305	Kuhbanan	3	2	11			108	45.5	77.5	3.3	1.6	3.1	0.19	0.072	0.14	Kohan Villag (Kuhbanan)	4/11/87	4.5	5.0			24	28	4	20	VI+		B	1,4
128	1307	Sirch	1	2	30			87	38.5	78	1.15	0.58	1	0.039	0.021	0.034		4/22/87		4.6	4.6		33s	18	24	45	IV		C	1,4,5
129	1303	Bostan-abad	4	2	20			145	33	93	4.8	1.35	4	0.033	0.073	0.21		7/22/87	3.8	4.2			20	31	10				B	1
130	1300-1	Birjand	1	0.6	15			54	56	42.5	6	3.6	3.8	0.81	0.51	0.47		11/24/87	4.4	5.3			41	26	8			Rv/SS	A	1
131	1300-3	Birjand	1	2	6			10.7	11.4	13								11/27/87		4.7			33s	23	20				D	1
132	1351	ehran (Sharif Universit	1	1.5	8			10.3	27	11							Manjil	6/20/90	7.7	6.8		7.3	19	210		189	IV+	Rv/SS	B	1,2,4,5,8
1133	1352	Tehran (BHRC)	1	1.5	6			26	15	19.5							Manjil	6/20/90	7.7	6.8		7.3	19	209		189	VI+	Rv/SS	B	1,2,4,5,8
134	1353	Ghazvin	3	0.3 BHRC	25	0.3	25	188	90	134	15.4	7.6	11.7	3.9	2.8	3.0	Manjil	6/20/90	7.7	6.8		7.3	19	54	78	52	VI+	Rv/SS	A	1,2,4,5,8
135	1354	Abhar	4	0.4	30			149	75	232							Manjil	6/20/90	7.7	6.8		7.3	19	91	80	69	VI+	Rv/SS	B	1,2,4,5,8
136	1355	Rudsar	4	0.6	15			102	69	83	9.6	5.2	7.9				Manjil	6/20/90	7.7	6.8		7.3	19	89	68	70	VI+	Rv/SS	A	1,2,4,5,8
137	1357-1	Lahijan	4	0.1 BHRC	25			106	75	176	13.5	7.3	36.3	7.1	4.15	15.5	Manjil	6/20/90	7.7	6.8		7.3	19	97	98	61	VI+	Rv/SS	A	1,2,4,5,8
138	1358	Tonkabon	4	1.5	15			115	26.5	72							Manjil	6/20/90	7.7	6.8		7.3	19	131	100	105	VI+	Rv/SS	B	1,2,4,5,8
139	1360	Manjil	2	0.5	40			536	184	416	10.7	4.1	9.7				Manjil	6/20/90	7.7	6.8		7.3	19	9	12	1	X	Rv/SS	A	1,2,4,5,8
140	1361	Gachsar	3	6	20			16.5	30.5	19.5							Manjil	6/20/90	7.7	6.8		7.3	19	185	176	170	V+	Rv/SS	B	1,2,4,5,8
141	1362-1	Abbar	1	0.1 BHRC	25			526	548	503	38	48.4	43.6	16.3	20.4	20.2	Manjil	6/20/90	7.7	6.8		7.3	19	43	40	8	VIII+	Rv/SS	A	1,2,4,5,8
142	1363-1	Kahrizak	4	0.4 BHRC	16	0.4	16	46	28	35	7.1	2.8	6.0	1.45	0.50		Manjil	6/20/90	7.7	6.8		7.3	19	224		202	V	Rv/SS	A	1,2,4,5,8
143	1364	Zanjan	1	0.1 BHRC	25			125	51	60	14.6	5.1	9.5	6.3	3.9	4.0	Manjil	6/20/90	7.7	6.8		7.3	19	75	80	57	V+	Rv/SS	A	1,2,4,5,8
144	1365	Ardebil	4	0.4	16	0.4	16	30	15	29	3.5	2.9	2.6	0.86	0.47	0.41	Manjil	6/20/90	7.7	6.8		7.3	19	195		180	V+	Rv/SS	A	1,2,4,5,8
145	1366	Tehran (Chizar)	1	0.7	10			13	18.4	13.3							Manjil	6/20/90	7.7	6.8		7.3	19	212		189	IV+	Rv/SS	B	1,2,4,5,8
146	1369	Rudshur	4	0.4 BHRC	16			40	32	44	4.2	4.8	6.2	0.88	1.3	1.6	Manjil	6/20/90	7.7	6.8		7.3	10	198		185	IV+	Rv/SS	A	1,2,4,5,8
147	1370-2	Robat-Karim	1	0.4 BHRC	16	0.4	16	13	19	17	0.68	1.24	1.05	0.13	0.16	0.15	Manjil	6/20/90	7.7	6.8		7.3	10	207		185	VI+	Rv/SS	A	1,2,4,5,8
148	1371-2	Karaj	1	0.4 BHRC	16	0.4	16	35	13	12	3.5	1.5	1.4	0.59	0.25	0.24	Manjil	6/20/90	7.7	6.8		7.3	10	177		151	V+	Rv/SS	A	1,2,4,5,8
149	1372	Eshtehard	4	0.3 BHRC	16	0.4	16	72	44	77	6.1	2.5	6.0	1.05	0.57	1.22	Manjil	6/20/90	7.7	6.8		7.3	10	143	140	122	V+-VI	Rv/SS	A	1,2,4,5,8
150	1357-2	Lahijan	4	2	10	0.1	20	11.7	14	13							Manjil	6/26/90		4.2			10	45					C	1

No	Code (BHRC)	Station	Site	Filters to procces (1st filtering for acceleration & velocity		Filters to procces (2nd filtering for Displacement (if used)		Peak Ground Acceleration (cm/s^2) *			Peak Ground Velocity (cm/s)			Peak Ground Displacement (cm)			Macroseismic epicenter (Region)	Date	Ms	mb	ML	Mw	Focal Depth (km)	Epicentral Distance (km)	Hypocentral distanc	Macroseismic epicenter distance (km)	Intensity (MSK)	Focal Mechanism	Q	Ref
				HP	LP	HP	LP	H1	V	H2	H1	V	H2	H1	V	H2														
151	1393-2	Abbar	1	5	10			41.5	13.4	23							Manjil	6/26/90		4.2			10	99					C	1
152	1393-4	Abbar	1	3	15			58.5	79	45.7	1.7	1.25	1.3	0.058	0.024	0.039	Manjil	6/26/90	4.1	4.8			10	63	24				B	1
153	1367	Manjil	2	2	30			37.5	24	38.5	0.4	0.46	0.66	0.011	0.014	0.015	Manjil	6/29/90		4.4			10	75					B	1
154	1368-1	Rudbar	3	1	40			97	62	143.5	1.7	1.3	2.5	0.081	0.00 03	0.098	Manjil	6/29/90		4.4			10	66	8				B	1
155	1368-2	Rudbar	3	3	25	1	40	25.5	15.4	17.5							Manjil	6/29/90		4.5			10	38					B	1
156	1393-7	Abbar	1	2	10	3	15	48	21.3	62.6							Manjil	6/29/90		4.5			10	80	38				C	1
157	1368-5	Rudbar	3	4	30			66	23	36	0.76	0.29	0.66	0.013	0.0079	0.018	Manjil	7/1/90	3.5	4.6			10	75	20				B	1
158	1393-9	Abbar	1	2	25			45	16	37	1.2	0.44	1.1				Manjil	7/1/90	3.6	4.7			10	87	20				B	1
159	1368-8	Rudbar	3	4	30			76.7	22.5	56							Manjil	7/2/90		4.4			10	59	15				C	1
160	1377-1	Manjil	2	0.7 : H 1 : V	30	07 :H 1 :V	30	177	88.5	245	7.9	1.6	6.5	0.38	0.091	0.39	Manjil	7/6/90	4.4	5.3			35	18	20			Rv/SS	A	1
161	1382-1	Rudbar	3	3	10			48.5	18.3	38.5							Manjil	7/6/90	5.2	4.5			51	16					C	2
162	1382-2	Rudbar	3	3	15			25.3	13	39.5							Manjil	7/6/90		4.2			10	45					C	2
163	1377-2	Manjil	2	1	25			102	40	54	4.3	1.1	2.1	0.2	0.06	0.12	Manjil	7/6/90		4.3			36	57	24				C	2
164	1382-8	Rudbar	3	4	10			16.3	8.3	10.2							Manjil	7/24/90		4.5			10	37	7				C	1
165	1382-11	Rudbar	3	2	20			81	32	66.5							Manjil	8/6/90		4.5			33s	40					B	2
166	1397-8	Manjil	2	4	15			57	19	50	1.5	0.45	1.2				Manjil	8/23/90		4.4			10	66	28				B	2
167	1449	Ahar	4	3 BHRC	16			17	15	17.5	0.41	0.24	0.28	0.01	0.0043	0.009		9/24/90		4.6			10	84					B	1,5
168	1420-1	Rudbar	3	4	20			26	13.7	27.5							Manjil	8/23/91		4.4			33s	16					D	1,5
169	1420-2	Rudbar	3	4	30			61	16.3	63.2							Rostam-Abad	11/28/91	5.0	5.6	5.5		16	28		14		Rv/SS	B	1,5
170	1491	Kavar (PTT)	2	0.2		3	16	42	19	26	1.15	0.375	0.56	0.048	0.014	0.0175		3/8/94			5.7				12	38			C	5
171	1492-2	Zarrat (school)	1	0.2		0.5		24	11	21	0.72	0.57	1	0.044	0.057	0.056		3/17/94		4.8			33s	34					C	1
172	1500-4	Zanjiran	2	0.2		0.1		65	38	75	2.4	0.65	1.70	0.13	0.041	0.078		3/17/94		4.8			33s	17	12				C	1
173	1492-4	Zarrat (school)	1	0.2		0.4		52	22	51	1.65	0.58	1.55	0.0805	0.025	0.0845		3/18/94		4.4			33s	37	21				C	1
174	1494-4	Kavar (PTT)	2	0.1		0.4		9.6	11	14	0.39	0.26	0.52	0.03	0.019	0.032		3/18/94		4.4			33s	60					C	1
175	1500-6	Zanjiran	2	0.2		0.5		32	23	50	0.83	0.53	1.0	0.04	0.03	0.074		3/18/94		4.4			33s	18	11				C	1
176	1500-8	Zanjiran	2	0.2		0.5		26	27	51	0.78	0.635	1.60	0.038	0.028	0.097		3/19/94		4.4			33s	42	11				C	1
177	1492-5	Zarrat (school)	1	0.1		0.7		37	20	51	1.1	0.57	2.0	0.079	0.035	0.085		3/23/94		4.7			33s	31	20				C	1
178	1500-13	Zanjiran	2	0.1				41	24	48	0.074	0.39	0.88	0.05	0.032	0.028		3/23/94		4.7			33s	22	6				C	1
179	1492-6	Zarrat (school)	1	0.1		0.3		213	61	245	9.7	2.6	14.5	0.41	0.45	0.7	Firouzabad-Maymand	3/30/94		5.5		5.4	54	17	24		III	SS	A	1
180	1492-7	Zarrat (school)	1	0.1		0.3		16	6.8	17	0.55	0.205	0.71	0.042	0.027	0.055		4/1/94		4.6			33s	32					C	1
181	1492-8	Zarrat (school)	1	0.1		0.2		56	21	49	2.3	0.99	2.9	0.23	0.17	0.23		4/3/94	4.8	5.2		5.2	23	33	24			SS	A	1
182	1492-9	Zarrat (school)	1	0.1		0.3		19	10	22	0.62	0.39	0.83	0.058	0.051	0.076		4/3/94		4.7			33s	26					C	1
183	1492-11	Zarrat (school)	1	0.1		0.3		12	9.5	10	0.415	0.21	0.44	0.00 0	0.016	0.0235		4/30/94		4.1			33s	23					C	1
184	1502-2	Zanjiran	2	0.4		0.7		29	20	27	0.5	0.28	0.38	0.02	0.011	0.022		5/25/94		4.3			33s	17					C	1
185	1492-13	Zarrat (school)	1	0.2		0.4		29	20	43	1.1	0.405	1.2	0.048	0.015	0.046		6/5/94		4.5	4.8		33s	79	27				C	1,5
186	1502-4	Zanjiran	2	0.1		0.8		193	72	180	4.1	1.2	4.0	0.14	0.04	0.14		6/5/94		4.5	4.8		33s	60	10				C	1,5
187	1492-14	Zarrat (school)	1	0.1		0.7		25	18	21	1.1	0.89	0.93	0.17	0.115	0.117		6/11/94	4.2	4.8			18	29					B	1
188	1502-6	Zanjiran	2	0.2		0.4		36	30	48	1.1	0.68	0.92	0.038	0.083	0.12		6/11/94	4.2	4.8			18	9	19				B	1
189	1502-7	Zanjiran	2	0.1		0.5		14	11	17	0.28	0.16	0.38	0.016	0.012	0.017		6/13/94		4.2			33s	4	20				C	1
190	1492-15	Zarrat (school)	1	0.1		0.2		111	37	85	3.95	1.1	2.2	0.245	0.15	0.22		6/18/94		5.1			11	21					B	1
191	1493-1	Firouzabad	3	0.2		0.6		11	10	6.8	0.52	0.44	0.43	0.085	0.062	0.056		6/18/94		5.1			11	18					B	1
192	1502-8	Zanjiran	2	0.1		0.5		96	51	95	2.4	1.7	2.7	0.19	0.17	0.16		6/18/94		5.1			11	17	8				B	1
193	1492-16	Zarrat (school)	1	0.1		0.2		308	104	257	12.6	4.0	10.3	2.6	0.405	1.3	Ebrahimabad	6/20/94	5.7	5.9		5.9	9	29		29	IV	SS	A	1,7
194	1493-2	Firouzabad	3	0.1		0.4		244	116	282	9.3	5.05	9.3	1.46	1.1	87	Ebrahimabad	6/20/94	5.7	5.9		5.9	9	17		17	VI	SS	A	1,7
195	1495	Maharloo (PTT)	1	0.1		0.5		21	12	19	1.7	0.95	1.56	0.27	0.14	0.22	Ebrahimabad	6/20/94	5.7	5.9		5.9	9	50		50	III	SS	A	1,7
196	1498	Babanar	2	0.1		0.2		28	15	29	1.89	1.38	1.53	0.35	0.29	0.395	Ebrahimabad	6/20/94	5.7	5.9		5.9	9	63		63	III	SS	A	1,7
197	1502-9	Zanjiran	2	0.3		0.3		1057	993	1070	28.20	14.85	43.85	1.99	0.91	2.085	Ebrahimabad	6/20/94	5.7	5.9		5.9	9	7		7	VIII	SS	A	1,7
198	1492-19	Zarrat (school)	1	0.1		0.1		15	10	19	0.51	0.285	0.485	0.028	0.012	0.024		6/21/94	4.5	4.4			33s	27	15				C	1
199	1492-20	Zarrat (school)	1	0.1		0.3		26	8.5	18	0.92	0.24	0.64	0.044	0.023	0.046		6/21/94		4.7			41	26	16				B	1
200	1493-4	Firouzabad	3	0.1		0.1		12	9.2	10	0.49	0.28	0.38	0.028	0.024	0.016		6/21/94		4.7			41	18					B	1
201	1492-22	Zarrat (school)	1	0.1		0.2		11	4.5	10	0.32	0.12	0.30	0.018	0.0083	0.016		6/22/94		4.3			10	38	15				B	1
202	1492-23	Zarrat (school)	1	0.2		0.4		15	8.3	19	0.45	0.165	0.445	0.018	0.0082	0.021		6/24/94		4.0			33s	147	20				C	1
203	1501-4	Zanjiran	2	0.1		0.6		9.9	11	16	0.2	0.23	0.38	0.009	0.0075	0.0092		6/24/94		4.0			33s	122	15				C	1
204	1513	Bandar-Torkman	4	0.2		0.4		20	11	33	1.0	0.57	2.2	0.22	0.14	0.22	Gorgan	7/23/94		4.9	5.1		31	60		32	IV		B	1,5
205	1508-1	Hosseiniyeh- Olia Andi	4	0.7		0.7		187	129	103	9.1	2.4	6.7	0.78	0.14	0.53	North Andimeshk	7/31/94	5.3	5.3		5.6	43	20	22		III	Rv/SS	A	1,4
206	1525	Karkheh Dam	1	0.1		0.1		13	15	13	1.1	0.7	0.98	0.32	0.26	0.25	N.Andimeshk Dareh-Shahr	7/31/94	5.3	5.3		5.6	43	26			III	Rv/SS	A	1,4
207	1526-1	Dez Dam	1	0.1		0.1		26	26	22	1.3	2.2	2.1	0.26	0.46	0.67	N.Andimeshk Dareh-Shahr	7/31/94	5.3	5.3		5.6	43	11	18		III	Rv/SS	A	1,4
208	1526-2	Dez Dam	1	0.1		0.2		4.6	10	7.2	0.27	0.64	0.56	0.034	0.077	0.08	N.Andimeshk	7/31/94		5.2			73	8	17		III		B	1,4
209	1527	Andimeshk	1	0.3		0.3		28	29	26	1.7	1.6	1.3	0.0.33	0.26	0.21	North Andimeshk - Dareh-Sha	7/31/94	5.3	5.3		5.6	43	7	35		IV	Rv/SS	A	1,4
210	1522	Ghaemiyeh (Chenar-S	3	0.3		0.3		12	4.9	8.8	0.31	0.13	0.23	0.015	0.011	0.0095		9/5/94		5.0			33s	57	18				C	1
211	1506-11	Hosseiniyeh- Olia Andi	4	0.1		0.3		11	6.3	11	0.39	0.27	0.48	0.077	0.036	0.055	Dezful	9/20/94	4.4	5.5		5.1	33s	50		37	III	Rv/SS	B	1,4
212	1507	Dez Dam	1	0.1		0.2		23	18	25	0.98	0.61	1.0	0.15	0.088	0.12	Dezful	9/20/94	4.4	5.5		5.1	33s	27		25		Rv/SS	B	1
213	1506-1	Andimeshk	1	0.1		0.2		7.5	6	10	0.27	0.20	0.40	0.025	0.020	0.027	Dezful	9/20/94	4.4	4.5		5.1	33s	35	12	15		Rv/SS	B	1
214	1506-2	Andimeshk	1	0.1		0.1		17	20	36	1.1	1.1 33	2.1	0.13	0.2	0.34	Dezful	9/20/94			4.9				19	15			B	4,5
215	1523-24	Jovakan	1	0.8		1.5		29	10	19	0.25	0.11	0.22	0.0030	0.0013	0.0027	NW Farashband	9/20/94		3.6			33s	8	15				C	1
216	1520-3	Kavar	2	0.3		0.6		11	10	13	0.35	0.2	0.36	0.013	0.004	0.021		9/29/94		3.6			33s	20	6				C	1
217	1523-25	Jovakan	1	0.3		0.6		23	11	13	0.30	0.085	0.14	0.0098	0.000 0	0.0037	N. Dayyer	9/29/94		3.8			33s	12	14				C	1
218	1528-1	Fin (N.Bandar-Abbas)	3	0.3		0.5		55	33	32	0.76	0.35	0.51	0.012	0.008	0.011	Relocated to Fin North Band	10/28/94		4.2			33s	4	4				C	1
219	1530-1	Nir (Ardebil)	3	0.1		0.3		84	46	59	2.6	0.88	3.6	0.2	0.08	0.0 33	Ardebil	11/2/94		5.0	4.9		10	35	20				B	1,5
220	1550-1	Masal	3	0.1		0.1		19	6.6	24	0.83	0.29	0.84	0.085	0.042	0.105	Foumanat	12/3/94		4.8	4.6		33s	25		22			C	1,5
221	1519-3	Zarrat	1	0.4		0.2		47	21	61	1.5	0.5	2.2	0.059	0.028	0.082	NE Firoozabad	12/8/94		5.0			33s	24					C	1
222	1520-4	Kavar	2	0.1		0.6		19	13	38	0.5	0.27	0.88	0.023	0.015	0.029	NE Firoozabad	12/8/94		5.0			33s	25	22				C	1
223	1523-28	Jovakan	1	0.1				137	42	97	3.0	0.71	3.2	0.135	0.00 03	0.15	SE Jovakan	12/8/94		5.0			33s	10	16				C	1
224	1519-4	Zarrat	1	0.1		0.4		65	23	53	1.9	0.65	1.9	0.11	0.044	0.12	NE Firoozabad	12/15/94		4.7			33s	22	20				C	1
225	1520-5	Kavar	2	0.4		0.4		14	12	27	0.44	0.32	0.78	0.00 0	0.021	0.045	NE Firoozabad	12/15/94		4.7			33s	23	19				C	1

No	Code (BHRC)	Station	Site	Filters to procces (1st filtering for acceleration & velocity		Filters to procces (2nd filtering for Displacement (if used)		Peak Ground Acceleration (cm/s²)			Peak Ground Velocity (cm/s)			Peak Ground Deplacement (cm)			Macroseismic epicenter (Region)	Date	Ms	mb	ML	Mw	Focal Depth (km)	Epicentral Distance (km)	Hypocentral distanc	Macroseismic epicenter distance (km)	Intensity (MSK)	Focal Mechanism	Q	Ref
				HP	LP	HP	LP	H1	V	H2	H1	V	H2	H1	V	H2														
226	1579	Kuhestak	3	0.2		0.7		7.3	3.7	11	0.205	0.080	0.32	0.01	0.0027	0.013		1/4/95		4.6			33s	105					C	1
227	1532	Deh-Balla - N. Farrash	2	0.1		0.6		35	18	31	0.56	0.26	0.52	0.025	0.017	0.024		1/21/95		4.7	4.6		33s	32					C	1 5
228	1528-3	Fin	3	0.1		0.3		545	416	496	18	9.5	14.5	0.97	0.35	0.61	West Fin area	1/24/95	5.1	4.9		5.0	33s	22	8	5	VI	Rv/SS	B	1 4
229	1555	Firouzabad	3	0.1		0.6		16	9.6	23	0.41	0.16	0.42	0.017	0.0054	0.018	Firouzabad	2/19/95		4.4	4.3		33s	55	19	0-5			C	1,4,5
230	1547-1	Sefidrud Dam (Crest)	1	0.2		0.5		56	12	14	1.9	0.27	0.53	0.075	0.012	0.031		3/7/95			2.7				15	8			B	4 5
231	1563	Dorahun	3	0.3		0.5		16	6.3	15	0.44	0.165	0.42	0.021	0.016	0.023		3/8/95		4.3			33s	70	13				C	1
232	1564	Baba-Monir	4	0.1		0.5		18	13	20	0.63	0.34	0.89	0.026	0.024	0.055	fell at Jasuj & Gachsaran	3/22/95		4.8	4.8		33s	23					C	1,4,5
2233	1575-1	Babakalan (Gachsaran	2	0.1		0.6		24	14	20	0.38	0.165	0.40	0.009	0.0085	0.0145	Gachsaran & Yasuj	3/22/95		4.8			33s	20					C	1
234	1545-1	Kavar	2	0.1		0.4		21	12	14	0.6	0.21	0.35	0.029	0.011	0.021		4/2/95		4.5			34	30	40				B	1
235	1562-1	Zarrat	1	0.1		0.6		29	11	14	0.69	0.205	0.45	0.0029	0.0023	0.0019	N Firouzabad	4/2/95		4.8	4.8		34	30		35			B	1,4,5
236	1558	Bandar-Deylam	4	0.4		0.1		56	1.2	10	0.5	0.11	1.15	0.105	0.016	0.135	Ahvaz,Izeh Genaveh , Behba	4/22/95	4.9	5.1			25	95					B	1
237	1581	Lendeh	1	0.1		0.3		17	12	20	1.25	0.87	1.1 33	0.145	0.100	0.205		4/22/95	4.9	5.1			25	51				Rv/SS	A	1
238	1535-2	Rudbar	3	0.1		0.5		99	87	94	3.1	1.8	3.7	0.14	0.12	0.23	N Rudbar	4/28/95		4.8			33s	30	8				C	1
239	1548	Astaneh	4	0.1		0.2		14	4.6	6.5	0.46	0.10	0.29	0.051	0.019	0.041		4/28/95		4.8			33s	45					C	1
240	1536-2	Ghir	4	0.1		0.3		39	31	42	1.10	0.6	1.15	0.058	0.036	0.058	SW Ghir	5/3/95		4.7	4.5		33s	28					C	1 5
241	1625-1	Ghaleh-Ganj (Kahnou	1	0.2		0.6		21	12	14	0.48	0.19	0.425	0.028	0.013	0.025		5/12/95		4.0			33s	47					C	1
242	1621	Darreh-Shahr - Ilam	1			0.4		18	14	13	0.55	0.0.33	0.55	0.041	0.0175	0.035		5/17/95			3.9				10	7			B	4 5
243	1551-2	Shabastar	1	0.1		0.2		39	82	40	0.78	1.23	1.02	0.024	0.03	0.043	N Shabastar	5/18/95		4.2			33s	16	22				C	1
244	1594	Khorramabad	2	0.1		0.4		17	15	20	0.38	0.175	0.60	0.0186	0.0075	0.0225	Near Khoramabad	5/28/95			3.9				18	15			C	4 5
245	1543	Namin	3	0.1		0.4		11	7	15	0.35	0.12	0.44	0.017	0.006	0.02	Ardebil area	5/27/95	4.6	4.8			33s	82					C	1
246	1590-2	Sisakht	1	0.3		1.5		23	21	22	0.31	0.29	0.39	0.0084	0.0053	0.0057		5/27/95	3.8	4.6			51	70					B	1
247	161633-1-	Namin	3	0.1		0.6		10	6	15	0.35	0.125	0.435	0.013	0.0058	0.017	Parsabad, Moghan, Germi K	5/27/95	4.6	4.8	4.6		33s	80			III		C	1,4,5
248	151533-2-	Selfabad (S. Kazerun)	1	0.1		0.5		21	10	16	1.15	0.53	0.53	0.09	0.036	0.037		5/31/95	4.0	5.0			25	20	20				B	1
249	1620-1	Doab (Pol-e Sefid)	3	0.2		0.6		115	49	72	2.7	0.83	1.5	0.062	0.014	0.051		6/3/95		4.0			33s	6	20				C	1
250	1626	Hassan-Kelf	3	0.1		0.6		59	37	38	1.88	0.72	1.0	0.056.	0.016	0.029		6/28/95	4.2	5.1			33s	5	14	5	IV		C	1 4
251	1569	Mahan	4	0.2		0.5		14	3	7	0.30	0.143	0.19	0.024	0.0085	0.012	Joshan , Hashtadan, Sirch	9/4/95	3.9	4.4			33s	20		28			C	1 4
252	1647-1	Dalin (SE Sepidan-Far	2	0.1		0.7		45	20	39	0.92	0.41	0.91	0.024	0.015	0.029		10/5/95		3.7			33s	14	12				C	1
253	1537	Sefidrud Dam	1	0.1		0.2		20	12	10	0.85	.44	0.37	0.12	0.095	0.047	N. Rudbar	10/15/95		4.9		5.2	33s	32	25			SS/Rv	B	1
254	1541	Rasht (University)	3	0.1				16	6.4	23	0.78	0.28	2.1	0.13	0.095	0.29		10/15/95		4.9		5.2	33s	28	20				C	1
255	1615-1	Abbar	1	0.1		0.1		7	9	18	0.5	0.34	0.70	0.074	0.085	0.054	Zanjan & Gilan area	10/15/95		4.9		5.2	33s	42			IV	SS/Rv	B	1
256	1632-1	Masal	3	0.1		0.1		7	4	8	0.89	0.0.33	0.60	0.11	0.051	0.089	Gilan -Zanjan	10/15/95		4.9		5.2	33s	52			III	SS/Rv	B	1
257	1586	Ziaratali -N. Bandarab	1	0.1		1.5		16	8	11	0.48	0.16	0.28	0.023	0.012	0.019		11/6/95	4.6	5.1			33s	21					C	1
258	1625-2	Ghaleh-Ganj (Kahnou	1	0.1		0.3		20	17	28	0.52	0.47	1.0	0.042	0.055	0.080		11/6/95	4.6	5.1			33s	49					C	1
259	1539	Mashad (Sakhi	4	0.1		0.4		19	16	14	0.74	0.43	0.73	0.058	0.015	0.049	E Mashhad (Fariman Mashh	11/9/95	3.8	4.9	5.6		33s	70					C	1
260	1559	Khurmodj	1	0.1		0.5		41	19	40	0.56	0.29	0.495	0.018	0.017	0.018		11/14/95		4.2			33s	15					C	1 4
261	1560-1	Lali	3	0.1		0.7		118	156	98	3.8	2.45	2.7	0.10.1	0.076	0.143	Lali region	11/24/95		4.5	4.1		73	19	19	15			C	1
262	1572	Masjed-Soleyman	3	0.1		0.5		14	7.1	18	0.4	0.17	0.68	0.016	0.0085	0.022	Lali region	11/24/95		4.5	4.1		73	45		45			B	1,4,5
263	1560-4	Lali	3	0.1		0.5		80	61	107	2.6	1.55	2.7	0.14	0.125	0.05	Lali region	11/27/95		5.0			61	18		15			B	1,4,5
264	1566	Shiraz	4	0.2		0.5		12	8.9	10	0.31	0.27	0.40	0.02	0.0125	0.022	Shiraz	12/31/95		4.7	4.7		33s	35		25			B	1.5
265	1602-1	Kavar Dam	2	0.4		0.8		28	9.2	17	0.67	0.158	0.53	0.024	0.0058	0.017	Shiraz and its suburb	12/31/95		4.3	4.7		33s	30	33		III		C	1,4,5
266	1602-2	Kavar Dam	2	0.3		0..4		38	13	32	1.2	0.38	0.88	0.072	0.023	0.047	Shiraz and its suburb	12/31/95		4.7	4.8		33s	28	24		III		C	1,4,5
267	1571-6	Shabankareh (Borazja	4	0.5		0.5		120.8	37.5	65.8	3.27	0.586	1.82	0.115	0.0123	0.082	Shabankareh	1/24/98	4.2	4.5			45	3	18				C	1,4,5
268	1571-11	Shabankareh (Borazja	4	1.2		1		13	6.90	12.20	0.0.33	0.12	0.387	0.0099	0.0024	0.0122	Shabankareh	1/24/98	4.5	4.4			35	12	18				B	1
269	1571-16	Shabankareh (Borazja	4	0.8		0.7		19.3	10.8	21.5	0.44	0.19	0.63	0.0125	0.0039	0.0207	Shabankareh	1/24/98	4.6	4.7			58	7	16				B	1
270	1583-3	Saadabad (Borazjan)	1	0.5		0.5		74	22.2	45.9	2.2	0.51	0.55	0.076	0.03	0.058	Shabankareh	1/24/98	4.5	4.4			35	10	21				B	1
271	1583-4	Saadabad	1	0.4		0.4		34.1	9.98	18.3	0.97	0.205	0.505	0.048	0.014	0.02 3	Shabankareh	1/24/98	4.6	4.7			58	7	21				B	1
272	1571-30	Shabankareh (Borazja	4	0.8		0.8		21.9	14.9	24.4	0.44	0.23	0.53	0.016	0.0052	0.0173	Shabankareh	1/25/98	4.7	4.5			49	4	20				B	1
273	1583-7	Saadabad (Borazjan)	1	0.4		0.4		22.3	6.30	17.6	0.73	0.17	0.50	0.031	0.0072	0.0195	Shabankareh	1/25/98	4.7	4.5			49	16	21				B	1
274	1571-32	Shabankareh (Borazja	4	0.4		0.4		25.2	24.4	44.8	0.57	0.415	1.01	0.0165	0.008	0.029	Shabankareh	1/26/98		3.9	3.1		32	34	21				B	1
275	1571-34	Shabankareh	4	0.1		1		5.66	8.16	12.7	0.14	0.094	0.264	0.004	0.0015	0.0082	Shabankareh	1/26/98	4.3	4.6			33s	12	20				B	1 5
276	1571-35	Shabankareh	4	0.4		0.6		28.7	17.3	36.0	0.82	0.32	0.98	0.026	0.008	0.0395	Shabankareh	1/26/98		4.4			33s	16	22				C	1
277	1589-1	Saadabad (Borazjan)	1	0.3		0.3		46.7	17.9	50.0	1.25	0.34	1.57	0.117	0.021	0.077	Shabankareh	1/26/98	4.3	4.6			33s	11	22				C	1
278	1589-2	Saadabad (Borazjan)	1	0.5		0.5		15.5	5.23	16.1	0.58	0.125	0.44	0.03	0.0083	0.017	Shabankareh	1/26/98		4.4			33s	6	22				C	1
279	1599-1	Firouzabad	3	0.1		0.5		24.1	14.3	11.3	0.92	0.325	0.355	0.0435	0.0073	0.015		1/26/98		4.4			33s	26					C	1

Appendix 2 Some Examples of determining the macroseismic epicenters

Some of the epicenters are relocated, based on the damage reports and the reports by the national Iranian seism ic network. The following explained events are those their macroseismic epicenter (based on the damages to th e inhabitant areas) were not already reported. The suggested intensities in Appendix 1 may be compared with the accelerations registered in the same place, and may provide a bases for possible studies on the attenuation s of the intensities in Iran. The suggested intensities - all in MSK scale - are presented in Appendix 1. All of the following mentioned localities are shown in Figure 2.6. The most important cases are explained briefly here in:

- Vendik earthquake 7-11-1976 (Ms6.4; mb5.8) demolished Vendik village in the north of Ghaen. A visit to Vend ik (December 1996) made it clear that the village was evacuated after the quake. Almost all of the buildings w ere destroyed. Another village (Kalateh-e Hadj-Mohammad-Alam) in a distance of about 7 km towards north east of Vendik, has also been destroyed but as the inhabitants (who still work in the farmlands of Vendik) said, the damages in Hadj-Mohammad-Alam ware less severe than in Vendik. Twelve people have died in Vendik. This quake m ade some losses in Ghaen (12 people injured with some buildings destroyed).

- Chalderan earthquake 24-11-1976 (Ms7.3; mb6.1; ML6.8) shocked a frontier region between Iran and Turkey. The quake caused a lot of damage in the Iranian side of the frontier. Several landslides (in the form of rock-blo ck slides and debris slides) were reported in areas near Maku , Siah-Cheshmeh and Kelisa-Kandi. One person was reported dead in Siah-Cheshmeh, and in Maku two great blocks fell on some rural buildings of the city and caus ed a lot of damages. Another quake which may be thought of as the aftershock of the Chalderan earthquake has sh aken Siah-Cheshmeh in 6-12-1976 (Ms4.2, mb4.4).

-Chourzagh (Tarom-Olia) earthquake 22-7-1983 (Ms5.0; mb5.6) in the north Zanjan province caused some losses (3 killed and 38 injured in Chourzagh). The property losses were reported from Chourzagh, Abbar and Hendi-Kandi areas.

- Tonkabon earthquake 20-12-1983 (mb4.8; ML4.5), shocked the city of Tonkabon and its suburban villages. The Tehran station of IGTU reported a foreshock of a magnitude ML3.0, and some aftershocks with magnitudes betw een ML3.0 to ML3.7, but no more data is published on the times and the locations of these foreshock and afters hocks.

- Kaboudar-Ahang earthquake 9-5-1985 (ML3.1) is just reported by the local stations of the national network (IGTU) that shocked the region between Kaboudar-Ahang and Razan.

- Fataviyeh (Bastak) earthquakes 16-1-1987 (ML4.5), and 19-1-1987 (ML4.0) are registered in the site of the Ol d-Lar city in southern Zagros, and are just reported by the local stations of the IGTU. Some 40 aftershocks fol lowed these two main events. Based on some reported minor quake impressions in the Fataviyeh villages and it s uburbs, an intensity of III is estimated for the epicentral area.

- Kohan (Kuhbanan) earthquake 11-4-1987 (Ms4.5; mb5.0) caused panic among the inhabitants and some damage in form of the rural building collapses in the village of Kohan and the breaking of windows in the city of K ohbanan.

- Gol (Khusf) earthquake 24-11-1987 (mb5.3) caused some damage in the Gol villages and Khusf city in the wes t and southwest of Birjand.

- Rostamabad earthquake 28-11-1991 (Ms5.0; mb5.6; ML5.5) damaged some recently reconstructed buildings (after the great earthquake of Manjil 20-6-1990, Mw7.3 in the same region). Two people collapsed and died in the panic provoked by this shock.

- Ebrahimabad (Firouzabad) earthquake 20-6-1994 (Ms5.7; mb5.9; Mw5.9) caused severe damages in the central Z agros area between Shiraz and Firouzabad. The quake demolished the most of the buildings in Ebrahimabad, Jov akan and Zanjiran. Some minor damage was observed in Firouzabad (some cracks in walls and minor damages in the rural buildings). Three people were killed in this earthquake (2 in Ebrahimabad and one in Zanjiran).

Chapitre 3

Les Effets de Site

Résumé Les effets de site sont étudiés dans ce chapitre en utilisant les données de mouvements forts enregistrés par le réseau accélérométrique iranien. Vingt-six sites ont été choisis pour des mesures géosismiques. Le bruit de fond y a été enregistré, ainsi que dans vingt-quatre autres sites où ces mesures ont été les seuls tests réalisés. Des tests géoélectriques ont également été effectués sur les 24 sites où des études géosismiques ont été réalisées, mais ces résultats n'ont pas été utilisés car leur interprétation ne donnait pas de résultats très intéressants. Les rapports spectraux entre les composantes horizontales et verticales (« fonctions-récepteur ») ont aussi été calculés pour tous les enregistrements du catalogue de mouvements forts iraniens (137 sites en tout). Ces rapports ont été la base de notre classification de site, du point de vue de leurs réponses aux mouvements forts, car ils sont les seuls critères qui existent pour tous les sites, et les seuls qui montrent directement les réponses des sites aux mouvements forts. Ce critère de classification résulte d'une comparaison entre les fonctions récepteurs et les résultats des tests géotechniques (géosismique, bruit de fond). En bref, les sites avec les rapports H/V inférieurs à 3 pour toute fréquence inférieure à 15 Hz ont été considérés comme du 'rocher' (classe 1); les sites avec un rapport H/V dépassant 3 dans la bande de fréquence de 5 à 15Hz ont été classés dans la catégorie 2, ceux avec un rapport H/V dépassant de 3 dans la bande de 2 à 5 Hz sont classés en catégorie 3, ceux montrant un rapport H/V dépassant 3 pour les fréquences inférieures à 2Hz ont été classés dans la catégorie 4. Il s'avère que cette classification se corrèlle assez bien (dans 70% des cas) avec la valeur moyenne de la vitesse d'onde S sur les 30 premiers mètres, Vs30: pour la classe 1, $Vs30 > 700$ m/sec; pour la classe 2, $500 < Vs30 < 700$ m/sec; pour la classe 3, $300 < Vs < 500$ m/sec; et pour la classe 4, $Vs30 < 300$m/sec. Le bruit de fond ne présente qu'un accord très partiel avec ces classifications: dans les sites de type de classe 3 et 4 on trouve les rapports H/V présentant une certaine similarité avec les fonctions-récepteurs. Ce rśultat mitigé pourrait être la conséquence des situations topographiques (l'existences de deux chaînes des montagnes importantes dans le plateau iranien) et météorologiques (aride et sec) du pays. La classification présentée dans ce chapitre est le premier travail sur les effets de site accompli à partir du réseau accélérométrique en Iran.

Site Characterizations for the Iranian Strong Motion Network

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Abstract 26 sites of the Iranian strong motion network, having provided numerous records of good quality, were selected for a site effect study with the objective of obtaining a reliable site categorization for a later statistical work on Iranian strong motion data. For each site, superficial Vp and Vs profiles were measured with refraction techniques, microtremor recordings were obtained and analyzed with the H/V technique and the available three-component accelerograms by the receiver function technique. The aggregation of these results allows the proposition of a four-class categorization based on the H/V spectral ratio of strong ground motions, which demonstrate a satisfactory correlation with S-wave velocity profile. Iran has a particular geological and meteorological situation compared to other seismic countries such as Japan or California; a mountainous country with dry weather condition and low water table in most areas. These conditions result in a relatively small number of sites with low frequency amplification, while many sites exhibit moderate amplifications in the intermediate and high frequency range.

3.1 Introduction

The strong motion accelerometric network in Iran is installed throughout the country in different site conditions. The Kinemetrics SMA-1 analog instruments were initially installed since 1975, and then they have been gradually expanded by the SSA-2 digital instruments since the Manjil earthquake of 1990; Mw7.4, in NW Iran. The number of the instruments in this network is 1000 stations (by the end of 1997). The stations have been mainly chosen within the cities or villages for an easy maintenance. However there are no double stations (functioning as a local network on a soil site and its corresponding rock outcrop) to compare easily the soil and rock motions in different earthquakes. Meanwhile, there is no down-hole array, yet, to compare the motions on the surface and on the base rock.

The previous studies on site effects on the strong ground motions in Iran were limited to some, recent, studies on the soil effects on strong motion records during the great earthquakes (Zaré 1994; 1995; 1996a & 1996b). On the other hand, some microzonation case studies were also performed in some great cities in Iran (Jafari et al 1995, 1996).

The scope of this study was to investigate the site effects on the strong ground motions in Iran. It is also tried to select a variety of different soil and geologic conditions in such a way that at the end of this study, there will be possible to present a site categorization to be used in the seismic hazard studies and the attenuation models for Iran. Meanwhile we hoped to determine a site categorization adaptable to the geological and meteorological situations of Iran. We intended to develop a method that would not be somewhat limited by the depth of the surface deposits. Finally it is tried to suggest a site classification to be mostly reliable and easily applicable (i.e. the site categorization in the United States is based on Vs_{30} which, in our opinion is not optimal; Boore et al. 1997).

In this article the results of a study on the site characterizations of some selected sites of the network are presented. We explain, first, the methodology of the study. Then an overview on the general situations of the sites and the different performed methods are described. The results of the different tests are presented afterward. Finally a 4-class site categorization is introduced.

3.2 The methodology

Fifty sites were studied. These sites were chosen from a database of 279 records (already processed and developed; Zaré, et al. 1998). The sites were chosen on the bases of the number and quality of corresponding records, as well as on the amplitude of the recorded motion and its dependence with a great earthquake (to compare cases of the same events). The site studies were carried out with different methods: geoseismic tests to determine the compressional and shear waves in a profile under the station, microtremor studies (with SS-1 instruments and SSR-1 sensors), and geoelectric studies. Finally the site geological observations were performed to understand the geologic frame in each locality (type of the superficial layers, the depth of the water table, etc...). Among the fifty aforementioned sites, in 24 sites microtremor tests were applied, the geoseismic tests were performed in the 26 more important sites (the names of the sites and the results of the performed test are summarized in table I).

Table I: The results of the site effect studies on 138 sites in Iran; comprising 50 sites where the geotechnical tests carried out.

Table 1
The results of the site effect studies, and the site classification for strong motion stations in Iran.

No	Station	Site categorization	Number of records	Site geology	Vs over 1st 30 m (m s^{-1})	Amplification of H/V on microtremorts	Amplification of H/V on strong motions	Site based on surface geology (BHRC)	Electric resistivities (ohmm)	Q
1	Abbar	1	5	Stiff alluvium	621	1 2(0.2–20 Hz)	< 4 (2–5 Hz)	3	5–17 (1st 30 m)	A1
2	Abhar	4	1	Silt–clay in surface	263	> 2 (0.2–2 Hz)	> 4 (0.2–0.3 and 1–4 Hz)	4	3–25 (1st 25 m)	A1
3	Aghajari	2	1				> 4 (4–6 Hz)	1		C
4	Ahar	1	1				1–2 (3–10 Hz)	4		D
5	Ammarloo (Jirandeh)	3	6				> 4(3-5 Hz)			C
6	Andimeshk	1	3				2–3 (3–7 Hz)	2		C
7	Ardal	3	4				> 4 (2.5–3.5 Hz)	2		C
8	Ardebil	4	1				> 4(1–2.5 and 4–5 Hz)	3		C
9	Astaneh	4	1				> 4(0.7–2 Hz)	3		C
10	Avaj	1	2				3(4–7 Hz)	4		D
11	Babakalan (Gachsaran)	2	1				> 4(7–11 Hz)	2		C
12	Baba-Monir	4	1				> 4(0.9–1.7 Hz)			C
13	Babanar	2	1				> 4(5–6 Hz)			C
14	Bajestan	3	3	Silt–clay in surface		> 2(2–[illegible] Hz)	> 4(3–6 Hz)	2		D
15	Bam	1	1				1–2(0.7–10 Hz)	4		C
16	Bandarabbas (S)	2	3	Sand beach of the Persian Gulf		1-2(1–[illegible] Hz)	> 4(6–10 Hz)	3		B
17	Bandar-Deylam	4	1				> 4(0.3–3 Hz)			C
18	Bandar-lengeh	3	1				> 4(3–5 Hz)			C
19	Bandar-Torkman	4	1				> 4(0.9–3.5 Hz)	3		C
20	Birjand	1	4	Stiff alluvium		1(0.2–20 Hz)	1–3(0.7–7 Hz)	2		B
21	Boroujerd	3	1				> 4(2.5–3.5 Hz)	4		C
22	Boshruyeh	1	1				1–2(1–5 Hz)	2		C
23	Bostanabad	4	1				> 4(1–2.5 Hz)	2		C
24	Dalin (SE Sepidan-Fars)	2	1				> 4(5.5–6.5 Hz)			D
25	Darreh-Shahr Ilam	1	1				2–3(2–6 Hz)			C
26	Dastgerd	2	1				> 4(8–11 Hz)	2		C
27	Deh-Balla - N. Farrashband	2	1				> 4(7–11 Hz)			C
28	Delvar	2	1				> 4(9.5–10 Hz)			C
29	Deyhuk	1	3	Stiff alluvium	826	[illegible]-2(0.4–20 Hz)	2–4(2–15 Hz)	2	3–5 (1st 12 m)	A2
30	Dez Dam	1	3	Hard conglomerate			1–2(1–15 Hz)	1		C
31	Doab (Pol-e Sefid)	3	5				> 4(2.5–4 and 6.5–8 Hz)	2		C
32	Dorahun	3	1				> 4(3.5–7 Hz)			C
33	Doroud	4	1				> 4(1.5–2.5 Hz)	3		B
34	Eshtehard	4	1	Silt–clay in surface		1(0.4–20 Hz)	4(0.5–0.65 Hz)	4	20–80 (1st 25 m)	B
35	Estalkh-Posht	2	1				> 4(5–10 Hz)	1		C
36	Farrashband	1	1				1–3(5–11 Hz)			D
37	Farsan	1	1				1–2(5–8 Hz)	3		D
38	Ferdows	1	1	Stiff alluvium		1(0.4–15 Hz)	2–3(0.3–5 Hz)	2		B
39	Fin (N.Bandar-Abbas)	3	31	Soft alluvium	480	2–4(4–[illegible] Hz)	> 4(2.5–5 Hz)	2		A1
40	Firouzabad	3	11	Soft alluvium	478	2–3(4–[illegible] Hz)	> 4(1.5–4.5 Hz)	3	14–90 (1st 33 m)	A1
41	Gachsar	3	1				> 4(2.5–4.5 Hz)	2		C
42	Ghaemiyeh (Chenar-Shahijan)	3	1				> 4(2.5–4.5 Hz)	1		C
43	Ghaen	1	3	Stiff alluvium	867	1(0.6–25 Hz)	2–3(0.4–0.6 and 3–7 Hz)	2	1.5–100 (1st 21 m)	A2
44	Gavbandi	3	1				> 4(3–6 Hz)			C
45	Ghaleh-Ganj	1	1				2–3(2–11 Hz)			C
46	Ghazvin	3	1	Cohesionless gravel	424	1–2 (4–[illegible] Hz)	3–4(1–5 Hz)	2	10–50 (1st 20 m)	A2
47	Gheshm-Island	1	1				1–2(1.5–8 Hz)	2		C

Table 1 (*continued*)

No	Station	Site categorization	Number of records	Site geology	Vs over 1st 30 m (m s^{-1})	Amplification of H/V on microtremors	Amplification of H/V on strong motions	Site based on surface geology (BHRC)	Electric resistivities (ohmm)	Q
48	Ghir	3	1	Gravel		1(4–15 Hz)	3–4(4.5–5.5 Hz)	1		B
49	Gilvan	1	2				2–3(4–7 Hz)	2		D
50	Golbaf	3	13	Soft alluvium	439	1(4–8 Hz)	> 4(3–5 Hz)	3	4–8 (1st 19 m)	A2
51	Gonabad	4	3	Soft alluvium		1(0.2–40 Hz)	3–4(0.8–1.5 Hz)	3		B
52	Hajiabad	3	1				> 4(3.5–4.5 Hz)	1		C
53	Hassan-Keif	3	1				> 4(2.5–3.5 Hz)			C
54	Hosseiniyeh- Olia Andimeshk	4	11	Soft alluvium	563	1–2(0.2–6 Hz)	> 4(0.3–1 Hz)	1		A2
55	Jovakan	1	30	Soft alluvium in surface	1017	1–2(0.6–9 Hz)	2–3(5–8 Hz)	2	5–30 (1st 25 m)	A1
56	Kahrizak	4	1	Clay and marl		1–2(0.6–2 Hz)	3–4(0.4–2 Hz)	4		B
57	Kakhk	1	1	Sandstone	2200	2–4(0.8–10 Hz)	2–3(1.5–6 Hz)	1		A2
58	Karaj	1	1	Course grain gravels		1(0.4–25 Hz)	1–3(0.5–10 Hz)	2		B
59	Karkheh Dam	1	1				1–3(1–10 Hz)	1		C
60	Kashmar	3	2				3–4(2–3.5 Hz)	2		C
61	Kavar	2	13	Hard conglomerate	946	1(1–10 Hz)	2–4(1–9 Hz)	1	6–120 (1st 35 m)	A2
62	Kavar Dam	2	4				> 4(4–8 Hz)	1		C
63	Kazerun	2	2				> 4(5–11 Hz)	4		C
64	Kerman	4	2	Soft alluvium		3(0.2–1.1 Hz)	> 4(1.5–3 Hz)	3		B
65	Khaf	2	6				> 4(5–8 Hz)	2		C
66	Khanzanun	1	3				2–3(2–7 Hz)			C
67	Khezri	1	2	Hard conglomerate		1(0.2–25 Hz)	2–3(0.4–4 Hz)	3		B
68	Khonj	1	1				2–3(3–7 Hz)	3		C
69	Khorramabad	2	3				3–4(4–7 Hz)	2		C
70	Khoy	3	1				> 4(4–4.5 Hz)	2		C
71	Khurmodj	1	1				2–3(3.5–20 Hz)			C
72	Kiasar	2	1				> 4(6–7 Hz)	2		C
73	Kolur	1	1				> 4(15 Hz)			C
74	Kuhbanan	3	1	Soft alluvium		–2(0.3–9 Hz)	3–4(2–6 Hz)	4		B
75	Kuhestak	3	1				> 4(2.5–6 Hz)	2		C
76	Kushk-Nosrat	4	1				> 4(0.7–1.5 Hz)	1		C
77	Lahijan	4	1	Clay and silt	264	–4(0.8–2 Hz)	3–4(0.8–1.5 Hz)	4	4–10 (1st 10 m)	A1
78	Lali	3	8				> 4(3–5 Hz)	2		C
79	Lamerd	1	1				2–3(0.8–10 Hz)			C
80	Lar -Fars	1	2				1–2(4–15 Hz)			C
81	Lendeh	1	1				2–3(1.5–2 Hz)	2		C
82	Mahan	4	1				> 4(0.1–1.5 Hz)	2		C
83	Maharloo (PTT)	1	1				2–3(1.5–6 Hz)	1		C
84	Maku	2	4	Soft alluvium in surface	652		3–4(4–8 Hz)	2		B
85	Manjil	2	7	Fine gravel in surface	589	2–3(6–11 Hz)	> 4(5–7 Hz)	3	13–60 (1st 22 m)	A1
86	Maraveh-Tappeh	3	1				> 4(3–6 Hz)	2		C
87	Masal	3	3				3–4(2.5–7 Hz)	2		C
88	Mashad (Sakht-Azma)	4	1				3–4(0.5–2.5 Hz)	3		C
89	Masjed-Soleyman	3	1				> 4(2.5–5 Hz)	1		C
90	Minab	1	2				2–3(1.5–5 Hz)	3		C
91	Musian	3	2				> 4(2.5–6.5 Hz)			C
92	Naghan	1	16	Soft alluvium in surface	768	–2(0.2–25 Hz)	1–2(1–20 Hz)	2	6–200 (1st 25 m)	A1
93	Namin	3	2				> 4(3.5–7 Hz)	1		C
94	Nir (Ardebil)	3	2				3–4(2–6 Hz)			C
95	Noorabad-Mamassani	3	5				> 4(3.5–5 Hz)	4		C

Table 1 (*continued*)

No	Station	Site categorization	Number of records	Site geology	Vs over 1st 30 m (m s^{-1})	Amplification of H/V on microtremors	Amplification of H/V on strong motions	Site based on surface geology (BHRC)	Electric resistivities (ohmm)	Q
96	Old Lar	1	1				1–2(3–10 Hz)	2		C
97	Pol-Sefid	4	3				> 4(0.2–3 Hz)			C
98	Rasht (Housing Bureau)	3	2	Cohesionless gravel		1–2(0.6–3 Hz)	> 4(2–4 Hz)	3		B
99	Rasht (University)	3	1	Thick fine gravel		1–2(0.2–5 Hz)	> 4(2–2.5 Hz)	2		B
100	Ravar	3	1	Soft soil in surface		1–3(0.2–3 Hz)	3–4(1.5–3.5 Hz)			B
101	Rayen	1	1	Soft soil in surface		1–2(0.6–20 Hz)	1–2(0.2–7 Hz)	2		B
102	Robat-Karim	1	1	Coarse grain gravels		1–3(0.6–1.5 Hz)	1–2(0.2–2 Hz)	2		B
103	Roshtkhar	1	2				1–3(0.8–5 Hz)	4		C
104	Rudbar	3	22	Cohesionless river gravels	339	1–3(3–7 Hz)	> 4(3.4–5.5 Hz)	3		A1
105	Rudsar	4	1	Sand beach of Caspian sea	215	1–2(0.4–25 Hz)	> 4(0.25–0.7 Hz)	3	4–20 (1st 16 m)	A2
106	Rudshur	4	1	Silt and clay in surface			3–4(7–1.5 Hz)	3		C
107	Saadabad (Borazjan)	1	7	Fine gravel in surface	958	1–2(0.2–2 Hz)	3–4(2.5–9 Hz)	1		A2
108	Saman	2	1				> 4(5–11 Hz)			C
109	Sarbaz	2	1				> 4(4.5–6 Hz)			C
110	Sedeh	3	4	Silt and clay in surface		2–3(4–[illegible] Hz)	3–4(3–4 Hz)	4		B
111	Sefidabeh (School)	2	1	Hard gravels			> 4(5.5–8 Hz)	2		C
112	Sefidabeh (Microwave)	1	1	Sandstone and shale			2–3(1.5–7 Hz)	1		C
113	Seifabad (S. Kazerun)	1	1				1–2(0.8–1 Hz)	1		C
114	Selseleh	3	1				> 4(3–5 Hz)			C
115	Shabankareh (Borazjan)	4	37	Silty sand in surface	337		3–4(3–6 Hz)	3		B
116	Shabastar	1	3				2–3(2–9 Hz)			C
117	Shahid Yaaghubi Dam (S. Mashhad)	3	1				> 4(3–7.5 Hz)			C
118	Shalamzar	3	2				> 4(3–5 Hz)	4		C
119	Shiraz	4	1	Silt and clay in surface		–4(0.5–1 Hz)	> 4(0.2–1.1 Hz)	2		B
120	Siah-Cheshmeh	1	3				2–3(4–8 Hz)	4		C
121	Silvaneh	4	1				> 4(0.7–3 Hz)			C
122	Sirch	1	1	Fine gravel in surface		–2(0.8–6 Hz)	2–3(0.2–15 Hz)	3		B
123	Sisakht	1	4				2–3(7–10.5 Hz)			C
124	Tabas	1	9	Fine gravel in surface	715	–2(0.2–25 Hz)	2–3(1–15 Hz)	2	10–130 (1st 21 m)	A1
125	Talesh	3	5	Clay–silty gravel	514	–3(0.6–2 Hz)	3–4(0.8–4.5 Hz)	4	10–100 (1st 28 m)	A2
126	Tasuj	2	1				> 4(6.5–8 Hz)			C
127	Taybad	4	1				> 4(0.3–0.5 Hz)	3		C
128	Tehran (BHRC)	1	1	Coarse grain gravels		–2(0.6–15 Hz)	2–3(2–3 Hz)	2		D
129	Tehran (Chizar)	1	1	Coarse grain gravels		1–3(1–4 Hz)	1–3(0.3–5 Hz)	3		C
130	Tehran (Sharif University)	1	1	Fine gravel in surface		–2(0.6–7 Hz)	1–2(2–3 Hz)	2		D
131	Tonkabon	4	1	Artificial soil	209		> 4(1.5–2.5 Hz)	3	4–21 (1st 25 m)	A2
132	Torbat-Heydarieh (SH)	3	1				> 4(2–4 Hz)	2		C
133	Torbat-Jam	1	2				1–2(3.5–9 Hz)	4		C
134	Vendik	2	10	Fine gravel in surface	597	–2(0.2–20 Hz)	> 4(8–15 Hz)	3	2.5–100 (1st 27 m)	A2
135	Zanjan	1	1				2–3(1.5–5 Hz)	3		C
136	Zanjiran	2	36	Fine gravel in surface	672	1–1.5(0.3–10 Hz)	3–4(7–11 Hz)	1	10–140 (1st 15 m)	A2
137	Zarrat (school)	1	30	Fine gravel in surface	704	1–3(0.2–8 z)	3–4(3–7 Hz)	1	5–30 (1st 7.5 m)	C
138	Ziaratali -N. BandarAbbas	1	1				2–3(3–10 Hz)			C

In all of the sites, the obtained strong motion records are studied to obtain their horizontal to vertical spectral ratio (receiver function for the strong motions; RF SMS). Calculating the same ratio for microtremors (H/V ratio for the microtremors; H/V MTS), we have been able to compare the H/V ratio for noises and earthquakes. No geotechnical boring was done through this study, and no data of this type was found in the location of the stations.

Here we have tried to determine the degree of coincidence between different methods of site characterizations. This comparison and likely coincidence were possible especially in sites where we had results from all methods. Finally we describe the factors that may have some affections on site amplifications (besides site geology) which could alter our site characterization results.

3.3 An overview on the general situation of the sites and the tests

The locations of each selected site are shown in Figure 3.1. The sites are mostly located in the western and northern Lut area (in central-east Iran), the western Alborz Mountains and the central Zagros region, which correspond to areas hit by the largest events over the last 22 years.

The shear wave velocities in deep layers can not be found by the geoseismic tests; the effective investigation depth for the geoseismic tests is about 30 to 35 meters. The microtremor tests have been proposed, mainly in Japan, to provide some information on site conditions since seismic noise contains surface and body waves which are filtered by surface layers. The geoelectric tests may distinguish very grossly between rock and soil types within a depth of a few tens metres. The results from the geoelectric tests give a range of electric resistivities depending on the ionization of the soil particles. The characteristic resistivities for fine and coarse grain alluviums may juxtapose a lot. It is therefore very difficult to distinguish between different types of sites through the geoelectric tests. Based on the aforementioned reason the results of geoelectric tests will neither be presented here nor be used in the site categorization.

In the absence of down-hole arrays and rock outcrop motions, we have used the H/V method having then an idea of the response of each site to a strong ground motion.

Most of the strong motion sites in Iran are installed on foothills, for the sake of better climate and topographic situations in most areas of the country. On the other hand, in most cases, the sites are alluvial or firm grounds, and the soft soil sites may be found only near the coast (Lahijan, Rudsar and Tonkabon) or in the plains (Talesh, Golbaf, Shiraz and south

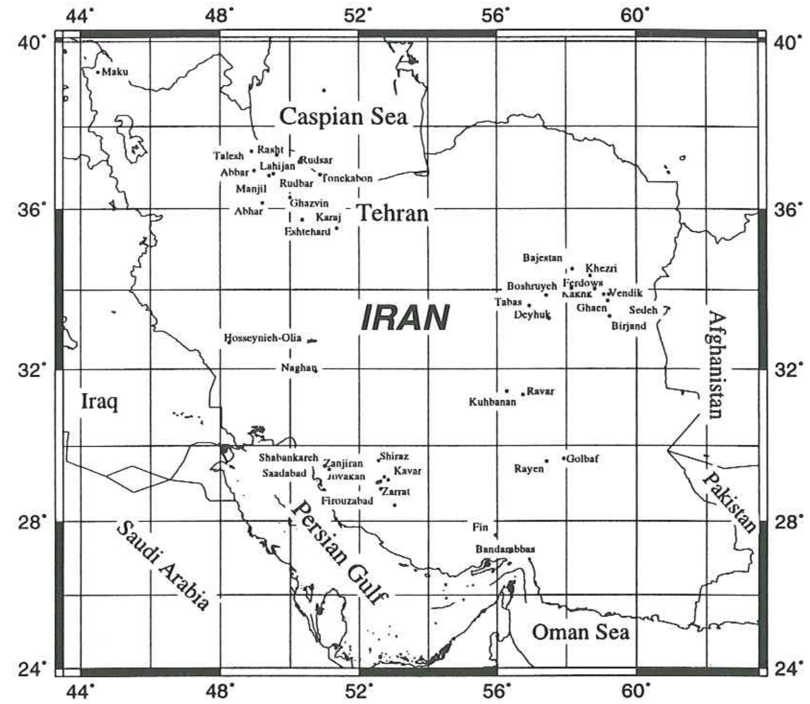

FIG. 3.1 – *The locations of the stations which are studied and presented in this paper.*

Tehran). A summary of the tests performed in each of 50 sites is presented in table-I. As is shown in the table, in most of these sites a microtremor test was done and in each the local geological situation was observed. The comparison of the local geological observations with the results of the tests may show us the degree of reliability of these observations in each place.

3.3.1 Receiver function method for strong motions

Since there are no station pairs located one on soil and another on rock in a nearby distance, and as there is no down-hole array in the country, we had to use single-station estimates of H/V ratio for site effects. This method, also called the receiver function technique, has been shown to be efficient (Theodulidis et al., 1996, Riepl et al. 1998), in pointing out the site fundamental frequency, and its stability makes it applicable, in principle, even when one single three-component recording is available. The formulation used for the H/V method is based on the spectral ratio (R_{hv}) between the smoothed horizontal components and the smoothed vertical component:

$$R_{hv} = \frac{\sqrt{\frac{S_{H1}^2}{2\sqrt{T_{H1}}} + \frac{S_{H2}^2}{2\sqrt{T_{H2}}}}}{\frac{S_v(f)}{\sqrt{T_v}}} \tag{3.1}$$

where T_{H1}, T_{H2} and T_V are the signal duration for the horizontals and vertical components respectively. Since the same time windows are used the same for all of the components, this relationship might be simplified as;

$$R_{hv} = \frac{\sqrt{\frac{1}{2} S_{H1}(f)^2 + S_{H2}(f)^2}}{S_V(f)} \tag{3.2}$$

In this study, this ratio was considered to be significant only when the signal to noise ratio R_{sn} for both components exceeds a given threshold value, taken equal to 3. The signal to noise ratio (R_{sn}) is computed as:

$$R_{sn} = \frac{\frac{S(f)}{\sqrt{t_s}}}{\frac{N(f)}{\sqrt{t_n}}} \tag{3.3}$$

where t_s and t_n are the window duration for the signal and noise parts, respectively. A R_{sn} ratio over 3 is selected as the proper ratio to distinguish the signal from the noise. The resultant R_{sn} ratios for two horizontal components are compared with the same ratio calculated for the vertical component in different frequencies.

The implied smoothing is the smoothing proposed by Konno and Ohmachi (1998), which keeps corrects amplitudes whatever the frequency. The stability is found acceptable especially in the sites with many records. The standard deviation of this ratio (RF SMS) is found to be about 1.5. The standard deviations of the digital and the analog records for the RF SMS method are shown in the sites with more than 10 records (Figure 3.2). This figure shows that the standard deviations for the digital records are less than the analog ones, and on the other hand in most cases the standard deviations do not pass 2. Therefore it may be concluded that the use of RF SMS as the main criteria to distinguish the site responses was reliable.

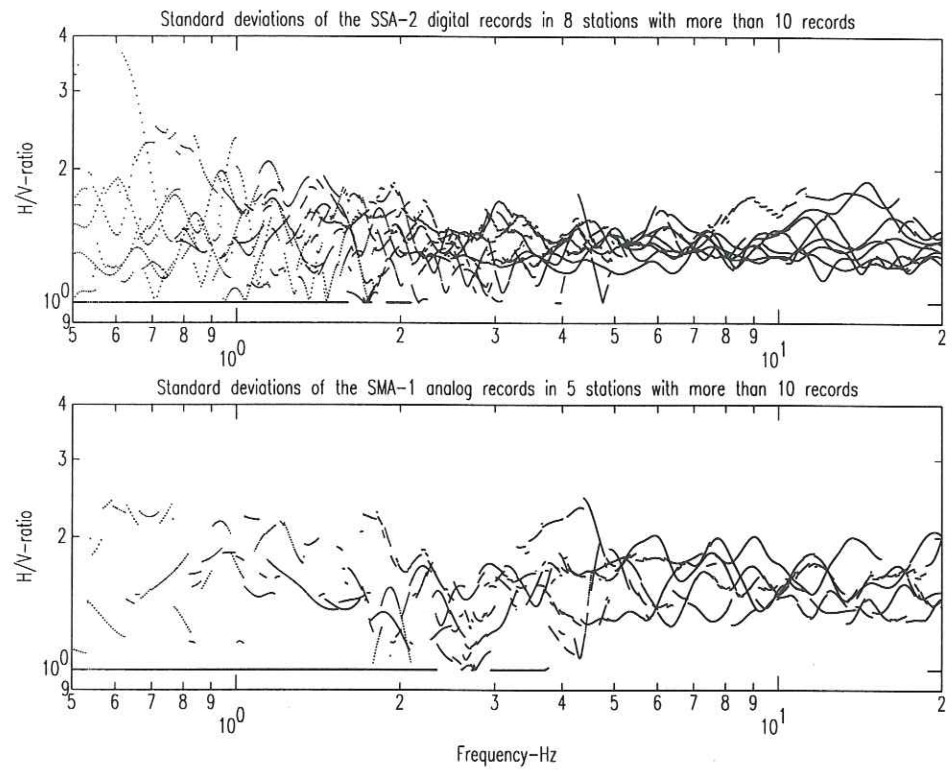

FIG. 3.2 – *The comparison of the standard deviations for the digital (SSA-2; a) and analog (SMA-1; b) recorders in the sites with more than 10 records.*

3.3.2 Microtremors

The microtremor tests are performed in 47 sites, using SSR-1 sensors with a minimum sensitivity of 0.1 Hz. Five windows of 3 minutes duration are selected in each site. In each coordinate, only the best stationary parts of the tremors are considered. The spectral ratio (R_{hv}) formulation for the microtremors are the same as the strong motions. The H/V MTS are compared in each site with the relative RF SMS.

3.3.3 Geoseismic tests

The geoseimic tests in 26 sites displayed the compressional and shear wave velocities in the superficial first 30 meters of depth using the refraction method. The theoretical transfer function (TTF) could then be computed in each case with 1D programs based on the geoseismic results in each case. There were some cases where the S wave velocities at depth were low (Golbaf, Lahijan). In these cases no velocity contrast may be seen in these depths, meanwhile the receiver function showed the amplifications in low and middle frequencies. No damping measurement was done at the studied sites.

Since it is necessary to place a row of 24 geophones with the interval distances of 4 to 5 meters to do the geoseismic tests, and according to the location of the stations which are mainly in the central parts of the cities, the tests were not always possible to be done in the same place of the stations. In these cases we have tried to do this test in the nearest possible place. Therefore the velocity profile tests in Deyhuk, Firouzabad, Ghaen Ghazvin, Golbaf, Kavar, Rudbar, Rudsar, Saadabad, Shabankareh, Tabas, Tonkabon and Zarrat are performed in the distances of 200 to 1000 meters away from the location of strong motion accelerographs. This problem might be the source of the incoherence between the strong motion and geoseismic results. The rest of the tests are performed in the distances of less than 200 meter too the stations.

3.4 The results of the geoseimic tests, microtremors and H/V for Strong Motions

For twenty-six sites shown in Figure 3.1, some information from the receiver functions, the noise recordings, and the velocity profiles could be simultaneously found from which a theoretical 1D-transfer function for vertically incident S waves could be computed. It has been tried to consider the sites where the most important earthquakes were recorded. Meanwhile, in three sites (Maku, Shabankareh, Tonkabon) a reliable results have not been obtained on the vertical component, and thus the microtremor results were eliminated. In 23 other sites, only performed microtremor test were performed in order to compare them with RF SMS. For some of the sites, a good consistency between all three techniques could be observed, while for some others the agreement was not so close. In particular, the noise results were very disappointing compared with studies made in other countries (Riepl et al., 1998; Duval, 1994; Bard et al., 1997, Lachet et al. 1996).

3.4.1 Sites with a satisfactory agreement between the results of the different methods

A satisfactory similarity between the different methods was obtained only for less than one half of the studied sites. The sites with the best similarities for the different tests are, for instance, Fin (Figure 3.3), Firouzabad (Figure 3.4), Ghaen (Figure 3.5) , Jovakan (Figure 3.6), Lahijan (Figure 3.7), Manjil (Figure 3.8), Naghan (Figure 3.9), Rudbar (Figure 3.10), Tabas

(Figure 3.11) and Zanjiran (Figure 3.12). This means that the factors affecting the amplifications were very different. In almost all cases, the peaks on the H/V MTS had low amplitude, much lower than those of the H/V ratio strong motion spectra (RF SMS) and the theoretical transfer functions (TTF). However poor agreement was observed at Lahijan (Figure 3.7) between RF SMS and TTF because the S wave velocity profile was not deep enough. The presence of the low velocity surface layer was essential to find a satisfactory agreement between methods.

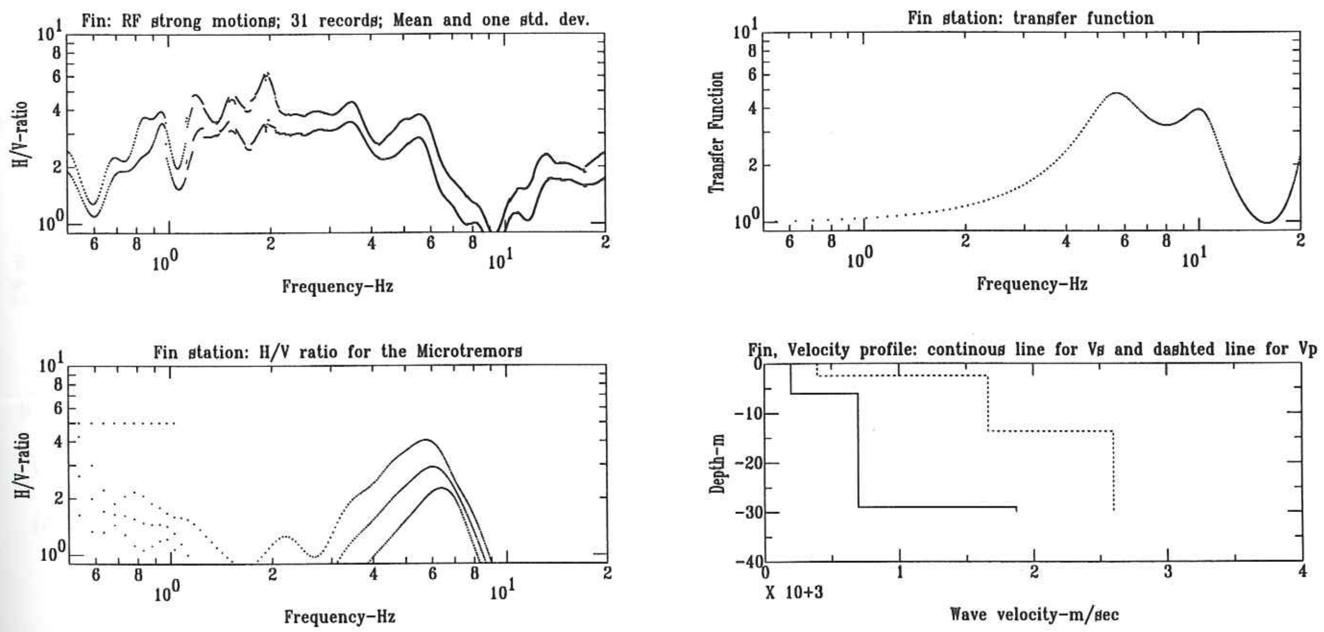

FIG. 3.3 – *The results of the site tests in Fin (North Bandarabbas) station (RF SMS, H/V MTS , transfer function and velocity profile).*

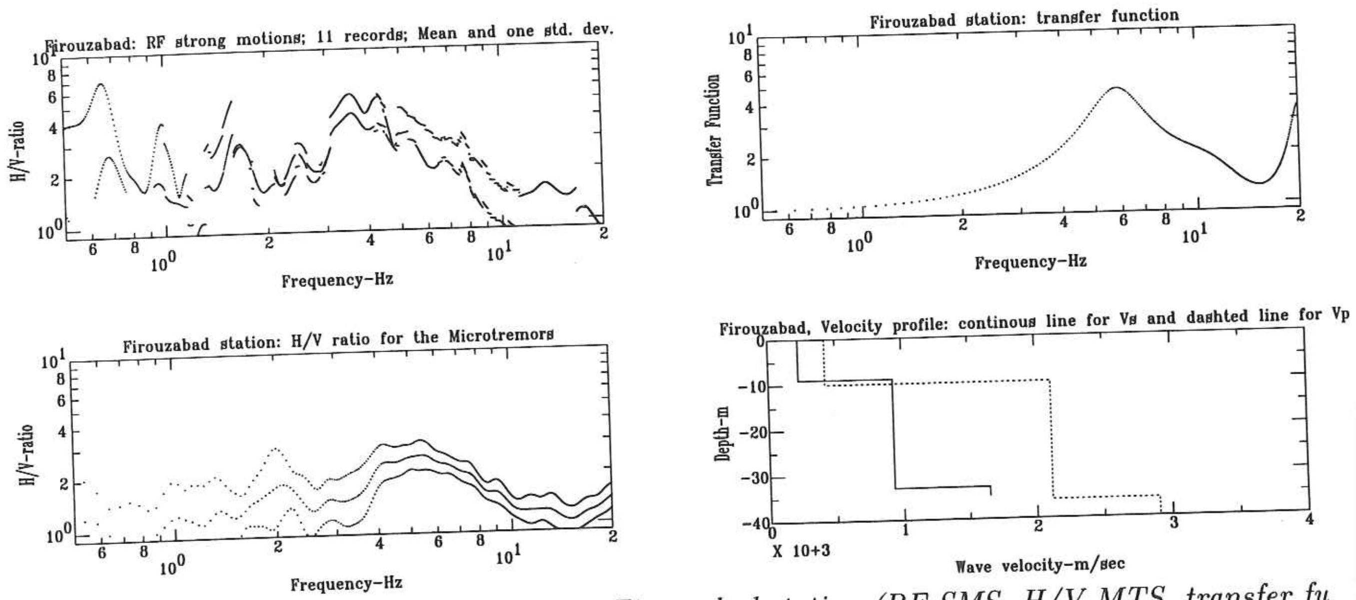

FIG. 3.4 – *The results of the site tests in Firouzabad station (RF SMS, H/V MTS, transfer fu nction and velocity profile).*

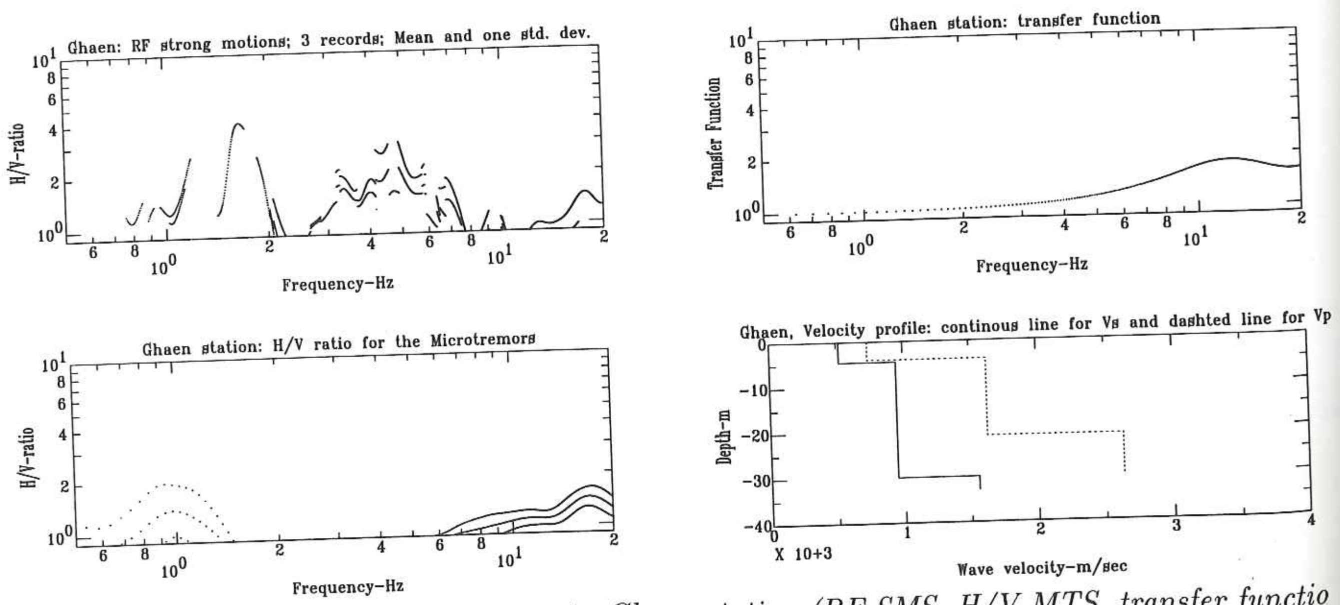

FIG. 3.5 – *The results of the site tests in Ghaen station (RF SMS, H/V MTS, transfer functio n and velocity profile).*

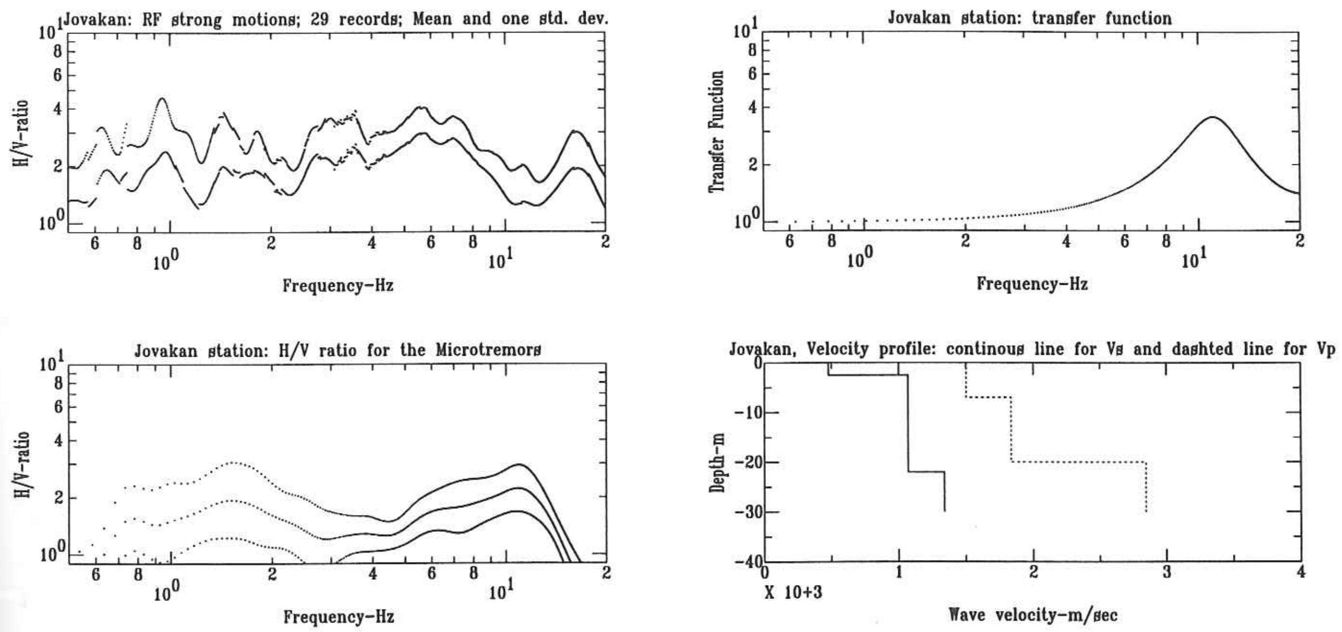

FIG. 3.6 – *The results of the site tests in Jovakan station (RF SMS, H/V MTS, transfer funct ion and velocity profile).*

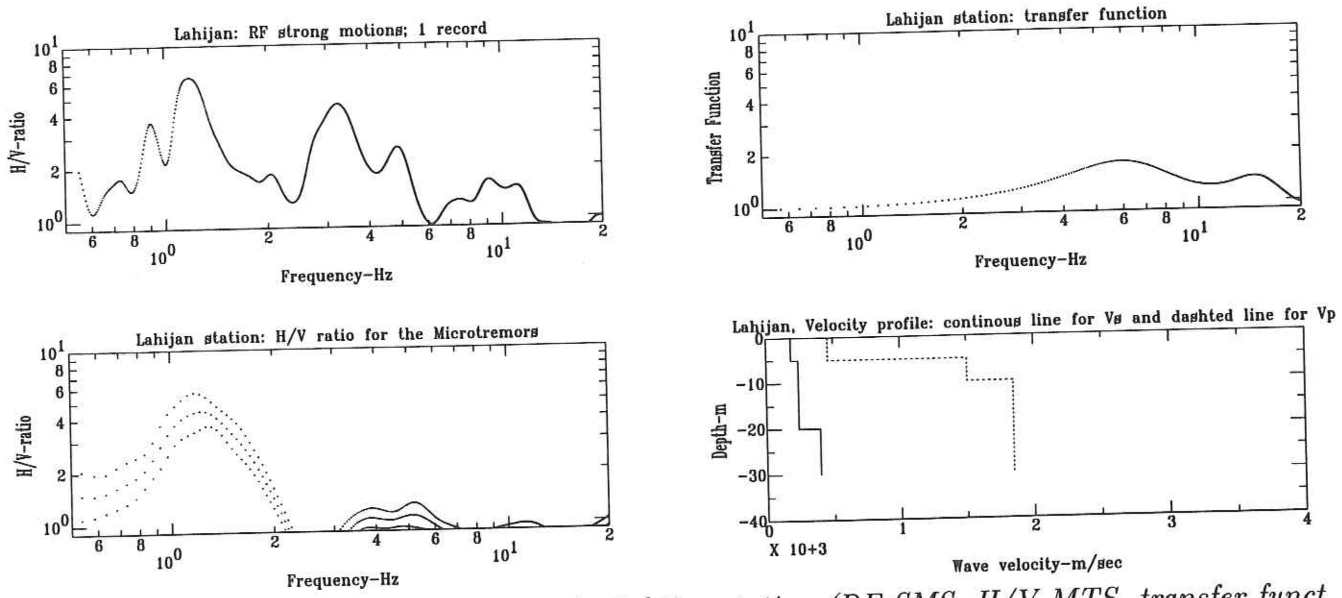

FIG. 3.7 – *The results of the site tests in Lahijan station (RF SMS, H/V MTS, transfer funct ion and velocity profile).*

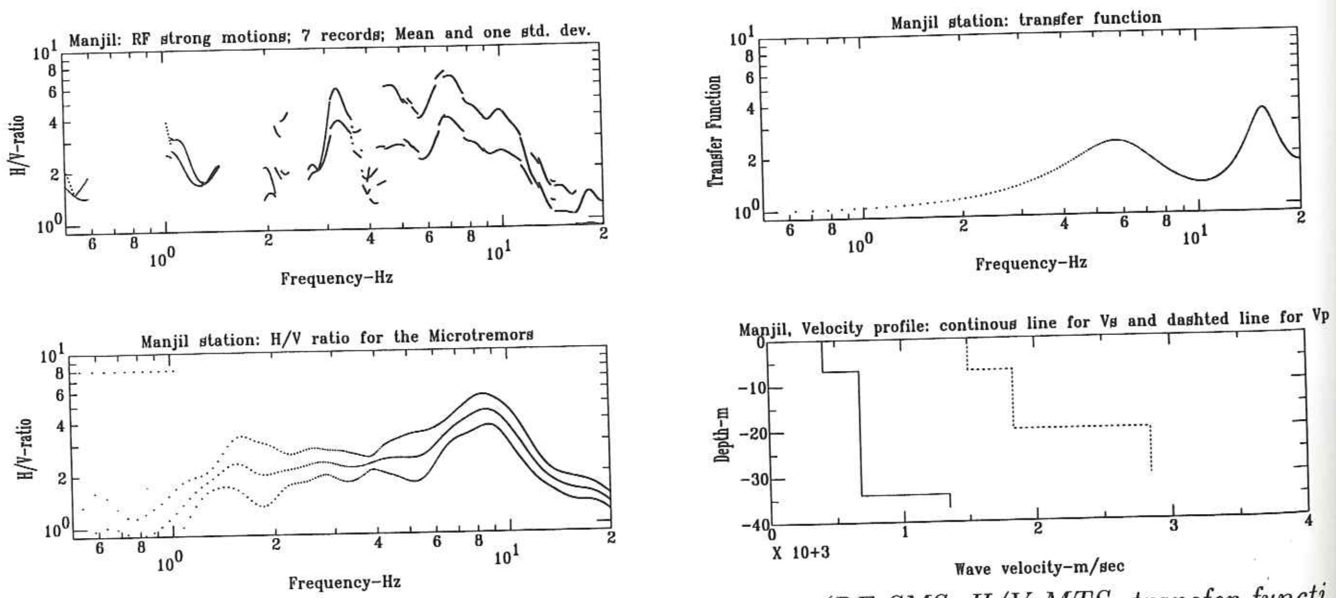

FIG. 3.8 – *The results of the site tests in Manjil station (RF SMS, H/V MTS, transfer functi on and velocity profile).*

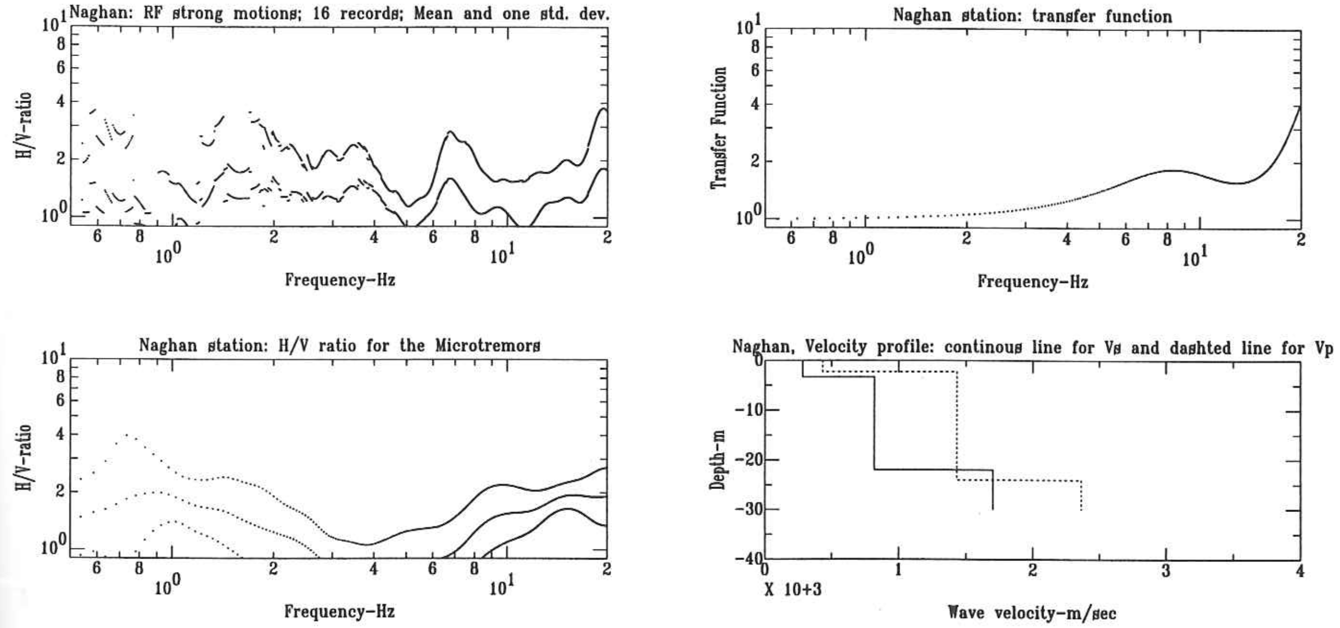

FIG. 3.9 – *The results of the site tests in Naghan station (RF SMS, H/V MTS, transfer functi on and velocity profile).*

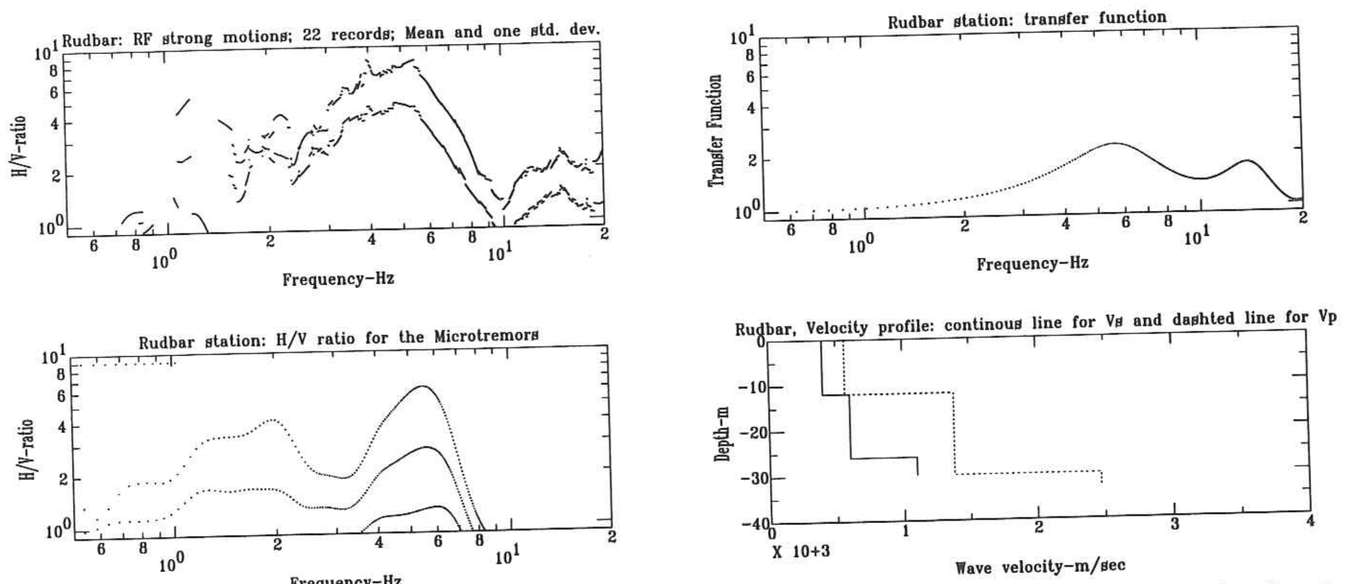

FIG. 3.10 – *The results of the site tests in Rudbar station (RF SMS, H/V MTS, transfer funct ion and velocity profile).*

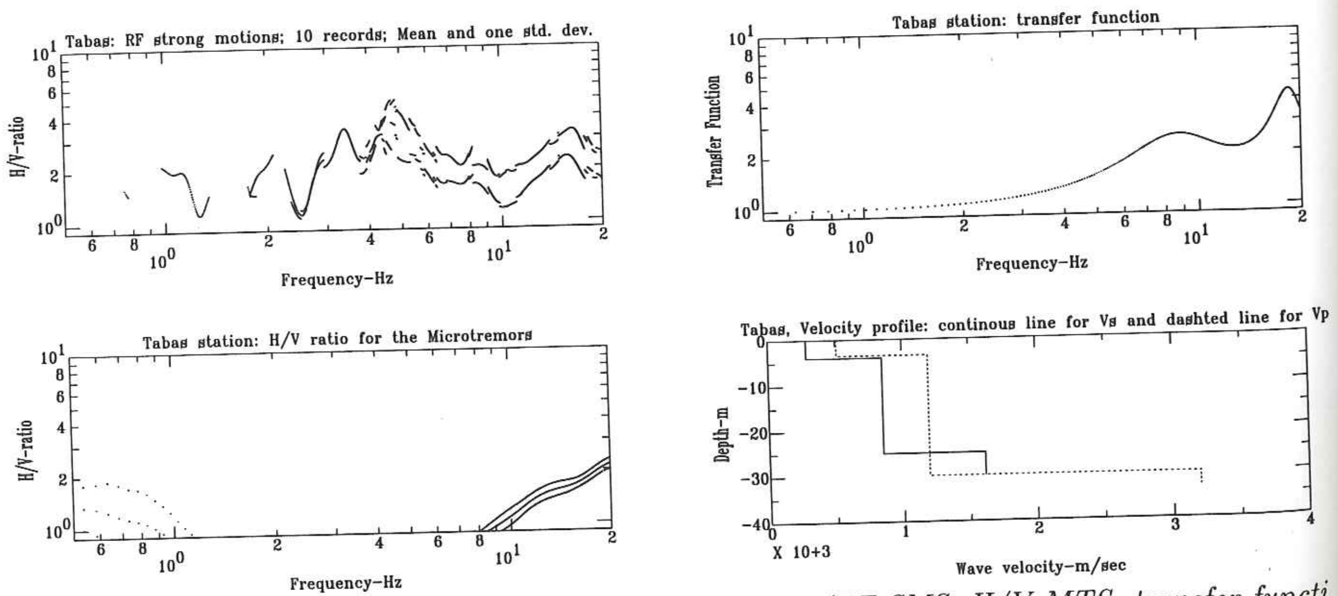

FIG. 3.11 – *The results of the site tests in Tabas station (RF SMS, H/V MTS, transfer functi on and velocity profile).*

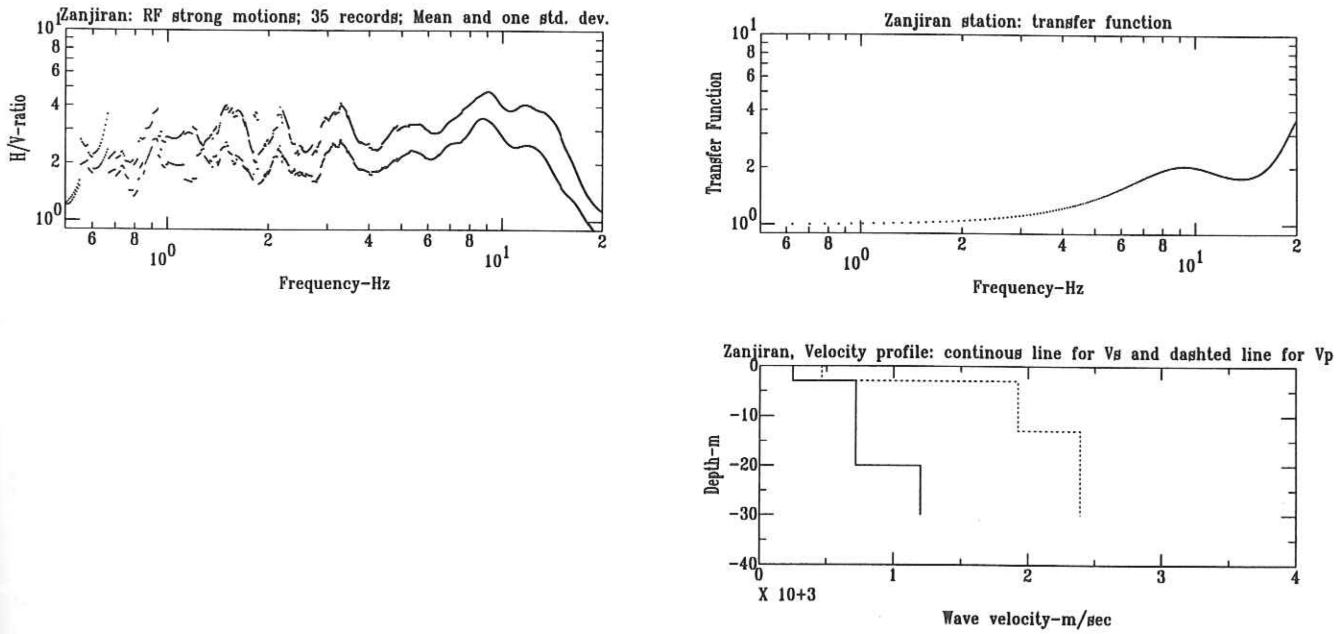

FIG. 3.12 – *The results of the site tests in Zanjiran station (RF SMS, transfer function and velocity profile).*

3.4.2 Sites without agreement: failure of the microtremor technique

Based on the present studies, the results of the microtremor test appear to be reliable just for sites exhibiting significant amplifications at low and/or intermediate frequencies (less than 5 Hz) caused by a low velocity superficial layer. In some of the sites the thick alluvium deposits cause the amplifications in low and middle frequencies (less than 5Hz) on RF SMS, which the H/V MTS did not exhibited the same peaks, for instance in Ghazvin (Figure 3.13). In Rudsar (Figure 3.14) the velocity the transfer function has not shown the peaks in low frequencies (evident on RF SMS). In the soft soil sites, it seems that a high contrast in the superficial layers is needed to cause the evident amplifications in H/V MTS. For example in Golbaf (Figure 3.15) which shows a low average velocity in the first 30 meters (439m/s) the amplifications on the RF SMS may not be seen on the same spectra for the microtremors. A high contrast in about 40 metres depth, with a Vs velocity of about 1500 to 200 m/s is might be sufficient to explain this low frequency amplification in RF SMS in this site.

