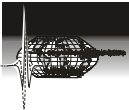


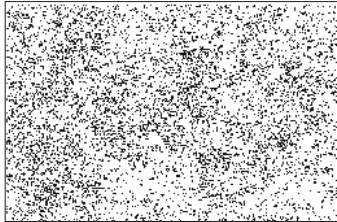
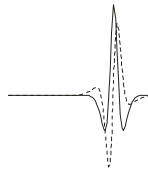
Plan



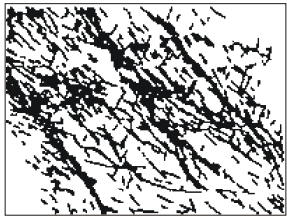
- Problématique
- Formalisme
- ① - Paléointensité relative du champ magnétique terrestre
- Pointés automatiques de phases sismiques
- ② - Analyse de la distribution spatiale des séismes
- Analyse d'organisations minérales des roches magmatiques
- Conclusions et perspectives



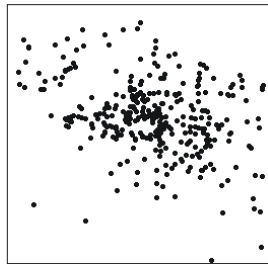
Distributions spatiales 2D



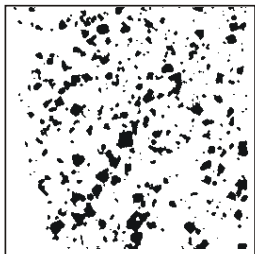
Galaxies (3000 deg²)



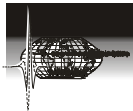
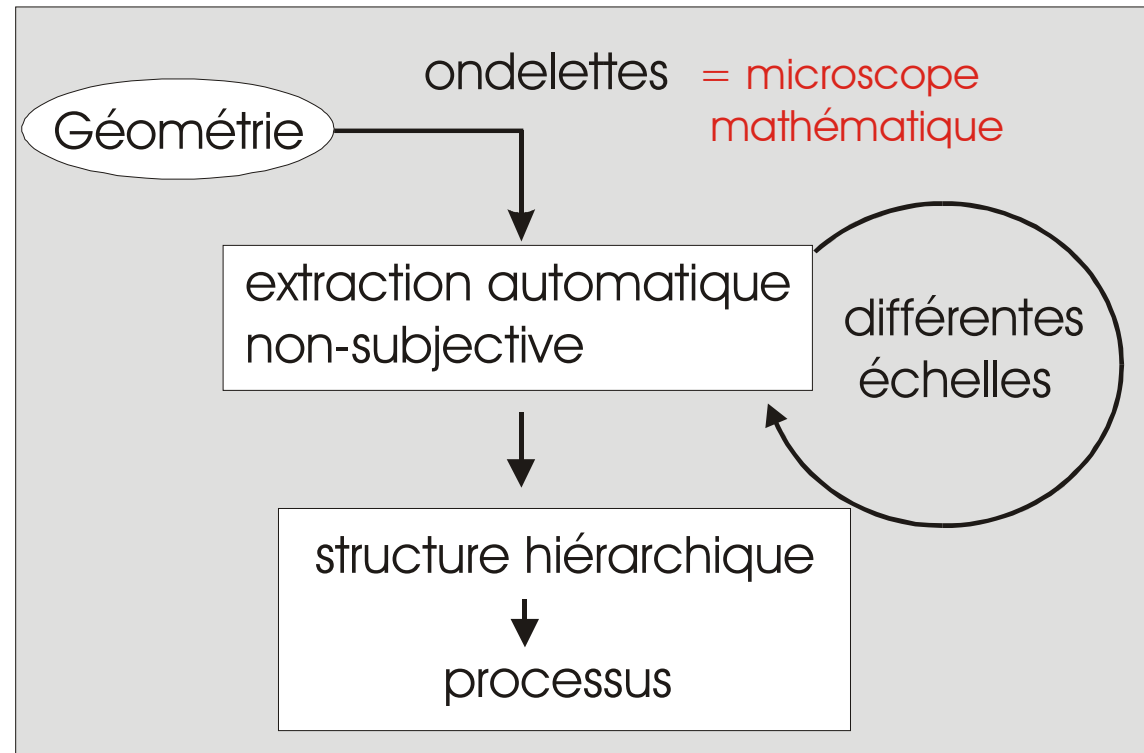
Fractures (~100 km)