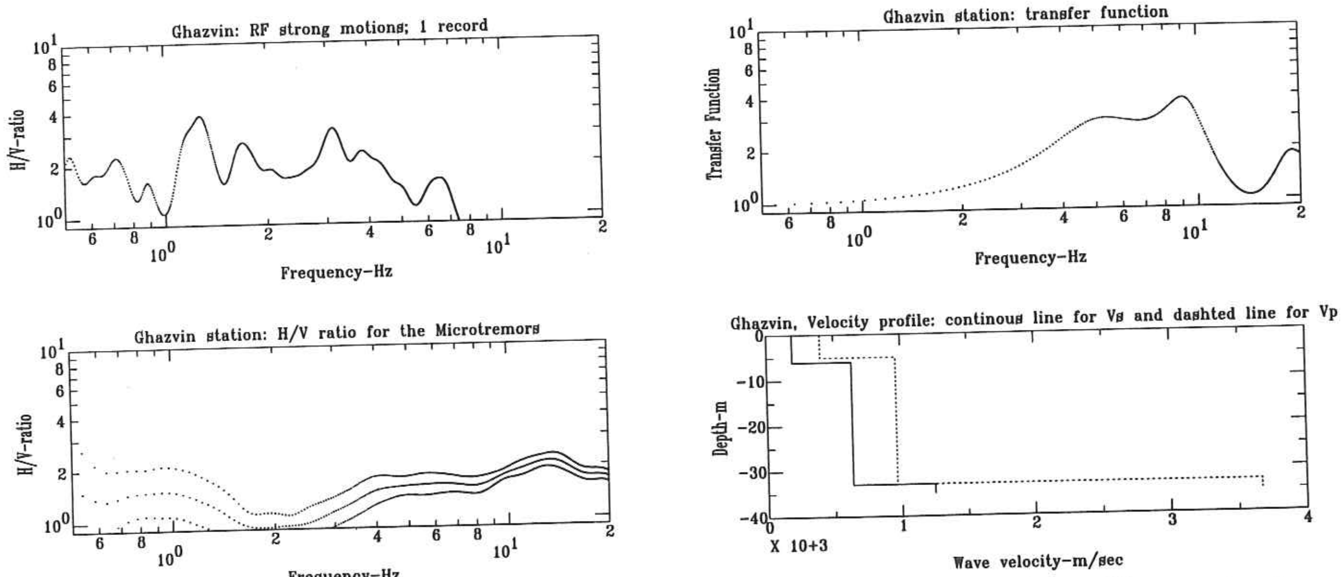

FIG. 3.13 – *The results of the site tests in Ghazvin station (RF SMS, H/V MTS, transfer function and velocity profile).*

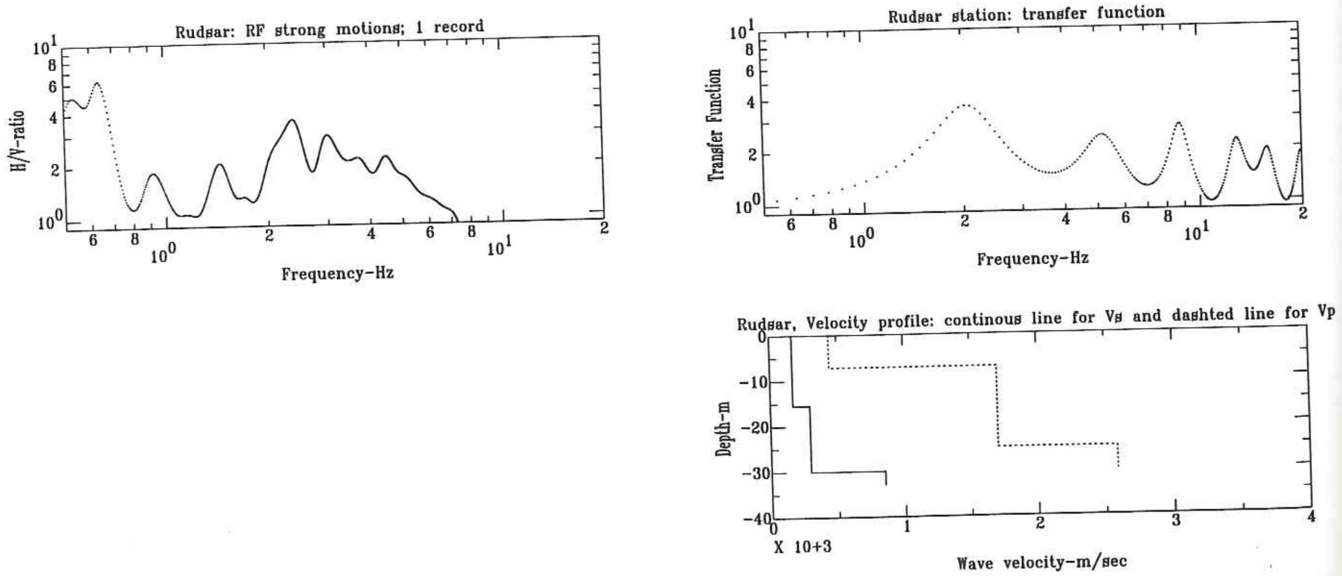

FIG. 3.14 – *The results of the site tests in Rudsar station (RF SMS, transfer function and velocity profile).*

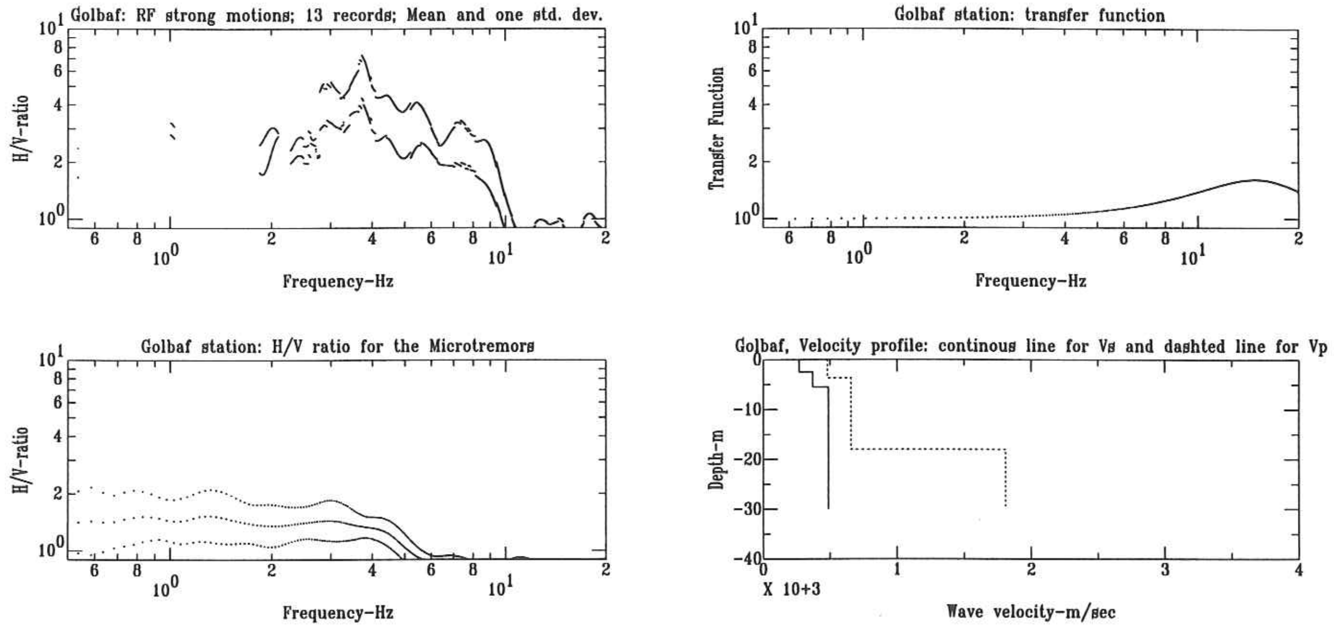

FIG. 3.15 – *The results of the site tests in Golbaf station (RF SMS, H/V MTS, transfer function and velocity profile).*

There are cases for which there were not each result, however it was possible to compare the amplifications, which may be measured through the H/V MTS and RF SMS. The similarities between H/V ratios for noise and strong motions are observed for instance in Bajestan (Figure 3.16), Sedeh Figure 3.17), and Shiraz (Figure 3.18). These sites show total accordance between the RF SMS and H/V MTS.

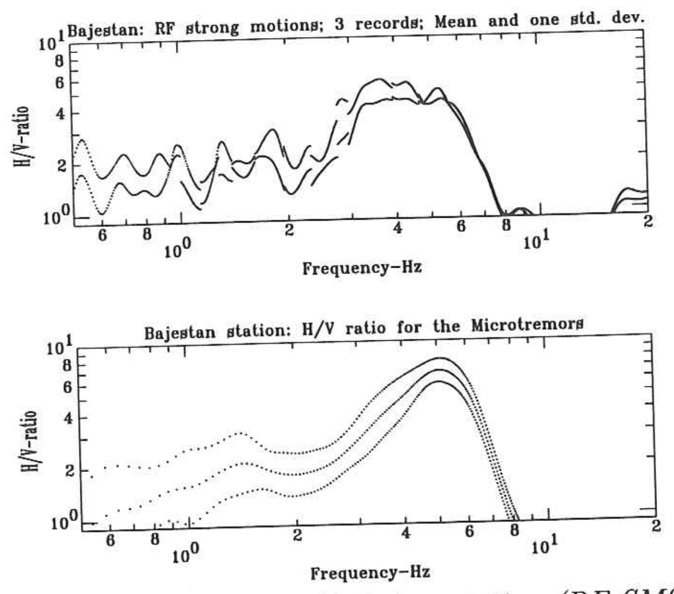

FIG. 3.16 – *The H/V ratio results in Bajestan station (RF SMS, H/V MTS).*

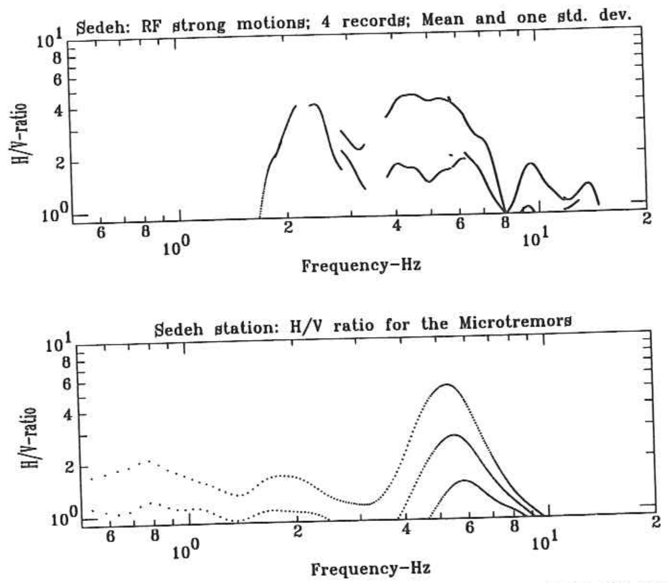

FIG. 3.17 – *The H/V ratio results in Sedeh station (RF SMS, H/V MTS).*

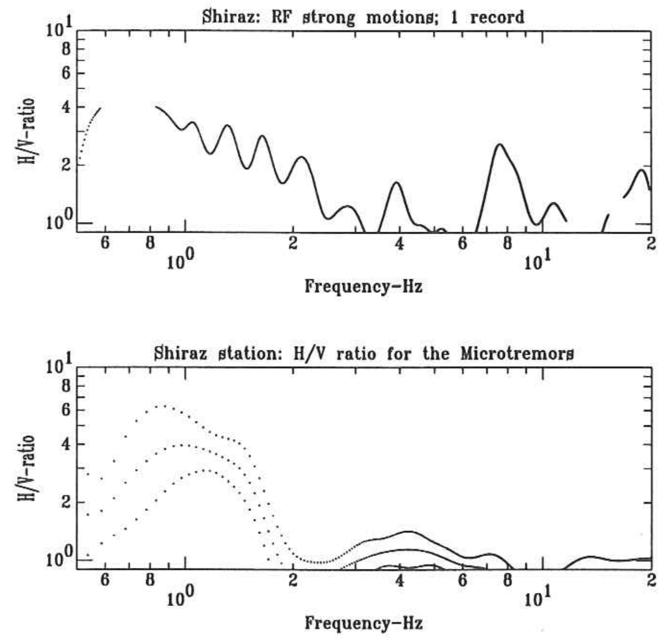

FIG. 3.18 – *The H/V ratio results in Shiraz station (RF SMS, H/V MTS).*

3.4.3 A preliminary conclusion on the results of the different methods

Among the methods that are used to study the site conditions, the only method that may reveal the site response to ground motions is to study the three component strong motion records (RF SMS). The benefit gained from this method is that we had at least one record in each of the stations and this is the only method that may be applied at each location. On the other hand, the RF SMS is a method that does not have the limitations of the other methods. The velocity profiles measured by the geoseismic methods are limited to the first 30-35 metres; the microtremors have shown the important amplifications just in the soft soil sites, and the geoelectric tests do not give the precise measurements to distinguish the different sites. The study on the amplifications based on the 3 component records has another benefit. In the sites where there are thick alluvial layers on the surface (with a thickness of more than 30 metres) on a very high velocity layer at greater depths, the RF SMS is the only way to observe such amplification in low frequencies. In this case the other methods will show just the high velocity alluvium with some amplifications in high to very high frequencies (more than 15Hz).

In addition, the RF SMS is a very stable method (Figure 3.15)

3.5 A Site Categorization

The relatively good relationship between the S-wave velocity profiles and the RF results allowed us to propose a multi-class site categorization based on the RF curves. This classification is simply based on the amplitude and level of the highest peak on the RF curve:

* site category #1 corresponds to flat RF curves (i.e., peak amplitude below 3-4), or those presenting a peak with an amplitude larger than 3-4 at frequencies beyond 15 Hz

* site category #2 corresponds to RF curves presenting a peak with an amplitude larger than 3-4 at frequencies between 5 and 15 Hz

* site category #3 corresponds to RF curves presenting a peak with an amplitude larger than 3-4 at frequencies between 2 and 5 Hz

* site category #4 corresponds to RF curves presenting a peak with an amplitude larger than 3-4 at frequencies below 2 Hz

According to these criteria, the 26 studied sites are classified and presented later (see 4.1). The RF curves for these sites of each class are depicted in Figure 3.19.

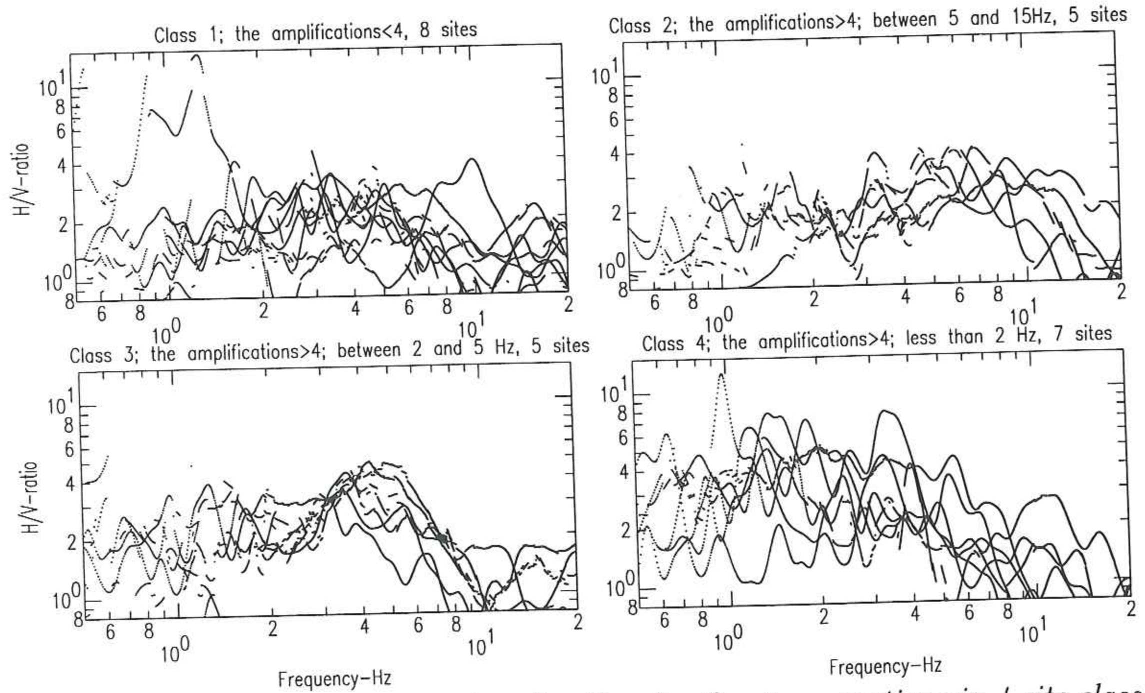

FIG. 3.19 – *The comparison of the receiver function for the strong motions in 4 site classes.(the results of 26 sites with the most records).*

On the other hand, there are the cases where the RF amplitude is not equal 4 (as it is defined above), but passes 3. In these cases it is tried to observe the results of other tests (if available) to distinguish the site conditions. In such intermediate cases, we have used the Vs and Vp profiles and the microtremor results to decide on the case. However if the peaks did not approach 3 at all, that site is classified as rock site (class 1).

The measured velocity profiles corresponding to each of these classes are grouped in Figure 3.20. The main characteristic of category 1 is that the S-wave exceeds 700 m/s at depths beyond 5 m, although the values may be much lower at very shallow depths (thin layers with resonance frequencies exceeding 15 Hz). On the opposite, the velocity profiles in category 4 exhibit low velocities at surface (below 250 m/s) and at depth (below 500 m/s down to 30 m) except for three "exceptional" sites for which there was a clear discrepancy between velocity profile and RF curve, that we checked several times and could not interpret. Velocity profiles for categories 2 and 3 are intermediate.

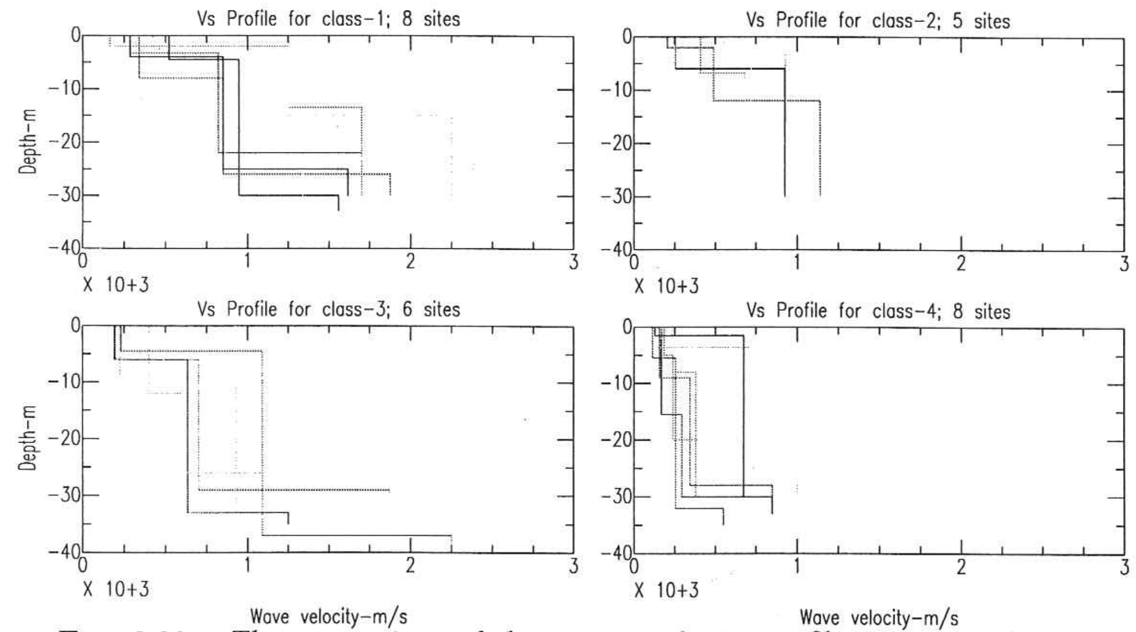

FIG. 3.20 – *The comparison of shear wave velocity profiles in 4 site classes.*

The microtremor H/V spectra corresponding to each of these 4 categories are displayed in Figure 3.21. It clearly shows that, to the contrary of many published studies, microtremors could not, in our case, point out the fundamental frequency; this negative result may perhaps be related to the absence of strong impedance contrasts in velocity profiles, except for some class-4 sites. In any case, it requires further work, and probably new measurements, before it can be understood.

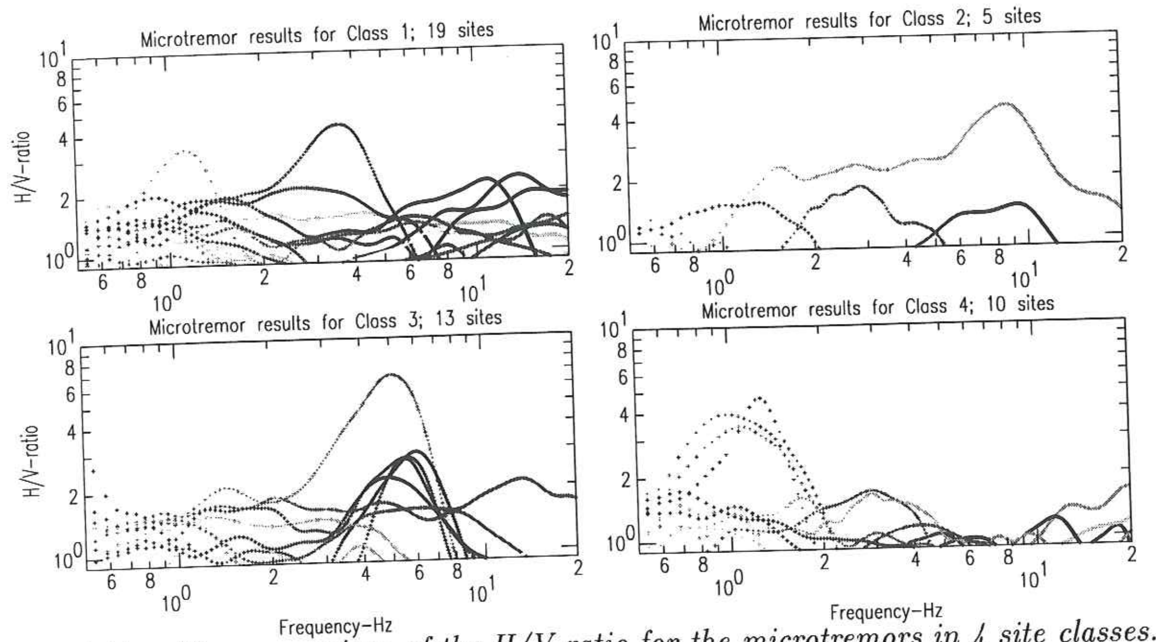

FIG. 3.21 – *The comparison of the H/V ratio for the microtremors in 4 site classes.*

3.5.1 The Average of Vs for upper 30 meters

The average value of shear wave velocity over the topmost 30 metres has been proposed as a criterion to distinguish the site characteristics in response to the ground motions (Boore et al. 1993, Boore et al 1997, NEHRP 1994). Such a criterion has certainly some drawbacks, since it does not take into account the velocity profile at greater depths, which may have a prominent influence on the low frequency response. However, since there was not any other information for the Iranian sites, the relationship between our site categorization and these average velocities Vs_{30} are tested. This average shear wave velocity Vs_{30} is defined as:

$$\frac{30}{Vs_{30}} = \frac{h_1}{Vs_1} + \frac{h2}{Vs_2} + ... + \frac{h_n}{Vs_n} \quad (3.4)$$

with:

$$h_1 + h_2 + h_3 + ... + h_n = 30m \quad (3.5)$$

The corresponding values for our 26 sites are listed in Table II, and the distribution of Vs_{30} for different site classes is shown in Figure 3.22. Although the values at depth are much less reliable than at the near surface, we are rather confident in our estimate of Vs_{30} since the "deep" values have only a limited influence in the result. Table II thus points out a rather clear correlation between Vs_30 and our definition for the site classes 1 to 4, based on RF SMS: our criteria on RF SMS may therefore be almost equivalently replaced by the criteria on Vs_{30} , as indicated in Table III: the correspondence turns out to be valid for 20 out of our 26 studied sites (i.e., 77% of the cases).

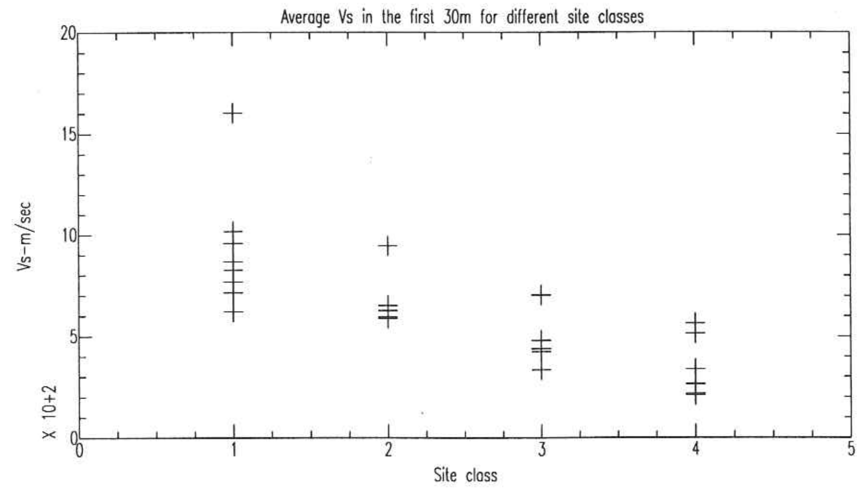

FIG. 3.22 – *The distribution of Vs_{30} for four site classes.*

Table II: Average velocities for each site, in each category

No	Site	class	Vs_{30}	No	Site	class	Vs_{30}
1	Abbar	1	621	14	Fin	3	480
2	Deyhuk	1	826	15	Firouzabad	3	478
3	Ghaen	1	867	16	Ghazvin	3	424
4	Jovakan	1	1017	17	Golbaf	3	439
5	Kakhk	1	1602	18	Rudbar	3	334
6	Naghan	1	768	19	Zarrat	3	704
7	Saadabad	1	958	20	Abhar	4	263
8	Tabas	1	715	21	Hosseinieh	4	563
9	Kavar	2	946	22	Lahijan	4	264
10	Maku	2	652	23	Rudsar	4	215
11	Manjil	2	589	24	Shabankareh	4	337
12	Vendik	2	597	25	Talesh	4	514
13	Zanjiran	2	627	26	Tonkabon	4	209

Table III: The 4 class site categorization

Group	Frequency Band of the Amplification	Vs_{30} m/s	Sites
1	$F >= 15Hz$	$Vs_{30} >= 700$	Abbar, Deyhuk, Ghaen, Jovakan, Kakhk, Naghan, Saadabad, Tabas
2	$5 =< F < 15Hz$	$500 =< Vs_{30} < 700$	Kavar, Maku, Manjil,Vendik, Zanjiran
3	$2 =< F < 5Hz$	$300 =< Vs_{30} < 500$	Fin, Firouzabad, Ghazvin,Golbaf, Rudbar, Zarrat
4	$F < 2Hz$	$Vs_{30} < 300$	Abhar, Lahijan, Hosseinieh, Rudsar, Shabankareh,Tonkabon,Talesh

3.5.2 Discrepancies from the defined criteria

There exist some cases where peaks on RF SMS appear in a frequency band that is not consistent with Vs_{30}. The most important reasons for these discrepancies may be considered in different ways. The source effects may in some cases affect the H/V ratio [for instance, when a station was very close to the earthquake source (such as in Tabas)]. In some other cases one may think that a high velocity layer may be found at depths greater than 30 meters, which could not be imaged by geoseismic methods (i.e. for an average surface velocity of 500 m/s there may exist significant amplifications at low frequencies ($f < 1Hz$) if the corresponding thickness exceeds 125 m).

In the Hosseinieh-Olia station the peaks on RF SMS were observed in the frequency band of less than 2Hz but the Vs_{30} is more than 500m/s (563m/s) (Figure 3.23). The low frequency high amplifications on RF SMS (which may be seen on RF MTS as well) in Talesh (Figure 3.24) and $Vs_{30} = 508m/s$ is also inconsistent with the limits observed for most of the other sites. The most important reasons for these discrepancies may be considered in different ways. The source effects may be more effective than site effects, where the station was very close to the earthquake; the Saadabad records which are obtained in the epicentral distances of 8-16 km (Zaré et al 1998) shows low frequency amplifications which may be associated with directivity effects or near field pulses. The high contrast of a superficial low velocity layer with a very higher velocity sub-layer may cause the lower average value of Vs_{30} in Hosseinieh. There is a superficial layer with $Vs = 130m/s$ and a thickness of 1.5m situated adjacent to a hard sub-layer with $Vs = 672m/s$. In Talesh a high velocity layer might be found at great depth of more than 30 (for a velocity of 730 m/s it might be expected a depth of about 100m to have the amplification of 0.8 to 1Hz). The same situation may be expected for Ghazvin which shows the lower amplifications in 1-2 Hz. If this situation is to be justified with the site effects, a high contrast in a depth of more than 100m is needed.

3.5.3 Application to all Iranian strong motion data

The RF SMS method is performed to determine the site conditions for all of the Iranian strong motion data. The result of this application for 138 site (comprising the studied sites) is shown in Table-1. This criterion is applied to categorize the Iranian sites for which strong motion records are available with satisfactory quality. The final statistics corresponding to the 138 sites is as follows: 51 sites are in class 1 (37%), 22 sites in class 2 (16%), 39 sites in class 3 (29%), and 25 sites in class 4 (18%) (Figures 3.22 and 3.26).

3.5.4 Quality factor for the site determination

To determine the quality of the information that is developed in this study we have used a quality factor in 4 steps ordered from the best to the worst quality: A to D. If there existed all of the data for a site; the "A" quality was assigned. The order is subdivided to A1 for the coordination between the different results, and A2 for the cases when the H/V MTS or the Vs_{30} contradicted the RF SMS. Otherwise, when there were not the velocity profiles but there

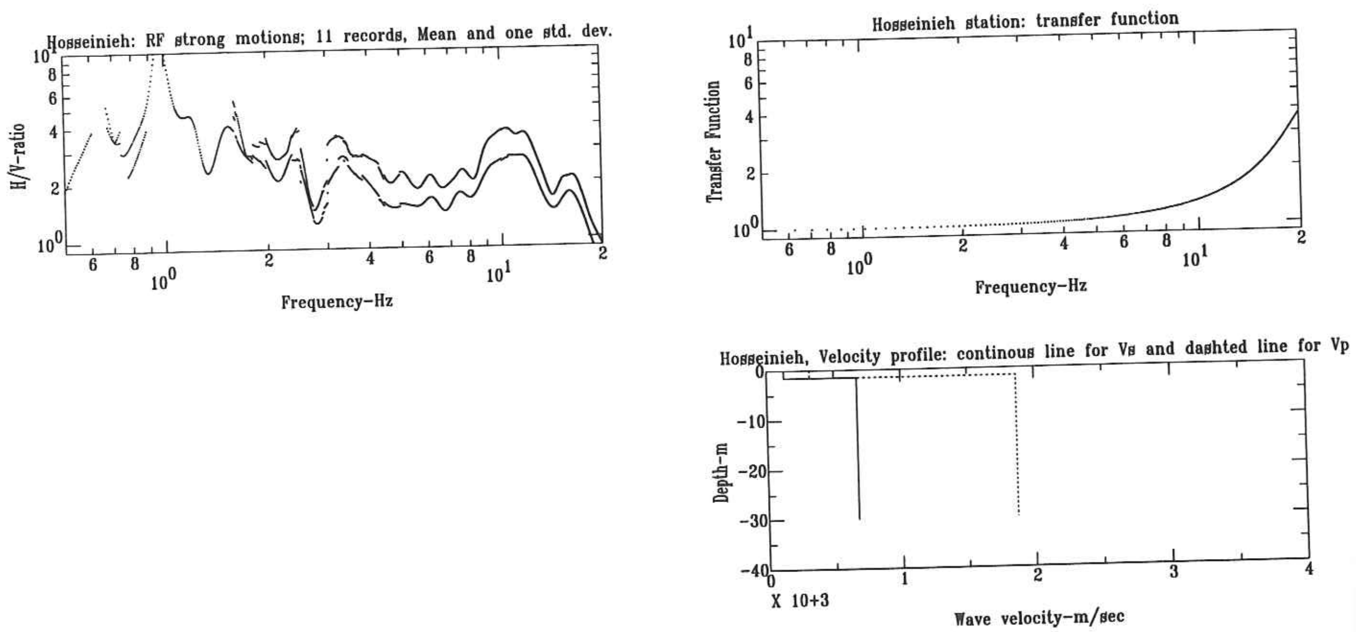

FIG. 3.23 – *The results of the site tests in Hosseinieh-Olia station (RF SMS, transfer function and velocity profile).*

were all of the other results (H/V MTS and RF SMS) then the "B" quality is marked. If there was just the RF SMS, the "C" is assigned, and in the worst case (when the quality of the record and consequently the quality of the RF SMS was not reliable) "D" is used. These assignments are shown in Table-I.

3.6 Conclusions

We conclude that the 26 sites considered in this study may be grouped in four classes: class 1 corresponds to an average velocity Vs_{30} larger than 700 m/s, and no site amplification below 15 Hz; class 2 corresponds to an average velocity Vs_{30} between 500 and 700 m/s, and an RF curve exceeding 3-4 between 5 and 15 Hz; class 3 corresponds to an average velocity Vs_30 between 300 and 500 m/s, and a RF curve exceeding 3-4 between 2 and 5 Hz; finally class 4 corresponds to soft sites with an average velocity Vs30 below 300 m/s, and an RF curve exceeding 3-4 below 2Hz .

This new record based classification may be compared to the previous 4 class classification

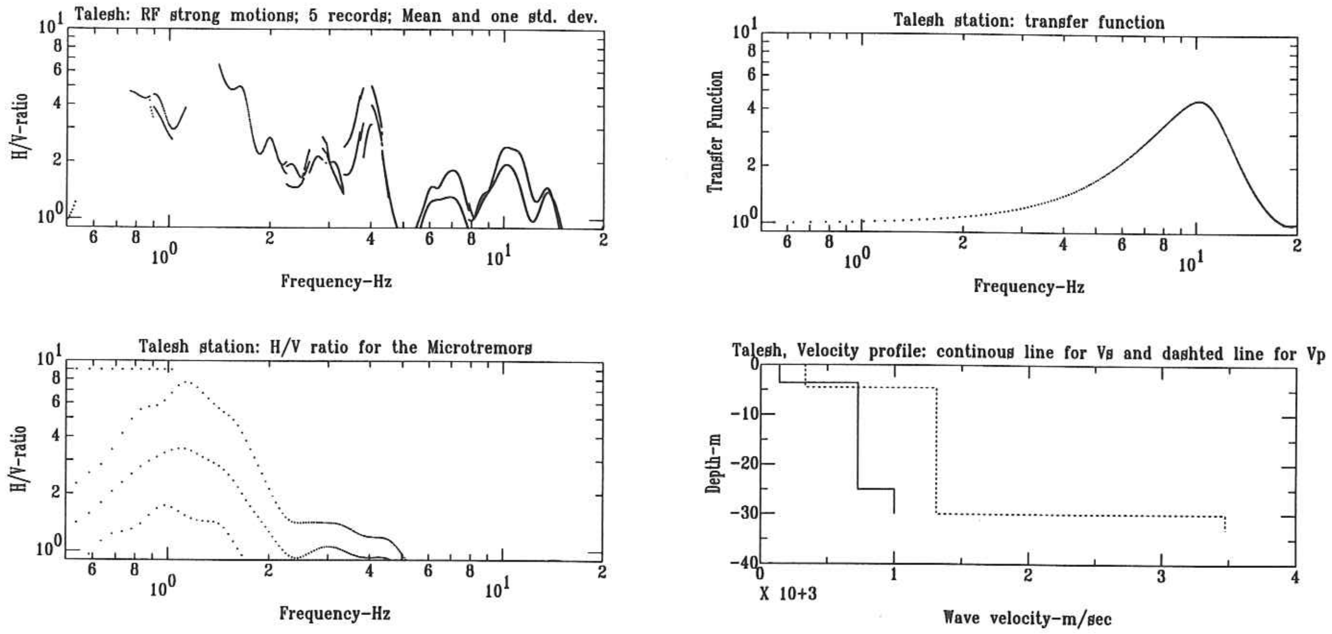

FIG. 3.24 – *The results of the site tests in Talesh station (RF SMS, H/V MTS, transfer function and velocity profile).*

performed by BHRC (1993) on a pure geological basis: it shows that pure surface geological observations are very poor in assessing the real response of the sites to strong motions. In our study, only in just 22 cases (over the 138 sites; i.e. 16%) the surface geological observations agree with the detailed sites studies (table III, Figure 3.27). In this figure it is shown that the determination of the sites classes based on the surface observation may result in very biased conclusions, such that each site classes may be mistaken for another one.

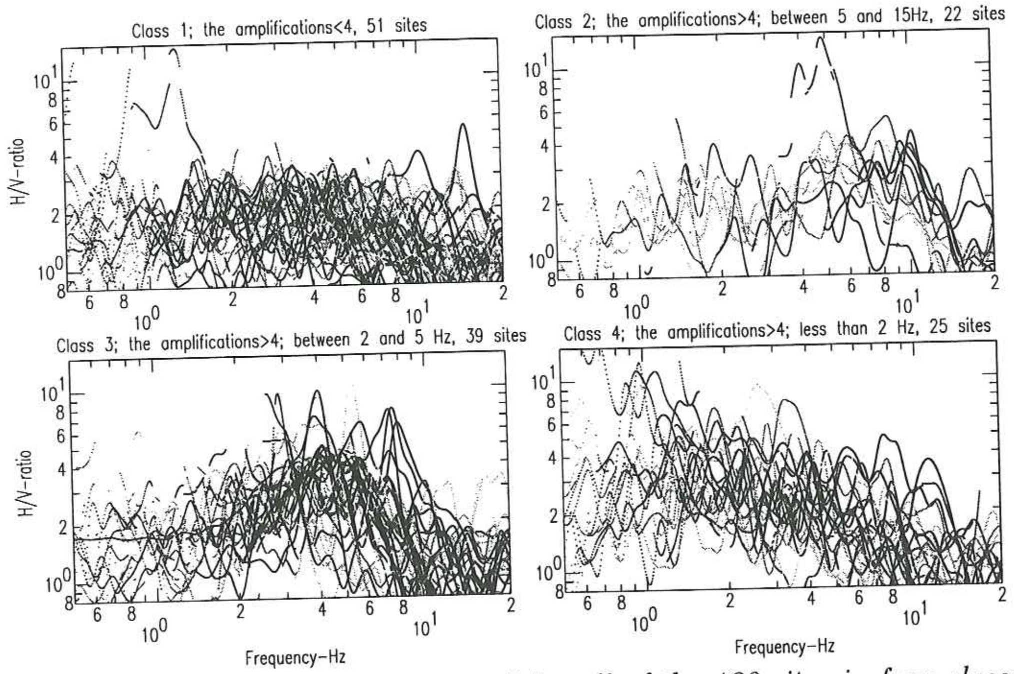

FIG. 3.25 – *The results of the RF SMS for all of the 138 sites in four classes.*

We insist that the RF SMS method seemed stable for a lot of the studied sites, therefore we have applied this method for the first time as our essential criteria to classify the site responses. Meanwhile the microtremors studies were not consistent with the strong motion results in our studies in Iran, which might be justified with the dry-arid climate mountainous conditions in most part of Iran; in any case the further microtremor tests should be performed. Similar studies might also be conducted in the neighboring countries of Iran; such as Turkey, Pakistan, Afghanistan Iraq, Caucasus and central Asian republics to develop and extrapolate the hazard mitigation results for this seismogenic region. In Iran, future developments of the strong motion network should favor the installation of instruments pairs; one on rock outcrop and another on nearby soil. This will provide the possibility to compare the H/V results with classical site to reference ratio. Other developments may be proposed in the form of "local arrays" for site studies in regions with high seismicity rate, and an important industrial and urban situation. We propose the first array of these series around the important city of Shiraz in southern Iran, where there is a high seismic activity, while a great part of the east of this city is located on soft soils and the underground water level is very high. Another local array with first priority of importance may be proposed for the city of Rasht on the shorelines of the Caspian sea in

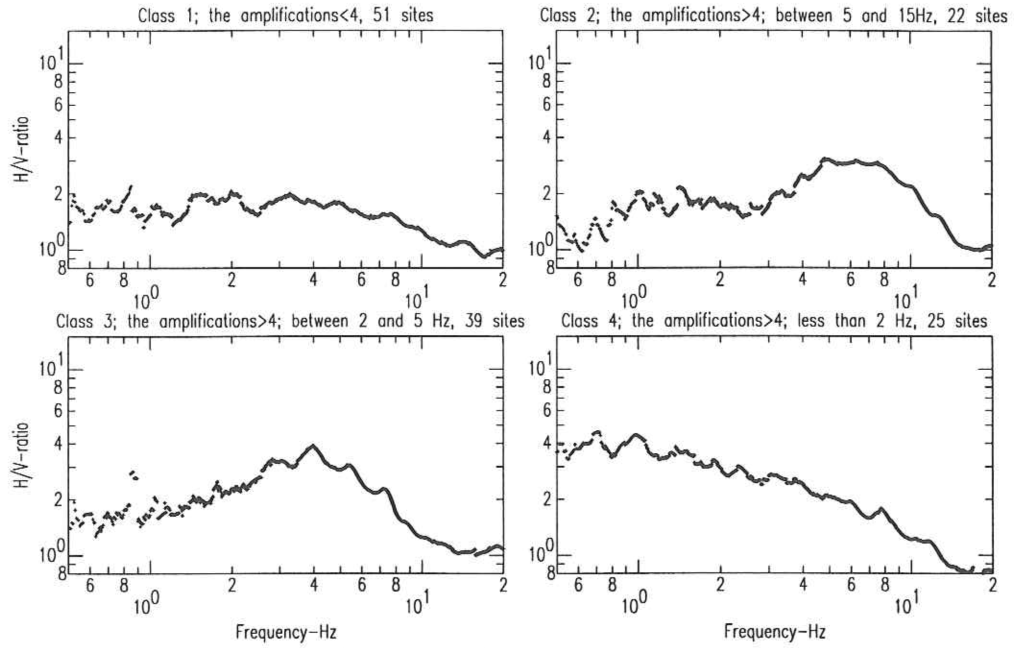

FIG. 3.26 – *Average spectra for 4 site classes (using the RF SMS of all 138 sites).*

northern Iran (near the epicenter of the Manjil earthquake of 1990; Mw7.3).

Acknowledgement

In this study many individuals have assisted us; most notably Messrs. Shirazian, Azadmanesh, Akbari and Mohseni (in IIEES) who assisted this project in the field studies, and Mirzaei-Alavijeh, Mahmoudi and Jalali in BHRC (Building and Housing Research Center, Tehran) who have completed the geoelectric tests. The financial support in Iran was provided by IIEES, and in France (for the first author) was provided by a French scholarship (Ministère Français des Affaires Etrangères), which are both duly acknowledged. The first author wants to thank F. Zoueshtiagh who has given some suggestions for article layout. Our thanks also go to Douglas McLean who has proof-read this text and has given comments to correct the orthography.

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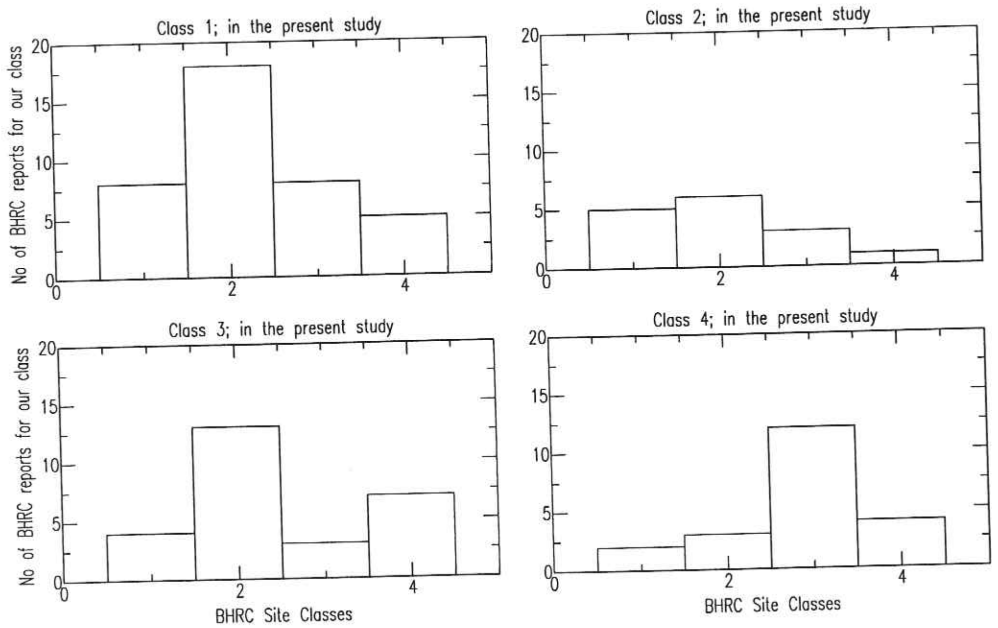

FIG. 3.27 – *The comparison of the site classification in this study and that of BHRC (1993); The BHRC site classes are compared to each of the four classes defined in the present st recor*

Chapitre 4

Études particulières: la source sismique et Kappa

Résumé Les enregistrements accélérométriques ont permis l'étude du moment sismique en Iran. Les fréquences-coins des spectres de Fourier et les plateaux des spectres sont mesurés pour un ensemble de 468 enregistrements (de 360 événements), même si les paramètres des sources étaient a priori connus (enregistrements télésismiques) pour seulement 190 événements. D'autres paramètres de la source sismique comme la fréquence maximale (f_{max}), et la chute de contrainte sont calculés et discutés aussi dans ce chapitre. Le moment sismique est utilisé pour déterminer la magnitude de moment, utilisé dans la suite des études sur les mouvements forts. Les valeurs de M_w sont proches de Ms pour les magnitudes supérieures à 6.0, et de mb, pour les magnitudes inférieures à 6.0. Les ML rapportés par les centres sismologiques iraniens sont plus dispersés mais sont cependant en accord avec les M_w, surtout pour les magnitudes inférieures à 6.0 .

La chute de contrainte pour les séismes en Iran est représentative des régions intra-plaque. Ces valeurs sont entre 30 et 500 bars pour la plupart des séismes. D'autre part l'étude de la dépendance de f_{max} en fonction de la distance et la magnitude, montre une sensibilité presque similaire avec la magnitude et la distance, avec cependant un coefficient de corrélation sont un peu plus elevé pour la dépendance avec la magnitude. La dépendance des fréquences-coins en fonction de la magnitude et la distance est aussi étudiée, et on trouve une très bonne correlation/négative avec la magnitude.

4.1 Seismic Moment and Stress Drop for the Strong Motion Accelerograms in Iran

Mehdi Zaré , Pierre-Yves Bard and Mohsen Ghafory-Ashtiany

Article en préparation

Abstract The moment magnitude (M_w) for the events recorded by the Iranian strong motion network is derived from the corner frequencies and spectral levels measured in the Fourier spectra of the corrected accelerograms. The calculation is done over a data-set of 468 three components time-histories (from 379 events), out of which the teleseismic source data were available for only 190 events. The hypocentral distances are also estimated based on the difference in the arrival times of compressional and shear waves. The comparison of the calculated moment magnitude and the reported teleseismic Ms, mb and Mw, and local ML values indicates that the calculated Mw's are consistent with the teleseismic Mw's; a good approximation is $Mw = Ms$

for the magnitudes over 6, and $Mw = mb$ for magnitudes below 6. The ML values inferred by local seismological networks in Iran (corresponding to magnitudes below 6) exhibit a larger scatter with, however, an average satisfactory agreement. The magnitudes for moderate events (mostly in southern Iran, Zagros region, for which no report existed on their source) are thus estimated by this method. In addition, the estimated stress drops for this data-set (between 30 and 500 bar) correspond better to intra-plate earthquake.

4.1.1 Introduction

The purpose of this study is to determine the magnitude of the earthquakes recorded in the Iranian network, for which no teleseismic or local information exists on their localisation and magnitude. The moment magnitude is thus derived from the Iranian strong motion data (corresponding to earthquakes occurred between 1975 and February 1997). The strong motion data in this study were recorded by two types of instruments: the analog SMA-1 instruments have been installed in Iran since 1975, but have been steadily replaced by the digital SSA-2 instruments after the Manjil earthquake of 1990 (M_w7.3). Some 468 three component accelerograms, out of 750 uncorrected records, are selected and filtered. The investigated data set comprises 169 analog and 299 digital records: out of which the source parameters were available only for 279 records (169 analog and 110 digital; Bard et al 1998). Since it was essential to use as much data as possible to establish the attenuation laws for Iran, and the application of a uniform magnitude scale was necessary, the moment magnitudes are calculated.

The earthquake magnitudes in Iran are reported by the international bodies for larger events (PDE monthly reports and ISC bulletins), as well as the local seismologic centers (Institute of Geophysics, Tehran University, IGTU).

In this paper, after a brief outline of method used to calculate the seismic moment, it is applied to the Iranian records for which no teleseismic source data could be found, and the results are presented in a Table (Appendix 4.1). The correlation of the estimated M_w with the other magnitude scales is indicated. Then, the causes for discrepancies from the ideal model are described. The stress drop estimations are presented as well.

4.1.2 Methodology of the Study: the $\omega^{-\gamma}$ model

Haskell (1964) has already proposed a simple source model for the estimation of high frequency ground motions. The simple seismic source models are explained by Aki (1967), and Brune (1970; 1971). In this model, the far field displacement spectrum is characterized by a flat level Ω proportional to Mo at long periods, a corner frequency f_c proportional to inverse of the source dimension, and a high frequency spectral decay in the form $(\frac{f}{f_c})^{-\gamma}$. Taking the γ values as 2 or 3, we have the ω-square or ω-cube model, respectively (ω is the angular frequency in radians per second, equal to $2\pi f$). Hanks (1982) has shown that with a ω-square model, for which the acceleration spectra would be flat after the corner frequency, f_c, the high frequency decay may in the acceleration spectrum be explained by the attenuation along the wave path. As proposed by Hanks (1979), the displacement spectra may be represented by;

$\Omega = \frac{\overline{\Omega_0}}{1+(\frac{f}{f_c})^{\gamma}}$

where $\overline{\Omega_0}$ is the value of the low frequency flat part of the displacement spectrum. For far-field S-waves due to a double couple source embedded in an elastic, homogeneous, isotropic half-space, we have:

$\overline{\Omega_0} = \frac{1}{4\pi R_h} \cdot \frac{M_o}{\rho} \cdot \frac{1}{\beta^3} \cdot (R'_{\theta\phi}) \cdot F_s$

where β is the shear wave velocity of the medium, ρ its density; (around 2.8×10^3 kg/m3), R_h the hypocentral distance, $R'_{\theta\phi}$ the double couple radiation pattern for SH or SV waves (about 0.6 in average), F_s is the free surface amplification factor (to be taken equal to 2).

The value of the flat part of the acceleration spectrum, A_0, may be related to $\overline{\Omega_0}$ with

$A_0 = \overline{\Omega_0} \cdot {\omega_c}^2$

Hence, M_o could be written as

$$M_0 = (\frac{A_0}{(2\pi f_c)^2} \cdot \frac{4\pi R_h \cdot \rho \cdot \beta^3}{R'_{\theta\phi} \cdot F_s} \qquad (4.1)$$

In the following, β is taken equal to 3×10^3 m/sec, and $\rho = 2.8 \times 10^3$ kg/m3.

Kanamori (1977) has defined a new magnitude scale based on the seismic moment, that is more reliable measure of the size of the great earthquakes. This scale is defined as:

$$M_w = 0.667 \times \log M_o - 6.0 \qquad (4.2)$$

We used the formula 4.1 and 4.2 to calculate M_w for the events recorded in Iranian strong motion network.

The static stress drop is related to the moment magnitude and source radius (Kanamori and Anderson 1975). The source radius might be estimated using the Brune model (1970) by:

$$r_0 = \frac{2.34}{2\pi} \cdot \frac{\beta}{f_c} \qquad (4.3)$$

r_0 is the source radius in meter. For circular faults, the stress drop is related to r_0 with:

$$\Delta\sigma = \frac{7}{16} \cdot \frac{M_0}{{r_0}^3} \qquad (4.4)$$

where $\Delta\sigma$ is the stress drop, in Pascal ($1Pa = 10^{-5}$ bar).

4.1.3 The sources of Uncertainties

Some essential causes for uncertainties or errors may be classified as follows:

- The pre-event memory does not exist in analog data. Therefore, the determination of the first arrival of P waves, and then the hypocentral distances were difficult for such data in Iran. This difficulty does not exist, fortunately, for most of the digital records.

- The handy digitalization of the SMA-1 records made a lot of problems to pick a corner frequency the f_c and A_0.

- In digital records of moderate magnitude events $M < 4$, the spectral amplitudes are very low. Therefore, it was sometimes difficult to distinguish the signals from the noises coming from the sensor. The cases with high noise level are eliminated.

- In very high amplitude records of high earthquakes ($M > 7.0$ distances below 50km), the interferences of different waves make it impossible to identify P and S waves. Therefore, this method of calculation of M_w, is to be used with caution for such records. The fault distance should be obtained by other means (aftershock studies, for instance).

4.1.4 Results

To establish the Iranian strong motion catalogue, some 169 records were selected from a total of 430 three component analog accelerograms (Bard et al 1998a). The first arrival of the P waves was not always clear, therefore it was difficult to calculate the hypocentral distance, R_h using the difference of S and P arrivals;

$$R_h = 8 \times (t_s - t_p) \qquad (4.5)$$

The digital records, which are the main purpose of this article, present more suitable conditions; for 110 digital records the source parameters, were available from teleseismic studies (ISC, NEIC), while for 192 others there were not. A pre-event memory at the beginning of almost all of the SSA-2 records permitted the observation of t_p and t_s more easily. On the other hand, the satisfactory quality of digital records provides the opportunity for more precise measurement of the corner frequencies and the flat part of the acceleration spectra.

An example from a digital record

A digital (SSA-2) three component accelerogram that is obtained in Hosseinieh village (southern Iran; Figure 4.1) is shown in Figure 4.2. This record was obtained during an earthquake on 31 July 1994, with reported source parameters of Ms=5.3, mb=5.3, M_w =5.6, a focal depth of 43 km according to NEIC, and ML4.5 (IGTU). Regarding the epicenter coordinates for this event, the epicentral distance for the record would be found as 20 km, and the hypocentral distance at 45km. A closer zoom on the first 6 seconds of the record is indicated in Figure 4.3. The first arrivals for P and S waves, t_p and t_s, are estimated at 1.5 $\pm$ 0.3 and 4.7$\pm$0.3, respectively, therefore Rh equals 25.6km$\pm$ 5km. Taking to account highest peaks of the amplitude spectra, A_0 equals 0.35m/sec $\pm$0.15 (Figure 4.4), and f_c is measured at 1.2$\pm$0.3 Hz. The seismic moment is therefore, Mo = 3.9 $\times$ 10^{17} N-m. With 4.2, we have M_w=5.5 $\pm$ 0.3.

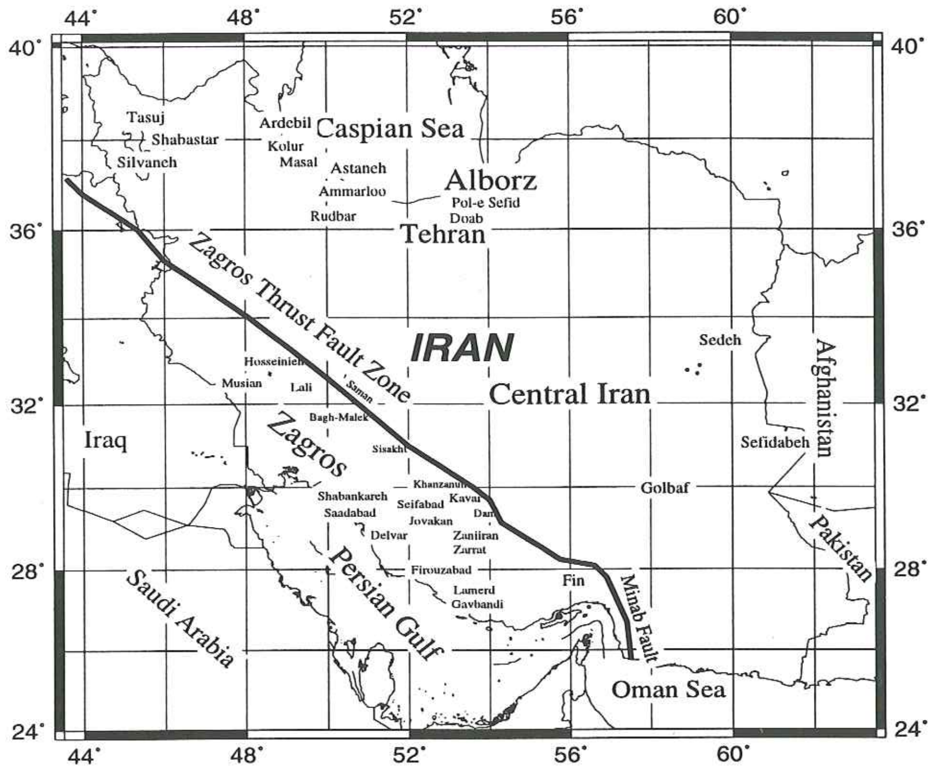

FIG. 4.1 – *The locations of the studied selected accelerometric sites in Iran in this paper.*

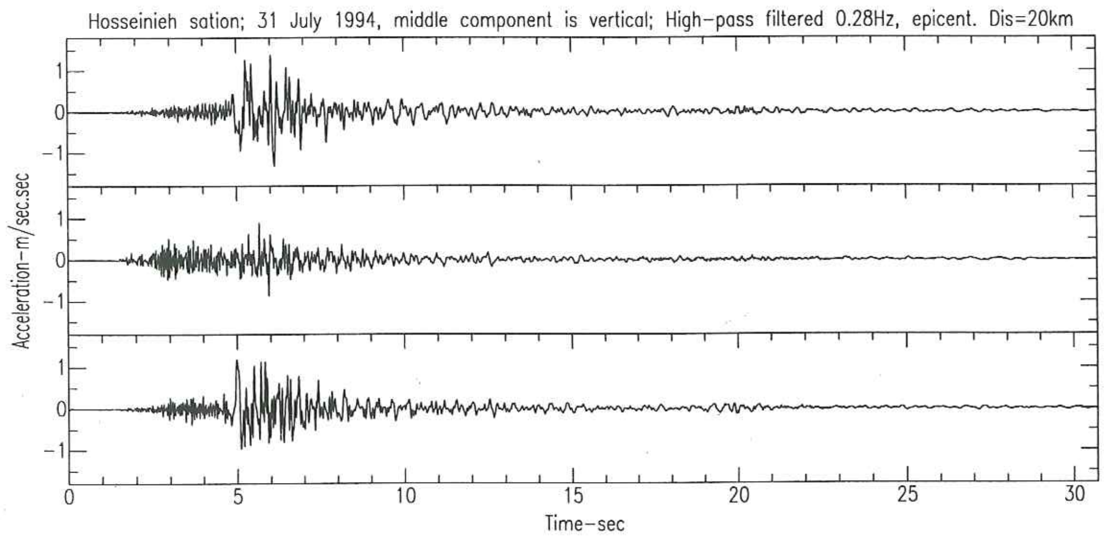

FIG. 4.2 – *Hossienieh record of the event of 31 July 1994.*

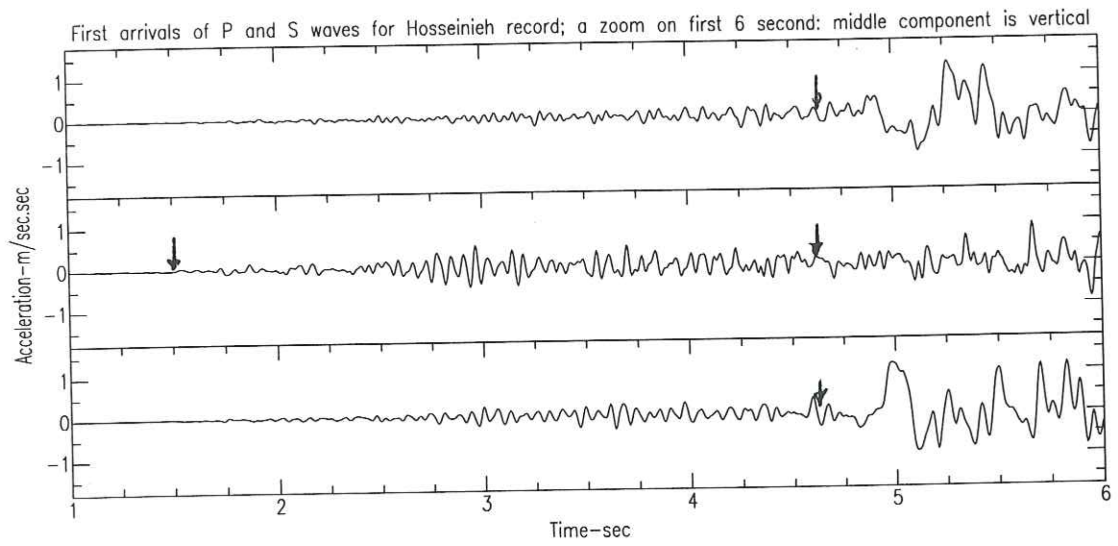

FIG. 4.3 – *A zoom on the first 6 seconds of the record in Fig.4.2; the first arrow at 1.5 seconds for tp and the second on at 4.7 seconds for ts.*

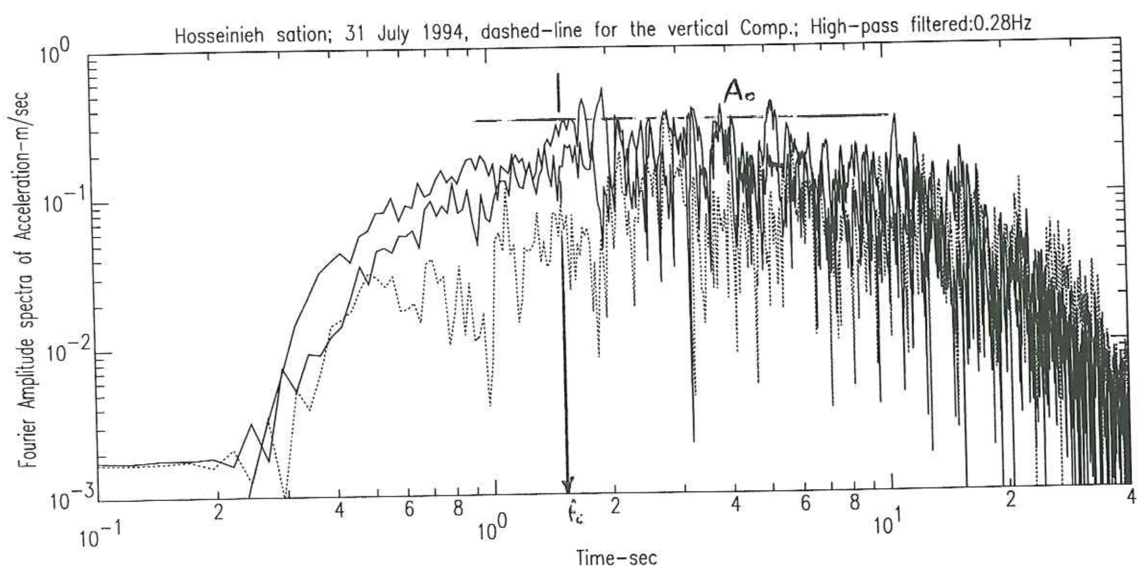

FIG. 4.4 – *The Fourier Amplitude Spectra of Acceleration of Hosseinieh record.*

4.1.5 Application of the method for the records with no reported source

The recent digital acceleremetric data in Iran, recorded after January 1994, contains a lot of records with only the triggering time. To use these data in the attenuation studies, the moment magnitudes and the hypocentral distance are calculated according to the method outlined in the previous section. The results are displayed in Appendix 4.1, listing for each record the BHRC code, the station name, the site class (based on the site classes 1 to 4, already defined by Zaré et al 1999a), the date (as mentioned in the header of the record), the high-pass filter used to avoid the low-frequency noise, the horizontal and the vertical peak ground accelerations (HPGA and VPGA, respectively), the corner frequency, the stress drop in bar, the hypocentral distance and finally the calculated moment magnitude (M_w). Most data presented in Appendix 4.1 were recorded in Zagros region, however a few data come from western Alborz in Caspian Sea shoreline, Azarbaijan in NW, as well as some records from eastern Iran (Figure 4.1).

For 27 events, several stations triggered, allowing an investigation on the stability and reliability of this M_w determination. The results are displayed in Figure 4.5, with stability for the f_c and stress drop calculation for the same 27 events. This figure exhibits an average standard deviation on moment magnitude of 0.19, corresponding to a factor of $10^{\frac{0.19}{0.667}} = 10^{0.28} \approx 3$ on seismic moment. The average standard deviations for $log f_c$ and stress drop are 0.47 and 8.93, respectively.

Comparison of the calculated M_w with reported teleseismic magnitudes

The calculated M_w's are plotted against the teleseismic reported Ms's, mb's, and Mw's and ML's, in Figure 4.6. It is evident that;

- The calculated M_w's are consistent with reported teleseismic Mw's.

- For magnitudes over 6, the calculated M_w are in agreement with Ms values, but for magnitudes below 6, they coincide more with the mb values (mb values saturate in magnitudes around 6-6.0; Figure 4.7). - The local magnitudes inferred from the local seismological network in Iran are more scattered but agree however with the calculated M_w values. These values correspond to magnitudes below 6.

Stress Drop estimation

The stress drop is estimated using formula 4.4 and presented in Appendix 4.1. The stress drop depends to the corner frequency, f_c (4.3 and 4.4). The observed f_c's for Alborz-Central

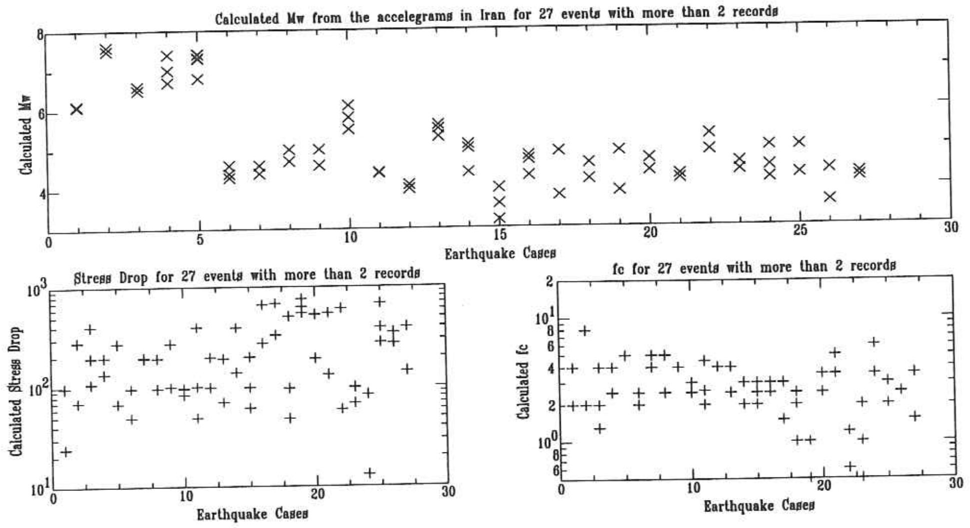

FIG. 4.5 – *The stability of the M_w's calculated in this study, for 27 cases and f_c and stress drop for 13 events with more than 2 records.*

Iran and Zagros are plotted in Figure 4.8 against M_w. They are between 1 and 10 Hz for most of the records. No important difference may be seen between these two regions on this limited data-set. The stress drop values are then obtained and traced against fc in Figure 4.9 and against Mw in Figure 4.10. The estimations of the stress drops in Iran are mostly between 30 and 500 bars (3 to 50 MPa). According to Kanamori and Anderson (1975) and Kanamori (1977), they are thus representative for the intra-plate earthquakes.

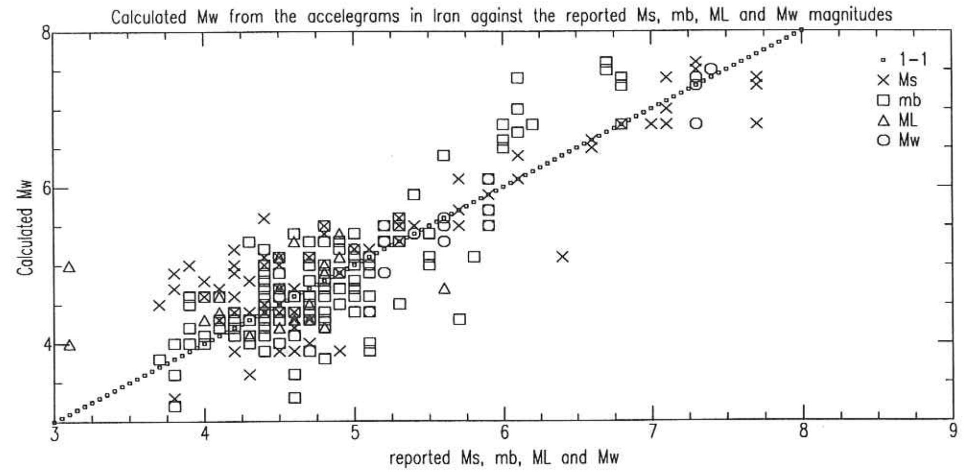

FIG. 4.6 – *Comparison between calculated M_w and the teleseismic and local magnitudes.*

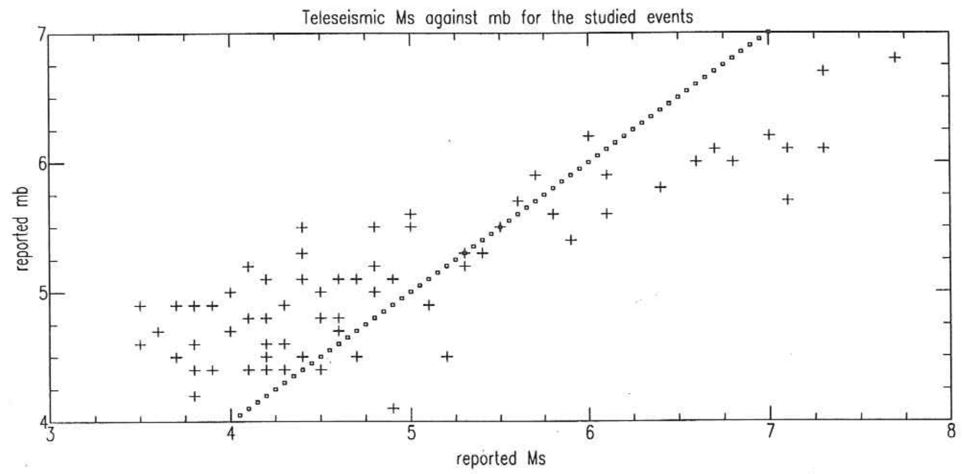

FIG. 4.7 – *Comparison between Ms and mb values*

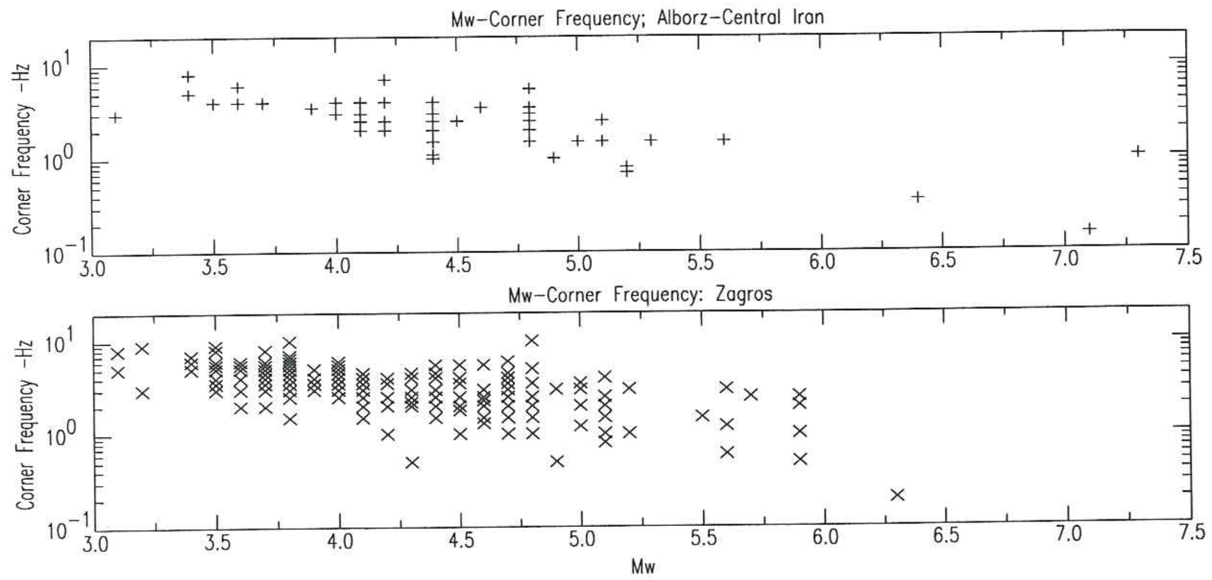

FIG. 4.8 – *The observed corner frequencies against M_w for Alborz-Central Iran and Zagros regions.*

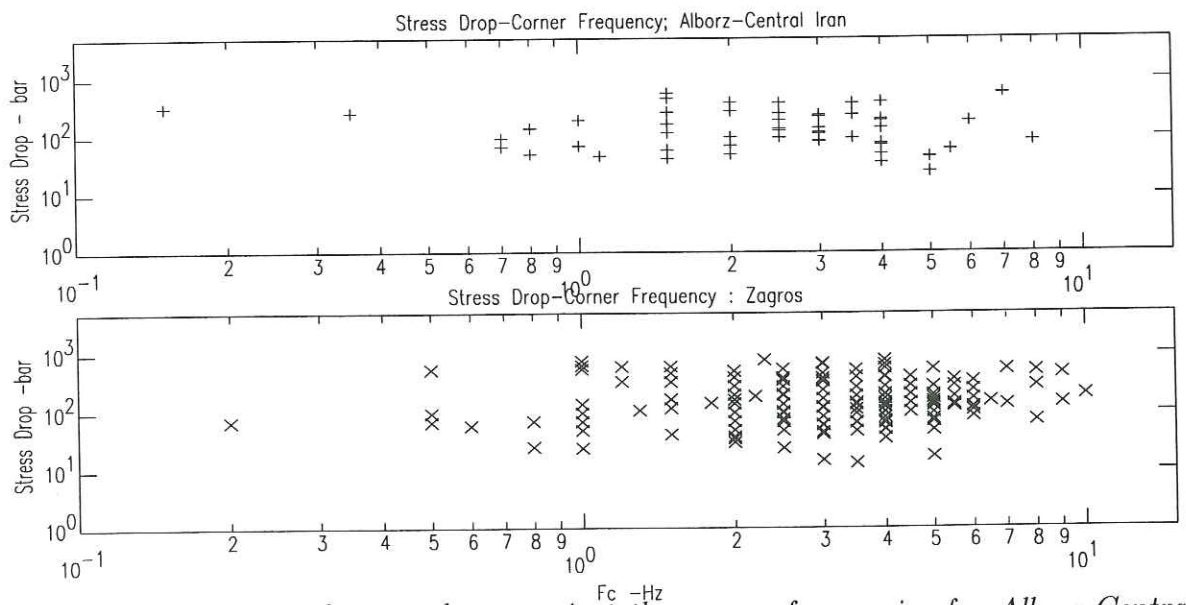

FIG. 4.9 – *The estimated stress drops against the corner frequencies for Alborz-Central Iran and Zagros regions.*

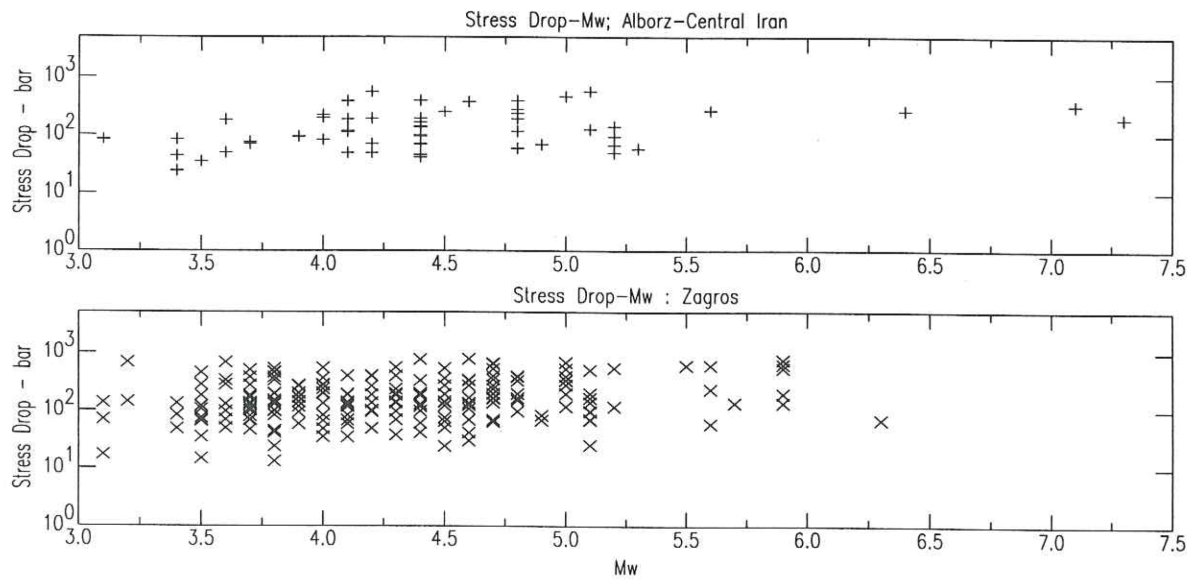

FIG. 4.10 – *The estimated stress drops against M_w for Alborz- Central Iran and Zagros regions.*

Dependence of f_c and f_{max} to magnitude and distance

The dependence of f_c and f_{max} to magnitude and distance is investigated, with the two following relationships :

$$\log f = a \cdot M + c + \sigma_1 \cdot P \tag{4.6}$$

$$\log f = -b \cdot \log R_h + d + \sigma_2 \cdot P \tag{4.7}$$

where a and b are the coefficients of M_w and R_h, respectively, c and d are constants and σ_1 and σ_2 are standard deviation and P percentile. The obtained coefficients are given in Table 4.1 for f_c and in Table 4.2 for f_{max}. The correlation coefficient (R) for f_c show that f_c depends completely to M_w where no correlation is evident between f_c and hypocentral distance. The dependence of f_{max} to M_w and hypocentral distance is similar (with a slightly higher R for the dependence on M_w).

Table 4.1: The coefficients for relationships 4.6 and 4.7, for f_c .

a	c	σ_1	R
-.345	1.940	0.151	0.579
b	d	σ_2	R
0.295	0.825	0.253	0.001

Table 4.2: The coefficients for relationships 4.6 and 4.7, for f_{max}, for horizontal and vertical components.

Comp.	a	c	σ_1	R
Hori.	-.185	1.781	0.162	0.468
Vert.	-.130	1.785	0.145	0.469
	b	d	σ_2	R
Hori.	0.386	1.623	0.167	0.398
Vert.	0.341	1.647	0.148	0.400

4.1.6 Conclusions

The moment magnitudes calculated from the Iranian strong motion data provide satisfactory results: The calculated values are consistent with teleseismic estimates of M_w, while they agree with Ms for magnitudes larger than 6, and with mb for magnitudes below 6. It becomes therefore possible to use the records from events within low to medium magnitude range (M3-5) in the attenuation studies, even though there does not exist any teleseismic or local report. These data in Iran were recently made available using the new digital SSA-2 network. Of course, it would be better to have an improved seismological network in Iran, so as to locate precisely and have more reliable magnitude determinations. On the other hand, it is suggested to improve the maintenance of the accelerometric network in Iran, so as to systematically assign source characteristics to each strong motion record. In particular the use of a GPS system is recommended to obtain an absolute timing for all the instruments in this network. The present situations, without precise timing, greatly impairs detailed source studies, which is really a pity with so many instruments installed in such an active seismic area.

Acknowledgement

The BHRC (Building and Housing Research Center, Tehran) who have released the raw strong motion records is greatly thanked. A financial support in France (for the first author) provided by a French scholarship (Ministère Français des Affaires Etrangères) is duly acknowledged. Douglas Maclean is greatly acknowledged for controlling the orthography of this article.

4.2 Décroissance de l'amplitude à haute fréquence dans le spectre de Fourier de l'Accélération: coefficient Kappa

Résumé La décroissance à haute fréquence du spectre de Fourier de l'accélération est étudiée sur les données iraniennes, pour détecter d'eventuelles non-linéaités dans les sols peu rigides. Cette décroissance est caractérisée par le paramètre Kappa (Anderson et Hough 1984), dont la valeur a été estimée seulement pour les données ayant un bon rapport signal sur bruit à haute fréquence. Lorsque κ pouvait être mesuré sur un même site, pour plusieurs enregistrements présentant différents niveaux d'accélération, nous avons étudié les variations de κ avec cette accélération. Nous avons d'autre part repris la classification par site et étudié les variations statistiques de κ (tous les sites d'une même catégorie mélangés) avec le niveau d'accélération, de même que les variations de κ avec le type de site. Les résultats de ces analyses restent très floues: κ semble cependant affecté légèrement quand la rigidité du site diminue, indiquant que κ serait au moins partiellement lié à l'atténuation de proche-surface.

4.2.1 Introduction

La décroissance haute fréquence des spectres de Fourier de l'accélération A(f) est souvent caractérisée par un paramètre appelé κ, correspondant à une décroissance en $e^{-\kappa f}$. Deux interprétations existent, liant cette décroissance à l'atténuation de la croûte et du sol (Anderson et Hough 1984, Durward et al. 1996, Hanks 1982, Lacave-Lachet et al. 1998) ou à la source (Papageorgiou and Aki 1983, Gariel et Campillo 1989). Hanks (1982) suppose que la fréquence maximale (f_{max}) est induite par l'atténuation anélastique propose dans une relation entre κ et la distance à la source. Lachet-Lacave et al (1998) reprennent cette interprétation pour détecter des non-linéarités dans les enregistrements obtenus lors de la séquence du séisme de Kobé (1995) au Japon; les sols mous soumis à de fortes accélération devraient en effet voir leur amortissement augmenter, et donc κ augmenter. A l'opposé, Papageorgiou et Aki (1983) ont montré que la décroissance en haute fréquence serait liée à l'existence d'une zone de collision (non-élasticité de la faille) à l'avant du front de la rupture, dont la taille contrôlerait la fréquence f_{max}. Gariel et Campillo (1989), en utilisant une approche numérique, ont confirmé que deux facteurs liés à la source peuvent expliquer la décroissance haute fréquence: la présence de cette 'zone de cohésion', mais aussi le ralentissement lissé du front de rupture.

La méthodologie des études sur κ est présentée d'abord. Les relations de κ avec la distance

sont ensuite étudiées pour les différentes régions de l'Iran.

4.2.2 La méthodologie des calculs de Kappa

La partie haute fréquence d'un spectre d'accélération peut être représentée comme suite:

$$A(f) = A_1 e^{-\pi\kappa f} pour f > f_{max}$$

où $A(f)$ est le spectre de l'accélération, et A_1 est une constante qui dépend des propriétés de la source, de la distance épicentrale et peut-être d'autre facteurs, f est la fréquence, κ est le coefficient de décroissance, et f_{max} est une fréquence au-dessus laquelle la forme spectrale ne peut pas être distinguée de la décroissance exponentielle. En supposant un milieu simple sur un demi-espace élastique, on peut écrire:

$$\kappa = \int \frac{ds}{Q\beta}$$

où ds est l'element de rai sismique, Q est la facteur de qualité, et β est la vitesse des ondes S.

Cette intégrale peut se décomposer en 2 termes: l'un correspondant à la propagation dans les milieux très superficiels a proximité de la station d'enregistrement et l'autre à la propagation dans la croûte profonde:

$$\kappa = \frac{l_c}{Q(f)\cdot\beta_c} + \frac{h_s}{Q_s\cdot\beta_s}$$

où l_c est la distance totale parcourue dans la croûte, caractérisée par un facteur de qualité $Q_c(f)$ et une vitesse d'onde S, β_c; h_s est l'épaisseur des milieux superficiels, Q_s leur facteur de qualité, et β_s leur vitèsse d'onde de cisaillement. Selon cette décomposition, le premier terme va produire un coefficient κ qui va augmenter avec la distance source-site (l_c), tandis que le second sera sensible aux effets non-linéaires, puisque en un site donné, Q_s devrait diminuer, et β_s aussi, quand l'accélération augmente beaucoup.

4.2.3 Les résultats

Les valeurs de κ ainsi calculées sont représentées en fonction de la distance pour les régions de Zagros, et Alborz-Iran Central et pour 4 catégories des sites différents dans les Figures 4.11 à 4.13, respectivement. Les résultats du Zagros sont très dispersés, et ne correspondent qu'à de faible distances (la plupart avec $R_h < 20km$). Ces données viennent des enregistrements plutôt digitaux obtenus pour des séismes de magnitude inférieure à 6 (Figure 4.11). Les résultats en Alborz-Iran Central (pour les séismes des magnitudes de moins de 6, pour comparer avec les données du Zagros, Figure 4.12) montrent des variations moins rapides avec la distance (Figures 4.12 et 4.13). Pour mieux expliquer les valeurs de kappa en champ-proche, il y aurait besoin d'études supplémentaires.

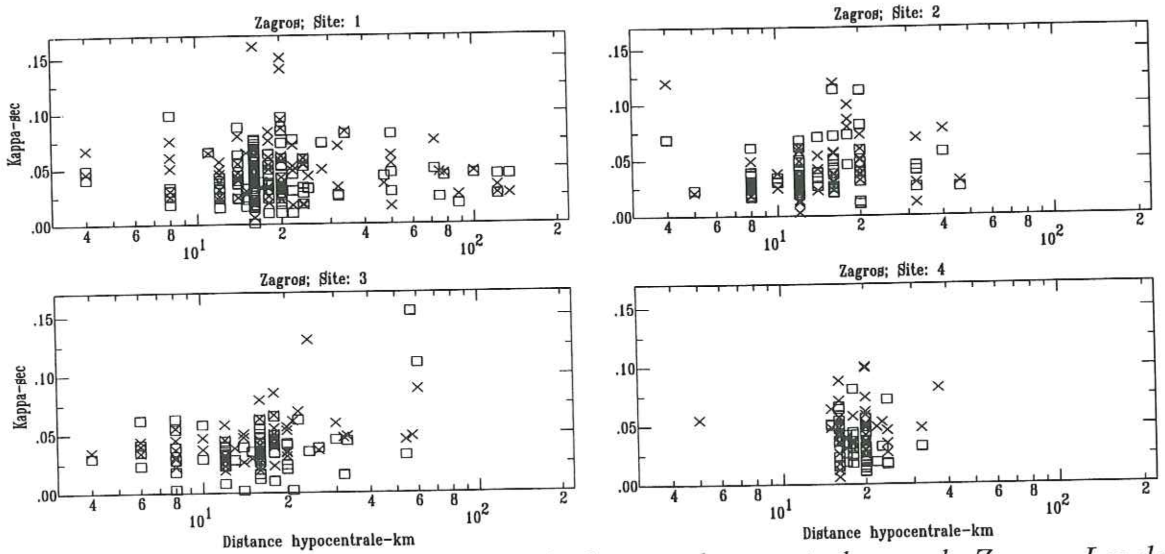

FIG. 4.11 – *Les valeurs de κ en fonction de la distance hypocentrale pour le Zagros. Les données sont présentées pour différentes catégories de site. Les croix correspondent aux composantes horizontales et les rectengules aux composantes verticales.*

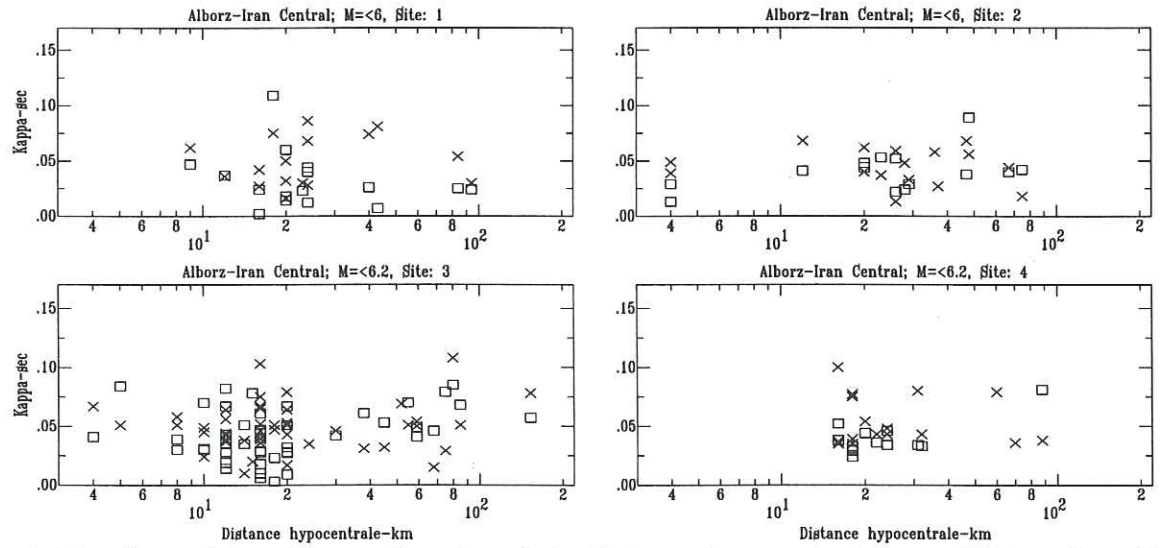

FIG. 4.12 – *Les valeurs de κ en fonction de la distance hypocentrale pour l'Alborz-Iran Central; les événements de magnitudes moins de 6. Les données sont présentées pour les catégories différentes de site. Les croix correspondent aux composantes horizontales et les rectengules aux composantes verticales.*

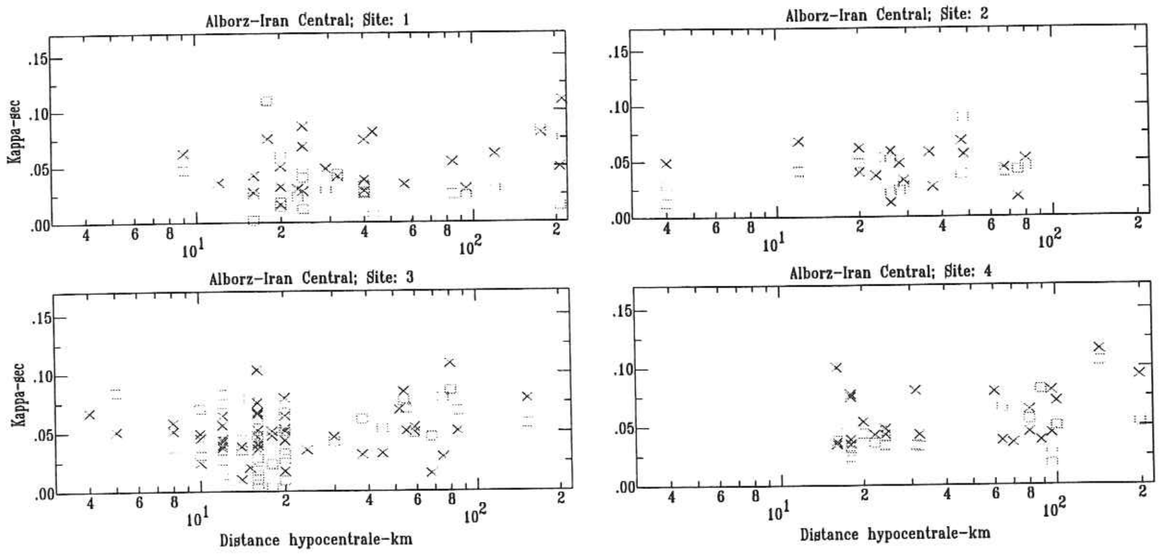

FIG. 4.13 – *Les valeurs de κ en fonction de la distance hypocentrale pour la région de l'Alborz-Iran Central (sans limitation de la magnitude). . Les données ont présentées pour les catégories différentes de site. Les croix correspondent aux composantes horizontales et les rectengules aux composantes verticales.*

Pour en être sur, nous avons considéré quelques séismes particuliares pour lesquels nous disposions de plusieurs enregistrements (Ebrahimabad, etc..). La Figure 4.14 pourait montrer une legère augmentation de κ avec la distance, notament pour le séisme de Manjil, mais les valeurs varient beaucoup d'un séisme à l'autre, de telle sorte qu'il est impossible de distinger une dépendance de κ avec la distance pour séismes correspondants. Par ailleurs, les valeurs de κ ont été présentées en fonction de l'accélération maximale pour les sites avec plusieurs enregistrements en Figure 4.15. Ces résultats montrent la variation de κ plus ou moins similaires pour les types différents de sol, et aucun tendence à l'implification de κ avec l'accélération maximales.

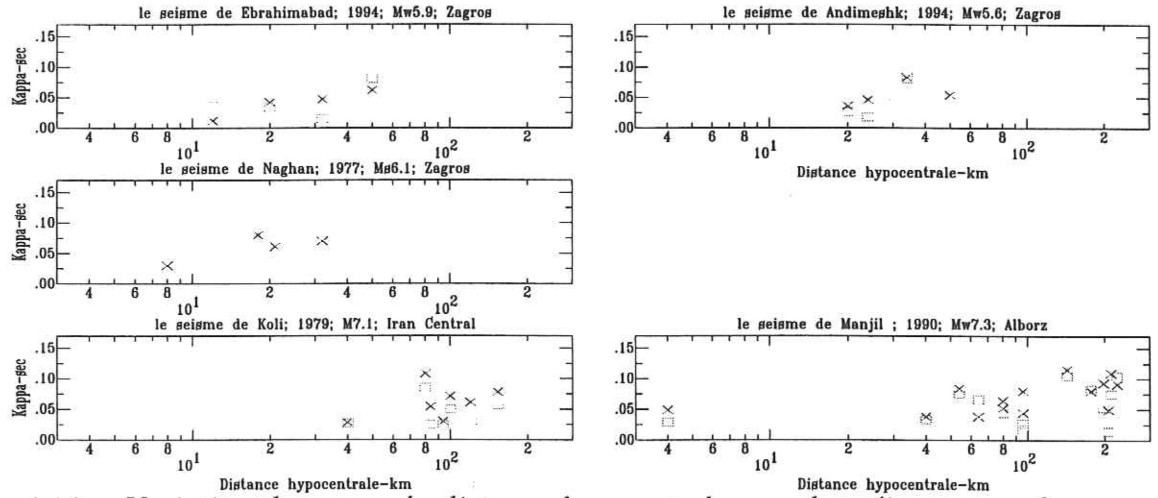

FIG. 4.14 – *Variation de κ avec la distance hypocentrale pour les séismes avec les magnitudes supérieure à de 5.9 pour les régions de Zagros, Alborz-Iran Central [Ebrahimabad 1994, Andimeshk, 1994, et Naghan 1977 dans la région de Zagros, et Koli 1979 en Iran Central et Manjil 1990 en Alborz]. Les croix correspondent aux composantes horizontales, et les rectengles aux composantes verticales.*

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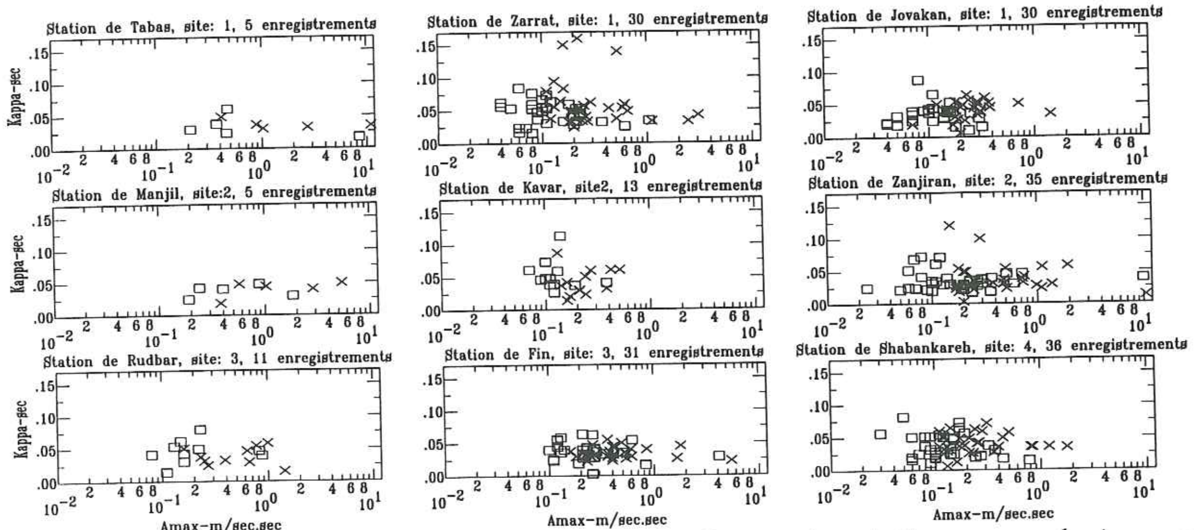

FIG. 4.15 – *Variation de κ avec l'accélération maximale pour les stations avec plusieurs enregistrements: Tabas, Zarrat, Jovakan (site 1), Manjil, Kavar et Zanjiran (site 2), Rudbar et Fin (site 3) et Shabankareh (site 4). Les croix correspondent aux composantes horizontales et les rectangles aux composantes verticals.*

Ces résultats au κ suggérent une tr'es faibles influence des conditions de site dans les données iraniennes. Concernent un autre faible dépendance avec la distance, nous en concluons que probablement la théorie de Papageorgiou et Aki, et Gariel et Campillo (1989), selon laquelle les effets de source sont prédominants sur le comportement haute fréquence, est plus en d'accord avec ces résultats actuels.

4.2.4 Conclusion

Les études sur le paramètre de κ en Iran montrent essentiellement une très forte dispersion, surtout dans les premiers 20km (surtout dans les données de Zagros) à telle point qu'il est impossible de détecter une tendance. Pour aller plus loin, il faudrait disposer de données de réseaux accélérométriques locaux avec plus des stations numériques, en comparant les données des chocs principaux et des répliques enregistrés sur les sites différents et par des distances différentes. Nous proposons l'observation de la forme de spectre de l'accélération en haute fréquence surtout pour le champ-proche des sources sismiques les les plus importantes les plus connues en Iran. Ce type des études particulières permettent de relier κ à l'atténuation superficielle ou profonde.

Appendix 4.1: The Iranian digital records (SSA-2 instruments) for which the source parameters are estimated directly for the records.

No	Code BHRC	Station	Site	Event	HP filter (Hz)	PGA (H1) m/sec2	PGA (V) m/sec2	PGA (H2) m/sec2	f max (H) Hz	f max (V) Hz	fc (Hz)	Stress Drop (Bar)	Ao m/sec	Hypo Dist. (km)	Mw calc.
1	1512-1	Sedeh	3	0?/0?/94	0.44	.435	.650	.438			2.5	251.6	0.1	16	4.5
2	1505	Sefidabeh (Microwave)	1	1/3/94	0.20	.088	.093	.134	10.0	10.0	2	98.1	0.04	24	4.4
3	1504-1	Sefidabeh (School)	2	1/3/94	0.27	.068	.032	.052			4	24.15	0.006	16	3.4
4	1492-1	Zarrat	1	8/3/94	0.10	.420	.190	.258	12.0	15.0	4	393.5	0.09	16	4.2
5	1503-1	Zanjiran	2	9/3/94	0.24	.191	.105	.193	18.0	18.0	5	193.2	0.06	12	3.8
6	1503-2	Zanjiran	2	9/3/94	0.24	.258	.201	.115	25.0	30.0	8	280.9	0.055	12	3.5
7	1494-1	Kavar	2	11/3/94	0.25	.191	.230	.176	30.0	35.0	2	69.5	0.05	12	4.3
8	1500-1	Zanjiran	2	11/3/94	0.28	.216	.107	.138	10.0	10.0	8	280.9	0.08	8	3.5
9	1500-2	Zanjiran	2	13/3/94	0.25	.178	.104	.109	26.0	30.0	9	142.0	0.03	8	3.2
10	1500-3	Zanjiran	2	14/3/94	0.25	.095	.078	.166	28.0	30.0	4	555.8	0.25	8	4.3
11	1492-3	Zarrat	1	17/3/94	0.14	.728	.272	.613	20.0	25.0	2	195.7	0.10	16	4.6
12	1494-2	Kavar	2	17/3/94	0.25	.145	.080	.223	10.0	15.0	1.3	107.2	0.08	20	4.8
13	1494-3	Kavar	2	17/3/94	0.20	.242	.115	.211	15.0	15.0	2.5	382.3	0.20	12	4.6
14	1500-5	Zanjiran	2	17/3/94	0.23	1.111	.299	.730	18.0	22.0	4	402.6	0.10	16	4.2
15	1500-7	Zanjiran	2	18/3/94	0.25	.099	.061	.198	25.0	30.0	6	118.5	0.045	8	3.5
16	1500-9	Zanjiran	2	19/3/94	0.28	.119	.061	.177	25.0	30.0	5	136.8	0.04	12	3.1
17	1500-10	Zanjiran	2	20/3/94	0.20	.277	.141	.351	20.0	25.0	3	234.5	0.10	12	4.3
18	1500-11	Zanjiran	2	20/3/94	0.30	.153	.136	.182	20.0	25.0	3	83.2	0.035	12	4.0
19	1500-12	Zanjiran	2	21/3/94	0.30	.386	.154	.298	30.0	35.0	4.5	140.8	0.075	8	3.8
20	1492-10	Zarrat	1	12/4/94	0.44	.201	.062	.052	20.0	20.0	7	133.3	0.02	14	3.4
21	1492-12	Zarrat	1	7/5/94	0.25	.153	.066	.166	10.0	10.0	2.5	135.7	0.04	20	4.2
22	1502-1	Zanjiran	2	20/5/94	0.21	.149	.049	.144	15.0	20.0	3	117.5	0.045	16	4.1
23	1502-3	Zanjiran	2	5/6/94	0.21	.112	.081	.235	25.0	28.0	10	194.8	0.025	12	3.2
24	1502-5	Zanjiran	2	6/6/94	0.20	.377	.194	.716	20.0	28.0	4	393.5	0.15	10	4.2
25	1492-17	Zarrat	1	20/6/94	0.25	.214	.078	.227	18.0	18.0	2.2	184.5	0.10	16	4.5
26	1492-18	Zarrat	1	20/6/94	0.20	.090	.038	.129	11.0	15.0	4	197.3	0.045	16	4.0
27	1493-3	Firouzabad	3	20/6/94	0.20	.128	.078	.135	6.0	8.0	2.5	135.7	0.05	18	4.3
28	1492-21	Zarrat	1	21/6/94	0.24	.159	.095	.157	18.0	18.0	4.5	396.8	0.07	18	4.1
29	1518-1	Firouzabad	3	22/6/94	0.40	.359	.073	.084	30.0	30.0	5	17.2	0.015	4	3.1
30	1501-1	Zanjiran	2	23/6/94	0.20	.842	.374	1.092	20.0	22.0	8	501.4	0.11	12	3.7
31	1501-2	Zanjiran	2	23/6/94	0.20	.153	.106	.234	22.0	25.0	8	70.6	0.02	8	3.1
32	1501-3	Zanjiran	2	23/6/94	0.32	.197	.065	.168	22.0	25.0	3	41.7	0.02	12	3.8
33	1501-5	Zanjiran	2	24/6/94	0.27	.248	.097	.476	20.0	22.0	5.5	182.1	0.065	8	3.7
34	1501-6	Zanjiran	2	24/6/94	0.23	.250	.122	.198	25.0	30.0	4	49.6	0.035	5	3.6
35	1501-7	Zanjiran	2	24/6/94	0.23	1.352	.596	1.367	22.0	25.0	2.5	270.6	0.020	8	4.5
36	1501-8	Zanjiran	2	25/6/94	0.24	.154	.073	.214	20.0	25.0	5.5	128.9	0.03	12	3.6
37	1501-9	Zanjiran	2	25/6/94	0.24	.486	.238	.438	25.0	30.0	3.5	263.6	0.15	8	4.2
38	1523-1	Jovakan	1	6/7/94	0.26	.199	.144	.114	20.0	20.0	5	48.6	0.015	12	3.4
39	1523-2	Jovakan	1	7/7/94	0.20	.148	.073	.139	18.0	18.0	2.5	48.2	0.03	12	4.0
40	1523-3	Jovakan	1	7/7/94	0.20	.261	.166	.293	20.0	20.0	4	98.9	0.03	16	3.8
41	1523-4	Jovakan	1	9/7/94	0.20	.339	.153	.233	20.0	20.0	3.5	132.2	0.04	18	4.0
42	1519-1	Zarrat	1	10/7/94	0.20	.133	.050	.099	18.0	18.0	5	272.8	0.05	20	3.9
43	1523-5	Jovakan	1	10/7/94	0.20	.154	.095	.112	18.0	20.0	5	68.5	0.015	16	3.5
44	1518-2	Firouzabad	3	13/7/94	0.20	.126	.076	.080	6.0	10.0	2.5	96.1	0.04	16	4.2
45	1523-6	Jovakan	1	13/7/94	0.20	.288	.158	.263	18.0	18.0	2	49.2	0.06	16	4.2
46	1523-7	Jovakan	1	16/7/94	0.20	.129	.067	.142	18.0	18.0	4	555.8	0.03	16	4.3
47	1523-9	Jovakan	1	18/7/94	0.20	.183	.112	.184	21.0	21.0	2.5	24.1	0.015	14	3.8
48	1523-10	Jovakan	1	20/7/94	0.27	.190	.043	.113	10.0	10.0	4	70.1	0.02	15	3.7
49	1523-11	Jovakan	1	24/7/94	0.21	.129	.180	.224	21.0	21.0	6	83.9	0.025	12	3.4
50	1523-12	Jovakan	1	28/7/94	0.21	.307	.114	.260	21.0	21.0	5	48.6	0.015	12	3.4
51	1523-13	Jovakan	1	29/7/94	0.25	.183	.049	.088	28.0	28.0	5	136.8	0.04	12	3.7
52	1506-2	Hosseinieh	4	31/7/94	0.20	.498	.130	.319	9.0	15.0	2	138.6	0.06	20	4.5
53	1506-3	Hosseinieh	4	31/7/94	0.20	.146	.094	.257	12.0	18.0	2	69.5	0.04	20	4.3
54	1506-4	Hosseinieh	4	31/7/94	0.28	1.788	.470	1.244	5.0	8.0	1.5	463.9	0.30	20	5.1
55	1506-5	Hosseinieh	4	31/7/94	0.21	.272	.145	.185	12.0	18.0	1.5	116.6	0.08	20	4.7
56	1506-6	Hosseinieh	4	31/7/94	0.21	.191	.060	.155	10.0	12.0	4.5	140.9	0.03	20	3.8
57	1506-7	Hosseinieh	4	31/7/94	0.21	.118	.075	.084	15.0	20.0	3	83.2	0.04	18	4.1
58	1506-8	Hosseinieh	4	31/7/94	0.21	.261	.141	.349	10.0	12.0	3	234.5	0.09	25	4.3
59	1506-9	Hosseinieh	4	31/7/94	0.21	.234	.108	.144	12.0	12.0	3	117.5	0.04	20	4.1
60	1520-1	Kavar	2	1/8/94	0.25	.169	.106	.117	20.0	20.0	4	70.1	0.025	12	3.7
61	1506-10	Hosseinieh	4	2/8/94	0.21	.184	.072	.080	18.0	20.0	1.5	41.4	0.03	18	4.4
62	1519-2	Zarrat	1	12/8/94	0.20	.118	.058	.148	12.0	18.0	5	193.2	0.04	15	3.8
63	1523-14	Jovakan	1	12/8/94	0.20	.206	.254	.124	21.0	21.0	4	197.3	0.05	16	4.0
64	1523-15	Jovakan	1	12/8/94	0.20	.380	.140	.338	18.0	18.0	4	197.3	0.05	16	4.0

No	Code BHRC	Station	Site	Event	HP filter (Hz)	PGA (H1) m/sec2	PGA (V) m/sec2	PGA (H2) m/sec2	f max (H) Hz	f max (V) Hz	fc (Hz)	Stress Drop (Bar)	Ao m/sec	Hypo Dist. (km)	Mw calc.
65	1523-16	Jovakan	1	14/8/94	0.20	.181	.176	.176	22.0	22.0	4	98.9	0.04	14	3.8
66	1518-3	Firouzabad	3	20/8/94	0.20	.134	.159	.118	7.0	10.0	2.5	96.1	0.03	20	4.2
67	1523-17	Jovakan	1	20/8/94	0.27	.172	.130	.246	18.0	20.0	5	193.2	0.03	18	3.8
68	1520-2	Kavar	2	26/8/94	0.20	.163	.114	.151	18.0	18.0	4	270.7	0.04	20	4.0
69	1523-18	Jovakan	1	26/8/94	0.20	.254	.148	.310	18.0	19.0	4	98.9	0.03	16	3.8
70	1523-19	Jovakan	1	28/8/94	0.20	.170	.041	.061	17.0	17.0	5	96.9	0.02	16	3.6
71	1523-20	Jovakan	1	28/8/94	0.24	.217	.097	.238	30.0	30.0	5	96.9	0.025	12	3.6
72	1523-21	Jovakan	1	7/9/94	0.24	.206	.067	.129	28.0	28.0	5	68.5	0.015	16	3.5
73	1523-22	Jovakan	1	9/9/94	0.24	.204	.102	.207	28.0	28.0	4.5	99.7	0.03	12	3.7
74	1533-1	Seifabad	1	10/9/94	0.20	.127	.098	.132	15.0	15.0	4	197.3	0.04	18	4.0
75	1523-23	Jovakan	1	19/9/94	0.28	.707	.296	.660	18.0	18.0	7	530.	0.10	16	3.8
76	1523-26	Jovakan	1	12/10/94	0.25	.049	.238	.075	20.0	20.0	3	14.8	0.01	18	3.5
77	1518-4	Firouzabad	3	26/10/94	0.20	.126	.059	.140	6.0	8.0	2.5	96.1	0.04	16	4.2
78	1523-27	Jovakan	1	26/10/94	0.25	.168	.084	.308	20.0	20.0	3	83.2	0.04	14	4.0
79	1531	Lamerd	1	27/10/94	0.20	.317	.107	.112	25.0	30.0	6	333.9	0.05	16	3.8
80	1528-2	Fin	3	29/10/94	0.20	.250	.205	.237	18.0	20.0	3.5	132.2	0.05	16	4.0
81	1550-2	Masal	3	7/12/94	0.20	.125	.056	.120	6.0	8.0	3	117.5	0.045	16	4.1
82	1523-29	Jovakan	1	29/12/94	0.25	.366	.143	.372	18.0	18.0	2.5	270.6	0.08	22	4.5
83	1519-5	Zarrat	1	30/12/94	0.20	.243	.122	.215	19.0	21.0	4.5	396.8	0.085	18	4.1
84	1520-6	Kavar	2	30/12/94	0.20	.144	.087	.237	9.0	11.0	2.6	100.6	0.04	16	4.2
85	1523-30	Jovakan	1	30/12/94	0.25	.112	.051	.116	18.0	18.0	2	49.2	0.06	8	4.2
86	1573	Bagh-Malek	2	1/1/95	0.20	.134	.041	.073	10.0	11.0	2.5	135.7	0.06	16	4.3
87	1529-2	Lali	3	6/1/95	0.20	.104	.079	.159	12.0	15.0	4	98.9	0.03	12	3.8
88	1549-4	Ammarloo	3	6/1/95	0.20	.637	.487	.584	22.0	22.0	4	197.3	0.08	10	4.0
89	1529-3	Lali	3	7/1/95	0.20	.259	.150	.239	8.0	10.0	2	138.6	0.10	18	4.5
90	1523-31	Jovakan	1	12/1/95	0.25	.269	.069	.248	20.0	20.0	4	139.7	0.04	16	3.9
91	1528-22	Fin	3	24/1/95	0.25	.521	.279	.422	20.0	28.0	4	197.3	0.06	16	4.0
92	1528-23	Fin	3	24/1/95	0.25	.609	.269	.522	17.0	20.0	3.5	132.2	0.08	8	4.0
93	1528-24	Fin	3	24/1/95	0.25	.398	.267	.395	20.0	28.0	3	117.5	0.05	12	4.1
94	1528-26	Fin	3	24/1/95	0.25	1.795	.834	1.433	20.0	22.0	3	452.9	0.15	16	4.5
95	1528-27	Fin	3	24/1/95	0.25	.229	.112	.153	18.0	20.0	4	35.2	0.025	6	3.5
96	1528-28	Fin	3	24/1/95	0.25	.203	.126	.214	20.0	28.0	4	139.7	0.04	16	3.9
97	1528-29	Fin	3	24/1/95	0.25	.402	.209	.276	20.0	25.0	3.5	263.6	0.10	12	4.2
98	1528-10	Fin	3	24/1/95	0.20	1.652	.617	1.165	20.0	22.0	2.5	377.4	0.15	16	4.6
99	1528-11	Fin	3	24/1/95	0.23	.268	.121	.183	19.0	22.0	3	58.9	0.03	12	3.9
100	1528-12	Fin	3	24/1/95	0.23	.837	.512	.841	20.0	25.0	3.5	186.7	0.15	6	4.1
101	1528-13	Fin	3	24/1/95	0.23	.370	.132	.380	22.0	28.0	3	58.9	0.035	10	3.9
102	1528-14	Fin	3	24/1/95	0.23	.171	.137	.226	20.0	22.0	3.5	66.3	0.04	8	3.8
103	1528-15	Fin	3	24/1/95	0.23	.395	.275	.605	22.0	28.0	4	35.1	0.03	6	3.5
104	1528-16	Fin	3	24/1/95	0.34	.173	.141	.263	19.0	22.0	2.5	68.0	0.04	14	4.1
105	1528-17	Fin	3	24/1/95	0.20	.544	.214	.385	22.0	28.0	3.5	65.0	0.04	14	3.9
106	1528-18	Fin	3	24/1/95	0.25	.370	.134	.289	20.0	22.0	3.5	66.2	0.025	12	3.8
107	1528-19	Fin	3	24/1/95	0.25	.123	.119	.162	22.0	28.0	3	58.9	0.04	8	3.9
108	1528-20	Fin	3	24/1/95	0.25	.219	.112	.222	20.0	25.0	3.5	186.7	0.05	20	4.1
109	1528-21	Fin	3	24/1/95	0.25	.130	.105	.245	19.0	20.0	3	117.5	0.06	12	4.1
110	1528-4	Fin	3	24/1/95	0.20	.420	.256	.385	18.0	22.0	3.5	132.2	0.10	8	4.0
111	1528-5	Fin	3	24/1/95	0.20	.398	.264	.399	18.0	22.0	3	117.5	0.15	6	4.1
112	1528-6	Fin	3	24/1/95	0.20	.357	.210	.346	21.0	26.0	3.5	132.2	0.10	8	4.0
113	1528-7	Fin	3	24/1/95	0.20	.239	.190	.211	20.0	22.0	3.5	46.9	0.03	8	3.7
114	1528-8	Fin	3	24/1/95	0.25	.406	.229	.251	18.0	22.0	3.5	186.7	0.06	16	4.1
115	1528-9	Fin	3	24/1/95	0.18	.435	.259	.469	20.0	22.0	3.5	132.2	0.06	14	4.0
116	1528-30	Fin	3	25/1/95	0.25	.365	.223	.277	20.0	20.0	3.5	93.6	0.035	12	3.9
117	1528-31	Fin	3	25/1/95	0.25	.171	.115	.184	15.0	18.0	3.5	132.2	0.04	16	4.0
118	1631-1	Musian	3	27/1/95	0.38	.184	.112	.304	16.0	18.0	3	117.5	0.035	16	4.1
119	1592	Golbaf	3	17/2/95	0.28	.148	.112	.100	8.0	12.0	1.5	41.4	0.05	12	4.4
120	1535-1	Rudbar	3	7/3/95	0.20	.255	.164	.274	18.0	20.0	4	139.7	0.055	10	3.9
121	1564-1	Khanzanun	1	9/3/95	0.20	.173	.125	.117	12.0	18.0	2	34.8	0.02	16	4.1
122	1650-1	Firouzabad	3	25/3/95	0.38	.302	.191	.294	6.0	11.0	1.5	166.4	0.10	12	4.7
123	1545-2	Kavar	2	4/4/95	0.20	.144	.071	.159	9.0	11.0	2.5	48.2	0.03	12	4.0
124	1590-1	Sisakht	1	6/4/95	0.25	.261	.317	.273	30.0	33.0	9	452.9	0.05	16	3.5
125	1562-2	Zarrat	1	16/4/95	0.20	.275	.185	.160	12.0	18.0	4		0.10	16	4.2
126	1655	Saman	2	18/4/95	0.38	.182	.088	.136	25.0	28.0	5	44.0	0.01	14	3.4
127	1558	Shabankareh	4	2/5/95	0.20	.132	.096	.118	10.0	11.0	4	67.9	0.015	18	3.7
128	1529-1	Lali	3	14/5/95	0.20	.091	.036	.137	10.0	12.0	4	197.3	0.04	18	4.0
129	1535-3	Rudbar	3	17/5/95	0.20	.228	.111	.123	12.0	18.0	2	49.2	0.035	12	4.2

No	Code BHRC	Station	Site	Event	HP filter (Hz)	PGA (H1) m/sec2	PGA (V) m/sec2	PGA (H2) m/sec2	f max (H) Hz	f max (V) Hz	fc (Hz)	Stress Drop (Bar)	Ao m/sec	Hypo Dist. (km)	Mw calc.
130	1551-1	Shabastar	1	17/5/95	0.20	.247	.314	.138	11.0	19.0	4	197.3	0.04	24	4.0
131	1546	Tasuj	2	18/5/95	0.20	.168	.083	.127	15.0	18.0	2.5	191.6	0.06	20	4.4
132	1551-3	Shabastar	1	18/5/95	0.20	.133	.062	.104	18.0	22.0	4	70.05	0.08	24	4.2
133	1552	Pol-e Sefid	4	2/6/95	0.20	.308	.133	.181	20.0	25.0	3.5	186.7	0.04	18	4.1
134	1635-1	Pol-e Sefid	4	2/6/95	0.38	.306	.133	.181	20.0	25.0	3.5	186.7	0.04	18	4.1
135	1576	Gavbandi	3	18/6/95	0.20	.150	.158	.228	25.0	30.0	5	75.5	0.02	12	3.5
136	1542	Ammarloo	3	10/7/95	0.20	.207	.077	.091	18.0	20.0	4	49.6	0.02	12	3.6
137	1635-2	Pol-e Sefid	4	27/7/95	0.38	.171	.181	.078	18.0	25.0	3	82.2	0.025	20	4.0
138	1557	Delvar	2	28/7/95	0.20	.133	.043	.061	18.0	22.0	4	100.6	0.02	20	3.8
139	1620-2	Doab	3	28/7/95	0.28	.643	.230	.385	20.0	25.0	3	113.2	0.03	20	4.1
140	1620-3	Doab	3	14/8/95	0.28	.155	.067	.069	18.0	22.0	4.0	70.1	0.02	18	3.7
141	1620-4	Doab	3	15/8/95	0.28	.331	.135	.148	20.0	30.0	3.5	93.6	0.03	18	3.9
142	1631-2	Musian	3	16/8/95	0.38	.074	.035	.129	11.0	15.0	4	70.1	0.02	16	3.7
143	1549-1	Ammarloo	3	7/9/95	0.20	.170	.261	.478	11.0	12.0	3.5	75.4	0.025	12	3.7
144	1549-2	Ammarloo	3	21/9/95	0.28	.136	.164	.164	15.0	17.0	4	35.1	0.015	12	3.5
145	1540	Rasht (Hous.)	3	13/10/95	0.40	.122	.031	.102	6.0	8.0	1	68.9	0.09	16	4.9
146	1637-1	Rasht (Hous.)	3	13/10/95	0.38	.123	.031	.103	7.0	8.0	0.7	66.6	0.09	16	5.2
147	1564-2	Khanzanun	1	23/10/95	0.20	.525	.244	.563	12.0	18.0	3	83.2	0.06	8	4.9
148	1620-5	Doab	3	26/10/95	0.28	.149	.050	.073	22.0	35.0	6	83.9	0.01	20	3.4
149	1590-3	Sisakht	1	2/11/95	0.28	.186	.159	.191	30.0	30.0	5.5	129.7	0.025	15	3.6
150	1538	Kolur	1	3/11/95	0.20	.268	.151	.360	40.0	40.0	6	181.2	0.06	16	3.6
151	1544	Silvaneh	4	14/11/95	0.20	.434	.198	.228	10.0	12.0	2.5	191.6	0.10	16	4.4
152	1560-2	Lali	3	24/11/95	0.20	.171	.134	.165	12.0	18.0	4	197.3	0.04	20	4.0
153	1560-3	Lali	3	25/11/95	0.20	.195	.183	.143	8.0	12.0	5	193.2	0.035	16	3.6
154	1560-5	Lali	3	27/11/95	0.20	.197	.143	.171	15.0	18.0	3	45.2	0.03	8	3.8
155	1590-4	Sisakht	1	14/12/95	0.28	.241	.293	.267	28.0	30.0	6	105.8	0.02	14	3.5
156	1549-3	Ammarloo	3	29/12/95	0.20	.300	.124	.244	22.0	28.0	3.5	93.6	0.04	12	3.9
157	1602-3	Kavar Dam	2	31/12/95	0.28	.125	.031	.112	8.0	10.0	4.5	280.9	0.035	32	4.0
158	1571-1	Shabankareh	4	23/1/96	0.20	.402	.325	.296	18.0	20.0	3	120.8	0.05	16	4.1
159	1571-2	Shabankareh	4	23/1/96	0.25	.236	.123	.087	15.0	18.0	6	120.8	0.02	16	3.5
160	1571-3	Shabankareh	4	23/1/96	0.30	.086	.175	.314	12.0	16.0	5	125.8	0.025	16	3.7
161	1571-10	Shabankareh	4	24/1/96	0.25	.534	.418	.837	11.0	18.0	3	679.4	0.35	24	4.6
162	1571-12	Shabankareh	4	24/1/96	0.25	.103	.104	.117	11.0	15.0	6	236.4	0.03	20	3.7
163	1571-13	Shabankareh	4	24/1/96	0.25	.123	.092	.193	10.0	18.0	5.5	182.1	0.035	18	3.7
164	1571-14	Shabankareh	4	24/1/96	0.24	.117	.077	.214	10.0	12.0	5.5	182.1	0.035	16	3.7
165	1571-15	Shabankareh	4	24/1/96	0.24	.167	.091	.159	10.0	12.0	5.5	128.9	0.03	15	3.6
166	1571-17	Shabankareh	4	24/1/96	0.28	.105	.105	.146	18.0	22.0	6.5	150.7	0.025	17	3.5
167	1571-18	Shabankareh	4	24/1/96	0.28	.032	.047	.116	18.0	20.0	6	167.4	0.025	18	3.5
168	1571-19	Shabankareh	4	24/1/96	0.28	.253	.101	.167	12.0	18.0	5.5	363.2	0.06	16	3.8
169	1571-20	Shabankareh	4	24/1/96	0.28	.102	.061	.133	12.0	18.0	6	333.9	0.05	16	3.8
170	1571-21	Shabankareh	4	24/1/96	0.28	.116	.078	.172	12.0	15.0	6	236.4	0.04	16	3.7
171	1571-22	Shabankareh	4	24/1/96	0.28	.080	.152	.499	18.0	22.0	3.5	140.9	0.04	16	4.0
172	1571-23	Shabankareh	4	24/1/96	0.28	.109	.151	.163	15.0	20.0	6	167.4	0.03	16	3.6
173	1571-24	Shabankareh	4	24/1/96	0.28	.109	.035	.083	9.0	11.0	4	197.3	0.035	20	4.0
174	1571-25	Shabankareh	4	24/1/96	0.28	.199	.145	.260	15.0	19.0	3.5	110.1	0.025	20	3.9
175	1571-4	Shabankareh	4	24/1/96	0.44	.082	.164	.342	15.0	18.0	5	171.1	0.02	17	3.7
176	1571-5	Shabankareh	4	24/1/96	0.47	.121	.134	.380	12.0	18.0	4	120.8	0.03	16	3.8
177	1571-6	Shabankareh	4	24/1/96	0.47	.100	.166	.246	15.0	18.0	4	80.5	0.02	16	3.7
178	1571-7	Shabankareh	4	24/1/96	0.47	.199	.267	.632	15.0	20.0	4	768.	0.04	17	3.9
179	1571-9	Shabankareh	4	24/1/96	0.52	.083	.064	.179	11.0	15.0	4	64.2	0.015	17	3.7
180	1583-5	Saadabad	1	24/1/96	0.25	.227	.046	.215	20.0	22.0	2.5	96.1	0.03	22	4.2
181	1583-6	Saadabad	1	24/1/96	0.25	.152	.092	.172	18.0	18.0	3.5	186.7	0.035	25	4.1
182	1571-26	Shabankareh	4	25/1/96	0.28	.236	.270	.811	20.0	25.0	4	201.3	0.04	20	4.0
183	1571-27	Shabankareh	4	25/1/96	0.28	.089	.096	.121	11.0	15.0	6	236.4	0.035	20	3.7
184	1571-28	Shabankareh	4	25/1/96	0.28	.213	.187	.277	12.0	15.0	5.5	362.2	0.06	20	3.9
185	1571-29	Shabankareh	4	25/1/96	0.28	.214	.144	.237	11.0	19.0	5.5	280.9	0.08	20	4.0
186	1571-31	Shabankareh	4	25/1/96	0.28	.043	.093	.135	13.0	20.0	4	50.3	0.01	20	3.6
187	1571-33	Shabankareh	4	26/1/96	0.28	.951	.787	1.771	11.0	17.0	5.5	182.1	0.025	20	3.7
188	1571-36	Shabankareh	4	26/1/96	0.28	.045	.061	.140	12.0	16.0	5.5	128.9	0.025	15	3.6
189	1701-1	Ardebil	4	28/2/97	0.15	1.639	.599	1.201	6.0	11.0	0.4	69.2	0.8	32	6.3

Chapitre 5

Durée et Énergie des Mouvements Forts

Résumé Ce chapitre est consacré a l'etude de différents paramètres "énergétiques", c'est à dire liés à l'énergie vehiculée par les accélérogrammes (durée, accélération moyenne quadratique, "énergie"). Comme dans les autres chapitres, une distinction est faite entre Zagros et le reste de l'Iran, et la dépendance de chacun de ces paramètres en fonction de la magnitude, de la distance et des conditions de site est precisée grâce à des régressions. L'influence de ces dernières est d'ailleur trouvée très faible, surtout pour la durée.

Duration and Energy Content of the Strong Motions in Iran

Mehdi Zaré , Pierre-Yves Bard and Mohsen Ghafory-Ashtiany

Article summis au "Journal of Earthquake Engineering"

Abstract The energy content and the strong motion duration are studied in Iran. Several parameter [root mean square acceleration, a_{rms}, the "energy of acceleration", e_a, proportional to Arias Intensity, and strong motions duration] are calculated for a data-base of 468 three component accelerograms, all recorded during the last 24 years in Iran. Empirical relationships are established for the strong motion duration, as a function of e_a, PGA on one side, and moment magnitude and hypocentral distances on the others. The dependence of e_a and a_{rms} with magnitude and distance is studied as well. Investigations on the possible influence of site conditions on the duration, did not point out any significant dependence in this regard. The probable trends in the results of Zagros region may be studied with more percise data. For such trends, there is no more explanation with this quantity of the data.

5.1 Introduction

The strong motion network in Iran has provided a significant amount of records from various regions of the country for the last 24 years. This network was equipped first with Kinemetrics SMA-1 analog instruments (1975) which have been gradually replaced and densified with SSA-2 digital instruments after the Manjil earthquake of 1990, M_w7.4, in NW Iran. The number of installed instruments in this network was reported to be about 1000 stations by the end of 1997. The stations have been mainly chosen within the cities or villages for an easy maintenance. A

listing of these data is published by BHRC, the organism that maintains this network presently in Iran (BHRC 1993).

The scope of this study is to investigate the energy content of Iranian data, and to derive empirical relationships for the energy-related parameters: strong motion duration, e_a and a_{rms}. The data-set used in this study, already presented in Bard et al. (1998), Zaré et al. (1999b), consists of 468 three component records. The source parameters were derived from teleseismic records for 190 events (279 recordings) (Bard et al 1998), while moment magnitudes and hypocentral distances were derived from the strong motion data themselves for 185 events (189 records) (Zaré et al 1999b).

The methodology of the study is explained first. The seismogenic zones in Iran, in view point of the strong motions, are detailed. The relationships for the energy content and duration are discussed. The empirical attenuation relationships are established and presented for the duration, e_a and a_{rms}.

5.2 Seismogenic zones in Iran and site conditions

The seismotectonics of Iran was first investigated by Nabavi (1976), Berberian (1976, 1977, 1981, ...etc), and more recently in the seismotectonic reports after each destructive earthquake in Iran (i.e. Zaré 1995, Zaré 1997). The main seismogenic zones in Iran are distinguished based on tectonic and neotectonic factors. To define such seismotectonic zones, it is necessary to have sufficient neotectonic diagnosis as well as the seismic source data. Previous works are mostly concentrated on studies on focal mechanisms and focal depths, as well as on seismicity studies (Ambraseys and Melville 1982, Jackson and McKenzie 1984, Berberian 1995, ... etc).

Some differences in seismicity rates are obvious at least between the two regions of Iran: Zagros in SW and west, and Alborz-Central Iran, in the center, north and east (Figure 5.1). The Zagros thrust fault zone is the main geologic frontier between the Zagros and the rest of the country (mainly Central Iran). The time of the event, the distance to source and the exact timing on the digital records (if accessible) were the criteria to attribute each record to the seismic events in these zones. The pre-existing seismic data from Zagros area shows higher seismic activity rate than the other regions. In this area the middle range magnitudes (M4-6) are more frequent (Figure 5.2). In Alborz-Central Iran zone, the earthquake are less frequent with higher magnitudes than Zagros (Figure 5.2), and more destructive. The Tabas earthquake of (1978, M_w7.4, Central-Iran) and Manjil earthquake (1990, M_w7.3, Alborz belt) are examples of such destructive events. Most of the focal mechanisms in Iran (in Zagros and in other regions) are compressional and strike slip (Bard et al 1998) in relation with the local plate tectonics context.

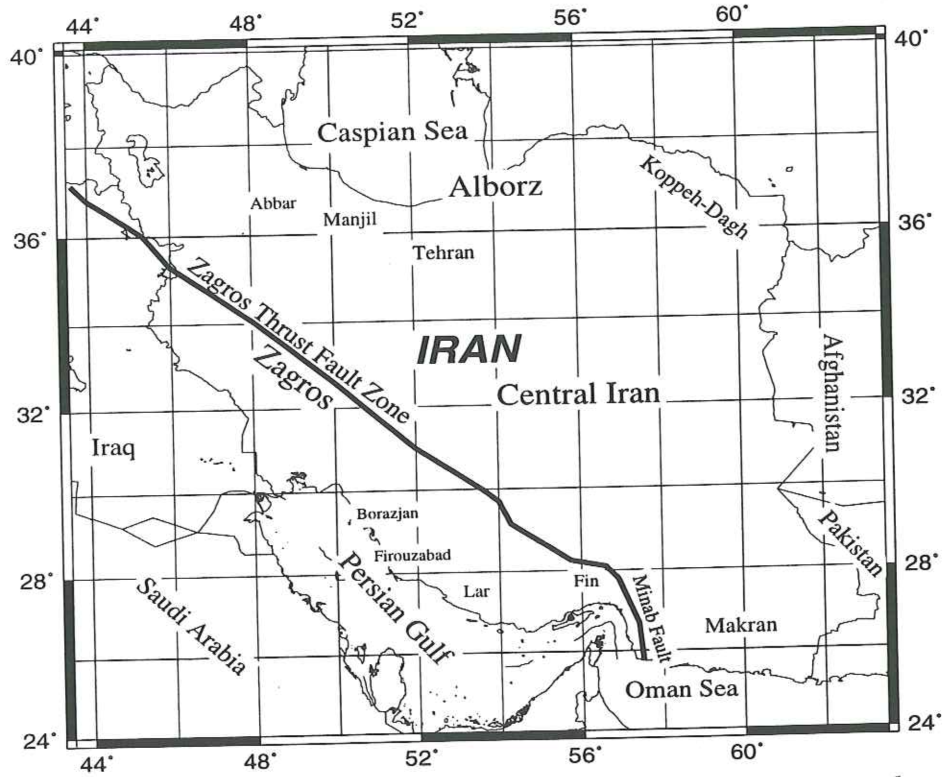

FIG. 5.1 – *The studied area; the regions discussed in the text are shown.*

The accelerometric data-base of Iran (Bard et al 1998) is not homogeneous; most of the data are recorded in Zagros, but no record exists from Makran (due to the lack of important earthquake in the last decades, and where few stations have been installed). The reasons for the fewer stations in this region were the sparse population in Makran region. Since the most destructive earthquakes have shocked the Alborz and Central-Iran region, the most distant records are obtained in these two regions (Figure 5.2).

The site conditions for the Iranian strong motions have already been studied (Zaré et al 1999a). Site class 1 is defined as sites that do not exhibit any significant amplification below 15 Hz. It corresponds to rock and stiff sediment sites with an average S-wave velocity over the top 30 meters in excess of 700m/sec. Site class 2 is determined as sites for which the receiver function (RF) exhibits a fundamental peak exceeding 3 at a frequency located between 5 and 15 Hz. It was shown to correspond to stiff sediments and/or soft rocks with V_{s30} between 500 and 700 m/sec. Site class 3 is defined as sites for which RF shows peaks exceeding 3 between 2 and 5Hz, and corresponds to alluvial sites with V_{s30} between 300 and 500 m/sec. Finally site class 4

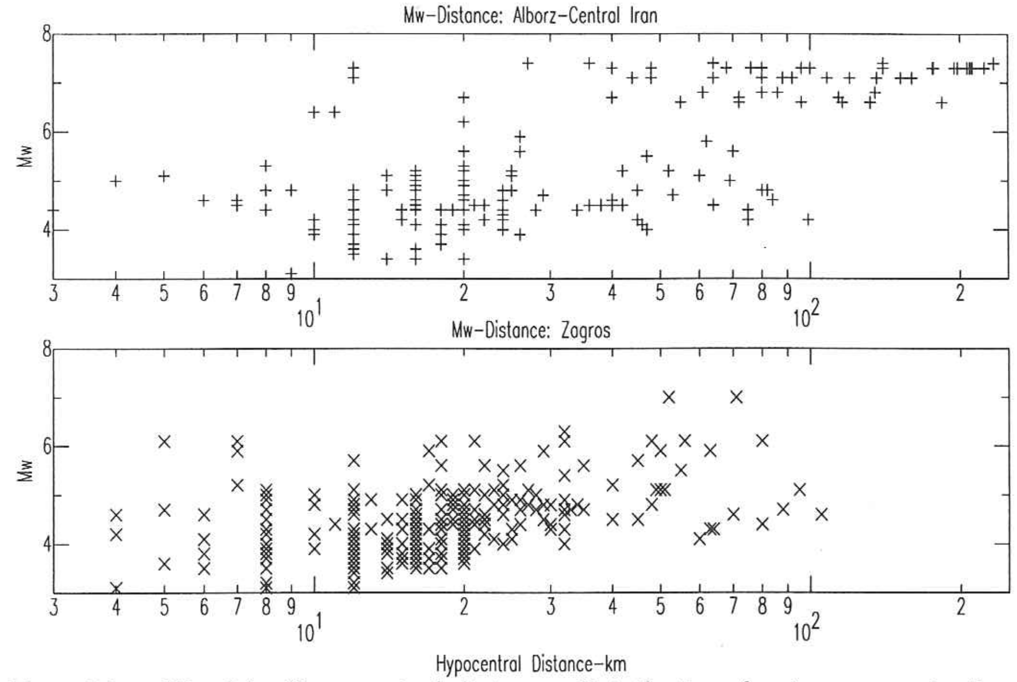

FIG. 5.2 – *The M_w-Hypocentral distance distribution for two areas in Iran.*

is defined as sites for which RF exhibits a fundamental peak exeeding 3 below 2Hz, and it may be viewed as corresponding to thick soft alluvium. This ranking was the result of geotechnical measurements on 24 sites (compressional and shear wave velocity and microtremors) and the calculation of the receiver function using the three component accelerograms.

5.3 Methodology

The duration of strong motions is defined in different ways. Some authors have used the "bracketed duration" (Bullen and Bolt 1985), which is the elapsed time window between the first and last acceleration excursions greater than a given level (i.e. 0.05g) (Page et al 1975). Another known definition in the earthquake engineering literature is the "cumulative duration" (Bullen and Bolt 1985), which is based on the concept of the cumulative energy obtained by integrating the squared accelerations. In this concept, duration is the time interval required to accumulate a predefined fraction of total energy (95% for Husid et al.,1969; 90% for Trifunac and Brady, 1975; and 70% for some other authors). Trifunac and Brady (1975) take the part between of 5% and 95% of total energy.

The Fourier amplitude spectra (A_ω) of an acceleration time-history, $a(t)$, is the absolute value of the Fourier transform of $a(t)$ (Vanmarke and Lai 1980);

$$A_\omega = | \int_{-\infty}^{+\infty} a(t)e^{-i\omega t}dt| = | \int_0^{t_0} a(t)e^{-i\omega t}dt|$$

ω is the angular frequency in rad/sec, $i = \sqrt{-1}$ and t_0 is the length of the accelerogram (sec). To explain how the total strong motion energy is distributed over frequency, one may use the squared Fourier amplitude spectrum, $A^2(\omega)$. The integral of $A^2(\omega)$ over the frequencies is a representative for the total strong motion "energy", related to the Arias intensity, I_0 [Arias 1970]. This parameter shows the total energy per unit mass for the entire acceleration record for all single degree of freedom oscillators;

$$I_0 = \frac{\pi}{2g} \int_0^{t_0} a^2(t)dt$$

We have considered here a related formulation:

$$e_a = \int_0^{t_0} a^2(t)dt = \int_{-\infty}^{+\infty} a^2(t)dt = \frac{1}{2\pi} \int_{-\infty}^{+\infty} A^2(\omega)d(\omega) = \frac{1}{\pi} \int_0^{\infty} A^2(\omega)d(\omega)$$

In this article, we name this quality the "energy of acceleration" (e_a):

$$e_a = \int_0^{t_0} a^2(t)dt$$

a_{rms} is the square root of the average of the squared ordinates for a given duration, t2-t1, (Udwadia and Trifunac 1974):

$$a_{rms} = \left(\frac{1}{t_2-t_1} \int_{t_1}^{t_2} a^2(t)dt\right)^{\frac{1}{2}}$$

$$a_{rms} = \sqrt{\frac{\Sigma e_a}{t_2-t_1}}$$

McCann and Shah (1979) have defined an evolutionary RMS function (CRF), which represents the average rate of energy as a function of time:

$$CRF(t) = \left(\frac{1}{t} \int_0^t a^2(t)dt\right)^{\frac{1}{2}}$$

CRF allows another definition of duration, (the end of the signal is the time after which CRF(t) decreases).

The cumulative integral of squared acceleration for a record of Manjil earthquake (M_w7.3, 20 June 1990, hypocentral distance= 40km) obtained at Abbar (site class: rock, Figure 5.1) is shown in Figure 5.3. This record is obtained in Alborz ranges in northern Iran. The duration for this time-history (taking to account the intervals of 5% to 95%) are 31.92 and 35.06 for the horizontals and 35.96 for vertical component, respectively. These values are 8.64 and 20.68 for horizontals and 13.52 for vertical components, respectively, applying the intervals of 5% to 75%.

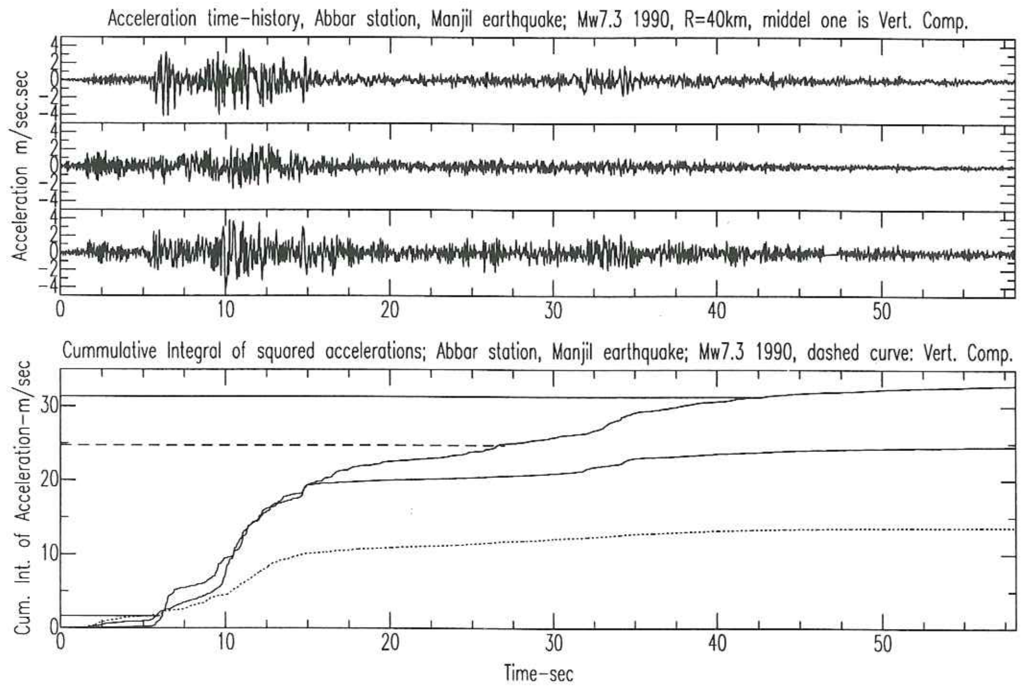

FIG. 5.3 – *The time-history of the acceleration (up) and the cumulative integral of squared acceleration (down), for the Abbar record (Manjil, Iran earthquake of 20 June 1990, M_w7.3). The lines show the 5% and 95% limits, and a dashed line shows the 75% limit for the horizontal component that has the highest values. The vertical component is shown by dotted line as well.*

Vanmarke and Lai (1980) have proposed an approximate relationship between the a_{rms} and PGA based on the random vibration theory:

$$r = \frac{a_{max}}{a_{rms}} \tag{5.1}$$

with T_0 for the strong motion durtion and Having

$$e_a = \frac{T_0 \cdot a_{rms}^2}{0.90} \tag{5.2}$$

with an approximation we have:

$$e_a \approx T_0 \cdot a_{rms}^2 \tag{5.3}$$

With (5.1) and (5.2), we have:

$$T_0 = r^2 \cdot \frac{e_a}{a_{max}^2} \tag{5.4}$$

We therefore computed the ratio $\frac{e_a}{a_{max}^2}$ for all our records, and investigated its relationship with the actual strong motion duration, T_0. We have studied as well the dependence of T_0, e_a and a_{rms} as a function of the magnitude and distance.

5.4 Results

The results of our calculations are presented in a Table in Appendix 5.1. For each component of the records the values of e_a, strong motion duration $T-0$ and a_{rms}, are given based on the definition of Udwadia and Trifunac (1974) (5%-75%), and Trifunac and Brady (1975) (5% to 95%).

5.4.1 Comparison of Strong Motion Intervals: 5%-95% and 5%-75%

The different intervals of 5% to 95% and 5% to 75% are examined in this study. The general tendency is that: the a_{rms} values calculated for 5% to 75% intervals, are equal to or larger than a_{rms} obtained by 5% to 95% intervals (Appendix 5.1).

The relationship for a_{rms} and the duration values calculated by these two intervals are shown in Figures 5.4 to 5.7. The linear relationship between a_{rms1} (5%-75%) and a_{rms2} (5%-95%) is

$$a_{rms1} = b \cdot a_{rms2} + \sigma \cdot P \tag{5.5}$$

where b is the coefficient, σ is standard deviation, P is the percentile index. The coefficients for the entire of the data-base are supplied in table 5.1:

Table 5.1: Result of the regression for relationship (5.5)

Data/comp.	b	R(Coef.Corr.)	Sigma
Iranian data (Vert. comp)	1.124	0.981	0.0014
Iranian data (Hori. comp)	1.375	0.981	0.0020

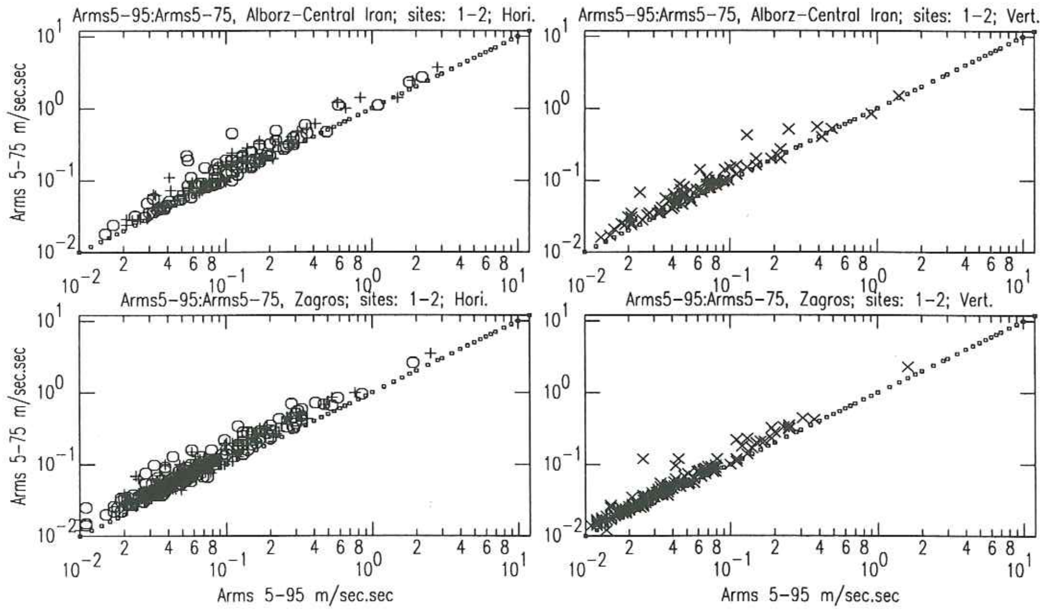

FIG. 5.4 – *The a_{rms} values calculated for different intervals are plotted against each other; site classes 1 and 2, for two areas; two different symbols in the left side figures stand for two horizontal components (Alborz-Central-Iran top, Zagros bottom).*

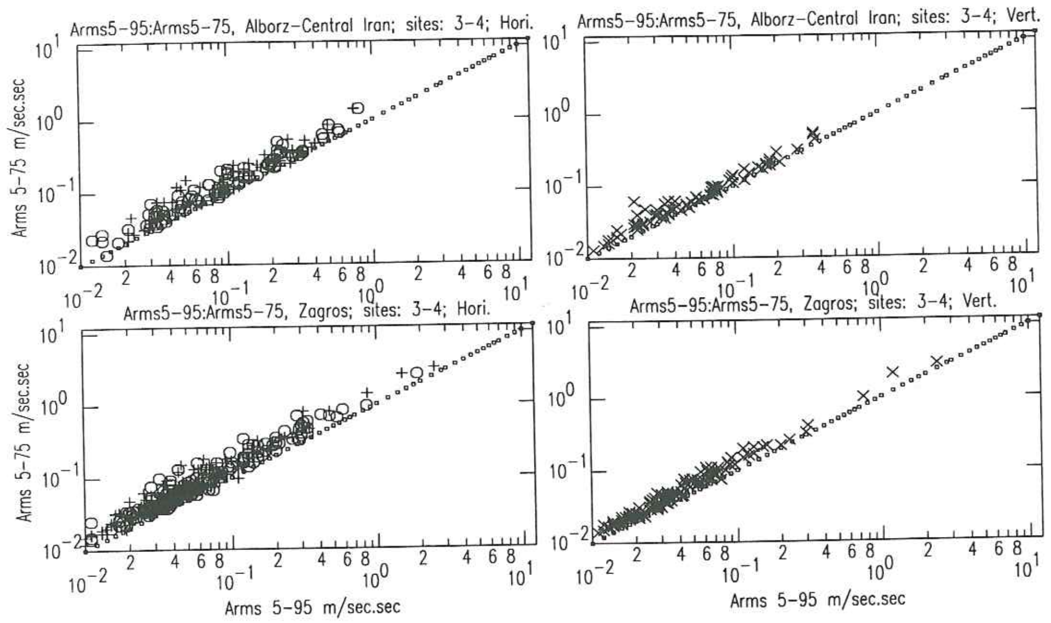

FIG. 5.5 – *The a_{rms} values calculated for different intervals are plotted against each other; site classes 3 and 4, for two areas; two different symbol in the left side figures stand for two horizontal components (Alborz-Central-Iran top, Zagros bottom).*

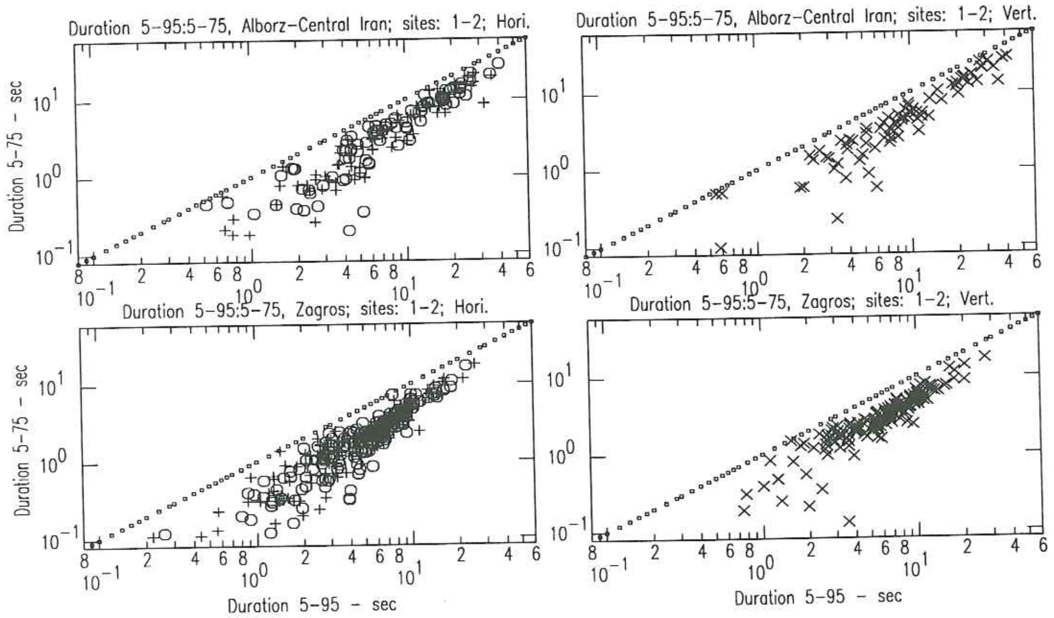

FIG. 5.6 – *The strong motion duration values calculated for different intervals are plotted against each other; site classes 1 and 2, for two areas; two different symbol in the left side figures stand for two horizontal components (Alborz-Central-Iran top, Zagros bottom).*

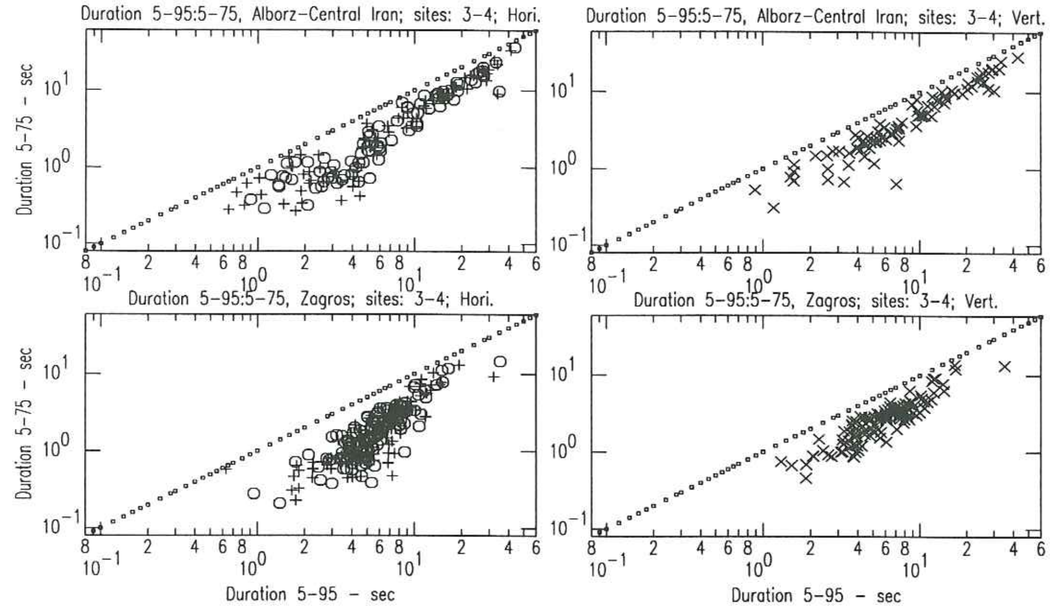

FIG. 5.7 – *The strong motion duration values calculated for different intervals are plotted against each other; site classes 3 and 4, for two areas; two different symbol in the left side figures stand for two horizontal components (Alborz-Central-Iran top, Zagros bottom).*

The linear relationship for the durations estimated for 5%-75% intervals (T_{01}: 5-75) and 5%-95% intervals (T_{02}: 5-95) may be shown in similar way;

$$T_{01} = b \cdot T_{02} + \sigma \cdot P \tag{5.6}$$

The results for such relationship using the entire of the Iranian data are given in table 5.2:

Table 5.2: Result of the regression for relationship (5.6)

Data/comp.	b	R(Coef.Corr.)	Sigma
Iranian data (Vert. comp)	0.578	0.984	1.460
Iranian data (Hori. comp)	0.541	0.927	1.558

In this study, as the differences in data (grouped in four sites classes) were not very clear for a_{rms} and duration estimations, the data are regrouped in two groups; group 1 which represent the original site classes of 1 and 2, and the group 2 replaced the site classes 3 and 4. The comparison of the duration for group 1 (classes 1-2) and group 2 (classes 3-4) is shown in Figures 5.4 and 5.5 for Zagros and Alborz-Central Iran region. The duration estimations for site group 2 in Alborz-Central Iran are found in the range of 0.8 to 40 seconds, while in the Zagros region the durations are calculated in the range of 2 to 12 seconds (Figure 5.5). The relationship between the a_{rms} estimations with the two intervals, for the site groups 1 and 2, for Zagros and Alborz-Central Iran regions, are shown in Figures 5.6 and 5.7.

5.4.2 Empirical Relationships for the Strong Motion Duration in Iran

The duration is one of the most important strong motion parameters. Several researchers have declared that the duration and the energy content of the strong motions may reveal the seismic performance of the structures (Jeong and Iwan 1988, Uang and Bertero 1990). Recent developments in different countries provide the possibility to examine the different method to define such parameters using different catalogues (Koliopoulos et 1998).

Attenuation of Duration

To investigate the dependence of duration with M_w and hypocentral distance, a linear model is first considered. A one-step method is applied, in which all the parameters are determined simultaneously by maximizing the likelihood of the set of observations. This approach, which is used by Joyner and Boore (1993) and Brillinger and Preisler (1984, 1985), led to results comparable with the two-step method (Boore et al 1994). The two-step method is used further in this article to find the attenuation of a_{rms} and ea.

All of the duration values are plotted against M_w and hypocentral distances in Figure 5.8. These data similarly shown in Figures 5.9 and 5.10 for the two different geographycal zones (Zagros, Alborz-Central Iran) and the two site groups, against M_w and hypocentral distances, respectively. Such a relationship was already proposed by Trifunac and Brady (1975) as;

$$T_0 = a \cdot M_w + b \cdot X + \sigma \cdot P \quad (5.7)$$

where X is the hypocentral distance in kilometers. The results of the regression using relationship (5.7) are presented in Table 5.3. The residuals of the predicted T_0 values by (5.7) are shown in Figures 5.11 and 5.12 against hypocentral distance and M_w, respectively.

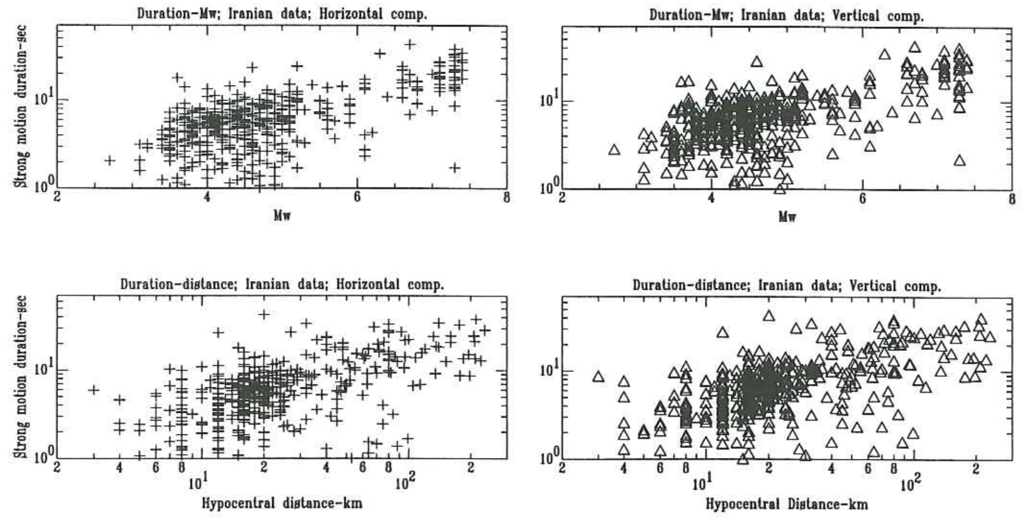

FIG. 5.8 – *Distribution of duration values against M_w (top) and Hypocentral Distances (bottom) for entire data of Iran.*

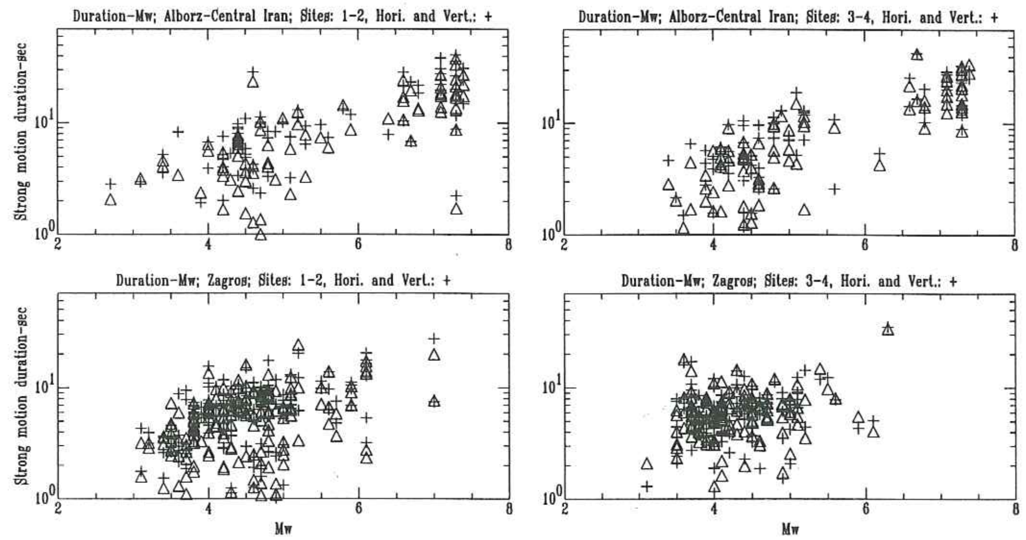

FIG. 5.9 – *Distribution of duration values against M_w for two areas. (triangles for horizontal and crosses for vertical components), left; site group 1, right; site group 2, Alborz-Central Iran; bottom*

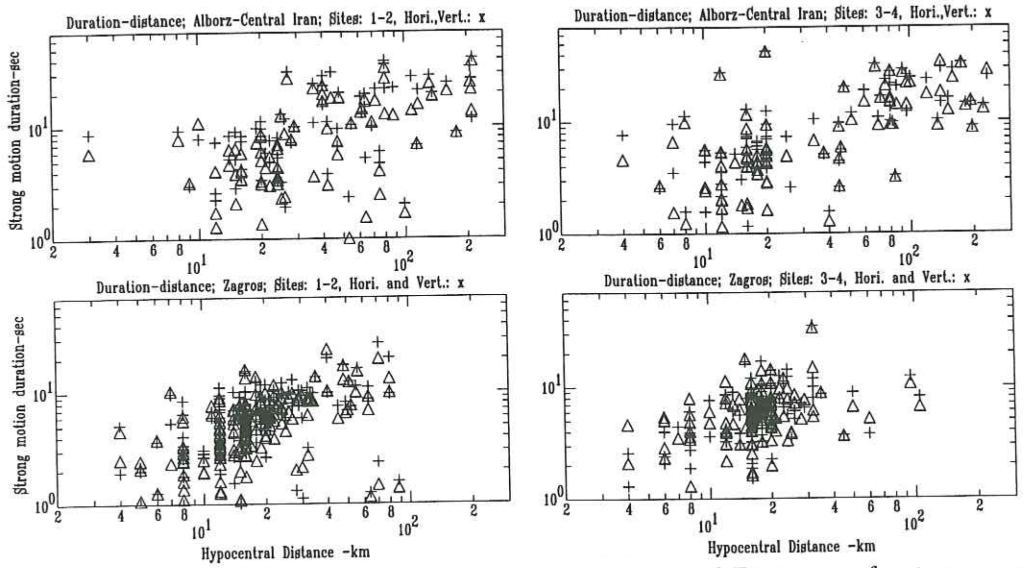

FIG. 5.10 – *Distribution of duration values against hypocentral Distances for two areas.(triangles for horizontal and crosses for vertical components), left; site group 1, right; site group 2, Alborz-Central Iran; bottom*

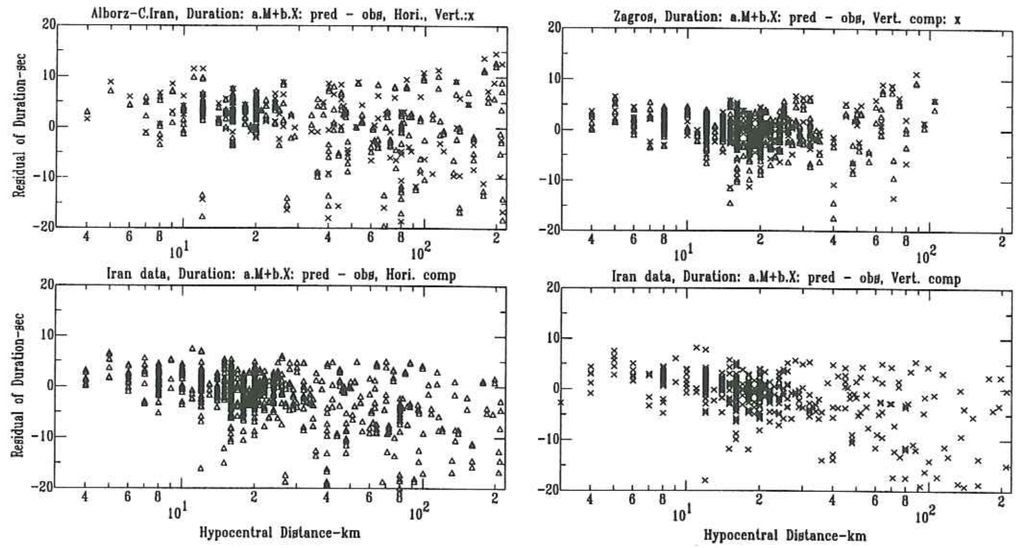

FIG. 5.11 – *Residual of the predicted duration values (obtained by relationship 5.7), against hypocentral distances, in Alborz-Central Iran, Zagros and entire of the data base. Horizontal and vertical components are considered. (triangles for horizontal and crosses for vertical components)*

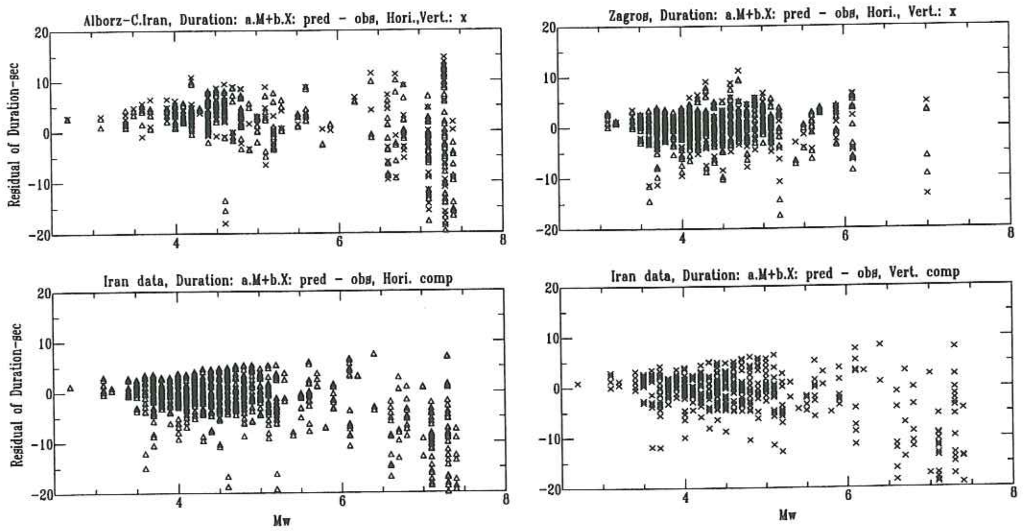

FIG. 5.12 – *Residual of the predicted duration values (obtained by relationship 5.7), against M_w, in Alborz-Central Iran, Zagros and entire of the data base; the horizontal and vertical components are considered. (triangles for horizontal and crosses for vertical components)*

Table 5.3: Result of the regression for relationship (5.7)

Region/comp.	a	b	R(Coef. Corr.)	Sigma
Central Iran, Alborz (Vert.)	1.799	0.053	0.622	5.024
Central Iran, Alborz (Hori.)	1.477	0.052	0.651	6.760
Zagros (Vertical comp.)	1.140	0.084	0.484	3.453
Zagros (Horizontal comp.)	1.085	0.064	0.425	3.326
Iranian data (Vertical)	1.356	0.073	0.676	5.056
Iranian data (Horizontal)	1.181	0.065	0.653	4.730

A slihtly different form of the distance-magnitude relationship was also tried, corresponsing to formula 5.8, where the $\log T_0$ and $\log X$ are replacing the linear terms of 5.7:

$$\log T_0 = a \cdot M_w + b \cdot \log X + \sigma \cdot P \tag{5.8}$$

The coefficients using this equation are presented in table-5.4:

Table 5.4: Result of the regression for relationship (5.8)

Region/comp.	a	b	R(Coef. Corr.)	10^{Sigma}
Central Iran, Alborz (Vert.)	0.111	0.217	0.693	0.277
Central Iran, Alborz (Hori.)	0.097	0.202	0.615	0.338
Zagros (Vertical comp.)	0.046	0.445	0.488	0.219
Zagros (Horizontal comp.)	0.047	0.404	0.410	0.240
Iranian data (Vertical)	0.080	0.323	0.705	0.287
Iranian data (Horizontal)	0.071	0.304	0.637	0.287

The residuals of the $\log T_0$ predicted values by 5.8 are presented in Figures 5.13 and 5.14, against distance and M_w, respectively. These results reveal that the Alborz-Central Iran data are more sensible to the variation of the magnitudes, where the Zagros data show more sensibility to the hypocentral distances.

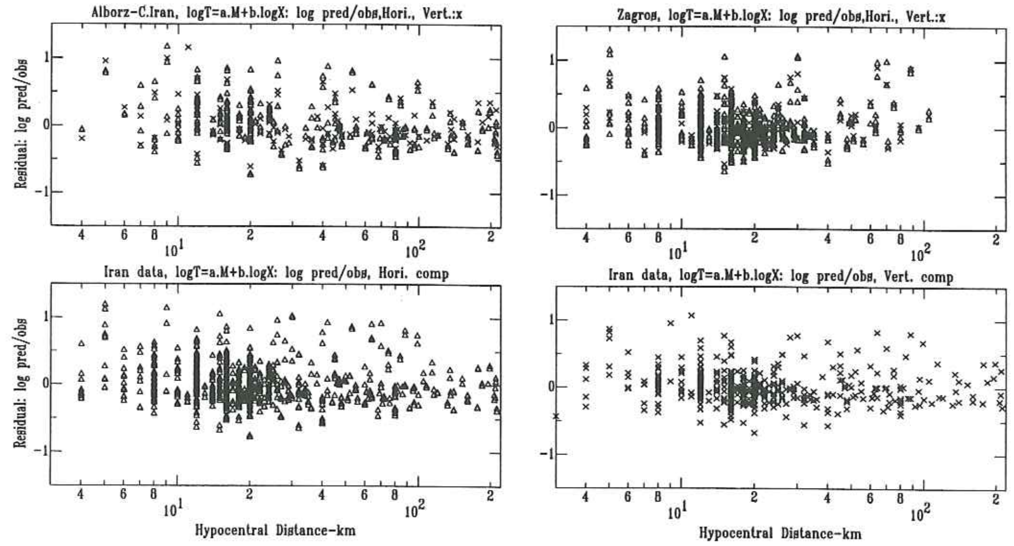

FIG. 5.13 – *The residual of the predicted duration values (obtained by relationship 5.8), against hypocentral distances, in Alborz-Central Iran, Zagros and entire of the data base; the horizontal and vertical components are determined. triangles for horizontal and crosses for vertical components*

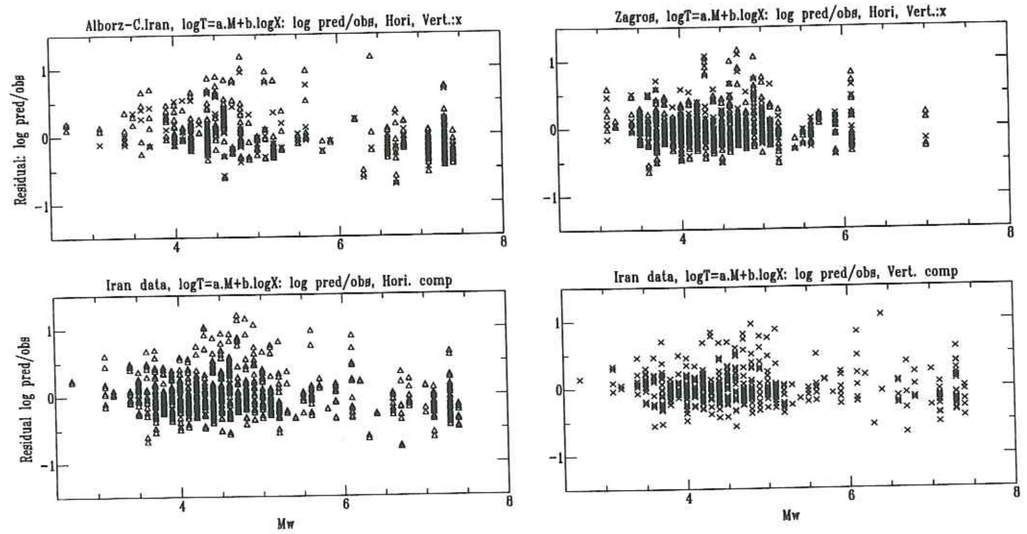

FIG. 5.14 – *The residual of the predicted duration values (obtained by relationship 5.8), against M_w, in Alborz-Central Iran, Zagros and entire of the data base; the horizontal and vertical components are determined. (triangles for horizontal and crosses for vertical components)*

As it can be seen in Figure 5.10, the distribution of the duration values against 'distances' are not similar in Zagros and Alborz-Central Iran areas; most of the data in the former area are found at short distances (0 to 50 km). This difference comes from the occurrence of the higher magnitude data in Alborz-Central Iran region. Most of the Alborz-Central Iran data are recorded using the analog, Kinemetrics SMA-1 instruments, in which the sensibility of the triggering is obviously lower than that of the digital SSA-2 recorders (the instruments that have recorded most of the Zagros data). Hence, it seems that the duration of the strong motions in Alborz-Central Iran area might be systematically under-estimated; because most of the Zagros records are triggered with weaker motions and maybe the instrument have started sooner and stopped later than that might be found with a analog instrument. Therefore, the same regression for relationship (5.8) has been repeated on Alborz-Central Iran data, using only data obtained within 50km, which are representative for the damaging earthquakes (Figure 5.15). The results are shown in Table 5.5;

Table 5.5: Result of the regression for relationship (5.8) for the first 50km (Hypo. Distance)

Region/comp.	a	b	R(Coef. Corr.)	Sigma
Central Iran, Alborz (Vert.)	0.103	0.216	0.505	0.300
Central Iran, Alborz (Hori.)	0.097	0.145	0.392	0.363
Zagros (Vertical comp.)	0.009	0.590	0.489	0.202
Zagros (Horizontal comp.)	0.013	0.536	0.416	0.227
Iranian data (Vertical)	0.010	0.512	0.682	0.234
Iranian data (Horizontal)	0.011	0.552	0.697	0.285

These results indicate slightly lower standard deviation for Zagros and entire of the database, while the coefficient of correlation decreasing for all regions, in comparison with the values in table 5.4 (for all distances). The residuals of $\log T_0$ for the predictions in the first 50km are shown in Figures 5.16 and 5.17.

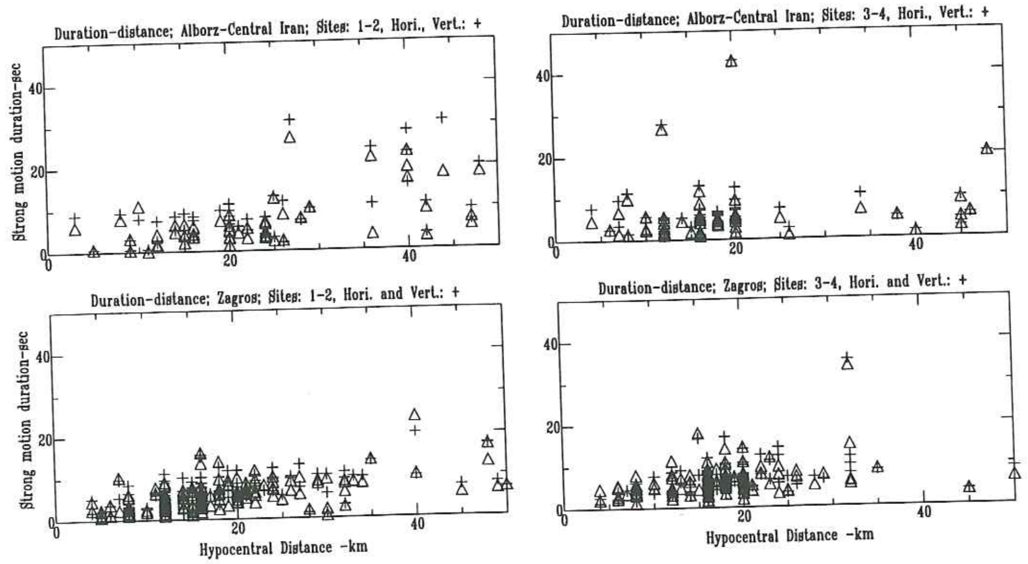

FIG. 5.15 – *Distribution of duration values against the hypocentral distances (below 50km) for two areas in Iran. (triangles for horizontal and crosses for vertical components)*

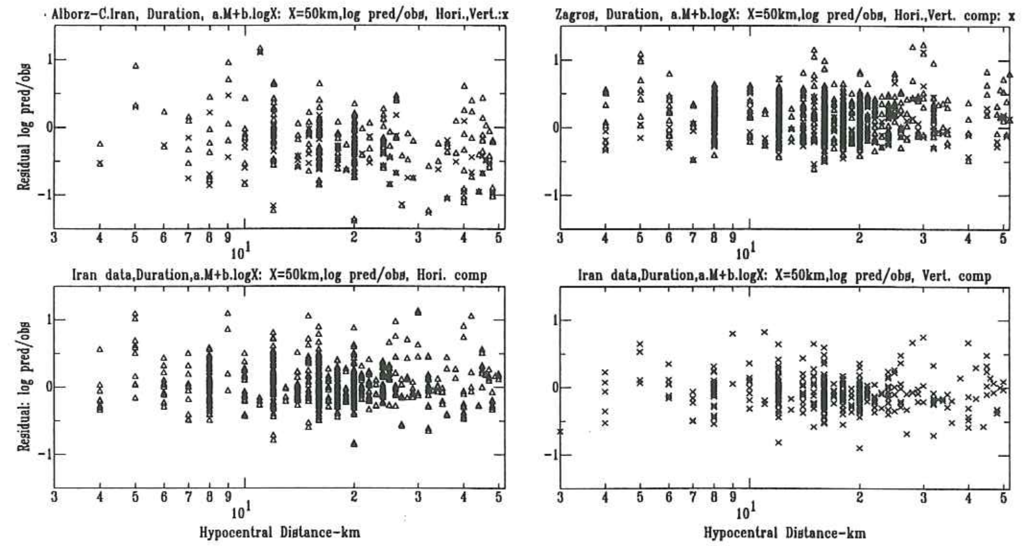

FIG. 5.16 – *Residual of the predicted duration values (obtained by relationship (5.8) for first 50km distances), against hypocentral distances, in Alborz-Central Iran, Zagros and entire of the data base; the horizontal and vertical components are considered. (triangles for horizontal and crosses for vertical components)*

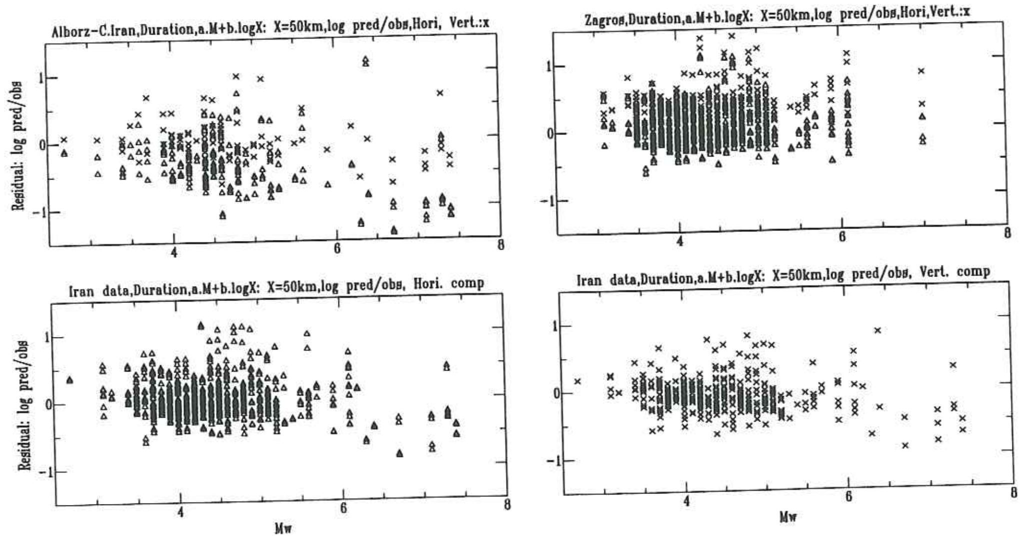

FIG. 5.17 – *The residual of the predicted duration values (obtained by relationship (5.8) for first 50km distances), against M_w, in Alborz-Central Iran, Zagros and entire of the data base; the horizontal and vertical components are determined . (triangles for horizontal and crosses for vertical components)*

Duration - energy relationship

The relationship between the duration (measured with the 95% interval) are plotted against the ratio of $\frac{e_a}{a_{max}^2}$ in Figures 5.18 to 5.20. The data for all sites are separated for Zagros and Alborz-Central Iran in Figure 5.18.

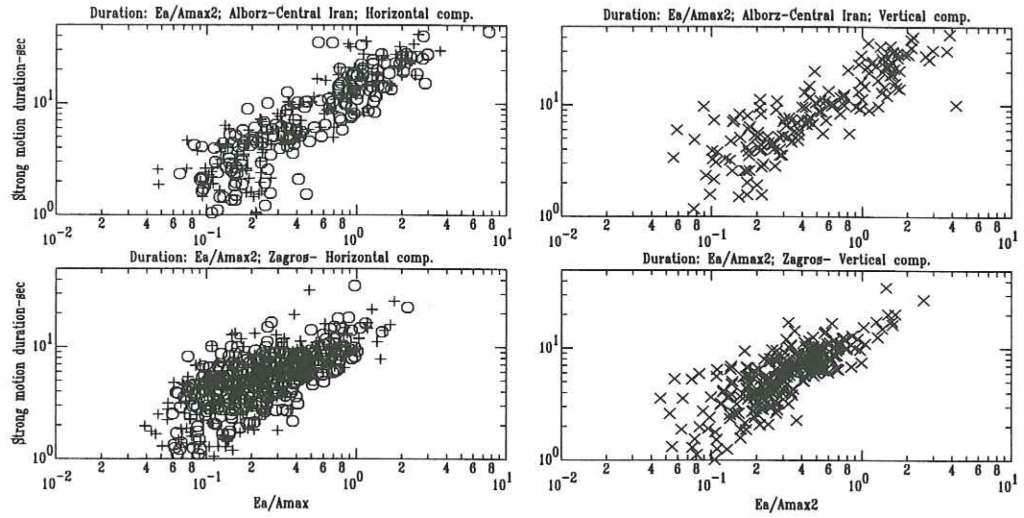

FIG. 5.18 – *Strong motion duration, against $\frac{e_a}{a_{max}^2}$ for two areas in Iran. (two horizontal components; left, and the vertical component; right, Alborz-Central Iran; top, Zagros; bottom, are distiguished)*

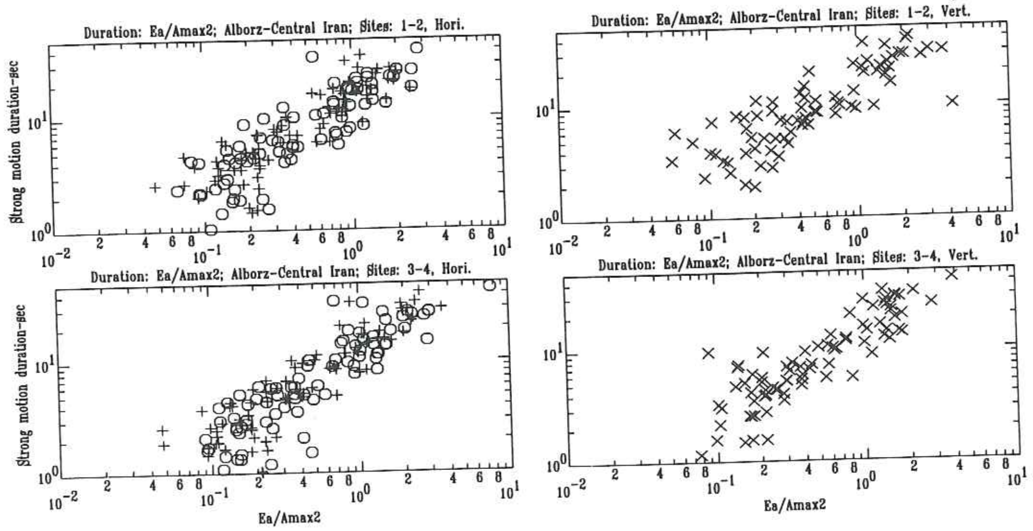

FIG. 5.19 – *Strong motion duration, against $\frac{e_a}{a^2_{max}}$ for two site groups, in Central Iran, Alborz area. (two horizontal components; left, and the vertical component; right, site group 1; top, site group 2; bottom, are distiguished)*

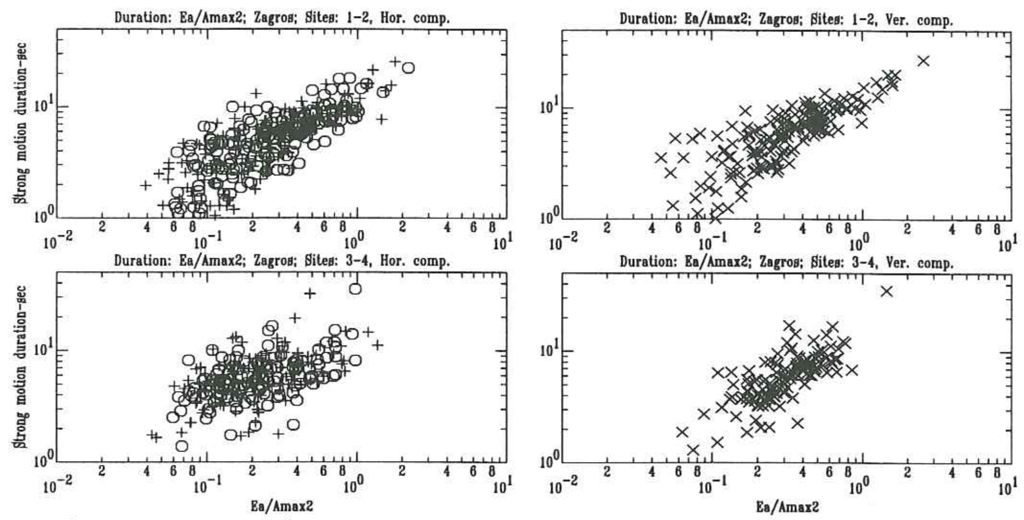

FIG. 5.20 – *Strong motion duration, against $\frac{e_a}{a^2_{max}}$ for two site groups, in Zagros area. (two horizontal components; left, and the vertical component; right, are distiguished)*

To establish empirical relationships for the duration, the dependence of the duration is first studied as a function of $\frac{e_a}{a^2_{max}}$, as well as the M_w and hypocentral distances. In all of established relationships, it is tried to find the formula with the best fit to the data. It must be mentioned that since no systematic important differnce in view point of the site effect was found on the other parameters discussed here, the site factor is eliminated from our duration relationships.

In the following empirical relationships, the interval of 5%-95% is used to establish the empirical relationships.

The relationship 5.3 may be written as;

$$T_0 = A \cdot \left(\frac{e_a}{a^2_{max}}\right)^b$$

and taking the logarithm of the two sides of this relationship, we have;

$$\log T_0 = a + b \cdot \log\left(\frac{e_a}{a^2_{max}}\right) + \sigma \cdot P \tag{5.9}$$

σ is the standard deviation.

Using a one-step method, the regression is done in order to find the parameters a and b for the average of the horizontal components and the vertical component and for Zagros, Alborz-

Central Iran and entire of the data-base. For all of the regressions the correlation coefficient and the standard deviation are presented as well. The results for relationship 5.9, are shown in Table 5.6:

Table 5.6: Result of the regression for relationship 5.9

Region/comp.	a	b	R(Coef. Corr.)	Sigma
Central Iran, Alborz (Vert.)	1.165	0.746	0.827	0.204
Central Iran, Alborz (Hori.)	1.135	0.873	0.858	0.194
Zagros (Vertical comp.)	1.108	0.689	0.811	0.157
Zagros (Horizontal comp.)	1.078	0.603	0.703	0.186
Iranian data (Vertical)	1.140	0.730	0.843	0.176
Iranian data (Horizontal)	1.120	0.713	0.841	0.199

5.4.3 Attenuation of a_{rms} and e_a

The empirical attenuation relationships for a_{rms} and the energy of acceleration (e_a) are similarly obtained, applying a two-step regression, using the magnitude, distance and the site factors as the dependent variables. The method to establish such relationships for Iran was followed essentially after Joyner and Boore (1981) and Fukushma and Tanaka (1990). This method is used to fit a model to multiple independent variables (magnitude, distance, site,...). Hence, using this method, it is possible to do the regression for the dependence to magnitude and the dependence to distance, as well as the dependence to other terms, separately. In this method the parameters controlling distance and site effects dependence and a set of the amplitude factors, one for each event, must be determined in the first step, by maximizing the likelihood of the set of the observation. The determination of the parameters controlling the magnitude dependence is then performed in a second step, by maximizing the likelihood of the set of the amplitude factors (Joyner and Boore 1993). The applied formula is:

$$\log A = a \cdot M_w + b \cdot X - d \cdot \log X + c_i \cdot S_i + \sigma \cdot P \qquad (5.10)$$

where A is the strong motion parameter, a is the coefficient for moment magnitude; M_w, b is a coefficient related to anelastic attenuation, c_i is a constant which related to 4 site classes (Zaré et al 1999a), S_i. The d coefficient for the $logX$ term correspond to the geometrical expansion. This coefficient is fixed to 1 and 0.5 corresponding to pure body and surface waves, respectively.

The coefficients of the regression using the relationship 5.10 are presented in tables 5.7 and 5.8 for a_{rms} and e_a, respectively.

Table 5.7: The regression coefficients for a_{rms}, applying equation (5.10), with d=1.

Region/comp.	a	b	c1	c2	c3	c4	Sigma
Central Iran, Alborz (Vert.)	0.367	0.0008	-1.836	-1.821	-1.819	-1.785	0.328
Central Iran, Alborz (Hori.)	0.383	0.0010	-1.713	-1.610	-1.677	-1.727	0.350
Zagros (Vertical comp.)	0.438	-0.0036	-2.077	-2.116	-2.022	-1.997	0.352
Zagros (Horizontal comp.)	0.458	-0.0015	-1.992	-1.962	-1.971	-2.034	0.341
Iranian data (Vertical)	0.324	0.0010	-1.553	-1.420	-1.642	-1.514	0.350
Iranian data (Horizontal)	0.317	0.0011	-1.350	-1.081	-1.333	-1.244	0.401

Table 5.8: Regression coefficients for e_a, applying equation (5.10), with d=1

Region/comp.	a	b	c1	c2	c3	c4	Sigma
Central Iran, Alborz (Vert.)	0.848	-0.0040	-4.509	-4.501	-4.480	-4.359	0.572
Central Iran, Alborz (Hori.)	0.881	-0.0037	-4.353	-4.176	-4.236	-3.286	0.582
Zagros (Vertical comp.)	0.953	-0.0159	-4.777	-4.808	-4.643	-4.556	0.617
Zagros (Horizontal comp.)	0.982	-0.0113	-4.655	-4.543	-4.488	-4.635	0.586
Iranian data (Vertical)	0.802	-0.0036	-4.134	-4.093	-4.370	-4.069	0.591
Iranian data (Horizontal)	0.815	-0.0035	-3.963	-3.678	-3.986	-3.725	0.628

As it is evident from the c1 to c4 coefficients in tables 5.7 and 5.8, the site effects were not very important in these regressions. The attenuation of the estimated values using (5.10) with the coefficients of tables 5.7, estimated for magnitudes of 5, 6 and 7 events on the rock sites are shown in Figures 5.21 to 5.23, for Alborz-Central Iran, Zagros and entire of the data-base, respectively. The results show that taking d=1 (body waves attenuation) induce greater estimations for the near-source distances (less than 20km). Using d=0.5 (surface waves attenuation), larger values are obtained at distances more than 60km, for the Alborz-Central Iran and entire of the data-base; Figures 5.21 and 5.23). According to the lesser data for the greater distances and a conservative approach for the near field distance, it is suggested to use the coefficients with d=1 for e_a and a_{rms} . However special studies are recomanded for the near-field of the large magnitude events, using a deterministic approach on the records obtained in similar conditions.

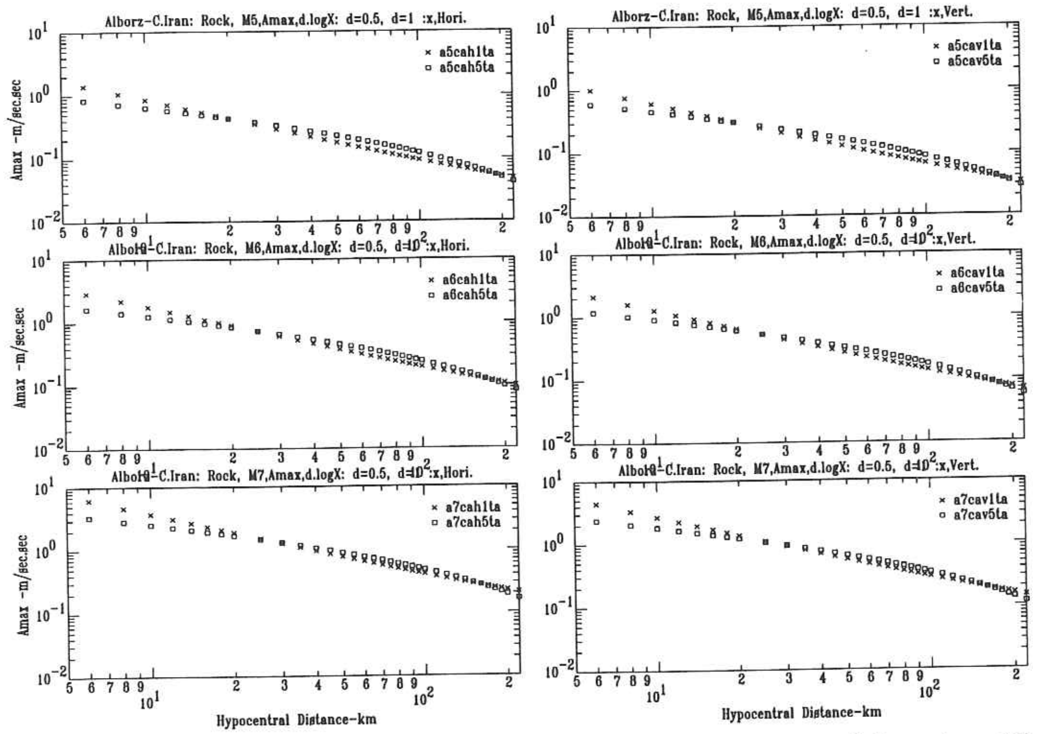

FIG. 5.21 – *Attenuation of a_{rms} with distance for magnitudes 5, 6 and 7, using Alborz-Central Iran data. The results are presented for different d values (quadrangles for d=0.5, and crosses for d=1.0); horizontal component, left; vertical component, right*

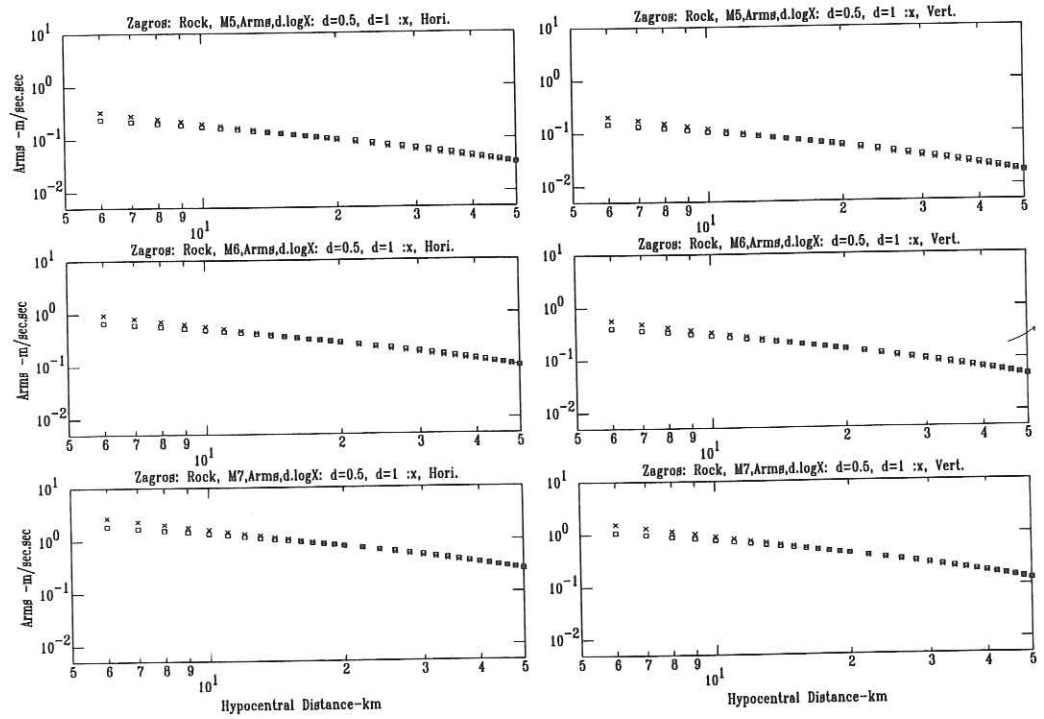

FIG. 5.22 – *Attenuation of a_{rms} with distance for magnitudes 5, 6 and 7, using Zagros data. The results are presented for different d values. (quadrangles for d=0.5, and crosses for d=1.0); horizontal component, left; vertical component, right*

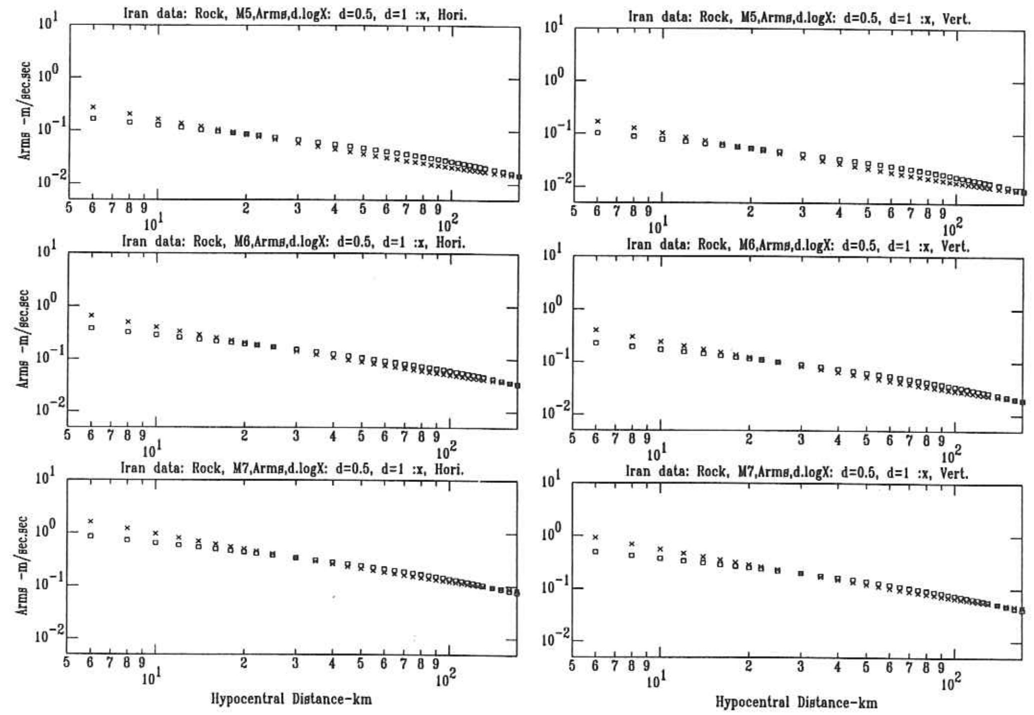

FIG. 5.23 – *Attenuation of a_{rms} with distance for magnitudes 5, 6 and 7, using Iranian database. The results are presented for different d values (quadrangles for d=0.5, and crosses for d=1.0); horizontal component, left; vertical component, right*

5.5 Conclusions

This article presented investigations on the energy content and the duration values on the Iranian strong motion data. The duration has been calculated using the cumulative integral of the acceleration values. All results are detailed in Appendix 5.1. The conclusions and the propositions for the further studies may be summarized as follows;

- The content of energy of the strong motions is different in Zagros area and the rest of the country). This difference comes partially from the difference in the seismicity rates in Zagros belt, or other reasons (comparing Figures 5.19 and 5.20).

- The Alborz-Central Iran region which represent the seismicity with greater earthquakes recorded in larger distances, shows higher duration.

- According to the distribution of the data which are sub-grouped to Zagros and Alborz-Central Iran groups, and since two probable trends may be assumed in Zagros data, more sophisticated studies may be carried out using higher quality data. Such studies may be followed using the local accelergraph networks to be installed in the high seismic zones (for instance the zones such as Firouzabad, Fin in north Bandarabbas, Lar in southern Fars province or Borazjan in the Bushehr province; Figure 5.1).

- No important influence of site conditions would be detected on duration values. It might come from 95% interval choice.

- The attenuation of a_{rms} and e_a show some differences in the estimations in the near and far source distances. The limits for the application of such relationship must be considered in the future: the attenuation coefficients for the Zagros area give proper results in the distances less than 50km, and for the Alborz-Central Iran region in the distances less than 200km. The entire of the data-base might be used in distances up to 170km. The magnitude limits are the $M_w3.0$ to $M_w7.4$ for Alborz-Central Iran and $M_w3.0$ to $M_w7.0$ for Zagros region.

Acknowledgement

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Appendix 5.1: The database of the duration/energy content study, developed for the Iranian strong motion and applied in this paper.

No	Record	Station	Site	Date	Mw	R km	Dur (H1) sec 5-95	Dur (V) sec 5-95	Dur (H2) sec 5-95	Arms (H1) m/s.s 5-95	Arms(V) m/s.s 5-95	Arms (H2) m/s.s 5 95	dur (H1) sec 5-75	dur (V) sec 5-75	dur (H2) sec 5-75	Arms (H1) m/s.s 5-75	Arms (V) m/s.s 5-75	Arms (H2) m/s.s 5-75	Ea (H1) m2/s3	Ea (V) m2/s3	Ea (H2) m2/s3
1	1012	Kiasar	2	05/11/74	4.5	64	1.53	5.22	1.56	.1400	.0320	.1200	.78	3.34	1.06	.1700	.0350	.1200	.0340	.0058	.0240
2	1006-1	Bandarabbas	2	07/03/75	6.1	48	15.04	20.25	11.38	.2300	.1100	.3300	7.10	13.76	5.82	.2900	.1200	.4100	.8700	.2900	1.400
3	1006-2	Bandarabbas	2	07/03/75	5.2	40	16.33	16.27	14.43	.0430	.0370	.0530	11.39	12.68	8.73	.0450	.0370	.0600	.0330	.0250	.0450
4	1007	Minab	1	07/03/75	6.1	80	16.02	17.51	18.23	.0410	.0260	.0350	10.35	11.39	10.81	.0440	.0290	.0400	.0290	.0140	.0250
5	1008	Gheshm Island	1	07/03/75	6.1	56	25.60	20.13	22.57	.0370	.0360	.0360	17.61	8.82	16.73	.0400	.0480	.0370	.0390	.0280	.0320
6	1013	Tonkabon	4	13/03/75	4.4	34	5.83	10.53	7.72	.0890	.0210	.0630	2.13	4.97	4.04	.1300	.0270	.0770	.0510	.0051	.0340
7	1009	Minab	1	12/04/75	4.8	48	11.19	17.34	14.70	.0660	.0200	.0390	2.42	8.94	6.58	.1200	.0240	.0510	.0540	.0074	.0250
8	1026	Shiraz	4	02/06/75	4.1	60	3.64	3.78	6.71	.0900	.0610	.0370	.72	.87	2.16	.1800	.1100	.0570	.0320	.0150	.0100
9	1014-4	Hajiabad	3	08/10/75	5.4	32	14.53	11.88	15.17	.1800	.1100	.1600	7.27	4.86	7.82	.2300	.1500	.2000	.5300	.1700	.4500
10	1024	Maraveh-Tappeh	3	27/12/75	4.6	6	2.76	2.56	2.63	.7400	.3700	.8000	.65	1.49	.65	1.4000	.4300	1.4000	1.7000	.4000	1.900
11	1034-1	Maku	2	27/02/76	3.9	26	2.38	1.92	2.35	.1300	.0970	.1300	.66	.59	.68	.2100	.1500	.2200	.0430	.0200	.0460
12	1034-2	Maku	2	02/04/76	4.6	12	.68	2.58	1.88	.6600	.1900	.2900	.21	1.76	1.27	1.0000	.2000	.3100	.3300	.0980	.1800
13	1040-3	Naghan-1	1	05/09/76	4.7	88	1.28	1.58	1.49	.1200	.1400	.1200	.42	.81	.62	.1800	.1700	.1600	.0200	.0320	.0220
14	1043	Ghaen	1	07/11/76	6.4	10	11.20	7.82	10.58	.3100	.3900	.3500	3.48	3.02	2.94	.4800	.5500	.5900	1.2000	1.3000	1.400
15	1047-8	Vendik	2	07/11/76	6.4	11	.11	.60	.13	2.800	.4200	2.2000	.05	.51	.07	3.7000	.4000	2.7000	.9800	.1200	.7200
16	1047-9	Vendik	2	07/11/76	4.8	9	.30	.55	.52	.5800	.2200	.4900	.05	.50	.45	1.2000	.2000	.4700	.1100	.0290	.1400
17	1047-10	Vendik	2	09/11/76	5.1	5	.66	.58	.71	.2100	.2500	.2500	.58	.10	.48	.2000	.5100	.2700	.0320	.0390	.0510
18	1046-1	Maku	2	24/11/76	7.3	48	16.07	20.10	20.40	.1600	.0690	.1300	6.56	9.43	8.81	.2300	.0880	.1700	.4900	.1000	.3600
19	1046-2	Maku	2	24/11/76	5.5	47	7.61	9.57	7.02	.1400	.0430	.1300	3.99	4.76	3.94	.1700	.0540	.1500	.1600	.0190	.1300
20	1049-1	Siah-Cheshmeh	1	06/12/76	4.4	3	7.05	9.72	7.38	.0880	.0530	.1000	3.14	6.46	4.36	.1200	.0570	.1200	.0610	.0300	.0870
21	1049-2	Siah-Cheshmeh	1	06/12/76	4.4	19	6.10	8.74	5.78	.0350	.0190	.0580	3.06	4.26	4.46	.0430	.0240	.0580	.0081	.0036	.0220
22	1049-3	Siah-Cheshmeh	1	12/12/76	4.8	14	6.11	8.35	6.42	.0260	.0150	.0380	3.70	5.03	4.54	.0290	.0170	.0400	.0046	.0020	.0110
23	1050-1	Bandarabbas	2	21/03/77	7.0	52	21.56	27.32	17.98	.2200	.1100	.3000	11.40	17.09	8.86	.2700	.1200	.3700	1.2000	.3700	1.700
24	1052	Gheshm-Island	1	21/03/77	7.0	71	7.75	7.44	7.55	.0750	.0520	.0740	6.04	5.07	7.21	.0750	.0550	.0670	.0490	.0220	.0460
25	1054-1	Naghan-1	1	06/04/77	6.1	7	2.78	3.18	2.70	2.500	1.600	1.9000	1.06	1.20	1.12	3.5000	2.3000	2.6000	19.000	8.8000	11.00
26	1055	Farsan	1	06/04/77	6.1	32	14.00	12.59	13.59	.0490	.0280	.0560	9.38	7.32	7.41	.0520	.0320	.0670	.0370	.0110	.0480
27	1058	Dastgerd	2	06/04/77	6.1	18	3.95	5.08	4.16	.2300	.1300	.2300	1.32	2.31	2.02	.3500	.1700	.2900	.2200	.1000	.2500
28	1059	Ardal	4	06/04/77	6.1	21	1.62	5.32	3.02	.1800	.0480	.1300	.56	2.00	1.08	.2700	.0690	.1900	.0600	.0130	.0540
29	1056-5	Naghan-1	1	12/04/77	4.9	15	.44	2.41	1.75	.1800	.0420	.0790	.11	.35	.32	.3100	.0960	.1600	.0150	.0047	.0120
30	1060-2	Naghan-1	1	04/05/77	4.8	20	3.21	2.64	5.02	.0340	.0510	.0310	.87	.98	1.31	.0570	.0740	.0540	.0040	.0076	.0054
31	1080-8	Naghan-1	1	21/10/77	5.0	19	3.39	5.24	3.06	.2200	.1600	.2900	1.57	2.23	1.99	.2900	.2100	.3200	.1900	.1400	.2900
32	1092-1	Aghajari	2	31/03/78	4.4	30	2.56	5.90	1.70	.0700	.0210	.1200	.66	1.56	.16	.1200	.0350	.3400	.0140	.0028	.0260
33	1080-10	Naghan-1	1	12/04/78	4.9	15	1.19	1.01	.96	.2400	.3100	.3300	.40	.39	.38	.3700	.4400	.4700	.0780	.1100	.1200
34	1080-11	Naghan-1	1	20/05/78	5.0	28	1.39	1.32	2.64	.1100	.1100	.0670	.31	.25	.57	.2000	.2200	.1300	.0180	.0180	.0130
35	1080-12	Naghan-1	1	11/08/78	4.3	30	.56	1.12	.53	.2800	.1100	.2800	.13	.84	.06	.5200	.1100	.7000	.0500	.0140	.0460
36	1094-1	Kazerun	2	29/08/78	4.9	12	7.63	7.05	4.71	.0840	.0390	.1700	2.36	3.18	2.03	.1300	.0510	.2300	.0600	.0120	.1600
37	1082-1	Deyhuk	1	16/09/78	7.4	36	34.01	30.20	34.91	.4900	.3600	.5000	9.03	10.51	9.76	.8400	.5300	.8400	9.0000	4.2000	9.700
38	1083-1	Boshruyeh	1	16/09/78	7.4	64	21.58	24.34	22.56	.2700	.2100	.2600	15.04	16.58	14.12	.2800	.2200	.2900	1.7000	1.2000	1.700
39	1084-1	Tabas	1	16/09/78	7.4	27	16.56	14.88	18.30	1.900	1.400	1.8000	7.98	10.36	8.46	2.4000	1.5000	2.3000	66.000	32.000	66.00
40	1086	Bajestan	3	16/09/78	7.4	140	27.64	31.10	26.36	.1500	.0470	.1500	21.30	24.58	21.47	.1500	.0460	.1500	.7000	.0750	.6800
41	1090-2	Kashmar	3	16/09/78	7.4	234	29.66	25.52	27.62	.1100	.0780	.1200	18.58	18.22	16.29	.1200	.0810	.1400	.3700	.1700	.4600
42	1082-6	Deyhuk	1	17/09/78	4.7	53	.97	2.34	1.04	.1700	.0740	.1300	.18	1.34	.34	.3500	.0860	.2100	.0310	.0140	.0210
43	1103-1	Tabas	1	24/09/78	4.5	22	3.59	4.88	2.39	.0560	.0360	.0890	1.43	1.54	.62	.0780	.0560	.1500	.0120	.0070	.0210
44	1104-2	Deyhuk	1	24/09/78	4.5	42	.76	3.79	5.26	.1700	.0450	.0550	.18	.77	.35	.3200	.0880	.1900	.0260	.0086	.0180
45	1093-2	Khonj	1	12/10/78	4.2	75	3.69	4.67	4.30	.0570	.0480	.0660	1.45	1.30	1.74	.0810	.0810	.0910	.0130	.0120	.0210
46	1103-3	Tabas	1	12/10/78	4.9	20	3.50	8.28	2.67	.1400	.0530	.2200	.67	3.38	.42	.2800	.0730	.4900	.0770	.0250	.1500
47	1098-3	Talesh	3	04/11/78	6.2	20	4.38	5.42	4.20	.1100	.0720	.1000	.66	3.09	1.00	.2400	.0840	.1800	.0570	.0310	.0470
48	1096-1	Naghan-1	1	14/12/78	6.1	5	.57	.78	.88	.2600	.2500	.2600	.23	.31	.40	.3600	.3500	.3300	.0440	.0540	.0630
49	1096-2	Naghan-1	1	14/12/78	4.7	5	1.87	1.98	.26	.0480	.0440	.3000	.31	.21	.12	.1000	.1200	.4000	.0047	.0043	.0270
50	1097-2	Naghan-2	1	14/12/78	4.7	5	.22	.75	3.91	.3300	.1300	.0430	.11	.19	.33	.4100	.2300	.1300	.0270	.0140	.0081
51	1103-9	Tabas	1	26/12/78	4.5	21	4.42	5.86	4.24	.0590	.0410	.1100	1.35	1.87	.20	.0940	.0640	.4500	.0170	.0110	.0600
52	1102	Bajestan	3	16/01/79	6.8	135	7.88	10.32	10.43	.1300	.0350	.0930	4.39	5.14	5.11	.1500	.0430	.1200	.1400	.0140	.1000
53	1106	Sedeh	3	16/01/79	6.8	80	17.33	13.34	15.20	.0820	.0770	.1000	11.70	8.18	9.74	.0880	.0870	.1100	.1300	.0880	.1700
54	1107	Khezri	1	16/01/79	6.8	61	13.59	18.51	13.16	.0680	.0450	.0820	8.45	12.36	8.16	.0760	.0490	.0920	.0700	.0420	.0990
55	1109	Gonabad	4	16/01/79	6.8	86	15.98	20.62	12.30	.0610	.0360	.0860	9.28	13.11	5.80	.0700	.0400	.1100	.0660	.0300	.1000
56	1113	Khaf	2	16/01/79	6.8	80	11.85	21.73	13.86	.1800	.0640	.1500	8.19	15.15	8.86	.1900	.0680	.1600	.4100	.1000	.3300
57	1103-11	Tabas	1	17/01/79	5.1	16	6.10	7.43	5.52	.1200	.1000	.2000	2.23	2.47	1.63	.1800	.1500	.3200	.1000	.0840	.2400
58	1103-12	Tabas	1	13/02/79	5.5	55	10.01	11.30	9.94	.1100	.0760	.1300	7.16	8.10	7.27	.1100	.0790	.1400	.1300	.0730	.1900
59	1125-2	Aghajari	2	28/03/79	5.1	25	3.14	3.20	1.44	.1100	.0920	.2200	.92	1.02	.44	.1900	.1400	.3600	.0460	.0300	.0810
60	1117	Sedeh	3	14/11/79	6.6	96	20.90	25.88	23.09	.0510	.0270	.0510	14.55	13.67	13.73	.0530	.0320	.0580	.0590	.0210	.0660
61	1118	Ghaen	1	14/11/79	6.6	55	11.28	10.35	10.05	.0790	.0800	.1200	6.29	5.97	5.03	.0930	.0930	.1500	.0770	.0750	.1500
62	1121	Khaf	2	14/11/79	6.6	72	16.91	21.67	17.17	.1800	.0910	.1900	10.36	13.97	9.80	.2000	.1000	.2200	.5800	.2000	.6800
63	1124	Roshtkhar	1	14/11/79	6.6	116	14.40	21.11	17.11	.0470	.0330	.0380	7.86	14.60	10.58	.0560	.0350	.0430	.0350	.0260	.0270
64	1130-2	Kashmar	3	14/11/79	6.6	184	13.18	14.40	14.15	.0660	.0390	.0740	7.46	7.28	9.23	.0780	.0480	.0800	.0650	.0240	.0850
65	1132-1	Ferdows	1	14/11/79	6.6	132	25.45	28.40	23.03	.0660	.0410	.0800	19.41	20.48	15.59	.0670	.0430	.0860	.1200	.0530	.1600
66	1143-1	Khaf	2	23/11/79	5.0	69	10.84	10.01	10.93	.0450	.0270	.0490	6.26	5.18	7.07	.0520	.0330	.0540	.0250	.0082	.0290
67	1131	Torbat-Heydarieh	3	27/11/79	7.1	160	23.89	29.51	25.14	.1400	.0630	.1200	15.61	20.41	16.61	.1500	.0670	.1300	.5000	.1300	.3800
68	1134-2	Bajestan	3	27/11/79	7.1	152	12.26	22.12	12.92	.2900	.0900	.2700	7.62	15.51	7.89	.3200	.0950	.3100	1.1000	.2000	1.100
69	1135	Kakhk	1	27/11/79	7.1	88	17.68	19.84	19.78	.1200	.0710	.0780	11.12	12.97	13.06	.1400	.0770	.0840	.3100	.1100	.1300
70	1137	Birjand	1	27/11/79	7.1	136	17.84	30.66	18.35	.0980	.0400	.0850	11.99	23.97	12.97	.1000	.0400	.0890	.1900	.0540	.1500
71	1138-1	Sedeh	3	27/11/79	7.1	80	20.86	24.51	20.52	.1700	.0730	.1700	15.72	16.79	13.89	.1700	.0780	.1800	.6700	.1500	.6300
72	1139	Ghaen	1	27/11/79	7.1	44	11.44	16.16	13.70	.4000	.2800	.3300	6.30	10.66	8.71	.4700	.3100	.3700	2.0000	1.4000	1.700
73	1140-1	Khezri	1	27/11/79	7.1	80	14.84	21.73	15.44	.1900	.1300	.1900	9.38	12.03	7.88	.2100	.1500	.2400	.6100	.4000	.6400
74	1141-1	Taybad	4	27/11/79	7.1	120	27.44	38.47	26.20	.1900	.0800	.2000	16.23	26.57	17.20	.2200	.0850	.2200	1.1000	.2700	1.200
75	1142-1	Gonabad	4	27/11/79	7.1	92	17.30	23.74	17.82	.1700	.1300	.2000	8.76	13.92	7.61	.2200	.1500	.2700	.5900	.4300	.8100
76	1143-2	Khaf	2	27/11/79	7.1	64	27.11	29.26	27.56	.3300	.1800	.3300	18.72	19.76	19.79	.3500	.1900	.3500	3.3000	1.0000	3.400
77	1143-3	Khaf	2	27/11/79	4.6	40	17.08	19.51	17.77	.0740	.0420	.0730	9.58	11.63	10.31	.0870	.0480	.0840	.1000	.0380	.1000
78	1144-2	Roshtkhar	1	27/11/79	7.1	108	24.35	28.41	22.42	.0930	.0970	.1100	15.10	19.97	11.84	.1000	.1000	.1300	.2400	.3000	.3100
79	1145	Torbat-Jam	1	27/11/79	7.1	160	14.35	27.64	13.34	.1000	.0540	.1100	12.90	24.14	11.40	.0960	.0510	.1000	.1700	.0890	.1700
80	1143-4	Khaf	2	28/11/79	4.7	29	10.19	10.03	10.19	.1200	.1300	.1200	2.86	5.43	4.14	.1900	.0570	.1800	.1500	.0260	.1800
81	1136-2	Tabas	1	02/12/79	4.8	12	3.00	7.30	5.07	.2300	.0690	.1700	1.02	2.20	1.15	.3400	.1100	.3100	.1700	.0390	.1600
82	1136-3	Tabas	1	12/01/80	5.9	26	8.60	11.78	8.72	.2800	.1500	.3600	3.19	5.36	4.30	.4000	.2000	.4500	.7400	.3100	1.300
83	1151	Rudsar	4	13/01/80	5.0	16	10.26	7.12	7.10	.1600	.1800	.2300	3.39	3.34	2.25	.2400	.2300	.3600	.2900	.2500	.4300
84	1149	Khorramabad	2	31/03/80	4.6	4	3.85	5.11	5.24	.1200	.0370	.0850	2.13	1.94	2.20	.1400	.0520	.1200	.0590	.0076	.0420
85	1182	Sarbaz	2	11/08/80	4.6	16	3.81	4.23	4.42	.1600	.0820	.1000	2.51	2.34	2.18	.1700	.0970	.1300	.1100	.0320	.0510
86	1160	Boroujerd	3	15/09/80	4.4	20	1.78	2.27	2.16	.2800	.2300	.3000	.65	1.47	.96	.4100	.2600	.4000	.1600	.1400	.2200
87	1153-1	Kushk-Nosrat	1	19/12/80	5.8	62	14.40	13.24	14.21	.0450	.0330	.0380	8.24	8.05	8.98	.0530	.0380	.0420	.0330	.0160	.0230
88	1168	Kerman	4	11/06/81	6.7	72	15.95	16.75	16.43	.0960	.0520	.0820	8.74	9.78	9.06	.1100	.0600	.0980	.1600	.0500	.1200
89	1169	Rayen	1	11/06/81	6.7	40	21.28	23.26	17.84	.0720	.0720	.0880	12.90	12.74	9.56	.0810	.0860	.1100	.1200	.1300	.1500
90	1172-6	Golbaf	3	11/06/81	6.7	20	8.07	6.77	5.74	.0630	.0710	.0830	2.38	2.48	1.51	.1000	.1000	.1400	.0360	.0380	.0440
91	1179	Bam	1	11/06/81	6.7	114	41.46	42.92	44.02	.0790	.0590	.0870	32.96	28.86	36.14	.0780	.0640	.0850	.2800	.1700	.3700
92	1174	Kerman	4	28/07/81	7.1	48	21.68	20.33	18.85	.2100	.1500	.2000	10.47	11.11	9.93	.2700	.1800	.2500	1.1000	.4900	.8500

No	Record	Station	Site	Date	Mw	R km	Dur (H1) sec 5-95	Dur (V) sec 5-95	Dur (H2) sec 5-95	Arms (H1) m/s.s 5-95	Arms(V) m/s.s 5-95	Arms (H2) m/s.s 5 95	dur (H1) sec 5-75	dur (V) sec 5-75	dur (H2) sec 5-75	Arms (H1) m/s.s 5-75	Arms (V) m/s.s 5-75	Arms (H2) m/s.s 5-75	Ea (H1) m2/s3	Ea (V) m2/s3	Ea (H2) m2/s3
93	1176-5	Golbaf	3	28/07/81	7.1	12	28.82	27.74	24.52	.4900	.3600	.5800	13.38	11.18	12.76	.6400	.5000	.7200	7.7000	4.1000	9.300
94	1176-25	Golbaf	3	29/07/81	4.4	16	5.63	5.29	3.93	.0440	.0410	.0570	2.42	2.54	1.20	.0590	.0520	.0910	.0120	.0098	.0140
95	1183-6	Golbaf	3	10/08/81	4.1	46	5.82	5.57	5.96	.0370	.0300	.0360	2.42	2.35	1.80	.0500	.0410	.0570	.0088	.0057	.0085
96	1183-8	Golbaf	3	20/08/81	4.6	16	1.62	3.97	2.08	.2100	.0750	.2200	1.02	1.85	.32	.2300	.0970	.5000	.0790	.0250	.1100
97	1191-3	Golbaf	3	07/01/82	4.1	12	4.59	5.30	3.56	.1100	.0710	.2400	1.77	2.27	.79	.1600	.0960	.4500	.0650	.0300	.2300
98	1191-4	Golbaf	3	21/01/82	4.4	18	4.02	6.70	3.44	.0480	.0220	.0460	.56	2.90	.69	.1100	.0300	.0920	.0100	.0037	.0082
99	1191-5	Golbaf	3	30/01/82	4.4	18	6.84	4.41	3.20	.0450	.0560	.1000	2.86	2.09	.62	.0610	.0710	.2100	.0150	.0150	.0370
100	1195	Doroud	4	01/09/82	4.9	25	3.54	3.49	4.33	.0860	.0670	.0620	1.39	1.41	1.12	.1200	.0920	.1100	.0290	.0170	.0180
101	1220-1	Farrashband	1	01/06/83	4.3	63	9.60	8.66	8.64	.0370	.0330	.0450	3.31	2.54	3.11	.0550	.0550	.0670	.0140	.0110	.0200
102	1211-1	Gilvan	1	22/07/83	5.6	20	7.11	7.34	4.88	.0520	.0390	.0690	3.86	3.31	2.13	.0620	.0520	.0920	.0210	.0130	.0250
103	1211-2	Gilvan	1	23/07/83	4.4	15	7.23	9.06	5.57	.0370	.0210	.0410	4.07	4.61	2.78	.0440	.0260	.0510	.0110	.0046	.0100
104	1214-1	Shalamzar	3	17/08/83	4.9	16	1.71	1.52	1.75	.4700	.3100	.3300	.47	.67	.72	.8000	.4100	.4500	.4200	.1600	.2100
105	1216-1	Ardal	3	17/08/83	4.9	26	7.00	6.12	7.37	.1100	.0880	.1100	2.92	2.63	3.04	.1400	.1200	.1500	.0860	.0530	.0930
106	1216-2	Ardal	3	28/08/83	4.5	29	9.27	6.55	6.05	.0480	.0380	.0700	3.80	3.80	3.57	.0660	.0440	.0800	.0230	.0110	.0320
107	1218	Tonkabon	4	20/12/83	4.8	16	6.73	7.39	4.69	.1000	.0790	.1900	3.45	3.38	2.02	.1200	.1000	.2500	.0750	.0510	.1800
108	1224-3	Ardal	3	01/06/84	5.0	10	6.48	7.65	5.62	.1800	.0960	.2300	2.89	3.72	1.85	.2400	.1200	.3600	.2400	.0780	.3400
109	1226-2	Shalamzar	3	01/06/84	5.0	16	2.96	2.07	2.12	.8600	.7500	.7300	.82	.89	.89	1.4000	1.0000	1.0000	2.5000	1.3000	1.300
110	1233-2	Naghan-1	1	01/06/84	5.0	10	2.85	3.04	2.09	.3600	.3700	.5300	1.59	1.86	1.05	.4300	.4200	.6600	.4100	.4700	.6500
111	1228-2	Khoy	3	29/06/84	4.6	7	4.93	9.61	8.32	.0210	.0096	.0150	3.72	8.10	6.99	.0220	.0092	.0140	.0025	.0010	.0021
112	1240-4	Ghir	3	02/02/85	4.5	18	4.29	3.28	5.38	.0390	.0250	.0290	1.38	1.87	2.38	.0600	.0290	.0390	.0071	.0023	.0051
113	1240-6	Ghir	3	02/02/85	5.2	7	3.27	4.43	3.75	.3400	.1500	.2600	1.36	1.70	1.37	.4600	.2100	.3800	.4200	.1100	.2800
114	1247-1	Avaj	1	09/05/85	3.1	9	2.29	2.96	4.07	.1300	.0800	.0580	.79	1.41	.94	.2000	.1000	.1100	.0430	.0210	.0150
115	1291-1	Kazerun	2	12/07/86	5.7	45	5.86	7.53	5.75	.0760	.0270	.0690	2.55	4.25	2.21	.1000	.0320	.0980	.0380	.0061	.0300
116	1308	Bandar-lengeh	3	09/08/86	5.1	23	5.88	6.61	5.05	.1100	.0690	.1800	3.55	3.18	2.71	.1300	.0870	.2200	.0800	.0350	.1800
117	1289-1	Noorabad-Mamassani	3	10/10/86	4.3	32	5.34	10.01	7.05	.0780	.0260	.0610	2.25	3.30	2.54	.1100	.0400	.0890	.0370	.0076	.0290
118	1289-3	Noorabad-Mamassani	3	10/10/86	4.9	32	4.96	7.97	5.87	.2600	.0860	.2200	2.09	2.66	3.21	.3500	.1300	.2600	.3600	.0650	.3100
119	1289-2	Noorabad-Mamassani	3	18/10/86	4.9	13	6.52	9.01	7.49	.1500	.0660	.1100	2.71	3.21	3.54	.2100	.0970	.1500	.1700	.0440	.1100
120	1289-4	Noorabad-Mamassani	3	20/11/86	5.2	24	7.44	14.30	8.14	.2300	.0740	.2000	2.72	6.34	3.76	.3400	.0980	.2600	.4400	.0870	.3600
121	1289-5	Noorabad-Mamassani	3	20/12/86	5.5	24	7.80	12.30	11.69	.0850	.0340	.0450	3.70	6.00	6.14	.1100	.0430	.0550	.0630	.0160	.0270
122	1311-1	Old Lar	1	16/01/87	4.5	16	7.38	7.91	8.60	.0760	.0670	.0680	3.87	3.57	3.98	.0930	.0880	.0880	.0470	.0390	.0440
123	1311-2	Old Lar	1	19/01/87	4.0	24	7.86	7.19	6.68	.0390	.0340	.0490	4.06	4.26	3.02	.0480	.0390	.0640	.0140	.0095	.0180
124	1319-1	Naghan-2	1	20/01/87	4.6	4	2.23	1.91	2.74	.1700	.1900	.1300	.53	.55	.47	.3200	.3200	.2800	.0760	.0800	.0530
125	1320-2	Naghan-1	1	20/01/87	4.6	6	1.43	1.26	1.10	.1900	.2300	.2900	.37	.48	.35	.3300	.3300	.4500	.0570	.0760	.1000
126	1319-2	Naghan-2	1	12/03/87	4.3	64	.88	1.25	1.42	.3300	.2000	.2000	.31	.48	.34	.4900	.2800	.3500	.1100	.0560	.0610
127	1305	Kuhbanan	3	11/04/87	5.0	4	4.69	7.69	4.54	.2500	.0950	.2300	1.85	4.06	1.50	.3500	.1200	.3400	.3300	.0780	.2600
128	1307	Sirch	1	22/04/87	4.6	24	3.17	3.85	3.91	.1000	.0630	.1000	.89	2.10	.90	.1700	.0750	.1900	.0370	.0170	.0460
129	1303	Bostan-abad	4	22/07/87	4.2	10	5.20	5.57	6.09	.3400	.1200	.2200	1.80	3.88	2.07	.5200	.1200	.3300	.6900	.0850	.3300
130	1300-1	Birjand	1	24/11/87	5.3	8	8.07	9.28	7.48	.1700	.1500	.1600	4.36	5.91	4.77	.2000	.1600	.1800	.2500	.2200	.2200
131	1300-3	Birjand	1	27/11/87	4.7	20	9.03	9.67	8.06	.0330	.0330	.0340	5.32	7.05	4.84	.0380	.0350	.0390	.0110	.0120	.0110
132	1351	Tehran (Sharif Univ.)	1	20/06/90	7.3	210	14.51	11.66	12.76	.0250	.0470	.0300	7.82	4.75	7.06	.0290	.0640	.0360	.0097	.0280	.0130
133	1353	Ghazvin	3	20/06/90	7.3	76	18.04	26.46	24.50	.3600	.2200	.2900	6.56	13.48	10.96	.5300	.2700	.3900	2.6000	1.4000	2.300
134	1354	Abhar	4	20/06/90	7.3	80	22.73	23.61	19.13	.3800	.1700	.5900	15.61	15.98	11.94	.4100	.1900	.6600	3.7000	.8000	7.400
135	1355	Rudsar	4	20/06/90	7.3	68	29.06	27.86	27.28	.2300	.1600	.2100	16.65	18.24	17.88	.2700	.1700	.2300	1.7000	.7600	1.400
136	1357-1	Lahijan	4	20/06/90	7.3	96	33.96	32.62	27.72	.2700	.1800	.4600	21.80	20.14	15.40	.3000	.2100	.5500	2.8000	1.2000	6.600
137	1359	Tonkabon	4	20/06/90	7.3	100	18.40	24.69	26.25	.3000	.0700	.2100	10.98	16.18	17.52	.3400	.0760	.2200	1.9000	.1300	1.200
138	1360	Manjil	2	20/06/90	7.3	12	1.61	2.23	1.83	1.500	.4900	1.1000	1.38	1.54	1.31	1.4000	.5200	1.1000	3.8000	.5900	2.400
139	1361	Gachsar	3	20/06/90	7.3	176	32.43	33.47	33.27	.1200	.0730	.1600	24.47	25.35	23.17	.1200	.0740	.1700	.4800	.2000	.9700
140	1362-1	Abbar	1	20/06/90	7.3	40	31.92	35.96	35.06	.8300	.9100	.5900	8.64	13.52	20.68	1.4000	.8400	1.1000	25.000	14.000	33.00
141	1363-1	Kahrizak	4	20/06/90	7.3	224	15.14	14.58	15.14	.1400	.0830	.1400	8.94	9.24	8.94	.1700	.0920	.1700	.3500	.1100	.3500
142	1364	Zanjan	1	20/06/90	7.3	80	35.84	40.92	39.96	.2100	.1100	.1500	19.52	28.06	28.00	.2500	.1200	.1600	1.8000	.5700	1.00
143	1365	Ardebil	4	20/06/90	7.3	195	8.28	8.98	9.02	.1100	.0500	.0880	6.02	6.96	6.10	.1100	.0500	.0940	.1000	.0250	.0770
144	1366	Tehran (Chizar)	1	20/06/90	7.3	212	17.92	14.74	18.58	.0440	.0480	.0380	11.49	8.37	12.66	.0490	.0560	.0400	.0390	.0370	.0290
145	1369	Rudshur	4	20/06/90	7.3	198	14.42	12.10	13.84	.1000	.1000	.1400	8.88	8.84	8.58	.1200	.1100	.1600	.1800	.1500	.2900
146	1370-2	Robat-Karim	1	20/06/90	7.3	207	16.20	15.74	17.52	.0290	.0590	.0390	13.34	7.74	10.12	.0290	.0740	.0450	.0150	.0600	.0290
147	1371-2	Karaj	1	20/06/90	7.3	177	11.84	13.94	13.96	.0950	.0440	.0370	5.86	10.22	7.88	.1200	.0460	.0440	.1200	.0300	.0220
148	1372	Eshtehard	4	20/06/90	7.3	140	26.64	33.74	22.60	.1600	.0900	.1700	14.50	20.24	13.50	.1900	.1000	.2000	.7800	.3000	.7600
149	1352	Tehran (BHRC)	1	20/06/90	7.3	209	8.85	8.81	8.55	.0690	.0340	.0740	6.25	4.55	5.70	.0720	.0420	.0800	.0470	.0110	.0520
150	1357-2	Lahijan	4	26/06/90	4.2	45	9.00	9.70	9.01	.0290	.0220	.0350	5.32	5.75	5.97	.0330	.0250	.0380	.0083	.0050	.0120
151	1393-2	Abbar	1	26/06/90	4.2	99	1.45	2.02	1.92	.1400	.0460	.0850	.45	.60	1.29	.2200	.0740	.0910	.0310	.0047	.0150
152	1393-4	Abbar	1	28/06/90	4.8	24	4.22	3.30	4.45	.0970	.1300	.0890	3.04	.23	3.34	.1000	.4200	.0910	.0440	.0600	.0390
153	1367	Manjil	2	29/06/90	4.4	75	2.56	5.97	2.34	.0410	.0240	.0540	.26	.58	.11	.1100	.0680	.2200	.0049	.0039	.0077
154	1368-1	Rudbar	3	29/06/90	4.4	8	1.58	1.58	.90	.2700	.2100	.4500	1.38	1.14	.38	.2500	.2100	.6200	.1300	.0740	.2100
155	1368-2	Rudbar	3	29/06/90	4.5	38	4.46	5.11	6.06	.0520	.0220	.0320	.42	1.18	1.65	.1500	.0400	.0540	.0140	.0027	.0070
156	1393-7	Abbar	1	29/06/90	4.5	36	4.28	10.87	2.90	.1000	.0280	.1100	1.05	5.37	.77	.1800	.0350	.1900	.0480	.0093	.0390
157	1368-5	Rudbar	3	01/07/90	4.6	20	1.46	7.37	4.39	.1800	.0400	.0750	.33	2.34	1.15	.3300	.0620	.1300	.0510	.0130	.0270
158	1393-9	Abbar	1	01/07/90	4.7	20	.77	11.22	1.95	.1600	.0210	.0870	.29	3.09	.39	.2300	.0350	.1700	.0230	.0055	.0160
159	1368-8	Rudbar	3	02/07/90	4.4	15	1.87	3.06	1.72	.1000	.0360	.0950	1.45	1.71	1.16	.1000	.0420	.1000	.0220	.0044	.0170
160	1377-1	Manjil	2	06/07/90	5.3	20	2.60	6.40	3.94	.4100	.1300	.3300	.92	3.39	2.20	.6100	.1500	.3900	.4900	.1100	.4800
161	1382-1	Rudbar	3	06/07/90	5.2	16	.85	7.07	2.55	.2300	.0210	.1000	.62	.64	.56	.2300	.0620	.1900	.0490	.0036	.0280
162	1382-2	Rudbar	3	06/07/90	4.2	45	4.27	4.44	5.07	.0650	.0300	.1100	.90	1.46	1.62	.1200	.0470	.1700	.0200	.0045	.0640
163	1377-2	Manjil	2	08/07/90	4.3	24	2.85	5.32	3.32	.2100	.0620	.1500	.69	.88	1.00	.3700	.1400	.2500	.1300	.0230	.0890
164	1382-8	Rudbar	3	24/07/90	4.5	7	1.02	3.51	2.08	.0660	.0160	.0420	.72	1.12	1.17	.0690	.0250	.0500	.0049	.0010	.0041
165	1382-11	Rudbar	3	06/08/90	4.5	40	1.05	1.57	1.53	.2800	.0980	.3100	.44	.69	1.12	.3800	.1300	.3200	.0890	.0170	.1600
166	1397-8	Manjil	2	23/08/90	4.4	28	5.40	7.21	10.01	.1100	.0430	.0840	.97	4.63	4.31	.2400	.0480	.1100	.0790	.0150	.0780
167	1449	Ahar	4	24/09/90	4.6	84	3.36	3.28	2.98	.0370	.0250	.0330	.64	.68	.72	.0750	.0480	.0580	.0051	.0023	.0035
168	1420-1	Rudbar	3	23/08/91	4.4	16	.65	1.17	1.10	.0790	.0360	.0740	.28	.31	.29	.1100	.0620	.1300	.0045	.0017	.0067
169	1420-2	Rudbar	3	28/11/91	5.6	26	.73	2.59	1.21	.3200	.0340	.2800	.47	.72	.79	.3600	.0570	.3100	.0860	.0033	.1100
170	1512-1	Sedeh	3	01/01/94	4.5	16	5.51	4.19	2.49	.0890	.1200	.1000	1.64	1.79	.88	.1400	.1700	.1500	.0480	.0720	.0280
171	1505	Sefidabeh (Microwave)	1	01/03/94	4.4	24	7.02	8.02	6.80	.0210	.0130	.0240	4.09	4.03	2.93	.0240	.0160	.0320	.0033	.0015	.0043
172	1504-1	Sefidabeh (School)	2	01/03/94	3.4	16	3.74	3.56	4.43	.0096	.0084	.0091	2.04	2.35	2.30	.0110	.0091	.0110	.0004	.0003	.0004
173	1491	Kavar	2	08/03/94	5.7	12	3.08	4.77	4.24	.0970	.0420	.0630	.65	1.65	1.50	.1900	.0630	.0930	.0320	.0093	.0190
174	1492-1	Zarrat	1	08/03/94	4.2	16	5.98	5.61	4.57	.0420	.0270	.0610	2.58	3.44	1.78	.0560	.0310	.0860	.0120	.0046	.0190
175	1503-1	Zanjiran	2	09/03/94	3.8	12	3.60	4.18	4.86	.0590	.0320	.0380	1.76	1.95	3.13	.0750	.0420	.0420	.0140	.0049	.0080
176	1503-2	Zanjiran	2	09/03/94	3.5	12	4.42	3.62	5.10	.0490	.0410	.0380	2.35	1.45	2.44	.0590	.0570	.0490	.0120	.0068	.0084
177	1494-1	Kavar	2	11/03/94	4.3	12	3.71	5.09	5.58	.0610	.0250	.0330	1.85	1.97	2.40	.0760	.0350	.0450	.0150	.0035	.0068
178	1500-1	Zanjiran	2	11/03/94	3.5	8	2.74	4.03	3.92	.0510	.0230	.0320	1.43	2.06	2.28	.0620	.0280	.0370	.0079	.0023	.0044
179	1500-2	Zanjiran	2	13/03/94	3.2	8	2.90	3.16	2.87	.0240	.0160	.0280	1.89	1.78	.56	.0260	.0190	.0550	.0018	.0009	.0024

No	Record	Station	Site	Date	Mw	R km	Dur (H1) sec 5-95	Dur (V) sec 5-95	Dur (H2) sec 5-95	Arms (H1) m/s.s 5-95	Arms(V) m/s.s 5-95	Arms (H2) m/s.s 5 95	dur (H1) sec 5-75	dur (V) sec 5-75	dur (H2) sec 5-75	Arms (H1) m/s.s 5-75	Arms (V) m/s.s 5-75	Arms (H2) m/s.s 5-75	Ea (H1) m2/s3	Ea (V) m2/s3	Ea (H2) m2/s3
180	1500-3	Zanjiran	2	14/03/94	4.3	8	3.15	4.05	2.67	.1600	.0740	.2100	1.54	2.04	1.09	.2100	.0930	.2900	.0950	.0250	.1300
181	1492-2	Zarrat	1	17/03/94	4.8	34	7.42	9.80	9.26	.0650	.0290	.0560	3.86	5.15	4.05	.0800	.0350	.0750	.0350	.0092	.0320
182	1500-4	Zanjiran	2	17/03/94	4.8	12	6.02	6.33	5.08	.1600	.0810	.1700	1.88	2.34	1.32	.2600	.1200	.2900	.1800	.0460	.1600
183	1492-3	Zarrat	1	17/03/94	4.6	16	6.67	6.33	5.61	.0450	.0220	.0550	3.60	3.42	2.44	.0540	.0260	.0730	.0150	.0033	.0190
184	1494-2	Kavar	2	17/03/94	4.8	20	8.64	11.06	9.34	.0470	.0310	.0420	3.95	4.84	5.53	.0620	.0410	.0480	.0220	.0120	.0180
185	1494-3	Kavar	2	17/03/94	4.6	12	3.53	4.15	3.09	.1400	.0790	.1600	1.31	2.10	1.64	.2000	.0980	.2000	.0790	.0290	.0910
186	1500-5	Zanjiran	2	17/03/94	4.2	16	3.01	4.18	4.08	.2100	.0760	.1400	1.88	2.50	2.45	.2400	.0860	.1600	.1500	.0270	.0930
187	1492-4	Zarrat	1	18/03/94	4.4	21	6.20	7.32	6.02	.1100	.0560	.1200	3.10	4.24	1.76	.1400	.0650	.1900	.0850	.0260	.0890
188	1494-4	Kavar	2	18/03/94	4.4	80	9.55	9.63	10.32	.0290	.0230	.0330	5.71	5.63	5.86	.0340	.0270	.0380	.0092	.0057	.0120
189	1500-6	Zanjiran	2	18/03/94	4.4	11	6.72	5.95	5.98	.0840	.0650	.0940	3.19	2.68	2.14	.1100	.0850	.1400	.0530	.0280	.0590
190	1500-7	Zanjiran	2	18/03/94	3.5	8	2.59	3.13	2.31	.0290	.0170	.0480	1.14	1.63	.81	.0390	.0200	.0710	.0024	.0010	.0058
191	1500-8	Zanjiran	2	19/03/94	4.4	11	7.59	6.72	7.73	.0780	.0590	.0760	3.61	2.79	2.98	.1000	.0800	.1100	.0520	.0260	.0500
192	1500-9	Zanjiran	2	19/03/94	3.1	12	3.27	4.32	3.10	.0320	.0160	.0360	.95	2.14	1.16	.0520	.0200	.0520	.0037	.0013	.0045
193	1500-10	Zanjiran	2	20/03/94	4.3	12	3.53	3.69	2.07	.0690	.0370	.1000	1.75	2.35	.63	.0870	.0410	.1600	.0190	.0057	.0240
194	1500-11	Zanjiran	2	20/03/94	4.0	12	7.15	5.43	5.29	.0280	.0270	.0370	3.37	2.57	2.23	.0360	.0350	.0500	.0063	.0045	.0079
195	1500-12	Zanjiran	2	21/03/94	3.8	8	3.22	3.34	3.37	.0710	.0410	.0640	.71	1.71	1.00	.1300	.0510	.1000	.0180	.0063	.0150
196	1492-5	Zarrat	1	23/03/94	4.7	20	6.32	6.63	5.61	.1000	.0450	.1300	2.11	3.44	1.63	.1600	.0550	.2100	.0720	.0150	.1100
197	1500-13	Zanjiran	2	23/03/94	4.7	8	2.56	3.10	2.72	.1200	.0670	.1500	1.62	1.97	1.04	.1300	.0740	.2200	.0390	.0150	.0730
198	1492-6	Zarrat	1	30/03/94	5.2	24	7.12	9.78	7.00	.5300	.1600	.5800	2.15	4.80	2.64	.8500	.2100	.8400	2.2000	.2900	2.600
199	1492-7	Zarrat	1	01/04/94	4.6	32	9.93	10.98	7.82	.0410	.0200	.0570	4.62	6.00	4.03	.0530	.0230	.0700	.0180	.0047	.0280
200	1492-8	Zarrat	1	03/04/94	5.2	24	10.89	12.16	9.10	.1200	.0560	.1600	4.98	7.43	4.13	.1600	.0630	.2000	.1800	.0420	.2400
201	1492-9	Zarrat	1	03/04/94	4.7	26	8.95	10.05	8.99	.0580	.0280	.0580	5.10	5.89	4.44	.0670	.0320	.0720	.0330	.0086	.0330
202	1492-10	Zarrat	1	12/04/94	3.4	14	1.42	1.54	4.75	.0490	.0140	.0072	1.38	1.50	1.33	.0440	.0120	.0120	.0037	.0003	.0003
203	1492-11	Zarrat	1	30/04/94	4.1	23	8.14	6.81	7.85	.0360	.0200	.0340	3.72	4.03	4.07	.0470	.0230	.0410	.0120	.0030	.0099
204	1492-12	Zarrat	1	07/05/94	4.2	20	4.88	5.49	4.43	.0280	.0140	.0340	2.36	2.29	.92	.0350	.0190	.0660	.0042	.0012	.0058
205	1502-1	Zanjiran	2	20/05/94	4.1	16	4.34	6.51	5.28	.0340	.0130	.0280	1.74	3.48	1.92	.0470	.0160	.0410	.0056	.0012	.0047
206	1502-2	Zanjiran	2	25/05/94	4.3	17	5.47	6.25	5.90	.0730	.0340	.0590	2.61	2.73	2.75	.0930	.0450	.0760	.0320	.0078	.0230
207	1492-13	Zarrat	1	05/06/94	4.8	27	6.35	7.47	5.30	.0800	.0450	.1000	2.57	4.84	2.12	.1100	.0490	.1400	.0450	.0170	.0610
208	1502-4	Zanjiran	2	05/06/94	4.8	10	2.93	3.94	3.45	.4700	.1900	.4700	1.07	2.09	1.21	.6800	.2300	.6900	.7200	.1600	.8300
209	1502-3	Zanjiran	2	05/06/94	3.2	12	2.58	2.62	1.25	.0280	.0190	.0570	1.67	1.54	.30	.0310	.0210	.1000	.0022	.0010	.0045
210	1502-5	Zanjiran	2	06/06/94	4.2	10	2.23	2.83	1.65	.1100	.0510	.1900	1.20	2.03	.64	.1400	.0530	.2700	.0320	.0083	.0660
211	1492-14	Zarrat	1	11/06/94	4.8	29	9.19	7.67	7.57	.0530	.0380	.0650	3.62	3.53	3.23	.0740	.0500	.0870	.0290	.0130	.0350
212	1502-6	Zanjiran	2	13/06/94	4.8	19	8.10	7.12	8.03	.0850	.0610	.0840	3.26	3.08	3.97	.1200	.0820	.1100	.0640	.0300	.0640
213	1502-7	Zanjiran	2	18/06/94	4.2	20	6.31	6.98	6.25	.0360	.0230	.0380	2.74	3.41	3.24	.0480	.0290	.0460	.0090	.0041	.0098
214	1492-15	Zarrat	1	18/06/94	5.1	21	6.39	9.08	6.80	.2200	.0690	.2100	2.09	3.98	2.33	.3400	.0920	.3200	.3400	.0480	.3400
215	1493-1	Firouzabad	3	18/06/94	5.1	18	9.61	11.70	10.24	.0290	.0150	.0270	5.69	7.00	4.80	.0330	.0170	.0350	.0087	.0030	.0085
216	1502-8	Zanjiran	2	20/06/94	5.1	8	7.59	6.88	6.31	.1600	.1200	.2000	2.33	2.52	2.11	.2600	.1800	.3000	.2200	.1100	.2800
217	1492-16	Zarrat	1	20/06/94	5.9	29	7.67	11.09	6.17	.7600	.2500	.8500	3.51	5.57	3.85	.9900	.3100	.9500	4.9000	.7400	4.900
218	1493-2	Firouzabad	3	20/06/94	5.9	17	8.84	10.44	9.26	.5000	.2500	.4100	2.89	4.98	2.32	.7600	.3200	.7200	2.4000	.7400	1.700
219	1495	Maharloo (PTT)	1	20/06/94	5.9	50	15.73	14.96	16.20	.0690	.0350	.0500	7.26	7.34	8.06	.0890	.0440	.0620	.0820	.0210	.0450
220	1498	Babanar	2	20/06/94	5.9	63	12.82	15.46	14.11	.0690	.0370	.0700	8.30	7.62	6.98	.0750	.0470	.0880	.0670	.0240	.0770
221	1502-9	Zanjiran	2	20/06/94	5.9	7	5.46	4.32	5.56	2.500	2.400	2.8000	2.68	2.17	2.33	3.2000	2.9000	3.9000	39.000	27.000	50.00
222	1492-17	Zarrat	1	20/06/94	4.5	16	9.58	10.60	9.00	.0380	.0190	.0400	3.83	4.59	3.29	.0520	.0250	.0580	.0150	.0042	.0160
223	1492-18	Zarrat	1	20/06/94	4.0	16	5.44	6.43	5.71	.0230	.0120	.0250	2.75	3.47	2.13	.0290	.0140	.0360	.0033	.0010	.0040
224	1493-3	Firouzabad	3	20/06/94	4.3	18	10.14	9.68	10.40	.0340	.0230	.0310	4.86	4.49	5.41	.0430	.0300	.0380	.0130	.0059	.0110
225	1492-19	Zarrat	1	21/06/94	4.5	15	7.32	9.10	8.09	.0450	.0180	.0400	2.64	4.01	2.80	.0650	.0240	.0610	.0160	.0034	.0150
226	1492-20	Zarrat	1	21/06/94	4.7	16	7.57	10.11	8.14	.0690	.0220	.0590	3.06	4.75	4.24	.0950	.0290	.0720	.0400	.0057	.0320
227	1493-4	Firouzabad	3	21/06/94	4.7	18	9.95	10.19	9.31	.0350	.0220	.0320	5.57	6.08	4.65	.0420	.0250	.0400	.0140	.0052	.0110
228	1492-21	Zarrat	1	21/06/94	4.1	18	5.16	5.95	5.53	.0320	.0210	.0370	2.66	3.46	2.46	.0400	.0240	.0490	.0060	.0029	.0084
229	1492-22	Zarrat	1	22/06/94	4.3	15	7.32	7.69	6.41	.0230	.0120	.0270	2.92	3.70	2.32	.0320	.0160	.0400	.0042	.0013	.0053
230	1518-1	Firouzabad	3	22/06/94	3.1	4	.63	1.30	3.55	.1100	.0160	.0110	.58	.75	.59	.0970	.0180	.0230	.0079	.0004	.0005
231	1501-1	Zanjiran	2	23/06/94	3.7	12	1.05	1.87	.80	.2600	.1000	.3300	.31	1.38	.20	.4300	.1000	.5900	.0800	.0220	.0990
232	1501-2	Zanjiran	2	23/06/94	3.1	8	2.06	1.77	1.11	.0340	.0240	.0530	1.27	1.29	.57	.0380	.0250	.0660	.0026	.0012	.0035
233	1501-3	Zanjiran	2	23/06/94	3.8	12	4.65	5.98	5.10	.0250	.0140	.0230	1.68	3.00	1.42	.0370	.0170	.0380	.0033	.0013	.0030
234	1492-23	Zarrat	1	24/06/94	4.0	20	6.86	7.73	5.95	.0400	.0190	.0480	3.01	3.95	3.15	.0530	.0240	.0580	.0120	.0031	.0150
235	1501-4	Zanjiran	2	24/06/94	4.0	15	7.03	5.82	6.16	.0290	.0250	.0350	3.27	2.21	2.12	.0370	.0350	.0530	.0066	.0040	.0084
236	1501-5	Zanjiran	2	24/06/94	3.7	8	1.29	2.76	.91	.0720	.0240	.1400	.60	1.61	.18	.0920	.0280	.2800	.0074	.0018	.0200
237	1501-6	Zanjiran	2	24/06/94	3.6	5	2.47	2.15	2.38	.0450	.0320	.0430	1.22	1.21	1.06	.0560	.0380	.0570	.0054	.0025	.0049
238	1501-7	Zanjiran	2	24/06/94	4.5	8	2.77	2.95	2.06	.2600	.1700	.3100	.71	1.40	.48	.4500	.2100	.5600	.2100	.0890	.2100
239	1501-8	Zanjiran	2	25/06/94	3.6	12	1.28	2.72	1.34	.0470	.0180	.0430	.65	1.62	.44	.0580	.0210	.0660	.0032	.0010	.0028
240	1501-9	Zanjiran	2	25/06/94	4.2	8	1.81	2.89	1.88	.1600	.0610	.1200	.87	1.51	.81	.2000	.0750	.1700	.0490	.0120	.0320
241	1523-1	Jovakan	1	06/07/94	3.4	12	3.14	2.60	3.97	.0250	.0200	.0180	1.37	1.50	1.71	.0340	.0230	.0250	.0022	.0011	.0015
242	1523-2	Jovakan	1	07/07/94	4.0	12	5.61	6.69	5.28	.0320	.0190	.0340	2.63	3.49	2.45	.0410	.0230	.0430	.0062	.0027	.0066
243	1523-3	Jovakan	1	07/07/94	3.8	16	4.88	5.51	5.16	.0440	.0270	.0390	2.13	2.38	2.12	.0590	.0360	.0540	.0110	.0045	.0089
244	1523-4	Jovakan	1	09/07/94	4.0	18	2.20	4.61	2.71	.0670	.0280	.0520	.67	2.78	1.21	.1100	.0320	.0690	.0110	.0041	.0081
245	1519-1	Zarrat	1	10/07/94	3.9	20	5.51	6.67	5.29	.0220	.0110	.0200	1.87	3.16	1.36	.0330	.0140	.0340	.0029	.0009	.0023
246	1523-5	Jovakan	1	10/07/94	3.5	16	4.51	3.67	4.59	.0200	.0170	.0170	1.85	2.13	2.21	.0280	.0200	.0220	.0021	.0012	.0015
247	1518-2	Firouzabad	3	13/07/94	4.2	16	9.54	8.01	8.77	.0210	.0160	.0220	4.37	3.26	4.22	.0280	.0230	.0270	.0048	.0024	.0046
248	1523-6	Jovakan	1	13/07/94	4.2	16	6.28	8.73	6.65	.0500	.0270	.0480	2.38	4.75	3.33	.0720	.0320	.0600	.0180	.0069	.0170
249	1523-7	Jovakan	1	16/07/94	4.3	16	6.23	7.53	6.26	.0200	.0120	.0220	2.54	3.98	2.90	.0280	.0140	.0290	.0029	.0011	.0035
250	1523-9	Jovakan	1	18/07/94	3.8	14	5.92	6.93	4.63	.0440	.0260	.0500	2.24	3.56	1.74	.0630	.0320	.0720	.0130	.0051	.0130
251	1523-10	Jovakan	1	20/07/94	3.7	15	2.76	7.78	3.30	.0250	.0080	.0190	.34	2.79	.81	.0630	.0120	.0340	.0020	.0005	.0013
252	1513	Bandar-Torkman	4	23/07/94	5.1	60	15.53	18.89	14.53	.0500	.0220	.0610	7.38	9.64	6.22	.0640	.0280	.0820	.0440	.0110	.0590
253	1523-11	Jovakan	1	24/07/94	3.4	12	4.26	3.55	3.02	.0240	.0230	.0350	1.76	1.57	1.61	.0330	.0300	.0430	.0027	.0021	.0042
254	1523-12	Jovakan	1	28/07/94	3.4	12	1.30	3.65	1.21	.0580	.0180	.0580	.16	1.73	.12	.1500	.0230	.1600	.0048	.0013	.0045
255	1523-13	Jovakan	1	29/07/94	3.7	12	2.50	9.44	4.51	.0240	.0060	.0110	.24	2.39	.69	.0690	.0110	.0250	.0016	.0004	.0006
256	1506-1	Hosseiniyeh-Olia	4	31/07/94	5.6	22	6.57	9.65	6.74	.3200	.1500	.3000	1.96	4.28	1.88	.5200	.2000	.5100	.7600	.2500	.6900
257	1525	Karkheh Dam	1	31/07/94	5.6	26	13.10	13.66	14.57	.0330	.0290	.0290	6.38	6.48	7.47	.0420	.0370	.0360	.0160	.0130	.0140
258	1526-1	Dez Dam	1	31/07/94	5.6	18	7.50	7.82	8.57	.0630	.0720	.0570	3.56	4.05	3.84	.0800	.0880	.0750	.0330	.0450	.0310
259	1526-2	Dez Dam	1	31/07/94	5.2	17	8.07	8.07	8.18	.0140	.0180	.0150	4.38	4.33	3.90	.0170	.0210	.0190	.0018	.0028	.0020
260	1527	Andimeshk	1	31/07/94	5.6	35	14.78	14.09	13.97	.0640	.0550	.0650	7.77	7.75	7.27	.0780	.0660	.0790	.0680	.0480	.0660
261	1506-2	Hosseinieh	4	31/07/94	4.5	20	4.43	7.86	4.88	.0700	.0270	.0560	.96	2.41	.81	.1300	.0420	.1200	.0240	.0062	.0170
262	1506-3	Hosseinieh	4	31/07/94	4.3	20	7.80	7.42	4.74	.0220	.0200	.0380	3.45	3.40	1.45	.0290	.0260	.0610	.0043	.0032	.0078
263	1506-4	Hosseinieh	4	31/07/94	5.1	20	4.03	6.09	4.91	.3100	.1100	.2000	.46	1.36	.96	.8100	.2000	.3900	.4300	.0760	.2100
264	1506-5	Hosseinieh	4	31/07/94	4.7	20	5.80	7.28	7.86	.0620	.0330	.0380	1.62	3.02	2.54	.1000	.0460	.0590	.0250	.0090	.0130
265	1506-6	Hosseinieh	4	31/07/94	3.8	20	4.24	7.20	3.38	.0320	.0140	.0340	1.11	3.96	.81	.0550	.0170	.0610	.0047	.0016	.0043
266	1506-7	Hosseinieh	4	31/07/94	4.1	18	6.19	7.46	8.57	.0270	.0170	.0140	2.00	2.96	3.10	.0420	.0230	.0210	.0052	.0023	.0019
267	1506-8	Hosseinieh	4	31/07/94	4.3	25	5.05	6.31	4.32	.0610	.0390	.0690	1.79	3.32	1.34	.0910	.0470	.1100	.0210	.0110	.0230
268	1506-9	Hosseinieh	4	31/07/94	4.1	20	2.92	6.20	3.73	.0570	.0220	.0350	.94	3.68	1.62	.0890	.0250	.0470	.0110	.0032	.0050
269	1520-1	Kavar	2	01/08/94	3.7	12	2.07	2.55	2.49	.0370	.0230	.0270	.95	1.15	1.58	.0480	.0300	.0300	.0031	.0015	.0020
270	1506-10	Hosseinieh	4	02/08/94	4.4	18	4.07	6.92	7.70	.0340	.0180	.0170	1.04	3.41	3.42	.0600	.0230	.0220	.0053	.0025	.0025
271	1519-2	Zarrat	1	12/08/94	3.8	15	6.49	7.36	5.39	.0220	.0110	.0310	2.77	3.66	2.15	.0300	.0140	.0430	.0036	.0010	.0056

No	Record	Station	Site	Date	Mw	R km	Dur (H1) sec 5-95	Dur (V) sec 5-95	Dur (H2) sec 5-95	Arms (H1) m/s.s 5-95	Arms(V) m/s.s 5-95	Arms (H2) m/s.s 5 95	dur (H1) sec 5-75	dur (V) sec 5-75	dur (H2) sec 5-75	Arms (H1) m/s.s 5-75	Arms (V) m/s.s 5-75	Arms (H2) m/s.s 5-75	Ea (H1) m2/s3	Ea (V) m2/s3	Ea (H2) m2/s3
272	1523-14	Jovakan	1	12/08/94	4.0	16	6.41	5.26	6.82	.0300	.0290	.0280	2.82	2.43	3.20	.0400	.0370	.0370	.0064	.0048	.0061
273	1523-15	Jovakan	1	12/08/94	4.0	16	3.29	5.90	4.55	.0650	.0290	.0490	.63	2.48	1.67	.1300	.0400	.0710	.0160	.0057	.0120
274	1523-16	Jovakan	1	14/08/94	3.8	14	4.59	4.03	4.25	.0370	.0360	.0370	2.18	1.89	2.36	.0480	.0460	.0440	.0071	.0058	.0065
275	1518-3	Firouzabad	3	20/08/94	4.2	20	6.80	5.02	7.74	.0230	.0250	.0190	2.38	1.91	3.99	.0340	.0360	.0240	.0039	.0035	.0032
276	1523-17	Jovakan	1	20/08/94	3.8	18	7.85	6.74	6.57	.0230	.0200	.0290	3.90	3.13	2.70	.0280	.0260	.0400	.0045	.0029	.0063
277	1520-2	Kavar	2	26/08/94	4.0	20	4.25	4.59	3.63	.0390	.0260	.0440	1.53	1.79	1.53	.0570	.0360	.0590	.0070	.0034	.0077
278	1523-18	Jovakan	1	26/08/94	3.8	16	4.09	5.80	4.27	.0470	.0250	.0470	1.17	3.25	1.13	.0770	.0290	.0800	.0100	.0039	.0100
279	1523-19	Jovakan	1	28/08/94	3.6	16	4.69	8.82	7.24	.0200	.0077	.0110	.92	3.68	3.13	.0390	.0100	.0150	.0020	.0006	.0010
280	1523-20	Jovakan	1	28/08/94	3.6	12	1.34	3.21	1.25	.0510	.0180	.0500	.28	1.74	.32	.0980	.0210	.0870	.0039	.0011	.0035
281	1522	Chenar-Shahijan	3	05/09/94	5.0	18	7.49	7.49	8.05	.0230	.0120	.0190	2.77	2.71	2.15	.0340	.0180	.0320	.0045	.0012	.0032
282	1523-21	Jovakan	1	07/09/94	3.5	16	3.28	4.59	4.44	.0290	.0140	.0190	1.30	2.37	2.60	.0410	.0170	.0220	.0031	.0010	.0018
283	1523-22	Jovakan	1	09/09/94	3.7	12	1.53	3.08	1.64	.0580	.0250	.0580	.90	2.28	.75	.0670	.0260	.0760	.0058	.0022	.0061
284	1533-1	Seifabad	1	10/09/94	4.0	18	6.61	6.23	6.25	.0280	.0210	.0340	2.65	3.27	2.44	.0390	.0260	.0480	.0058	.0031	.0079
285	1523-23	Jovakan	1	19/09/94	3.8	16	1.58	4.76	1.94	.1500	.0470	.1300	.34	2.70	.44	.2900	.0550	.2500	.0400	.0120	.0380
286	1506-11	Hosseiniyeh-Olia	4	20/09/94	5.1	50	10.12	12.93	9.50	.0280	.0150	.0310	5.59	6.45	4.91	.0340	.0190	.0370	.0091	.0032	.0099
287	1507	Dez Dam	1	20/09/94	5.1	27	6.57	8.90	6.69	.0530	.0410	.0590	3.46	4.53	3.62	.0640	.0510	.0710	.0210	.0170	.0260
288	1508-1	Andimeshk	1	20/09/94	5.1	12	8.46	8.91	8.59	.0210	.0130	.0210	5.36	3.93	3.88	.0230	.0180	.0280	.0041	.0018	.0043
289	1508-2	Andimeshk	1	20/09/94	4.9	19	9.64	11.66	8.92	.0550	.0370	.0600	4.88	4.88	4.51	.0680	.0500	.0750	.0330	.0180	.0360
290	1523-24	Jovakan	1	20/09/94	3.8	15	1.96	4.05	1.95	.0380	.0170	.0380	.20	1.97	.25	.1000	.0210	.0920	.0031	.0012	.0031
291	1520-3	Kavar	2	29/09/94	3.8	6	3.85	3.64	3.70	.0310	.0250	.0340	1.94	1.26	2.00	.0390	.0370	.0410	.0042	.0024	.0049
292	1523-25	Jovakan	1	29/09/94	3.8	14	5.46	5.17	6.28	.0330	.0210	.0250	2.37	2.30	2.71	.0440	.0280	.0330	.0066	.0027	.0043
293	1523-26	Jovakan	1	12/10/94	3.5	18	7.23	3.56	7.32	.0100	.0250	.0110	4.24	.13	4.11	.0120	.1200	.0140	.0008	.0026	.0011
294	1518-4	Firouzabad	3	26/10/94	4.2	16	7.26	8.86	5.83	.0270	.0140	.0360	3.10	4.47	2.11	.0370	.0180	.0520	.0061	.0020	.0082
295	1523-27	Jovakan	1	26/10/94	4.0	14	7.54	10.14	6.67	.0280	.0170	.0350	3.75	4.84	2.46	.0350	.0210	.0510	.0068	.0032	.0090
296	1531	Lamerd	1	27/10/94	3.8	16	1.72	4.07	4.65	.0640	.0250	.0210	.31	1.92	1.67	.1300	.0320	.0310	.0079	.0028	.0023
297	1528-1	Fin	3	28/10/94	4.2	4	4.80	2.59	4.49	.0590	.0740	.0600	.75	.92	.98	.1300	.1100	.1100	.0180	.0160	.0180
298	1528-2	Fin	3	29/10/94	4.0	16	6.44	3.21	4.71	.0360	.0490	.0490	1.75	1.01	1.43	.0610	.0770	.0790	.0092	.0085	.0130
299	1530-1	Nir (Ardebil)	3	02/11/94	5.0	20	5.72	7.00	5.95	.1400	.1000	.1300	1.45	3.01	1.77	.2500	.1400	.2200	.1300	.0810	.1200
300	1550-1	Masal	3	03/12/94	4.8	25	4.84	7.32	5.05	.0520	.0170	.0550	2.27	3.66	1.65	.0670	.0220	.0840	.0150	.0025	.0170
301	1550-2	Masal	3	07/12/94	4.1	16	4.75	5.95	5.10	.0300	.0140	.0300	2.39	3.51	2.52	.0380	.0160	.0380	.0049	.0012	.0052
302	1519-3	Zarrat	1	08/12/94	5.0	24	5.93	6.57	4.68	.1200	.0560	.1500	1.77	3.80	2.22	.2000	.0650	.1900	.1000	.0230	.1200
303	1520-4	Kavar	2	08/12/94	5.0	22	7.26	7.66	5.59	.0530	.0340	.0970	3.48	4.28	2.52	.0680	.0400	.1300	.0230	.0096	.0580
304	1523-28	Jovakan	1	08/12/94	5.0	16	2.75	6.80	2.75	.2600	.0700	.2300	.66	2.93	.60	.4600	.0940	.4300	.2000	.0370	.1600
305	1519-4	Zarrat	1	15/12/94	4.7	20	5.62	6.82	6.45	.1500	.0610	.1200	1.63	3.42	2.03	.2400	.0760	.1800	.1300	.0280	.0970
306	1520-5	Kavar	2	15/12/94	4.7	19	9.12	9.09	7.43	.0430	.0300	.0540	5.16	5.24	3.51	.0510	.0350	.0690	.0190	.0090	.0240
307	1523-29	Jovakan	1	29/12/94	4.5	22	5.79	8.47	5.44	.0690	.0320	.0760	2.29	4.17	1.57	.0960	.0400	.1200	.0300	.0097	.0350
308	1519-5	Zarrat	1	30/12/94	4.1	18	5.76	6.93	6.57	.0600	.0320	.0540	3.25	3.86	2.83	.0700	.0380	.0730	.0230	.0079	.0210
309	1520-6	Kavar	2	30/12/94	4.2	16	5.76	7.67	4.78	.0310	.0170	.0490	2.14	3.73	1.84	.0450	.0210	.0690	.0062	.0024	.0130
310	1523-30	Jovakan	1	30/12/94	4.2	8	5.82	8.43	6.45	.0310	.0120	.0270	2.03	3.36	2.71	.0460	.0170	.0370	.0062	.0014	.0052
311	1573	Bagh-Malek	2	01/01/95	4.3	16	6.85	10.22	8.81	.0280	.0086	.0170	2.39	4.36	2.94	.0420	.0120	.0260	.0061	.0008	.0028
312	1579	Kuhestak	3	04/01/95	4.6	105	7.56	8.12	5.71	.0220	.0089	.0310	3.43	3.44	2.86	.0230	.0120	.0390	.0041	.0007	.0062
313	1529-2	Lali	3	06/01/95	3.8	12	4.42	3.93	5.12	.0260	.0190	.0290	1.88	1.62	1.50	.0350	.0260	.0470	.0033	.0016	.0047
314	1549-4	Ammarloo	3	06/01/95	4.0	10	2.18	1.57	2.65	.1300	.1700	.1400	.67	.92	1.32	.2100	.2000	.1700	.0440	.0510	.0540
315	1529-3	Lali	3	07/01/95	4.5	18	10.97	10.30	10.64	.0560	.0330	.0590	5.23	5.01	5.36	.0720	.0410	.0730	.0380	.0120	.0410
316	1523-31	Jovakan	1	12/01/95	3.9	16	3.13	5.36	3.43	.0370	.0160	.0360	.93	2.60	.90	.0610	.0200	.0610	.0049	.0014	.0049
317	1532	Deh-Balla -N. Farrashband	2	21/01/95	4.7	32	8.69	9.38	8.05	.0800	.0440	.0840	4.89	4.88	4.38	.0940	.0540	.1000	.0620	.0200	.0630
318	1528-3	Fin	3	24/01/95	4.9	16	2.26	1.87	3.81	1.500	1.200	1.3000	.59	.46	.88	2.6000	2.1000	2.4000	5.9000	2.9000	7.200
319	1528-22	Fin	3	24/01/95	4.0	16	3.19	3.88	3.00	.0990	.0650	.0920	.81	1.99	1.52	.1700	.0800	.1100	.0350	.0180	.0280
320	1528-23	Fin	3	24/01/95	4.0	8	4.98	3.97	5.11	.0780	.0620	.0800	.87	1.21	.75	.1600	.0990	.1800	.0330	.0170	.0360
321	1528-24	Fin	3	24/01/95	4.1	12	5.06	3.62	4.53	.0740	.0630	.0820	1.25	1.19	1.29	.1300	.0960	.1400	.0310	.0160	.0340
322	1528-26	Fin	3	24/01/95	4.5	16	3.17	4.32	4.86	.3100	.1600	.2600	.78	1.78	1.23	.5600	.2200	.4500	.3500	.1200	.3600
323	1528-27	Fin	3	24/01/95	3.5	6	2.28	2.09	3.48	.0400	.0360	.0310	.71	.88	.94	.0640	.0490	.0520	.0041	.0030	.0036
324	1528-28	Fin	3	24/01/95	3.9	16	7.23	3.87	5.36	.0280	.0280	.0400	1.33	1.00	1.13	.0580	.0490	.0760	.0063	.0034	.0094
325	1528-29	Fin	3	24/01/95	4.2	12	6.90	5.62	8.76	.0610	.0440	.0430	1.21	1.82	3.61	.1300	.0680	.0590	.0280	.0120	.0180
326	1528-10	Fin	3	24/01/95	4.6	16	4.29	4.24	3.57	.2900	.1300	.3700	1.02	1.20	.83	.5300	.2100	.6700	.4100	.0770	.5400
327	1528-11	Fin	3	24/01/95	3.9	12	2.95	3.21	3.88	.0460	.0340	.0350	.59	1.44	.86	.0900	.0450	.0660	.0069	.0041	.0053
328	1528-12	Fin	3	24/01/95	4.1	6	5.50	5.55	5.84	.1500	.0910	.1300	.91	1.54	1.69	.3200	.1500	.2200	.1400	.0520	.1200
329	1528-13	Fin	3	24/01/95	3.9	10	1.84	3.26	2.53	.0670	.0330	.0550	.33	1.28	.42	.1400	.0470	.1200	.0093	.0041	.0086
330	1528-14	Fin	3	24/01/95	3.8	8	10.89	11.99	11.05	.0280	.0210	.0320	7.42	8.41	3.01	.0300	.0220	.0550	.0093	.0059	.0130
331	1528-15	Fin	3	24/01/95	3.5	6	1.66	1.88	.95	.0620	.0480	.1200	.31	.69	.28	.1300	.0700	.1900	.0072	.0048	.0150
332	1528-16	Fin	3	24/01/95	4.1	14	11.80	8.55	10.75	.0280	.0300	.0430	2.79	2.67	2.09	.0500	.0470	.0860	.0099	.0085	.0220
333	1528-17	Fin	3	24/01/95	3.9	14	4.56	3.24	5.46	.0640	.0530	.0510	.47	1.25	1.05	.1800	.0750	.1000	.0210	.0099	.0160
334	1528-18	Fin	3	24/01/95	3.8	12	1.76	2.41	2.88	.0550	.0360	.0420	.23	1.04	.76	.1300	.0480	.0720	.0059	.0035	.0056
335	1528-19	Fin	3	24/01/95	3.9	8	7.53	5.57	7.07	.0270	.0230	.0310	3.95	3.13	2.63	.0330	.0270	.0450	.0061	.0032	.0077
336	1528-20	Fin	3	24/01/95	4.1	20	3.76	3.82	4.43	.0440	.0320	.0460	1.04	1.55	1.19	.0740	.0440	.0790	.0082	.0043	.0110
337	1528-21	Fin	3	24/01/95	4.1	12	9.06	6.07	6.80	.0300	.0250	.0460	4.43	2.85	3.38	.0380	.0320	.0570	.0090	.0041	.0160
338	1528-4	Fin	3	24/01/95	4.0	8	5.18	4.40	6.23	.0810	.0570	.0700	2.65	1.92	1.81	.1000	.0760	.1100	.0380	.0160	.0340
339	1528-5	Fin	3	24/01/95	4.1	6	5.04	4.03	5.80	.0780	.0560	.0790	.98	1.06	1.20	.1600	.0960	.1500	.0340	.0140	.0400
340	1528-6	Fin	3	24/01/95	4.0	8	5.13	3.74	4.59	.0620	.0430	.0810	.91	.89	.65	.1300	.0770	.1900	.0220	.0075	.0340
341	1528-7	Fin	3	24/01/95	3.7	8	3.49	2.73	3.77	.0360	.0330	.0380	.72	.88	.78	.0690	.0510	.0740	.0049	.0032	.0061
342	1528-8	Fin	3	24/01/95	4.1	16	6.81	3.89	6.09	.0430	.0410	.0450	.70	1.23	1.39	.1200	.0640	.0830	.0140	.0071	.0140
343	1528-9	Fin	3	24/01/95	4.0	14	3.37	3.13	2.78	.0660	.0470	.0870	.68	1.00	.80	.1300	.0740	.1400	.0160	.0078	.0230
344	1528-30	Fin	3	25/01/95	3.9	12	7.24	3.90	8.68	.0450	.0430	.0350	.48	1.79	.97	.1500	.0560	.0920	.0160	.0081	.0120
345	1528-31	Fin	3	25/01/95	4.0	16	6.83	4.80	5.67	.0280	.0250	.0400	2.04	1.63	1.52	.0460	.0380	.0680	.0060	.0033	.0100
346	1631-1	Musian	3	27/01/95	4.1	16	1.84	3.69	1.39	.0560	.0270	.0640	.56	2.19	.21	.0890	.0310	.1400	.0064	.0030	.0063
347	1592	Golbaf	3	17/02/95	4.4	12	5.66	4.84	5.05	.0360	.0300	.0320	2.21	2.22	2.90	.0510	.0390	.0370	.0081	.0047	.0058
348	1555	Firouzabad	3	19/02/95	4.4	19	6.89	6.99	6.13	.0250	.0190	.0330	2.84	3.26	1.89	.0340	.0240	.0530	.0047	.0027	.0075
349	1547-1	Sefidrud Dam	1	07/03/95	2.7	15	2.13	4.38	3.05	.1900	.0270	.0330	.87	2.34	1.07	.2600	.0320	.0490	.0820	.0035	.0037
350	1535-1	Rudbar	3	07/03/95	3.9	10	2.00	2.84	2.13	.0510	.0480	.0550	.78	1.45	.70	.0720	.0590	.0840	.0059	.0071	.0071
351	1563	Dorahun	3	08/03/95	4.3	13	4.60	6.10	4.81	.0430	.0160	.0420	1.60	3.26	1.24	.0650	.0190	.0730	.0096	.0017	.0096
352	1564-1	Khanzanun	1	09/03/95	4.1	16	4.15	5.59	4.74	.0250	.0170	.0190	1.26	2.20	1.45	.0400	.0230	.0310	.0029	.0017	.0020
353	1554	Baba-Monir	4	22/03/95	4.8	23	12.01	11.19	11.84	.0420	.0310	.0470	5.62	4.53	4.94	.0540	.0430	.0640	.0230	.0120	.0290
354	1575-1	Babakalan	2	22/03/95	4.8	20	3.40	5.39	5.99	.0550	.0310	.0540	1.20	2.81	2.06	.0810	.0380	.0810	.0110	.0059	.0190
355	1650-1	Firouzabad	3	25/03/95	4.7	12	6.43	7.20	8.03	.0860	.0470	.0650	2.72	3.53	3.27	.1200	.0590	.0890	.0530	.0180	.0370
356	1545-1	Kavar	2	02/04/95	4.5	40	9.77	9.91	10.71	.0420	.0250	.0340	6.37	6.79	7.23	.0460	.0270	.0370	.0190	.0070	.0140
357	1562-1	Zarrat	1	02/04/95	4.8	30	9.03	10.36	9.86	.0550	.0220	.0400	5.22	6.35	5.21	.0640	.0250	.0480	.0300	.0057	.0170
358	1545-2	Kavar	2	04/04/95	4.0	12	2.47	3.91	2.79	.0360	.0150	.0310	.93	.94	1.18	.0520	.0270	.0420	.0035	.0010	.0030
359	1590-1	Sisakht	1	06/04/95	3.5	16	2.48	2.88	2.94	.0780	.0790	.0690	1.96	2.18	2.32	.0770	.0800	.0680	.0170	.0200	.0160
360	1562-2	Zarrat	1	16/04/95	4.2	16	5.81	5.55	7.01	.0570	.0400	.0430	1.58	3.33	3.00	.0970	.0460	.0580	.0210	.0099	.0140
361	1655	Saman	2	18/04/95	3.7	14	4.31	5.18	4.88	.0350	.0210	.0350	1.91	2.95	2.63	.0460	.0240	.0420	.0059	.0025	.0067

No	Record	Station	Site	Date	Mw	R km	Dur (H1) sec 5-95	Dur (V) sec 5-95	Dur (H2) sec 5-95	Arms (H1) m/s.s 5-95	Arms(V) m/s.s 5-95	Arms (H2) m/s.s 5 95	dur (H1) sec 5-75	dur (V) sec 5-75	dur (H2) sec 5-75	Arms (H1) m/s.s 5-75	Arms (V) m/s.s 5-75	Arms (H2) m/s.s 5-75	Ea (H1) m2/s3	Ea (V) m2/s3	Ea (H2) m2/s3
362	1556	Bandar-Deylam	4	22/04/95	5.1	95	11.09	12.27	10.17	.0190	.0042	.0230	8.48	9.08	7.27	.0190	.0043	.0240	.0043	.0002	.0061
363	1581	Lendeh	1	22/04/95	5.1	51	11.90	12.43	12.84	.0510	.0290	.0420	5.99	6.54	6.44	.0630	.0350	.0520	.0340	.0120	.0250
364	1535-2	Rudbar	3	26/04/95	4.8	8	2.49	2.59	2.80	.2500	.2000	.2200	.97	1.00	.73	.3600	.2900	.3800	.1800	.1200	.1500
365	1548	Astaneh	4	26/04/95	4.8	16	8.88	11.30	10.89	.0290	.0130	.0180	3.25	6.74	6.71	.0420	.0150	.0210	.0081	.0022	.0041
366	1558	Shabankareh	4	02/05/95	3.7	18	6.30	5.38	7.62	.0240	.0210	.0190	1.64	1.97	3.23	.0410	.0310	.0250	.0039	.0027	.0030
367	1536-2	Ghir	4	03/05/95	4.7	28	5.30	7.12	5.01	.1200	.0660	.1200	2.88	1.99	2.80	.1400	.1100	.1500	.0790	.0340	.0860
368	1625-1	Ghaleh-Ganj (Kahnoudj)	1	12/05/95	4.0	47	5.02	6.72	6.22	.0420	.0250	.0320	1.30	3.94	3.74	.0730	.0280	.0360	.0099	.0045	.0070
369	1529-1	Lali	3	14/05/95	4.0	18	4.92	6.84	5.24	.0250	.0120	.0290	1.32	3.61	1.49	.0430	.0150	.0470	.0035	.0011	.0048
370	1621	Darreh-Shahr - Ilam	1	17/05/95	4.5	14	6.38	5.64	7.36	.0480	.0330	.0370	2.58	2.03	3.69	.0660	.0490	.0460	.0160	.0070	.0110
371	1535-3	Rudbar	3	17/05/95	4.2	12	2.62	3.55	2.92	.0420	.0300	.0330	.63	1.61	.87	.0750	.0390	.0530	.0051	.0035	.0035
372	1551-1	Shabastar	1	17/05/95	4.0	24	6.35	3.90	6.42	.0340	.0480	.0280	3.00	1.82	3.95	.0430	.0620	.0310	.0081	.0100	.0055
373	1551-2	Shabastar	1	18/05/95	4.2	22	5.89	3.36	4.17	.0560	.1100	.0810	3.22	1.19	2.97	.0670	.1600	.0850	.0210	.0450	.0310
374	1546	Tasuj	2	18/05/95	4.4	20	5.01	7.55	5.79	.0330	.0160	.0320	1.10	3.22	1.45	.0620	.0210	.0560	.0060	.0021	.0064
375	1551-3	Shabastar	1	18/05/95	4.2	24	2.61	4.03	4.08	.0210	.0150	.0150	1.07	2.43	2.16	.0290	.0170	.0180	.0013	.0010	.0010
376	1594	Khorramabad	2	26/05/95	4.2	20	6.20	6.88	4.61	.0320	.0190	.0380	2.81	3.81	.79	.0430	.0220	.0820	.0073	.0027	.0075
377	1543	Namin	3	27/05/95	4.8	82	8.46	9.85	10.29	.0330	.0160	.0320	4.36	5.00	3.70	.0410	.0200	.0480	.0100	.0029	.0120
378	1590-2	Sisakht	1	27/05/95	4.6	70	.92	2.35	2.02	.0970	.0560	.0570	.64	1.81	1.50	.1000	.0560	.0580	.0096	.0081	.0073
379	1633-1	Namin	3	27/05/95	4.8	80	8.47	10.11	10.34	.0330	.0160	.0320	4.37	5.07	3.70	.0410	.0200	.0480	.0100	.0029	.0120
380	1533-2	Seifabad (S. Kazerun)	1	31/05/95	5.0	20	5.99	8.59	7.34	.0440	.0220	.0390	1.57	3.93	2.70	.0750	.0290	.0570	.0130	.0046	.0120
381	1552	Pol-e Sefid	4	02/06/95	4.1	18	3.40	6.09	5.15	.0450	.0210	.0300	.37	2.44	.72	.1200	.0300	.0710	.0077	.0031	.0051
382	1635-1	Pol-e Sefid	4	02/06/95	4.1	18	3.41	6.09	5.16	.0450	.0210	.0300	.37	2.44	.72	.1200	.0300	.0710	.0077	.0031	.0051
383	1620-1	Doab (Pol-e Sefid)	3	03/06/95	4.0	20	1.91	3.88	1.36	.2600	.1000	.2100	.34	2.78	.56	.5400	.1100	.2900	.1400	.0460	.0680
384	1576	Gavbandi	3	18/06/95	3.5	12	4.56	3.56	3.46	.0250	.0350	.0390	1.84	1.84	1.57	.0350	.0430	.0510	.0033	.0048	.0058
385	1626	Hassan-Keif	3	26/06/95	5.1	14	4.34	5.19	4.38	.1100	.0730	.0900	1.10	2.24	.65	.1900	.0980	.2000	.0570	.0310	.0390
386	1542	Ammarloo	3	10/07/95	3.6	12	.82	1.50	1.50	.0420	.0240	.0280	.32	.78	.73	.0590	.0290	.0360	.0016	.0009	.0013
387	1635-2	Pol-e Sefid	4	27/07/95	4.0	20	5.34	4.76	5.91	.0230	.0290	.0180	3.06	1.88	3.42	.0270	.0400	.0210	.0033	.0044	.0021
388	1557	Delvar	2	28/07/95	3.8	20	5.34	6.05	6.36	.0210	.0130	.0150	1.94	2.73	2.62	.0310	.0170	.0200	.0027	.0011	.0015
389	1620-2	Doab	3	28/07/95	4.1	20	1.88	4.04	1.35	.1400	.0580	.1300	.49	2.54	.59	.2500	.0640	.1700	.0440	.0150	.0230
390	1620-3	Doab	3	14/08/95	3.7	18	3.11	6.52	5.78	.0330	.0140	.0140	.88	2.85	1.87	.0550	.0180	.0220	.0037	.0014	.0012
391	1620-4	Doab	3	15/08/95	3.9	18	2.12	5.68	4.70	.0940	.0240	.0290	.62	2.61	1.16	.1500	.0310	.0510	.0210	.0037	.0044
392	1631-2	Musian	3	16/08/95	3.7	16	6.05	8.30	2.99	.0100	.0077	.0230	2.06	2.91	.38	.0150	.0110	.0560	.0007	.0005	.0017
393	1569	Mahan	4	04/09/95	4.4	20	4.06	9.52	5.88	.0220	.0069	.0140	.75	3.62	1.26	.0460	.0099	.0270	.0022	.0005	.0013
394	1549-1	Ammarloo	3	07/09/95	3.7	12	1.95	.89	1.44	.0550	.1000	.1300	.81	.53	.77	.0760	.1100	.1600	.0066	.0099	.0280
395	1549-2	Ammarloo	3	21/09/95	3.5	12	2.44	2.16	1.64	.0270	.0340	.0370	1.45	1.48	.69	.0310	.0360	.0500	.0020	.0028	.0025
396	1647-1	Dalin (SE Sepidan-Fars)	2	05/10/95	3.7	12	2.66	2.81	2.63	.1200	.0790	.1200	1.30	1.74	.94	.1500	.0890	.1700	.0400	.0200	.0390
397	1540	Rasht (Hous.)	3	13/10/95	4.9	16	11.73	12.96	11.52	.0310	.0096	.0330	7.39	7.90	8.57	.0340	.0110	.0340	.0120	.0013	.0140
398	1637-1	Rasht (Hous.)	3	13/10/95	5.2	16	11.73	12.94	11.51	.0310	.0097	.0330	7.39	7.95	8.57	.0340	.0110	.0340	.0120	.0013	.0140
399	1537	Sefidrud Dam	1	15/10/95	5.2	25	12.47	13.01	12.53	.0470	.0210	.0170	5.82	4.75	5.13	.0600	.0310	.0240	.0300	.0065	.0041
400	1541	Rasht (University)	3	15/10/95	5.2	20	9.69	12.47	9.18	.0330	.0150	.0490	3.96	6.58	3.01	.0460	.0180	.0760	.0120	.0030	.0250
401	1615-1	Abbar	1	15/10/95	5.2	42	10.34	11.02	8.90	.0230	.0180	.0290	5.80	4.36	2.51	.0280	.0250	.0480	.0063	.0039	.0084
402	1632-1	Masal	3	15/10/95	5.2	52	10.27	11.94	10.36	.0210	.0096	.0210	4.36	4.90	3.43	.0290	.0130	.0320	.0051	.0012	.0051
403	1564-2	Khanzanun	1	23/10/95	4.9	8	1.48	2.58	1.23	.1000	.0650	.1500	.32	1.33	.27	.2000	.0800	.2700	.0180	.0120	.0290
404	1620-5	Doab	3	26/10/95	3.4	20	1.74	4.63	3.96	.0330	.0110	.0120	.27	2.67	.81	.0740	.0130	.0230	.0021	.0006	.0006
405	1590-3	Sisakht	1	02/11/95	3.6	15	3.24	3.73	3.42	.0450	.0340	.0370	2.46	2.48	2.41	.0450	.0370	.0390	.0072	.0047	.0052
406	1538	Kolur	1	03/11/95	3.6	16	4.65	8.27	2.17	.0320	.0200	.0720	.92	2.58	.37	.0640	.0310	.1500	.0053	.0035	.0120
407	1586	Ziaratali -N. Bandarabbas	1	06/11/95	5.1	21	7.99	8.65	9.28	.0350	.0190	.0250	3.52	4.72	3.70	.0460	.0230	.0350	.0110	.0035	.0063
408	1625-2	Ghaleh-Ganj (Kahnoudj)	1	06/11/95	5.1	49	6.59	8.14	6.51	.0460	.0320	.0530	1.72	3.24	1.66	.0790	.0450	.0920	.0150	.0095	.0200
409	1539	Mashad (Sakht-Azma)	4	09/11/95	5.6	70	8.65	10.86	9.78	.0490	.0370	.0400	3.30	4.99	5.05	.0700	.0480	.0490	.0230	.0160	.0180
410	1559	Khurmodj	1	14/11/95	4.2	15	4.21	6.48	3.83	.0560	.0260	.0500	2.17	3.32	1.36	.0690	.0330	.0730	.0150	.0050	.0100
411	1544	Silvaneh	4	14/11/95	4.4	16	3.50	5.16	4.07	.0880	.0430	.0630	.85	2.15	1.75	.1600	.0590	.0840	.0300	.0110	.0180
412	1560-1	Lali	3	24/11/95	4.5	19	2.79	3.69	4.51	.3100	.3000	.2400	.66	2.29	1.84	.5600	.3300	.3300	.3000	.3600	.2900
413	1572	Masjed-Soleyman	3	24/11/95	4.5	45	8.78	6.09	5.89	.0320	.0180	.0610	3.23	2.73	2.70	.0470	.0240	.0800	.0100	.0023	.0250
414	1560-2	Lali	3	24/11/95	4.0	20	3.44	4.71	3.20	.0400	.0310	.0440	.88	2.61	1.61	.0690	.0370	.0550	.0060	.0050	.0069
415	1560-3	Lali	3	25/11/95	3.8	18	2.84	3.71	3.63	.0430	.0330	.0320	.79	2.55	1.29	.0720	.0350	.0470	.0059	.0044	.0041
416	1560-4	Lali	3	27/11/95	5.0	18	6.72	4.23	4.84	.1400	.2000	.2200	1.47	2.84	1.35	.2700	.2200	.3700	.1500	.2000	.2600
417	1560-5	Lali	3	27/11/95	3.8	8	3.95	3.92	4.09	.0370	.0350	.0390	1.72	2.52	1.72	.0500	.0380	.0530	.0062	.0053	.0070
418	1590-4	Sisakht	1	14/12/95	3.5	14	2.74	2.64	2.80	.0450	.0630	.0490	1.57	1.76	1.78	.0530	.0680	.0540	.0062	.0120	.0074
419	1549-3	Ammarloo	3	29/12/95	3.9	12	1.66	2.79	2.34	.0770	.0320	.0590	1.01	1.70	.53	.0870	.0370	.1100	.0110	.0033	.0091
420	1566	Shiraz	4	31/12/95	4.7	35	9.44	8.62	8.26	.0240	.0230	.0260	3.63	6.32	3.35	.0340	.0230	.0350	.0059	.0050	.0060
421	1602-1	Kavar Dam	2	31/12/95	4.7	33	8.79	9.89	8.53	.0460	.0180	.0390	3.62	5.36	4.26	.0640	.0220	.0480	.0210	.0036	.0140
422	1602-2	Kavar Dam	2	31/12/95	4.8	24	8.45	9.47	9.11	.1100	.0350	.0800	3.67	4.94	3.89	.1400	.0430	.1100	.1100	.0130	.0650
423	1602-3	Kavar Dam	2	31/12/95	4.0	32	5.59	10.97	6.95	.0350	.0078	.0280	2.43	6.33	2.40	.0460	.0091	.0420	.0075	.0007	.0061
424	1571-1	Shabankareh	4	23/01/96	4.1	16	4.32	5.62	7.18	.0700	.0530	.0400	.78	2.93	2.78	.1500	.0650	.0560	.0240	.0180	.0130
425	1571-2	Shabankareh	4	23/01/96	3.5	16	2.25	4.45	3.95	.0410	.0280	.0230	.45	2.83	1.26	.0810	.0310	.0350	.0043	.0038	.0023
426	1571-3	Shabankareh	4	23/01/96	3.7	16	8.97	4.18	3.90	.0130	.0420	.0420	3.20	2.90	1.08	.0190	.0450	.0710	.0017	.0082	.0078
427	1571-8	Shabankareh	4	24/01/96	4.5	18	2.76	5.71	3.83	.2100	.0830	.1400	.73	2.96	1.11	.3600	.1000	.2200	.1300	.0440	.0790
428	1571-11	Shabankareh	4	24/01/96	4.4	18	6.84	7.84	8.04	.0200	.0150	.0170	.94	3.54	2.19	.0480	.0190	.0290	.0031	.0019	.0026
429	1571-16	Shabankareh	4	24/01/96	4.7	16	7.48	10.72	8.65	.0250	.0180	.0240	.93	3.78	2.26	.0620	.0270	.0420	.0051	.0040	.0057
430	1583-3	Saadabad	1	24/01/96	4.4	21	13.22	17.01	14.99	.0750	.0280	.0550	10.39	12.00	11.13	.0740	.0290	.0560	.0820	.0150	.0500
431	1583-4	Saadabad	1	24/01/96	4.7	21	5.07	8.75	5.28	.0470	.0180	.0390	1.58	4.59	1.91	.0750	.0220	.0570	.0130	.0032	.0087
432	1571-10	Shabankareh	4	24/01/96	4.6	24	19.32	16.75	16.48	.0720	.0770	.1000	13.09	13.78	11.80	.0770	.0750	.1000	.1100	.1100	.1900
433	1571-12	Shabankareh	4	24/01/96	3.7	20	5.44	6.69	5.50	.0160	.0160	.0170	1.11	3.14	1.52	.0320	.0210	.0290	.0016	.0019	.0019
434	1571-13	Shabankareh	4	24/01/96	3.7	18	7.39	7.95	3.99	.0150	.0140	.0290	2.31	3.28	.69	.0240	.0200	.0610	.0020	.0019	.0037
435	1571-14	Shabankareh	4	24/01/96	3.7	16	7.93	7.55	4.62	.0160	.0140	.0270	2.34	3.07	.47	.0250	.0190	.0760	.0021	.0016	.0038
436	1571-15	Shabankareh	4	24/01/96	3.6	15	5.39	6.06	4.96	.0190	.0190	.0230	1.46	2.62	.84	.0320	.0260	.0490	.0021	.0025	.0029
437	1571-17	Shabankareh	4	24/01/96	3.5	17	7.05	5.38	4.14	.0110	.0190	.0210	2.48	2.73	.86	.0170	.0230	.0400	.0010	.0021	.0020
438	1571-18	Shabankareh	4	24/01/96	3.5	18	12.73	9.53	5.59	.0047	.0076	.0150	7.17	3.05	.64	.0055	.0120	.0380	.0003	.0006	.0013
439	1571-19	Shabankareh	4	24/01/96	3.8	16	5.53	6.25	5.85	.0340	.0250	.0280	.76	3.62	2.38	.0810	.0290	.0390	.0073	.0043	.0052
440	1571-20	Shabankareh	4	24/01/96	3.8	16	8.15	8.21	8.20	.0170	.0160	.0170	1.68	3.81	1.93	.0330	.0210	.0300	.0027	.0023	.0025
441	1571-21	Shabankareh	4	24/01/96	3.7	16	11.76	10.16	10.05	.0130	.0130	.0170	5.70	5.50	3.36	.0170	.0160	.0260	.0023	.0020	.0032
442	1571-22	Shabankareh	4	24/01/96	4.0	16	10.89	7.41	5.34	.0200	.0330	.0680	6.82	3.13	.39	.0230	.0450	.2200	.0050	.0089	.0270
443	1571-23	Shabankareh	4	24/01/96	3.6	16	10.24	6.41	8.20	.0110	.0190	.0150	3.40	2.78	2.44	.0160	.0250	.0240	.0013	.0025	.0020
444	1571-24	Shabankareh	4	24/01/96	4.0	20	7.34	8.51	7.81	.0140	.0089	.0130	2.85	4.22	3.31	.0200	.0110	.0180	.0017	.0008	.0015
445	1571-25	Shabankareh	4	24/01/96	3.9	20	5.85	6.45	5.28	.0280	.0280	.0370	1.93	3.91	1.39	.0430	.0320	.0640	.0051	.0056	.0082
446	1571-4	Shabankareh	4	24/01/96	3.9	17	8.52	5.36	4.32	.0150	.0320	.0430	2.92	3.17	.84	.0220	.0360	.0860	.0021	.0059	.0089
447	1571-5	Shabankareh	4	24/01/96	3.8	16	8.44	6.00	3.71	.0170	.0280	.0530	3.03	3.12	.59	.0250	.0340	.1200	.0028	.0053	.0120
448	1571-6	Shabankareh	4	24/01/96	3.7	16	8.46	5.12	3.98	.0150	.0290	.0410	2.80	2.89	.57	.0230	.0340	.0960	.0021	.0048	.0075
449	1571-7	Shabankareh	4	24/01/96	4.2	17	8.99	5.66	5.58	.0390	.0730	.0970	4.18	3.13	.86	.0500	.0870	.2200	.0150	.0340	.0580

No	Record	Station	Site	Date	Mw	R km	Dur (H1) sec 5-95	Dur (V) sec 5-95	Dur (H2) sec 5-95	Arms (H1) m/s.s 5-95	Arms(V) m/s.s 5-95	Arms (H2) m/s.s 5 95	dur (H1) sec 5-75	dur (V) sec 5-75	dur (H2) sec 5-75	Arms (H1) m/s.s 5-75	Arms (V) m/s.s 5-75	Arms (H2) m/s.s 5-75	Ea (H1) m2/s3	Ea (V) m2/s3	Ea (H2) m2/s3
450	1571-9	Shabankareh	4	24/01/96	3.7	17	7.15	5.48	2.94	.0100	.0150	.0280	1.96	3.27	.61	.0170	.0170	.0540	.0008	.0013	.0026
451	1583-5	Saadabad	1	24/01/96	4.2	22	3.75	7.16	3.99	.0350	.0120	.0280	.71	3.24	.42	.0700	.0150	.0760	.0050	.0011	.0035
452	1583-6	Saadabad	1	24/01/96	4.1	25	5.11	5.60	3.93	.0220	.0150	.0320	2.14	1.62	.32	.0300	.0250	.0980	.0027	.0015	.0045
453	1571-30	Shabankareh	4	25/01/96	4.5	20	6.46	6.46	5.55	.0380	.0410	.0460	2.66	4.43	2.51	.0520	.0440	.0600	.0100	.0120	.0130
454	1583-7	Saadabad	1	25/01/96	4.5	21	3.76	6.65	4.90	.0360	.0140	.0240	.45	3.21	.69	.0920	.0180	.0560	.0055	.0015	.0031
455	1571-26	Shabankareh	4	25/01/96	4.0	20	7.16	4.73	2.45	.0340	.0660	.1500	1.91	2.87	.62	.0580	.0750	.2700	.0093	.0230	.0650
456	1571-27	Shabankareh	4	25/01/96	3.7	20	6.36	5.57	6.13	.0160	.0210	.0160	2.44	2.78	1.93	.0230	.0260	.0250	.0018	.0028	.0017
457	1571-28	Shabankareh	4	25/01/96	3.9	20	6.15	4.51	5.34	.0250	.0390	.0350	2.02	2.35	2.11	.0390	.0480	.0490	.0044	.0076	.0072
458	1571-29	Shabankareh	4	25/01/96	4.0	20	6.47	6.46	5.55	.0380	.0410	.0460	2.66	4.43	2.51	.0520	.0440	.0600	.0100	.0120	.0130
459	1571-31	Shabankareh	4	25/01/96	3.6	20	7.04	6.44	4.78	.0092	.0160	.0210	2.71	3.40	1.29	.0130	.0190	.0350	.0007	.0018	.0023
460	1571-32	Shabankareh	4	26/01/96	3.9	21	6.23	4.86	4.32	.0360	.0570	.0650	1.99	2.65	.75	.0560	.0680	.1400	.0090	.0170	.0200
461	1571-34	Shabankareh	4	26/01/96	4.6	20	7.49	6.51	4.82	.0100	.0130	.0170	3.79	3.19	1.32	.0120	.0160	.0280	.0008	.0012	.0015
462	1571-35	Shabankareh	4	26/01/96	4.4	22	7.24	6.80	6.73	.0450	.0380	.0440	2.81	3.75	2.17	.0640	.0450	.0680	.0170	.0110	.0150
463	1589-1	Saadabad	1	26/01/96	4.6	22	9.35	12.58	9.97	.0710	.0300	.0590	6.90	9.12	6.73	.0730	.0310	.0630	.0530	.0130	.0380
464	1589-2	Saadabad	1	26/01/96	4.4	22	4.09	7.88	4.59	.0260	.0110	.0260	.82	3.59	.64	.0510	.0140	.0620	.0030	.0010	.0035
465	1599-1	Firouzabad	3	26/01/96	4.4	26	8.76	9.12	9.84	.0490	.0280	.0340	3.65	5.51	6.30	.0680	.0320	.0370	.0240	.0080	.0120
466	1571-33	Shabankareh	4	26/01/96	3.7	20	13.14	10.59	10.01	.1100	.1300	.2000	7.15	7.61	6.25	.1400	.1400	.2300	.1900	.2100	.4600
467	1571-36	Shabankareh	4	26/01/96	3.6	15	12.80	5.17	4.15	.0046	.0130	.0190	6.16	2.20	.78	.0058	.0170	.0380	.0003	.0009	.0016
468	1701-1	Ardebil	4	28/02/97	6.3	32	32.12	35.18	35.33	.1900	.1200	.1900	9.27	13.40	14.68	.3100	.1600	.2600	1.3000	.5200	1.400

Chapitre 6

L'Atténuation des Mouvements Forts en Iran

Résumé Les données des mouvements forts en Iran sont utilisées pour établir les lois d'atténuation empiriques pour différents paramètres de mouvements forts: Amax, Vmax, Dmax et les ordonnées spectrales des spectres de réponses. Les variables explicatives sont la magnitude, la distance hypocentrale et les conditions de site. Deux approches ont été essayées pour les régression (une et deux étapes), et les résultats sont très proches l'un de l'autre: les résultats de la première approche (deux étapes) sont présentés d'abord, ensuite viennent ceux de la deuxième approche (une étape). Les résultats de la régression faite en une seule étape sous-estiment les mouvements forts à faible distance ($< 20km$), mais les surestiment pour des distances supérieures à 100km par rapport aux résultats de la régression en deux étapes.

La base de données se compose de 468 accélérogrammes, en 3 composantes, enregistrés au cours des 24 dernières années en Iran. Basé sur ces données, on divise le pays en deux régions géographiques: pour la période d'observation (1975-1997), les plus forts séismes ont eu lieu dans les régions de l'Iran central et dans l'Alborz ($M > 7$), et ont été enregistrés jusqu'à 220km de distance, alors que les séismes du Zagros ont été plus modérés (M4-6), et enregistrés seulement jusqu'à environ 60 km. Cette différence, et une différence possible entre l'atténuation dans ces deux grandes régions, impose des coefficients différents pour les relations d'atténuation. Les effets de site observés à partir de ces régressions ne sont pas très importants, mais malgré tout sont en accord avec la classification de site préalablement choisie. Les effets non-linéaires ont aussi été recherchés dans ces études mais les résultats semblent montrer des phénomène contraires avec les amplifications d'autant plus grandes que le mouvement est forts; aucune explication exacte n'a pu être trouvée pour cette observation, mais peut-être ces résultats sont la réponse de sites d'alluvions assez raides dans le champ-proche des séismes, quant les niveaux des nappes phréatiques sont très bas. Dans notre proposition pour la poursuite des installations de stations accélérométriques en Iran, nous insistons sur l'importance du problème du champ-proche en Iran. Les réseaux locaux dans les régions à sismicité très importante peuvent aussi fournir les données plus précises pour la suite des études sur la loi d'atténuation en Iran.

Strong Motion Attenuation in Iran

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Abstract The Iranian strong ground motions data are used to derive the empirical attenuation laws for different strong motion parameters: peak acceleration, peak velocity, peak

displacement, response spectral ordinates. The empirical relationships are established for the strong motion parameters as a function of moment magnitude, hypocentral distance, and a constant parameter representing the site conditions. The one and two step approaches for the regressions are applied, and the results are found to be near to each other, while only the results for the two step approach are presented in this paper. The data set consists of 468 three component accelerograms, all recorded during the last 24 years in Iran. It is split in two subsets corresponding to two geographical areas: during the period of observation (1975-1997), stronger earthquakes occurred in central Iran and Alborz region and were recorded at distances as far as 220km, whereas the Zagros belt experienced only moderate events (M4-6) recorded at distances up to about 60km. This difference, and a probable difference in attenuation between these two main regions, cause different coefficients for the attenuation relationships. The soil effects are considered in the regressions: the resulting site dependence is not very large, but does agree with our previous site classification for Iran.

6.1 Introduction

The Iranian strong motion records are obtained by a national network operated by BHRC (Building and Housing Research Center) and installed in different cities and villages throughout the country (Figure 6.1). As it is outlined in a previous paper (Bard et al 1998), this network first consisted of Kinemetrics SMA-1 analog instruments (1975-1989), which were complemented by numerous SSA-2 digital instruments after the Manjil earthquake of 1990. By the end of 1997, the number of instruments was reported to be 1000 stations, while the location of 386 SSA-2 and 79 SMA-1 stations are reported and plotted in Figure- 1. The stations are mainly installed within cities or villages for easy maintenance. A preliminary listing of the recorded data as of 1993 was published by BHRC. A complete catalog is available in Bard et al 1998).

The attenuation relationships in Iran have never been established using the whole Iranian data set. The purpose of this paper was therefore to fill that gap. The mentioned cleaned catalog is used, that keeps only the data for which the magnitude and epicentral distance are known, and for which the signal to noise ratio is satisfactory. The data set consists of 468 three component records. The source parameters were derived from the teleseismic studies for 279 records (Bard et al 1998) and directly from the strong motion records for the remaining 189 records, using a source model (Zaré et al 1999b). The site conditions were devoted special attention and measurements, which led to a new categorization in four different site classes, on the basis of H/V ratio for strong motion records. Details may be found in Zaré et al 1999a.

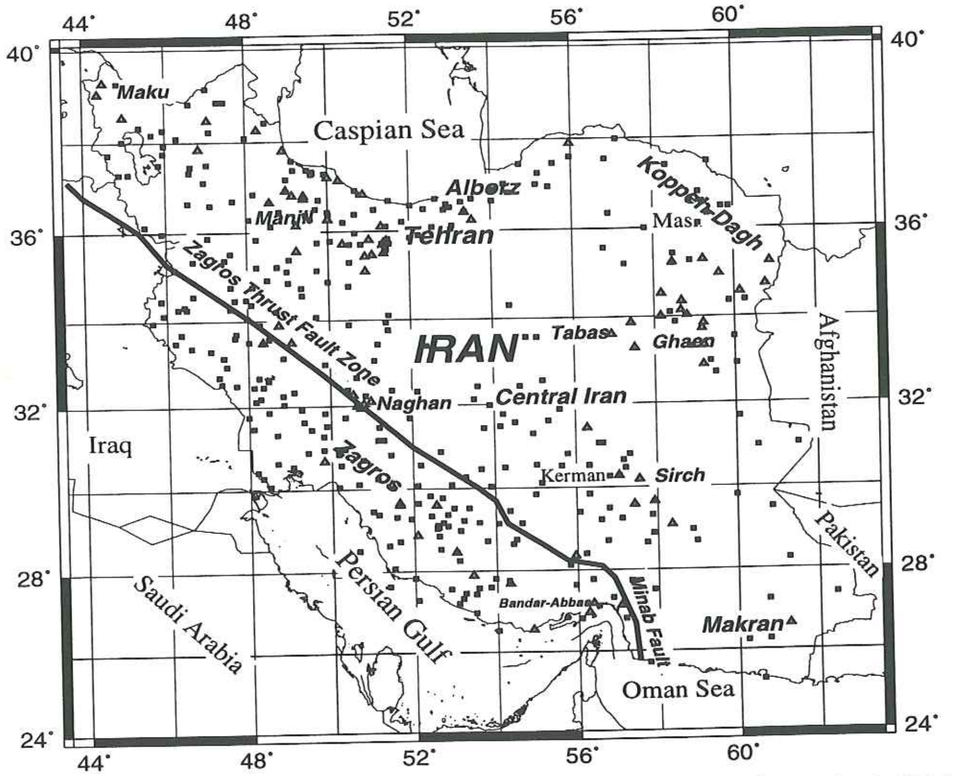

FIG. 6.1 – *The strong motion network of Iran (stations installed by the end of 1996) the location of the new instruments are not still reported. The SSA-2 instruments are shown with triangles and the SMA-1 station are marked with quadrangles (special thanks to H. Mirzaei-Alavijeh of BHRC for the location of the new SSA-2 instruments). Iranian seismogenic zones and the Zagros thrust fault zone-Minab fault, which represent the frontier between the Alborz-Central Iran area and the Zagros area, are shown on the map.*

The scope of this study is to investigate attenuation laws for the strong motions in Iran, in form of different parameters. An attempt was also performed to look for some difference in the attenuation in different regions. Another scope was to provide the design spectra for sample sites in Alborz (Tehran, on a rock site) and in Zagros (a sample site on the Persian Gulf).

In this article the methodology of the study is explained first, followed by the criteria to establish the data-base. The results of the study are then presented for the various parameters. The coefficients of the regression are presented not only for the spectral values but also for the parameters such as peak ground acceleration (PGA), peak ground velocity (PGV) and peak ground displacement (PGD). All coefficients are presented for horizontal and vertical components and separated for the Zagros and non-Zagros region (Alborz-Central Iran), and finally for the entire of the Iranian data.

6.2 Methodology

The establishment of the attenuation relationships for a given region may provide information to be used in other regions with similar characteristics. Meanwhile, it has benn repeatedly claimed in recent years that a attenuation relationship, as an empirical model fitted to the data from a specific area, may not be easily used in other regions with different tectonic and crustal specifications (Abrahamson and Silva 1997, Abrahmson and Shedlock 1997).

6.2.1 The applied approaches

To establish the attenuation relationships for Iran, the approach presented by Joyner and Boore (1981) and Fukushma and Tanaka (1990) was followed. A two-step regression is used to fit a model to multiple independent variables (magnitude, distance, site,...). In this method the parameters controlling distance and site effects dependence and a set of amplitude factors, one for each event, must be determined in the first step, by maximizing the likelihood of the set of observation . The determination of the parameters controlling the magnitude dependence is then performed in a second step, by maximizing the likelihood of the set of amplitude factors (Joyner and Boore 1993).

Another possible approach is the one-step method, in which all the parameters are obtained simultaneously by maximizing the likelihood of the set of observations. This approach, which is used by Joyner and Boore (1993) and Brillinger and Preisler (1984, 1985), yields similar results to the two-step method for the spectral ordinates using the north-western American data (Boore et al 1994).

6.2.2 Fundamental form

The genuine form of the dependence is:

$$\log A = a \cdot M_w + b \cdot X - d \cdot \log X + c_i \cdot S_i + \sigma \cdot P \quad (6.1)$$

where A is the strong motion parameter, a is the coefficient for magnitude M; b is the coefficient related to the anelastic attenuation with distance X; c_i is a constant depending on the sites class S; σ_i is the sigma value of 84 percent ($P = 1$), to be added to the mean (50 percent values; $P = 0$). The d coefficient for the $\log X$ term is introduced to allow a geometrical expansion which may be different from the body wave dependence. In this study the moment magnitude M_w is used for M and hypocentral distance is used for X (except for two cases which will be explained later). The site conditions are divided in 4 categories according to Zaré et al 1999a. In many of the computations presented below, d is set equal to 1, so that this regression formula is similar to:

$$y = \frac{k}{X} \cdot e^{-qX}$$

where k is a function of M, and q is a constant. This form represents a simple point-source geometric expansion with constant (Q) anelastic attenuation. We have examined the X^{-d} form, as shown in equation 6.1, such that:

$$y = \frac{k}{X^d} \cdot e^{-qX} \tag{6.2}$$

Joyner and Boore (1981) have shown that such form should apply only to a harmonic component of the ground motion, and not to the peak values, however its application to the peak values (determining empirically) would be a proper approximation.

Ambraseys (1995) proposed attenuation relationships for Europe using the same model. He eliminated the anelastic attenuation coefficient term $b.X$, for the vertical component estimations claiming that for the vertical records (of European data) of magnitudes Ms 4.0-7.9 and the focal depths less than 30km, a two-step regression was found to be inadequate in size to determine both the anelastic and geometric distance terms (Ambraseys 1995, Ambraseys and Simpson 1996). The distance term used by Ambraseys in the mentioned papers and by Joyner and Boore (1981), Boore et al (1997) is:

$$X = (R^2 + h^2)^{0.5}$$

where R is the distance to the surface projection of ruptured area, and h is the focal depth. Fukushima and Tanaka (1990) and Fukushima et al (1988) have defined the term of

$$X = (R + j \cdot 10^{e \cdot M})$$

where R is the rupture distance, j and e are the coefficients to be filtered, and M is the surface wave magnitude. This expression shouldreduce to $X = R$ for large distances. Hardly

and Helmberger (1980) have shown that near the faults, little geometrical attenuation exists. Therefore they suggested a functional form of the effective attenuation versus distance, for the strike-slip earthquakes. For this function, we have:

$$X = [R + C(M)]^{-t}$$

in which X is the modified epicentral distance for the near source earthquakes, R is the epicentral distance, $C(M)$ is a function of magnitude and t is a coefficient. This function is used by Campbell (1981) to present the attenuation relationship for the near-field strong motions:

$$PGA = a \cdot \exp b \cdot M[R + C(M)]^{-j}$$

The near-field attenuation is a function of the fault dimensions, therefore Esteva (1970) has shown that the parameter relating the fault rupture dimensions scales exponentially with magnitude; $C(M) = c_1 \exp(c_2 \cdot M)$.

6.2.3 Ground Motion Parameters

The regressions were performed for various ground motion parameters; PGA, PGV and PGD, and for the spectral accelerations ($S_a(T)$). The regression on Sa(T) was fulfilled for 146 different frequencies and 5 percent of damping (between 0.1 and 50 Hz, periods between 0.02 and 10 seconds; see Annexe 9.1) such that more point are applied for low frequencies in comparison with the high frequencies. The general form of the attenuation relationship for the spectral acceleration (Sa) is;

$$\log Sa(T) = a(T) \cdot M_w + b(T) \cdot X - d \cdot \log X + c_i(T) \cdot S_i + \sigma(T) \cdot P \tag{6.3}$$

This relationship has the same form as equation 6.1 , just the spectral acceleration and the coefficients a, b, c and σ are functions of the period (T). Caillot (1992) used a slightly different form of such formula with the Neperian logarithm of $Sa(T)$ and eliminating the term related to the anelastic attenuation coefficient, while adding a coefficient to observe the geometric expansion for the Italian data:

$$\ln Sa(T) = a(T) \cdot M_w + b(T) \cdot \ln X + c_i(T) \cdot S_i + \sigma(T) \cdot P$$

6.3 The input data-base

The data-base used as the input for this study consists of 468 three components accelerograms (169 analogs by SMA-1 instruments and 299 digitals by SSA-2 recorders, Appendix 6.1), recorded between 1975 and February 1996 by the national network (Figure 6.1). This data-base comprises 279 analog and digital records with fairly well known source parameters (Bard et al 1998) and 189 other digital accelerograms which were very well recorded, and for which no source data was directly available. The moment magnitude and hypocentral distance for these records have thus been estimated directly from the strong motion records. The hypocentral distance was obtained from the S-P time difference, while the seismic moment was directly calculated from the level of acceleration spectra plateau and the corner frequency (Zaré et al 1999b).

The magnitude range for the whole data set is $2.7 = M \leq 7.4$ while the range for hypocentral distances is $4 \leq X \leq 240km$ (Figure 6.2). The focal depths range is 9-133km but the focal depth determination is very imprecise and the majority of the events are shallow (Bard et al 1998a). The two horizontal components of each record are included separately in the study, therefore the number of the horizontal records entered to the regressions was twice the vertical ones.

6.3.1 The magnitude values

The magnitude used here is the moment magnitude, to give a uniform and reliable scale. The moment magnitude was systematically calculated for the well recorded earthquakes (with little noise). When it was not possible to calculate M_w precisely because of the high noise level, other magnitudes were converted to M_w using the correlation with M_w specifically derived for Iran (Zaré et al 1999b). According to this correlation, M_w is taken equal to M_s for magnitudes greater than 6 and equal to mb and ML for magnitudes less than 6. Ambraseys and Free (1997) showed for a European data-base (including a few Iranian data) that such correlation exists between Ms and M_w not only for the moment magnitude relationship (Hanks and Kanamori 1979, used in Zaré et al 1998b) but also for a new empirical non-linear relationship established by them.

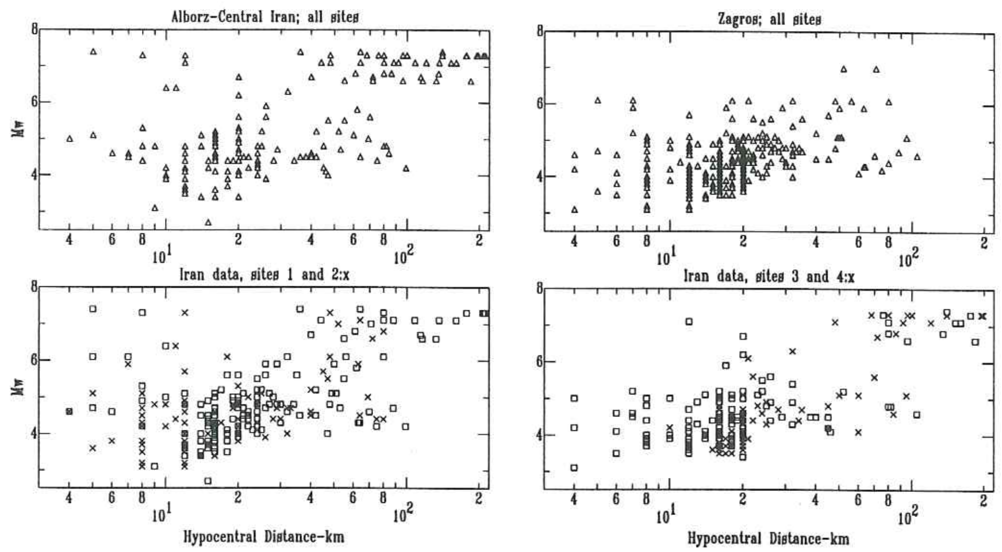

FIG. 6.2 – *The statistics of the Iranian data for Alborz-Central Iran, Zagros and entire of the data; the attribution of the records to the site classes is shown for the entire of the data.*

6.3.2 Distance parameter

When discussing the choice of the "distance parameter" one must keep in mind the significant uncertainties in teleseismic epicenter localizations and large uncertainties in determining focal depths for the Iranian earthquakes. It is important however to define this parameter so that the future use of the attenuation law will be easy.

The focal depths for most of the Iranian records (below M_w6.0) are estimated using the teleseismic reports, because of the lack of a dense seismic array in Iran. This situation is similar even for some larger events ($M_w > 6.0$). Kadinsky-Cade and Barazanji (1982) showed that for the Zagros data in southern Iran, there is a discrepancy between the depths reported by ISC and those of NEIC. Neglecting the values of 33km (depth at which events are arbitrarily located when the iteration process used in their location yields large residuals), the ISC depths are systematically reported to be greater than the NEIC depths.

The only earthquakes with Mw greater than 6.0 for which the focal depths are constrained by waveform observations are:

- The Sarkhun earthquake, 7 March 1975 (Ms6.1 depth=11km);
- The Khurgu, earthquake, 21 March 1977 (Ms7.0, depth=12km) (both by Jackson and

Mckenzie 1984);

- The Naghan, earthquake, 6 April 1977 (Ms6.1, depth=43km), (Ni and Barazanji 1986);

- The Tabas, earthquake, 16 September 1978 (Mw7.4, depth=10km, Berberian 1982);

- The Manjil, earthquake, 20 June 1990 (Mw7.3, depth=19km, Eslami and Mozaffari 1992, and 14km, Berberian et al 1992);

We have decided to define the distance variable for the regression as the "hypocentral distance". This distance is controlled by the difference in the arrivals of the compressional and shear wave for each record. Such information is available without any ambiguity only with the SSA-2 digital records, since the SMA-1 instruments do not include any pre-event memory.

In the cases of near-source records (such as the Tabas record obtained at 5km distance from the Tabas 1978 earthquake fault , and Abbar record in the Manjil 1990 earthquake at 8km distance to fault zone), it was impossible to distinguish the phases and the first arrivals, so we have taken the distance to the fault zone (R_f) as our variable X (which is has more physical concept than hypocentral distance; R_h). Ambraseys and Sbrulov (1998) indicated that in the near-field cases (such as Tabas record) the point-source model may over-estimate the predictions of peak values and spectral ordinates. They showed that the over-parameterization of the attenuation model may not reduce variability of the predictions from point-source models, however they suggested a better understanding of source location, direction and thickness of the non-seismogenic zone for the near-field records.

On the other hand, the Tabas record exhibits a very specific near-source spectra, such that it was estimated that an important directivity effect was probable on this record (Zaré 1996). It is hence suggested that for magnitudes greater than M_w7.0, and distances less than 20km, and magnitudes greater than M_w6.0 with distances less than 10km as well, the prediction of strong motion parameter should deserve a special study, for instance through a search of corresponding near -source records in the Iranian data-set or in another data-set which represents similar seismotectonic characteristics. In such conditions near-field records might be studied by a deterministic approach to predict the probable strong motion parameters.

Since the differences between the hypocentral and epicentral distances are not too large for shallow earthquakes (less than 35km depth), it is suggested that in further use of the presented attenuation laws in this article, the "surface distance to fault" be replaced in the formula whenever the estimation of the depth of the seismic source is impossible. We propose that such surface projected distance might give a good estimation of the hypocentral distances.

6.3.3 Geological areas

The Iranian data falls into two geological groups; the Zagros data and Central Iran and Alborz data (Figure 6.1). The Zagros thrust fault zone (Figure 6.1) is the main geologic frontier between the Zagros and non-Zagros regions. The pre-existing seismic data from Zagros area shows higher seismic activity rate than the other regions. In the Zagros area middle range magnitudes (M4-6) are more frequent. In Alborz-Central Iran zone earthquakes are less frequent but have generally higher magnitudes than Zagros, and are therefore more destructive (Tabas earthquake, 1978, Central-Iran; and Manjil earthquake, 1990, Alborz) . The Zagros thrust fault zone is the main geologic frontier between these two areas. On the other hand, the Zagros data are mostly recorded in the near-field distances (below 60km), while there exist records at distances greater than 220km in Alborz-Central Iran region. The time of the event, the distance to source and the exact timing on the digital records (if accessible), the magnitude of the corresponding event and the amplitude of the records were the main criteria to attribute each record to the seismic events in these zones. Since the strong motions are limited to relatively near distances, and most of our records were obtained within 50km (Figure 6.2), the events are distinguishable for each of the mentioned zones.

6.3.4 Site Categorization

Site conditions are considered through the categorization in four site classes on the basis of the receiver function (Zaré et al 1999a). Site class 1 is defined as sites that do not exhibit any significant amplification below 15 Hz. It corresponds to rock and stiff sediment sites with an average S-wave velocity over the top 30 meters in excess of 700m/sec. Site class 2 consists of sites for which the receiver function (RF) exhibits a fundamental peak exceeding 3 at a frequency located between 5 and 15 Hz. It was shown to correspond to stiff sediments and/or soft rocks with V_s30 between 500 and 700 m/sec. Site class 3 consists of the sites for which RF shows a peak with an amplitude exceeding 3 between 2 and 5Hz, and corresponds to alluvial sites with V_s30 between 300 and 500 m/sec. Finally site class 4 is defined as sites for which RF indicates peaks with amplitudes greater than 3 at frequencies below 2Hz, and it may be viewed as corresponding to thick soft alluvium. This ranking was the result of geotechnical measurements on 50 sites (compressional and shear wave velocity, microtremors) and the calculation of the receiver function for strong motions using three component accelerograms. This categorization shows some similarity to that of Boore et al (1993, 1994) (based on the average V_s for the top 30m) for the northwestern American data. The average V_s limits to distinguish the site classes in Boore et al (1993,1994) reports are 180 m/sec, 360 m/sec, 750 m/sec and greater than 750 m/sec (to be compared with our values of 300, 500 and 700 m/sec).

6.3.5 Fault mechanism

According to the regional tectonic conditions of Iranian plateau, the fault mechanisms of most of the earthquakes are compressional, strike-slip or a combination of these two mechanisms. In an earlier study (Bard et 1998), it was shown that out of the 100 focal mechanisms of the records that are available, 40 correspond to strike-slip/reverse mechanisms, 31 to pure strike slip, 24 to pure reverse and 4 to pure vertical plane. Hence further usage of the attenuation law in this article should be limited to the sources with such mechanisms. It must be noted that since the time of installation of the Iranian accelerometric network, no earthquake with a normal (extension) fault solution has been recorded in this network.

6.4 Results

The results of regressions are presented in the form of spectral ordinates and the peak values. The values of the coefficients and the residuals between the predicted and the observed values for the maximum of the strong motion parameters (PGA, PGV and PGD) are estimated. The predicted spectra are presented for two different situations in Zagros and Alborz-Central Iran, and the smoothed (design) spectra to be proposed. The representative spectra are calculated using the attenuation laws for the spectral accelerations (Sa).

As explained before for the equations 6.1, 6.2, and 6.3, surface wave-like attenuation may be reproduced applying $d = 0.5$ for $d \cdot \log X$. To find the lowest possible standard deviation, different values are examined for d , and the lowest sigma value were obtained for $d = 0.3$ on the vertical components and $d = 0.1$ for the horizontal components. These variations may be investigated further to find the other effective factors in the attenuation in the Iranian crust. However we will present here only the calculations with $d = 0.5$ and $d = 1$, because of their physical meaning in relation with surface and body waves, respectively.

The calculations on the response spectra are limited to the frequency bands for which a good signal to noise ratio (R_{sn}) could be found. The accelerometric data are already band-pass filtered, considering a R_{sn} fixed to be 3 (Bard et al 1998, Zaré et al 1998b). Therefore in the frequency bands for which R_sn was lower than 3, the accelerogram is considered to be noisy and the spectral values are eliminated from the calculations. The sum of the selected point for

the regressions after such sieving is shown in Figure 6.3. According to this figure, the records in Alborz-Central Iran which were mostly analog (SMA-1) records contained a lot of noise and suffered more from the filters, while the Zagros data which are mostly digital show proper signals.

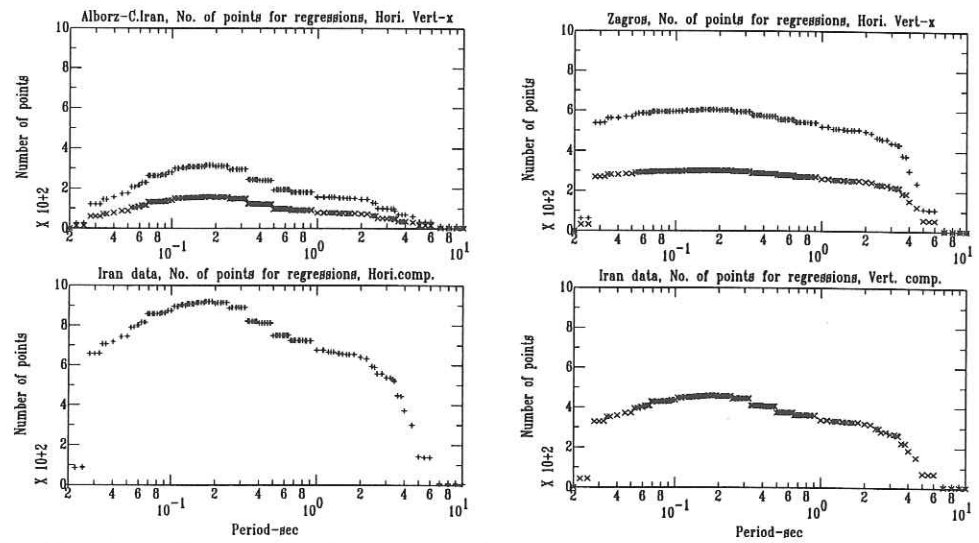

FIG. 6.3 – *Number of spectral values after eliminating the values with low signal to noise ratios.*

6.4.1 Attenuation coefficients for peak values

The strong motion parameters (A value in equation 6.1) selected in this section are PGA, PGV and PGD. Other parameters (energy and duration) were investigated in a separate study (Zaré et al 1999b).

The values of the coefficients of the regression for PGA, PGV and PGD in equation 6.1 are shown in Tables-6.1 to 6.3. The attenuation curves (Figures 6.4, 6.5 and 6.6) are presented for Alborz-Central Iran, Zagros and the Iranian data (entire of the data-base). The Iranian strong motion data show some differences in at least two main regions: Zagros and Alborz-Central Iran (Tables-6.1 to 6.3).

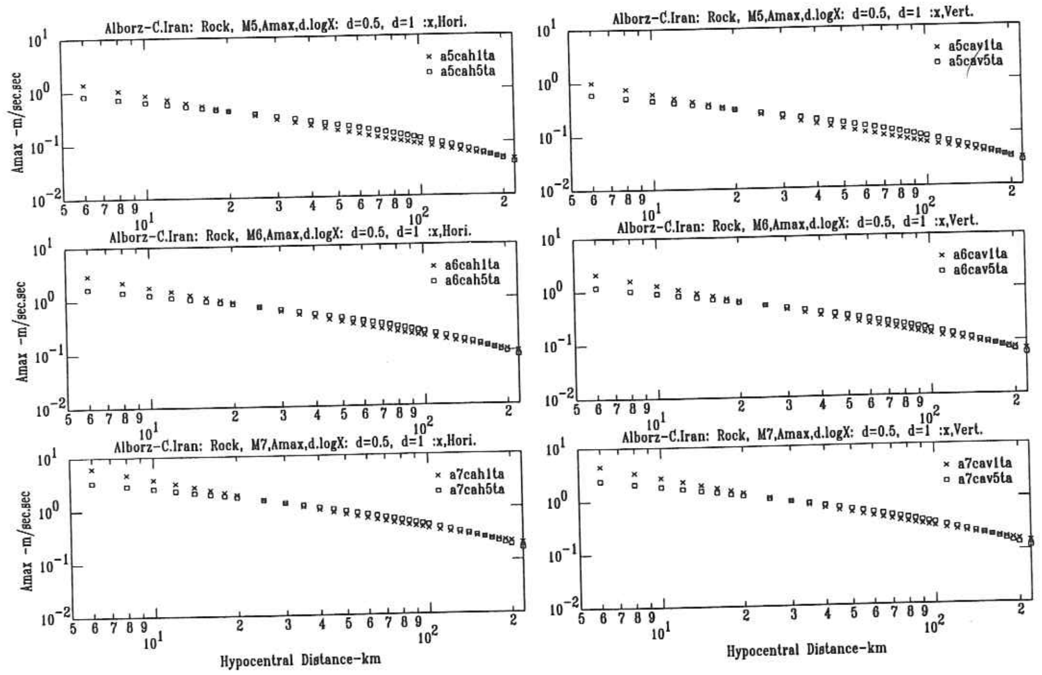

FIG. 6.4 – *Attenuation of PGA with distances for magnitudes 5.0, 6.0 and 7.0, in Alborz-Central Iran, left: horizontal and right: vertical components; quadrangle: d=0.5, cross: d=1.*

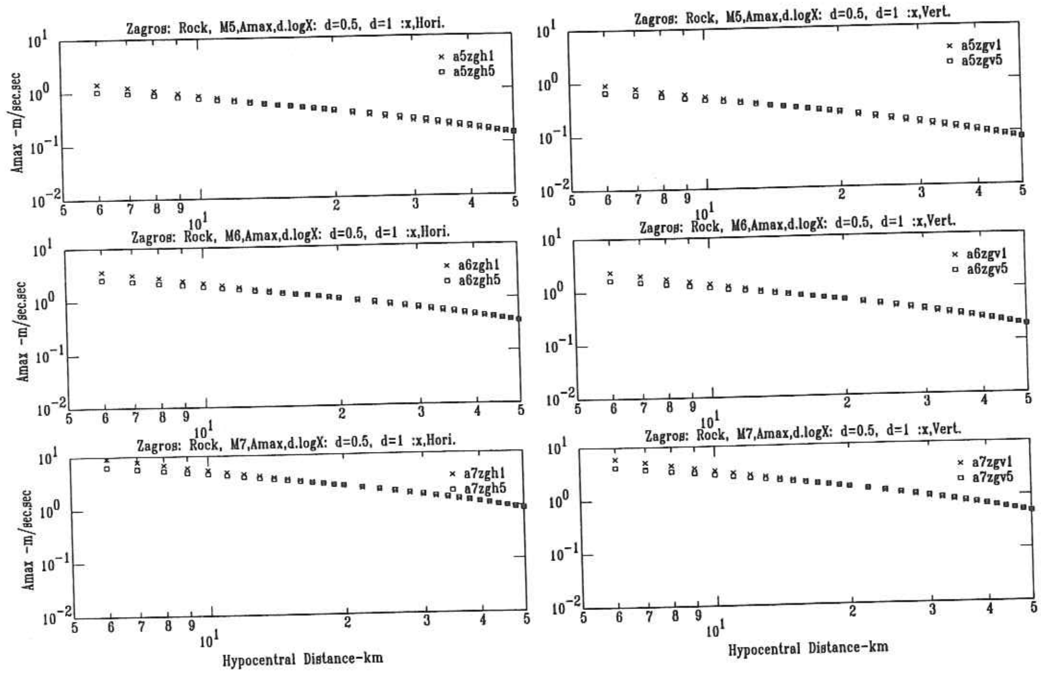

FIG. 6.5 – *The attenuation of PGA with the distances for the magnitudes 5.0, 6.0 and 7.0, for Zagros.*

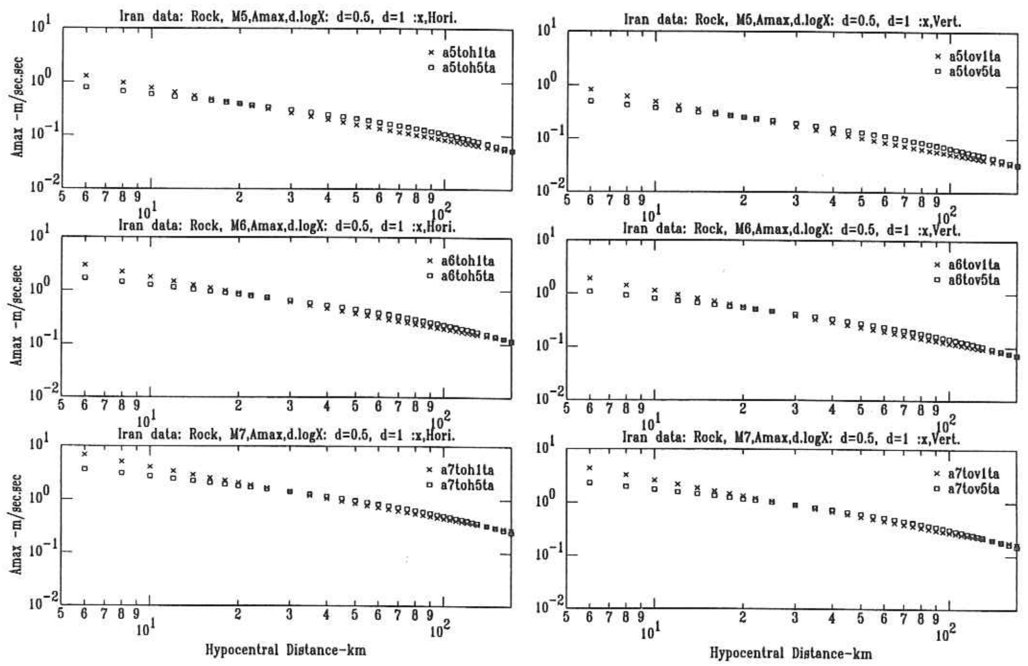

FIG. 6.6 – *The attenuation of PGA with the distances for the magnitudes 5.0, 6.0 and 7.0, for the entire of the data-base.*

The regressions were performed for $d = 0.5$ and $d = 1$, but the coefficients are just presented for $d = 1$, because the differences between the sigma values in these two case were not significant. The most important differences between these two cases is observed for the PGA values in Alborz-Central Iran data at distances less than 20km (Figure 6.4), where the regressions with $d = 1$ give the higher values for PGA.

Table 6.1: The coefficient for the attenuation of PGA, applying equation 6.1

Region/comp.	a	b	c1	c2	c3	c4	Sigma
Central Iran, Alborz (Vert.)	0.322	-0.0003	-0.828	-0.754	-0.971	-0.788	0.352
Central Iran, Alborz (Hori.)	0.322	-0.0004	-0.688	-0.458	-0.720	-0.585	0.394
Zagros (Vertical comp.)	0.406	-0.0038	-1.262	-1.333	-1.230	-1.777	0.356
Zagros (Horizontal comp.)	0.399	-0.0019	-1.047	-1.065	-1.020	-0.975	0.329
Iranian data (Vertical)	0.362	-0.0002	-1.124	-1.150	-1.139	-1.064	0.336
Iranian data (Horizontal)	0.360	-0.0003	-0.916	-0.852	-0.900	-0.859	0.333

Table 6.2: The coefficient for the attenuation of PGV, applying equation 6.1, for 381 cases

Region/comp.	a	b	c1	c2	c3	c4	Sigma
Central Iran, Alborz (Vert.)	0.466	0.0014	-3.108	-3.178	-3.328	-3.069	0.363
Central Iran, Alborz (Hori.)	0.471	0.0006	-2.865	-2.896	-2.969	-2.737	0.360
Zagros (Vertical comp.)	0.612	0.0028	-4.011	-4.101	-3.984	-3.917	0.319
Zagros (Horizontal comp.)	0.588	0.0040	-3.627	-3.651	-3.632	-3.502	0.315
Iranian data (Vertical)	0.548	0.0018	-3.675	-3.761	-3.702	-3.610	0.336
Iranian data (Horizontal)	0.538	0.0014	-3.335	-3.360	-3.348	-3.224	0.338

Table 6.3: The coefficient for the attenuation of PGD, applying equation 6.1, for 346 cases

Region/comp.	a	b	c1	c2	c3	c4	Sigma
Central Iran, Alborz (Vert.)	0.828	-0.0029	-5.861	-6.127	-6.023	-5.753	0.521
Central Iran, Alborz (Hori.)	0.828	-0.0036	-5.694	-5.837	-5.771	-5.352	0.489
Zagros (Vertical comp.)	0.784	0.0084	-6.043	-6.164	-6.144	-6.109	0.312
Zagros (Horizontal comp.)	0.797	0.0086	-5.893	-5.973	-5.954	-5.743	0.334
Iranian data (Vertical)	0.830	-0.0003	-6.051	-6.213	-6.163	-6.081	0.337
Iranian data (Horizontal)	0.829	-0.0010	-6.831	-5.942	-5.899	-5.645	0.388

The 'b' value, which represents the anelastic attenuation, was found to be the positive in some cases in Tables 6.1 to 6.3 . Such abnormal values is to be connected to the fixed values of 1 or 0.5 in the logX term in our regressions. The 'b' values, however, are very low. The residuals between the recorded and observed values of each of the parameters are shown in Figures 6.7 to 6.12, against the hypocentral distance and M_w. These residuals are presented for $d = 0.5$ and $d = 1$ (in equation 6.1), and it is evident that the difference of the residuals for $d = 0.5$ and $d = 1$ is not significant. In some cases (Figures 6.7, 6.9 and 6.11) lower residuals might be seen at greater distances for values calculated with a $d = 0.5$, especially for Alborz-Central Iran data. However these differences are not very large. The difference of the sigma values are found to be very low (for d=0.5 and d=1), while the sigma values are lower for d=0.5 (for Iranian data , sigma values for the horizontal components, for logarithm of PGA is found to be 0.333 and 0.318 while for logarithm of PGV they are 0.338 and 0.317 and for logarithm of PGD, they are 0.388 and 0.362 for d=1 and d=0.5, respectively).

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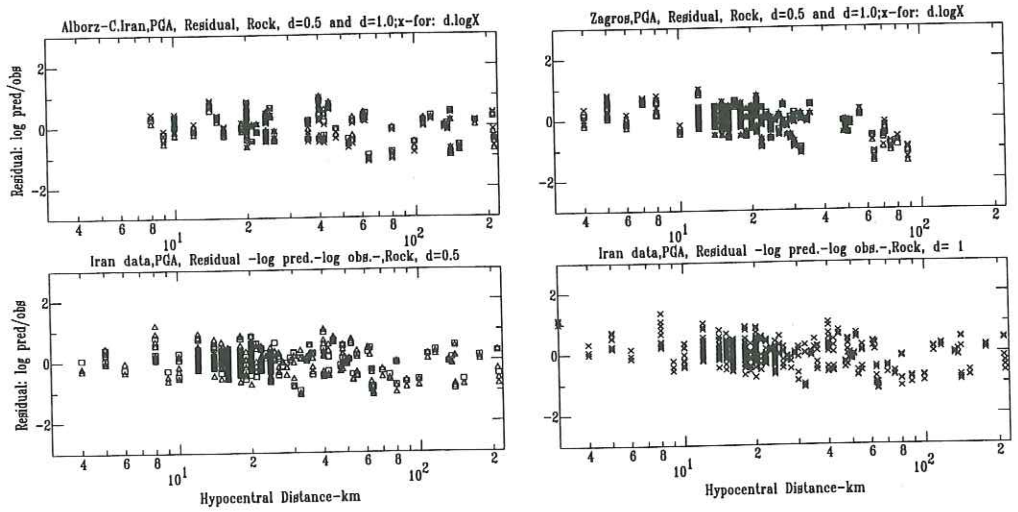

FIG. 6.7 – *The residual* ($\log predicted - \log observed$) *of the PGA against distance, on rock sites, for Alborz-Central Iran, Zagros and entire of the data-base; the results are shown for* $d = 0.5$ *(quadrangles) and* $d = 1$ *(crosses) for Alborz-Central and Zagros; the d=0.5 and d=1.0 results are seperated for Iran data (below).*

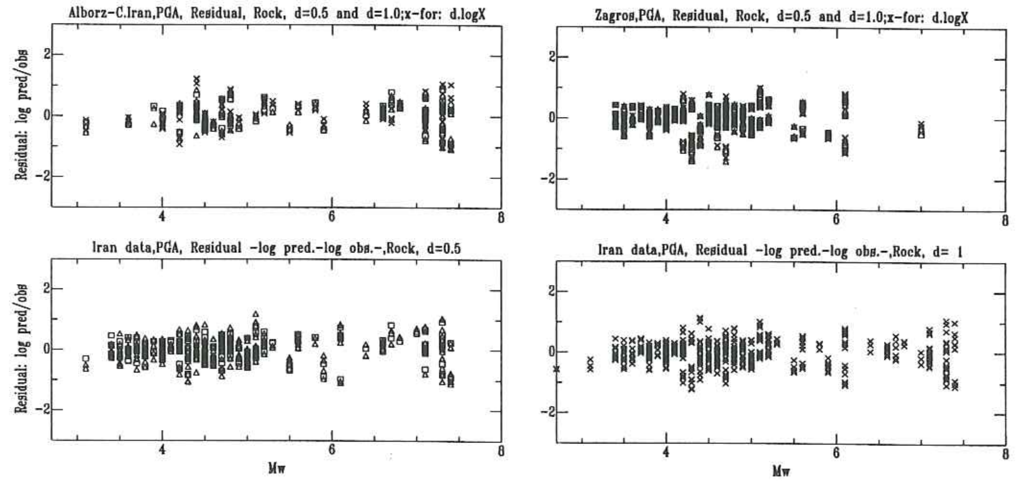

FIG. 6.8 – *The residual* ($\log predicted - \log observed$) *of the PGA against* M_w *, on rock sites, for Alborz-Central Iran, Zagros and entire of the data-base; the results are shown for* $d = 0.5$ *(quadrangles) and* $d = 1$ *(crosses) for Alborz-Central and Zagros; the d=0.5 and d=1.0 results are seperated for Iran data (below).*

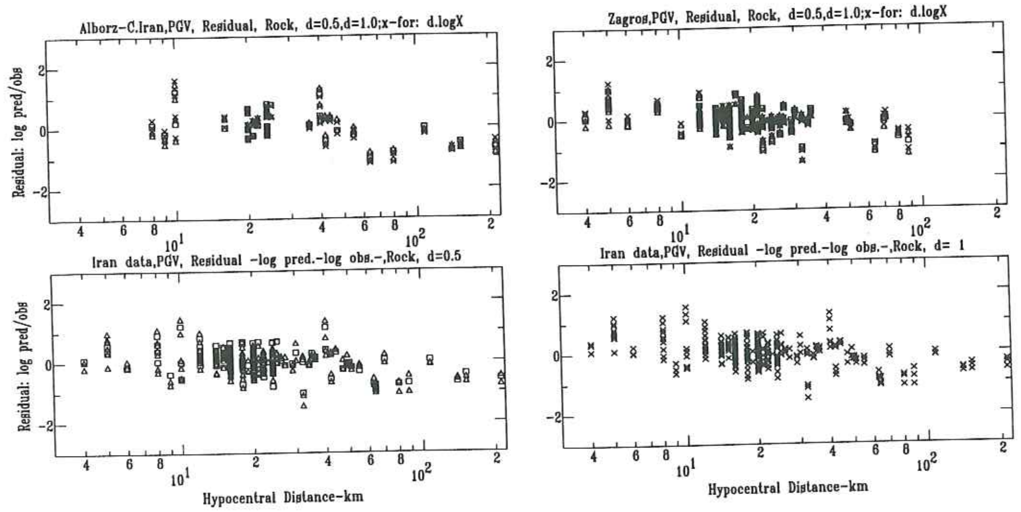

FIG. 6.9 – *The residual* ($\log predicted - \log observed$) *of the PGV against distance , on rock sites, for Alborz-Central Iran, Zagros and entire of the data-base; the results are shown for* $d = 0.5$ *(quadrangles) and* $d = 1$ *(crosses) for Alborz-Central and Zagros; the d=0.5 and d=1.0 results are seperated for Iran data (below).*

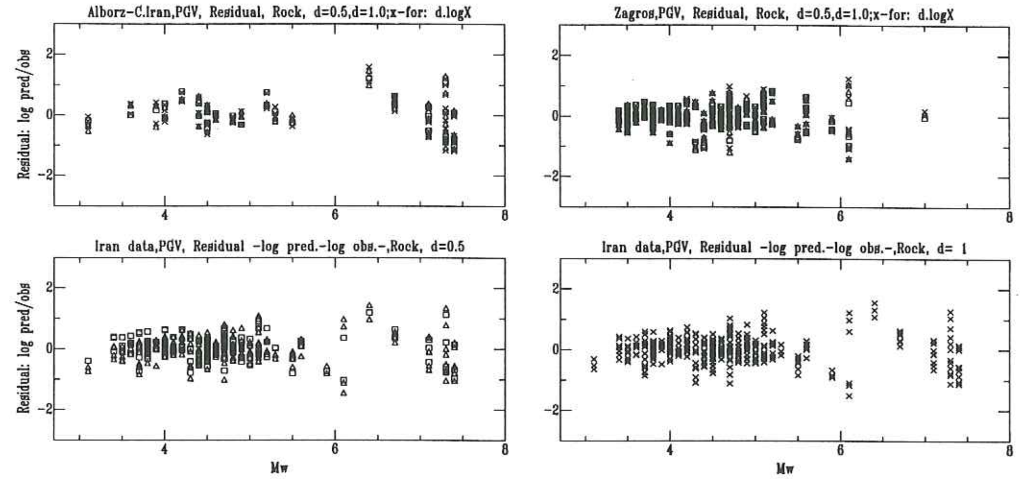

FIG. 6.10 – *The residual* ($\log predicted - \log observed$) *of the PGV against* M_w *, on rock sites, for Alborz-Central Iran, Zagros and entire of the data-base; the results are shown for* $d = 0.5$ *(quadrangles) and* $d = 1$ *(crosses) for Alborz-Central and Zagros; the d=0.5 and d=1.0 results are seperated for Iran data (below).*

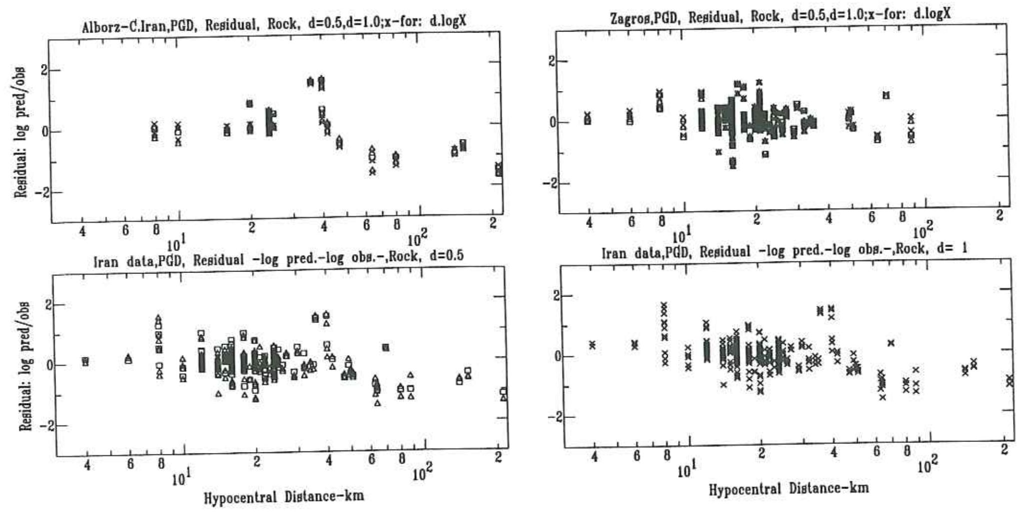

FIG. 6.11 – *The residual (log predicted − log observed) of the PGD against distance , on rock sites, for Alborz-Central Iran, Zagros and entire of the data-base; the results are shown for d = 0.5 (quadrangles) and d = 1 (crosses) for Alborz-Central and Zagros; the d=0.5 and d=1.0 results are seperated for Iran data (below).*

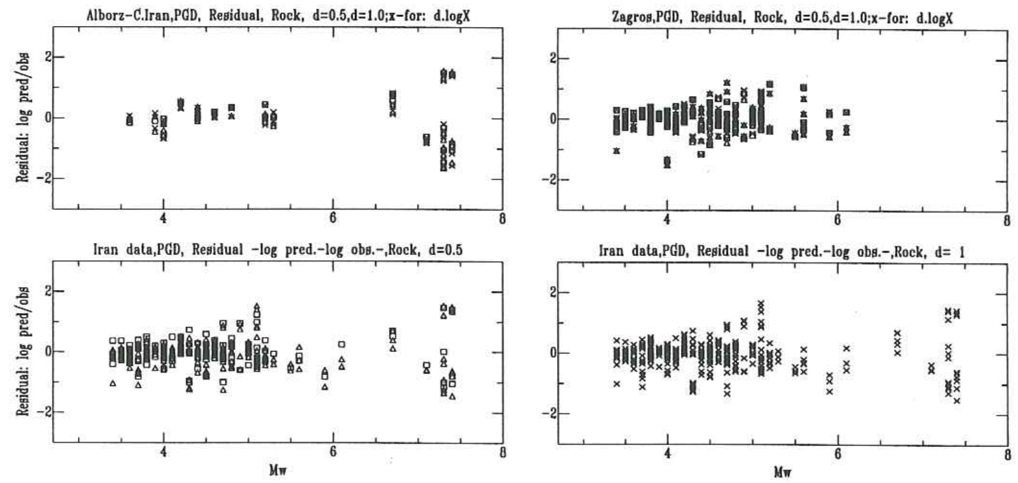

FIG. 6.12 – *The residual (log predicted − log observed) of the PGD against M_w , on rock sites, for Alborz-Central Iran, Zagros and entire of the data-base; the results are shown for d = 0.5 (quadrangles) and d = 1 (crosses) for Alborz-Central and Zagros; the d=0.5 and d=1.0 results are seperated for Iran data (below).*

6.4.2 Attenuation coefficients for spectral ordinates

The acceleration response spectra are calculated for all the records, keeping just the frequency bands with a R_{sn} ratio greater than 3. According to Figure 6.3, the analog records (most of the Alborz-Central Iran data) are much noisy at long periods , leading to a low number of useful data (Figure 6.13). The coefficients of a, b and c1, as well as the amplification of the second, third and fourth site classes ($c2 - c1$, $c3 - c1$ and $c4 - c1$) are presented separately for Alborz-Central Iran, Zagros and whole Iran, for different periods between 0.05 to 4 seconds (Figures 6.13 to 6.16).

The values for $d = 0.5$ are shown only for entire of the Iranian data (Figure 6.16). The values of sigma are generally lower for $d = 0.5$ in all periods, but still for the spectral values, such difference is not large. Finally, according to the difference between the results with $d = 1$ and $d = 0.5$ in the near-field and the fact that using $d = 0.5$ will underestimate parameters in near-field area (Figure 6.4 to 6.6), it is proposed to take $d = 1$ in this paper, which may be a more conservative approach. Additional strong records in near-field conditions in Iran are needed for more detailed investigations.

According to Figure 6.3, the reliable period bands for the different regions are 0.05 to 1 seconds for Alborz-Central Iran and 0.03 to 3 sec for the Zagros data. Therefore the great instability for the Alborz-Central Iran results after 0.5sec (Figure 6.13) might be understood.

The a values increase when the period increases (Figures 6.13 to 6.16) , which means an increasing magnitude dependence with longer periods as expected.

The positive b values for very large periods (beyond 3sec) might correspond to insufficient data (Figures 6.13 to 6.16). On the other hand, the negative b values at short periods may be an indication that attenuation of body waves were dominant, which in consequence gives more realistic values (negative sign for the coefficient of anelastic attenuation). The frequency content of the Zagros data is meaningful for such behavior; the Zagros records are representative for higher frequency, for which the body waves are more dominents. The same discussion might be done for the Iranian data (Figures 6.15 and 6.16) while the tendency for the positive 'b' values is evident when the period increases.

The site coefficients are consistent with the detailed site study on the Iranian strong motion sites (Zaré et al, 1999a). Amplifications at short periods ($< 0.2sec$) for the site class 2, in middle range periods (0.2 to 0.5 seconds) for site class 3, and and large periods ($> 0.5sec$) for site class 4, for most of the cases, do agree with the previous defined limits. However, the discrepancies from these limits seem to be significant for $c3$ and $c4$ for Alborz-Central Iran data

(Figure 6.13).

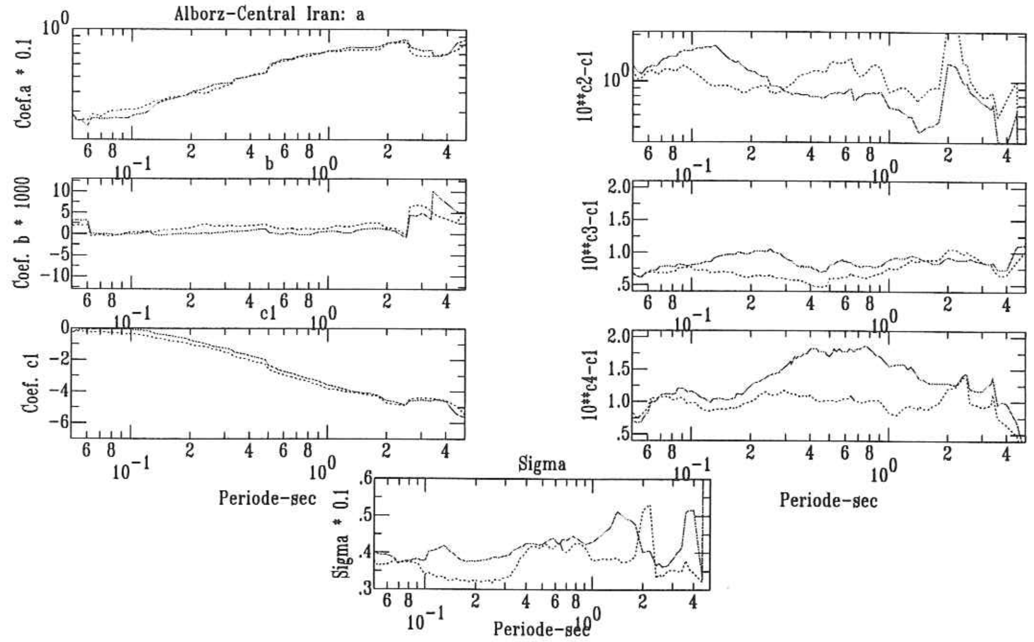

FIG. 6.13 – *Coefficients of the regression (difference from c1) (equation 6.3) against period, for the Alborz -Central Iran data. The site coefficients of the regression against period, for the Alborz-Central Iran data are given as well; solid lines :horizontal components, dotted line: vertical components.*

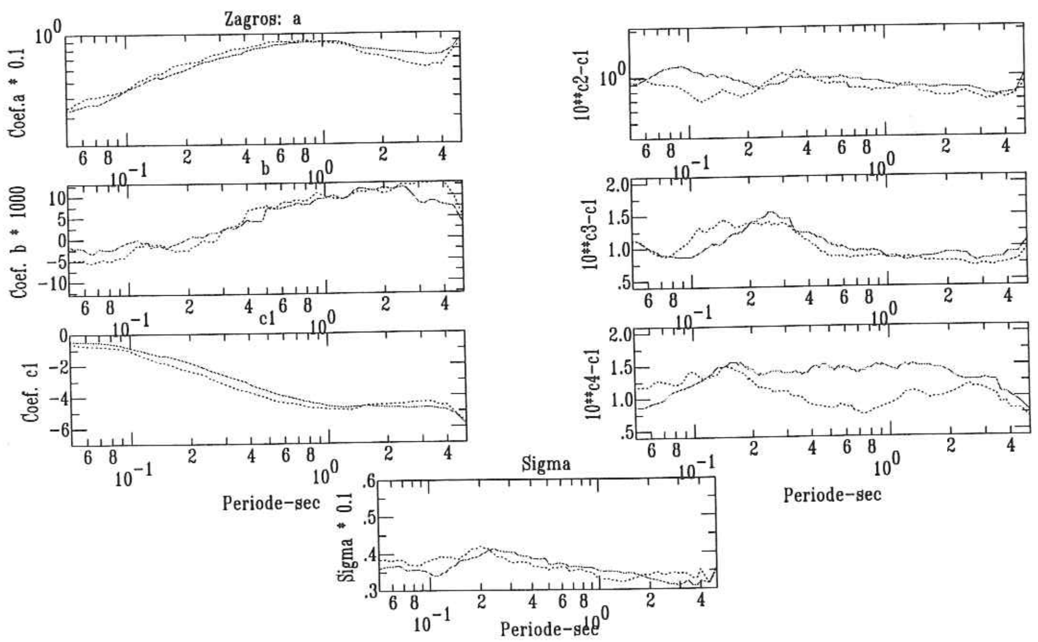

FIG. 6.14 – *Coefficients of the regression (difference from c1) (equation 6.3) against period, for the Zagros data. The site coefficients of the regression against period, for the Zagros data are given as well; solid lines :horizontal components, dotted line: vertical components.*

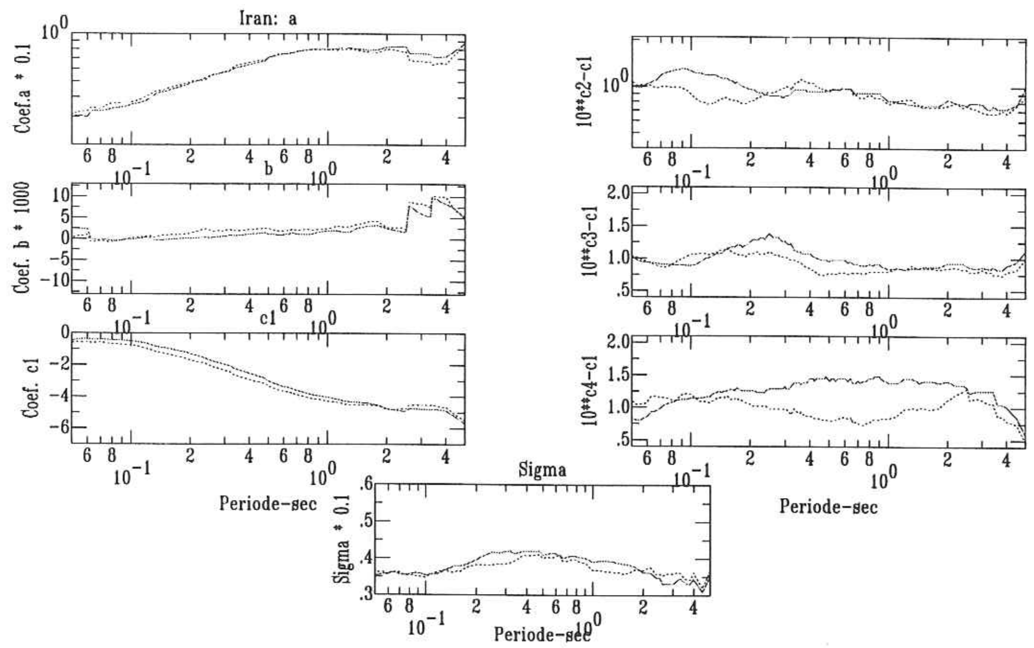

FIG. 6.15 – *The coefficients of the regression (difference from c1) (equation 6.3) against period, for the Iranian data, for d = 1. The site coefficients of the regression against period, for the Iranian data, for d=1 are given as well; solid lines :horizontal components, dotted line: vertical components.*

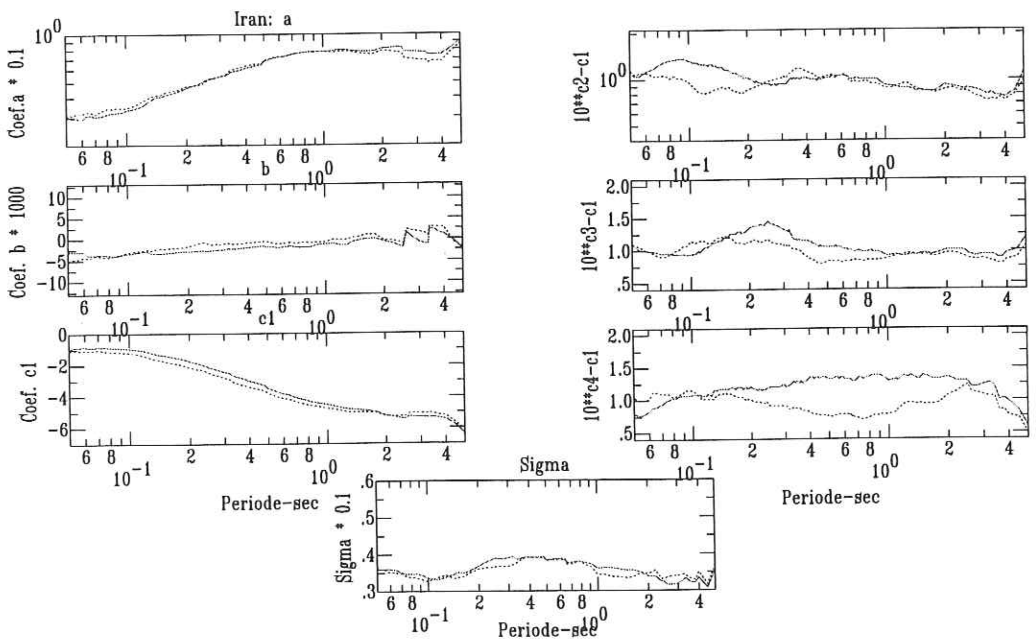

FIG. 6.16 – *The coefficients of the regression (difference from c1) (equation 6.3) against period, for the Iranian data, for d* = 0.5. *The site coefficients of the regression against period, for the Iranian data, for d=0.5 are given as well; solid lines :horizontal components, dotted line: vertical components.*

Differences between Alborz-Central Iran and Zagros data may be also observed in i) lower duration data for and lower magnitude (but more frequent) earthquakes in Zagros (Zaré et al 1999b) which cause probably the abnormal positive b values at high frequencies, and more rapid attenuation of strong motions in this region, and ii) the higher a values specially in middle periods in Zagros, which might be induced by the reason told for previous item. On the other hand, since there are more records in the Zagros region, site amplifications for class 3 are more evident for Zagros data (Figure 6.14) than for Alborz-Central Iran data (Figure 6.13).

6.4.3 Nonlinear effects in the Iranian strong motions?

The possible non-linear effects were looked for investigating the variation of the residuals as a function of PGA. In case of a soft soil (site class 4), a decrease of the high frequency content due to the non-linearity would be expected , which should reflect in an overestimation through prediction (*prediction > observation*). Simultaneously we would expect a reverse effect at long periods (*observation > prediction*). Such effects were looked for at several period values (0.1sec, 0.2 sec, 0.5 sec, 0.67sec, 1.0sec, 1.25sec, 2.0sec and 5.0sec). The difference between the observed values in the stations of class 4 and the predicted values (using $d = 1$ for $d \cdot \log X$) on the rock sites (for the same stations) are displayed in Figure 6.17 for the entire of the data-base. The difference between the observed and predicted values for the site class-4 are presented as well. These results show clear trends, with underestimation of spectral levels for realy strong motions, and overestimation at moderate leves, whatever the period. This result was expected only at long periods, and we have no explanation for these observations at short periods.

6.5 Response and Design Spectra for Alborz-Central Iran, and Zagros areas

The coefficients for spectral values based on the whole Iranian data set are applied to estimate the response spectra of accelerations and the velocities for some typical near and far field situation on rock site conditions (Figure 6.18). The mean and mean plus one sigma values are calculated for magnitudes of M_w6.0 at a distance of 10 km, and M_w7.4, at distances of 20km and 100km , with $d = 0.5$ and $d = 1$. The selection of the magnitude of 7.4 was made according to the highest magnitudes occurred in Iran since the beginning of the strong motion measurments in Iran (Tabas earthquake of 1978, M_w7.4).

The difference between d=0.5 and d=1.0 is clear only at short distances (10 and 20 km),

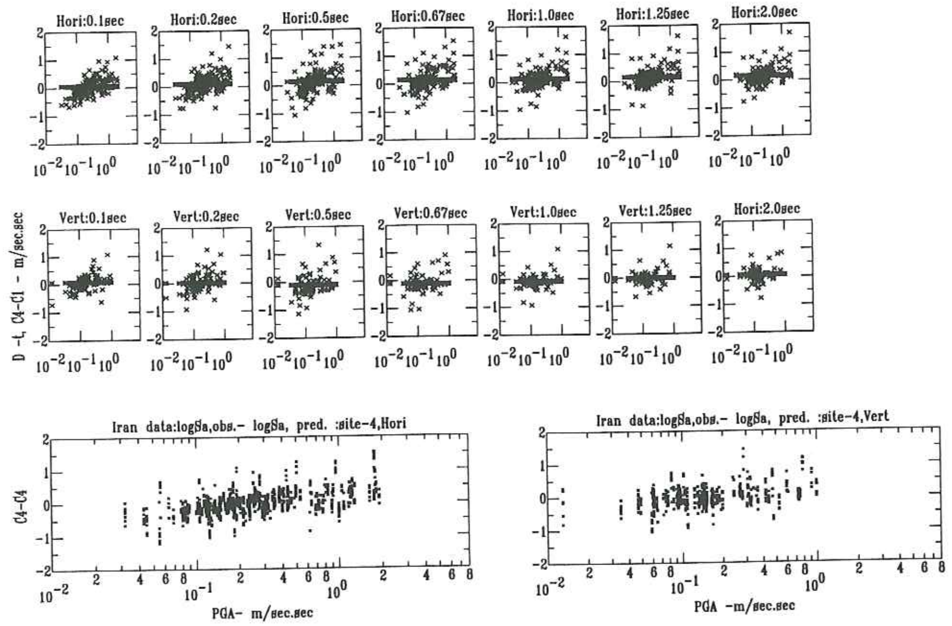

FIG. 6.17 – *Difference between the observed spectral acceleration values at class-4 sites and the corresponding predicted values on rock sites, for horizontal and vertical component for the entire of the data-base. The differences between observed and predicted values on rock sites are shown as well.*

with larger spectral values for $d = 1$. At 100km distance, results are almost the same. To show the results for different coeffcients provided for Alborz-Central Iran, Zagros and entire of the data-base, the PGA values are looked for a magnitude of 7.0 with twi different distances: The PGA values obtained with the coefficients in table-6.1 ($d = 1$), for a magnitude of 7.0 and a hypocentral distance of 20km are found to give $1.870m/sec^2$, $2.546m/sec^2$ and $2.032m/sec^2$ for Alborz-Central Iran, Zargos and entire of Iran data-base, respectively. With the same magnitude, and for a hypocentral distance of 50km, we obtain 0.770m/sec, 0.897m/sec and 0.833m/sec for the mentioned data-bases respectively.

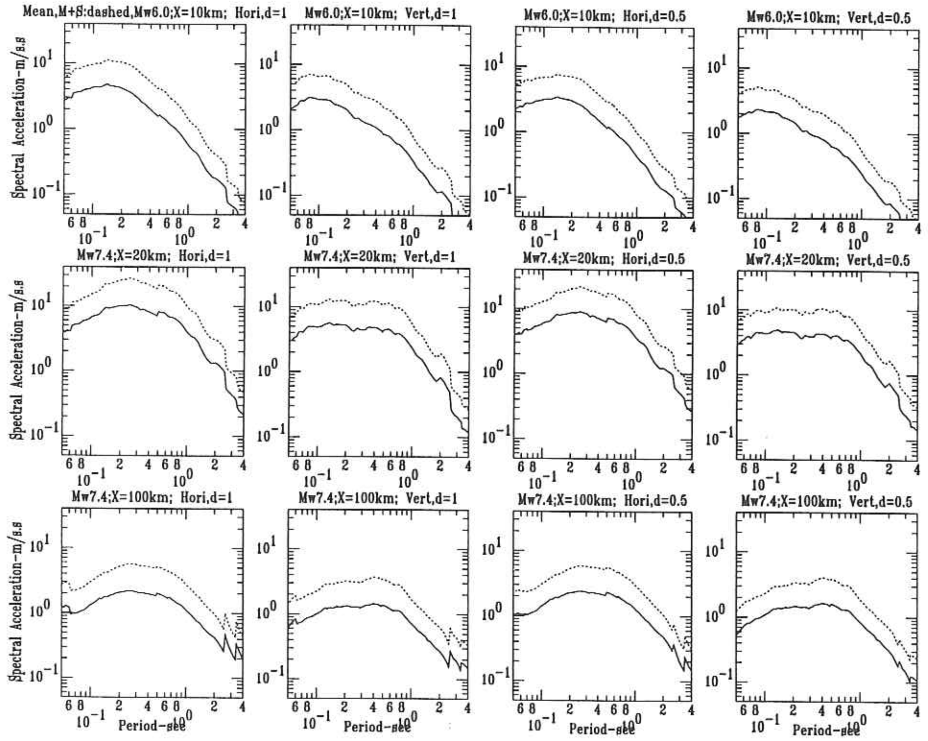

FIG. 6.18 – *Representative response spectra calculated using the coefficients for the Iranian data ($d = 0.5$ and $d = 1$), for M_w6.0, and 7.4, for 10 and 20km and 100km distances, respectively: for the 3 cases (Top: M_w=6.0, X=10km), (Middle: M_w=7.4, X=100km) and (Bottom: M_w=7.4, X=100); solid line: mean and dotted line: mean $+\sigma$, two left for figures d=1.0 (horizontal and vertical) and two right figures for d=0.5 (horizontal and vertical).*

Based on the results for the spectral ordinates, we will presents some response and design spectra for two different sites in Iran. The design spectra to be presented, is based on the response spectra of the records for a rock site in Tehran and a alluvial site in coastal area of the Persian Gulf (southern Zagros), with a average V_s in top 30m of 550m/sec (site class 2). To estimate the earthquake magnitude an empirical relationship for Iran is applied. This relationship is established using the fault rupture data coming form 22 earthquake faults (the events since 1336 till 1994) in Iran (Zaré 1995). This relationship predicts the moment magnitude having the fault rupture length:

$$M_w = 0.91 \cdot \ln L_R + 3.66 \quad (6.4)$$

where L_R is the rupture length in km. According to the mentioned study, in average, the rupture length might be estimated as about 0.37 of the total length of a major Iranian earthquake fault.

The main seismic sources nearby Tehran are North-Tehran fault and the Mosha fault. Taking a 120km segment of the Mosha fault and using equation 6.4, a magnitude M_w7.1 is found for a rock site for northern Tehran. The intersection of the Mosha and the North-Tehran faults (in the Kalan Village in NE of Tehran) has a distance of the 35km with Tehran.

A floating earthquake scenario for Zagros belt is considered. The highest magnitude occurred in Zagros during our period of observation (Khurgu 1977) was Ms7.0. The thickness of the crust is estimated to be 15km for the Coastal region in southern Zagros (based on the geological maps), therefore considering an earthquake at the bottom of the crust, such depth may be taken as the hypocentral distance. These parameters are used to select the response spectra for our site in the coastal region of Persian Gulf. The specifications of the selected records are shown in Tables 6.4 and 6.5 .

Table 6.4: Selected records to find the design spectra in Tehran:

Code BHRC	M_w	Hypocentral Distance(km)	Site
1082-1	7.4	36	1
1083-1	7.4	64	1
1084-1	7.4	5*	1
1107	6.8	61	1
1118	6.6	55	1
1139	7.1	44	1
1362-1	7.3	40	1

*:Tabas earthquake: Distance to the Fault zone

Table 6.5: Selected records to find the design spectra in a coastal area of Persian Gulf (southern Zagros):

Code BHRC	M_w	Hypocentral Distance(km)	Site
1006-1	6.1	48	2
1050-1	7.0	52	2
1058	6.1	18	2
1291-1	5.7	45	2
1491	5.7	12	2
1498	5.9	63	2
1502-9	5.9	9	2

All of the spectral acceleration and velocity values (calculated for a damping of 0.05) are normalized to PGA and PGV of each record and shown in Figure 6.19. To normalize the spectral velocities, the velocity spectral values for each record are devided by the observed PGV for that record. The mean and mean plus one sigma values are presented in Figure 6.20 and the smoothed spectra are given in Figure 6.21. According to high earthquake hazard in Iran, a conservative approach is applied to fit the smoothed spectra for these two examples (Figure 6.21). The higher spectral values are obvious for the design spectra in Tehran in longer periods, while in Zagros coast the spectra show more important values for shorter periods.

6.6 Conclusions

The attenuation of the strong ground motions in Iran was studied for the first time in this article. The regression coefficients are presented for the peak values and the spectral ordinates, which are generally in agreement with the coefficients presented by Joyner and Boore (1981), Boore et al (1993, 1994, 1997) and Fukushima et al (1995) for other regions of the world. Meanwhile the results of this study are in agreement with the Ambraseys attenuation relationships for Europe (comprising some few Iranian records) (Ambraseys 1995, Ambraseys and Simpson 1996). The conclusions are summarized below:

- The attenuation of the strong motions in Iran follows the general form of the attenuation of the strong motions in Mediterranean attenuation (Caillot 1992, using the Italian data, and Ambraseys 1995, for the European data). This general accordance might be studied more precisely if the location of the foci for the earthquakes was determined using the local networks in Iran.

- The attenuation seems to be different for, at least, two regions of Iranian plateau; the Zagros area and the Alborz-Central Iran region (Figure-3). The seismicity, strong motion duration

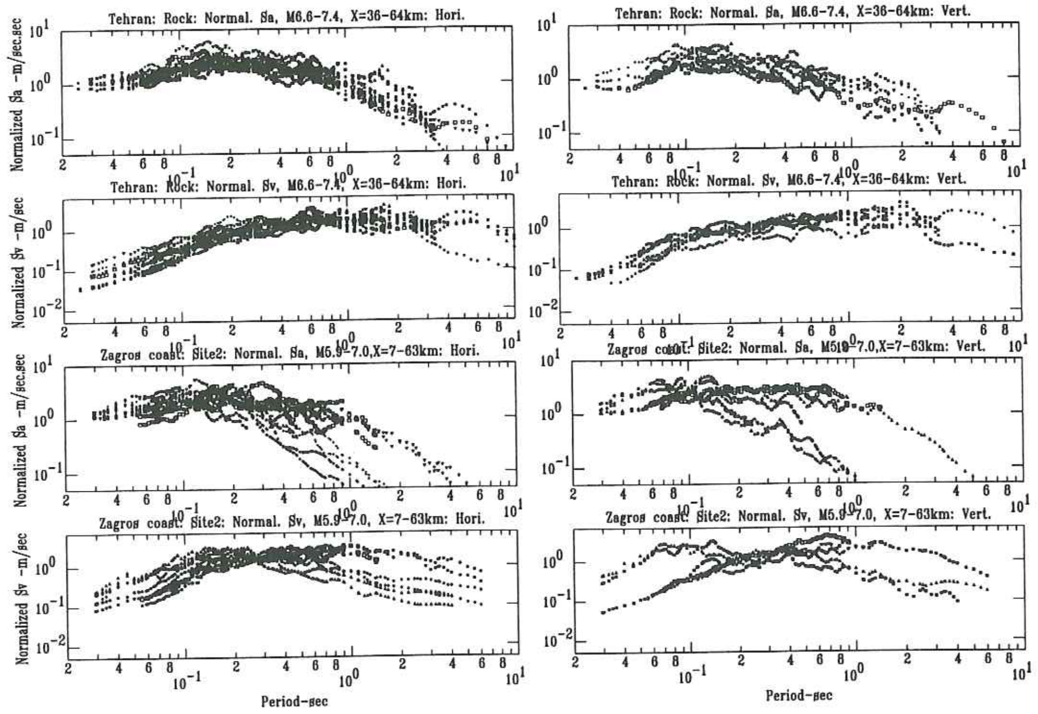

FIG. 6.19 – *The normalized response spectra for a rock site in Tehran and an alluvial sit e in the Zagros coastal region on the Persian Gulf (specification for the spectra are gi ven in Tables-6.4 and 6.5).*

and the crust specifications seems to be one of the major factors for this evident difference. On the other hand, the response spectra for the Zagros region are rich in short periods, while the larger period amplitudes may be seen in the Alborz- Central Iran data.

- The site factors, which are obtained for 4-class site categorization of Iran, do not contribute too much except for PGD. This may come from the meteorological and topographic situation of the Iranian plateau: most of the Iranian territory is dry and arid and most of the urban areas are located on the alluvial fans, nearby the foothills.

- The attenuationterm of the body waves and surface waves studied using a different coefficient for the geometric expansion term ($\log X$); the difference for these two cases was not two much, but the higher values obtained with $d = 1$ (body waves) in the near field distances (less than 20 hypocentral distances). The surface wave attenuation ($d = 0.5$) gives the higher values in greater distances. This difference may be observed especially for the Alborz-Central Iran data.

- The near-field records are still very few in the Iranian network especially for large earthquakes ($M_w > 6.0$) to investigate the near-source strong motions in Iran. The Tabas record (Tabas earthquake) and the Abbar record are the only records obtained in distances less than

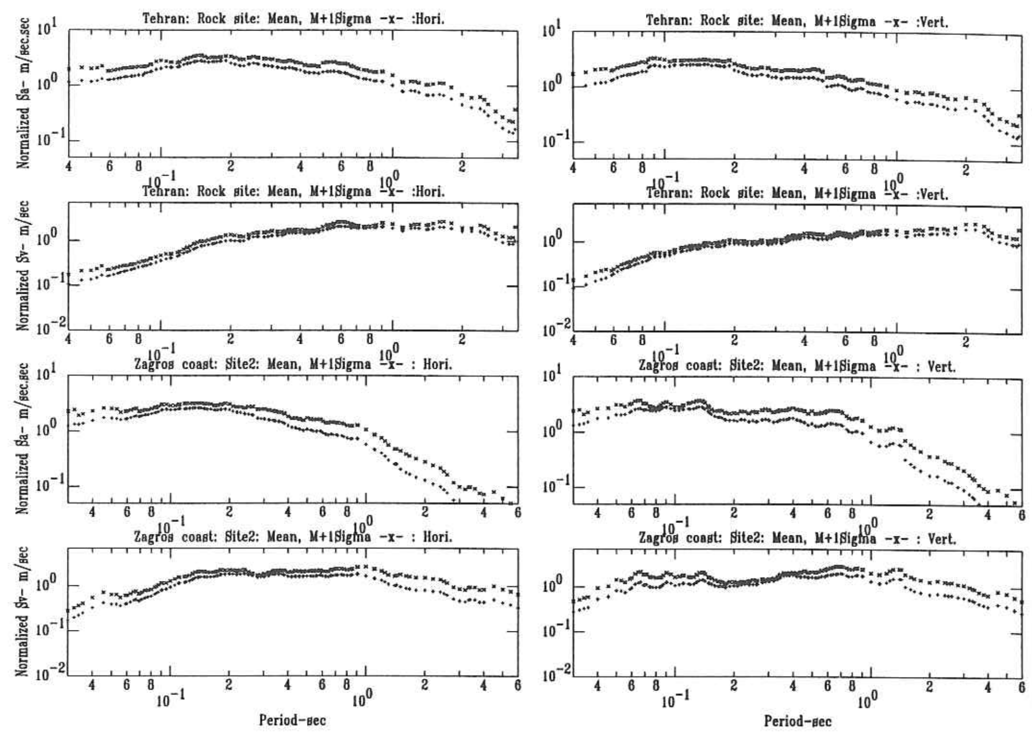

FIG. 6.20 – *The mean and mean plus one sigma of the response spectra presented in Fig:6.19*

10km the surface fault ruptures for an earthquake of magnitude greater than $M_w 7.0$. This problem causes a limitation in the use of the attenuation laws presented in this paper: for the near-source cases, it is suggested to select strong motions recorded in similar situations with a deterministic approach (hypocentral distances less than about 20km, or nearest distance to the fault rupture of 10km for the sources with magnitudes greater than 7.0).

- Strong motion attenuation studies should be continued in Iran to investigate the unknown aspects of this important subject, not only to be used to seismic risk studies in Iran and its neighboring countries, but also to contribute to strong motion studies in the east-Mediterranean and European region. The main subjects suggested for future investigations are listed below;

- The attenuation parameters such as absorption coefficient (κ) and the quality factor (Q) might be investigated with more precise data to be provided with the dense network which is expanding actually in Iran. Such studies may reveal clearly the causes for the different features of the attenuation in the crust of the Iranian plateau.

- The uniform hazard spectra for Iran might be studied, based on a precise seismicity study on Iran. Furthermore, the response spectra should be classified for each defined limit for the magnitude and distance values.

- The focal depth of seismic events in Iran should be determined, *a priori*, using a dense and online seismic network (to be installed in Iran). In the absence of such data, a large uncertainty

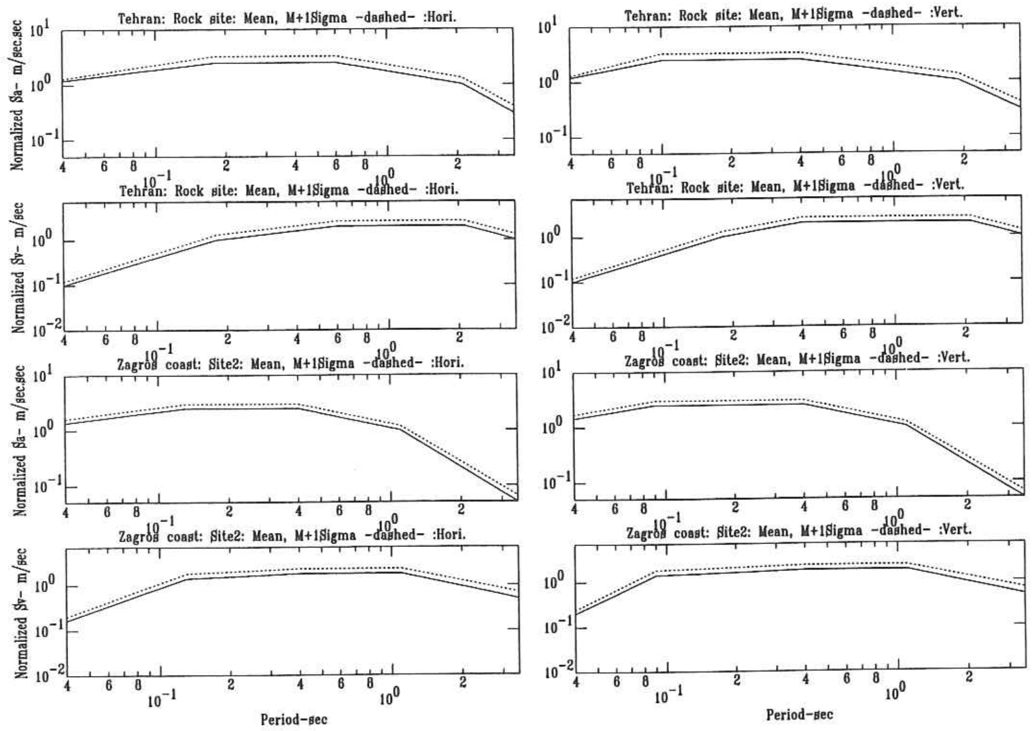

FIG. 6.21 – *The smoothed spectra for the response spectra shown in Fig:6.20*

will remain for the distance determinations. Such studies may help to compare the Iranian attenuation models with the other models.

- To develop the existing accelerometric network in Iran, the site and seismicity characteristics should be considered for the site selections. The installation of more instruments in the region which are sparsely populated but show high seismicity (like Makran and eastern Iran), may provide valuable information to be used everywhere.

- The studies on micro-earthquakes using the empirical Green functions for the capital of the country (Tehran), where no great and near earthquake was recorded in recent years but the seismic risk is very important, could be useful to estimate the earthquake strong motion for this city. Such estimations should be compared with real earthquakes in regions with similar condition.

- The near-source strong motions should be studied, using the dense arrays to be installed around quaternary faults. Because of the water-supply problem, most of the cities, villages and the industrial centers in Iran are located on or nearby the borders of hills and plains, where a lot of the quaternary faults are located. Such a situation highlights the need for a better understanding of the near-fault strong motion.

- Advanced source studies should be conducted in Iran. The directivity effect was an important amplification factor in the Tabas earthquake. On the other hand, the rupture modeling

may reveal the nature of the source processes in the destructive earthquakes in Iran. The first priority for such studies would be an absolute and simultaneous timing of the accelerometric network.

- The Iranian attenuation relationships should be compared with the neighboring countries relationships. The best possibility for such study is now to study the strong motions in Turkey (Anatolian plateau), which is geologically in the continuation of the Iranian plateau, and for which the strong motion data are now available.

- The site effect parameters might be studied more precisely for the attenuation models in Iran. Pairs of the stations on alluvium and nearby rock outcrop, as well as the down-hole arrays would help to understand better site effect in Iran. Using the present information, neither a more sophisticated definition of the site parameters nor the over-parameterization of the site factors would be helpful for a better understanding of the site effects. Such studies might be completed with a comparison with the similar study in highly seismic region, where strong motion and site effects are properly recorded and studied (such as Japan).

- The attenuation of macroseismic intensities might be studied more using the historical reports, which are accessible for Iran with a great civilized history and cultural heritage. Such studies may give a general view of the attenuation of the strong motion in the history (especially for the regions where strong motions are not yet recorded).

Acknowledgements

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6.7 Régression en une étape

Nous avons voulu ici simplement comparer les résultats obtenu avec deux types de régressions, une et deux étapes. Nous avons pour cela utilisé le logiciel STATISTICA. L'ensemble des données (déjà étudiés avec les régression dans deux étapes, discuté avant dans ce chapitre) ont été utilisées dans la régression dans une étape avec la même relation déjà utilisée:

$$\log A = a \cdot M_w + b \cdot X - d \cdot \log X + c_i \cdot S_i + \sigma \cdot P \qquad (6.5)$$

Les valeurs des coefficients de cette relation sont présentées dans le tableau 6.6 pour les paramètres différents (A_{rms}, e_a, A_{max}, V_{max}, D_{max});

Tableau 6.6: Les valeurs des coefficients de la régression en appliquant la relation 6.5 pour les paramètre différents;

Paramètre/comp.	a	b	c1	c2	c3	c4	Sigma	R
A_{rms}, Vertical	0.320	0.0029	-1.675	-1.650	-1.655	-1.647	0.327	0.566
A_{rms}, Horizontal	0.343	0.0027	-1.576	-1.466	-1.537	-1.610	0.339	0.607
e_a, Vertical	0.767	-0.0005	-4.233	-4.208	-4.198	-4.120	0.564	0.415
e_a, Horizontal	0.807	-0.0005	-4.104	-3.913	-3.982	-4.072	0.567	0.535
A_{max}, Vertical	0.307	0.0025	-0.937	-1.951	-0.948	-0.902	0.330	0.638
A_{max}, Horizontal	0.311	0.0023	-0.749	-0.685	-0.729	-0.715	0.328	0.682
V_{max}, Vertical	0.508	0.0040	-3.550	-3.631	-3.567	-3.517	0.325	0.689
V_{max}, Horizontal	0.501	0.0035	-3.216	-3.238	-3.221	-3.135	0.331	0.828
D_{max}, Vertical	0.750	0.0038	-5.787	-5.947	-5.887	-5.877	0.352	0.769
D_{max}, Horizontal	0.766	0.0023	-5.627	-5.738	-5.686	-5.491	0.353	0.781

Les résidus des entre valeurs prédites et valeurs observées sont présentés dans les Figures 6.22 à 6.26. Les valeurs prédits des paramètres A_{rms}, e_a, A_{max}, V_{max} et D_{max}, en utilisant les coefficients de tableau 6.6 avec la relation 6.5 (la régression dans une étape) ont été comparés avec les résultats de la méthode de la régression dans deux étapes (pour les même paramètres et le même jeu de données; l'ensemble des données iraniennes; Figures 6.27 à 6.31). Ces comparaisons montrent que les deux régressions prédisent les valeurs comparatifs pour une gamme de distance de 20-80km. A moins de 20km, la régression en une étapes sous-estime les paramètres de mouvements forts par rapport à la régression en deux étapes. Cette situation est inversée aux distances supérieurs à 80km. De plus, les estimations de V_{max} et D_{max} avec la régression en une étape, montrent une augmentation avec la distance, évolué de la distance de 80km qui

est illogique. Cette perturbation peut être considérée comme due à l'insuffisance des données à grande distance. Cela peut donc montrer que la méthode de régression en une étape est plus sensible à l'homogénéité de la distribution des données avec la distances, alors que cette condition est moins évidente pour la régression en deux étapes (Figures 6.27 à 6.31).

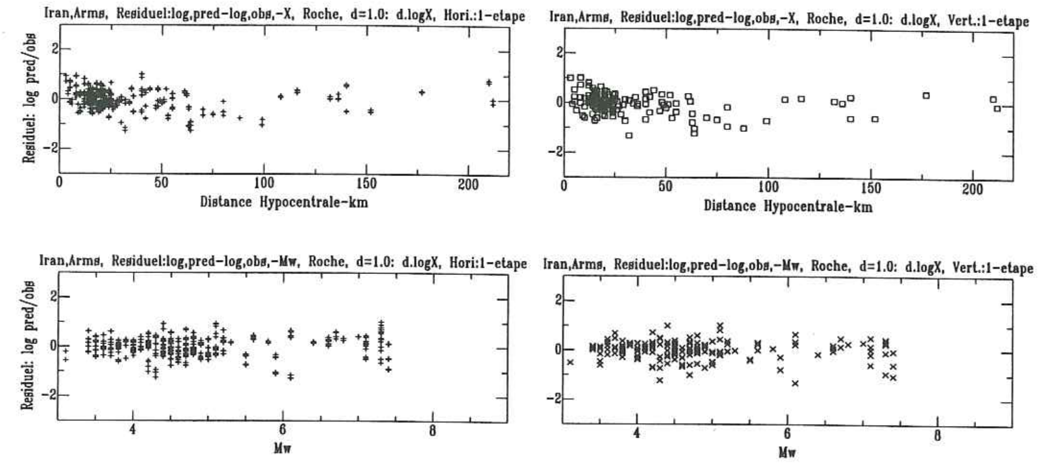

FIG. 6.22 – *Le résiduel (log prédit- log observé) de A_{rms} en fonction de la distance hypocentrale et de la magnitude, pour l'ensemble des données iraniennes avec d=1.0*

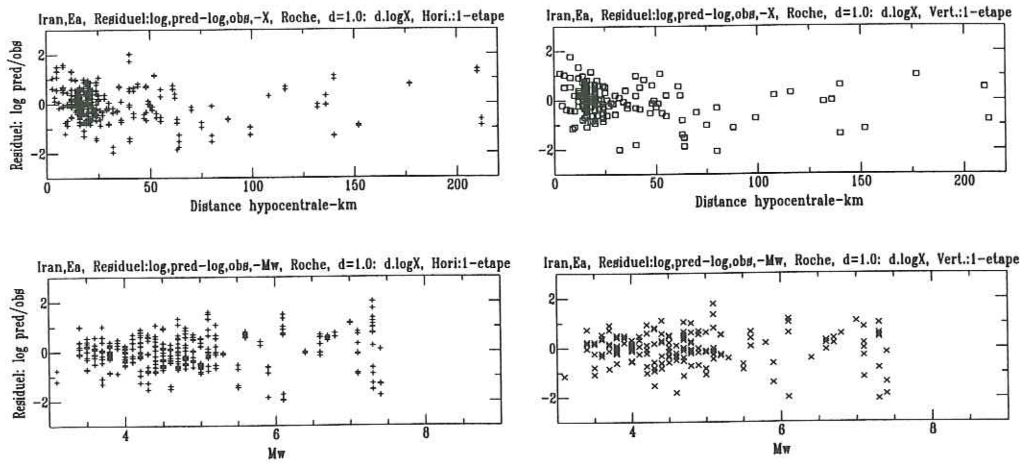

FIG. 6.23 – *Le résiduel (log prédit- log observé) de e_a en fonction de la distance hypocentrale et de la magnitude, pour l'ensemble des données iraniennes avec d=1.0*

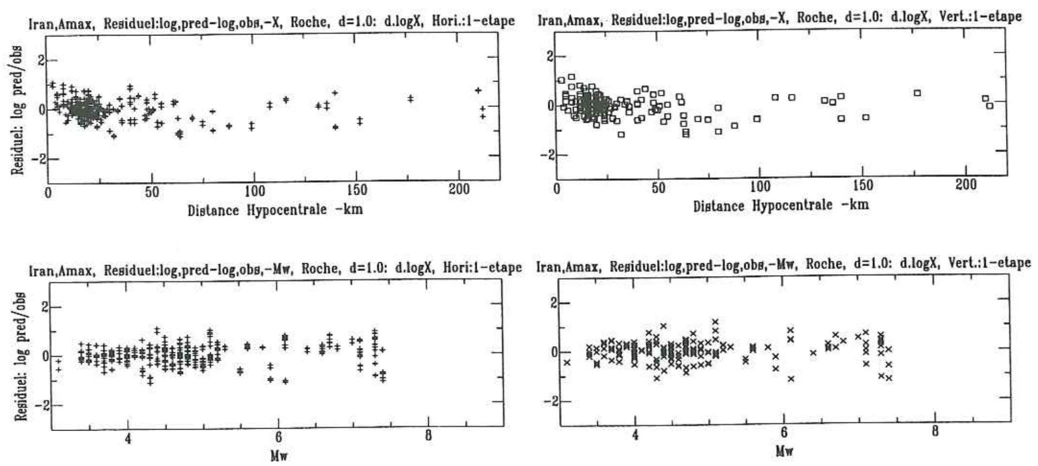

FIG. 6.24 – *Le résiduel (log prédit- log observé) de A_{max} en fonction de la distance hypocentrale et de la magnitude, pour l'ensemble des données iraniennes avec d=1.0*

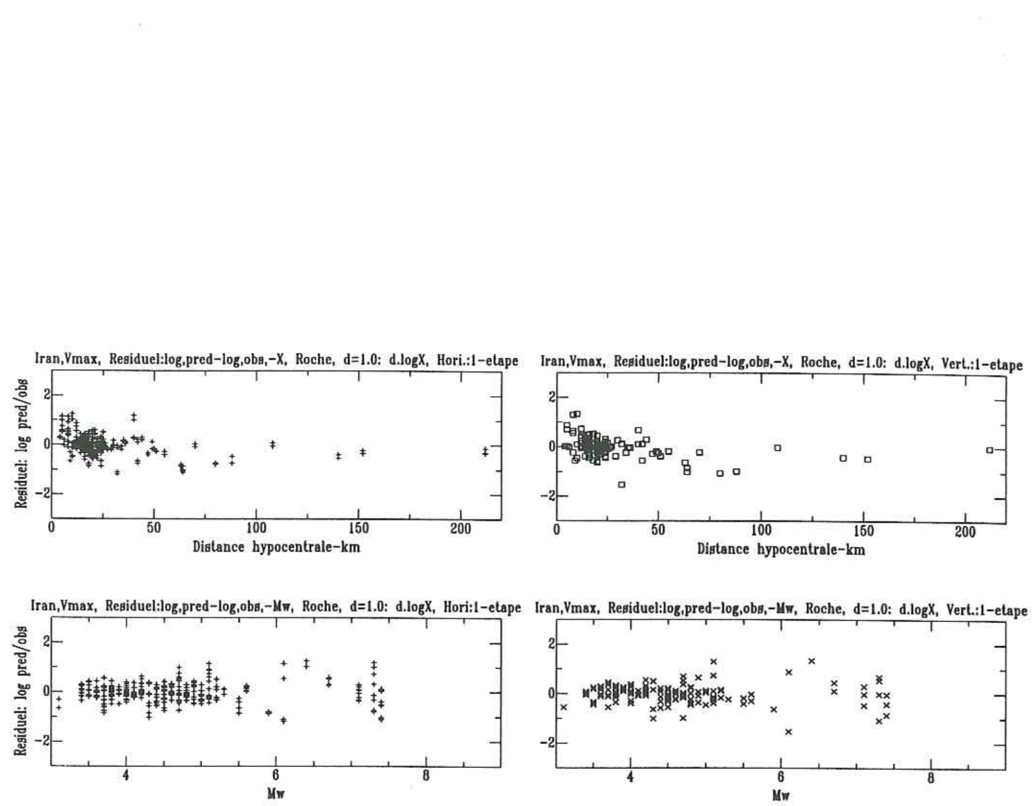

FIG. 6.25 – *Le résiduel (log prédit- log observé) de V_{max} en fonction de la distance hypocentrale et de la magnitude, pour l'ensemble des données iraniennes avec d=1.0*

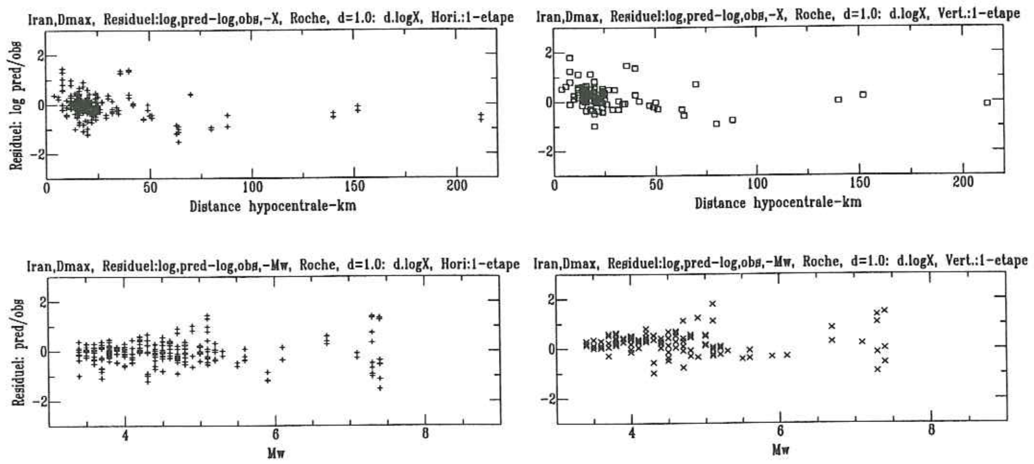

FIG. 6.26 – *Le résiduel (log prédit- log observé) de D_{max} en fonction de la distance hypocentrale et de la magnitude, pour l'ensemble des données iraniennes avec d=1.0*

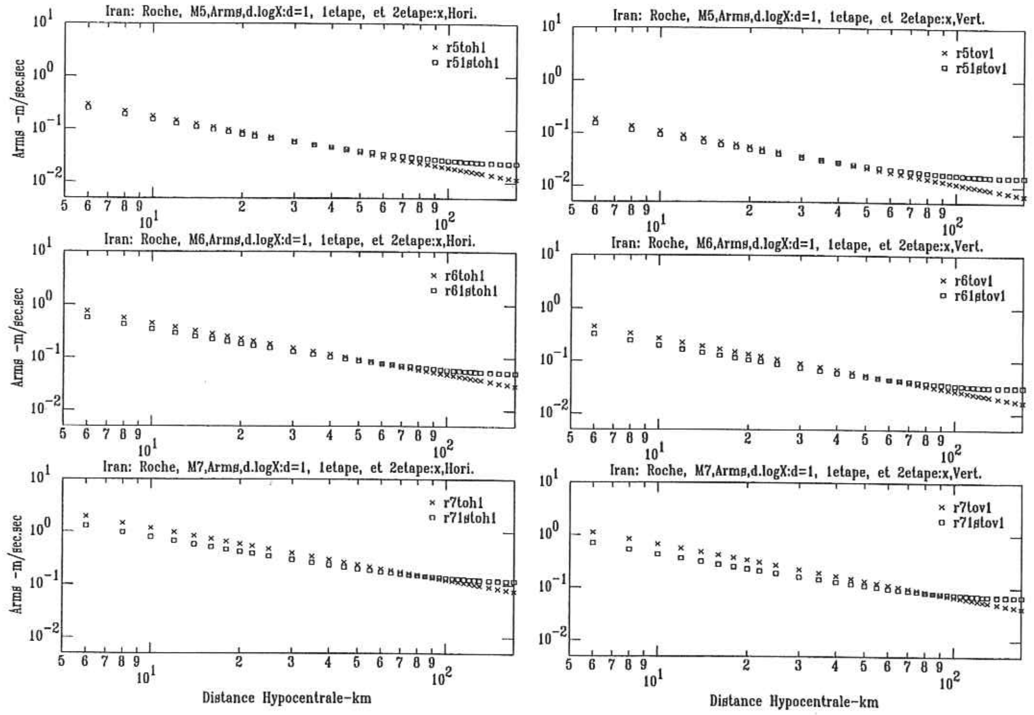

FIG. 6.27 – *L'atténuation de A_{rms} en fonction de la distance hypocentrale pour les magnitudes de 5.0, 6.0 et 7.0, basé sur les resultats de la régression en une-étape (les rectangulaires) et en deux-étapes (les croix) pour l'ensemble des données iraniennes.*

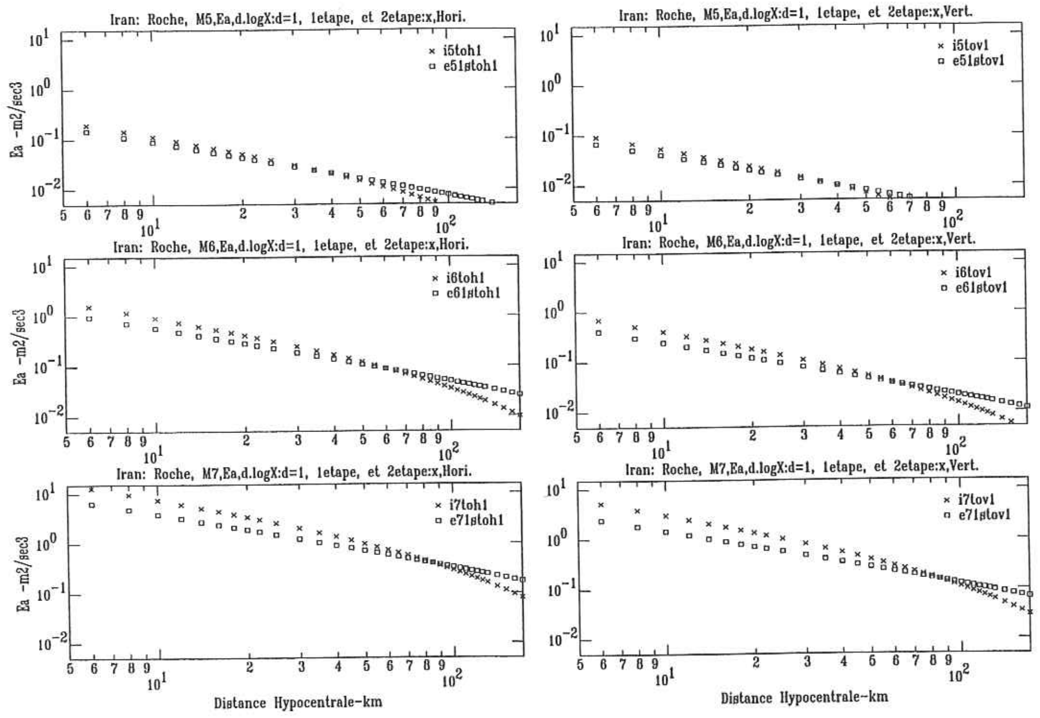

FIG. 6.28 – *L'atténuation de* e_a *en fonction de la distance hypocentrale pour les magnitudes de 5.0, 6.0 et 7.0, basé sur les resultats de la régression en une-étape (les rectangulaires) et en deux-étapes (les croix) pour l'ensemble des données iraniennes.*

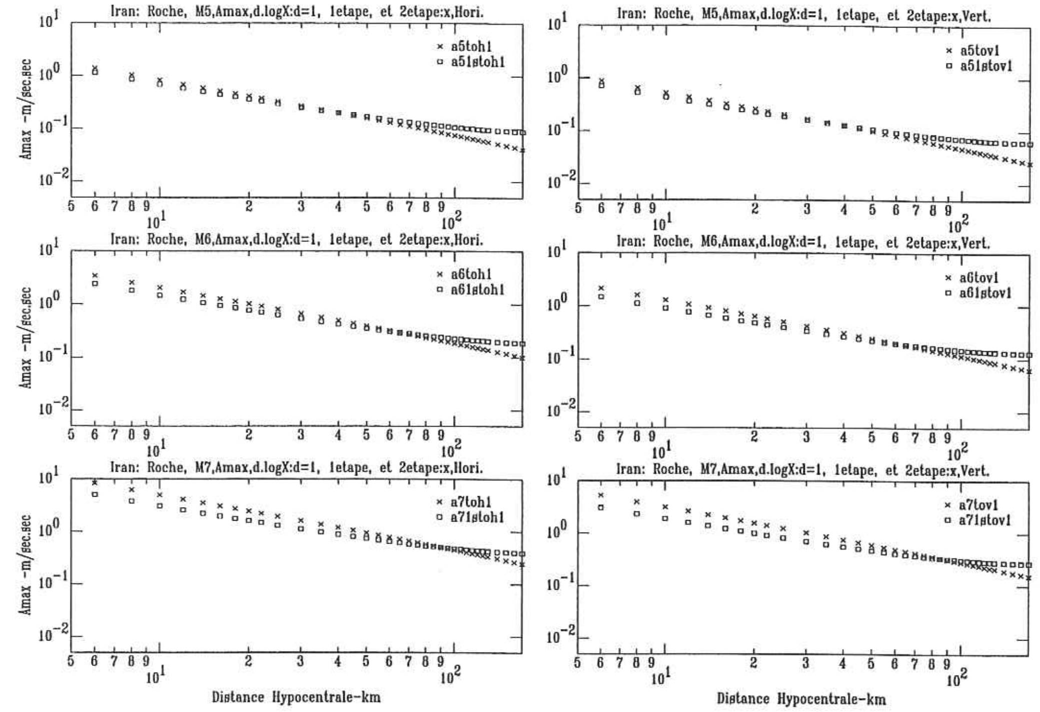

FIG. 6.29 – *L'atténuation de* A_{max} *en fonction de la distance hypocentrale pour les magnitudes de 5.0, 6.0 et 7.0, basé sur les resultats de la régression en une étape (les rectangulaires) et en deux-étapes (les croix) pour l'ensemble des données iraniennes.*

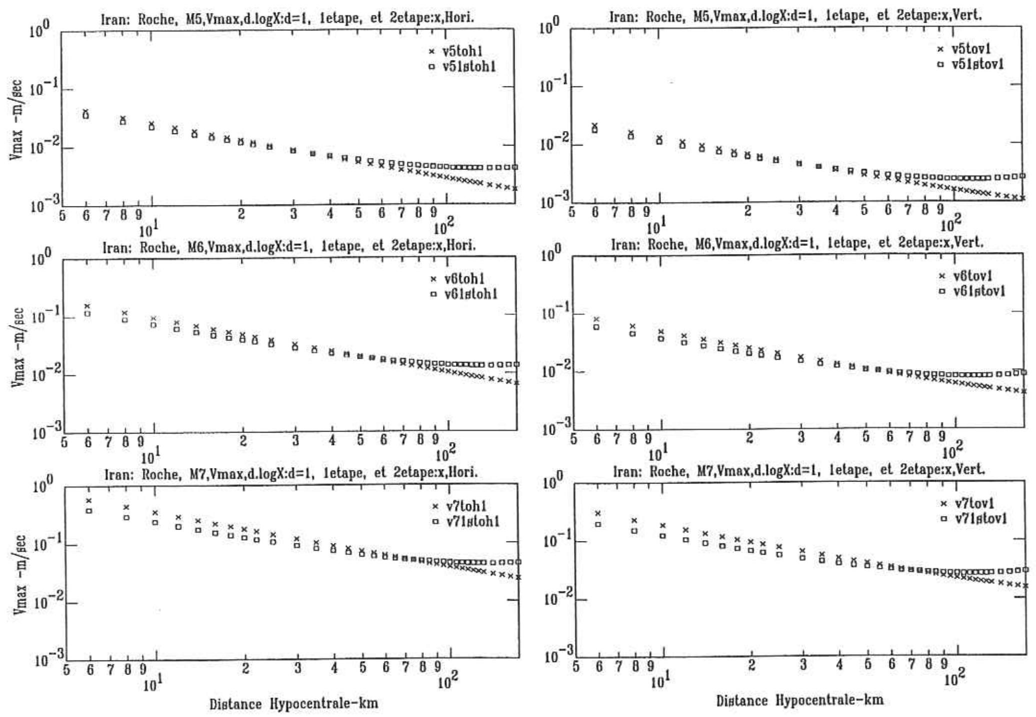

FIG. 6.30 – *L'atténuation de* V_{max} *en fonction de la distance hypocentrale pour les magnitudes de 5.0, 6.0 et 7.0, basé sur les resultats de la régression en une-étape (les rectangulaires) et en deux-étapes (les croix) pour l'ensemble des données iraniennes.*

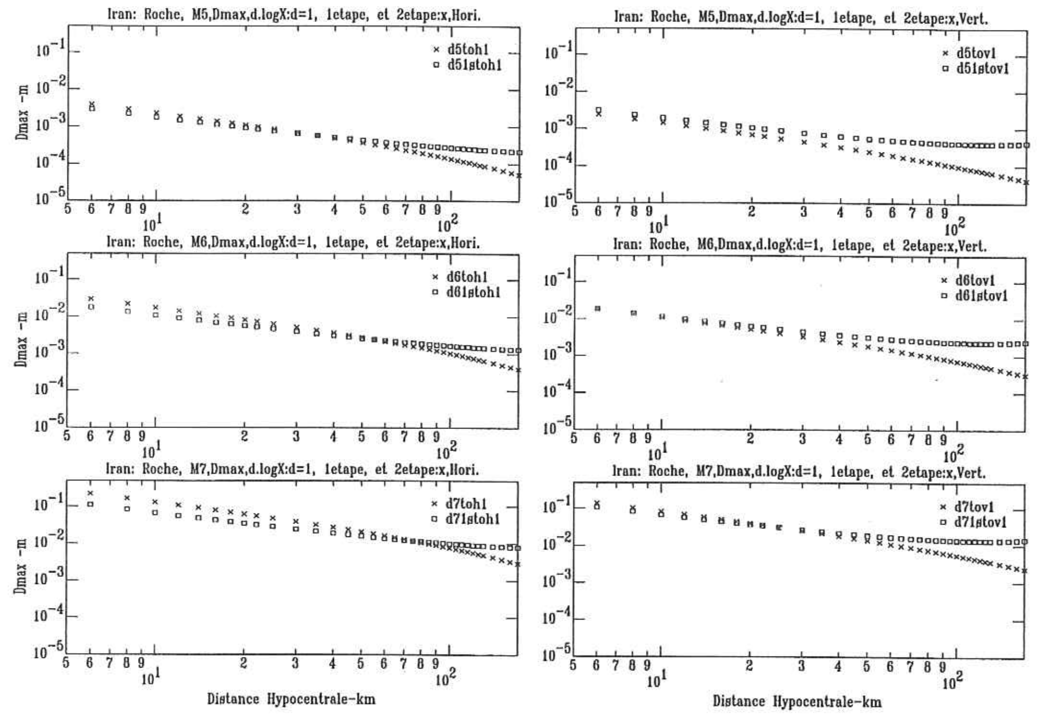

FIG. 6.31 – *L'atténuation de* D_{max} *en fonction de la distance hypocentrale pour les magnitudes de 5.0, 6.0 et 7.0, basé sur les resultats de la régression en une-étape (les rectangulaires) et en deux-étapes (les croix) pour l'ensemble des données iraniennes.*

Une autre forme de cette relation est étudiée qui ne se serte plus de l'atténuation anélastique et de l'expansion géométrique, mais en cherchant la meilleur décroissance "logaritmique" avec la distance:

$$\log A = a \cdot M_w - b \cdot \log X + c_i \cdot S_i + \sigma \cdot P \quad (6.6)$$

Les résultats des calculs en utilisant cette formule-la sont présentés dans le tableau 6.7:

Tableau 6.7 : Valeurs des coefficients de régression en appliquant la relation 6.6;

Paramètre/comp.	a	b	c1	c2	c3	c4	Sigma	R
A_{rms}, Vertical	0.308	0.581	-2.081	-2.048	-2.047	-2.081	0.320	0.407
A_{rms}, Horizontal	0.319	0.539	-1.992	-1.863	-1.929	-2.023	0.327	0.489
e_a, Vertical	0.728	0.889	-4.275	-4.240	-4.236	-4.187	0.570	0.162
e_a, Horizontal	0.752	0.768	-4.168	-3.959	-4.036	-4.167	0.570	0.226
A_{max}, Vertical	0.286	0.571	-1.327	-1.324	-1.317	-1.317	0.324	0.398
A_{max}, Horizontal	0.281	0.547	-1.135	-0.050	-1.092	-1.129	0.317	0.479
V_{max}, Vertical	0.500	0.447	-4.118	-4.172	-4.107	-4.108	0.317	0.487
V_{max}, Horizontal	0.480	0.434	-3.759	-3.750	-3.732	-3.708	0.319	0.539
D_{max}, Vertical	0.722	0.357	-6.393	-6.501	-6.453	-6.510	0.339	0.509
D_{max}, Horizontal	0.729	0.471	-6.080	-6.148	-6.105	-5.978	0.343	0.411

6.8 Les études sur la nonlinéarité possible dans les données iraniennes

La possibilité des effets de nonlinéarité sous forte accélération a été analysée par l'études des résidus des valeurs maximales de l'accélération (A_{max}). Ces résidus logarithmiques (logarithme des valeurs observées moins logarithme des valeurs prédites) sont représentés en fonction des valeurs de A_{max} observées pour les 4 sites différents et pour les deux types de régression (1 et 2 étapes)(Figures 6.32 à 6.35). Ces figures montrent une claire augmentation des résidus avec l'augmentation des valeurs de A_{max} observés, et une décroissance avec l'augmentation des Amax prédits. Cet effet est contraire a l'effet attendu, qui devrait être une décroissance de l'amplification à forte accélération. Cette observation peut s'interpréter comme la conséquence de la situation géologique du pays: la plupart des sites accélérométriques sont situés sur les alluvions raides et secs et sur les 25 ans d'existance du réseau accélérométrique iranien aucun

séismes ne s'est produit dans les régions côtières (où se trouvent les sols mous). Selon ces résultats, il faut donc insister encore sur la nécessité d'être prudent dans l'applications des lois d'atténuation présentées dans cette étude; pour les site à faible distance de forts séisme.

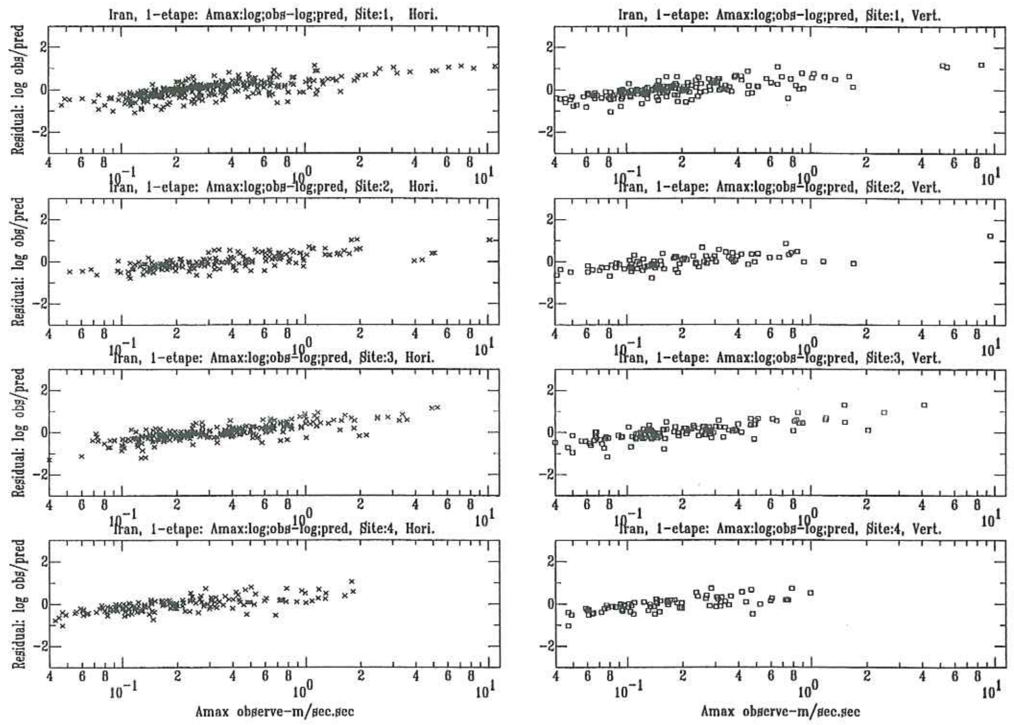

FIG. 6.32 – *Les résiduels (log observé - log prédit) de A_{max} en fonction de A_{max} observé pour les catégories différents des sites en utilisant de la régression en une-étape, pour l'ensemble des données iraniennes*

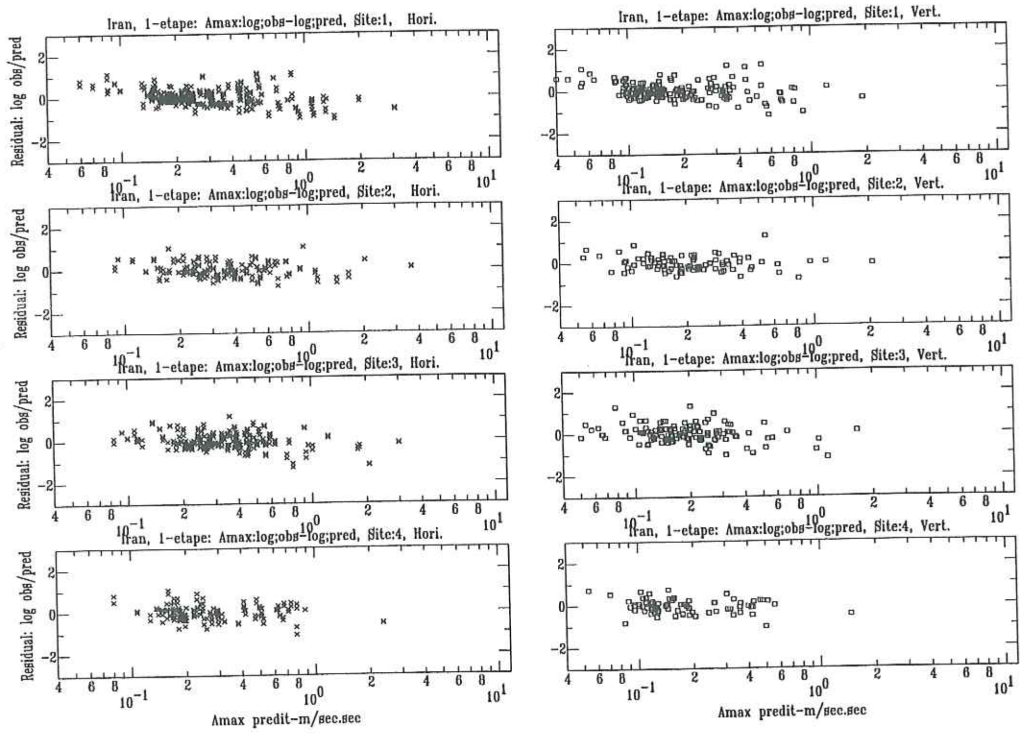

FIG. 6.33 – *Les résiduels (log observé - log prédit) de A_{max} en fonction de A_{max} prédit pour les catégories différents des sites en utilisant de la régression en une-étape, pour l'ensemble des données iraniennes*

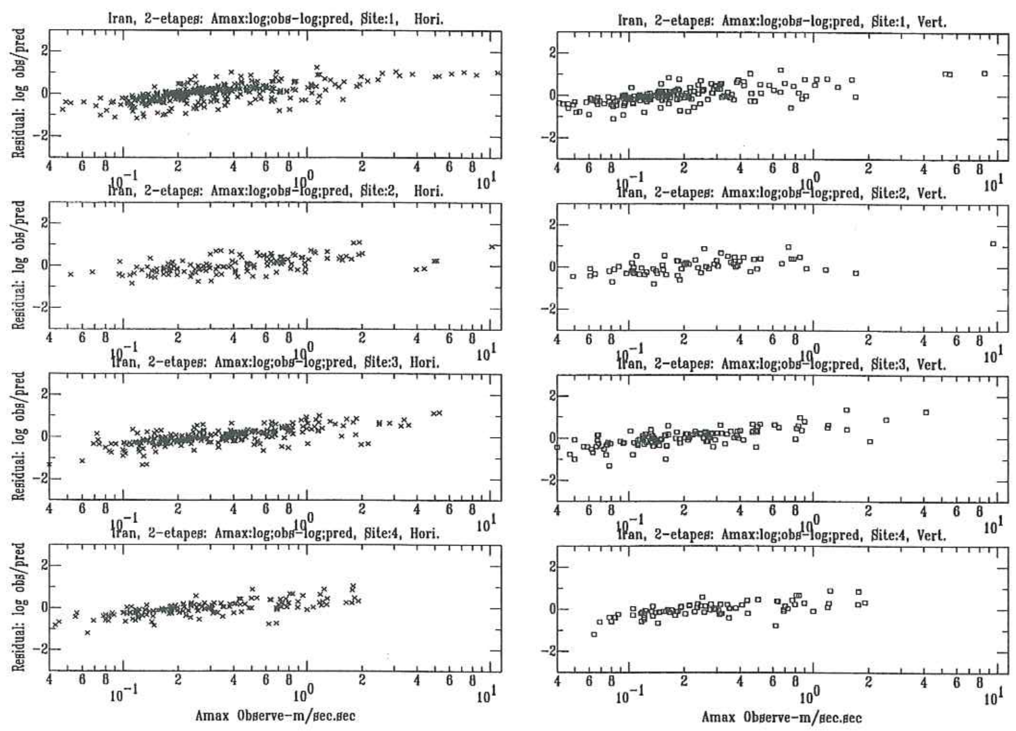

FIG. 6.34 – *Les résiduels (log observé - log prédit) de A_{max} en fonction de A_{max} observé pour les catégories différents des sites en utilisant de la régression en deux-étapes, pour l'ensemble des données iraniennes*

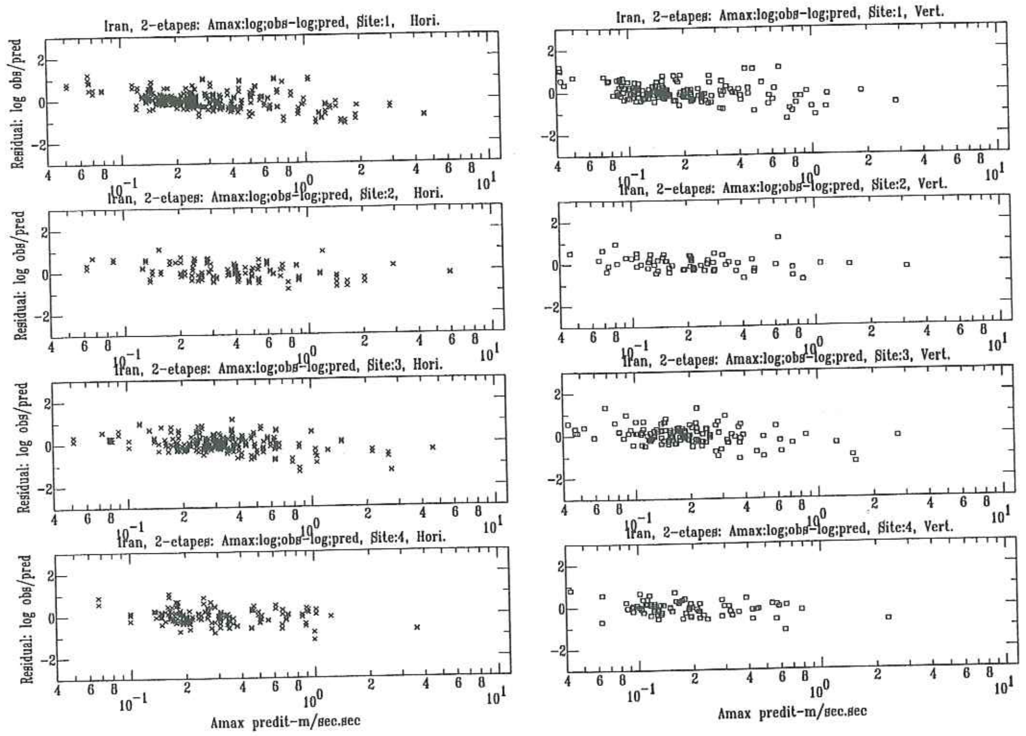

FIG. 6.35 – *Les résiduels (log observé - log prédit) de A_{max} en fonction de A_{max} prédit pour les catégories différents des sites en utilisant de la régression en deux-étapes, pour l'ensemble des données iraniennes*

Pour examiner si cette dérive non-linéaire inverse à l'effet attendu était due à une mauvaise prise en compte de l'expansion géométrique, nous avons influé sur les lois d'atténuation des ordonnées spectrales en modifiant le coefficient d, et en étudiant les variations des résidus lorsque d varie de 0.5 à 3.0 . Les écarts-type pour ces estimations sont présentés sur la Figure 6.36; on peut conclure que, quelque soit la période, le plus faible écarte-type est obtenu pour d=0.5. Ce résultat peut indiquer que les grands résidus pour les forts valeurs de A_{max} n'ont rien à voir avec la valeur de d, et ne contribuent donc pas d'une maniere representantative à la forme de la loi d'atténuation.

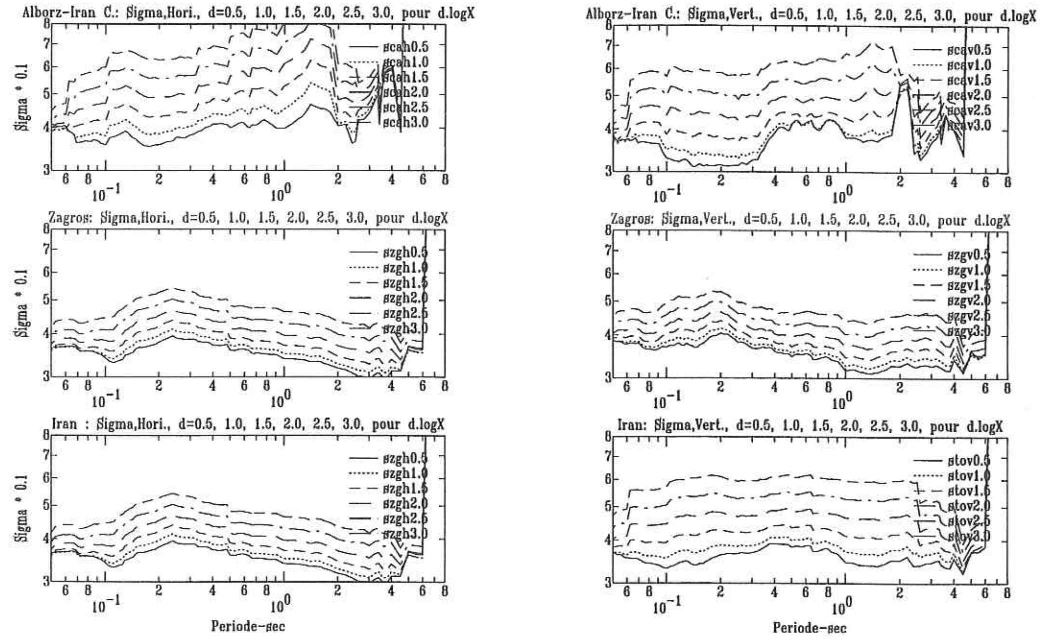

FIG. 6.36 – *Les valeurs différents de Sigma avec d de 0.5 à 3.0 pour les régressions en fonction des périodes différents. Les résultats ont pésentés pour les régions de l'Alborz-Iran Central, le Zagros, et l'ensemble des données iraniennes*

Appendix 6.1: The data-base used in this study.

No	Site	record	Mw	R (km)	Duration (H1) sec	Duration (V) sec	Duration (H2) sec	Arms (H1) m/sec2	Arms (V) m/sec2	Arms (H2) m/sec2	Ea (H1) m2/sec3	Ea (V) m2/sec3	Ea (H2) m2/sec3	PGA (H1) m/sec2	PGA (V) m/sec2	PGA (H2) m/sec2	PGV (H1) m/sec	PGV (V) m/sec	PGV (H2) m/sec	PGD (H1) m	PGD (V) m	PGD (H2) m
1	2	1012-00	4.5	64	1.53	5.22	1.56	.1400	.0320	.1200	.0340	.0058	.0240	.390	.157	.300						
2	2	1006-01	6.1	48	15.04	20.25	11.38	.2300	.1100	.3300	.8700	.2900	1.4000	.863	.417	1.287	.0629	.0329	.0847			
3	2	1006-02	5.2	40	16.33	16.27	14.43	.0430	.0370	.0530	.0330	.0250	.0450	.167	.125	.260						
4	1	1007-00	6.1	80	16.02	17.51	18.23	.0410	.0260	.0350	.0290	.0140	.0250	.217	.094	.168						
5	1	1008-00	6.1	56	25.60	20.13	22.57	.0370	.0360	.0360	.0390	.0280	.0320	.148	.137	.121						
6	4	1013-00	4.4	34	5.83	10.53	7.72	.0890	.0210	.0630	.0510	.0051	.0340	.428	.102	.192						
7	1	1009-00	4.8	48	11.19	17.34	14.70	.0660	.0200	.0390	.0540	.0074	.0250	.357	.077	.154						
8	4	1026-01	4.1	60	3.64	3.78	6.71	.0900	.0610	.0370	.0320	.0150	.0100	.505	.286	.251						
9	3	1014-04	5.4	32	14.53	11.88	15.17	.1800	.1100	.1600	.5300	.1700	.4500	.669	.471	.796						
10	3	1024-00	4.6	6	2.76	2.56	2.63	.7400	.3700	.8000	1.7000	.4000	1.9000	3.270	1.533	3.595	.0717	.0234	.0968			
11	2	1034-01	3.9	26	2.38	1.92	2.35	.1300	.0970	.1300	.0430	.0200	.0460	.432	.316	.537	.0119	.0084	.0144			
12	2	1034-02	4.6	12	.68	2.58	1.88	.6600	.1900	.2900	.3300	.0980	.1800	1.997	.845	1.022						
13	1	1040-03	4.7	88	1.28	1.58	1.49	.1200	.1400	.1200	.0200	.0320	.0220	.437	.452	.495	.0090	.0170	.0169	.000460	.001400	.001300
14	1	1043!-0	6.4	10	11.20	7.82	10.58	.3100	.3900	.3500	1.2000	1.3000	1.4000	1.150	1.700	1.570	.0110	.0028	.0065			
15	2	1047-08	6.4	11	.11	.60	.13	2.8000	.4200	2.2000	.9800	.1200	.7200	5.117	1.167	4.982	.0742	.0223	.0571			
16	2	1047-09	4.8	9	.30	.55	.52	.5800	.2200	.4900	.1100	.0290	.1400	1.750	.674	1.559	.0164	.0053	.0160	.000370	.000234	.000560
17	2	1047-10	5.1	5	.66	.58	.71	.2100	.2500	.2500	.0320	.0390	.0510	.602	.920	.978	.0122	.0199	.0066	.000270	.000190	.000680
18	2	1046-01	7.3	48	16.07	20.10	20.40	.1600	.0690	.1300	.4900	.1000	.3600	.891	.455	.685						
19	2	1046-02	5.5	47	7.61	9.57	7.02	.1400	.0430	.1300	.1600	.0190	.1300	.718	.212	.408						
20	1	1049-01	4.4	3	7.05	9.72	7.38	.0880	.0530	.1000	.0610	.0300	.0870	.402	.153	.337						
21	1	1049-02	4.4	19	6.10	8.74	5.78	.0350	.0190	.0580	.0081	.0036	.0220	.119	.082	.166						
22	1	1049-03	4.8	14	6.11	8.35	6.42	.0260	.0150	.0380	.0046	.0020	.0110	.081	.053	.134						
23	2	1050-01	7.0	52	21.56	27.32	17.98	.2200	.1100	.3000	1.2000	.3700	1.7000	.973	.379	1.504	.0556	.0275	.0768			
24	1	1052-00	7.0	71	7.75	7.44	7.55	.0750	.0520	.0740	.0490	.0220	.0460	.184	.149	.266						
25	1	1054!-1	6.1	7	2.78	3.18	2.70	2.5000	1.6000	1.9000	19.0000	8.8000	11.0000	7.200	5.200	6.150	.4600	.5400	.3800	.010000	.010200	.003200
26	1	1055-00	6.1	32	14.00	12.59	13.59	.0490	.0280	.0560	.0370	.0110	.0480	.155	.093	.180						
27	2	1058-00	6.1	18	3.95	5.08	4.16	.2300	.1300	.2300	.2200	.1000	.2500	.981	.493	.816						
28	4	1059-00	6.1	21	1.62	5.32	3.02	.1800	.0480	.1300	.0600	.0130	.0540	.685	.477	.623						
29	1	1056-05	4.9	15	.44	2.41	1.75	.1800	.0420	.0790	.0150	.0047	.0120	.649	.219	.370	.0072	.0059	.0084			
30	1	1060-02	4.8	20	3.21	2.64	5.02	.0340	.0510	.0310	.0040	.0076	.0054	.127	.168	.159						
31	1	1080-08	5.0	19	3.39	5.24	3.06	.2200	.1600	.2900	.1900	.1400	.2900	1.056	.780	1.587						
32	2	1092-01	4.4	30	2.56	5.90	1.70	.0700	.0210	.1200	.0140	.0028	.0260	.442	.183	.640	.0066	.0028	.0072			
33	1	1080-10	4.9	15	1.19	1.01	.96	.2400	.3100	.3300	.0780	.1100	.1200	.720	1.019	1.061						
34	1	1080-11	5.0	28	1.39	1.32	2.64	.1100	.1100	.0670	.0180	.0180	.0130	.513	.572	.360						
35	1	1080-12	4.3	30	.56	1.12	.53	.2800	.1100	.2800	.0500	.0140	.0460	1.171	.417	1.137						
36	2	1094-01	4.9	12	7.63	7.05	4.71	.0840	.0390	.1700	.0600	.0120	.1600	.408	.160	.826						
37	1	1082-01	7.4	36	34.01	30.20	34.91	.4900	.3600	.5000	9.0000	4.2000	9.7000	3.204	1.618	3.757	.1758	.1183	.2400	.040002	.027052	.059408
38	1	1083!-1	7.4	64	21.58	24.34	22.56	.2700	.2100	.2600	1.7000	1.2000	1.7000	.980	.870	.940	.0980	.0760	.1140	.001900	.001600	.002300
39	1	1084!-1	7.4	27	16.56	14.88	18.30	1.9000	1.4000	1.8000	66.0000	32.0000	66.0000	11.030	8.480	8.410	1.1300	.3600	.9700	.900000	.120000	.355000
40	3	1086-00	7.4	140	27.64	31.10	26.36	.1500	.0470	.1500	.7000	.0750	.6800	.795	.159	.581	.0457	.0145	.0318			
41	3	1090-02	7.4	234	29.66	25.52	27.62	.1100	.0780	.1200	.3700	.1700	.4600	.321	.246	.394						
42	1	1082-06	4.7	53	.97	2.34	1.04	.1700	.0740	.1300	.0310	.0140	.0210	.676	.390	.440						
43	1	1103-01	4.5	22	3.59	4.88	2.39	.0560	.0360	.0890	.0120	.0070	.0210	.226	.301	.421	.0048	.0033	.0077			
44	1	1104-02	4.5	42	.76	3.79	5.26	.1700	.0450	.0550	.0260	.0086	.0180	.500	.280	.355	.0204	.0069	.0164			
45	1	1093-02	4.2	75	3.69	4.67	4.30	.0570	.0480	.0660	.0130	.0120	.0210	.323	.188	.234						
46	1	1103-03	4.9	20	3.50	8.28	2.67	.1400	.0530	.2200	.0770	.0250	.1500	.659	.343	1.052	.0167	.0066	.0308			
47	3	1098-03	6.2	20	4.38	5.42	4.20	.1100	.0720	.1000	.0570	.0310	.0470	.556	.287	.517	.0140	.0072	.0127			
48	1	1096-01	6.1	5	.57	.78	.88	.2600	.2500	.2600	.0440	.0540	.0630	.710	.754	.807	.0110	.0108	.0452			
49	1	1096-02	4.7	5	1.87	1.98	.26	.0480	.0440	.3000	.0047	.0043	.0270	.252	.226	.668	.0030	.0030	.0077			
50	1	1097-02	4.7	5	.22	.75	3.91	.3300	.1300	.0430	.0270	.0140	.0081	.812	.454	.359	.0091	.0138	.0052			
51	1	1103-09	4.5	21	4.42	5.86	4.24	.0590	.0410	.1100	.0170	.0110	.0600	.277	.176	.853	.0057	.0048	.0166			
52	3	1102-00	6.8	135	7.88	10.32	10.43	.1300	.0350	.0930	.1400	.0140	.1000	.375	.151	.278						
53	3	1106-00	6.8	80	17.33	13.34	15.20	.0820	.0770	.1000	.1300	.0880	.1700	.353	.384	.466						
54	1	1107-00	6.8	61	13.59	18.51	13.16	.0680	.0450	.0820	.0700	.0420	.0990	.276	.165	.362						
55	4	1109-00	6.8	86	15.98	20.62	12.30	.0610	.0360	.0860	.0660	.0300	.1000	.221	.193	.314						
56	2	1113-00	6.8	80	11.85	21.73	13.86	.1800	.0640	.1500	.4100	.1000	.3300	.689	.304	.663						
57	1	1103-11	5.1	16	6.10	7.43	5.52	.1200	.1000	.2000	.1000	.0840	.2400	.553	.459	.780						
58	1	1103-12	5.5	55	10.01	11.30	9.94	.1100	.0760	.1300	.1300	.0730	.1900	.858	.419	.872	.0186	.0084	.0254			
59	2	1125-02	5.1	25	3.14	3.20	1.44	.1100	.0920	.2200	.0460	.0300	.0810	.608	.476	.790						
60	3	1117-00	6.6	96	20.90	25.88	23.09	.0510	.0270	.0510	.0590	.0210	.0660	.281	.124	.208						
61	1	1118-00	6.6	55	11.28	10.35	10.05	.0790	.0800	.1200	.0770	.0750	.1500	.313	.319	.420						
62	2	1121-00	6.6	72	16.91	21.67	17.17	.1800	.0910	.1900	.5800	.2000	.6800	.734	.370	.744						
63	1	1124-00	6.6	116	14.40	21.11	17.11	.0470	.0330	.0380	.0350	.0260	.0270	.166	.126	.140						
64	3	1130-02	6.6	184	13.18	14.40	14.15	.0660	.0390	.0740	.0650	.0240	.0850	.262	.119	.261						
65	1	1132-01	6.6	132	25.45	28.40	23.03	.0660	.0410	.0800	.1200	.0530	.1600	.245	.166	.297						
66	2	1143-01	5.0	69	10.84	10.01	10.93	.0450	.0270	.0490	.0250	.0082	.0290	.187	.104	.212						
67	3	1131-00	7.1	160	23.89	29.51	25.14	.1400	.0630	.1200	.5000	.1300	.3800	.465	.284	.372						
68	3	1134-02	7.1	152	12.26	22.12	12.92	.2900	.0900	.2700	1.1000	.2000	1.1000	1.158	.374	.947						
69	1	1135-00	7.1	88	17.68	19.84	19.78	.1200	.0710	.0780	.3100	.1100	.1300	.478	.284	.308						
70	1	1137-00	7.1	136	17.84	30.66	18.35	.0980	.0400	.0850	.1900	.0540	.1500	.278	.121	.244	.0402	.0218	.0486			
71	3	1138-01	7.1	80	20.86	24.51	20.52	.1700	.0730	.1700	.6700	.1500	.6300	.836	.357	.761						
72	1	1139-00	7.1	44	11.44	16.16	13.70	.4000	.2800	.3300	2.0000	1.4000	1.7000	1.968	1.193	1.339	.1092	.0928	.0847	.018558	.010384	.012059
73	1	1140-00	7.1	80	14.84	21.73	15.44	.1900	.1300	.1900	.6100	.4000	.6400	.721	.516	.774						
74	4	1141-01	7.1	120	27.44	38.47	26.20	.1900	.0800	.2000	1.1000	.2700	1.2000	.780	.356	.688						
75	4	1142-01	7.1	92	17.30	23.74	17.82	.1700	.1300	.2000	.5900	.4300	.8100	.739	.611	.895						
76	2	1143-02	7.1	64	27.11	29.26	27.56	.3300	.1800	.3300	3.3000	1.0000	3.4000	1.286	.762	1.526						
77	2	1143-03	4.6	40	17.08	19.51	17.77	.0740	.0420	.0730	.1000	.0380	.1000	.344	.185	.324	.0127	.0096	.0134			
78	1	1144-02	7.1	108	24.35	28.41	22.42	.0930	.0970	.1100	.2400	.3000	.3100	.405	.384	.538						
79	1	1145-00	7.1	160	14.35	27.64	13.34	.1000	.0540	.1100	.1700	.0890	.1700	.434	.183	.317	.0571	.0320	.0423			
80	2	1143-04	4.7	29	10.19	10.03	10.19	.1200	.1300	.1200	.1500	.1800	.1500	.646	.206	.609						
81	1	1136-02	4.8	12	3.00	7.30	5.07	.2300	.0690	.1700	.1700	.0390	.1600	.865	.341	.706						
82	1	1136-03	5.9	26	8.60	11.78	8.72	.2800	.1500	.3600	.7400	.3100	1.3000	1.487	.659	1.938						
83	4	1151-00	5.0	16	10.26	7.12	7.10	.1600	.1800	.2300	.2900	.2500	.4300	.911	.914	1.052	.0389	.0277	.0433			
84	2	1149-00	4.6	4	3.85	5.11	5.24	.1200	.0370	.0850	.0590	.0076	.0420	.508	.137	.303						
85	2	1182-00	4.6	16	3.81	4.23	4.42	.1600	.0820	.1000	.1100	.0320	.0510	.682	.397	.486	.0198	.0096	.0126			
86	3	1160-00	4.4	20	1.78	2.27	2.16	.2800	.2300	.3000	.1600	.1400	.2200	.731	.616	.763						
87	1	1153-01	5.8	62	14.40	13.24	14.21	.0450	.0330	.0380	.0330	.0160	.0230	.139	.130	.129						
88	4	1168-00	6.7	72	15.95	16.75	16.43	.0960	.0520	.0820	.1600	.0500	.1200	.328	.198	.310						
89	1	1169I-0	6.7	40	21.28	23.26	17.84	.0720	.0720	.0880	.1200	.1300	.1500	.250	.370	.370	.0280	.0220	.0260	.005800	.006600	.004300
90	3	1172-06	6.7	20	8.07	6.77	5.74	.0630	.0710	.0830	.0360	.0380	.0440	.348	.285	.503						
91	1	1179I-0	6.7	114	41.46	42.92	44.02	.0790	.0590	.0870	.2800	.1700	.3700	.330	.210	.220	.0270	.0170	.0235	.004900	.003100	.005100
92	4	1174-00	7.1	48	21.68	20.33	18.85	.2100	.1500	.2000	1.1000	.4900	.8500	1.002	.525	1.000	.0656	.0276	.0685			
93	3	1176I-5	7.1	12	28.82	27.74	24.52	.4900	.3600	.5800	7.7000	4.1000	9.3000	1.980	2.040	2.160	.1350	.0840	.1750			
94	3	1176-25	4.4	16	5.63	5.29	3.93	.0440	.0410	.0570	.0120	.0098	.0140	.178	.181	.213	.0045	.0023	.0083			
95	3	1183-06	4.1	46	5.82	5.57	5.96	.0370	.0300	.0360	.0088	.0057	.0085	.136	.102	.153						
96	3	1183-08	4.6	16	1.62	3.97	2.08	.2100	.0750	.2200	.0790	.0250	.1100	.582	.341	1.103	.0196	.0045	.0270			
97	3	1191-03	4.1	12	4.59	5.30	3.56	.1100	.0710	.2400	.0650	.0300	.2300	.454	.318	.782	.0148	.0088	.0328			
98	3	1191-04	4.4	18	4.02	6.70	3.44	.0480	.0220	.0460	.0100	.0037	.0082	.274	.093	.175						
99	3	1191-05	4.4	18	6.84	4.41	3.20	.0450	.0560	.1000	.0150	.0150	.0370	.253	.245	.511	.0042	.0034	.0084			
100	4	1195-00	4.9	25	3.54	3.49	4.33	.0860	.0670	.0620	.0290	.0170	.0180	.294	.311	.306	.0112	.0074	.0069	.000570	.000273	.000423
101	1	1220-01	4.3	63	9.60	8.66	8.64	.0370	.0330	.0450	.0140	.0110	.0200	.206	.150	.201						
102	1	1211-01	5.6	20	7.11	7.34	4.88	.0520	.0390	.0690	.0210	.0130	.0250	.302	.353	.325						
103	1	1211-02	4.4	15	7.23	9.06	5.57	.0370	.0210	.0410	.0110	.0046	.0100	.220	.131	.153						
104	3	1214-01	4.9	16	1.71	1.52	1.75	.4700	.3100	.3300	.4200	.1600	.2100	1.581	1.213	1.208	.0447	.0282	.0333	.001422	.001305	.001865
105	3	1216-01	4.9	26	7.00	6.12	7.37	.1100	.0880	.1100	.0860	.0530	.0930	.527	.400	.610	.0154	.0071	.0172	.000697	.000324	.000749
106	3	1216-02	4.5	29	9.27	6.55	6.05	.0480	.0380	.0700	.0230	.0110	.0320	.182	.128	.211						
107	4	1218-00	4.8	16	6.73	7.39	4.69	.1000	.0790	.1900	.0750	.0510	.1800	.485	.340	.703	.0143	.0069	.0304	.000523	.000248	.001325
108	3	1224-03	5.0	10	6.48	7.65	5.62	.1800	.0960	.2300	.2400	.0780	.3400	.538	.417	.756						
109	3	1226-02	5.0	16	2.96	2.07	2.12	.8600	.7500	.7300	2.5000	1.3000	1.3000	3.400	2.487	2.493	.0962	.0602	.0944	.003816	.001935	.004408
110	1	1233-02	5.0	10	2.85	3.04	2.09	.3600	.3700	.5300	.4100	.4700	.6500	1.263	1.362	1.868	.0288	.0319	.0651	.001161	.001463	.004446
111	3	1228-02	4.6	7	4.93	9.61	8.32	.0210	.0096	.0150	.0025	.0010	.0021	.060	.050	.040						
112	3	1240-04	4.5	18	4.29	3.28	5.38	.0390	.0250	.0290	.0071	.0023	.0051	.233	.107	.197						
113	3	1240-06	5.2	7	3.27	4.43	3.75	.3400	.1500	.2600	.4200	.1100	.2800	1.852	.802	1.552	.0183	.0091	.0127			
114	1	1247-01	3.1	9	2.29	2.96	4.07	.1300	.0800	.0580	.0430	.0210	.0150	.645	.309	.303	.0115	.0045	.0051			
115	2	1291-01	5.7	45	5.86	7.53	5.75	.0760	.0270	.0690	.0380	.0061	.0300	.330	.105	.264						
116	3	1308-00	5.1	23	5.88	6.61	5.05	.1100	.0690	.1800	.0800	.0350	.1800	.366	.271	.656	.0151	.0087	.0211	.000590	.000500	.000985
117	3	1289-01	4.3	32	5.34	10.01	7.05	.0780	.0260	.0610	.0370	.0076	.0290	.275	.123	.278						
118	3	1289-03	4.9	32	4.96	7.97	5.87	.2600	.0860	.2200	.3600	.0650	.3100	1.014	.497	.788	.0220	.0087	.0245	.000575	.000263	.000920
119	3	1289-02	4.9	13	6.52	9.01	7.49	.1500	.0660	.1100	.1700	.0440	.1100	.644	.294	.445	.0158	.0051	.0140	.000449	.000117	.000415
120	3	1289-04	5.2	24	7.44	14.30	8.14	.2300	.0740	.2000	.4400	.0870	.3600	1.004	.494	.608	.0250	.0066	.0168	.000757	.000189	.000596
121	3	1289-05	5.5	24	7.80	12.30	11.69	.0850	.0340	.0450	.0630	.0160	.0270	.365	.147	.208	.0080	.0029	.0028			
122	1	1311-01	4.5	16	7.38	7.91	8.60	.0760	.0670	.0680	.0470	.0390	.0440	.320	.282	.353	.0070	.0053	.0053	.000189	.000110	.000125
123	1	1311-02	4.0	24	7.86	7.19	6.68	.0390	.0340	.0490	.0140	.0095	.0180	.171	.147	.331						
124	1	1319-01	4.6	4	2.23	1.91	2.74	.1700	.1900	.1300	.0760	.0800	.0530	1.174	.914	.648	.0175	.0156	.0155	.000890	.000684	.000899
125	1	1320-02	4.6	6	1.43	1.26	1.10	.1900	.2300	.2900	.0570	.0760	.1000	.643	.832	1.062	.0141	.0114	.0232	.000664	.000354	.000825

No	Site	record	Mw	R (km)	Duration (H1) sec	Duration (V) sec	Duration (H2) sec	Arms (H1) m/sec2	Arms (V) m/sec2	Arms (H2) m/sec2	Ea (H1) m2/sec3	Ea (V) m2/sec3	Ea (H2) m2/sec3	PGA (H1) m/sec2	PGA (V) m/sec2	PGA (H2) m/sec2	PGV (H1) m/sec	PGV (V) m/sec	PGV (H2) m/sec	PGD (H1) m	PGD (V) m	PGD (H2) m
126	1	1319-02	4.3	64	.88	1.25	1.42	.3300	.2000	.2000	.1100	.0560	.0610	1.132	.662	.684	.0234	.0123	.0158	.000775	.000493	.000977
127	3	1305-00	5.0	4	4.69	7.69	4.54	.2500	.0950	.2300	.3300	.0780	.2600	1.009	.488	.733	.0393	.0142	.0257	.001783	.000638	.001193
128	1	1307-01	4.6	24	3.17	3.85	3.91	.1000	.0630	.1000	.0370	.0170	.0460	.535	.311	.580	.0137	.0057	.0083	.000443	.000233	.000309
129	4	1303-00	4.2	10	5.20	5.57	6.09	.3400	.1200	.2200	.6900	.0850	.3300	1.286	.322	.796	.0582	.0141	.0353	.003016	.000703	.001842
130	1	1300-01	5.3	8	8.07	9.28	7.48	.1700	.1500	.1600	.2500	.2200	.2200	.642	.477	.492	.0484	.0335	.0296	.005998	.005025	.003816
131	1	1300-03	4.7	20	9.03	9.67	8.06	.0330	.0330	.0340	.0110	.0120	.0110	.097	.115	.107						
132	1	1351-00	7.3	210	14.51	11.66	12.76	.0250	.0470	.0300	.0097	.0280	.0130	.105	.251	.116						
133	3	1353I-1	7.3	76	18.04	26.46	24.50	.3600	.2200	.2900	2.6000	1.4000	2.3000	1.860	.900	1.340	.1540	.0760	.1170	.039000	.028000	.030000
134	4	1354-00	7.3	80	22.73	23.61	19.13	.3800	.1700	.5900	3.7000	.8000	7.4000	1.282	.728	1.906						
135	4	1355-00	7.3	68	29.06	27.86	27.28	.2300	.1600	.2100	1.7000	.7600	1.4000	.892	.737	.688	.1000	.0473	.0884			
136	4	1357A-1	7.3	96	33.96	32.62	27.72	.2700	.1800	.4600	2.8000	1.2000	6.6000	1.080	.750	1.760	.1350	.0730	.3630	.071000	.041500	.155000
137	4	1359-00	7.3	100	18.40	24.69	26.25	.3000	.0700	.2100	1.9000	.1300	1.2000	1.173	.303	.727						
138	2	1360-00	7.3	12	1.61	2.23	1.83	1.5000	.4900	1.1000	3.8000	.5900	2.4000	4.382	1.712	3.958	.0937	.0389	.0941			
139	3	1361-00	7.3	176	32.43	33.47	33.27	.1200	.0730	.1600	.4800	.2000	.9700	.499	.388	.951						
140	1	1362I-1	7.3	40	31.92	35.96	35.06	.8300	.9100	.5900	25.0000	33.0000	14.0000	5.260	5.480	5.030	.3800	.4840	.4360	.163000	.204000	.203000
141	4	1363I-1	7.3	224	15.14	14.58	15.14	.1400	.0830	.1400	.3500	.1100	.3500	.460	.280	.350	.0710	.0280	.0600	.015000	.007000	.015000
142	1	1364I-0	7.3	80	35.84	40.92	39.96	.2100	.1100	.1500	1.8000	.5700	1.0000	1.250	.510	.600	.1460	.0510	.0950	.063000	.039000	.040000
143	4	1365I-1	7.3	195	8.28	8.98	9.02	.1100	.0500	.0880	.1000	.0250	.0770	.300	.150	.290	.0350	.0290	.0260	.006600	.005700	.004900
144	1	1366-00	7.3	212	17.92	14.74	18.58	.0440	.0480	.0380	.0390	.0370	.0290	.140	.189	.133						
145	4	1369I-0	7.3	198	14.42	12.10	13.84	.1000	.1000	.1400	.1800	.1500	.2900	.400	.320	.440	.0420	.0480	.0620	.008800	.013000	.016000
146	1	1370I-2	7.3	207	16.20	15.74	17.52	.0290	.0590	.0390	.0150	.0600	.0290	.130	.190	.170	.0068	.0124	.0105	.001300	.001600	.001500
147	1	1371I-2	7.3	177	11.84	13.94	13.96	.0950	.0440	.0370	.1200	.0300	.0220	.350	.130	.120	.0350	.0150	.0140	.005900	.002500	.002400
148	4	1372I-0	7.3	140	26.64	33.74	22.60	.1600	.0900	.1700	.7800	.3000	.7600	.720	.440	.770	.0610	.0250	.0600	.010500	.005700	.012200
149	1	1352-00	7.3	209	8.85	8.81	8.55	.0690	.0340	.0740	.0470	.0110	.0520	.271	.146	.209						
150	4	1357-02	4.2	45	9.00	9.70	9.01	.0290	.0220	.0350	.0083	.0050	.0120	.111	.237	.135						
151	1	1393-02	4.2	99	1.45	2.02	1.92	.1400	.0460	.0850	.0310	.0047	.0150	.388	.165	.248						
152	1	1393-04	4.8	24	4.22	3.30	4.45	.0970	.1300	.0890	.0440	.0600	.0390	.601	.698	.470	.0174	.0117	.0128	.000609	.000227	.000314
153	2	1367-00	4.4	75	2.56	5.97	2.34	.0410	.0240	.0540	.0049	.0039	.0077	.322	.257	.341	.0040	.0042	.0064	.000093	.000088	.000152
154	3	1368-01	4.4	8	1.58	1.58	.90	.2700	.2100	.4500	.1300	.0740	.2100	.841	.869	1.150	.0173	.0129	.0308	.000594	.000329	.001034
155	3	1368-02	4.5	38	4.46	5.11	6.06	.0520	.0220	.0320	.0140	.0027	.0070	.243	.132	.183						
156	1	1393-07	4.5	36	4.28	10.87	2.90	.1000	.0280	.1100	.0480	.0093	.0390	.422	.185	.522						
157	3	1368-05	4.6	20	1.46	7.37	4.39	.1800	.0400	.0750	.0510	.0130	.0270	.738	.303	.458	.0076	.0031	.0062	.000155	.000068	.000154
158	1	1393-09	4.7	20	.77	11.22	1.95	.1600	.0210	.0870	.0230	.0055	.0160	.374	.162	.320						
159	3	1368-08	4.4	15	1.87	3.06	1.72	.1000	.0360	.0950	.0220	.0044	.0170	.677	.203	.423						
160	2	1377-01	5.3	20	2.60	6.40	3.94	.4100	.1300	.3300	.4900	.1100	.4800	1.636	.783	1.919	.0595	.0166	.0914	.005238	.001002	.004269
161	3	1382-01	5.2	16	.85	7.07	2.55	.2300	.0210	.1000	.0490	.0036	.0280	.437	.161	.331						
162	3	1382-02	4.2	45	4.27	4.44	5.07	.0650	.0300	.1100	.0200	.0045	.0640	.246	.132	.390						
163	2	1377-02	4.3	24	2.85	5.32	3.32	.2100	.0620	.1500	.1300	.0230	.0890	1.049	.345	.586	.0316	.0121	.0175	.001757	.000633	.000730
164	3	1382-08	4.5	7	1.02	3.51	2.08	.0660	.0160	.0420	.0049	.0010	.0041	.151	.075	.100						
165	3	1382-11	4.5	40	1.05	1.57	1.53	.2800	.0980	.3100	.0890	.0170	.1600	.647	.314	.588						
166	2	1397-08	4.4	28	5.40	7.21	10.01	.1100	.0430	.0840	.0790	.0150	.0780	.582	.186	.553	.0125	.0030	.0100			
167	4	1449I-0	4.6	84	3.36	3.28	2.98	.0370	.0250	.0330	.0051	.0023	.0035	.170	.150	.175	.0041	.0024	.0028	.000100	.000043	.000090
168	3	1420-01	4.4	16	.65	1.17	1.10	.0790	.0360	.0740	.0045	.0017	.0067	.222	.149	.238	.0041	.0027	.0046	.000088	.000048	.000106
169	3	1420-02	5.6	26	.73	2.59	1.21	.3200	.0340	.2800	.0860	.0033	.1100	.675	.136	.669	.0153	.0028	.0150	.000408	.000071	.000419
170	3	1512-01	4.5	16	5.51	4.19	2.49	.0890	.1200	.1000	.0480	.0720	.0280	.435	.650	.438	.0175	.0359	.0106	.001217	.005974	.000998
171	1	1505-00	4.4	24	7.02	8.02	6.80	.0210	.0130	.0240	.0033	.0015	.0043	.088	.093	.134	.0026	.0016	.0037	.000141	.000120	.000302
172	2	1504-01	3.4	16	3.74	3.56	4.43	.0096	.0084	.0091	.0004	.0003	.0004	.068	.032	.052	.0010	.0007	.0008	.000057	.000039	.000040
173	2	1491-00	5.7	12	3.08	4.77	4.24	.0970	.0420	.0630	.0320	.0093	.0190	.420	.190	.258	.0119	.0035	.0055	.000653	.000114	.000209
174	1	1492-01	4.2	16	5.98	5.61	4.57	.0420	.0270	.0610	.0120	.0046	.0190	.191	.105	.193	.0045	.0028	.0064	.000289	.000114	.000317
175	2	1503-01	3.8	12	3.60	4.18	4.86	.0590	.0320	.0380	.0140	.0049	.0080	.258	.201	.115	.0043	.0026	.0031	.000115	.000089	.000119
176	2	1503-02	3.5	12	4.42	3.62	5.10	.0490	.0410	.0380	.0120	.0068	.0084	.191	.230	.176	.0031	.0030	.0031	.000058	.000079	.000091
177	2	1494-01	4.3	12	3.71	5.09	5.58	.0610	.0250	.0330	.0150	.0035	.0068	.216	.107	.138	.0062	.0019	.0032	.000436	.000119	.000192
178	2	1500-01	3.5	8	2.74	4.03	3.92	.0510	.0230	.0320	.0079	.0023	.0044	.178	.104	.109	.0029	.0011	.0016	.000080	.000069	.000058
179	2	1500-02	3.2	8	2.90	3.16	2.87	.0240	.0160	.0280	.0018	.0009	.0024	.095	.078	.166	.0013	.0009	.0022	.000027	.000053	.000064
180	2	1500-03	4.3	8	3.15	4.05	2.67	.1600	.0740	.2100	.0950	.0250	.1300	.728	.272	.613	.0130	.0055	.0160	.000517	.000269	.000522
181	1	1492-02	4.8	34	7.42	9.80	9.26	.0650	.0290	.0560	.0350	.0092	.0320	.242	.115	.211	.0071	.0055	.0094	.000513	.000572	.000702
182	2	1500-04	4.8	12	6.02	6.33	5.08	.1600	.0810	.1700	.1800	.0460	.1600	.641	.358	.748	.0239	.0089	.0149	.001804	.000539	.000854
183	1	1492-03	4.6	16	6.67	6.33	5.61	.0450	.0220	.0550	.0150	.0033	.0190	.145	.080	.223	.0048	.0028	.0082	.000378	.000200	.000383
184	2	1494-02	4.8	20	8.64	11.06	9.34	.0470	.0310	.0420	.0220	.0120	.0180	.239	.143	.150	.0101	.0052	.0049	.000806	.000536	.000390
185	2	1494-03	4.6	12	3.53	4.15	3.09	.1400	.0790	.1600	.0790	.0290	.0910	.516	.387	.472	.0108	.0058	.0110	.000422	.000255	.000337
186	2	1500-05	4.6	16	3.01	4.18	4.08	.2100	.0760	.1400	.1500	.0730	.0930	1.111	.299	.730	.0202	.0042	.0151	.000530	.000149	.000414
187	1	1492-04	4.4	21	6.20	7.32	6.02	.1000	.0560	.1200	.0850	.0260	.0840	.527	.226	.508	.0130	.0059	.0153	.000707	.000227	.000500
188	2	1494-04	4.4	80	9.55	9.63	10.32	.0290	.0230	.0330	.0092	.0057	.0120	.096	.110	.141	.0039	.0024	.0051	.000283	.000275	.000372
189	2	1500-06	4.4	11	6.72	5.95	5.98	.0840	.0650	.0940	.0530	.0280	.0590	.322	.238	.494	.0079	.0054	.0102	.000324	.000233	.000558
190	2	1500-07	3.5	8	2.59	3.13	2.31	.0290	.0170	.0480	.0024	.0010	.0058	.099	.061	.198	.0018	.0009	.0032	.000084	.000066	.000121
191	1	1500-08	4.4	11	7.59	6.72	7.73	.0780	.0590	.0760	.0520	.0260	.0450	.263	.284	.516	.0072	.0063	.0166	.000449	.000389	.001043
192	2	1500-09	3.1	12	3.27	4.32	3.10	.0320	.0160	.0360	.0037	.0013	.0045	.119	.061	.177	.0019	.0008	.0029	.000090	.000051	.000091
193	2	1500-10	4.3	12	3.53	3.69	2.07	.0690	.0370	.1000	.0190	.0057	.0240	.277	.141	.351	.0053	.0024	.0064	.000178	.000102	.000186
194	2	1500-11	4.0	12	7.15	5.43	5.29	.0280	.0270	.0370	.0063	.0045	.0079	.153	.126	.182	.0027	.0018	.0041	.000096	.000075	.000302
195	2	1500-12	3.8	8	3.22	3.34	3.37	.0710	.0410	.0640	.0180	.0063	.0150	.386	.154	.298	.0050	.0030	.0046	.000133	.000049	.000095
196	1	1492-05	4.7	20	6.32	6.63	5.61	.1000	.0450	.1300	.0720	.0150	.1100	.368	.202	.513	.0108	.0056	.0190	.000084	.000317	.000977
197	2	1500-13	4.7	8	2.56	3.10	2.72	.1200	.0670	.1500	.0390	.0150	.0530	.408	.247	.475	.0070	.0039	.0085	.000431	.000372	.000330
198	1	1492-06	5.2	24	7.12	9.78	7.00	.5300	.1600	.5800	2.2000	.2900	2.6000	2.136	.607	2.443	.0824	.0249	.1327	.005836	.005641	.007782
199	1	1492-07	4.6	32	9.93	10.98	7.82	.0410	.0200	.0570	.0180	.0047	.0280	.184	.067	.174	.0055	.0020	.0067	.000445	.000327	.000557
200	1	1492-08	5.2	24	10.89	12.16	9.10	.1200	.0560	.1600	.1800	.0420	.2400	.578	.212	.487	.0220	.0098	.0272	.002351	.002184	.002721
201	1	1492-09	4.7	26	8.95	10.05	8.99	.0580	.0280	.0530	.0330	.0086	.0330	.198	.098	.220	.0059	.0038	.0076	.000837	.000615	.000646
202	1	1492-10	3.4	14	1.42	1.54	1.75	.0340	.0140	.0350	.0017	.0003	.0016	.201	.062	.052	.0053	.0010	.0014	.000081	.000064	.000165
203	1	1492-11	4.1	23	8.14	6.81	7.85	.0360	.0200	.0340	.0120	.0030	.0099	.124	.094	.103	.0039	.0015	.0044	.000452	.000177	.000273
204	1	1492-12	4.2	20	4.88	5.49	4.43	.0280	.0140	.0340	.0042	.0012	.0058	.149	.049	.166	.0028	.0013	.0023	.000111	.000060	.000196
205	2	1502-01	4.1	16	4.34	6.51	5.28	.0430	.0130	.0280	.0058	.0012	.0047	.149	.144	.169	.0052	.0025	.0041	.000146	.000103	.000107
206	2	1502-02	4.3	17	5.47	6.25	5.90	.0730	.0540	.0600	.0320	.0078	.0230	.295	.276	.433	.0110	.0037	.0114	.000210	.000150	.000279
207	1	1492-13	4.8	27	6.35	7.47	5.30	.0800	.0450	.1000	.0450	.0170	.0420	.295	.205	.304	.0112	.0047	.0114	.000390	.000186	.000382
208	2	1502-04	4.8	10	2.93	3.94	3.45	.4700	.1900	.4700	.7200	.1600	.8300	1.935	.733	1.804	.0386	.0112	.0411	.001756	.000644	.001715
209	2	1502-03	3.2	12	2.58	2.62	1.25	.0280	.0190	.0570	.0022	.0010	.0045	.112	.081	.235	.0013	.0009	.0031	.000036	.000028	.000073
210	2	1502-05	4.2	10	2.23	2.83	1.65	.1100	.0510	.1900	.0320	.0083	.0660	.516	.377	.164	.0089	.0086	.0091	.000268	.000131	.000466
211	1	1492-14	4.8	29	8.19	7.67	7.57	.0530	.0380	.0650	.0230	.0110	.0320	.356	.255	.213	.0184	.0068	.0101	.001566	.001098	.001212
212	2	1502-06	4.8	19	8.10	7.12	8.03	.0850	.0450	.0850	.0640	.0130	.0640	.356	.291	.472	.0027	.0015	.0030	.001022	.000707	.001823
213	2	1502-07	4.2	20	6.31	6.98	6.25	.0360	.0230	.0380	.0090	.0041	.0098	.143	.114	.176	.0395	.0103	.0223	.000241	.000148	.000284
214	1	1492-15	5.1	21	6.39	9.08	6.80	.2200	.0690	.2100	.3400	.0480	.3400	1.115	.361	.841	.0050	.0043	.0052	.001941	.001189	.002370
215	3	1493-01	5.1	18	9.61	11.70	10.24	.0290	.0150	.0270	.0087	.0030	.0085	.115	.068	.102	.0240	.0163	.0330	.000734	.000790	.000718
216	1	1502-08	5.1	8	7.59	6.88	6.31	.1600	.1200	.2000	.2200	.1100	.2800	.948	.513	.934	.1108	.0357	.0955	.001969	.001352	.002315
217	1	1492-16	5.9	29	7.67	11.09	6.17	.7600	.2500	.8500	4.9000	.7400	4.9000	3.058	1.038	2.569	.0882	.0524	.0906	.027484	.004789	.012797
218	3	1493-02	5.9	17	8.84	10.44	9.26	.5000	.2500	.4100	2.4000	.7400	1.7000	2.479	1.201	2.834	.0140	.0084	.0140	.011052	.010047	.011059
219	1	1495-00	5.9	50	15.73	14.96	16.20	.0690	.0350	.0500	.0820	.0210	.0450	.221	.124	.198	.0156	.0153	.0156	.002986	.001203	.002859
220	2	1498-00	5.9	63	12.82	15.46	14.11	.0690	.0370	.0700	.0670	.0240	.0770	.286	.153	.393	.0153	.0153	.0156	.003015	.004010	.004309
221	2	1502-09	5.9	7	5.46	4.32	5.56	2.5000	2.4000	2.8000	39.0000	27.0000	50.0000	10.302	9.492	10.163	.3271	.1618	.4150	.034226	.011762	.026371
222	1	1492-17	4.5	16	9.58	10.60	9.00	.0380	.0190	.0400	.0150	.0042	.0160	.214	.078	.127	.0072	.0020	.0066	.000336	.000099	.000290
223	1	1492-18	4.0	16	5.44	6.43	5.71	.0230	.0120	.0250	.0033	.0010	.0038	.090	.038	.129	.0022	.0008	.0037	.000093	.000045	.000130
224	3	1493-03	4.3	18	10.14	9.68	10.40	.0340	.0160	.0310	.0130	.0034	.0110	.128	.078	.165	.0043	.0025	.0047	.000254	.000142	.000232
225	1	1492-19	4.5	15	7.52	7.57	9.10	.0450	.0180	.0400	.0160	.0034	.0150	.157	.105	.193	.0051	.0026	.0063	.000276	.000207	.000283
226	1	1492-20	4.7	16	7.57	10.11	8.14	.0690	.0220	.0590	.0400	.0057	.0320	.269	.185	.181	.0090	.0022	.0063	.000543	.000285	.000413
227	3	1493-04	4.7	18	9.95	10.19	9.31	.0350	.0220	.0320	.0140	.0052	.0110	.129	.090	.109	.0047	.0027	.0044	.000305	.000235	.000209
228	1	1492-21	4.1	18	5.16	5.95	5.53	.0320	.0120	.0370	.0060	.0010	.0079	.159	.084	.095	.0033	.0014	.0028	.000108	.000051	.000072
229	1	1492-22	4.3	15	7.32	7.69	6.41	.0230	.0120	.0270	.0042	.0011	.0053	.111	.046	.106	.0038	.0011	.0031	.000239	.000046	.000061
230	3	1518-01	3.1	4	.63	1.30	3.55	.1100	.0160	.0110	.0079	.0004	.0005	.359	.073	.084	.0042	.0008	.0018	.000211	.000062	.000288
231	2	1501-01	3.7	12	1.05	1.87	.80	.2600	.1000	.3300	.0800	.0220	.0990	.842	.374	1.092	.0113	.0037	.0125	.000110	.000047	.000062
232	2	1501-02	3.1	8	2.06	1.77	1.11	.0340	.0240	.0530	.0026	.0012	.0035	.153	.106	.234	.0018	.0011	.0033	.000110	.000052	.000107
233	2	1501-03	3.8	12	4.65	5.98	5.10	.0250	.0140	.0230	.0033	.0013	.0031	.150	.065	.168	.0027	.0007	.0030	.000129	.000119	.000098
234	1	1492-23	4.0	20	6.86	7.73	5.95	.0400	.0190	.0480	.0120	.0031	.0150	.155	.082	.189	.0040	.0016	.0043	.000120	.000141	.000130
235	1	1501-04	4.0	15	7.03	5.82	6.16	.0250	.0350	.0360	.0052	.0066	.0040	.084	.096	.117	.0022	.0021	.0036	.000075	.000084	.000157
236	2	1501-05	3.7	8	1.29	2.76	.91	.0720	.0240	.1400	.0074	.0018	.0200	.248	.184	.476	.0034	.0009	.0075	.000079	.000085	.000079
237	2	1501-06	3.6	5	2.47	2.15	2.38	.0450	.0320	.0430	.0054	.0025	.0049	.250	.122	.198	.0039	.0012	.0039	.000048	.000033	.000076
238	2	1501-07	4.5	8	2.77	2.95	2.06	.2600	.1700	.3100	.2100	.0890	.2100	1.352	.596	1.367	.0286	.0069	.0198	.001587	.000242	.000633
239	2	1501-08	3.6	12	1.28	2.72	1.34	.0470	.0180	.0430	.0032	.0010	.0028	.154	.073	.214	.0019	.0011	.0039	.000053	.000038	.000070
240	2	1501-09	4.2	8	1.81	2.89	1.88	.1200	.0490	.1200	.0320	.0110	.0320	.486	.238	.438	.0067	.0026	.0079	.000157	.000082	.000300
241	1	1523-01	3.4	12	3.14	2.60	3.97	.0250	.0100	.0190	.0022	.0002	.0011	.099	.144	.114	.0024	.0013	.0014	.000072	.000035	.000034
242	1	1501-02	4.0	12	5.61	6.69	5.28	.0320	.0190	.0340	.0062	.0027	.0066	.148	.073	.139	.0046	.0012	.0041	.000247	.000083	.000240
243	1	1523-03	3.8	16	4.88	5.81	5.16	.0400	.0270	.0390	.0110	.0047	.0081	.289	.161	.165	.0036	.0024	.0044	.000128	.000095	.000076
244	1	1523-04	4.0	18	2.20	4.61	2.71	.0670	.0280	.0520	.0110	.0041	.0081	.339	.153	.293	.0059	.0016	.0081	.000137	.000082	.000142
245	1	1519-01	3.9	20	5.51	6.67	5.29	.0220	.0110	.0200	.0029	.0009	.0023	.133	.050	.099	.0026	.0009	.0020	.000096	.000063	.000086
246	1	1523-05	3.5	16	4.51	3.67	4.59	.0200	.0170	.0170	.0020	.0012	.0015	.154	.095	.112	.0021	.0008	.0013	.000052	.000040	.000074
247	3	1518-02	4.2	16	9.54	8.01	8.77	.0210	.0160	.0220	.0048	.0024	.0046	.126	.076	.080	.0027	.0016	.0027	.000231	.000169	.000143
248	1	1523-06	4.2	16	6.28	8.73	6.65	.0500	.0270	.0480	.0180	.0069	.0170	.288	.158	.293	.0066	.0029	.0057	.000116	.000107	.000260
249	1	1523-07	4.3	16	6.23	7.53	6.26	.0200	.0120	.0220	.0029	.0011	.0035	.129	.067	.142	.0027	.0010	.0020	.000129	.000107	.000067
250	1	1523-09	3.8	14	5.92	6.93	4.63	.0440	.0260	.0500	.0120	.0051	.0130	.183	.112	.184	.0035	.0019	.0042	.000142	.000129	.000194

No	Site	record	Mw	R (km)	Duration (H1) sec	Duration (V) sec	Duration (H2) sec	Arms (H1) m/sec2	Arms (V) m/sec2	Arms (H2) m/sec2	Ea (H1) m2/sec3	Ea (V) m2/sec3	Ea (H2) m2/sec3	PGA (H1) m/sec2	PGA (V) m/sec2	PGA (H2) m/sec2	PGV (H1) m/sec	PGV (V) m/sec	PGV (H2) m/sec	PGD (H1) m	PGD (V) m	PGD (H2) m
251	1	1523-10	3.7	15	2.76	7.78	3.30	.0250	.0080	.0190	.0020	.0005	.0013	.190	.043	.113	.0028	.0007	.0019	.000089	.000041	.000062
252	4	1513-00	5.1	60	15.53	18.89	14.53	.0500	.0220	.0610	.0440	.0110	.0590	.181	.083	.279	.0122	.0059	.0164	.003218	.001598	.003368
253	1	1523-11	3.4	12	4.26	3.55	3.02	.0240	.0230	.0350	.0027	.0021	.0042	.129	.180	.224	.0021	.0016	.0032	.000062	.000062	.000110
254	1	1523-12	3.4	12	1.30	3.65	1.21	.0580	.0180	.0580	.0048	.0013	.0045	.307	.114	.260	.0041	.0014	.0031	.000120	.000049	.000086
255	1	1523-13	3.7	12	2.50	9.44	4.51	.0240	.0060	.0110	.0016	.0004	.0006	.183	.049	.088	.0026	.0007	.0011	.000099	.000042	.000059
256	4	1506-01	5.6	22	6.57	9.65	6.74	.3200	.1500	.3000	.7600	.2500	.6900	1.821	.993	1.218	.0703	.0219	.0843	.007724	.001142	.005637
257	1	1525-00	5.6	26	13.10	13.66	14.57	.0330	.0290	.0290	.0160	.0130	.0140	.136	.152	.132	.0112	.0087	.0100	.003831	.002295	.002766
258	1	1526-01	5.6	18	7.50	7.82	8.57	.0630	.0720	.0570	.0330	.0450	.0310	.258	.268	.223	.0126	.0230	.0203	.002066	.006643	.005849
259	1	1526-02	5.2	17	8.07	8.07	8.18	.0140	.0180	.0150	.0018	.0028	.0020	.047	.107	.071	.0025	.0059	.0055	.000403	.001314	.000583
260	1	1527-00	5.6	35	14.78	14.09	13.97	.0640	.0550	.0650	.0680	.0480	.0660	.285	.289	.267	.0193	.0113	.0148	.004226	.002889	.002451
261	4	1506-02	4.5	20	4.43	7.86	4.88	.0700	.0270	.0650	.0240	.0062	.0170	.498	.130	.319	.0168	.0042	.0107	.001184	.000139	.000488
262	4	1506-03	4.3	20	7.80	7.42	4.74	.0220	.0200	.0380	.0043	.0032	.0078	.146	.094	.257	.0038	.0023	.0089	.000372	.000164	.000913
263	4	1506-04	5.1	20	4.03	6.09	4.91	.3100	.1100	.2000	.4300	.0760	.2100	1.788	.470	1.244	.0985	.0219	.0574	.013785	.001269	.005944
264	4	1506-05	4.7	20	5.80	7.28	7.86	.0620	.0330	.0380	.0250	.0090	.0130	.272	.145	.185	.0113	.0061	.0082	.001291	.000337	.000485
265	4	1506-06	3.8	20	4.24	7.20	3.38	.0320	.0140	.0340	.0047	.0016	.0043	.191	.060	.155	.0040	.0018	.0041	.000099	.000059	.000228
266	4	1506-07	4.1	18	6.19	7.46	8.57	.0270	.0170	.0140	.0052	.0023	.0019	.118	.075	.084	.0051	.0021	.0024	.000384	.000109	.000262
267	4	1506-08	4.3	25	5.05	6.31	4.32	.0610	.0390	.0690	.0210	.0110	.0230	.261	.141	.349	.0088	.0048	.0072	.000606	.000170	.000264
268	4	1506-09	4.1	20	2.92	6.20	3.73	.0570	.0220	.0350	.0110	.0032	.0050	.234	.108	.144	.0060	.0017	.0027	.000204	.000067	.000103
269	2	1520-01	3.7	12	2.07	2.55	2.49	.0370	.0230	.0270	.0031	.0015	.0020	.169	.106	.117	.0023	.0012	.0017	.000105	.000042	.000125
270	4	1506-10	4.4	18	4.07	6.92	7.70	.0340	.0180	.0170	.0053	.0025	.0025	.184	.072	.080	.0044	.0021	.0032	.000253	.000028	.000339
271	1	1519-02	3.8	15	6.49	7.36	5.39	.0220	.0110	.0310	.0036	.0010	.0056	.118	.058	.148	.0030	.0011	.0033	.000098	.000070	.000130
272	1	1523-14	4.0	16	6.41	5.26	6.82	.0300	.0290	.0280	.0064	.0048	.0061	.206	.254	.124	.0025	.0023	.0018	.000155	.000069	.000092
273	1	1523-15	4.0	16	3.29	5.90	4.55	.0650	.0290	.0490	.0160	.0057	.0110	.380	.140	.338	.0044	.0022	.0061	.000146	.000070	.000238
274	1	1523-16	3.8	14	4.59	4.03	4.25	.0370	.0360	.0370	.0071	.0058	.0065	.181	.176	.176	.0026	.0021	.0038	.000097	.000041	.000158
275	3	1518-03	4.2	20	6.80	5.02	7.74	.0230	.0250	.0190	.0039	.0035	.0032	.134	.159	.118	.0028	.0023	.0026	.000104	.000107	.000121
276	1	1523-17	3.8	18	7.85	6.74	6.57	.0230	.0200	.0290	.0045	.0029	.0063	.172	.114	.151	.0029	.0015	.0042	.000096	.000076	.000162
277	2	1520-02	4.0	20	4.25	4.59	3.63	.0390	.0260	.0440	.0070	.0034	.0077	.163	.104	.157	.0029	.0016	.0038	.000083	.000046	.000089
278	1	1523-18	3.8	16	4.09	5.80	4.27	.0470	.0250	.0470	.0100	.0039	.0100	.254	.148	.310	.0051	.0015	.0053	.000210	.000057	.000238
279	1	1523-19	3.6	16	4.69	8.82	7.24	.0200	.0077	.0110	.0020	.0006	.0010	.170	.041	.061	.0029	.0007	.0010	.000181	.000098	.000082
280	1	1523-20	3.6	12	1.34	3.21	1.25	.0510	.0180	.0500	.0039	.0011	.0035	.217	.097	.238	.0035	.0010	.0024	.000082	.000069	.000090
281	3	1522-00	5.0	18	7.49	7.49	8.05	.0230	.0120	.0190	.0045	.0012	.0032	.129	.047	.080	.0029	.0011	.0024	.000134	.000120	.000090
282	1	1523-21	3.5	16	3.28	4.59	4.44	.0290	.0140	.0190	.0031	.0010	.0018	.206	.067	.129	.0029	.0007	.0013	.000080	.000071	.000039
283	1	1523-22	3.7	12	1.53	3.08	1.64	.0580	.0250	.0580	.0058	.0022	.0061	.204	.102	.207	.0036	.0014	.0034	.000101	.000050	.000095
284	1	1533-01	4.0	18	6.61	6.23	6.25	.0280	.0210	.0340	.0058	.0031	.0079	.127	.098	.132	.0041	.0016	.0041	.000131	.000086	.000112
285	1	1523-23	3.8	16	1.58	4.76	1.94	.1500	.0470	.1300	.0400	.0120	.0380	.707	.296	.660	.0106	.0039	.0071	.000228	.000112	.000331
286	4	1506-11	5.1	50	10.12	12.93	9.50	.0280	.0150	.0310	.0091	.0032	.0099	.113	.061	.121	.0043	.0028	.0048	.000819	.000379	.000625
287	1	1507-00	5.1	27	6.57	8.90	6.69	.0530	.0410	.0590	.0210	.0170	.0260	.234	.188	.258	.0106	.0064	.0094	.001389	.000672	.001472
288	1	1508-01	5.1	12	8.46	8.91	8.59	.0210	.0130	.0210	.0041	.0018	.0043	.075	.060	.113	.0028	.0020	.0039	.000285	.000150	.000183
289	1	1508-02	4.9	19	9.64	11.66	8.92	.0550	.0370	.0600	.0330	.0180	.0360	.181	.201	.359	.0104	.0129	.0123	.001253	.002008	.003528
290	1	1523-24	3.8	15	1.96	4.05	1.95	.0360	.0170	.0280	.0031	.0012	.0031	.282	.100	.188	.0024	.0010	.0021	.000059	.000037	.000049
291	2	1520-03	3.8	6	3.85	3.64	3.70	.0310	.0250	.0340	.0052	.0027	.0049	.119	.118	.132	.0033	.0019	.0036	.000134	.000051	.000205
292	1	1523-25	3.6	16	5.46	5.17	6.28	.0330	.0210	.0250	.0066	.0027	.0043	.228	.113	.137	.0032	.0009	.0014	.000170	.000046	.000064
293	1	1523-26	3.8	18	7.23	3.56	7.32	.0100	.0250	.0110	.0008	.0026	.0011	.049	.238	.075	.0008	.0024	.0009	.000069	.000064	.000065
294	3	1518-04	4.2	16	7.26	8.86	5.83	.0270	.0140	.0360	.0061	.0020	.0082	.126	.059	.194	.0032	.0017	.0049	.000153	.000111	.000224
295	1	1523-27	4.0	14	7.54	10.14	6.67	.0280	.0170	.0350	.0060	.0032	.0090	.168	.084	.308	.0034	.0013	.0064	.000180	.000090	.000330
296	1	1531-00	3.8	16	1.72	4.07	4.65	.0640	.0250	.0210	.0072	.0028	.0023	.317	.167	.112	.0052	.0017	.0034	.000162	.000056	.000148
297	3	1528-01	4.2	4	4.80	2.59	4.49	.0590	.0740	.0600	.0180	.0160	.0180	.544	.333	.332	.0073	.0034	.0050	.000170	.000076	.000130
298	3	1528-02	4.6	16	6.44	3.21	4.71	.0360	.0490	.0490	.0092	.0085	.0130	.216	.205	.237	.0056	.0040	.0046	.000178	.000114	.000209
299	3	1530-01	5.0	20	5.72	7.00	5.95	.1400	.1000	.1300	.1300	.0810	.1200	.825	.468	.575	.0271	.0085	.0369	.002705	.000790	.003778
300	3	1550-01	4.8	25	4.84	7.32	5.05	.0520	.0170	.0550	.0150	.0025	.0170	.192	.066	.247	.0080	.0028	.0096	.000800	.000353	.000691
301	3	1550-02	4.1	16	4.75	5.95	5.10	.0300	.0140	.0300	.0049	.0012	.0052	.125	.056	.120	.0038	.0015	.0029	.000163	.000105	.000226
302	1	1519-03	5.0	24	5.93	6.57	4.68	.1200	.0560	.1500	.1000	.0230	.1200	.467	.211	.610	.0148	.0048	.0226	.000542	.000257	.000800
303	2	1520-04	5.0	22	7.26	7.66	5.59	.0530	.0340	.0970	.0230	.0096	.0580	.191	.133	.375	.0049	.0026	.0093	.000251	.000180	.000239
304	1	1523-28	5.0	16	2.75	6.80	2.75	.2600	.0700	.2300	.2000	.0370	.1600	1.420	.327	1.013	.0286	.0065	.0306	.001171	.000396	.001408
305	1	1519-04	4.7	20	5.62	6.82	6.45	.1500	.0610	.1200	.1300	.0280	.0970	.647	.238	.536	.0173	.0062	.0196	.001200	.000502	.000919
306	2	1520-05	4.7	19	9.12	9.09	7.43	.0430	.0300	.0540	.0190	.0090	.0230	.144	.130	.276	.0047	.0033	.0071	.000286	.000105	.000465
307	1	1523-29	4.5	22	5.79	8.47	5.44	.0690	.0320	.0760	.0300	.0097	.0350	.366	.143	.372	.0075	.0038	.0121	.000411	.000303	.000676
308	1	1519-05	4.1	18	5.76	6.93	6.57	.0600	.0260	.0540	.0230	.0079	.0210	.243	.122	.215	.0075	.0024	.0069	.000343	.000134	.000415
309	2	1520-06	4.2	16	5.76	7.67	4.78	.0310	.0170	.0490	.0062	.0024	.0130	.144	.087	.237	.0038	.0016	.0053	.000114	.000089	.000190
310	1	1523-30	4.2	8	5.82	8.43	6.45	.0310	.0120	.0290	.0070	.0014	.0052	.116	.051	.116	.0031	.0015	.0025	.000136	.000091	.000130
311	2	1573-00	4.3	16	6.85	10.22	8.81	.0280	.0086	.0270	.0062	.0008	.0059	.134	.041	.073	.0036	.0010	.0024	.000233	.000104	.000182
312	1	1579-00	4.6	105	7.56	8.12	5.71	.0220	.0089	.0310	.0041	.0007	.0062	.072	.037	.113	.0020	.0007	.0033	.000087	.000063	.000123
313	3	1529-02	3.8	12	4.42	3.93	5.12	.0260	.0190	.0290	.0033	.0016	.0041	.104	.079	.159	.0026	.0014	.0041	.000099	.000077	.000102
314	3	1549-04	4.0	12	1.57	2.65	1.30	.1300	.1700	.1400	.0440	.0510	.0540	.637	.487	.584	.0119	.0085	.0129	.000490	.000265	.000230
315	3	1529-03	4.5	18	10.97	10.30	10.64	.0560	.0330	.0590	.0380	.0120	.0410	.239	.150	.239	.0074	.0033	.0085	.000525	.000360	.000634
316	1	1523-31	3.9	16	3.13	5.36	3.43	.0370	.0160	.0360	.0049	.0014	.0049	.269	.089	.248	.0048	.0013	.0046	.000138	.000066	.000141
317	2	1532-00	4.7	32	8.69	8.38	8.16	.0800	.0440	.0840	.0620	.0160	.0630	.327	.181	.304	.0050	.0025	.0051	.000363	.000253	.000317
318	3	1528-03	4.5	19	2.26	1.87	3.81	1.5000	1.2000	1.5000	5.9000	2.9000	7.2000	5.294	4.123	4.941	.1697	.0900	.1426	.012030	.005089	.006029
319	3	1528-22	4.0	16	3.19	3.88	3.00	.0990	.0650	.0920	.0350	.0180	.0280	.521	.279	.422	.0068	.0031	.0049	.000147	.000091	.000143
320	3	1528-23	4.0	8	4.98	3.97	5.11	.0780	.0620	.0830	.0300	.0170	.0360	.609	.269	.522	.0075	.0032	.0062	.000198	.000097	.000182
321	3	1528-24	4.1	12	5.06	3.62	4.53	.0740	.0630	.0820	.0310	.0160	.0340	.398	.267	.395	.0085	.0043	.0074	.000275	.000126	.000227
322	3	1528-26	4.5	16	3.17	4.32	4.86	.3100	.1600	.2600	.3500	.1200	.3600	1.795	.834	1.433	.0266	.0148	.0195	.000957	.000413	.000675
323	3	1528-27	3.5	6	2.28	2.09	3.48	.0400	.0360	.0310	.0041	.0030	.0036	.229	.112	.153	.0034	.0014	.0016	.000061	.000041	.000047
324	3	1528-28	3.9	12	7.23	3.87	5.36	.0280	.0280	.0400	.0063	.0034	.0094	.203	.126	.214	.0035	.0022	.0036	.000146	.000065	.000115
325	3	1528-29	4.2	12	6.90	8.76	6.00	.0610	.0400	.0440	.0280	.0120	.0160	.402	.209	.276	.0083	.0043	.0037	.000378	.000178	.000143
326	3	1528-10	4.6	16	4.29	4.24	3.57	.2900	.1300	.3700	.4100	.0770	.5400	1.652	.617	1.165	.0412	.0154	.0373	.002362	.000628	.001366
327	3	1528-11	3.9	12	2.95	3.21	3.88	.0460	.0340	.0350	.0069	.0038	.0048	.230	.135	.271	.0039	.0016	.0026	.000085	.000066	.000102
328	3	1528-12	4.1	6	5.50	5.55	5.84	.1500	.0910	.1300	.1400	.0520	.1200	.837	.512	.841	.0182	.0080	.0144	.001056	.000254	.000659
329	3	1528-13	3.9	10	1.84	3.20	2.53	.0670	.0330	.0500	.0093	.0041	.0068	.370	.132	.380	.0036	.0017	.0030	.000071	.000057	.000073
330	3	1528-14	3.8	8	10.89	11.99	11.05	.0280	.0200	.0270	.0088	.0050	.0078	.170	.112	.126	.0039	.0017	.0039	.000320	.000095	.000129
331	3	1528-15	3.5	6	1.66	1.88	.95	.0620	.0480	.1200	.0072	.0048	.0150	.395	.275	.605	.0031	.0027	.0049	.000072	.000062	.000072
332	3	1528-16	4.1	14	11.80	8.55	10.75	.0280	.0300	.0430	.0099	.0085	.0220	.173	.141	.263	.0032	.0028	.0041	.000147	.000085	.000101
333	3	1528-17	3.9	14	4.56	3.24	5.46	.0640	.0530	.0510	.0210	.0099	.0160	.544	.214	.385	.0060	.0027	.0030	.000277	.000097	.000158
334	3	1528-18	3.8	12	1.76	2.41	2.88	.0550	.0360	.0420	.0059	.0035	.0056	.370	.134	.289	.0035	.0016	.0021	.000054	.000051	.000058
335	3	1528-19	3.9	8	7.53	5.57	7.07	.0250	.0130	.0310	.0061	.0032	.0077	.123	.119	.162	.0022	.0015	.0029	.000155	.000051	.000114
336	3	1528-20	4.1	20	3.76	3.82	4.43	.0440	.0320	.0460	.0082	.0043	.0110	.219	.112	.222	.0046	.0036	.0034	.000268	.000131	.000136
337	3	1528-21	4.1	12	9.06	6.07	6.80	.0300	.0250	.0460	.0090	.0041	.0160	.130	.105	.245	.0033	.0014	.0041	.000262	.000093	.000194
338	3	1528-04	4.0	8	5.18	4.40	6.23	.0810	.0570	.0700	.0340	.0160	.0340	.420	.256	.385	.0058	.0036	.0057	.000241	.000112	.000221
339	3	1528-05	4.1	6	5.04	4.03	5.80	.0780	.0560	.0790	.0300	.0140	.0400	.398	.264	.399	.0098	.0057	.0079	.000360	.000159	.000330
340	3	1528-06	4.0	8	5.13	3.74	4.59	.0620	.0450	.0810	.0220	.0075	.0340	.357	.210	.346	.0093	.0043	.0106	.000315	.000140	.000356
341	3	1528-07	3.7	8	3.49	2.73	4.77	.0360	.0330	.0380	.0049	.0032	.0061	.239	.190	.211	.0034	.0025	.0029	.000098	.000055	.000100
342	3	1528-08	4.4	12	6.81	3.89	6.09	.0430	.0450	.0540	.0140	.0071	.0170	.229	.246	.229	.0053	.0037	.0042	.000161	.000106	.000157
343	3	1528-09	4.0	14	3.37	3.13	2.78	.0660	.0470	.0870	.0150	.0066	.0160	.435	.259	.469	.0045	.0033	.0047	.000193	.000090	.000195
344	3	1528-30	3.9	12	7.24	3.90	8.68	.0450	.0430	.0350	.0150	.0081	.0078	.230	.365	.277	.0054	.0031	.0030	.000268	.000084	.000099
345	3	1631-01	4.0	16	6.83	4.80	5.67	.0280	.0250	.0400	.0056	.0029	.0081	.120	.171	.146	.0025	.0019	.0035	.000215	.000062	.000310
346	3	1631-02	4.1	16	7.84	3.69	1.39	.0280	.0290	.0460	.0064	.0030	.0063	.184	.112	.304	.0057	.0015	.0073	.000332	.000061	.000304
347	3	1592-00	4.4	12	5.66	4.84	5.05	.0360	.0300	.0320	.0081	.0047	.0058	.148	.112	.100	.0061	.0026	.0057	.000197	.000268	.000569
348	3	1555-00	4.4	10	6.89	6.99	6.13	.0250	.0190	.0330	.0047	.0027	.0075	.163	.094	.232	.0037	.0016	.0049	.000149	.000222	.000248
349	1	1547-01	2.7	15	2.13	4.38	3.05	.1200	.0270	.0200	.0042	.0037	.0025	.552	.128	.147	.0182	.0024	.0052	.000692	.000155	.000309
350	3	1535-01	3.9	10	2.00	2.84	2.13	.0510	.0480	.0550	.0059	.0071	.0077	.255	.164	.274	.0057	.0023	.0074	.000212	.000147	.000414
351	3	1563-00	4.3	13	4.60	6.10	4.81	.0430	.0160	.0500	.0085	.0015	.0120	.196	.062	.157	.0047	.0016	.0046	.000216	.000200	.000401
352	1	1564-01	4.1	16	4.15	5.59	4.74	.0250	.0170	.0190	.0029	.0017	.0020	.139	.093	.128	.0033	.0019	.0021	.000169	.000129	.000079
353	4	1554-00	4.8	23	12.01	11.19	11.84	.0420	.0310	.0430	.0230	.0120	.0290	.184	.140	.203	.0060	.0031	.0086	.000344	.000229	.000512
354	4	1575-01	4.8	20	3.40	5.39	5.99	.0550	.0310	.0540	.0110	.0059	.0170	.242	.145	.207	.0035	.0016	.0034	.000114	.000074	.000190
355	3	1650-01	4.7	12	6.43	7.20	8.03	.0860	.0470	.0650	.0530	.0180	.0370	.302	.191	.294	.0166	.0070	.0104	.001848	.000665	.001492
356	2	1545-01	4.5	40	9.77	9.91	10.71	.0320	.0250	.0340	.0100	.0070	.0150	.209	.123	.147	.0059	.0018	.0053	.000326	.000149	.000321
357	1	1562-01	4.8	30	9.03	10.36	9.86	.0550	.0220	.0430	.0190	.0057	.0170	.292	.116	.145	.0070	.0019	.0045	.000245	.000173	.000189
358	1	1546-02	4.0	12	2.47	3.91	2.79	.0360	.0150	.0310	.0035	.0010	.0030	.144	.071	.159	.0034	.0011	.0028	.000129	.000082	.000094
359	2	1545-02	4.0	12	2.17	2.88	2.94	.0780	.0790	.0690	.0130	.0170	.0160	.261	.317	.273	.0037	.0034	.0036	.000132	.000088	.000169
360	1	1590-01	3.5	16	2.48	2.88	2.18	.0430	.0270	.0420	.0047	.0020	.0037	.160	.185	.160	.0062	.0022	.0034	.000191	.000139	.000247
361	1	1582-02	4.2	16	5.81	5.55	7.01	.0570	.0400	.0430	.0210	.0099	.0140	.275	.185	.160	.0021	.0010	.0026	.000050	.000030	.000051
362	1	1655-00	3.7	14	4.31	5.18	4.88	.0350	.0210	.0350	.0059	.0022	.0061	.156	.088	.136	.0047	.0011	.0102	.000965	.000110	.000170
363	1	1556-00	5.1	95	11.09	12.27	10.17	.0190	.0140	.0220	.0042	.0023	.0050	.105	.047	.104	.0118	.0085	.0122	.001377	.001240	.001757
364	1	1581-00	5.1	51	11.90	12.43	12.84	.0510	.0290	.0420	.0340	.0120	.0250	.250	.181	.126	.0106	.0073	.0108	.001440	.001484	.001841
365	3	1535-02	4.8	8	2.49	2.59	2.80	.2500	.2000	.2200	.1800	.1200	.1500	.986	.850	.933	.0302	.0188	.0355	.000461	.000218	.000322
366	1	1548-00	4.8	16	8.88	11.30	10.89	.0290	.0130	.0180	.0081	.0022	.0041	.148	.047	.064	.0045	.0021	.0031	.000118	.000063	.000081
367	4	1536-02	4.7	28	5.30	7.12	5.01	.1200	.0660	.1200	.0790	.0340	.0760	.432	.360	.307	.0149	.0060	.0118	.000446	.000325	.000553
368	1	1625-01	4.0	47	5.02	6.72	6.22	.0420	.0250	.0320	.0099	.0045	.0070	.227	.103	.149	.0048	.0019	.0040	.000298	.000132	.000272
369	3	1529-01	4.0	18	4.92	6.84	5.24	.0250	.0120	.0290	.0035	.0011	.0048	.091	.036	.124	.0035	.0008	.0025	.000089	.000048	.000113
370	1	1621-00	4.5	14	6.38	5.64	7.36	.0480	.0330	.0370	.0160	.0070	.0110	.180	.158	.134	.0055	.0032	.0050	.000455	.000308	.000512
371	3	1535-03	4.2	16	2.59	3.55	2.92	.0420	.0300	.0330	.0051	.0031	.0035	.104	.089	.111	.0049	.0030	.0034	.000249	.000100	.000118
372	1	1551-01	4.0	24	6.35	3.90	6.42	.0340	.0480	.0280	.0081	.0100	.0055	.247	.314	.138	.0062	.0039	.0044	.000206	.000164	.000169
373	1	1551-02	4.2	22	5.89	3.36	4.17	.0560	.1100	.0610	.0210	.0450	.0160	.386	.897	.399	.0075	.0113	.0096	.000299	.000339	.000412
374	2	1546-00	4.4	20	5.01	7.55	5.79	.0330	.0160	.0320	.0066	.0020	.0064	.168	.067	.104	.0041	.0014	.0033	.000212	.000159	.000262
375	1	1551-03	4.2	24	2.61	4.03	4.08	.0210	.0150	.0150	.0013	.0010	.0010	.133	.062	.104	.0024	.0010	.0018	.000062	.000074	.000071

No	Site	record	Mw	R (km)	Duration (H1) sec	Duration (V) sec	Duration (H2) sec	Arms (H1) m/sec2	Arms (V) m/sec2	Arms (H2) m/sec2	Ea (H1) m2/sec3	Ea (V) m2/sec3	Ea (H2) m2/sec3	PGA (H1) m/sec2	PGA (V) m/sec2	PGA (H2) m/sec2	PGV (H1) m/sec	PGV (V) m/sec	PGV (H2) m/sec	PGD (H1) m	PGD (V) m	PGD (H2) m
376	2	1594-00	4.2	20	6.20	6.88	4.61	.0320	.0190	.0380	.0073	.0027	.0075	.160	.141	.233	.0038	.0017	.0061	.000530	.000185	.000306
377	3	1543-00	4.8	82	8.46	9.85	10.29	.0330	.0160	.0320	.0100	.0029	.0120	.120	.068	.162	.0034	.0011	.0042	.000160	.000123	.000256
378	1	1590-02	4.6	70	.92	2.35	2.02	.0970	.0560	.0570	.0096	.0081	.0073	.215	.246	.251	.0028	.0028	.0036	.000062	.000044	.000063
379	3	1633-01	4.8	80	8.47	10.11	10.34	.0330	.0160	.0320	.0100	.0029	.0120	.120	.067	.161	.0038	.0029	.0046	.000547	.000736	.000470
380	1	1533-02	5.0	20	5.99	8.59	7.34	.0440	.0220	.0390	.0130	.0046	.0120	.209	.105	.163	.0105	.0046	.0062	.000980	.000715	.000551
381	4	1552-00	4.1	18	3.40	6.09	5.15	.0450	.0210	.0300	.0077	.0031	.0051	.308	.133	.181	.0054	.0024	.0049	.000259	.000063	.000225
382	4	1635-01	4.1	18	3.41	6.09	5.16	.0450	.0210	.0300	.0077	.0031	.0051	.306	.133	.181	.0055	.0025	.0050	.000224	.000046	.000246
383	3	1620-01	4.0	20	1.91	3.88	1.36	.2600	.1000	.2100	.1400	.0460	.0680	1.125	.468	.680	.0252	.0079	.0147	.000669	.000138	.000468
384	3	1576-00	3.5	12	4.56	3.56	3.46	.0250	.0350	.0390	.0033	.0048	.0058	.150	.158	.228	.0019	.0018	.0035	.000069	.000091	.000099
385	3	1626-00	5.1	14	4.34	5.19	4.38	.1100	.0730	.0900	.0570	.0310	.0390	.650	.392	.408	.0173	.0062	.0093	.000881	.001230	.000569
386	3	1542-00	3.6	12	.82	1.50	1.50	.0420	.0240	.0280	.0016	.0009	.0013	.207	.077	.091	.0022	.0011	.0017	.000064	.000053	.000064
387	4	1635-02	4.0	20	5.34	4.76	5.91	.0230	.0290	.0180	.0033	.0044	.0021	.171	.181	.078	.0041	.0029	.0032	.000218	.000062	.000123
388	2	1557-00	3.8	20	5.34	6.05	6.36	.0210	.0130	.0150	.0027	.0011	.0015	.133	.043	.061	.0026	.0005	.0019	.000094	.000069	.000103
389	3	1620-02	4.1	20	1.88	4.04	1.35	.1400	.0580	.1300	.0440	.0150	.0230	.643	.230	.385	.0104	.0023	.0050	.000285	.000071	.000151
390	3	1620-03	3.7	18	3.11	6.52	5.78	.0330	.0140	.0140	.0037	.0014	.0012	.155	.067	.069	.0040	.0007	.0015	.000107	.000063	.000066
391	3	1620-04	3.9	18	2.12	5.68	4.70	.0940	.0240	.0290	.0210	.0037	.0044	.331	.135	.148	.0072	.0017	.0041	.000175	.000070	.000128
392	3	1631-02	3.7	16	6.05	8.30	2.99	.0100	.0077	.0230	.0007	.0005	.0017	.074	.035	.129	.0010	.0007	.0031	.000092	.000022	.000172
393	4	1569-00	4.4	20	4.06	9.52	5.88	.0220	.0069	.0140	.0022	.0005	.0013	.126	.049	.069	.0025	.0014	.0018	.000282	.000170	.000173
394	3	1549-01	3.7	12	1.95	.89	1.44	.0550	.1000	.1300	.0066	.0099	.0280	.170	.261	.478	.0035	.0040	.0096	.000140	.000150	.000296
395	3	1549-02	3.5	12	2.44	2.16	1.64	.0270	.0340	.0370	.0020	.0028	.0025	.136	.164	.164	.0017	.0023	.0032	.000050	.000054	.000075
396	2	1647-01	3.7	12	2.66	2.81	2.63	.1200	.0790	.1200	.0400	.0200	.0390	.463	.270	.398	.0085	.0036	.0093	.000314	.000531	.000487
397	3	1540-00	4.9	16	11.73	12.96	11.52	.0310	.0096	.0330	.0120	.0013	.0140	.122	.031	.102	.0065	.0018	.0078	.001116	.000367	.001055
398	3	1637-01	5.2	16	11.73	12.94	11.51	.0310	.0097	.0330	.0120	.0013	.0140	.123	.031	.103	.0066	.0019	.0079	.001165	.000400	.001141
399	1	1537-00	5.2	25	12.47	13.01	12.53	.0470	.0210	.0170	.0300	.0065	.0041	.208	.125	.109	.0077	.0045	.0039	.001175	.000989	.000529
400	3	1541-00	5.2	20	9.69	12.47	9.18	.0330	.0150	.0490	.0120	.0030	.0250	.170	.063	.236	.0079	.0032	.0205	.001287	.000674	.002960
401	1	1615-01	5.2	42	10.34	11.02	8.90	.0230	.0180	.0290	.0063	.0039	.0084	.086	.086	.212	.0051	.0034	.0066	.000621	.000801	.000753
402	3	1632-01	5.2	52	10.27	11.94	10.36	.0210	.0096	.0210	.0051	.0012	.0051	.101	.040	.086	.0076	.0042	.0061	.001379	.001151	.000657
403	1	1564-02	4.9	8	1.48	2.58	1.23	.1000	.0650	.1500	.0180	.0120	.0290	.525	.244	.563	.0102	.0028	.0087	.000278	.000116	.000173
404	3	1620-05	3.4	20	1.74	4.63	3.96	.0330	.0110	.0120	.0021	.0006	.0006	.149	.050	.073	.0023	.0004	.0010	.000048	.000044	.000038
405	1	1590-03	3.6	15	3.24	3.73	3.42	.0450	.0340	.0370	.0072	.0047	.0052	.186	.159	.191	.0025	.0019	.0026	.000084	.000108	.000071
406	1	1538-00	3.6	16	4.65	8.27	2.17	.0320	.0200	.0720	.0053	.0035	.0120	.268	.151	.360	.0029	.0015	.0047	.000099	.000081	.000147
407	1	1586-00	5.1	21	7.99	8.65	9.28	.0350	.0190	.0250	.0110	.0035	.0063	.166	.082	.113	.0048	.0052	.0032	.000397	.001299	.000869
408	1	1625-02	5.1	49	6.59	8.14	6.51	.0460	.0320	.0530	.0150	.0095	.0200	.179	.177	.285	.0051	.0057	.0095	.000526	.001078	.000864
409	4	1539-00	5.6	70	8.65	10.86	9.78	.0490	.0370	.0400	.0230	.0160	.0180	.191	.168	.147	.0071	.0044	.0071	.000527	.000188	.000588
410	1	1559-00	4.2	15	4.21	6.48	3.83	.0560	.0260	.0500	.0150	.0050	.0100	.391	.193	.393	.0054	.0029	.0046	.000319	.000229	.000201
411	4	1544-00	4.4	16	3.50	5.16	4.07	.0880	.0430	.0630	.0300	.0110	.0180	.434	.198	.228	.0118	.0040	.0061	.000548	.000137	.000593
412	3	1560-01	4.5	19	2.79	3.69	4.51	.3100	.3000	.2400	.3000	.3600	.2900	1.167	1.518	.992	.0354	.0225	.0259	.001918	.001304	.001570
413	3	1572-00	4.5	45	8.78	6.09	5.89	.0320	.0180	.0610	.0100	.0023	.0250	.146	.071	.190	.0037	.0018	.0067	.000263	.000175	.000309
414	3	1560-02	4.0	20	3.44	4.71	3.20	.0400	.0310	.0440	.0060	.0050	.0069	.171	.134	.165	.0057	.0031	.0040	.000168	.000088	.000127
415	3	1560-03	3.8	18	2.84	3.71	3.63	.0430	.0330	.0320	.0059	.0044	.0041	.195	.183	.143	.0054	.0032	.0028	.000171	.000077	.000089
416	3	1560-04	5.0	18	6.72	4.23	4.84	.1400	.2000	.2200	.1500	.2000	.2600	.789	.816	1.058	.0249	.0145	.0258	.001655	.000663	.001243
417	3	1560-05	3.8	8	3.95	3.92	4.09	.0370	.0350	.0390	.0062	.0053	.0070	.197	.143	.171	.0051	.0024	.0029	.000175	.000104	.000087
418	1	1590-04	3.5	14	2.74	2.64	2.80	.0450	.0630	.0490	.0062	.0120	.0074	.241	.293	.267	.0039	.0033	.0023	.000078	.000077	.000123
419	3	1549-03	3.9	12	1.66	2.79	2.34	.0770	.0320	.0590	.0110	.0033	.0091	.300	.124	.244	.0077	.0026	.0067	.000338	.000106	.000218
420	4	1566-00	4.7	35	9.44	8.62	8.26	.0240	.0230	.0260	.0059	.0050	.0060	.121	.086	.105	.0029	.0027	.0037	.000257	.000112	.000248
421	2	1602-01	4.7	33	8.79	9.89	8.53	.0460	.0180	.0390	.0210	.0036	.0140	.281	.091	.177	.0060	.0014	.0046	.000199	.000060	.000165
422	2	1602-02	4.8	24	8.45	9.47	9.11	.1100	.0350	.0800	.1100	.0130	.0650	.385	.139	.328	.0121	.0038	.0080	.000684	.000166	.000447
423	2	1602-03	4.0	32	5.59	10.97	6.95	.0350	.0078	.0280	.0075	.0007	.0061	.125	.031	.112	.0034	.0007	.0033	.000123	.000070	.000132
424	4	1571-01	4.1	16	4.32	5.62	7.18	.0700	.0530	.0400	.0240	.0180	.0130	.402	.325	.296	.0149	.0037	.0058	.000801	.000201	.000260
425	4	1571-02	3.5	16	2.25	4.45	3.95	.0410	.0280	.0230	.0043	.0038	.0023	.236	.123	.087	.0043	.0017	.0014	.000140	.000052	.000065
426	4	1571-03	3.7	16	8.97	4.18	3.90	.0130	.0420	.0420	.0017	.0082	.0078	.086	.175	.314	.0016	.0021	.0046	.000060	.000060	.000198
427	4	1571-08	4.5	18	2.76	5.71	3.83	.2100	.0830	.1400	.1300	.0440	.0790	1.181	.365	.641	.0274	.0052	.0156	.001395	.000141	.000637
428	4	1571-11	4.4	18	6.84	7.84	8.04	.0200	.0150	.0170	.0031	.0019	.0026	.128	.065	.121	.0031	.0012	.0031	.000091	.000022	.000130
429	4	1571-16	4.7	16	7.48	10.72	8.65	.0250	.0180	.0240	.0051	.0040	.0057	.184	.109	.213	.0047	.0018	.0051	.000115	.000047	.000250
430	1	1583-03	4.4	21	13.22	17.01	14.99	.0750	.0280	.0550	.0820	.0150	.0500	.726	.215	.442	.0194	.0050	.0156	.001174	.000223	.000623
431	1	1583-04	4.7	21	5.07	8.75	5.28	.0470	.0180	.0390	.0130	.0032	.0087	.331	.092	.176	.0120	.0020	.0046	.000542	.000112	.000198
432	4	1571-10	4.6	24	19.32	16.75	16.48	.0720	.0770	.1000	.1100	.1100	.1900	.534	.418	.837	.0154	.0070	.0303	.000676	.000294	.001397
433	4	1571-12	3.7	20	5.44	6.69	5.50	.0160	.0160	.0170	.0016	.0019	.0019	.103	.104	.117	.0026	.0015	.0030	.000057	.000061	.000084
434	4	1571-13	3.7	18	7.39	7.95	3.99	.0150	.0140	.0290	.0020	.0019	.0037	.123	.092	.193	.0025	.0013	.0050	.000067	.000079	.000268
435	4	1571-14	3.7	16	7.93	7.55	4.62	.0160	.0140	.0270	.0021	.0016	.0038	.117	.077	.214	.0031	.0015	.0052	.000118	.000068	.000208
436	4	1571-15	3.6	15	5.39	6.06	4.96	.0190	.0190	.0230	.0021	.0025	.0029	.167	.091	.159	.0027	.0016	.0036	.000103	.000088	.000206
437	4	1571-17	3.5	17	7.05	5.38	4.14	.0110	.0190	.0210	.0010	.0021	.0020	.105	.105	.146	.0013	.0012	.0025	.000051	.000050	.000109
438	4	1571-18	3.5	18	12.73	9.53	5.59	.0047	.0076	.0150	.0003	.0006	.0013	.032	.047	.116	.0008	.0006	.0025	.000052	.000053	.000091
439	4	1571-19	3.8	16	5.53	6.25	5.85	.0340	.0250	.0280	.0073	.0043	.0052	.253	.101	.167	.0061	.0017	.0047	.000188	.000039	.000276
440	4	1571-20	3.8	16	8.15	8.21	8.20	.0170	.0160	.0170	.0027	.0023	.0025	.102	.061	.133	.0027	.0012	.0032	.000140	.000072	.000176
441	4	1571-21	3.7	16	11.76	10.16	10.05	.0130	.0130	.0170	.0023	.0020	.0032	.116	.078	.172	.0026	.0011	.0047	.000106	.000087	.000280
442	4	1571-22	4.0	16	10.89	7.41	5.34	.0200	.0330	.0680	.0050	.0089	.0270	.080	.152	.499	.0019	.0022	.0168	.000080	.000138	.000662
443	4	1571-23	3.6	16	10.24	6.41	8.20	.0110	.0190	.0150	.0013	.0025	.0020	.109	.151	.163	.0019	.0019	.0024	.000077	.000084	.000109
444	4	1571-24	4.0	20	7.34	8.51	7.81	.0140	.0089	.0130	.0017	.0008	.0015	.109	.035	.083	.0029	.0006	.0025	.000193	.000063	.000149
445	4	1571-25	3.9	20	5.85	6.45	5.28	.0280	.0280	.0370	.0051	.0056	.0082	.199	.145	.260	.0042	.0020	.0058	.000225	.000083	.000246
446	4	1571-04	3.9	17	8.52	5.36	4.32	.0150	.0320	.0430	.0021	.0059	.0089	.082	.164	.342	.0020	.0018	.0064	.000077	.000031	.000274
447	4	1571-05	3.8	16	8.44	6.00	3.71	.0170	.0280	.0530	.0028	.0053	.0120	.121	.134	.380	.0029	.0018	.0083	.000140	.000036	.000350
448	4	1571-06	3.7	16	8.46	5.12	3.98	.0150	.0290	.0410	.0021	.0048	.0075	.100	.166	.246	.0026	.0022	.0063	.000104	.000045	.000263
449	4	1571-07	4.2	17	8.99	5.66	5.58	.0390	.0730	.0970	.0150	.0340	.0580	.199	.267	.632	.0044	.0040	.0129	.000191	.000094	.000681
450	4	1571-09	3.7	17	7.15	5.48	2.94	.0100	.0150	.0280	.0008	.0013	.0026	.083	.064	.179	.0017	.0010	.0037	.000065	.000023	.000143
451	1	1583-05	4.2	22	3.75	7.16	3.99	.0350	.0120	.0280	.0050	.0011	.0035	.227	.046	.215	.0073	.0018	.0056	.000207	.000111	.000146
452	1	1583-06	4.1	25	5.11	5.60	3.93	.0220	.0150	.0320	.0027	.0015	.0045	.152	.092	.172	.0034	.0021	.0046	.000190	.000076	.000261
453	4	1571-30	4.5	20	6.46	6.46	5.55	.0380	.0410	.0460	.0100	.0120	.0130	.216	.144	.235	.0046	.0026	.0057	.000218	.000067	.000229
454	1	1583-07	4.5	21	3.76	6.65	4.90	.0360	.0140	.0240	.0055	.0015	.0031	.220	.061	.172	.0081	.0015	.0053	.000422	.000062	.000188
455	4	1571-26	4.0	20	7.16	4.73	2.45	.0340	.0660	.1500	.0093	.0230	.0650	.236	.270	.811	.0045	.0036	.0161	.000093	.000091	.000755
456	4	1571-27	3.7	20	6.36	5.57	6.13	.0160	.0210	.0160	.0018	.0028	.0017	.089	.096	.121	.0025	.0013	.0021	.000085	.000067	.000089
457	4	1571-28	3.9	20	6.15	4.51	5.34	.0250	.0390	.0350	.0044	.0076	.0072	.213	.187	.277	.0034	.0026	.0053	.000150	.000065	.000239
458	4	1571-29	4.0	20	6.47	6.46	5.55	.0380	.0410	.0460	.0100	.0120	.0130	.214	.144	.237	.0048	.0027	.0058	.000301	.000093	.000372
459	4	1571-31	3.6	20	7.04	6.44	4.78	.0092	.0160	.0210	.0007	.0018	.0023	.043	.093	.135	.0011	.0010	.0030	.000053	.000079	.000106
460	4	1571-32	3.9	21	6.23	4.86	4.32	.0360	.0570	.0650	.0090	.0170	.0200	.245	.242	.437	.0049	.0038	.0105	.000278	.000076	.000463
461	4	1571-34	4.6	20	7.49	6.51	4.82	.0100	.0130	.0170	.0008	.0012	.0015	.055	.059	.123	.0012	.0011	.0027	.000260	.000321	.000149
462	4	1571-35	4.4	22	7.24	6.80	6.73	.0450	.0380	.0440	.0170	.0110	.0150	.281	.167	.354	.0086	.0032	.0093	.000457	.000089	.000653
463	1	1589-01	4.6	22	9.35	12.58	9.97	.0710	.0300	.0590	.0530	.0130	.0380	.463	.166	.485	.0146	.0037	.0187	.001473	.000172	.001124
464	1	1589-02	4.4	22	4.09	7.88	4.59	.0260	.0110	.0260	.0030	.0010	.0035	.153	.050	.152	.0041	.0010	.0048	.000308	.000056	.000217
465	3	1599-01	4.4	26	8.76	9.12	9.84	.0490	.0280	.0340	.0240	.0080	.0120	.234	.140	.111	.0088	.0031	.0034	.000465	.000206	.000300
466	4	1571-33	3.7	20	13.14	10.59	10.01	.1100	.1300	.2000	.1900	.2100	.4600	.951	.787	1.771	.0355	.0138	.0611	.001547	.000432	.004287
467	4	1571-36	3.6	15	12.80	5.17	4.15	.0046	.0130	.0190	.0003	.0009	.0016	.045	.061	.140	.0007	.0007	.0025	.000051	.000055	.000118
468	4	1701-01	6.3	32	32.12	35.18	35.33	.1900	.1200	.1900	1.3000	.5200	1.4000	1.639	.599	1.201	.1129	.0541	.1088	.024683	.016409	.038285

Chapitre 7

Conclusion Générale

7.1 Introdution

Ce mémoire a été consacré aux investigations sur les mouvements forts en Iran. Le premier catalogue des mouvements forts a été établi au cours de ce travail, et plusieur études "de base" sur ces données ont été effectuées. Le catalogue des données iraniennes des mouvement forts fournit une base de données très riche de cette région du monde qui possède une forte sismicité. Le réseau accélérométrique iranien, installé depuis 24 ans, fournit des informations sur les propriétés des séismes forts en Iran. Le réseau est toujours en cours de développement, surtout depuis le séisme de Manjil du 20 juin 1990. L'installation de stations sur différents types de sols a fourni la possibilité d'étudier les effets de site. Une classification des sites pour montrer leur réponse aux mouvements forts a été présentée. Dans ces études, l'énergie des mouvement forts et la durée ont été examinées. Les lois d'atténuations pour les mouvement forts ont été présentées pour les valeurs maximales et pour les valeurs spectrales.

Nous résumerons tout d'abord les principales conclusions de chaque thème, puis des suggestions générales pour continuer les études de "sismologie de l'ingénieur" en Iran seront exposées.

7.2 Catalogue des mouvements forts en Iran

Un catalogue des mouvements forts en Iran a été donc fourni. Ce catalogue donne les informations correspondant aux sources et aux sites des enregistrements accélérométriques. Les valeurs maximales de l'accélération, de la vitesse et du déplacement pour chaque enregistrement ont été présentées en compagnie des paramètres de la source pour l'événement correspondant à chaque enregistrement. Les données pour lesquelles on pouvait retrouver la source sismique par les bulletins télésismiques (279 enregistrements en trois composantes) sont composés de 169 enregistrements analogues (SMA-1) et 108 enregistrements digitaux (SSA-2). La plupart des données iranienne viennent de la région de Zagros, par contre il y a très peu d'enregistrements dans les régions comme Makran, Koppeh-Dagh et l'est de l'Iran (car ces régions sont très peu peuplées). La plupart de ces données correspondent à des séismes de magnitude 4 à 6, et à des distances comprises entre 0 et 80 kilomètres. Il existe également des enregistrements de séismes majeurs (comme le séisme de Tabas du 1978, et de Manjil du 1990) avec les magnitudes de plus de 7, qui ajoutent les données pour des distances de plus de 150km au catalogue présent. L'achèvement de ce catalogue s'est effectué en prenant en compte les 189 données digitales (en trois composantes) pour lesquels aucune information télésismique ne pouvait être trouvé.

7.3 Moment sismique et la chute de contrainte

Les moments sismiques ont été calculés pour toutes les données, y compris les données pour lesquelles les rapports télésismiques n'existent pas. Le niveau de l'amplitude maximale sur les spectres de Fourier de l'accélération (A_0) et les fréquences coin (f_c) ont été calculés. Les distances hypocentrales pour tous les enregistrements ont été estimés à partir des différences des arrivées des ondes P et S. Une échelle homogène de magnitude (M_w) a été choisie basée sur les résultats acquis pour les moments sismiques. Les magnitudes de moment (M_w) supérieures à 6.0 sont en accord avec les magnitudes d'ondes de surface (Ms), et les M_w inférieures à 6.0 sont proches des magnitudes d'ondes de volume (mb). En utilisant ce critère, les magnitudes de moment ont été estimées à partir de leur Ms ou mb (si leur magnitude était inférieure ou supérieure au 6.0), même pour les données pour lesquelles le calcul de M_w n'étaient pas possible. Cette homogénéisation était nécessaire pour les régressions qui sont effectuées pour la suite. Les chutes de contraintes ont été également étudiées, pour la première fois en Iran, en appliquant les résultats des mesures des fréquences coin et des amplitudes de spectres des Fourier des données. Les valeurs des chutes de contrainte pour les séismes iraniens, tombent bien dans le domaine des chutes de contrainte déjà présentées pour les séismes intra-plaque.

7.4 Études des effets de site

Les effets de sites dans les données iraniennes ont été étudiés en utilisant les résultats des investigations géotechniques. Des tests de profil de vitesse des onde S et P, de musures de bruit du fond et des profils géoélectriques ont été effectués en 26 sites, choisis en fonction de nombre d'enregistrements. Les tests de bruit du fond ont été réalisés également dans 24 autres sites. Les rapports H/V ont également été calculés pour tous les enregistrements (même pour ceux qui viennent des stations pour lesquelles les investigations géotechniques- géophysiques ont été faites). Les bandes de fréquences de l'amplification ont été utilisées pour distinguer les réponses variées des différents sols aux mouvement forts. Cette classification en 4 classes a été comparée aux résultats des profils des ondes S et P pour les 30 premiers mètres de profondeur (qui est en général la base des classifications des effets de sites dans les codes américains). Il y a un accord, dans 70% des cas, entre ces deux résultats: la classe 1 est le site le plus dur, avec les amplification du rapports H/V (R H/V) de moins de 3, ou plus de 3 dans les fréquences de plus de 15 Hz avec les Vs dans premier 30m de plus de 700m/s, la classe 2 concerne aux site avec les amplifications du R H/V plus de 3 pour les fréquences compris entre 5 au 15Hz avec les Vs pour le premier 30m entre 500m/sec et 700 m/sec, la classe 3 est composée des sites avec des amplification du R H/V plus de 3 pour les fréquences entre 2 et 5 Hz avec les Vs dans premier 30m entre 300m/sec et 500 m/sec, et la classe 4 est consisté des sites avec les amplification plus du R H/V de plus de 3 dans les fréquence de moins de 2Hz avec les Vs 1ér 30m de moins de 300m/sec (le site le plus mou). Cette classification a été la première dans les catégorisation des effets de sites du point de vue de leur réponse aux mouvements forts, dans laquelle les rapports H/V sont utilisées.

Les rapports H/V pour le bruit de fond (effectués pour 50 sites) ne sont que rarement en accord avec les rapports H/V des enregistrements de mouvement forts pour les mêmes sites. Cela peut être dû à la situation météorologique et topographique du plateau iranien. Les seuls exemples pour lesquels les rapports H/V des bruits du fonds montrent les amplifications dans les même bandes de fréquence que les rapports H/V de mouvements forts, sont les sites de classe 4, qui sont soit en bord de mer (comme les site de Lahijan et Rudsar), soit sur les sols mous d'épaisseur importante (Bajestan et Shiraz).

Les non-linéarités éventuellement ont été analysés en calculant de différences entre les observations sur les sites 3 et 4. Les valeurs observées pour les basses fréquence sont significatives pour ces effets, qui doivent être l'objet des prochaines études en Iran. On propose donc l'observation précise des mouvement forts dans les régions très sismiques (comme Zagros) sur les sols de types 3 et 4 (les sols mous) en utilisants les réseaux locaux. Les limites qui viennent des données doivent être respectés pour l'utilisation de ces lois: il faut appliquer les lois de cette thèse, pour une estimation optimum, dans les magnitude de 3 à 7 dans Zagros et 3 à 7.4 dans le reste de pays, et les distance de 10 à 50km dans Zagros et 20 a 200 pour le reste de pays. Les études détérministes spécifiques pour le champs proche (distance inférieure à 10km) doivent être utilisées.

7.5 Énergie et durée des mouvements forts en Iran

La durée est un paramètre d'énergie (l'énergie de l'accélération) proporsionnel à l'intensité d'Arias, et l'accélération moyenne quadratique (a_{rms}) ont été étudiées. Les durées sont différentes en Zagros et dans le reste du reste du pays. Ce problème vient probablement de la sismicité eblement des autre facteurs. κ a été étudié séparément pour les données iraniennes, et les résultats ont été plus ou moins différents pour la région de Zagros et pour le reste du pays, mais cette différence n'est pas très claire. Les atténuation de Arms et d'énergie de l'accélération (e_a) ont été également présentés dans ce chapitre. Les régressions sur les valeurs de la durée

donnent un écart-type moins fort quand on utilise les données obtenues pour des distances hypocentrales inférieur à 50km (où la plupart des données ont été enregistrées).

Les conditions des sites se sont avérés sans influence significative sur la durée.

Les estimations des modèles empiriques d'atténuation de A_{rms} et e_a pour les ondes de volumes et les ondes de surface sont différents surtout dans les premiers 20 km, où justement les valeurs prédites avec le coefficient des ondes de volume sont plus élevés.

7.6 Atténuation des mouvements forts en Iran

Les lois d'atténuation en Iran ont été présentées non seulement pour les valeurs maximales de l'accélération, de la vitesse et du déplacement, mais aussi pour les valeurs spectrales des l'accélération. Ces lois sont fournies séparément pour les régions de Alborz-Iran Central, Zagros, et pour l'ensemble des données iraniennes. Les régressions ont été faites en utilisant les paramètres explicatives comme la distance hypocentrale, la magnitude M_w et les coefficients de sites (pour l'ensemble des 4 classes présentées).

A partir des observations sur les sites 3 et 4, les valeurs observées pour les basses fréquence sont significatifs pour les effets inattendus. Ces effets doivent être étudiés dans les prochaines investigations en Iran. Une étude sur les basses fréquences basée sur les observations des mouvements forts dans les régions très sismique (comme Zagros) sur les sol de types 3 et 4 (les sols mous) en utilisants les réseaux locaux serait intéressante à mener.

Les limites qui viennent des données doivent être respectées pour l'utilisation de ces lois: il conviendra de n'appliquer les lois de cette thèse, que pour les distances comprises entre 10 et 50km dans le Zagrso (et magnitude comprise entre 4 et 6.5), et des distances comprises entre 20 rt 200km dans l'Iran-Cenral (magnitude comprise entre 4 et 7.4). Les études détérministes spécifiques sont recommandés pour le champ-proche.

7.7 Propositions pour la continuation de ces recherches

Les études sur les mouvements forts en Iran peuvent être développées dans plusieurs directions différentes. Mais au préalable, il est nécessaire de consolider et d'étendre le réseau accélérométrique en Iran, de façon à fournir une base des données plus riche. Les propositions pour la continuations des études en « Sismologie de l'ingénieur » en Iran sont classifiées comme suit:

1 . Le réseau sismographique du pays doit absolument être développé de façon à ce que les épicentres des événements sismiques en Iran soient localisés précisément. Ce problème est très important pour poursuivre les études des atténuations et de l'aléa sismique en Iran, parce que tant que les localisations ne sont pas précises, la détermination et la définition des distances pour les lois d'atténuation ne pourront pas être améliorées.

2. Des réseaux accéléromètriques locaux peuvent être installés dans les régions très actives (comme le Zagros) pour étudier les effets de sites ou de source avec les méthodes différentes. Dans ces réseaux locaux, les comparaisons des résultats des méthodes numériques et expérimentales seront possibles. Les régions côtières de la mer Caspienne et du golfe Persique sont les plaines où l'on trouve des sols mous avec une nappe phréatique assez superficielle: nous les proposons donc en priorité pour ces réseaux locaux. Ils peuvent aussi faire l'objet d'installations spécifiques dans les plaines de Gilan et de Mazandaran au nord, et Khuzestan au sud, et les plaines du sud de Téhéran, de l'est de Shiraz, au nord et à l'ouest de Bandarabbas, au sud de Tabriz, ... etc.).

3. L'installation d'un récepteur horaire sur toutes les stations pour les obtenir en temps absolu peut fournir les données nécessaires pour l'analyse de la rupture. En utilisant ce paramètre spectral, l'estimation préliminaire des zones macrosismiques sera possible avec un réseau dense.

4 . Le filtrage des enregistrements accéléromètriques en Iran doit se faire avec les estimations des spectres de signaux et du bruit. Les données disponibles, auparavant en Iran, quoique nombreuses, ont pu conduire à des mauvaises interprétations, voire à des erreurs en raison de l'inadéquation des traitements réalisés.

5. La distribution des données iraniennes sur le réseau « Internet » peut fournir l'occasion d'échange des données avec les scientifiques internationaux. Aujourd'hui, la communication entres les chercheurs des pays différents, qui ont des approches variées, est essentielle.

6. Les meilleurs données peuvent être utiliseés pour des estimations plus précises de l'énergie, de la durée, du moment sismique, du facteur de qualité (Q) et du facteur d'absorption (κ). Ces types des calculs peuvent aider à un meilleure compréhension des effets de source, de propagation et de site. Ces études peuvent aussi conduire à la possibilité d'un zonage en Iran de point de vue de l'atténuation des mouvement forts.

7. Le spectre d'aléa sismique uniforme devraient être étudié en Iran sur la base d'une étude précise de la sismicité de l'Iran.

8. La sélection de nouveaux sites des stations accéléromètriques en Iran doit être effectuée en considérant la situation géologique et sismologique des différentes régions de pays. En particulier des paires de stations proches (une sur l'alluvions et l'autre sur le rocher) peuvent fournir les

données pour les études expérimentales des effets de site.

9. Les études sur le champ-proche sont essentielles pour l'Iran. A cause de l'approvisionnement en eau, presque partout en Iran, les villes et les villages sont édifiée au pied des montagnes ou collines, où la nappe phréatique est très superficielle. Ces endroits correspondent en fait à la plupart des failles quaternaires. Donc beaucoup de zones urbaines se trouvent à proximité immédiate de sources importantes.

10. Les données accéléromètriques des pays voisins (surtout Turquie, Arménie, Azarbayjan) peuvent être le sujet d'études comparatives. Les situations géologiques en Iran et en Turquie sont similaires. Ce type d'études peut aider les investigations de l'aléa sismique dans la région méditerranéenne.

11.Enfin, l'étude de l'atténuation des intensités macrosismiques serait souhaitable aussi pour l'Iran. On propose la calibration de l'échelle européenne de EMS98 pour une étude plus précise sur les intensités en Iran. Les destructions historiques pourraient alors indiquer l'aléa sismique dans un pays comme Iran, qui a un grand héritage culturel, historique et archéologique.

Chapitre 8

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Chapitre 9

Annexes

Annexe-1: Valeurs de fréquence (Hz) pour lesquelles les regressions ont été effectues sur les ordonnées spectrales (d'après Fukushima: programme FORTRAN de la régression pour la loi d'atténuation)

0.100	0.111	0.125	0.143	0.167	0.182	0.200
0.222	0.250	0.263	0.278	0.294	0.300	0.312
0.333	0.357	0.385	0.400	0.417	0.455	0.500
0.556	0.600	0.625	0.667	0.700	0.714	0.769
0.800	0.833	0.900	0.909	1.000	1.100	1.111
1.176	1.200	1.250	1.300	1.333	1.400	1.429
1.471	1.500	1.515	1.562	1.600	1.613	1.667
1.700	1.724	1.786	1.800	1.852	1.900	1.923
2.000	2.083	2.100	2.174	2.200	2.273	2.300
2.381	2.400	2.500	2.600	2.632	2.700	2.778
2.800	2.900	2.941	3.000	3.125	3.155	3.300
3.333	3.448	3.571	3.600	3.800	3.850	4.000
4.167	4.200	4.400	4.550	4.600	4.800	5.000
5.250	5.263	5.500	5.556	5.750	5.882	6.000
6.250	6.500	6.667	6.750	7.000	7.143	7.250
7.500	7.692	7.750	8.000	8.333	8.500	9.000
9.091	9.500	10.000	10.500	11.000	11.111	11.500
11.765	12.00	12.500	13.00	13.333	13.500	14.000
14.286	14.500	15.000	15.385	16.000	16.667	17.00
18.000	18.868	20.000	22.000	25.000	28.000	29.412
31.000	33.333	34.000	40.000	45.000	50.000	

Annexe-2: Nombre des points utilisés, valeurs de Sigma, a, b, c1, c2, c3, c4 pour 146 fréquences indiquées dans l'Annexe-1, pour l'ensemble des données iraniennes (composante horizontale), pour d=1.0 .

Points 6.009E+00	8.009E+00	8.009E+00	8.009E+00	1.380E+02	1.380E+02	1.420E+02	3.000E+02
3.720E+02	4.440E+02	4.480E+02	5.200E+02	5.300E+02	5.360E+02	5.380E+02	5.580E+02
5.580E+02	5.900E+02	5.940E+02	6.320E+02	6.400E+02	6.540E+02	6.540E+02	6.540E+02
6.560E+02	6.600E+02	6.600E+02	6.660E+02	6.660E+02	6.660E+02	6.760E+02	6.760E+02
6.760E+02	7.220E+02	7.220E+02	7.220E+02	7.220E+02	7.240E+02	7.240E+02	7.240E+02
7.240E+02	7.240E+02	7.240E+02	7.240E+02	7.240E+02	7.500E+02	7.500E+02	7.500E+02
7.500E+02	7.500E+02	7.500E+02	7.500E+02	7.500E+02	7.500E+02	7.500E+02	7.500E+02
7.480E+02	8.120E+02	8.120E+02	8.120E+02	8.120E+02	8.120E+02	8.120E+02	8.120E+02
8.120E+02	8.120E+02	8.200E+02	8.200E+02	8.200E+02	8.200E+02	8.200E+02	8.200E+02
8.200E+02	8.220E+02	8.900E+02	8.900E+02	8.900E+02	8.900E+02	8.900E+02	8.900E+02
8.900E+02	8.900E+02	8.900E+02	8.860E+02	9.140E+02	9.140E+02	9.140E+02	9.140E+02
9.140E+02	9.140E+02	9.100E+02	9.200E+02	9.200E+02	9.200E+02	9.200E+02	9.200E+02
9.200E+02	9.140E+02	9.140E+02	9.140E+02	9.140E+02	9.140E+02	9.080E+02	9.080E+02
9.080E+02	9.080E+02	9.080E+02	9.080E+02	9.000E+02	9.040E+02	9.040E+02	8.960E+02
8.960E+02	8.960E+02	8.740E+02	8.740E+02	8.620E+02	8.620E+02	8.620E+02	8.620E+02
8.580E+02	8.580E+02	8.580E+02	8.580E+02	8.580E+02	8.580E+02	8.580E+02	8.580E+02
8.160E+02	8.160E+02	8.160E+02	8.020E+02	8.020E+02	7.920E+02	7.900E+02	7.440E+02
7.420E+02	7.180E+02	7.060E+02	7.060E+02	6.600E+02	6.580E+02	6.580E+02	8.801E+01
8.601E+01	9.360E-03						
σ 4.577E+00	6.746E+00	6.802E+00	6.872E+00	3.475E-01	3.479E-01	3.507E-01	3.095E-01
3.432E-01	3.309E-01	3.315E-01	3.411E-01	3.453E-01	3.411E-01	3.304E-01	3.306E-01
3.309E-01	3.477E-01	3.473E-01	3.616E-01	3.619E-01	3.770E-01	3.822E-01	3.839E-01
3.853E-01	3.876E-01	3.875E-01	3.932E-01	3.927E-01	3.943E-01	3.941E-01	3.937E-01
3.907E-01	4.007E-01	4.013E-01	4.034E-01	4.038E-01	4.057E-01	4.070E-01	4.071E-01
4.053E-01	4.042E-01	4.027E-01	4.024E-01	4.023E-01	4.091E-01	4.096E-01	4.101E-01
4.131E-01	4.141E-01	4.146E-01	4.145E-01	4.142E-01	4.124E-01	4.113E-01	4.111E-01
4.099E-01	4.203E-01	4.199E-01	4.190E-01	4.189E-01	4.192E-01	4.191E-01	4.193E-01
4.195E-01	4.198E-01	4.196E-01	4.192E-01	4.184E-01	4.165E-01	4.161E-01	4.143E-01
4.140E-01	4.144E-01	4.201E-01	4.202E-01	4.190E-01	4.190E-01	4.175E-01	4.152E-01
4.148E-01	4.164E-01	4.165E-01	4.172E-01	4.139E-01	4.133E-01	4.093E-01	4.067E-01
4.060E-01	4.015E-01	3.963E-01	3.915E-01	3.914E-01	3.876E-01	3.864E-01	3.830E-01
3.814E-01	3.801E-01	3.792E-01	3.789E-01	3.791E-01	3.790E-01	3.748E-01	3.736E-01
3.726E-01	3.691E-01	3.675E-01	3.671E-01	3.622E-01	3.593E-01	3.570E-01	3.564E-01
3.563E-01	3.560E-01	3.528E-01	3.566E-01	3.584E-01	3.587E-01	3.593E-01	3.590E-01
3.578E-01	3.564E-01	3.552E-01	3.545E-01	3.542E-01	3.555E-01	3.566E-01	3.577E-01
3.601E-01	3.609E-01	3.616E-01	3.577E-01	3.584E-01	3.569E-01	3.549E-01	3.533E-01
3.565E-01	3.514E-01	3.490E-01	3.461E-01	3.444E-01	3.373E-01	3.355E-01	3.734E-01
3.626E-01	1.715E-01						
a 1.541E+00	8.031E-01	8.441E-01	8.891E-01	8.447E-01	8.556E-01	8.787E-01	7.996E-01
7.207E-01	7.209E-01	7.163E-01	7.225E-01	7.496E-01	7.531E-01	7.555E-01	7.563E-01
7.573E-01	8.321E-01	8.361E-01	8.337E-01	8.279E-01	7.960E-01	7.921E-01	7.917E-01
7.981E-01	8.023E-01	8.033E-01	8.186E-01	8.178E-01	8.175E-01	8.051E-01	8.042E-01
7.975E-01	7.999E-01	7.997E-01	7.990E-01	7.979E-01	7.933E-01	7.881E-01	7.842E-01
7.759E-01	7.723E-01	7.659E-01	7.599E-01	7.565E-01	7.520E-01	7.487E-01	7.478E-01
7.458E-01	7.450E-01	7.436E-01	7.351E-01	7.328E-01	7.245E-01	7.176E-01	7.147E-01
7.063E-01	6.714E-01	6.700E-01	6.650E-01	6.623E-01	6.554E-01	6.538E-01	6.476E-01
6.461E-01	6.400E-01	6.294E-01	6.264E-01	6.220E-01	6.176E-01	6.163E-01	6.102E-01
6.068E-01	6.025E-01	5.805E-01	5.799E-01	5.761E-01	5.749E-01	5.690E-01	5.627E-01
5.611E-01	5.533E-01	5.510E-01	5.432E-01	5.291E-01	5.266E-01	5.134E-01	5.064E-01
5.042E-01	4.973E-01	4.899E-01	4.749E-01	4.745E-01	4.671E-01	4.652E-01	4.586E-01
4.549E-01	4.519E-01	4.451E-01	4.383E-01	4.338E-01	4.317E-01	4.309E-01	4.284E-01
4.258E-01	4.164E-01	4.084E-01	4.062E-01	3.939E-01	3.814E-01	3.760E-01	3.687E-01
3.675E-01	3.627E-01	3.590E-01	3.496E-01	3.460E-01	3.449E-01	3.427E-01	3.411E-01
3.413E-01	3.373E-01	3.325E-01	3.292E-01	3.281E-01	3.268E-01	3.258E-01	3.253E-01
3.276E-01	3.256E-01	3.243E-01	2.991E-01	2.980E-01	3.060E-01	3.014E-01	3.144E-01
3.249E-01	3.173E-01	3.317E-01	3.340E-01	3.324E-01	3.401E-01	3.425E-01	3.056E-01
2.879E-01	5.850E-02						

b 5.922E-03	5.972E-03	6.776E-03	5.850E-03	4.409E-03	4.146E-03	4.915E-03	7.097E-03
8.407E-03	8.752E-03	9.457E-03	9.710E-03	5.437E-03	5.491E-03	5.970E-03	6.802E-03
8.013E-03	1.593E-03	1.777E-03	2.094E-03	2.513E-03	3.216E-03	3.123E-03	3.108E-03
2.780E-03	2.603E-03	2.547E-03	1.595E-03	1.596E-03	1.576E-03	1.957E-03	1.969E-03
1.904E-03	1.620E-03	1.602E-03	1.275E-03	1.158E-03	1.087E-03	1.100E-03	1.080E-03
1.089E-03	1.158E-03	1.286E-03	1.406E-03	1.468E-03	1.114E-03	1.148E-03	1.144E-03
1.027E-03	9.429E-04	9.114E-04	9.717E-04	9.900E-04	1.065E-03	1.115E-03	1.110E-03
1.098E-03	1.431E-03	1.420E-03	1.354E-03	1.359E-03	1.316E-03	1.270E-03	1.212E-03
1.206E-03	1.104E-03	1.047E-03	1.025E-03	9.634E-04	8.996E-04	8.812E-04	8.098E-04
7.961E-04	7.666E-04	8.886E-04	8.519E-04	6.499E-04	6.073E-04	5.543E-04	5.312E-04
5.380E-04	3.808E-04	3.661E-04	2.695E-04	3.473E-04	3.542E-04	3.341E-04	2.659E-04
2.603E-04	1.786E-04	1.485E-04	1.976E-04	1.899E-04	1.102E-04	1.034E-04	4.705E-05
-2.017E-05	3.674E-05	-1.072E-04	-1.683E-04	-2.062E-04	-2.331E-04	-3.201E-04	-3.505E-04
-3.552E-04	-2.638E-04	-2.004E-04	-1.871E-04	3.150E-04	3.372E-04	3.425E-04	7.398E-05
6.016E-05	-5.306E-05	-1.338E-04	-9.428E-05	-2.561E-04	-2.810E-04	-4.098E-04	-4.644E-04
-4.930E-04	-3.864E-04	-3.086E-04	-2.372E-04	-2.226E-04	-2.529E-04	-2.597E-04	-2.825E-04
-2.516E-04	-1.742E-04	-1.853E-04	2.240E-03	2.289E-03	2.375E-03	2.396E-03	2.466E-03
1.956E-03	2.216E-03	1.269E-03	1.561E-03	7.757E-04	1.109E-03	1.097E-03	-1.235E-02
1.052E-02	6.078E-03						
c1: -1.141E+01	-5.845E+00	-5.997E+00	-6.113E+00	-5.696E+00	-5.673E+00	-5.718E+00	-5.293E+00
-4.867E+00	-4.845E+00	-4.799E+00	-4.788E+00	-4.805E+00	-4.793E+00	-4.775E+00	-4.758E+00
-4.737E+00	-4.904E+00	-4.899E+00	-4.826E+00	-4.747E+00	-4.534E+00	-4.451E+00	-4.421E+00
-4.392E+00	-4.360E+00	-4.347E+00	-4.337E+00	-4.302E+00	-4.269E+00	-4.165E+00	-4.153E+00
-4.043E+00	-3.965E+00	-3.956E+00	-3.900E+00	-3.874E+00	-3.817E+00	-3.761E+00	-3.721E+00
-3.642E+00	-3.610E+00	-3.559E+00	-3.519E+00	-3.497E+00	-3.448E+00	-3.415E+00	-3.405E+00
-3.368E+00	-3.347E+00	-3.329E+00	-3.259E+00	-3.242E+00	-3.181E+00	-3.128E+00	-3.105E+00
-3.032E+00	-2.847E+00	-2.834E+00	-2.779E+00	-2.757E+00	-2.699E+00	-2.681E+00	-2.624E+00
-2.612E+00	-2.549E+00	-2.463E+00	-2.439E+00	-2.396E+00	-2.349E+00	-2.337E+00	-2.282E+00
-2.257E+00	-2.223E+00	-2.075E+00	-2.063E+00	-2.004E+00	-1.989E+00	-1.935E+00	-1.881E+00
-1.869E+00	-1.793E+00	-1.773E+00	-1.708E+00	-1.610E+00	-1.594E+00	-1.502E+00	-1.448E+00
-1.432E+00	-1.378E+00	-1.322E+00	-1.221E+00	-1.218E+00	-1.164E+00	-1.152E+00	-1.110E+00
-1.086E+00	-1.062E+00	-1.016E+00	-9.734E-01	-9.434E-01	-9.291E-01	-9.044E-01	-8.887E-01
-8.749E-01	-8.291E-01	-7.890E-01	-7.775E-01	-7.201E-01	-6.552E-01	-6.259E-01	-5.749E-01
-5.683E-01	-5.400E-01	-5.208E-01	-4.819E-01	-4.656E-01	-4.611E-01	-4.494E-01	-4.436E-01
-4.418E-01	-4.330E-01	-4.187E-01	-4.085E-01	-4.047E-01	-4.003E-01	-3.963E-01	-3.945E-01
-4.087E-01	-4.050E-01	-4.057E-01	-3.489E-01	-3.474E-01	-3.891E-01	-3.859E-01	-4.788E-01
-5.458E-01	-5.676E-01	-6.294E-01	-6.566E-01	-6.504E-01	-7.124E-01	-7.275E-01	-3.130E-01
-6.437E-01	-9.121E+00						
c2: -1.598E+01	-1.259E+01	-1.279E+01	-1.298E+01	-5.685E+00	-5.660E+00	-5.722E+00	-5.400E+00
-5.012E+00	-4.984E+00	-4.939E+00	-4.912E+00	-4.940E+00	-4.926E+00	-4.892E+00	-4.862E+00
-4.835E+00	-5.016E+00	-5.007E+00	-4.925E+00	-4.834E+00	-4.654E+00	-4.575E+00	-4.544E+00
-4.517E+00	-4.481E+00	-4.468E+00	-4.446E+00	-4.409E+00	-4.374E+00	-4.258E+00	-4.245E+00
-4.127E+00	-4.011E+00	-4.002E+00	-3.940E+00	-3.914E+00	-3.855E+00	-3.800E+00	-3.759E+00
-3.681E+00	-3.648E+00	-3.597E+00	-3.556E+00	-3.533E+00	-3.459E+00	-3.424E+00	-3.413E+00
-3.378E+00	-3.358E+00	-3.341E+00	-3.278E+00	-3.261E+00	-3.199E+00	-3.147E+00	-3.124E+00
-3.055E+00	-2.874E+00	-2.863E+00	-2.810E+00	-2.788E+00	-2.728E+00	-2.710E+00	-2.653E+00
-2.640E+00	-2.576E+00	-2.486E+00	-2.460E+00	-2.416E+00	-2.371E+00	-2.359E+00	-2.304E+00
-2.278E+00	-2.245E+00	-2.123E+00	-2.112E+00	-2.057E+00	-2.045E+00	-1.995E+00	-1.940E+00
-1.927E+00	-1.850E+00	-1.830E+00	-1.769E+00	-1.663E+00	-1.645E+00	-1.545E+00	-1.487E+00
-1.469E+00	-1.405E+00	-1.338E+00	-1.231E+00	-1.228E+00	-1.162E+00	-1.147E+00	-1.094E+00
-1.062E+00	-1.038E+00	-9.820E-01	-9.268E-01	-8.909E-01	-8.750E-01	-8.521E-01	-8.304E-01
-8.121E-01	-7.576E-01	-7.142E-01	-7.019E-01	-6.491E-01	-5.806E-01	-5.494E-01	-4.896E-01
-4.829E-01	-4.523E-01	-4.218E-01	-3.719E-01	-3.515E-01	-3.475E-01	-3.406E-01	-3.361E-01
-3.393E-01	-3.328E-01	-3.244E-01	-3.185E-01	-3.173E-01	-3.206E-01	-3.243E-01	-3.286E-01
-3.673E-01	-3.683E-01	-3.801E-01	-3.312E-01	-3.349E-01	-3.968E-01	-3.929E-01	-4.686E-01
-5.120E-01	-5.228E-01	-6.046E-01	-6.408E-01	-6.754E-01	-7.437E-01	-7.587E-01	-5.208E-01
-9.290E-01	-9.168E+00						

c3: -1.607E+01	-1.264E+01	-1.285E+01	-1.303E+01	-5.621E+00	-5.609E+00	-5.670E+00	-5.313E+00
-4.918E+00	-4.922E+00	-4.876E+00	-4.846E+00	-4.866E+00	-4.856E+00	-4.835E+00	-4.828E+00
-4.795E+00	-4.951E+00	-4.932E+00	-4.865E+00	-4.784E+00	-4.586E+00	-4.513E+00	-4.482E+00
-4.455E+00	-4.433E+00	-4.419E+00	-4.412E+00	-4.378E+00	-4.346E+00	-4.231E+00	-4.220E+00
-4.116E+00	-4.014E+00	-4.003E+00	-3.941E+00	-3.917E+00	-3.860E+00	-3.806E+00	-3.767E+00
-3.686E+00	-3.654E+00	-3.601E+00	-3.558E+00	-3.535E+00	-3.475E+00	-3.439E+00	-3.427E+00
-3.382E+00	-3.357E+00	-3.337E+00	-3.269E+00	-3.252E+00	-3.192E+00	-3.139E+00	-3.116E+00
-3.045E+00	-2.856E+00	-2.843E+00	-2.788E+00	-2.765E+00	-2.697E+00	-2.676E+00	-2.610E+00
-2.595E+00	-2.522E+00	-2.434E+00	-2.409E+00	-2.365E+00	-2.317E+00	-2.303E+00	-2.241E+00
-2.212E+00	-2.172E+00	-1.990E+00	-1.977E+00	-1.910E+00	-1.893E+00	-1.833E+00	-1.769E+00
-1.754E+00	-1.669E+00	-1.648E+00	-1.573E+00	-1.493E+00	-1.476E+00	-1.384E+00	-1.336E+00
-1.322E+00	-1.272E+00	-1.223E+00	-1.139E+00	-1.136E+00	-1.086E+00	-1.073E+00	-1.033E+00
-1.009E+00	-9.928E-01	-9.508E-01	-9.146E-01	-8.932E-01	-8.833E-01	-8.748E-01	-8.608E-01
-8.471E-01	-8.039E-01	-7.699E-01	-7.597E-01	-7.145E-01	-6.563E-01	-6.314E-01	-6.036E-01
-6.003E-01	-5.870E-01	-5.727E-01	-5.361E-01	-5.134E-01	-5.086E-01	-4.977E-01	-4.915E-01
-4.922E-01	-4.793E-01	-4.625E-01	-4.517E-01	-4.482E-01	-4.441E-01	-4.389E-01	-4.352E-01
-4.461E-01	-4.394E-01	-4.376E-01	-3.783E-01	-3.745E-01	-4.114E-01	-3.976E-01	-4.681E-01
-5.235E-01	-5.262E-01	-6.026E-01	-6.317E-01	-6.439E-01	-6.997E-01	-7.156E-01	-5.017E-01
-8.063E-01	-9.180E+00						
c4: -1.606E+01	-1.258E+01	-1.281E+01	-1.298E+01	-5.914E+00	-5.884E+00	-5.955E+00	-5.359E+00
-4.860E+00	-4.819E+00	-4.776E+00	-4.690E+00	-4.702E+00	-4.691E+00	-4.675E+00	-4.663E+00
-4.646E+00	-4.781E+00	-4.773E+00	-4.696E+00	-4.600E+00	-4.388E+00	-4.305E+00	-4.269E+00
-4.237E+00	-4.216E+00	-4.204E+00	-4.178E+00	-4.145E+00	-4.109E+00	-4.024E+00	-4.013E+00
-3.903E+00	-3.803E+00	-3.794E+00	-3.734E+00	-3.708E+00	-3.659E+00	-3.605E+00	-3.570E+00
-3.496E+00	-3.465E+00	-3.417E+00	-3.379E+00	-3.358E+00	-3.290E+00	-3.259E+00	-3.248E+00
-3.209E+00	-3.186E+00	-3.167E+00	-3.100E+00	-3.083E+00	-3.025E+00	-2.972E+00	-2.950E+00
-2.883E+00	-2.684E+00	-2.671E+00	-2.618E+00	-2.597E+00	-2.541E+00	-2.524E+00	-2.467E+00
-2.454E+00	-2.390E+00	-2.324E+00	-2.300E+00	-2.260E+00	-2.216E+00	-2.204E+00	-2.145E+00
-2.118E+00	-2.078E+00	-1.956E+00	-1.945E+00	-1.888E+00	-1.874E+00	-1.822E+00	-1.771E+00
-1.759E+00	-1.680E+00	-1.660E+00	-1.597E+00	-1.511E+00	-1.495E+00	-1.407E+00	-1.356E+00
-1.339E+00	-1.279E+00	-1.218E+00	-1.121E+00	-1.118E+00	-1.061E+00	-1.047E+00	-1.002E+00
-9.756E-01	-9.590E-01	-9.125E-01	-8.725E-01	-8.456E-01	-8.314E-01	-8.135E-01	-7.962E-01
-7.820E-01	-7.407E-01	-7.049E-01	-6.951E-01	-6.552E-01	-5.920E-01	-5.649E-01	-5.172E-01
-5.104E-01	-4.829E-01	-4.653E-01	-4.324E-01	-4.153E-01	-4.116E-01	-4.019E-01	-3.988E-01
-4.043E-01	-4.011E-01	-3.917E-01	-3.866E-01	-3.863E-01	-3.964E-01	-4.021E-01	-4.053E-01
-4.327E-01	-4.342E-01	-4.383E-01	-4.144E-01	-4.182E-01	-4.841E-01	-4.828E-01	-5.604E-01
-6.185E-01	-6.326E-01	-6.995E-01	-7.263E-01	-7.136E-01	-7.746E-01	-7.875E-01	-3.844E-01
-7.539E-01	-9.069E+00						

Annexe-3: Nombre des points utilisés, valeurs de Sigma, a, b, c1, c2, c3, c4 pour 146 fréquences indiquée dans l'Annexe-1, pour l'ensemble des données iraniennes (composante verticale), pour d=1.0 .

Points 3.005E+00	4.005E+00	4.005E+00	4.005E+00	6.900E+01	6.900E+01	7.100E+01	1.500E+02
1.860E+02	2.220E+02	2.240E+02	2.600E+02	2.650E+02	2.680E+02	2.690E+02	2.790E+02
2.790E+02	2.950E+02	2.970E+02	3.160E+02	3.200E+02	3.270E+02	3.270E+02	3.270E+02
3.280E+02	3.300E+02	3.300E+02	3.330E+02	3.330E+02	3.330E+02	3.380E+02	3.380E+02
3.380E+02	3.610E+02	3.610E+02	3.610E+02	3.610E+02	3.620E+02	3.620E+02	3.620E+02
3.620E+02	3.620E+02	3.620E+02	3.620E+02	3.620E+02	3.750E+02	3.750E+02	3.750E+02
3.750E+02	3.750E+02	3.750E+02	3.750E+02	3.750E+02	3.750E+02	3.750E+02	3.750E+02
3.740E+02	4.060E+02	4.060E+02	4.060E+02	4.060E+02	4.060E+02	4.060E+02	4.060E+02
4.060E+02	4.060E+02	4.100E+02	4.100E+02	4.100E+02	4.100E+02	4.100E+02	4.100E+02
4.100E+02	4.110E+02	4.450E+02	4.450E+02	4.450E+02	4.450E+02	4.450E+02	4.450E+02
4.450E+02	4.450E+02	4.450E+02	4.430E+02	4.570E+02	4.570E+02	4.570E+02	4.570E+02
4.570E+02	4.570E+02	4.550E+02	4.600E+02	4.600E+02	4.600E+02	4.600E+02	4.600E+02
4.600E+02	4.570E+02	4.570E+02	4.570E+02	4.570E+02	4.570E+02	4.540E+02	4.540E+02
4.540E+02	4.540E+02	4.540E+02	4.540E+02	4.500E+02	4.520E+02	4.520E+02	4.480E+02
4.480E+02	4.480E+02	4.370E+02	4.370E+02	4.310E+02	4.310E+02	4.310E+02	4.310E+02
4.290E+02	4.290E+02	4.290E+02	4.290E+02	4.290E+02	4.290E+02	4.290E+02	4.290E+02
4.080E+02	4.080E+02	4.080E+02	4.010E+02	4.010E+02	3.960E+02	3.950E+02	3.720E+02
3.710E+02	3.590E+02	3.530E+02	3.530E+02	3.300E+02	3.290E+02	3.290E+02	4.400E+01
4.300E+01	4.680E-03						
σ 1.136E+01	6.430E+00	6.567E+00	6.626E+00	3.728E-01	3.616E-01	3.664E-01	3.193E-01
3.612E-01	3.415E-01	3.435E-01	3.532E-01	3.602E-01	3.627E-01	3.586E-01	3.597E-01
3.535E-01	3.584E-01	3.562E-01	3.766E-01	3.683E-01	3.704E-01	3.622E-01	3.599E-01
3.584E-01	3.621E-01	3.613E-01	3.630E-01	3.640E-01	3.641E-01	3.675E-01	3.679E-01
3.681E-01	3.866E-01	3.873E-01	3.903E-01	3.916E-01	3.965E-01	3.987E-01	3.976E-01
3.946E-01	3.935E-01	3.929E-01	3.928E-01	3.930E-01	4.071E-01	4.078E-01	4.082E-01
4.069E-01	4.053E-01	4.032E-01	4.022E-01	4.023E-01	4.037E-01	4.032E-01	4.029E-01
4.009E-01	4.099E-01	4.102E-01	4.108E-01	4.104E-01	4.092E-01	4.094E-01	4.083E-01
4.083E-01	4.083E-01	4.084E-01	4.080E-01	4.059E-01	4.009E-01	3.999E-01	3.959E-01
3.945E-01	3.924E-01	3.880E-01	3.873E-01	3.853E-01	3.850E-01	3.844E-01	3.839E-01
3.837E-01	3.846E-01	3.847E-01	3.814E-01	3.817E-01	3.814E-01	3.822E-01	3.826E-01
3.826E-01	3.818E-01	3.825E-01	3.798E-01	3.797E-01	3.774E-01	3.772E-01	3.739E-01
3.712E-01	3.696E-01	3.638E-01	3.648E-01	3.625E-01	3.612E-01	3.609E-01	3.618E-01
3.624E-01	3.657E-01	3.676E-01	3.680E-01	3.658E-01	3.641E-01	3.633E-01	3.582E-01
3.570E-01	3.545E-01	3.470E-01	3.481E-01	3.505E-01	3.505E-01	3.512E-01	3.515E-01
3.526E-01	3.531E-01	3.526E-01	3.540E-01	3.549E-01	3.589E-01	3.610E-01	3.619E-01
3.624E-01	3.619E-01	3.621E-01	3.566E-01	3.559E-01	3.624E-01	3.614E-01	3.645E-01
3.636E-01	3.679E-01	3.720E-01	3.677E-01	3.708E-01	3.622E-01	3.612E-01	4.500E-01
4.581E-01	1.715E-01						
a -9.794E-01	8.795E-01	8.838E-01	9.215E-01	7.535E-01	7.770E-01	8.302E-01	7.638E-01
6.501E-01	6.559E-01	6.529E-01	6.393E-01	6.678E-01	6.662E-01	6.726E-01	6.745E-01
6.868E-01	7.716E-01	7.757E-01	7.965E-01	8.036E-01	7.629E-01	7.666E-01	7.700E-01
7.774E-01	7.887E-01	7.903E-01	8.032E-01	8.024E-01	7.972E-01	7.906E-01	7.904E-01
7.989E-01	7.960E-01	7.960E-01	7.973E-01	7.984E-01	7.936E-01	7.886E-01	7.858E-01
7.805E-01	7.762E-01	7.658E-01	7.601E-01	7.571E-01	7.534E-01	7.523E-01	7.519E-01
7.496E-01	7.483E-01	7.466E-01	7.410E-01	7.397E-01	7.325E-01	7.247E-01	7.197E-01
7.078E-01	6.816E-01	6.819E-01	6.778E-01	6.762E-01	6.733E-01	6.728E-01	6.679E-01
6.656E-01	6.589E-01	6.498E-01	6.476E-01	6.424E-01	6.378E-01	6.362E-01	6.284E-01
6.246E-01	6.187E-01	5.908E-01	5.871E-01	5.784E-01	5.766E-01	5.691E-01	5.596E-01
5.580E-01	5.513E-01	5.488E-01	5.325E-01	5.152E-01	5.133E-01	5.067E-01	5.075E-01
5.073E-01	5.040E-01	5.000E-01	4.886E-01	4.882E-01	4.787E-01	4.768E-01	4.722E-01
4.695E-01	4.648E-01	4.601E-01	4.538E-01	4.468E-01	4.433E-01	4.412E-01	4.390E-01
4.382E-01	4.353E-01	4.283E-01	4.264E-01	4.141E-01	4.062E-01	4.017E-01	3.862E-01
3.842E-01	3.761E-01	3.709E-01	3.681E-01	3.684E-01	3.688E-01	3.661E-01	3.632E-01
3.641E-01	3.642E-01	3.590E-01	3.533E-01	3.505E-01	3.418E-01	3.379E-01	3.353E-01
3.417E-01	3.413E-01	3.420E-01	3.248E-01	3.239E-01	3.223E-01	3.152E-01	3.214E-01
3.127E-01	3.105E-01	3.237E-01	3.221E-01	3.233E-01	3.267E-01	3.283E-01	2.250E-01
1.520E-01	5.852E-02						

b 3.784E-03	5.087E-03	5.975E-03	4.481E-03	6.457E-03	5.985E-03	5.500E-03	6.662E-03
9.981E-03	1.002E-02	1.008E-02	1.020E-02	7.440E-03	8.008E-03	8.362E-03	8.432E-03
8.838E-03	2.367E-03	2.754E-03	2.718E-03	2.726E-03	4.171E-03	4.161E-03	4.086E-03
3.650E-03	3.473E-03	3.425E-03	2.923E-03	2.850E-03	2.856E-03	2.998E-03	2.980E-03
2.411E-03	2.269E-03	2.279E-03	2.153E-03	2.127E-03	2.264E-03	2.228E-03	2.221E-03
2.038E-03	2.025E-03	2.156E-03	2.202E-03	2.264E-03	1.999E-03	1.994E-03	1.990E-03
1.914E-03	1.876E-03	1.871E-03	1.890E-03	1.890E-03	1.997E-03	2.160E-03	2.248E-03
2.428E-03	2.538E-03	2.495E-03	2.458E-03	2.444E-03	2.380E-03	2.341E-03	2.242E-03
2.260E-03	2.246E-03	2.157E-03	2.092E-03	2.027E-03	1.965E-03	1.959E-03	1.928E-03
1.935E-03	1.943E-03	2.160E-03	2.186E-03	2.040E-03	1.991E-03	1.832E-03	1.943E-03
1.957E-03	1.785E-03	1.770E-03	2.102E-03	2.318E-03	2.319E-03	2.181E-03	1.938E-03
1.872E-03	1.625E-03	1.338E-03	1.160E-03	1.155E-03	1.111E-03	1.077E-03	1.004E-03
9.356E-04	1.128E-03	9.561E-04	8.501E-04	9.108E-04	9.391E-04	8.429E-04	7.535E-04
6.815E-04	4.574E-04	3.800E-04	3.590E-04	7.233E-04	5.603E-04	4.873E-04	4.422E-04
3.852E-04	2.992E-04	2.136E-04	-3.012E-06	-3.265E-04	-4.064E-04	-5.008E-04	-4.762E-04
-5.632E-04	-7.099E-04	-7.623E-04	-6.751E-04	-6.496E-04	-5.143E-04	-4.806E-04	-4.417E-04
-5.838E-04	-6.642E-04	-7.485E-04	9.246E-04	8.727E-04	7.052E-04	6.314E-04	2.161E-04
8.757E-05	-2.157E-04	-1.166E-03	-7.606E-04	-2.473E-03	-2.058E-03	-1.965E-03	-1.214E-02
1.075E-02	6.078E-03						
c1: 7.009E+00	-6.500E+00	-6.403E+00	-6.489E+00	-5.304E+00	-5.342E+00	-5.506E+00	-5.151E+00
-4.635E+00	-4.652E+00	-4.600E+00	-4.494E+00	-4.547E+00	-4.526E+00	-4.528E+00	-4.510E+00
-4.533E+00	-4.755E+00	-4.759E+00	-4.806E+00	-4.785E+00	-4.572E+00	-4.541E+00	-4.526E+00
-4.518E+00	-4.529E+00	-4.523E+00	-4.530E+00	-4.495E+00	-4.443E+00	-4.356E+00	-4.346E+00
-4.293E+00	-4.188E+00	-4.181E+00	-4.140E+00	-4.130E+00	-4.079E+00	-4.018E+00	-3.985E+00
-3.923E+00	-3.891E+00	-3.828E+00	-3.788E+00	-3.769E+00	-3.726E+00	-3.703E+00	-3.695E+00
-3.658E+00	-3.636E+00	-3.617E+00	-3.565E+00	-3.553E+00	-3.504E+00	-3.452E+00	-3.422E+00
-3.340E+00	-3.180E+00	-3.172E+00	-3.121E+00	-3.104E+00	-3.070E+00	-3.060E+00	-3.013E+00
-2.997E+00	-2.939E+00	-2.870E+00	-2.851E+00	-2.813E+00	-2.775E+00	-2.761E+00	-2.702E+00
-2.676E+00	-2.637E+00	-2.465E+00	-2.444E+00	-2.375E+00	-2.360E+00	-2.302E+00	-2.233E+00
-2.219E+00	-2.147E+00	-2.127E+00	-2.039E+00	-1.937E+00	-1.923E+00	-1.853E+00	-1.827E+00
-1.817E+00	-1.765E+00	-1.710E+00	-1.617E+00	-1.614E+00	-1.544E+00	-1.529E+00	-1.489E+00
-1.465E+00	-1.436E+00	-1.394E+00	-1.346E+00	-1.306E+00	-1.285E+00	-1.252E+00	-1.229E+00
-1.214E+00	-1.174E+00	-1.125E+00	-1.112E+00	-1.045E+00	-9.830E-01	-9.540E-01	-8.631E-01
-8.499E-01	-7.971E-01	-7.642E-01	-7.389E-01	-7.268E-01	-7.250E-01	-7.050E-01	-6.910E-01
-6.887E-01	-6.834E-01	-6.582E-01	-6.352E-01	-6.247E-01	-5.932E-01	-5.781E-01	-5.679E-01
-5.994E-01	-5.975E-01	-6.089E-01	-5.758E-01	-5.764E-01	-5.828E-01	-5.631E-01	-6.105E-01
-5.868E-01	-6.282E-01	-6.956E-01	-7.141E-01	-6.980E-01	-7.464E-01	-7.643E-01	-1.183E-01
-2.848E-01	-9.121E+00						
c2: -4.347E+00	-1.292E+01	-1.296E+01	-1.310E+01	-5.362E+00	-5.414E+00	-5.566E+00	-5.272E+00
-4.806E+00	-4.805E+00	-4.767E+00	-4.656E+00	-4.717E+00	-4.702E+00	-4.686E+00	-4.653E+00
-4.656E+00	-4.879E+00	-4.886E+00	-4.914E+00	-4.899E+00	-4.705E+00	-4.668E+00	-4.656E+00
-4.643E+00	-4.637E+00	-4.627E+00	-4.607E+00	-4.574E+00	-4.522E+00	-4.451E+00	-4.444E+00
-4.396E+00	-4.259E+00	-4.251E+00	-4.206E+00	-4.192E+00	-4.133E+00	-4.080E+00	-4.051E+00
-3.989E+00	-3.950E+00	-3.884E+00	-3.844E+00	-3.822E+00	-3.739E+00	-3.713E+00	-3.706E+00
-3.670E+00	-3.648E+00	-3.631E+00	-3.577E+00	-3.565E+00	-3.514E+00	-3.466E+00	-3.438E+00
-3.355E+00	-3.196E+00	-3.188E+00	-3.135E+00	-3.117E+00	-3.073E+00	-3.060E+00	-3.003E+00
-2.985E+00	-2.916E+00	-2.837E+00	-2.815E+00	-2.774E+00	-2.735E+00	-2.723E+00	-2.674E+00
-2.653E+00	-2.620E+00	-2.478E+00	-2.455E+00	-2.385E+00	-2.371E+00	-2.311E+00	-2.251E+00
-2.241E+00	-2.187E+00	-2.169E+00	-2.083E+00	-1.982E+00	-1.969E+00	-1.913E+00	-1.899E+00
-1.892E+00	-1.850E+00	-1.803E+00	-1.725E+00	-1.722E+00	-1.654E+00	-1.638E+00	-1.589E+00
-1.559E+00	-1.529E+00	-1.475E+00	-1.427E+00	-1.380E+00	-1.358E+00	-1.332E+00	-1.312E+00
-1.299E+00	-1.269E+00	-1.226E+00	-1.215E+00	-1.155E+00	-1.095E+00	-1.064E+00	-9.611E-01
-9.442E-01	-8.745E-01	-8.150E-01	-7.664E-01	-7.413E-01	-7.362E-01	-7.119E-01	-6.951E-01
-6.958E-01	-6.903E-01	-6.614E-01	-6.373E-01	-6.252E-01	-5.924E-01	-5.805E-01	-5.736E-01
-6.109E-01	-6.073E-01	-6.045E-01	-5.660E-01	-5.675E-01	-5.748E-01	-5.567E-01	-5.759E-01
-5.411E-01	-5.913E-01	-6.926E-01	-7.082E-01	-7.240E-01	-7.814E-01	-7.996E-01	-4.868E-01
-6.870E-01	-9.168E+00						

c3: -4.290E+00	-1.297E+01	-1.301E+01	-1.315E+01	-5.262E+00	-5.310E+00	-5.506E+00	-5.230E+00
-4.741E+00	-4.780E+00	-4.725E+00	-4.605E+00	-4.651E+00	-4.626E+00	-4.615E+00	-4.609E+00
-4.632E+00	-4.843E+00	-4.838E+00	-4.869E+00	-4.849E+00	-4.647E+00	-4.614E+00	-4.602E+00
-4.585E+00	-4.599E+00	-4.591E+00	-4.583E+00	-4.557E+00	-4.517E+00	-4.431E+00	-4.423E+00
-4.387E+00	-4.290E+00	-4.284E+00	-4.243E+00	-4.233E+00	-4.184E+00	-4.134E+00	-4.102E+00
-4.033E+00	-4.000E+00	-3.936E+00	-3.900E+00	-3.883E+00	-3.840E+00	-3.817E+00	-3.809E+00
-3.773E+00	-3.751E+00	-3.731E+00	-3.677E+00	-3.666E+00	-3.620E+00	-3.569E+00	-3.538E+00
-3.455E+00	-3.308E+00	-3.302E+00	-3.251E+00	-3.234E+00	-3.187E+00	-3.172E+00	-3.112E+00
-3.093E+00	-3.018E+00	-2.932E+00	-2.909E+00	-2.858E+00	-2.807E+00	-2.792E+00	-2.725E+00
-2.696E+00	-2.652E+00	-2.472E+00	-2.449E+00	-2.371E+00	-2.353E+00	-2.286E+00	-2.218E+00
-2.205E+00	-2.127E+00	-2.104E+00	-1.998E+00	-1.908E+00	-1.894E+00	-1.826E+00	-1.796E+00
-1.785E+00	-1.732E+00	-1.684E+00	-1.600E+00	-1.597E+00	-1.524E+00	-1.509E+00	-1.468E+00
-1.440E+00	-1.407E+00	-1.351E+00	-1.295E+00	-1.250E+00	-1.227E+00	-1.200E+00	-1.182E+00
-1.170E+00	-1.137E+00	-1.094E+00	-1.083E+00	-1.021E+00	-9.563E-01	-9.226E-01	-8.316E-01
-8.187E-01	-7.730E-01	-7.401E-01	-7.324E-01	-7.299E-01	-7.292E-01	-7.185E-01	-7.117E-01
-7.178E-01	-7.288E-01	-7.166E-01	-6.997E-01	-6.914E-01	-6.572E-01	-6.414E-01	-6.308E-01
-6.512E-01	-6.440E-01	-6.422E-01	-6.009E-01	-5.961E-01	-5.891E-01	-5.593E-01	-5.978E-01
-5.924E-01	-6.062E-01	-6.649E-01	-6.809E-01	-6.973E-01	-7.474E-01	-7.633E-01	-2.578E-01
-3.916E-01	-9.180E+00						
c4: -4.077E+00	-1.291E+01	-1.296E+01	-1.308E+01	-5.653E+00	-5.694E+00	-5.830E+00	-5.280E+00
-4.745E+00	-4.707E+00	-4.658E+00	-4.460E+00	-4.518E+00	-4.497E+00	-4.484E+00	-4.455E+00
-4.476E+00	-4.653E+00	-4.659E+00	-4.730E+00	-4.732E+00	-4.569E+00	-4.550E+00	-4.544E+00
-4.522E+00	-4.531E+00	-4.526E+00	-4.526E+00	-4.496E+00	-4.451E+00	-4.411E+00	-4.407E+00
-4.373E+00	-4.272E+00	-4.266E+00	-4.234E+00	-4.223E+00	-4.193E+00	-4.143E+00	-4.118E+00
-4.048E+00	-4.010E+00	-3.937E+00	-3.896E+00	-3.875E+00	-3.802E+00	-3.779E+00	-3.772E+00
-3.735E+00	-3.714E+00	-3.693E+00	-3.646E+00	-3.637E+00	-3.592E+00	-3.546E+00	-3.518E+00
-3.438E+00	-3.265E+00	-3.258E+00	-3.211E+00	-3.194E+00	-3.153E+00	-3.140E+00	-3.088E+00
-3.072E+00	-3.002E+00	-2.928E+00	-2.905E+00	-2.858E+00	-2.809E+00	-2.796E+00	-2.730E+00
-2.701E+00	-2.654E+00	-2.506E+00	-2.481E+00	-2.387E+00	-2.368E+00	-2.305E+00	-2.243E+00
-2.230E+00	-2.160E+00	-2.140E+00	-2.045E+00	-1.928E+00	-1.911E+00	-1.841E+00	-1.816E+00
-1.806E+00	-1.749E+00	-1.687E+00	-1.587E+00	-1.583E+00	-1.500E+00	-1.484E+00	-1.441E+00
-1.414E+00	-1.388E+00	-1.335E+00	-1.284E+00	-1.239E+00	-1.215E+00	-1.186E+00	-1.166E+00
-1.155E+00	-1.124E+00	-1.082E+00	-1.069E+00	-1.012E+00	-9.487E-01	-9.166E-01	-8.247E-01
-8.091E-01	-7.373E-01	-6.843E-01	-6.545E-01	-6.477E-01	-6.503E-01	-6.451E-01	-6.378E-01
-6.416E-01	-6.368E-01	-6.046E-01	-5.772E-01	-5.655E-01	-5.338E-01	-5.182E-01	-5.067E-01
-5.285E-01	-5.292E-01	-5.438E-01	-5.430E-01	-5.506E-01	-5.615E-01	-5.459E-01	-5.678E-01
-5.506E-01	-5.944E-01	-6.868E-01	-7.142E-01	-7.068E-01	-7.629E-01	-7.763E-01	-1.959E-01
-3.651E-01	-9.069E+00						

Annexe-4: Base des données de ce mémoire.

No	Record	Station	Site	Date	Mw	R(km)	Kh	Kv	Stress Drop (Bar)	Fc Corner freq. Hz	fmax (H) Hz	fmax (V) Hz	Dur (H1) sec	Dur (V) sec	Dur (H2) sec	Arms (H1) m/s	Arms (V) m/s	Arms (H2) m/s	Ea (H1) m2/s3	Ea (V) m2/s3	Ea (H2) m2/s3	PGA (H1) m/sec2	PGA (V) m/sec2	PGA (H2) m/sec2	Vmax (H1) m/sec	Vmax (V) m/sec	Vmax (H2) m/sec	Dmax (H1) m	Dmax (V) m	Dmax (H2) m
1	1012	Kiasar	2	05/11/74	4.5	64							1.53	5.22	1.56	.1400	.0320	.1200	.0340	.0058	.0240	.390	.157	.300						
2	1006-1	Bandarabbas	2	07/03/75	6.1	48							15.04	20.25	11.38	.2300	.1100	.3300	.8700	.2900	1.400	.863	.417	1.287	.0629	.0329	.0847			
3	1006-2	Bandarabbas	2	07/03/75	5.2	40							16.33	16.27	14.43	.0430	.0370	.0530	.0330	.0250	.0450	.167	.125	.260						
4	1007	Minab	1	07/03/75	6.1	80							16.02	17.51	18.23	.0410	.0260	.0350	.0290	.0140	.0250	.217	.094	.168						
5	1008	Gheshm Island	1	07/03/75	6.1	56							25.60	20.13	22.57	.0370	.0360	.0360	.0390	.0280	.0320	.148	.137	.121						
6	1013	Tonkabon	4	13/03/75	4.4	34							5.83	10.53	7.72	.0890	.0210	.0630	.0510	.0051	.0340	.428	.102	.192						
7	1009	Minab	1	12/04/75	4.8	48							11.19	17.34	14.70	.0660	.0200	.0390	.0540	.0074	.0250	.357	.077	.154						
8	1026	Shiraz	4	02/06/75	4.1	60							3.64	3.78	6.71	.0900	.0610	.0370	.0320	.0150	.0100	.505	.286	.251						
9	1014-4	Hajiabad	3	08/10/75	5.4	32							14.53	11.88	15.17	.1800	.1100	.1600	.5300	.1700	.4500	.669	.471	.796						
10	1024	Maraveh-	3	27/12/75	4.6	6							2.76	2.56	2.63	.7400	.3700	.8000	1.7000	.4000	1.900	3.270	1.533	3.595	.0717	.0234	.0968			
11	1034-1	Maku	2	27/02/76	3.9	26							2.38	1.92	2.35	.1300	.0970	.1300	.0430	.0200	.0460	.432	.316	.537	.0119	.0084	.0144			
12	1034-2	Maku	2	02/04/76	4.6	12							.68	2.58	1.88	.6600	.1900	.2900	.3300	.0980	.1800	1.997	.845	1.022						
13	1040-3	Naghan-1	1	05/09/76	4.7	88							1.28	1.58	1.49	.1200	.1400	.1200	.0200	.0320	.0220	.437	.452	.495	.0090	.0170	.0169	.000460	.001400	.001300
14	1043	Ghaen	1	07/11/76	6.4	10	0.240	0.308	262.7	0.35			11.20	7.82	10.58	.3100	.3900	.3500	1.2000	1.3000	1.400	1.150	1.700	1.570	.0110	.0028	.0065			
15	1047-8	Vendik	2	07/11/76	6.4	11							.11	.60	.13	2.800	.4200	2.200	.9800	.1200	.7200	5.117	1.167	4.982	.0742	.0223	.0571			
16	1047-9	Vendik	2	07/11/76	4.8	9							.30	.55	.52	.5800	.2200	.4900	.1100	.0290	.1400	1.750	.674	1.559	.0164	.0053	.0160	.000370	.000234	.000560
17	1047-10	Vendik	2	09/11/76	5.1	5							.66	.58	.71	.2100	.2500	.2500	.0320	.0390	.0510	.602	.920	.978	.0122	.0199	.0066	.000270	.000190	.000680
18	1046-1	Maku	2	24/11/76	7.3	48							16.07	20.10	20.40	.1600	.0690	.1300	.4900	.1000	.3600	.891	.455	.685						
19	1046-2	Maku	2	24/11/76	5.5	47							7.61	9.57	7.02	.1400	.0430	.1300	.1600	.0190	.1300	.718	.212	.408						
20	1049-1	Siah-Cheshmeh	1	06/12/76	4.4	3	0.075	0.027	194.1	1.0			7.05	9.72	7.38	.0880	.0530	.1000	.0610	.0300	.0870	.402	.153	.337						
21	1049-2	Siah-Cheshmeh	1	06/12/76	4.4	19	0.089	0.029	164.7	1.5			6.10	8.74	5.78	.0350	.0190	.0580	.0081	.0036	.0220	.119	.082	.166						
22	1049-3	Siah-Cheshmeh	1	12/12/76	4.8	14	0.075		116.6	1.5			6.11	8.35	6.42	.0260	.0150	.0380	.0046	.0020	.0110	.081	.053	.134						
23	1050-1	Bandarabbas	2	21/03/77	7.0	52							21.56	27.32	17.98	.2200	.1100	.3000	1.2000	.3700	1.700	.973	.379	1.504	.0556	.0275	.0768			
24	1052	Gheshm-Island	1	21/03/77	7.0	71							7.75	7.44	7.55	.0750	.0520	.0740	.0490	.0220	.0460	.184	.149	.266						
25	1054-1	Naghan-1	1	06/04/77	6.1	7							2.78	3.18	2.70	2.500	1.600	1.900	19.000	8.8000	11.00	7.200	5.200	6.150	.4600	.5400	.3800	.010000	.010200	.003200
26	1055	Farsan	1	06/04/77	6.1	32							14.00	12.59	13.59	.0490	.0280	.0560	.0370	.0110	.0480	.155	.093	.180						
27	1058	Dastgerd	2	06/04/77	6.1	18							3.95	5.08	4.16	.2300	.1300	.2300	.2200	.1000	.2500	.981	.493	.816						
28	1059	Ardal	4	06/04/77	6.1	21							1.62	5.32	3.02	.1800	.0480	.1300	.0600	.0130	.0540	.685	.477	.623						
29	1056-5	Naghan-1	1	12/04/77	4.9	15							.44	2.41	1.75	.1800	.0420	.0790	.0150	.0047	.0120	.649	.219	.370	.0072	.0059	.0084			
30	1060-2	Naghan-1	1	04/05/77	4.8	20	0.016	0.029	164.7	1.5	18.0	18.0	3.21	2.64	5.02	.0340	.0510	.0310	.0040	.0076	.0054	.127	.168	.159						
31	1080-8	Naghan-1	1	21/10/77	5.0	19	0.032	0.038	335.5	1.2	8.0	8.0	3.39	5.24	3.06	.2200	.1600	.2900	.1900	.1400	.2900	1.056	.780	1.587						
32	1092-1	Aghajari	2	31/03/78	4.4	30							2.56	5.90	1.70	.0700	.0210	.1200	.0140	.0028	.0260	.442	.183	.640	.0066	.0028	.0072			
33	1080-10	Naghan-1	1	12/04/78	4.9	15							1.19	1.01	.96	.2400	.3100	.3300	.0780	.1100	.1200	.720	1.019	1.061						
34	1080-11	Naghan-1	1	20/05/78	5.0	28							1.39	1.32	2.64	.1100	.1100	.0670	.0180	.0180	.0130	.513	.572	.360						
35	1080-12	Naghan-1	1	11/08/78	4.3	30							.56	1.12	.53	.2800	.1100	.2800	.0500	.0140	.0460	1.171	.417	1.137						
36	1094-1	Kazerun	2	29/08/78	4.9	12							7.63	7.05	4.71	.0840	.0390	.1700	.0600	.0120	.1600	.408	.160	.826						
37	1082-1	Deyhuk	1	16/09/78	7.4	36							34.01	30.20	34.91	.4900	.3600	.5000	9.0000	4.2000	9.700	3.204	1.618	3.757	.1758	.1183	.2400	.040002	.027052	.059408
38	1083-1	Boshruyeh	1	16/09/78	7.4	64							21.58	24.34	22.56	.2700	.2100	.2600	1.7000	1.2000	1.700	.980	.870	.940	.0980	.0760	.1140	.001900	.001600	.002300
39	1084-1	Tabas	1	16/09/78	7.4	27							16.56	14.88	18.30	1.900	1.400	1.800	66.000	32.000	66.00	11.030	8.480	8.410	1.1300	.3600	.9700	.900000	.120000	.355000
40	1086	Bajestan	3	16/09/78	7.4	140							27.64	31.10	26.36	.1500	.0470	.1500	.7000	.0750	.6800	.795	.159	.581	.0457	.0145	.0318			
41	1090-2	Kashmar	3	16/09/78	7.4	234							29.66	25.52	27.62	.1100	.0780	.1200	.3700	.1700	.4600	.321	.246	.394						
42	1082-6	Deyhuk	1	17/09/78	4.7	53							.97	2.34	1.04	.1700	.0740	.1300	.0310	.0140	.0210	.676	.390	.440						
43	1103-1	Tabas	1	24/09/78	4.5	22							3.59	4.88	2.39	.0560	.0360	.0890	.0120	.0070	.0210	.226	.301	.421	.0048	.0033	.0077			
44	1104-2	Deyhuk	1	24/09/78	4.5	42							.76	3.79	5.26	.1700	.0450	.0550	.0260	.0086	.0180	.500	.280	.355	.0204	.0069	.0164			
45	1093-2	Khonj	1	12/10/78	4.2	75	0.046	0.024	555.	7.0	11.0	18.0	3.69	4.67	4.30	.0570	.0480	.0660	.0130	.0120	.0210	.323	.188	.234						
46	1103-3	Tabas	1	12/10/78	4.9	20							3.50	8.28	2.67	.1400	.0530	.2200	.0770	.0250	.1500	.659	.343	1.052	.0167	.0066	.0308			
47	1098-3	Talesh	3	04/11/78	6.2	20							4.38	5.42	4.20	.1100	.0720	.1000	.0570	.0310	.0470	.556	.287	.517	.0140	.0072	.0127			
48	1096-1	Naghan-1	1	14/12/78	6.1	5							.57	.78	.88	.2600	.2500	.2600	.0440	.0540	.0630	.710	.754	.807	.0110	.0108	.0452			
49	1096-2	Naghan-1	1	14/12/78	4.7	5							1.87	1.98	.26	.0480	.0440	.3000	.0047	.0043	.0270	.252	.226	.668	.0030	.0030	.0077			
50	1097-2	Naghan-2	1	14/12/78	4.7	5							.22	.75	3.91	.3300	.1300	.0430	.0270	.0140	.0081	.812	.454	.359	.0091	.0138	.0052			
51	1103-9	Tabas	1	26/12/78	4.5	21							4.42	5.86	4.24	.0590	.0410	.1100	.0170	.0110	.0600	.277	.176	.853	.0057	.0048	.0166			
52	1102	Bajestan	3	16/01/79	6.8	135							7.88	10.32	10.43	.1300	.0350	.0930	.1400	.0140	.1000	.375	.151	.278						
53	1106	Sedeh	3	16/01/79	6.8	80							17.33	13.34	15.20	.0820	.0770	.1000	.1300	.0880	.1700	.353	.384	.466						
54	1107	Khezri	1	16/01/79	6.8	61							13.59	18.51	13.16	.0680	.0450	.0820	.0700	.0420	.0990	.276	.165	.362						
55	1109	Gonabad	4	16/01/79	6.8	86							15.98	20.62	12.30	.0610	.0360	.0860	.0660	.0300	.1000	.221	.193	.314						
56	1113	Khaf	2	16/01/79	6.8	80							11.85	21.73	13.86	.1800	.0640	.1500	.4100	.1000	.3300	.689	.304	.663						

No	Record	Station	Site	Date	Mw	R(km)	Kh	Kv	Stress Drop (Bar)	Fc Corner freq. Hz	fmax (H) Hz	fmax (V) Hz	Dur (H1) sec	Dur (V) sec	Dur (H2) sec	Arms (H1) m/s	Arms (V) m/s	Arms (H2) m/s	Ea (H1) m2/s3	Ea (V) m2/s3	Ea (H2) m2/s3	PGA (H1) m/sec2	PGA (V) m/sec2	PGA (H2) m/sec2	Vmax (H1) m/sec	Vmax (V) m/sec	Vmax (H2) m/sec	Dmax (H1) m	Dmax (V) m	Dmax (H2) m
57	1103-11	Tabas	1	17/01/79	5.1	16							6.10	7.43	5.52	.1200	.1000	.2000	.1000	.0840	.2400	.553	.459	.780						
58	1103-12	Tabas	1	13/02/79	5.5	55							10.01	11.30	9.94	.1100	.0760	.1300	.1300	.0730	.1900	.858	.419	.872	.0186	.0084	.0254			
59	1125-2	Aghajari	2	28/03/79	5.1	25							3.14	3.20	1.44	.1100	.0920	.2200	.0460	.0300	.0810	.608	.476	.790						
60	1117	Sedeh	3	14/11/79	6.6	96							20.90	25.88	23.09	.0510	.0270	.0510	.0590	.0210	.0660	.281	.124	.208						
61	1118	Ghaen	1	14/11/79	6.6	55							11.28	10.35	10.05	.0790	.0800	.1200	.0770	.0750	.1500	.313	.319	.420						
62	1121	Khaf	2	14/11/79	6.6	72							16.91	21.67	17.17	.1800	.0910	.1900	.5800	.2000	.6800	.734	.370	.744						
63	1124	Roshtkhar	1	14/11/79	6.6	116							14.40	21.11	17.11	.0470	.0330	.0380	.0350	.0260	.0270	.166	.126	.140						
64	1130-2	Kashmar	3	14/11/79	6.6	184							13.18	14.40	14.15	.0660	.0390	.0740	.0650	.0240	.0850	.262	.119	.261						
65	1132-1	Ferdows	1	14/11/79	6.6	132							25.45	28.40	23.03	.0660	.0410	.0800	.1200	.0530	.1600	.245	.166	.297						
66	1143-1	Khaf	2	23/11/79	5.0	69							10.84	10.01	10.93	.0450	.0270	.0490	.0250	.0082	.0290	.187	.104	.212						
67	1131	Torbat-Heydarieh	3	27/11/79	7.1	160							23.89	29.51	25.14	.1400	.0630	.1200	.5000	.1300	.3800	.465	.284	.372						
68	1134-2	Bajestan	3	27/11/79	7.1	152							12.26	22.12	12.92	.2900	.0900	.2700	1.1000	.2000	1.100	1.158	.374	.947						
69	1135	Kakhk	1	27/11/79	7.1	88							17.68	19.84	19.78	.1200	.0710	.0780	.3100	.1100	.1300	.478	.284	.308						
70	1137	Birjand	1	27/11/79	7.1	136							17.84	30.66	18.35	.0980	.0400	.0850	.1900	.0540	.1500	.278	.121	.244	.0402	.0218	.0486			
71	1138-1	Sedeh	3	27/11/79	7.1	80							20.86	24.51	20.52	.1700	.0730	.1700	.6700	.1500	.6300	.836	.357	.761						
72	1139	Ghaen	1	27/11/79	7.1	44	0.028	0.027	327.4	0.15	6.0	8.0	11.44	16.16	13.70	.4000	.2800	.3300	2.0000	1.4000	1.700	1.968	1.193	1.339	.1092	.0928	.0847	.018558	.010384	.012059
73	1140-1	Khezri	1	27/11/79	7.1	80							14.84	21.73	15.44	.1900	.1300	.1900	.6100	.4000	.6400	.721	.516	.774						
74	1141-1	Taybad	4	27/11/79	7.1	120							27.44	38.47	26.20	.1900	.0800	.2000	1.1000	.2700	1.200	.780	.356	.688						
75	1142-1	Gonabad	4	27/11/79	7.1	92							17.30	23.74	17.82	.1700	.1300	.2000	.5900	.4300	.8100	.739	.611	.895						
76	1143-2	Khaf	2	27/11/79	7.1	64							27.11	29.26	27.56	.3300	.1800	.3300	3.3000	1.0000	3.400	1.286	.762	1.526						
77	1143-3	Khaf	2	27/11/79	4.6	40							17.08	19.51	17.77	.0740	.0420	.0730	.1000	.0380	.1000	.344	.185	.324	.0127	.0096	.0134			
78	1144-2	Roshtkhar	1	27/11/79	7.1	108							24.35	28.41	22.42	.0930	.0970	.1100	.2400	.3000	.3100	.405	.384	.538						
79	1145	Torbat-Jam	1	27/11/79	7.1	160							14.35	27.64	13.34	.1000	.0540	.1100	.1700	.0890	.1700	.434	.183	.317	.0571	.0320	.0423			
80	1143-4	Khaf	2	28/11/79	4.7	29							10.19	10.03	10.19	.1200	.1300	.1200	.1500	.0260	.1800	.646	.206	.609						
81	1136-2	Tabas	1	02/12/79	4.8	12	0.036	0.037	390.2	2.0	10.0	10.0	3.00	7.30	5.07	.2300	.0690	.1700	.1700	.0390	.1600	.865	.341	.706						
82	1136-3	Tabas	1	12/01/80	5.9	26					8.0	8.0	8.60	11.78	8.72	.2800	.1500	.3600	.7400	.3100	1.300	1.487	.659	1.938						
83	1151	Rudsar	4	13/01/80	5.0	16							10.26	7.12	7.10	.1600	.1800	.2300	.2900	.2500	.4300	.911	.914	1.052	.0389	.0277	.0433			
84	1149	Khorramabad	2	31/03/80	4.6	4	0.120	0.069	69.5	2.0			3.85	5.11	5.24	.1200	.0370	.0850	.0590	.0076	.0420	.508	.137	.303						
85	1182	Sarbaz	2	11/08/80	4.6	16							3.81	4.23	4.42	.1600	.0820	.1000	.1100	.0320	.0510	.682	.397	.486	.0198	.0096	.0126			
86	1160	Boroujerd	3	15/09/80	4.4	20							1.78	2.27	2.16	.2800	.2300	.3000	.1600	.1400	.2200	.731	.616	.763						
87	1153-1	Kushk-Nosrat	1	19/12/80	5.8	62							14.40	13.24	14.21	.0450	.0330	.0380	.0330	.0160	.0230	.139	.130	.129						
88	1168	Kerman	4	11/06/81	6.7	72							15.95	16.75	16.43	.0960	.0520	.0820	.1600	.0500	.1200	.328	.198	.310						
89	1169	Rayen	1	11/06/81	6.7	40							21.28	23.26	17.84	.0720	.0720	.0880	.1200	.1300	.1500	.250	.370	.370	.0280	.0220	.0260	.005800	.006600	.004300
90	1172-6	Golbaf	3	11/06/81	6.7	20							8.07	6.77	5.74	.0630	.0710	.0830	.0360	.0380	.0440	.348	.285	.503						
91	1179	Bam	1	11/06/81	6.7	114							41.46	42.92	44.02	.0790	.0590	.0870	.2800	.1700	.3700	.330	.210	.220	.0270	.0170	.0235	.004900	.003100	.005100
92	1174	Kerman	4	28/07/81	7.1	48							21.68	20.33	18.85	.2100	.1500	.2000	1.1000	.4900	.8500	1.002	.525	1.000	.0656	.0276	.0685			
93	1176-5	Golbaf	3	28/07/81	7.1	12							28.82	27.74	24.52	.4900	.3600	.5800	7.7000	4.1000	9.300	1.980	2.040	2.160	.1350	.0840	.1750			
94	1176-25	Golbaf	3	29/07/81	4.4	16	0.036	0.040	135.7	2.5	8.0	11.0	5.63	5.29	3.93	.0440	.0410	.0570	.0120	.0098	.0140	.178	.181	.213	.0045	.0023	.0083			
95	1183-6	Golbaf	3	10/08/81	4.1	46	0.049	0.079	49.2	2.0	10.0	11.0	5.82	5.57	5.96	.0370	.0300	.0360	.0088	.0057	.0085	.136	.102	.153						
96	1183-8	Golbaf	3	20/08/81	4.6	16	0.066	0.029	372.4	3.5	8.0	11.0	1.62	3.97	2.08	.2100	.0750	.2200	.0790	.0250	.1100	.582	.341	1.103	.0196	.0045	.0270			
97	1191-3	Golbaf	3	07/01/82	4.1	12	0.042	0.019	382.3	2.5	5.0	11.0	4.59	5.30	3.56	.1100	.0710	.2400	.0650	.0300	.2300	.454	.318	.782	.0148	.0088	.0328			
98	1191-4	Golbaf	3	21/01/82	4.4	18	0.020	0.078	96.1	2.5	8.0	10.0	4.02	6.70	3.44	.0480	.0220	.0460	.0100	.0037	.0082	.274	.093	.175						
99	1191-5	Golbaf	3	30/01/82	4.4	18	0.038	0.037	45.9	1.1	8.0	10.0	6.84	4.41	3.20	.0450	.0560	.1000	.0150	.0150	.0370	.253	.245	.511	.0042	.0034	.0084			
100	1195	Doroud	4	01/09/82	4.9	25							3.54	3.49	4.33	.0860	.0670	.0620	.0290	.0170	.0180	.294	.311	.306	.0112	.0074	.0069	.000570	.000273	.000423
101	1220-1	Farrashband	1	01/06/83	4.3	63							9.60	8.66	8.64	.0370	.0330	.0450	.0140	.0110	.0200	.206	.150	.201						
102	1211-1	Gilvan	1	22/07/83	5.6	20							7.11	7.34	4.88	.0520	.0390	.0690	.0210	.0130	.0250	.302	.353	.325						
103	1211-2	Gilvan	1	23/07/83	4.4	15							7.23	9.06	5.57	.0370	.0210	.0410	.0110	.0046	.0100	.220	.131	.153						
104	1214-1	Shalamzar	3	17/08/83	4.9	16							1.71	1.52	1.75	.4700	.3100	.3300	.4200	.1600	.2100	1.581	1.213	1.208	.0447	.0282	.0333	.001422	.001305	.001865
105	1216-1	Ardal	3	17/08/83	4.9	26							7.00	6.12	7.37	.1100	.0880	.1100	.0860	.0530	.0930	.527	.400	.610	.0154	.0071	.0172	.000697	.000324	.000749
106	1216-2	Ardal	3	28/08/83	4.5	29							9.27	6.55	6.05	.0480	.0380	.0700	.0230	.0110	.0320	.182	.128	.211						
107	1218	Tonkabon	4	20/12/83	4.8	16							6.73	7.39	4.69	.1000	.0790	.1900	.0750	.0510	.1800	.485	.340	.703	.0143	.0069	.0304	.000523	.000248	.001325
108	1224-3	Ardal	3	01/06/84	5.0	10							6.48	7.65	5.62	.1800	.0960	.2300	.2400	.0780	.3400	.538	.417	.756						
109	1226-2	Shalamzar	3	01/06/84	5.0	16							2.96	2.07	2.12	.8600	.7500	.7300	2.5000	1.3000	1.300	3.400	2.487	2.493	.0962	.0602	.0944	.003816	.001935	.004408
110	1233-2	Naghan-1	1	01/06/84	5.0	10							2.85	3.04	2.09	.3600	.3700	.5300	.4100	.4700	.6500	1.263	1.362	1.868	.0288	.0319	.0651	.001161	.001463	.004446
111	1228-2	Khoy	3	29/06/84	4.6	7							4.93	9.61	8.32	.0210	.0096	.0150	.0025	.0010	.0021	.060	.050	.040						

No	Record	Station	Site	Date	Mw	R(km)	Kh	Kv	Stress Drop (Bar)	Fc Corner freq. Hz	fmax (H) Hz	fmax (V) Hz	Dur (H1) sec	Dur (V) sec	Dur (H2) sec	Arms (H1) m/s	Arms (V) m/s	Arms (H2) m/s	Ea (H1) m2/s3	Ea (V) m2/s3	Ea (H2) m2/s3	PGA (H1) m/sec2	PGA (V) m/sec2	PGA (H2) m/sec2	Vmax (H1) m/sec	Vmax (V) m/sec	Vmax (H2) m/sec	Dmax (H1) m	Dmax (V) m	Dmax (H2) m
112	1240-4	Ghir	3	02/02/85	4.5	18							4.29	3.28	5.38	.0390	.0250	.0290	.0071	.0023	.0051	.233	.107	.197						
113	1240-6	Ghir	3	02/02/85	5.2	7							3.27	4.43	3.75	.3400	.1500	.2600	.4200	.1100	.2800	1.852	.802	1.552	.0183	.0091	.0127			
114	1247-1	Avaj	1	09/05/85	3.1	9	0.062	0.047	83.2	3.0	11.0	15.0	2.29	2.96	4.07	.1300	.0800	.0580	.0430	.0210	.0150	.645	.309	.303	.0115	.0045	.0051			
115	1291-1	Kazerun	2	12/07/86	5.7	45							5.86	7.53	5.75	.0760	.0270	.0690	.0380	.0061	.0300	.330	.105	.264						
116	1308	Bandar-lengeh	3	09/08/86	5.1	23							5.88	6.61	5.05	.1100	.0690	.1800	.0800	.0350	.1800	.366	.271	.656	.0151	.0087	.0211	.000590	.000500	.000985
117	1289-1	Noorabad-Mamassani	3	10/10/86	4.3	32							5.34	10.01	7.05	.0780	.0260	.0610	.0370	.0076	.0290	.275	.123	.278						
118	1289-3	Noorabad-Mamassani	3	10/10/86	4.9	32							4.96	7.97	5.87	.2600	.0860	.2200	.3600	.0650	.3100	1.014	.497	.788	.0220	.0087	.0245	.000575	.000263	.000920
119	1289-2	Noorabad-Mamassani	3	18/10/86	4.9	13							6.52	9.01	7.49	.1500	.0660	.1100	.1700	.0440	.1100	.644	.294	.445	.0158	.0051	.0140	.000449	.000117	.000415
120	1289-4	Noorabad-Mamassani	3	20/11/86	5.2	24							7.44	14.30	8.14	.2300	.0740	.2000	.4400	.0870	.3600	1.004	.494	.608	.0250	.0066	.0168	.000757	.000189	.000596
121	1289-5	Noorabad-Mamassani	3	20/12/86	5.5	24							7.80	12.30	11.69	.0850	.0340	.0450	.0630	.0160	.0270	.365	.147	.208	.0080	.0029	.0028			
122	1311-1	Old Lar	1	16/01/87	4.5	16							7.38	7.91	8.60	.0760	.0670	.0680	.0470	.0390	.0440	.320	.282	.353	.0070	.0053	.0053	.000189	.000110	.000125
123	1311-2	Old Lar	1	19/01/87	4.0	24							7.86	7.19	6.68	.0390	.0340	.0490	.0140	.0095	.0180	.171	.147	.331						
124	1319-1	Naghan-2	1	20/01/87	4.6	4	0.046	0.041	41.4	1.5	20.0	20.0	2.23	1.91	2.74	.1700	.1900	.1300	.0760	.0800	.0530	1.174	.914	.648	.0175	.0156	.0155	.000890	.000684	.000899
125	1320-2	Naghan-1	1	20/01/87	4.6	6							1.43	1.26	1.10	.1900	.2300	.2900	.0570	.0760	.1000	.643	.832	1.062	.0141	.0114	.0232	.000664	.000354	.000825
126	1319-2	Naghan-2	1	12/03/87	4.3	64							.88	1.25	1.42	.3300	.2000	.2000	.1100	.0560	.0610	1.132	.662	.684	.0234	.0123	.0158	.000775	.000493	.000977
127	1305	Kuhbanan	3	11/04/87	5.0	4							4.69	7.69	4.54	.2500	.0950	.2300	.3300	.0780	.2600	1.009	.488	.733	.0393	.0142	.0257	.001783	.000638	.001193
128	1307	Sirch	1	22/04/87	4.6	24							3.17	3.85	3.91	.1000	.0630	.1000	.0370	.0170	.0460	.535	.311	.580	.0137	.0057	.0083	.000443	.000233	.000309
129	1303	Bostan-abad	4	22/07/87	4.2	10							5.20	5.57	6.09	.3400	.1200	.2200	.6900	.0850	.3300	1.286	.322	.796	.0582	.0141	.0353	.003016	.000703	.001842
130	1300-1	Birjand	1	24/11/87	5.3	8							8.07	9.28	7.48	.1700	.1500	.1600	.2500	.2200	.2200	.642	.477	.492	.0484	.0335	.0296	.005998	.005025	.003816
131	1300-3	Birjand	1	27/11/87	4.7	20							9.03	9.67	8.06	.0330	.0330	.0340	.0110	.0120	.0110	.097	.115	.107						
132	1351	Tehran (Sharif University)	1	20/06/90	7.3	210							14.51	11.66	12.76	.0250	.0470	.0300	.0097	.0280	.0130	.105	.251	.116						
133	1353	Ghazvin	3	20/06/90	7.3	76							18.04	26.46	24.50	.3600	.2200	.2900	2.6000	1.4000	2.300	1.860	.900	1.340	.1540	.0760	.1170	.039000	.028000	.030000
134	1354	Abhar	4	20/06/90	7.3	80							22.73	23.61	19.13	.3800	.1700	.5900	3.7000	.8000	7.400	1.282	.728	1.906						
135	1355	Rudsar	4	20/06/90	7.3	68							29.06	27.86	27.28	.2300	.1600	.2100	1.7000	.7600	1.400	.892	.737	.688	.1000	.0473	.0884			
136	1357-1	Lahijan	4	20/06/90	7.3	96							33.96	32.62	27.72	.2700	.1800	.4600	2.8000	1.2000	6.600	1.080	.750	1.760	.1350	.0730	.3630	.071000	.041500	.155000
137	1359	Tonkabon	4	20/06/90	7.3	100							18.40	24.69	26.25	.3000	.0700	.2100	1.9000	.1300	1.200	1.173	.303	.727						
138	1360	Manjil	2	20/06/90	7.3	12	0.049	0.029	194.1	1.0	10.0	18.0	1.61	2.23	1.83	1.500	.4900	1.100	3.8000	.5900	2.400	4.382	1.712	3.958	.0937	.0389	.0941			
139	1361	Gachsar	3	20/06/90	7.3	176							32.43	33.47	33.27	.1200	.0730	.1600	.4800	.2000	.9700	.499	.388	.951						
140	1362-1	Abbar	1	20/06/90	7.3	40							31.92	35.96	35.06	.8300	.9100	.5900	25.000	14.000	33.00	5.260	5.480	5.030	.3800	.4840	.4360	.163000	.204000	.203000
141	1363-1	Kahrizak	4	20/06/90	7.3	224							15.14	14.58	15.14	.1400	.0830	.1400	.3500	.1100	.3500	.460	.280	.350	.0710	.0280	.0600	.015000	.007000	.015000
142	1364	Zanjan	1	20/06/90	7.3	80							35.84	40.92	39.96	.2100	.1100	.1500	1.8000	.5700	1.00	1.250	.510	.600	.1460	.0510	.0950	.063000	.039000	.040000
143	1365	Ardebil	4	20/06/90	7.3	195							8.28	8.98	9.02	.1100	.0500	.0880	.1000	.0250	.0770	.300	.150	.290	.0350	.0290	.0260	.006600	.005700	.004900
144	1366	Tehran (Chizar)	1	20/06/90	7.3	212							17.92	14.74	18.58	.0440	.0480	.0380	.0390	.0370	.0290	.140	.189	.133						
145	1369	Rudshur	4	20/06/90	7.3	198							14.42	12.10	13.84	.1000	.1000	.1400	.1800	.1500	.2900	.400	.320	.440	.0420	.0480	.0620	.008800	.013000	.016000
146	1370-2	Robat-Karim	1	20/06/90	7.3	207							16.20	15.74	17.52	.0290	.0590	.0390	.0150	.0600	.0290	.130	.190	.170	.0068	.0124	.0105	.001300	.001600	.001500
147	1371-2	Karaj	1	20/06/90	7.3	177							11.84	13.94	13.96	.0950	.0440	.0370	.1200	.0300	.0220	.350	.130	.120	.0350	.0150	.0140	.005900	.002500	.002400
148	1372	Eshtehard	4	20/06/90	7.3	140							26.64	33.74	22.60	.1600	.0900	.1700	.7800	.3000	.7600	.720	.440	.770	.0610	.0250	.0600	.010500	.005700	.012200
149	1352	Tehran (BHRC)	1	20/06/90	7.3	209							8.85	8.81	8.55	.0690	.0340	.0740	.0470	.0110	.0520	.271	.146	.209						
150	1357-2	Lahijan	4	26/06/90	4.2	45							9.00	9.70	9.01	.0290	.0220	.0350	.0083	.0050	.0120	.111	.237	.135						
151	1393-2	Abbar	1	26/06/90	4.2	99							1.45	2.02	1.92	.1400	.0460	.0850	.0310	.0047	.0150	.388	.165	.248						
152	1393-4	Abbar	1	28/06/90	4.8	24							4.22	3.30	4.45	.0970	.1300	.0890	.0440	.0600	.0390	.601	.698	.470	.0174	.0117	.0128	.000609	.000227	.000314
153	1367	Manjil	2	29/06/90	4.4	75							2.56	5.97	2.34	.0410	.0240	.0540	.0049	.0039	.0077	.322	.257	.341	.0040	.0042	.0064	.000093	.000088	.000152
154	1368-1	Rudbar	3	29/06/90	4.4	8							1.58	1.58	.90	.2700	.2100	.4500	.1300	.0740	.2100	.841	.869	1.150	.0173	.0129	.0308	.000594	.000329	.001034
155	1368-2	Rudbar	3	29/06/90	4.5	38							4.46	5.11	6.06	.0520	.0220	.0320	.0140	.0027	.0070	.243	.132	.183						
156	1393-7	Abbar	1	29/06/90	4.5	36							4.28	10.87	2.90	.1000	.0280	.1100	.0480	.0093	.0390	.422	.185	.522						
157	1368-5	Rudbar	3	01/07/90	4.6	20							1.46	7.37	4.39	.1800	.0400	.0750	.0510	.0130	.0270	.738	.303	.458	.0076	.0031	.0062	.000155	.000068	.000154
158	1393-9	Abbar	1	01/07/90	4.7	20							.77	11.22	1.95	.1600	.0210	.0870	.0230	.0055	.0160	.374	.162	.320						
159	1368-8	Rudbar	3	02/07/90	4.4	15							1.87	3.06	1.72	.1000	.0360	.0950	.0220	.0044	.0170	.677	.203	.423						
160	1377-1	Manjil	2	06/07/90	5.3	20	0.040	0.048	58.5	1.5	10.0	15.0	2.60	6.40	3.94	.4100	.1300	.3300	.4900	.1100	.4800	1.636	.783	1.919	.0595	.0166	.0914	.005238	.001002	.004269
161	1382-1	Rudbar	3	06/07/90	5.2	16							.85	7.07	2.55	.2300	.0210	.1000	.0490	.0036	.0280	.437	.161	.331						

No	Record	Station	Site	Date	Mw	R(km)	Kh	Kv	Stress Drop (Bar)	Fc Corner freq. Hz	fmax (H) Hz	fmax (V) Hz	Dur (H1) sec	Dur (V) sec	Dur (H2) sec	Arms (H1) m/s	Arms (V) m/s	Arms (H2) m/s	Ea (H1) m2/s3	Ea (V) m2/s3	Ea (H2) m2/s3	PGA (H1) m/sec2	PGA (V) m/sec2	PGA (H2) m/sec2	Vmax (H1) m/sec	Vmax (V) m/sec	Vmax (H2) m/sec	Dmax (H1) m	Dmax (V) m	Dmax (H2) m
162	1382-2	Rudbar	3	06/07/90	4.2	45							4.27	4.44	5.07	.0650	.0300	.1100	.0200	.0045	.0640	.246	.132	.390						
163	1377-2	Manjil	2	08/07/90	4.3	24							2.85	5.32	3.32	.2100	.0620	.1500	.1300	.0230	.0890	1.049	.345	.586	.0316	.0121	.0175	.001757	.000633	.000730
164	1382-8	Rudbar	3	24/07/90	4.5	7							1.02	3.51	2.08	.0660	.0160	.0420	.0049	.0010	.0041	.151	.075	.100						
165	1382-11	Rudbar	3	06/08/90	4.5	40							1.05	1.57	1.53	.2800	.0980	.3100	.0890	.0170	.1600	.647	.314	.588						
166	1397-8	Manjil	2	23/08/90	4.4	28	0.048	0.024	390.4	2.0	8.0	8.0	5.40	7.21	10.01	.1100	.0430	.0840	.0790	.0150	.0780	.582	.186	.553	.0125	.0030	.0100			
167	1449	Ahar	4	24/09/90	4.6	84							3.36	3.28	2.98	.0370	.0250	.0330	.0051	.0023	.0035	.170	.150	.175	.0041	.0024	.0028	.000100	.000043	.000090
168	1420-1	Rudbar	3	23/08/91	4.4	16	0.028	0.057	139.7	3.0			.65	1.17	1.10	.0790	.0360	.0740	.0045	.0017	.0067	.222	.149	.238	.0041	.0027	.0046	.000088	.000048	.000106
169	1420-2	Rudbar	3	28/11/91	5.6	26							.73	2.59	1.21	.3200	.0340	.2800	.0860	.0033	.1100	.675	.136	.669	.0153	.0028	.0150	.000408	.000071	.000419
170	1512-1	Sedeh	3	01/01/94	4.5	16	0.075	0.061	251.6	2.5			5.51	4.19	2.49	.0890	.1200	.1000	.0480	.0720	.0280	.435	.650	.438	.0175	.0359	.0106	.001217	.005974	.000998
171	1505	Sefidabeh (Microwave)	1	01/03/94	4.4	24	0.086	0.040	98.1	2.0	10.0	10.0	7.02	8.02	6.80	.0210	.0130	.0240	.0033	.0015	.0043	.088	.093	.134	.0026	.0016	.0037	.000141	.000120	.000302
172	1504-1	Sefidabeh (School)	2	01/03/94	3.4	16	0.027	0.024	24.15	5.0			3.74	3.56	4.43	.0096	.0084	.0091	.0004	.0003	.0004	.068	.032	.052	.0010	.0007	.0008	.000057	.000039	.000040
173	1491	Kavar	2	08/03/94	5.7	12	0.061	0.037	135.7	2.5	12.0	15.0	3.08	4.77	4.24	.0970	.0420	.0630	.0320	.0093	.0190	.420	.190	.258	.0119	.0035	.0055	.000653	.000114	.000209
174	1492-1	Zarrat	1	08/03/94	4.2	16	0.049	0.066	393.5	4.0	18.0	18.0	5.98	5.61	4.57	.0420	.0270	.0610	.0120	.0046	.0190	.191	.105	.193	.0045	.0028	.0064	.000289	.000114	.000317
175	1503-1	Zanjiran	2	09/03/94	3.8	12	0.034	0.068	193.2	5.0	25.0	30.0	3.60	4.18	4.86	.0590	.0320	.0380	.0140	.0049	.0080	.258	.201	.115	.0043	.0026	.0031	.000115	.000089	.000119
176	1503-2	Zanjiran	2	09/03/94	3.5	12	0.025	0.024	280.9	8.0	30.0	35.0	4.42	3.62	5.10	.0490	.0410	.0380	.0120	.0068	.0084	.191	.230	.176	.0031	.0030	.0031	.000058	.000079	.000091
177	1494-1	Kavar	2	11/03/94	4.3	12	0.029		69.5	2.0	10.0	10.0	3.71	5.09	5.58	.0610	.0250	.0330	.0150	.0035	.0068	.216	.107	.138	.0062	.0019	.0032	.000436	.000119	.000192
178	1500-1	Zanjiran	2	11/03/94	3.5	8	0.018	0.036	280.9	8.0	26.0	30.0	2.74	4.03	3.92	.0510	.0230	.0320	.0079	.0023	.0044	.178	.104	.109	.0029	.0011	.0016	.000080	.000069	.000058
179	1500-2	Zanjiran	2	13/03/94	3.2	8	0.023	0.018	142.0	9.0	28.0	30.0	2.90	3.16	2.87	.0240	.0160	.0280	.0018	.0009	.0024	.095	.078	.166	.0013	.0009	.0022	.000027	.000053	.000064
180	1500-3	Zanjiran	2	14/03/94	4.3	8	0.032	0.037	555.8	4.0	20.0	25.0	3.15	4.05	2.67	.1600	.0740	.2100	.0950	.0250	.1300	.728	.272	.613	.0130	.0055	.0160	.000517	.000269	.000522
181	1492-2	Zarrat	1	17/03/94	4.8	34	0.034	0.053	195.7	2.0	15.0	15.0	7.42	9.80	9.26	.0650	.0290	.0560	.0350	.0092	.0320	.242	.115	.211	.0071	.0055	.0094	.000513	.000572	.000702
182	1500-4	Zanjiran	2	17/03/94	4.8	12	0.042	0.034	270.7	2.5	25.0	30.0	6.02	6.33	5.08	.1600	.0810	.1700	.1800	.0460	.1600	.641	.358	.748	.0239	.0089	.0149	.001804	.000539	.000854
183	1492-3	Zarrat	1	17/03/94	4.6	16	0.160	0.076	195.7	2.0	10.0	15.0	6.67	6.33	5.61	.0450	.0220	.0550	.0150	.0033	.0190	.145	.080	.223	.0048	.0028	.0082	.000378	.000200	.000383
184	1494-2	Kavar	2	17/03/94	4.8	20	0.051	0.115	107.2	1.3	20.0	20.0	8.64	11.06	9.34	.0470	.0310	.0420	.0220	.0120	.0180	.239	.143	.150	.0101	.0052	.0049	.000806	.000536	.000390
185	1494-3	Kavar	2	17/03/94	4.6	12	0.061	0.041	382.3	2.5	12.0	15.0	3.53	4.15	3.09	.1400	.0790	.1600	.0790	.0290	.0910	.516	.387	.472	.0108	.0058	.0110	.000422	.000255	.000337
186	1500-5	Zanjiran	2	17/03/94	4.2	16	0.056	0.051	402.6	4.0	18.0	22.0	3.01	4.18	4.08	.2100	.0760	.1400	.1500	.0270	.0930	1.111	.299	.730	.0202	.0042	.0151	.000530	.000149	.000414
187	1492-4	Zarrat	1	18/03/94	4.4	21	0.140	0.073	60.6	3.0	18.0	18.0	6.20	7.32	6.02	.1100	.0560	.1200	.0850	.0260	.0890	.527	.226	.508	.0130	.0059	.0153	.000707	.000227	.000500
188	1494-4	Kavar	2	18/03/94	4.4	80	0.037	0.038	98.1	2.0	18.0	18.0	9.55	9.63	10.32	.0290	.0230	.0330	.0092	.0057	.0120	.096	.110	.141	.0039	.0024	.0051	.000283	.000273	.000372
189	1500-6	Zanjiran	2	18/03/94	4.4	11	0.054	0.027	198.1	2.5	18.0	22.0	6.72	5.95	5.98	.0840	.0650	.0940	.0530	.0280	.0590	.322	.238	.494	.0079	.0054	.0102	.000324	.000233	.000558
190	1500-7	Zanjiran	2	18/03/94	3.5	8	0.049	0.024	118.5	6.0	25.0	30.0	2.59	3.13	2.31	.0290	.0170	.0480	.0024	.0010	.0058	.099	.061	.198	.0018	.0009	.0032	.000084	.000053	.000121
191	1500-8	Zanjiran	2	19/03/94	4.4	11	0.023	0.039	191.6	2.5	20.0	25.0	7.59	6.72	7.73	.0780	.0590	.0760	.0520	.0260	.0500	.284	.263	.516	.0072	.0063	.0166	.000449	.000389	.001043
192	1500-9	Zanjiran	2	19/03/94	3.1	12	0.028	0.029	136.8	5.0	25.0	30.0	3.27	4.32	3.10	.0320	.0160	.0360	.0037	.0013	.0045	.119	.061	.177	.0019	.0008	.0029	.000090	.000051	.000091
193	1500-10	Zanjiran	2	20/03/94	4.3	12	0.028	0.030	234.5	3.0	20.0	25.0	3.53	3.69	2.07	.0690	.0370	.1000	.0190	.0057	.0240	.277	.141	.351	.0053	.0024	.0062	.000178	.000102	.000186
194	1500-11	Zanjiran	2	20/03/94	4.0	12	0.026	0.029	83.2	3.0	20.0	25.0	7.15	5.43	5.29	.0280	.0270	.0370	.0063	.0045	.0079	.153	.136	.182	.0027	.0018	.0041	.000096	.000075	.000302
195	1500-12	Zanjiran	2	21/03/94	3.8	8	0.031	0.039	140.8	4.5	30.0	35.0	3.22	3.34	3.37	.0710	.0410	.0640	.0180	.0063	.0150	.386	.154	.298	.0050	.0013	.0026	.000133	.000049	.000095
196	1492-5	Zarrat	1	23/03/94	4.7	20	0.037	0.042	660.6	3.0	15.0	15.0	6.32	6.63	5.61	.1000	.0450	.1300	.0720	.0150	.1100	.368	.202	.513	.0108	.0056	.0190	.000684	.000317	.000977
197	1500-13	Zanjiran	2	23/03/94	4.7	8	0.037	0.031	270.7	2.5	15.0	18.0	2.56	3.10	2.72	.1200	.0670	.1500	.0390	.0150	.0730	.408	.247	.475	.0070	.0039	.0085	.000431	.000372	.000330
198	1492-6	Zarrat	1	30/03/94	5.2	24	0.033	0.026	603.9	1.5	15.0	15.0	7.12	9.78	7.00	.5300	.1600	.5800	2.2000	.2900	2.600	2.136	.607	2.443	.0824	.0249	.1327	.005836	.005641	.007782
199	1492-7	Zarrat	1	01/04/94	4.6	32	0.032	0.023	331.2	3.0	15.0	15.0	9.93	10.98	7.82	.0410	.0200	.0570	.0180	.0047	.0280	.184	.067	.174	.0055	.0020	.0067	.000445	.000327	.000557
200	1492-8	Zarrat	1	03/04/94	5.2	24	0.054	0.033	546.8	1.0	11.0	11.0	10.89	12.16	9.10	.1200	.0560	.1600	.1800	.0420	.2400	.578	.212	.487	.0220	.0098	.0272	.002351	.002184	.002721
201	1492-9	Zarrat	1	03/04/94	4.7	26	0.053	0.049	195.7	2.0	10.0	12.0	8.95	10.05	8.99	.0580	.0280	.0580	.0330	.0086	.0330	.198	.098	.220	.0059	.0038	.0076	.000837	.000615	.000646
202	1492-10	Zarrat	1	12/04/94	3.4	14	0.024	0.023	133.3	7.0	20.0	20.0	1.42	1.54	4.75	.0490	.0140	.0072	.0037	.0003	.0003	.201	.062	.052	.0053	.0010	.0014	.000681	.000064	.000165
203	1492-11	Zarrat	1	30/04/94	4.1	23	0.037	0.047	135.7	2.5	10.0	10.0	8.14	6.81	7.85	.0360	.0200	.0340	.0120	.0030	.0099	.124	.094	.103	.0040	.0020	.0043	.000452	.000177	.000273
204	1492-12	Zarrat	1	07/05/94	4.2	20	0.150	0.084	135.7	2.5	10.0	10.0	4.88	5.49	4.43	.0280	.0140	.0340	.0042	.0012	.0058	.153	.066	.166	.0039	.0015	.0044	.000111	.000060	.000196
205	1502-1	Zanjiran	2	20/05/94	4.1	16	0.120	0.041	117.5	3.0	15.0	20.0	4.34	6.51	5.28	.0340	.0130	.0280	.0056	.0012	.0047	.149	.049	.144	.0028	.0013	.0023	.000146	.000103	.000107
206	1502-2	Zanjiran	2	25/05/94	4.3	17	0.100	0.046	396.8	4.5	11.0	15.0	5.47	6.25	5.90	.0730	.0340	.0590	.0320	.0078	.0230	.295	.201	.276	.0052	.0025	.0041	.000210	.000150	.000279
207	1492-13	Zarrat	1	05/06/94	4.8	27	0.053	0.028	328.5	1.5	15.0	15.0	6.35	7.47	5.30	.0800	.0450	.1000	.0450	.0170	.0610	.295	.205	.433	.0110	.0037	.0114	.000390	.000186	.000382
208	1502-4	Zanjiran	2	05/06/94	4.8	10	0.058	0.031	679.3	3.0	25.0	25.0	2.93	3.94	3.45	.4700	.1900	.4700	.7200	.1600	.8300	1.935	.733	1.804	.0386	.0112	.0411	.001756	.000644	.001715
209	1502-3	Zanjiran	2	05/06/94	3.2	12	0.035	0.023	194.8	10.0	25.0	28.0	2.58	2.62	1.25	.0280	.0190	.0570	.0022	.0010	.0045	.112	.081	.235	.0013	.0009	.0024	.000036	.000028	.000073
210	1502-5	Zanjiran	2	06/06/94	4.2	10	0.038	0.034	393.5	4.0	20.0	28.0	2.23	2.83	1.65	.1100	.0510	.1900	.0320	.0083	.0660	.377	.194	.716	.0068	.0025	.0131	.000268	.000131	.000466
211	1492-14	Zarrat	1	11/06/94	4.8	29	0.057	0.033	97.3	1.0	10.0	10.0	9.19	7.67	7.57	.0530	.0380	.0650	.0290	.0130	.0350	.255	.164	.213	.0109	.0086	.0091	.001566	.001098	.001212
212	1502-6	Zanjiran	2	13/06/94	4.8	19	0.037	0.046	382.2	2.5	15.0	20.0	8.10	7.12	8.03	.0850	.0610	.0840	.0640	.0300	.0640	.356	.291	.472	.0104	.0061	.0101	.001022	.000707	.001823
213	1502-7	Zanjiran	2	18/06/94	4.2	20	0.027	0.038	96.1	2.5	18.0	20.0	6.31	6.98	6.25	.0360	.0230	.0380	.0090	.0041	.0098	.143	.114	.178	.0027	.0015	.0037	.000241	.000148	.000284
214	1492-15	Zarrat	1	18/06/94	5.1	21	0.033	0.032	503.2	2.0	10.0	11.0	6.39	9.08	6.80	.2200	.0690	.2100	.3400	.0480	.3400	1.115	.361	.841	.0395	.0103	.0223	.001941	.001189	.002370
215	1493-1	Firouzabad	3	18/06/94	5.1	18	0.041	0.041	48.8	1.0	5.0	6.0	9.61	11.70	10.24	.0290	.0150	.0270	.0087	.0030	.0085	.115	.068	.102	.0050	.0043	.0052	.000734	.000790	.000718

No	Record	Station	Site	Date	Mw	R(km)	Kh	Kv	Stress Drop (Bar)	Fc Corner freq. Hz	fmax (H) Hz	fmax (V) Hz	Dur (H1) sec	Dur (V) sec	Dur (H2) sec	Arms (H1) m/s	Arms (V) m/s	Arms (H2) m/s	Ea (H1) m2/s3	Ea (V) m2/s3	Ea (H2) m2/s3	PGA (H1) m/sec2	PGA (V) m/sec2	PGA (H2) m/sec2	Vmax (H1) m/sec	Vmax (V) m/sec	Vmax (H2) m/sec	Dmax (H1) m	Dmax (V) m	Dmax (H2) m
216	1502-8	Zanjiran	2	20/06/94	5.1	8	0.027	0.027	195.7	2.0	20.0	25.0	7.59	6.88	6.31	.1600	.1200	.2000	.2200	.1100	.2800	.948	.513	.934	.0240	.0163	.0330	.001969	.001352	.002315
217	1492-16	Zarrat	1	20/06/94	5.9	29	0.042	0.034	629.0	1.0	10.0	11.0	7.67	11.09	6.17	.7600	.2500	.8500	4.9000	.7400	4.900	3.058	1.038	2.569	.1108	.0357	.0955	.027484	.004789	.012797
218	1493-2	Firouzabad	3	20/06/94	5.9	17	0.047	0.015	542.4	0.5	6.0	10.0	8.84	10.44	9.26	.5000	.2500	.4100	2.4000	.7400	1.700	2.479	1.201	2.834	.0882	.0524	.0906	.011052	.010747	.011059
219	1495	Maharloo (PTT)	1	20/06/94	5.9	50					8.0	10.0	15.73	14.96	16.20	.0690	.0350	.0500	.0820	.0210	.0450	.221	.124	.198	.0156	.0084	.0140	.002986	.001203	.002859
220	1498	Babanar	2	20/06/94	5.9	63							12.82	15.46	14.11	.0690	.0370	.0700	.0670	.0240	.0770	.286	.153	.393	.0153	.0153	.0156	.003515	.004010	.004309
221	1502-9	Zanjiran	2	20/06/94	5.9	7	0.012	0.036	754.8	1.0	18.0	22.0	5.46	4.32	5.56	2.500	2.400	2.800	39.000	27.000	50.00	10.302	9.492	10.163	.3271	.1618	.4100	.034226	.011762	.026371
222	1492-17	Zarrat	1	20/06/94	4.5	16	0.053	0.015	184.5	2.2	18.0	18.0	9.58	10.60	9.00	.0380	.0190	.0400	.0150	.0042	.0160	.214	.078	.227	.0072	.0020	.0066	.000336	.000099	.000294
223	1492-18	Zarrat	1	20/06/94	4.0	16	0.055	0.056	197.3	4.0	11.0	15.0	5.44	6.43	5.71	.0230	.0120	.0250	.0033	.0010	.0040	.090	.038	.129	.0022	.0008	.0037	.000093	.000045	.000130
224	1493-3	Firouzabad	3	20/06/94	4.3	18	0.050	0.041	135.7	2.5	6.0	8.0	10.14	9.68	10.40	.0340	.0230	.0310	.0130	.0059	.0110	.128	.078	.135	.0043	.0025	.0038	.000254	.000142	.000232
225	1492-19	Zarrat	1	21/06/94	4.5	15	0.046	0.050	191.6	2.5	10.0	12.0	7.32	9.10	8.09	.0450	.0180	.0400	.0160	.0034	.0150	.157	.105	.193	.0051	.0026	.0047	.000276	.000207	.000283
226	1492-20	Zarrat	1	21/06/94	4.7	16	0.040	0.059	525.9	3.5	10.0	15.0	7.57	10.11	8.14	.0690	.0220	.0590	.0400	.0057	.0320	.269	.085	.181	.0090	.0022	.0063	.000543	.000285	.000413
227	1493-4	Firouzabad	3	21/06/94	4.7	18	0.042	0.034	191.6	2.5	7.0	8.0	9.95	10.19	9.31	.0350	.0220	.0320	.0140	.0052	.0110	.129	.090	.109	.0047	.0027	.0036	.000305	.000235	.000209
228	1492-21	Zarrat	1	21/06/94	4.1	18	0.083	0.036	396.8	4.5	18.0	18.0	5.16	5.95	5.53	.0320	.0210	.0370	.0060	.0029	.0084	.159	.095	.157	.0033	.0014	.0028	.000108	.000051	.000072
229	1492-22	Zarrat	1	22/06/94	4.3	15	0.079	0.062	197.3	4.0	10.0	12.0	7.32	7.69	6.41	.0230	.0120	.0270	.0042	.0013	.0053	.111	.046	.106	.0031	.0011	.0031	.000198	.000175	.000192
230	1518-1	Firouzabad	3	22/06/94	3.1	4	0.035	0.030	17.2	5.0	30.0	30.0	.63	1.30	3.55	.1100	.0160	.0110	.0079	.0004	.0005	.359	.073	.084	.0042	.0008	.0010	.000239	.000046	.000061
231	1501-1	Zanjiran	2	23/06/94	3.7	12	0.023	0.021	501.4	8.0	20.0	22.0	1.05	1.87	.80	.2600	.1000	.3300	.0800	.0220	.0990	.842	.374	1.092	.0113	.0037	.0125	.000211	.000062	.000288
232	1501-2	Zanjiran	2	23/06/94	3.1	8	0.031	0.061	70.6	8.0	22.0	25.0	2.06	1.77	1.11	.0340	.0240	.0530	.0026	.0012	.0035	.153	.106	.234	.0018	.0011	.0033	.000041	.000047	.000062
233	1501-3	Zanjiran	2	23/06/94	3.8	12	0.003	0.019	41.7	3.0	22.0	25.0	4.65	5.98	5.10	.0250	.0140	.0230	.0033	.0013	.0030	.197	.065	.168	.0032	.0007	.0030	.000110	.000052	.000107
234	1492-23	Zarrat	1	24/06/94	4.0	20	0.033	0.052	544.3	5.0	10.0	12.0	6.86	7.73	5.95	.0400	.0190	.0480	.0120	.0031	.0150	.155	.082	.189	.0043	.0016	.0043	.000195	.000119	.000196
235	1501-4	Zanjiran	2	24/06/94	4.0	15	0.023	0.021	132.2	3.5	20.0	22.0	7.03	5.82	6.16	.0290	.0250	.0350	.0066	.0040	.0084	.096	.117	.184	.0022	.0021	.0036	.000120	.000141	.000130
236	1501-5	Zanjiran	2	24/06/94	3.7	8	0.031	0.030	182.1	5.5	20.0	22.0	1.29	2.76	.91	.0720	.0240	.1400	.0074	.0018	.0200	.248	.097	.476	.0034	.0009	.0075	.000084	.000047	.000157
237	1501-6	Zanjiran	2	24/06/94	3.6	5	0.021	0.023	49.6	4.0	25.0	30.0	2.47	2.15	2.38	.0450	.0320	.0430	.0054	.0025	.0049	.250	.122	.198	.0039	.0012	.0022	.000128	.000085	.000079
238	1501-7	Zanjiran	2	24/06/94	4.5	8	0.029	0.017	270.6	2.5	22.0	25.0	2.77	2.95	2.06	.2600	.1700	.3100	.2100	.0890	.2100	1.352	.596	1.367	.0286	.0069	.0198	.001587	.000242	.000633
239	1501-8	Zanjiran	2	25/06/94	3.6	12	0.049	0.021	128.9	5.5	20.0	25.0	1.28	2.72	1.34	.0470	.0180	.0430	.0032	.0010	.0028	.154	.073	.214	.0019	.0011	.0039	.000053	.000038	.000070
240	1501-9	Zanjiran	2	25/06/94	4.2	8	0.031	0.021	263.6	3.5	25.0	30.0	1.81	2.89	1.88	.1600	.0610	.1200	.0490	.0120	.0320	.486	.238	.438	.0067	.0026	.0079	.000157	.000082	.000300
241	1523-1	Jovakan	1	06/07/94	3.4	12	0.045	0.039	48.6	5.0	20.0	20.0	3.14	2.60	3.97	.0250	.0200	.0180	.0022	.0011	.0015	.199	.144	.114	.0024	.0013	.0014	.000072	.000063	.000034
242	1523-2	Jovakan	1	07/07/94	4.0	12	0.038	0.025	48.2	2.5	18.0	18.0	5.61	6.69	5.28	.0320	.0190	.0340	.0062	.0027	.0066	.148	.073	.139	.0046	.0012	.0047	.000247	.000083	.000240
243	1523-3	Jovakan	1	07/07/94	3.8	16	0.034	0.038	98.9	4.0	20.0	20.0	4.88	5.51	5.16	.0440	.0270	.0390	.0110	.0045	.0089	.261	.166	.293	.0036	.0024	.0044	.000128	.000095	.000076
244	1523-4	Jovakan	1	09/07/94	4.0	18	0.060	0.053	132.2	3.5	20.0	20.0	2.20	4.61	2.71	.0670	.0280	.0520	.0110	.0041	.0081	.339	.153	.233	.0059	.0016	.0041	.000137	.000082	.000142
245	1519-1	Zarrat	1	10/07/94	3.9	20	0.094	0.053	272.8	5.0	18.0	18.0	5.51	6.67	5.29	.0220	.0110	.0200	.0029	.0009	.0023	.133	.050	.099	.0026	.0009	.0020	.000096	.000063	.000086
246	1523-5	Jovakan	1	10/07/94	3.5	16	0.042	0.040	68.5	5.0	18.0	20.0	4.51	3.67	4.59	.0200	.0170	.0170	.0021	.0012	.0015	.154	.095	.112	.0021	.0008	.0013	.000052	.000040	.000074
247	1518-2	Firouzabad	3	13/07/94	4.2	16	0.035	0.043	96.1	2.5	6.0	10.0	9.54	8.01	8.77	.0210	.0160	.0220	.0048	.0024	.0046	.126	.076	.080	.0027	.0016	.0027	.000123	.000100	.000143
248	1523-6	Jovakan	1	13/07/94	4.2	16	0.054	0.037	49.2	2.0	18.0	18.0	6.28	8.73	6.65	.0500	.0270	.0480	.0180	.0069	.0170	.288	.158	.263	.0066	.0029	.0057	.000231	.000169	.000260
249	1523-7	Jovakan	1	16/07/94	4.3	16	0.040	0.024	555.8	4.0	18.0	18.0	6.23	7.53	6.26	.0200	.0120	.0220	.0029	.0011	.0035	.129	.067	.142	.0027	.0010	.0026	.000116	.000107	.000067
250	1523-9	Jovakan	1	18/07/94	3.8	14	0.054	0.044	24.1	2.5	21.0	21.0	5.92	6.93	4.63	.0440	.0260	.0500	.0130	.0051	.0130	.183	.112	.184	.0035	.0019	.0042	.000142	.000129	.000194
251	1523-10	Jovakan	1	20/07/94	3.7	15	0.027	0.022	70.1	4.0	10.0	10.0	2.76	7.78	3.30	.0250	.0080	.0190	.0020	.0005	.0013	.190	.043	.113	.0028	.0007	.0019	.000089	.000041	.000062
252	1513	Bandar-Torkman	4	23/07/94	5.1	60	0.079		566.2	1.5	5.0	5.0	15.53	18.89	14.53	.0500	.0220	.0610	.0440	.0110	.0590	.181	.083	.279	.0122	.0059	.0164	.003218	.001598	.003368
253	1523-11	Jovakan	1	24/07/94	3.4	12	0.025	0.015	83.9	6.0	21.0	21.0	4.26	3.55	3.02	.0240	.0230	.0350	.0027	.0021	.0042	.129	.180	.224	.0021	.0016	.0032	.000062	.000062	.000110
254	1523-12	Jovakan	1	28/07/94	3.4	12	0.038	0.024	48.6	5.0	21.0	21.0	1.30	3.65	1.21	.0580	.0180	.0580	.0048	.0013	.0045	.307	.114	.260	.0041	.0014	.0031	.000120	.000049	.000086
255	1523-13	Jovakan	1	29/07/94	3.7	12	0.031	0.032	136.8	5.0	28.0	28.0	2.50	9.44	4.51	.0240	.0060	.0110	.0016	.0004	.0006	.183	.049	.088	.0026	.0007	.0011	.000099	.000042	.000059
256	1506-1	Hosseiniyeh-Olia	4	31/07/94	5.6	22	0.046	0.018	603.9	1.2	11.0	18.0	6.57	9.65	6.74	.3200	.1500	.3000	.7600	.2500	.6900	1.821	.993	1.218	.0703	.0219	.0843	.007724	.001142	.005637
257	1525	Karkheh Dam	1	31/07/94	5.6	26	0.054	0.046			8.0	11.0	13.10	13.66	14.57	.0330	.0290	.0290	.0160	.0130	.0140	.136	.152	.132	.0112	.0087	.0100	.003831	.002295	.002766
258	1526-1	Dez Dam	1	31/07/94	5.6	18	0.036	0.026	59.2	0.6	11.0	11.0	7.50	7.82	8.57	.0630	.0720	.0570	.0330	.0450	.0310	.258	.268	.223	.0126	.0230	.0203	.002066	.006643	.005849
259	1526-2	Dez Dam	1	31/07/94	5.2	17	0.042	0.070	24.2	1.0	11.0	11.0	8.07	8.07	8.18	.0140	.0180	.0150	.0018	.0028	.0020	.047	.107	.071	.0025	.0059	.0055	.000403	.001314	.000583
260	1527	Andimeshk	1	31/07/94	5.6	35	0.083	0.081	96.5	0.5	9.0	12.0	14.78	14.09	13.97	.0640	.0550	.0650	.0680	.0480	.0660	.285	.289	.267	.0193	.0113	.0148	.004226	.002889	.002451
261	1506-2	Hosseinieh	4	31/07/94	4.5	20	0.100	0.020	138.6	2.0	9.0	15.0	4.43	7.86	4.88	.0700	.0270	.0560	.0240	.0062	.0170	.498	.130	.319	.0168	.0042	.0107	.001184	.000139	.000488
262	1506-3	Hosseinieh	4	31/07/94	4.3	20	0.051	0.031	69.5	2.0	12.0	18.0	7.80	7.42	4.74	.0220	.0200	.0380	.0043	.0032	.0078	.146	.094	.257	.0038	.0023	.0089	.000372	.000164	.000913
263	1506-4	Hosseinieh	4	31/07/94	5.1	20	0.099	0.044	463.9	1.5	5.0	8.0	4.03	6.09	4.91	.3100	.1100	.2000	.4300	.0760	.2100	1.788	.470	1.244	.0985	.0219	.0574	.013785	.001269	.005944
264	1506-5	Hosseinieh	4	31/07/94	4.7	20	0.037	0.029	116.6	1.5	12.0	18.0	5.80	7.28	7.86	.0620	.0330	.0380	.0250	.0090	.0130	.272	.145	.185	.0113	.0061	.0082	.001291	.000337	.000485
265	1506-6	Hosseinieh	4	31/07/94	3.8	20	0.100	0.016	140.9	4.5	10.0	12.0	4.24	7.20	3.38	.0320	.0140	.0340	.0047	.0016	.0043	.191	.060	.155	.0040	.0018	.0041	.000099	.000059	.000228
266	1506-7	Hosseinieh	4	31/07/94	4.1	18	0.034	0.044	83.2	3.0	15.0	20.0	6.19	7.46	8.57	.0270	.0170	.0140	.0052	.0023	.0019	.118	.075	.084	.0051	.0021	.0024	.000384	.000109	.000262
267	1506-8	Hosseinieh	4	31/07/94	4.3	25	0.074	0.049	234.5	3.0	10.0	12.0	5.05	6.31	4.32	.0610	.0390	.0690	.0210	.0110	.0230	.261	.141	.349	.0088	.0048	.0072	.000606	.000170	.000264
268	1506-9	Hosseinieh	4	31/07/94	4.1	20	0.048	0.046	117.5	3.0	12.0	12.0	2.92	6.20	3.73	.0570	.0220	.0350	.0110	.0032	.0050	.234	.108	.144	.0060	.0017	.0027	.000204	.000067	.000103
269	1520-1	Kavar	2	01/08/94	3.7	12	0.020	0.048	70.1	4.0	20.0	20.0	2.07	2.55	2.49	.0370	.0230	.0270	.0031	.0015	.0020	.169	.106	.117	.0023	.0012	.0017	.000105	.000042	.000053
270	1506-10	Hosseinieh	4	02/08/94	4.4	18	0.058	0.034	41.4	1.5	18.0	20.0	4.07	6.92	7.70	.0340	.0180	.0170	.0053	.0025	.0025	.184	.072	.080	.0044	.0021	.0032	.000253	.000218	.000339

No	Record	Station	Site	Date	Mw	R(km)	Kh	Kv	Stress Drop (Bar)	Fc Corner freq. Hz	fmax (H) Hz	fmax (V) Hz	Dur (H1) sec	Dur (V) sec	Dur (H2) sec	Arms (H1) m/s	Arms (V) m/s	Arms (H2) m/s	Ea (H1) m2/s3	Ea (V) m2/s3	Ea (H2) m2/s3	PGA (H1) m/sec2	PGA (V) m/sec2	PGA (H2) m/sec2	Vmax (H1) m/sec	Vmax (V) m/sec	Vmax (H2) m/sec	Dmax (H1) m	Dmax (V) m	Dmax (H2) m
271	1519-2	Zarrat	1	12/08/94	3.8	15	0.064	0.016	193.2	5.0	12.0	18.0	6.49	7.36	5.39	.0220	.0110	.0310	.0036	.0010	.0056	.118	.058	.148	.0030	.0011	.0033	.000098	.000070	.000130
272	1523-14	Jovakan	1	12/08/94	4.0	16	0.045	0.036	197.3	4.0	21.0	21.0	6.41	5.26	6.82	.0300	.0290	.0280	.0064	.0048	.0061	.206	.254	.124	.0025	.0023	.0018	.000155	.000069	.000092
273	1523-15	Jovakan	1	12/08/94	4.0	16	0.045	0.028	197.3	4.0	18.0	18.0	3.29	5.90	4.55	.0650	.0290	.0490	.0160	.0057	.0120	.380	.140	.338	.0044	.0022	.0061	.000146	.000070	.000238
274	1523-16	Jovakan	1	14/08/94	3.8	14	0.040	0.039	98.9	4.0	22.0	22.0	4.59	4.03	4.25	.0370	.0360	.0370	.0071	.0058	.0065	.181	.176	.176	.0026	.0021	.0038	.000097	.000041	.000158
275	1518-3	Firouzabad	3	20/08/94	4.2	20	0.035	0.024	96.1	2.5	7.0	10.0	6.80	5.02	7.74	.0230	.0250	.0190	.0039	.0035	.0032	.134	.159	.118	.0028	.0023	.0026	.000104	.000107	.000121
276	1523-17	Jovakan	1	20/08/94	3.8	18			193.2	5.0	18.0	20.0	7.85	6.74	6.57	.0230	.0200	.0290	.0045	.0029	.0063	.172	.130	.246	.0023	.0016	.0042	.000096	.000076	.000162
277	1520-2	Kavar	2	26/08/94	4.0	20	0.042	0.048	270.7	4.0	18.0	18.0	4.25	4.59	3.63	.0390	.0260	.0440	.0070	.0034	.0077	.163	.114	.151	.0029	.0015	.0032	.000083	.000046	.000089
278	1523-18	Jovakan	1	26/08/94	3.8	16	0.039	0.037	98.9	4.0	18.0	19.0	4.09	5.80	4.27	.0470	.0250	.0470	.0100	.0039	.0100	.254	.148	.310	.0051	.0015	.0053	.000210	.000057	.000238
279	1523-19	Jovakan	1	28/08/94	3.6	16	0.018	0.020	96.9	5.0	17.0	17.0	4.69	8.82	7.24	.0200	.0077	.0110	.0020	.0006	.0010	.170	.041	.061	.0029	.0007	.0010	.000181	.000098	.000082
280	1523-20	Jovakan	1	28/08/94	3.6	12	0.056	0.042	96.9	5.0	30.0	30.0	1.34	3.21	1.25	.0510	.0180	.0500	.0039	.0011	.0035	.217	.097	.238	.0035	.0010	.0024	.000082	.000069	.000060
281	1522	Ghaemiyeh Chenar-Shahijan	3	05/09/94	5.0	18	0.048	0.154	331.2	3.0	12.0	15.0	7.49	7.49	8.05	.0230	.0120	.0190	.0045	.0012	.0032	.129	.047	.086	.0029	.0011	.0024	.000134	.000120	.000090
282	1523-21	Jovakan	1	07/09/94	3.5	16	0.006	0.039	68.5	5.0	28.0	28.0	3.28	4.59	4.44	.0290	.0140	.0190	.0031	.0010	.0018	.206	.067	.129	.0032	.0007	.0013	.000080	.000071	.000039
283	1523-22	Jovakan	1	09/09/94	3.7	12	0.049	0.037	99.7	4.5	28.0	28.0	1.53	3.08	1.64	.0580	.0250	.0580	.0058	.0022	.0061	.204	.102	.207	.0036	.0014	.0034	.000101	.000050	.000095
284	1533-1	Seifabad	1	10/09/94	4.0	18	0.075	0.045	197.3	4.0	15.0	15.0	6.61	6.23	6.25	.0280	.0210	.0340	.0058	.0031	.0079	.127	.098	.132	.0041	.0016	.0019	.000131	.000086	.000112
285	1523-23	Jovakan	1	19/09/94	3.8	16	0.051	0.028	530.	7.0	18.0	18.0	1.58	4.76	1.94	.1500	.0470	.1300	.0400	.0120	.0380	.707	.296	.660	.0106	.0039	.0071	.000228	.000112	.000331
286	1506-11	Hosseiniyeh-Olia	4	20/09/94	5.1	50	0.082	0.173	70.4	0.8	9.0	9.0	10.12	12.93	9.50	.0280	.0150	.0310	.0091	.0032	.0099	.113	.061	.121	.0043	.0028	.0048	.000819	.000379	.000625
287	1507	Dez Dam	1	20/09/94	5.1	27	0.049	0.073	97.3	1.0	8.0	11.0	6.57	8.90	6.69	.0530	.0410	.0590	.0210	.0170	.0260	.234	.188	.258	.0106	.0064	.0094	.001389	.000672	.001472
288	1508-1	Andimeshk	1	20/09/94	5.1	12	0.086	0.096	98.1	2.0	9.0	9.0	8.46	8.91	8.59	.0210	.0130	.0210	.0041	.0018	.0043	.075	.060	.113	.0028	.0020	.0039	.000285	.000150	.000183
289	1508-2	Andimeshk	1	20/09/94	4.9	19	0.071	0.076	68.3	0.5	9.0	11.0	9.64	11.66	8.92	.0550	.0370	.0600	.0330	.0180	.0360	.181	.201	.359	.0104	.0129	.0223	.001253	.002008	.003528
290	1523-24	Jovakan	1	20/09/94	3.8	15	0.050		194.8	10.0	30.0	30.0	1.96	4.05	1.95	.0380	.0170	.0380	.0031	.0012	.0031	.282	.100	.188	.0024	.0010	.0021	.000059	.000037	.000049
291	1520-3	Kavar	2	29/09/94	3.8	6	0.087	0.073	13.2	3.5	12.0	12.0	3.85	3.64	3.70	.0310	.0250	.0340	.0042	.0024	.0049	.110	.106	.132	.0033	.0019	.0038	.000134	.000051	.000205
292	1523-25	Jovakan	1	29/09/94	3.8	14	0.064	0.065	83.9	6.0	28.0	28.0	5.46	5.17	6.28	.0330	.0210	.0250	.0066	.0027	.0043	.228	.113	.137	.0032	.0009	.0014	.000170	.000046	.000050
293	1523-26	Jovakan	1	12/10/94	3.5	18	0.019	0.010	14.8	3.0	20.0	20.0	7.23	3.56	7.32	.0100	.0250	.0110	.0008	.0026	.0011	.049	.238	.075	.0008	.0024	.0009	.000069	.000064	.000065
294	1518-4	Firouzabad	3	26/10/94	4.2	16	0.079	0.062	96.1	2.5	6.0	8.0	7.26	8.86	5.83	.0270	.0140	.0360	.0061	.0020	.0082	.126	.059	.140	.0032	.0017	.0049	.000153	.000111	.000224
295	1523-27	Jovakan	1	26/10/94	4.0	14	0.039	0.087	83.2	3.0	20.0	20.0	7.54	10.14	6.67	.0280	.0170	.0350	.0068	.0032	.0090	.168	.084	.308	.0034	.0013	.0064	.000180	.000090	.000330
296	1531	Lamerd	1	27/10/94	3.8	16	0.023	0.001	333.9	6.0	25.0	30.0	1.72	4.07	4.65	.0640	.0250	.0210	.0079	.0028	.0023	.317	.107	.112	.0052	.0017	.0034	.000162	.000066	.000148
297	1528-1	Fin	3	28/10/94	4.2	4	0.033	0.033	186.9	3.5	20.0	20.0	4.80	2.59	4.49	.0590	.0740	.0600	.0180	.0160	.0180	.544	.333	.332	.0073	.0034	.0050	.000170	.000076	.000130
298	1528-2	Fin	3	29/10/94	4.0	16	0.024		132.2	3.5	18.0	20.0	6.44	3.21	4.71	.0360	.0490	.0490	.0092	.0085	.0130	.250	.205	.237	.0056	.0040	.0046	.000178	.000121	.000142
299	1530-1	Nir (Ardebil)	3	02/11/94	5.0	20	0.017	0.028	463.9	1.5	18.0	20.0	5.72	7.00	5.95	.1400	.1000	.1300	.1300	.0810	.1200	.825	.468	.575	.0271	.0085	.0369	.002705	.000790	.003778
300	1550-1	Masal	3	03/12/94	4.8	25	0.065	0.018	59.2	5.5	6.0	8.0	4.84	7.32	5.05	.0520	.0170	.0550	.0150	.0025	.0170	.192	.066	.247	.0080	.0028	.0096	.000800	.000353	.000691
301	1550-2	Masal	3	07/12/94	4.1	16	0.067	0.046	117.5	3.0	6.0	8.0	4.75	5.95	5.10	.0300	.0140	.0300	.0049	.0012	.0052	.125	.056	.120	.0038	.0015	.0029	.000163	.000105	.000226
302	1519-3	Zarrat	1	08/12/94	5.0	24	0.059	0.052	679.7	3.0	10.0	11.0	5.93	6.57	4.68	.1200	.0560	.1500	.1000	.0230	.1200	.467	.211	.610	.0148	.0048	.0226	.000542	.000257	.000800
303	1520-4	Kavar	2	08/12/94	5.0	22	0.032	0.059	390.4	2.0	10.0	10.0	7.26	7.66	5.59	.0530	.0340	.0970	.0230	.0096	.0580	.191	.133	.375	.0049	.0026	.0093	.000251	.000180	.000239
304	1523-28	Jovakan	1	08/12/94	5.0	16	0.035	0.015	276.4	2.0	20.0	20.0	2.75	6.80	2.75	.2600	.0700	.2300	.2000	.0370	.1600	1.420	.327	1.013	.0286	.0065	.0306	.001171	.000396	.001408
305	1519-4	Zarrat	1	15/12/94	4.7	20	0.048	0.045	345.9	2.5	11.0	15.0	5.62	6.82	6.45	.1500	.0610	.1200	.1300	.0280	.0970	.647	.238	.536	.0173	.0062	.0196	.001200	.000502	.000919
306	1520-5	Kavar	2	15/12/94	4.7	19	0.060	0.039	270.7	2.5	11.0	11.0	9.12	9.09	7.43	.0430	.0300	.0540	.0190	.0090	.0240	.144	.130	.276	.0047	.0033	.0071	.000286	.000185	.000465
307	1523-29	Jovakan	1	29/12/94	4.5	22	0.052	0.030	270.6	2.5	18.0	18.0	5.79	8.47	5.44	.0690	.0320	.0760	.0300	.0097	.0350	.366	.143	.372	.0075	.0038	.0121	.000411	.000303	.000676
308	1519-5	Zarrat	1	30/12/94	4.1	18	0.049	0.063	396.8	4.5	19.0	21.0	5.76	6.93	6.57	.0600	.0320	.0540	.0230	.0079	.0210	.243	.122	.215	.0075	.0024	.0069	.000343	.000134	.000415
309	1520-6	Kavar	2	30/12/94	4.2	16	0.023	0.048	100.6	2.5	9.0	11.0	5.76	7.67	4.78	.0310	.0170	.0490	.0062	.0024	.0130	.144	.087	.237	.0038	.0016	.0053	.000116	.000089	.000191
310	1523-30	Jovakan	1	30/12/94	4.2	8	0.050	0.018	49.2	2.0	18.0	18.0	5.82	8.43	6.45	.0310	.0120	.0270	.0062	.0014	.0052	.112	.051	.116	.0031	.0015	.0025	.000136	.000091	.000130
311	1573	Bagh-Malek	2	01/01/95	4.3	16	0.120	0.028	135.7	2.5	10.0	11.0	6.85	10.22	8.81	.0280	.0086	.0170	.0061	.0008	.0028	.134	.041	.073	.0036	.0010	.0024	.000233	.000104	.000182
312	1579	Kuhestak	3	04/01/95	4.6	105	0.130	0.035	30.2	2.0	8.0	11.0	7.56	8.12	5.71	.0220	.0089	.0310	.0041	.0007	.0062	.072	.037	.113	.0020	.0007	.0033	.000087	.000063	.000123
313	1529-2	Lali	3	06/01/95	3.8	12	0.019	0.040	98.9	4.0	12.0	15.0	4.42	3.93	5.12	.0260	.0190	.0290	.0033	.0016	.0047	.104	.079	.159	.0026	.0016	.0041	.000099	.000071	.000102
314	1549-4	Ammarloo	3	06/01/95	4.0	10	0.045	0.035	197.3	4.0	22.0	22.0	2.18	1.57	2.65	.1300	.1700	.1400	.0440	.0510	.0540	.637	.487	.584	.0119	.0085	.0129	.000490	.000265	.000320
315	1529-3	Lali	3	07/01/95	4.5	18	0.085	0.065	138.6	2.0	8.0	10.0	10.97	10.30	10.64	.0560	.0330	.0590	.0380	.0120	.0410	.259	.150	.239	.0074	.0033	.0085	.000525	.000360	.000634
316	1523-31	Jovakan	1	12/01/95	3.9	16	0.044	0.034	139.7	4.0	20.0	20.0	3.13	5.36	3.43	.0370	.0160	.0360	.0049	.0014	.0049	.269	.069	.248	.0048	.0013	.0046	.000138	.000066	.000141
317	1532	Deh-Balla - N. Farrashband	2	21/01/95	4.7	32	0.070	0.026	161.0	2.0	30.0	30.0	8.69	9.38	8.05	.0800	.0440	.0840	.0620	.0200	.0630	.327	.181	.304	.0050	.0025	.0051	.000363	.000253	.000317
318	1528-3	Fin	3	24/01/95	4.9	16	0.022	0.038	782.6	2.3	12.0	12.0	2.26	1.87	3.81	1.500	1.200	1.300	5.9000	2.9000	7.200	5.294	4.123	4.941	.1697	.0900	.1426	.012030	.005089	.006029
319	1528-22	Fin	3	24/01/95	4.0	16	0.035	0.036	197.3	4.0	20.0	28.0	3.19	3.88	3.00	.0990	.0650	.0920	.0350	.0180	.0280	.521	.279	.422	.0068	.0031	.0049	.000147	.000091	.000143
320	1528-23	Fin	3	24/01/95	4.0	8	0.029	0.028	132.2	3.5	17.0	20.0	4.98	3.97	5.11	.0780	.0620	.0800	.0330	.0170	.0360	.609	.269	.522	.0075	.0032	.0062	.000198	.000097	.000182
321	1528-24	Fin	3	24/01/95	4.1	12	0.027	0.042	117.5	3.0	20.0	28.0	5.06	3.62	4.53	.0740	.0630	.0820	.0310	.0160	.0340	.398	.267	.395	.0085	.0043	.0073	.000275	.000126	.000227
322	1528-26	Fin	3	24/01/95	4.5	16	0.045	0.016	452.9	3.0	20.0	22.0	3.17	4.32	4.86	.3100	.1600	.2600	.3500	.1200	.3600	1.795	.834	1.433	.0266	.0148	.0195	.000957	.000413	.000675
323	1528-27	Fin	3	24/01/95	3.5	6	0.034	0.023	35.2	4.0	18.0	20.0	2.28	2.09	3.48	.0400	.0360	.0310	.0041	.0030	.0036	.229	.112	.153	.0034	.0014	.0016	.000061	.000041	.000047

No	Record	Station	Site	Date	Mw	R(km)	Kh	Kv	Stress Drop (Bar)	Fc Corner freq. Hz	fmax (H) Hz	fmax (V) Hz	Dur (H1) sec	Dur (V) sec	Dur (H2) sec	Arms (H1) m/s	Arms (V) m/s	Arms (H2) m/s	Ea (H1) m2/s3	Ea (V) m2/s3	Ea (H2) m2/s3	PGA (H1) m/sec2	PGA (V) m/sec2	PGA (H2) m/sec2	Vmax (H1) m/sec	Vmax (V) m/sec	Vmax (H2) m/sec	Dmax (H1) m	Dmax (V) m	Dmax (H2) m
324	1528-28	Fin	3	24/01/95	3.9	16	0.034	0.055	139.7	4.0	20.0	28.0	7.23	3.87	5.36	.0280	.0280	.0400	.0063	.0034	.0094	.203	.126	.214	.0035	.0022	.0036	.000146	.000065	.000115
325	1528-29	Fin	3	24/01/95	4.2	12	0.023	0.027	263.6	3.5	20.0	25.0	6.90	5.62	8.76	.0610	.0440	.0430	.0280	.0120	.0180	.402	.209	.276	.0083	.0043	.0037	.000378	.000136	.000143
326	1528-10	Fin	3	24/01/95	4.6	16	0.026	0.054	377.4	2.5	20.0	22.0	4.29	4.24	3.57	.2900	.1300	.3700	.4100	.0770	.5400	1.652	.617	1.165	.0412	.0154	.0373	.002362	.000628	.001366
327	1528-11	Fin	3	24/01/95	3.9	12	0.030	0.044	58.9	3.0	19.0	22.0	2.95	3.21	3.88	.0460	.0340	.0350	.0069	.0041	.0053	.268	.121	.183	.0039	.0016	.0026	.000085	.000066	.000102
328	1528-12	Fin	3	24/01/95	4.1	6	0.040	0.035	186.7	3.5	20.0	25.0	5.50	5.55	5.84	.1500	.0910	.1300	.1400	.0520	.1200	.837	.512	.841	.0182	.0080	.0144	.001056	.000254	.000659
329	1528-13	Fin	3	24/01/95	3.9	10	0.037	0.058	58.9	3.0	22.0	28.0	1.84	3.26	2.53	.0670	.0330	.0550	.0093	.0041	.0086	.370	.132	.380	.0036	.0017	.0030	.000071	.000071	.000073
330	1528-14	Fin	3	24/01/95	3.8	8	0.022	0.039	66.3	3.5	20.0	22.0	10.89	11.99	11.05	.0280	.0210	.0320	.0093	.0059	.0130	.171	.137	.226	.0039	.0017	.0039	.000320	.000095	.000129
331	1528-15	Fin	3	24/01/95	3.5	6	0.040	0.041	35.1	4.0	22.0	28.0	1.66	1.88	.95	.0620	.0480	.1200	.0072	.0048	.0150	.395	.275	.605	.0031	.0027	.0049	.000072	.000062	.000072
332	1528-16	Fin	3	24/01/95	4.1	14	0.047		68.0	2.5	19.0	22.0	11.80	8.55	10.75	.0280	.0300	.0430	.0099	.0085	.0220	.173	.141	.263	.0024	.0020	.0029	.000147	.000085	.000101
333	1528-17	Fin	3	24/01/95	3.9	14	0.026	0.039	65.0	3.5	22.0	28.0	4.56	3.24	5.46	.0640	.0530	.0510	.0210	.0099	.0160	.544	.214	.385	.0060	.0027	.0030	.000277	.000097	.000158
334	1528-18	Fin	3	24/01/95	3.8	12	0.032	0.035	66.2	3.5	20.0	22.0	1.76	2.41	2.88	.0550	.0360	.0420	.0059	.0035	.0056	.370	.134	.289	.0035	.0016	.0021	.000054	.000054	.000058
335	1528-19	Fin	3	24/01/95	3.9	8	0.037	0.054	58.9	3.0	22.0	28.0	7.53	5.57	7.07	.0270	.0230	.0310	.0061	.0032	.0077	.123	.119	.162	.0022	.0015	.0029	.000155	.000051	.000114
336	1528-20	Fin	3	24/01/95	4.1	20	0.031	0.024	186.7	3.5	20.0	25.0	3.76	3.82	4.43	.0440	.0320	.0460	.0082	.0043	.0110	.219	.112	.222	.0046	.0026	.0034	.000135	.000061	.000138
337	1528-21	Fin	3	24/01/95	4.1	12	0.032	0.039	117.5	3.0	19.0	20.0	9.06	6.07	6.80	.0300	.0250	.0460	.0090	.0041	.0160	.130	.105	.245	.0033	.0014	.0041	.000262	.000093	.000194
338	1528-4	Fin	3	24/01/95	4.0	8	0.045	0.003	132.2	3.5	18.0	22.0	5.18	4.40	6.23	.0810	.0570	.0700	.0380	.0160	.0340	.420	.256	.385	.0076	.0036	.0057	.000298	.000112	.000222
339	1528-5	Fin	3	24/01/95	4.1	6	0.044	0.062	117.5	3.0	18.0	22.0	5.04	4.03	5.80	.0780	.0560	.0790	.0340	.0140	.0400	.398	.264	.399	.0098	.0057	.0079	.000360	.000159	.000330
340	1528-6	Fin	3	24/01/95	4.0	8	0.055	0.063	132.2	3.5	21.0	26.0	5.13	3.74	4.59	.0620	.0430	.0810	.0220	.0075	.0340	.357	.210	.346	.0093	.0043	.0106	.000315	.000140	.000356
341	1528-7	Fin	3	24/01/95	3.7	8	0.031	0.018	46.9	3.5	20.0	22.0	3.49	2.73	3.77	.0360	.0330	.0380	.0049	.0032	.0061	.239	.190	.211	.0034	.0025	.0029	.000098	.000055	.000100
342	1528-8	Fin	3	24/01/95	4.1	16	0.032	0.042	186.7	3.5	18.0	22.0	6.81	3.89	6.09	.0430	.0410	.0450	.0140	.0071	.0140	.406	.229	.251	.0053	.0037	.0042	.000161	.000106	.000157
343	1528-9	Fin	3	24/01/95	4.0	14	0.050	0.002	132.2	3.5	20.0	22.0	3.37	3.13	2.78	.0660	.0470	.0870	.0160	.0078	.0230	.435	.259	.469	.0045	.0033	.0047	.000193	.000090	.000195
344	1528-30	Fin	3	25/01/95	3.9	12	0.029	0.033	93.6	3.5	20.0	20.0	7.24	3.90	8.68	.0450	.0430	.0350	.0160	.0081	.0120	.365	.223	.277	.0054	.0031	.0030	.000268	.000084	.000099
345	1528-31	Fin	3	25/01/95	4.0	16	0.029		132.2	3.5	15.0	18.0	6.83	4.80	5.67	.0280	.0250	.0400	.0060	.0033	.0100	.171	.115	.184	.0025	.0019	.0035	.000082	.000062	.000130
346	1631-1	Musian	3	27/01/95	4.1	16	0.041	0.050	117.5	3.0	16.0	18.0	1.84	3.69	1.39	.0560	.0270	.0640	.0064	.0030	.0063	.184	.112	.304	.0057	.0015	.0073	.000332	.000061	.000304
347	1592	Golbaf	3	17/02/95	4.4	12	0.056	0.035	41.4	1.5	8.0	12.0	5.66	4.84	5.05	.0360	.0300	.0320	.0081	.0047	.0058	.148	.112	.100	.0081	.0026	.0057	.001297	.000268	.000569
348	1555	Firouzabad	3	19/02/95	4.4	19	0.056	0.042	117.6	3.0	9.0	15.0	6.89	6.99	6.13	.0250	.0190	.0330	.0047	.0027	.0075	.163	.094	.232	.0037	.0016	.0046	.000141	.000224	.000248
349	1547-1	Sefidrud Dam	1	07/03/95	2.7	15							2.13	4.38	3.05	.1900	.0270	.0330	.0820	.0035	.0037	.552	.128	.147	.0182	.0024	.0052	.000692	.000155	.000309
350	1535-1	Rudbar	3	07/03/95	3.9	10	0.024	0.030	139.7	4.0	18.0	20.0	2.00	2.84	2.13	.0510	.0480	.0550	.0059	.0071	.0071	.255	.164	.274	.0057	.0023	.0074	.000212	.000147	.000414
351	1563	Dorahun	3	08/03/95	4.3	13	0.029	0.035	37.7	2.0	18.0	20.0	4.60	6.10	4.81	.0430	.0160	.0420	.0096	.0017	.0096	.161	.062	.157	.0047	.0016	.0046	.000216	.000200	.000401
352	1564-1	Khanzanun	1	09/03/95	4.1	16	0.041	0.016	34.8	2.0	12.0	18.0	4.15	5.59	4.74	.0250	.0170	.0190	.0029	.0017	.0020	.173	.125	.117	.0033	.0019	.0021	.000169	.000129	.000079
353	1554	Baba-Monir	4	22/03/95	4.8	23	0.053	0.032			10.0	12.0	12.01	11.19	11.84	.0420	.0310	.0470	.0230	.0120	.0290	.184	.140	.203	.0060	.0031	.0086	.000344	.000220	.000512
354	1575-1	Babakalan (Gachsaran)	2	22/03/95	4.8	20	0.057	0.114	150.9	5.0	18.0	20.0	3.40	5.39	5.99	.0550	.0310	.0540	.0110	.0059	.0190	.242	.145	.207	.0035	.0016	.0040	.000114	.000074	.000190
355	1650-1	Firouzabad	3	25/03/95	4.7	12	0.058	0.023	166.4	1.5	6.0	11.0	6.43	7.20	8.03	.0860	.0470	.0650	.0530	.0180	.0370	.302	.191	.294	.0166	.0070	.0104	.001848	.000665	.001492
356	1545-1	Kavar	2	02/04/95	4.5	40	0.030	0.026	142.7	1.8	11.0	15.0	9.77	9.91	10.71	.0420	.0250	.0340	.0190	.0070	.0140	.209	.123	.147	.0059	.0018	.0032	.000326	.000149	.000321
357	1562-1	Zarrat	1	02/04/95	4.8	30	0.062	0.030	393.5	3.5	10.0	15.0	9.03	10.36	9.86	.0550	.0220	.0400	.0300	.0057	.0170	.292	.116	.145	.0070	.0019	.0045	.000245	.000173	.000189
358	1545-2	Kavar	2	04/04/95	4.0	12	0.014	0.061	48.2	2.5	9.0	11.0	2.47	3.91	2.79	.0360	.0150	.0310	.0035	.0010	.0030	.144	.071	.159	.0034	.0011	.0028	.000129	.000082	.000094
359	1590-1	Sisakht	1	06/04/95	3.5	16	0.020	0.017	452.9	9.0	30.0	33.0	2.48	2.88	2.94	.0780	.0790	.0690	.0170	.0200	.0160	.261	.317	.273	.0037	.0034	.0036	.000132	.000088	.000062
360	1562-2	Zarrat	1	16/04/95	4.2	16	0.033	0.059			12.0	18.0	5.81	5.55	7.01	.0570	.0400	.0430	.0210	.0099	.0140	.275	.185	.160	.0062	.0034	.0062	.000191	.000139	.000247
361	1655	Saman	2	18/04/95	3.7	14	0.017	0.019	44.0	5.0	25.0	28.0	4.31	5.18	4.88	.0350	.0210	.0350	.0059	.0025	.0067	.182	.088	.136	.0021	.0010	.0026	.000050	.000030	.000051
362	1556	Bandar-Deylam	4	22/04/95	5.1	95	0.088	0.016	68.9	1.0	3.0		11.09	12.27	10.17	.0190	.0042	.0230	.0043	.0002	.0061	.056	.013	.105	.0047	.0011	.0102	.000965	.000110	.001501
363	1581	Lendeh	1	22/04/95	5.1	51	0.068	0.075	25.4	0.8	8.0	10.0	11.90	12.43	12.84	.0510	.0290	.0420	.0340	.0120	.0250	.181	.126	.204	.0118	.0085	.0122	.001377	.001240	.001757
364	1535-2	Rudbar	3	26/04/95	4.8	8	0.058	0.039	276.4	2.0	18.0	20.0	2.49	2.59	2.80	.2500	.2000	.2200	.1800	.1200	.1500	.986	.850	.933	.0302	.0188	.0355	.001440	.001484	.001841
365	1548	Astaneh	4	26/04/95	4.8	16	0.035		191.6	2.5	9.0	11.0	8.88	11.30	10.89	.0290	.0130	.0180	.0081	.0022	.0041	.148	.047	.064	.0045	.0011	.0031	.000461	.000218	.000322
366	1558	Shabankareh	4	02/05/95	3.7	18	0.030	0.042	67.9	4.0	10.0	11.0	6.30	5.38	7.62	.0240	.0210	.0190	.0039	.0027	.0030	.132	.096	.118	.0026	.0018	.0024	.000118	.000063	.000081
367	1536-2	Ghir	4	03/05/95	4.7	28	0.023	0.010	137.5	1.0	8.0	10.0	5.30	7.12	5.01	.1200	.0660	.1200	.0790	.0340	.0860	.382	.307	.410	.0098	.0058	.0112	.000486	.000325	.000553
368	1625-1	Ghaleh-Ganj (Kahnoudj)	1	12/05/95	4.0	47	0.016	0.018	197.3	4.0	12.0	15.0	5.02	6.72	6.22	.0420	.0250	.0320	.0099	.0045	.0070	.227	.103	.149	.0048	.0019	.0040	.000298	.000132	.000272
369	1529-1	Lali	3	14/05/95	4.0	18	0.066	0.049	197.3	4.0	10.0	12.0	4.92	6.84	5.24	.0250	.0120	.0290	.0035	.0011	.0048	.091	.036	.137	.0026	.0008	.0025	.000089	.000048	.000113
370	1621	Darreh-Shahr - Ilam	1	17/05/95	4.5	14	0.042	0.036	138.6	2.0	18.0	25.0	6.38	5.64	7.36	.0480	.0330	.0370	.0160	.0070	.0110	.180	.158	.134	.0055	.0032	.0050	.000455	.000802	.000541
371	1535-3	Rudbar	3	17/05/95	4.2	12	0.037	0.014	49.2	2.0	12.0	18.0	2.62	3.55	2.92	.0420	.0300	.0330	.0051	.0035	.0035	.228	.111	.123	.0049	.0030	.0030	.000249	.000100	.000118
372	1551-1	Shabastar	1	17/05/95	4.0	24	0.043	0.034	197.3	4.0	11.0	19.0	6.35	3.90	6.42	.0340	.0480	.0280	.0081	.0100	.0055	.247	.314	.138	.0062	.0039	.0026	.000206	.000164	.000169
373	1551-2	Shabastar	1	18/05/95	4.2	22	0.048	0.046	393.5	4.0	12.0	19.0	5.89	3.36	4.17	.0560	.1100	.0810	.0210	.0450	.0310	.386	.897	.399	.0075	.0113	.0096	.000299	.000339	.000412
374	1546	Tasuj	2	18/05/95	4.4	20	0.062	0.044	191.6	2.5	15.0	18.0	5.01	7.55	5.79	.0330	.0160	.0320	.0060	.0021	.0064	.168	.083	.127	.0041	.0014	.0033	.000212	.000159	.000262
375	1551-3	Shabastar	1	18/05/95	4.2	24	0.035	0.024	70.05	4.0	18.0	22.0	2.61	4.03	4.08	.0210	.0150	.0150	.0013	.0010	.0010	.133	.062	.104	.0024	.0010	.0018	.000062	.000074	.000071
376	1594	Khorramabad	2	26/05/95	4.2	20	0.051	0.011	96.1	2.5	10.0	10.0	6.20	6.88	4.61	.0320	.0190	.0380	.0073	.0027	.0075	.160	.141	.233	.0038	.0017	.0061	.000530	.000185	.000306

No	Record	Station	Site	Date	Mw	R(km)	Kh	Kv	Stress Drop (Bar)	Fc Corner freq. Hz	fmax (H) Hz	fmax (V) Hz	Dur (H1) sec	Dur (V) sec	Dur (H2) sec	Arms (H1) m/s	Arms (V) m/s	Arms (H2) m/s	Ea (H1) m2/s3	Ea (V) m2/s3	Ea (H2) m2/s3	PGA (H1) m/sec2	PGA (V) m/sec2	PGA (H2) m/sec2	Vmax (H1) m/sec	Vmax (V) m/sec	Vmax (H2) m/sec	Dmax (H1) m	Dmax (V) m	Dmax (H2) m
377	1543	Namin	3	27/05/95	4.8	82	0.050	0.043	236.7	3.5	8.0	8.0	8.46	9.85	10.29	.0330	.0160	.0320	.0100	.0029	.0120	.120	.068	.162	.0034	.0011	.0042	.000160	.000123	.000256
378	1590-2	Sisakht	1	27/05/95	4.6	70	0.022	0.015	124.5	5.5	30.0	33.0	.92	2.35	2.02	.0970	.0560	.0570	.0096	.0081	.0073	.215	.246	.251	.0028	.0028	.0036	.000062	.000044	.000063
379	1633-1	Namin	3	27/05/95	4.8	80	0.052	0.044	234.5	3.0	8.0	10.0	8.47	10.11	10.34	.0330	.0160	.0320	.0100	.0029	.0120	.120	.067	.161	.0038	.0029	.0046	.000547	.000736	.000470
380	1533-2	Seifabad (S. Kazerun)	1	31/05/95	5.0	20	0.061	0.022	195.7	2.0	10.0	10.0	5.99	8.59	7.34	.0440	.0220	.0390	.0130	.0046	.0120	.209	.105	.163	.0105	.0046	.0062	.000980	.000715	.000551
381	1552	Pol-e Sefid	4	02/06/95	4.1	18	0.039	0.030	186.7	4.0	20.0	25.0	3.40	6.09	5.15	.0450	.0210	.0300	.0077	.0031	.0051	.308	.133	.181	.0054	.0024	.0049	.000259	.000063	.000225
382	1635-1	Pol-e Sefid	4	02/06/95	4.1	18	0.075	0.033	186.7	4.0	20.0	25.0	3.41	6.09	5.16	.0450	.0210	.0300	.0077	.0031	.0051	.306	.133	.181	.0055	.0025	.0050	.000224	.000046	.000246
383	1620-1	Doab (Pol-e Sefid)	3	03/06/95	4.0	20	0.051	0.009	220.2	3.0	20.0	21.0	1.91	3.88	1.36	.2600	.1000	.2100	.1400	.0460	.0680	1.125	.468	.680	.0252	.0079	.0147	.000669	.000138	.000468
384	1576	Gavbandi	3	18/06/95	3.5	12	0.045	0.001	75.5	5.0	25.0	30.0	4.56	3.56	3.46	.0250	.0350	.0390	.0033	.0048	.0058	.150	.158	.228	.0019	.0018	.0035	.000069	.000091	.000099
385	1626	Hassan-Keif	3	26/06/95	5.1	14	0.039	0.028	125.8	2.5	18.0	18.0	4.34	5.19	4.38	.1100	.0730	.0900	.0570	.0310	.0390	.650	.392	.408	.0173	.0062	.0093	.000881	.001230	.000569
386	1542	Ammarloo	3	10/07/95	3.6	12	0.044	0.043	49.6	4.0	18.0	20.0	.82	1.50	1.50	.0420	.0240	.0280	.0016	.0009	.0013	.207	.077	.091	.0022	.0011	.0017	.000064	.000053	.000064
387	1635-2	Pol-e Sefid	4	27/07/95	4.0	20	0.054	0.044	82.2	3.0	18.0	25.0	5.34	4.76	5.91	.0230	.0290	.0180	.0033	.0044	.0021	.171	.181	.078	.0041	.0029	.0032	.000218	.000062	.000123
388	1557	Delvar	2	28/07/95	3.8	20	0.073	0.083	100.6	4.0	18.0	22.0	5.34	6.05	6.36	.0210	.0130	.0150	.0027	.0011	.0015	.133	.043	.061	.0026	.0005	.0019	.000094	.000069	.000103
389	1620-2	Doab	3	28/07/95	4.1	20	0.064	0.032	113.2	3.0	20.0	25.0	1.88	4.04	1.35	.1400	.0580	.1300	.0440	.0150	.0230	.643	.230	.385	.0104	.0023	.0050	.000285	.000071	.000151
390	1620-3	Doab	3	14/08/95	3.7	18	0.051	0.023	70.1	4.0	18.0	22.0	3.11	6.52	5.78	.0330	.0140	.0140	.0037	.0014	.0012	.155	.067	.069	.0040	.0007	.0015	.000107	.000063	.000066
391	1620-4	Doab	3	15/08/95	3.9	18	0.047	0.003	93.6	3.5	20.0	30.0	2.12	5.68	4.70	.0940	.0240	.0290	.0210	.0037	.0044	.331	.135	.148	.0072	.0017	.0041	.000175	.000070	.000128
392	1631-2	Musian	3	16/08/95	3.7	16	0.019	0.012	70.1	4.0	11.0	15.0	6.05	8.30	2.99	.0100	.0077	.0230	.0007	.0005	.0017	.074	.035	.129	.0010	.0007	.0031	.000092	.000022	.000172
393	1569	Mahan	4	04/09/95	4.4	20	0.077	0.029	69.5	2.0	11.0	15.0	4.06	9.52	5.88	.0220	.0069	.0140	.0022	.0005	.0013	.126	.049	.069	.0025	.0014	.0018	.000282	.000170	.000173
394	1549-1	Ammarloo	3	07/09/95	3.7	12	0.044	0.043	75.4	4.0	11.0	12.0	1.95	.89	1.44	.0550	.1000	.1300	.0066	.0099	.0280	.170	.261	.478	.0035	.0040	.0096	.000140	.000150	.000296
395	1549-2	Ammarloo	3	21/09/95	3.5	12	0.064	0.082	35.1	4.0	15.0	17.0	2.44	2.16	1.64	.0270	.0340	.0370	.0020	.0028	.0025	.136	.164	.164	.0017	.0023	.0032	.000050	.000054	.000075
396	1647-1	Dalin (SE Sepidan-Fars)	2	05/10/95	3.7	12	0.025	0.030	125.4	4.0	20.0	20.0	2.66	2.81	2.63	.1200	.0790	.1200	.0400	.0200	.0390	.463	.270	.398	.0085	.0036	.0093	.000314	.000531	.000487
397	1540	Rasht (Hous.)	3	13/10/95	4.9	16	0.040	0.006	68.9	1.0	6.0	8.0	11.73	12.96	11.52	.0310	.0096	.0330	.0120	.0013	.0140	.122	.031	.102	.0065	.0018	.0078	.001116	.000367	.001055
398	1637-1	Rasht (Hous.)	3	13/10/95	5.2	16	0.103	0.047	66.6	0.7	7.0	8.0	11.73	12.94	11.51	.0310	.0097	.0330	.0120	.0013	.0140	.123	.031	.103	.0066	.0019	.0079	.001165	.000400	.001141
399	1537	Sefidrud Dam	1	15/10/95	5.2	25							12.47	13.01	12.53	.0470	.0210	.0170	.0300	.0065	.0041	.208	.125	.109	.0077	.0045	.0039	.001175	.000989	.000529
400	1541	Rasht (University)	3	15/10/95	5.2	20	0.079	0.067	94.0	0.7	8.0	10.0	9.69	12.47	9.18	.0330	.0150	.0490	.0120	.0030	.0250	.170	.063	.236	.0079	.0032	.0205	.001287	.000674	.002960
401	1615-1	Abbar	1	15/10/95	5.2	42	0.050	0.014	49.8	0.8	6.0	6.0	10.34	11.02	8.90	.0230	.0180	.0290	.0063	.0039	.0084	.086	.086	.212	.0051	.0034	.0066	.000621	.000801	.000753
402	1632-1	Masal	3	15/10/95	5.2	52	0.069		140.4	0.8	12.0	18.0	10.27	11.94	10.36	.0210	.0096	.0210	.0051	.0012	.0051	.101	.040	.086	.0076	.0042	.0061	.001379	.001151	.000657
403	1564-2	Khanzanun	1	23/10/95	4.9	8	0.060	0.030	83.2	3.0	12.0	18.0	1.48	2.58	1.23	.1000	.0650	.1500	.0180	.0120	.0290	.525	.244	.563	.0102	.0028	.0087	.000278	.000116	.000173
404	1620-5	Doab	3	26/10/95	3.4	20	0.043	0.027	83.9	8.0	22.0	35.0	1.74	4.63	3.96	.0330	.0110	.0120	.0021	.0006	.0006	.149	.050	.073	.0023	.0004	.0010	.000048	.000044	.000038
405	1590-3	Sisakht	1	02/11/95	3.6	15	0.030	0.032	129.7	5.5	30.0	30.0	3.24	3.73	3.42	.0450	.0340	.0370	.0072	.0047	.0052	.186	.159	.191	.0025	.0019	.0026	.000084	.000108	.000071
406	1538	Kolur	1	03/11/95	3.6	16	0.042	0.002	181.2	6.0	40.0	40.0	4.65	8.27	2.17	.0320	.0200	.0720	.0053	.0035	.0120	.268	.151	.360	.0029	.0015	.0047	.000099	.000081	.000147
407	1586	Ziaratali -N. Bandarabbas	1	06/11/95	5.1	21	0.066	0.072	98.1	2.0	8.0	10.0	7.99	8.65	9.28	.0350	.0190	.0250	.0110	.0035	.0063	.166	.082	.113	.0048	.0052	.0032	.000397	.001299	.000869
408	1625-2	Ghaleh-Ganj (Kahnoudj)	1	06/11/95	5.1	49	0.048	0.154	164.7	1.5	12.0	15.0	6.59	8.14	6.51	.0460	.0320	.0530	.0150	.0095	.0200	.179	.177	.285	.0051	.0057	.0095	.000526	.001078	.000864
409	1539	Mashad (Sakht-Azma)	4	09/11/95	5.6	70	0.036		264.2	1.5	30.0	30.0	8.65	10.86	9.78	.0490	.0370	.0400	.0230	.0160	.0180	.191	.168	.147	.0071	.0044	.0071	.000527	.000188	.000588
410	1559	Khurmodj	1	14/11/95	4.2	15	0.025	0.035	98.1	2.0	25.0	25.0	4.21	6.48	3.83	.0560	.0260	.0500	.0150	.0050	.0100	.391	.193	.393	.0054	.0029	.0046	.000319	.000229	.000201
411	1544	Silvaneh	4	14/11/95	4.4	16	0.037	0.038	191.6	2.5	10.0	12.0	3.50	5.16	4.07	.0880	.0430	.0630	.0300	.0110	.0180	.434	.198	.228	.0118	.0040	.0061	.000548	.000137	.000593
412	1560-1	Lali	3	24/11/95	4.5	19	0.053	0.041	539.8	2.5	10.0	15.0	2.79	3.69	4.51	.3100	.3000	.2400	.3000	.3600	.2900	1.167	1.518	.992	.0354	.0225	.0259	.001918	.001304	.001570
413	1572	Masjed-Soleyman	3	24/11/95	4.5	45	0.063	0.050	75.5	2.5	10.0	11.0	8.78	6.09	5.89	.0320	.0180	.0610	.0100	.0023	.0250	.146	.071	.190	.0037	.0018	.0067	.000263	.000175	.000309
414	1560-2	Lali	3	24/11/95	4.0	20	0.034	0.020	197.3	4.0	12.0	18.0	3.44	4.71	3.20	.0400	.0310	.0440	.0060	.0050	.0069	.171	.134	.165	.0057	.0031	.0040	.000168	.000088	.000127
415	1560-3	Lali	3	25/11/95	3.8	18	0.046	0.044	193.2	5.0	8.0	12.0	2.84	3.71	3.63	.0430	.0330	.0320	.0059	.0044	.0041	.195	.183	.143	.0054	.0032	.0028	.000171	.000077	.000089
416	1560-4	Lali	3	27/11/95	5.0	18	0.055	0.046	525.4	3.5	12.0	18.0	6.72	4.23	4.84	.1400	.2000	.2200	.1500	.2000	.2600	.789	.816	1.058	.0249	.0145	.0258	.001655	.000663	.001243
417	1560-5	Lali	3	27/11/95	3.8	8	0.059	0.045	45.2	3.0	15.0	18.0	3.95	3.92	4.09	.0370	.0350	.0390	.0062	.0053	.0070	.197	.143	.171	.0051	.0024	.0029	.000175	.000104	.000087
418	1590-4	Sisakht	1	14/12/95	3.5	14	0.024	0.023	105.8	6.0	28.0	30.0	2.74	2.64	2.80	.0450	.0630	.0490	.0062	.0120	.0074	.241	.293	.267	.0039	.0033	.0023	.000078	.000077	.000123
419	1549-3	Ammarloo	3	29/12/95	3.9	12	0.037	0.026	93.6	3.5	22.0	28.0	1.66	2.79	2.34	.0770	.0320	.0590	.0110	.0033	.0091	.300	.124	.244	.0077	.0026	.0067	.000338	.000106	.000218
420	1566	Shiraz	4	31/12/95	4.7	35	0.048	0.032	270.6	2.5	15.0	15.0	9.44	8.62	8.26	.0240	.0230	.0260	.0059	.0050	.0060	.121	.086	.105	.0029	.0027	.0037	.000257	.000112	.000248
421	1602-1	Kavar Dam	2	31/12/95	4.7	33	0.030	0.045	644.2	4.0	9.0	12.0	8.79	9.89	8.53	.0460	.0180	.0390	.0210	.0036	.0140	.281	.091	.177	.0060	.0014	.0046	.000199	.000060	.000165
422	1602-2	Kavar Dam	2	31/12/95	4.8	24	0.038	0.040	328.5	1.5	9.0	12.0	8.45	9.47	9.11	.1100	.0350	.0800	.1100	.0130	.0650	.385	.139	.328	.0121	.0038	.0080	.000684	.000166	.000447
423	1602-3	Kavar Dam	2	31/12/95	4.0	32	0.012	0.041	280.9	4.5	8.0	10.0	5.59	10.97	6.95	.0350	.0078	.0280	.0075	.0007	.0061	.125	.031	.112	.0034	.0007	.0033	.000123	.000070	.000132
424	1571-1	Shabankareh	4	23/01/96	4.1	16	0.035	0.037	120.8	3.0	18.0	20.0	4.32	5.62	7.18	.0700	.0530	.0400	.0240	.0180	.0130	.402	.325	.296	.0149	.0037	.0058	.000801	.000201	.000260

No	Record	Station	Site	Date	Mw	R(km)	Kh	Kv	Stress Drop (Bar)	Fc Corner freq. Hz	fmax (H) Hz	fmax (V) Hz	Dur (H1) sec	Dur (V) sec	Dur (H2) sec	Arms (H1) m/s	Arms (V) m/s	Arms (H2) m/s	Ea (H1) m2/s3	Ea (V) m2/s3	Ea (H2) m2/s3	PGA (H1) m/sec2	PGA (V) m/sec2	PGA (H2) m/sec2	Vmax (H1) m/sec	Vmax (V) m/sec	Vmax (H2) m/sec	Dmax (H1) m	Dmax (V) m	Dmax (H2) m
425	1571-2	Shabankareh	4	23/01/96	3.5	16	0.026	0.050	120.8	6.0	15.0	18.0	2.25	4.45	3.95	.0410	.0280	.0230	.0043	.0038	.0023	.236	.123	.087	.0043	.0017	.0014	.000140	.000052	.000065
426	1571-3	Shabankareh	4	23/01/96	3.7	16	0.071	0.064	125.8	5.0	12.0	16.0	8.97	4.18	3.90	.0130	.0420	.0420	.0017	.0082	.0078	.086	.175	.314	.0016	.0021	.0046	.000060	.000060	.000198
427	1571-8	Shabankareh (Borazjan)	4	24/01/96	4.5	18	0.035	0.030	339.7	3.0	16.0	21.0	2.76	5.71	3.83	.2100	.0830	.1400	.1300	.0440	.0790	1.181	.365	.641	.0274	.0052	.0156	.001395	.000141	.000637
428	1571-11	Shabankareh (Borazjan)	4	24/01/96	4.4	18	0.035	0.024	198.9	4.5	18.0	22.0	6.84	7.84	8.04	.0200	.0150	.0170	.0031	.0019	.0026	.128	.065	.121	.0031	.0012	.0031	.000091	.000022	.000130
429	1571-16	Shabankareh (Borazjan)	4	24/01/96	4.7	16	0.026	0.054	272.9	5.0	18.0	20.0	7.48	10.72	8.65	.0250	.0180	.0240	.0051	.0040	.0057	.184	.109	.213	.0047	.0018	.0051	.000115	.000047	.000250
430	1583-3	Saadabad (Borazjan)	1	24/01/96	4.4	21	0.029	0.018	377.4	3.0	18.0	20.0	13.22	17.01	14.99	.0750	.0280	.0550	.0820	.0150	.0500	.726	.215	.442	.0194	.0050	.0156	.001174	.000223	.000623
431	1583-4	Saadabad	1	24/01/96	4.7	21	0.017	0.018			12.0	18.0	5.07	8.75	5.28	.0470	.0180	.0390	.0130	.0032	.0087	.331	.092	.176	.0120	.0020	.0046	.000542	.000112	.000198
432	1571-10	Shabankareh	4	24/01/96	4.6	24	0.035	0.017	679.4	3.0	11.0	18.0	19.32	16.75	16.48	.0720	.0770	.1000	.1100	.1100	.1900	.534	.418	.837	.0154	.0070	.0303	.000676	.000294	.001397
433	1571-12	Shabankareh	4	24/01/96	3.7	20	0.052	0.027	236.4	6.0	11.0	15.0	5.44	6.69	5.50	.0160	.0160	.0170	.0016	.0019	.0019	.103	.104	.117	.0026	.0015	.0030	.000057	.000061	.000084
434	1571-13	Shabankareh	4	24/01/96	3.7	18	0.037	0.018	182.1	5.5	10.0	18.0	7.39	7.95	3.99	.0150	.0140	.0290	.0020	.0019	.0037	.123	.092	.193	.0025	.0013	.0050	.000067	.000079	.000268
435	1571-14	Shabankareh	4	24/01/96	3.7	16	0.048	0.036	182.1	5.5	10.0	12.0	7.93	7.55	4.62	.0160	.0140	.0270	.0021	.0016	.0038	.117	.077	.214	.0031	.0015	.0052	.000118	.000068	.000208
436	1571-15	Shabankareh	4	24/01/96	3.6	15	0.048	0.051	128.9	5.5	10.0	12.0	5.39	6.06	4.96	.0190	.0190	.0230	.0021	.0025	.0029	.167	.091	.159	.0027	.0016	.0036	.000103	.000088	.000206
437	1571-17	Shabankareh	4	24/01/96	3.5	17	0.030	0.019	150.7	6.5	18.0	22.0	7.05	5.38	4.14	.0110	.0190	.0210	.0010	.0021	.0020	.105	.105	.146	.0013	.0012	.0025	.000051	.000050	.000109
438	1571-18	Shabankareh	4	24/01/96	3.5	18	0.036	0.081	167.4	6.0	18.0	20.0	12.73	9.53	5.59	.0047	.0076	.0150	.0003	.0006	.0013	.032	.047	.116	.0008	.0006	.0025	.000052	.000053	.000091
439	1571-19	Shabankareh	4	24/01/96	3.8	16	0.041	0.023	363.2	5.5	12.0	18.0	5.53	6.25	5.85	.0340	.0250	.0280	.0073	.0043	.0052	.253	.101	.167	.0061	.0017	.0047	.000188	.000039	.000276
440	1571-20	Shabankareh	4	24/01/96	3.8	16	0.006	0.015	333.9	6.0	12.0	18.0	8.15	8.21	8.20	.0170	.0160	.0170	.0027	.0023	.0025	.102	.061	.133	.0027	.0012	.0032	.000140	.000072	.000176
441	1571-21	Shabankareh	4	24/01/96	3.7	16	0.036	0.051	236.4	6.0	12.0	15.0	11.76	10.16	10.05	.0130	.0130	.0170	.0023	.0020	.0032	.116	.078	.172	.0026	.0011	.0047	.000106	.000087	.000280
442	1571-22	Shabankareh	4	24/01/96	4.0	16	0.057	0.047	140.9	3.5	18.0	22.0	10.89	7.41	5.34	.0200	.0330	.0680	.0050	.0089	.0270	.080	.152	.499	.0019	.0022	.0168	.000080	.000138	.000662
443	1571-23	Shabankareh	4	24/01/96	3.6	16	0.012	0.049	167.4	6.0	15.0	20.0	10.24	6.41	8.20	.0110	.0190	.0150	.0013	.0025	.0020	.109	.151	.163	.0019	.0019	.0024	.000077	.000084	.000109
444	1571-24	Shabankareh	4	24/01/96	4.0	20	0.059	0.056	197.3	4.0	9.0	11.0	7.34	8.51	7.81	.0140	.0089	.0130	.0017	.0008	.0015	.109	.035	.083	.0029	.0006	.0025	.000193	.000063	.000149
445	1571-25	Shabankareh	4	24/01/96	3.9	20	0.042	0.032	110.1	3.5	15.0	19.0	5.85	6.45	5.28	.0280	.0280	.0370	.0051	.0056	.0082	.199	.145	.260	.0042	.0020	.0058	.000225	.000083	.000246
446	1571-4	Shabankareh	4	24/01/96	3.9	17	0.040	0.042	171.1	5.0	15.0	18.0	8.52	5.36	4.32	.0150	.0320	.0430	.0021	.0059	.0089	.082	.164	.342	.0020	.0018	.0064	.000077	.000031	.000274
447	1571-5	Shabankareh	4	24/01/96	3.8	16	0.017	0.066	120.8	4.0	12.0	18.0	8.44	6.00	3.71	.0170	.0280	.0530	.0028	.0053	.0120	.121	.134	.380	.0029	.0018	.0083	.000140	.000036	.000350
448	1571-6	Shabankareh	4	24/01/96	3.7	16	0.040	0.048	80.5	4.0	15.0	18.0	8.46	5.12	3.98	.0150	.0290	.0410	.0021	.0048	.0075	.100	.166	.246	.0026	.0022	.0063	.000104	.000045	.000263
449	1571-7	Shabankareh	4	24/01/96	4.2	17	0.039	0.035	768.	4.0	15.0	20.0	8.99	5.66	5.58	.0390	.0730	.0970	.0150	.0340	.0580	.199	.267	.632	.0044	.0040	.0129	.000191	.000094	.000681
450	1571-9	Shabankareh	4	24/01/96	3.7	17	0.038	0.026	64.2	4.0	11.0	15.0	7.15	5.48	2.94	.0100	.0150	.0280	.0008	.0013	.0026	.083	.064	.179	.0017	.0010	.0037	.000065	.000023	.000143
451	1583-5	Saadabad	1	24/01/96	4.2	22	0.017	0.010	96.1	2.5	20.0	22.0	3.75	7.16	3.99	.0350	.0120	.0280	.0050	.0011	.0035	.227	.046	.215	.0073	.0018	.0056	.000207	.000111	.000146
452	1583-6	Saadabad	1	24/01/96	4.1	25	0.043	0.032	186.7	3.5	18.0	18.0	5.11	5.60	3.93	.0220	.0150	.0320	.0027	.0015	.0045	.152	.092	.172	.0034	.0021	.0046	.000190	.000076	.000261
453	1571-30	Shabankareh (Borazjan)	4	25/01/96	4.5	20	0.062	0.024	201.3	4.0	12.0	20.0	6.46	6.46	5.55	.0380	.0410	.0460	.0100	.0120	.0130	.216	.144	.235	.0046	.0026	.0057	.000218	.000067	.000229
454	1583-7	Saadabad (Borazjan)	1	25/01/96	4.5	21	0.022	0.010	69.5	2.0	12.0	19.0	3.76	6.65	4.90	.0360	.0140	.0240	.0055	.0015	.0031	.220	.061	.172	.0081	.0015	.0053	.000422	.000062	.000188
455	1571-26	Shabankareh	4	25/01/96	4.0	20	0.035	0.021	201.3	4.0	20.0	25.0	7.16	4.73	2.45	.0340	.0660	.1500	.0093	.0230	.0650	.236	.270	.811	.0045	.0036	.0161	.000093	.000091	.000755
456	1571-27	Shabankareh	4	25/01/96	3.7	20	0.049	0.031	236.4	6.0	11.0	15.0	6.36	5.57	6.13	.0160	.0210	.0160	.0018	.0028	.0017	.089	.096	.121	.0025	.0013	.0021	.000085	.000067	.000089
457	1571-28	Shabankareh	4	25/01/96	3.9	20	0.059	0.056	362.2	5.5	12.0	15.0	6.15	4.51	5.34	.0250	.0390	.0350	.0044	.0076	.0072	.213	.187	.277	.0034	.0026	.0053	.000150	.000065	.000239
458	1571-29	Shabankareh	4	25/01/96	4.0	20	0.062	0.024	280.9	5.5	11.0	19.0	6.47	6.46	5.55	.0380	.0410	.0460	.0100	.0120	.0130	.214	.144	.237	.0048	.0027	.0058	.000301	.000093	.000372
459	1571-31	Shabankareh	4	25/01/96	3.6	20	0.029	0.011	50.3	4.0	13.0	20.0	7.04	6.44	4.78	.0092	.0160	.0210	.0007	.0018	.0023	.043	.093	.135	.0011	.0010	.0030	.000053	.000079	.000106
460	1571-32	Shabankareh	4	26/01/96	3.9	21	0.049	0.019	166.1	4.0	13.0	20.0	6.23	4.86	4.32	.0360	.0570	.0650	.0090	.0170	.0200	.245	.242	.437	.0049	.0038	.0105	.000278	.000076	.000463
461	1571-34	Shabankareh	4	26/01/96	4.6	20	0.025	0.019	128.9	5.5	11.0	18.0	7.49	6.51	4.82	.0100	.0130	.0170	.0008	.0012	.0015	.055	.059	.123	.0012	.0011	.0027	.000260	.000321	.000149
462	1571-35	Shabankareh	4	26/01/96	4.4	22	0.027	0.072	135.8	5.5	10.0	11.0	7.24	6.80	6.73	.0450	.0380	.0440	.0170	.0110	.0150	.281	.167	.354	.0086	.0032	.0093	.000457	.000089	.000653
463	1589-1	Saadabad	1	26/01/96	4.6	22	0.030	0.031	331.1	3.0	15.0	15.0	9.35	12.58	9.97	.0710	.0300	.0590	.0530	.0130	.0380	.463	.166	.485	.0146	.0037	.0187	.001473	.000172	.001124
464	1589-2	Saadabad	1	26/01/96	4.4	22	0.034	0.023	69.5	2.0			4.09	7.88	4.59	.0260	.0110	.0260	.0030	.0010	.0035	.153	.050	.152	.0041	.0010	.0048	.000308	.000056	.000217
465	1599-1	Firouzabad	3	26/01/96	4.4	26	0.037	0.043	166.4	3.0	8.0	10.0	8.76	9.12	9.84	.0490	.0280	.0340	.0240	.0080	.0120	.234	.140	.111	.0088	.0031	.0034	.000465	.000206	.000300
466	1571-33	Shabankareh	4	26/01/96	3.7	20	0.034	0.014	182.1	5.5	11.0	17.0	13.14	10.59	10.01	.1100	.1300	.2000	.1900	.2100	.4600	.951	.787	1.771	.0355	.0138	.0611	.001547	.000432	.004287
467	1571-36	Shabankareh	4	26/01/96	3.6	15	0.064	0.050	128.9	5.5	12.0	16.0	12.80	5.17	4.15	.0046	.0130	.0190	.0003	.0009	.0016	.045	.061	.140	.0007	.0007	.0025	.000051	.000055	.000118
468	1701-1	Ardebil	4	28/02/97	6.3	32	0.043	0.033	69.2	0.2	6.0	11.0	32.12	35.18	35.33	.1900	.1200	.1900	1.3000	.5200	1.400	1.639	.599	1.201	.1129	.0541	.1088	.024683	.016409	.038285

Thèse de Doctorat de l'Université Joseph Fourier
Grenoble I

Titre de l'ouvrage:
CONTRIBUTION À L'ÉTUDE DES MOUVEMENTS FORTS EN IRAN; DU CATALOGUE AUX LOIS D'ATTÉNUATION

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Résumé:
Les études de risque sismique en Iran sont dans leur phase initiale. Ainsi, il n'existait jusqu'à présent aucun catalogue d'enregistrements accélérométriques en Iran, et aucune étude sur l'ensemble des données iraniennes es n'avait été réalisée. Ce mémoire présente donc la première étude d'ensemble sur les mouvements forts en Iran. Un premier objectif a été d'établir un catalogue des mouvements forts d'Iran en faisant correspondre à chaque enregistrement de qualité suffisante, un événement sismique de localisation et magnitude connues ues, pour 279 enregistrements accélérométriques, analogues et digitaux. Cette correspondance a pu se faire sur la base des catalogues sismologiques internationaux (ISC, NEIC,... etc.) ou nationaux. Pour 189 autres enregistrements numériques, pour lesquelles aucune information télésismique ou locale n'était disponible, les distance hypocentrales et les moments sismiques ont été estimés sur la base des enregistrements eux-mêmes. Une attention particuliere a été accordée aux effets de sites, en choisissant notamment 50 stations accélérométriques du réseau national où les enregistrements ont été nombreux. Une nouvelle classification pour les effets de sites est proposée -basée sur les rapports H/V - qui s'avère relativement simple dans son principe, et plus fiable que les classifications déjà utilisées. Finalement, les lois d'atténuation pour différents paramètres de mouvement fort (dont Arms, Intensité Arias, PGA, PGV, et PGD, énergie, durée et valeurs spectrales) sont obtenues et discutées sur la base d'un total de 468 enregistrements accélérométriques en 3 composantes.

Mots Clés: Sismologie de l'ingénieur, Iran, mouvements forts, effets de site, loi d'atténuation, moment sismique, chute de contrainte, source, accélérograms, catalogue, durée, énergie, Zagros, Alborz, Iran-central