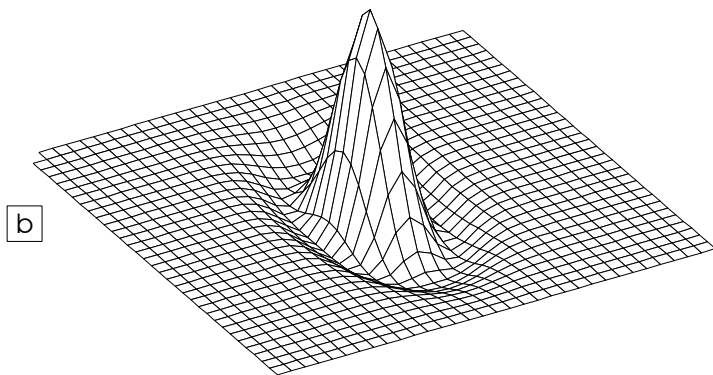
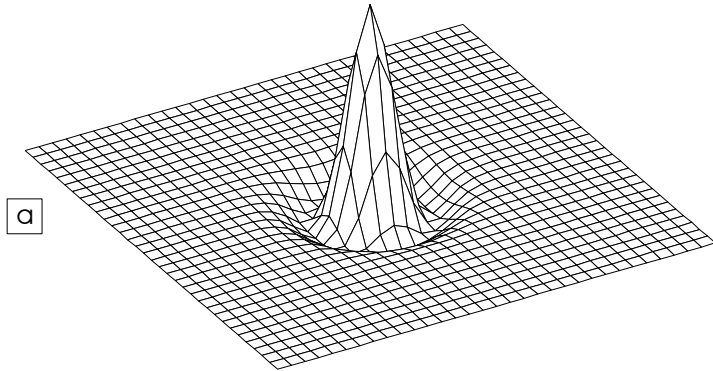
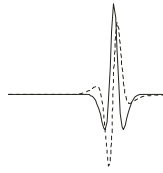
Epicentres (~km)



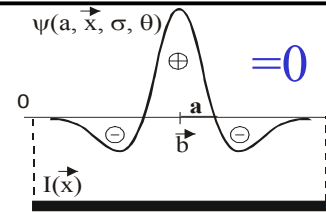
Grains (~cm)



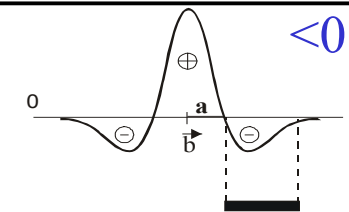
Ondelettes anisotropes 2D



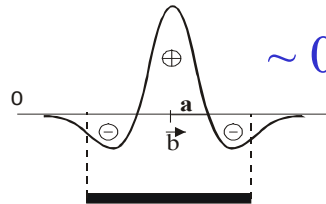
$a, b (b_x, b_y), \sigma, \theta$



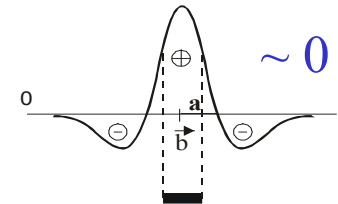
a



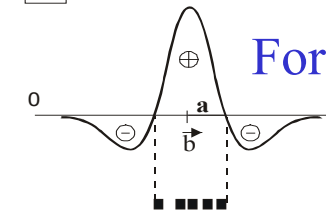
b



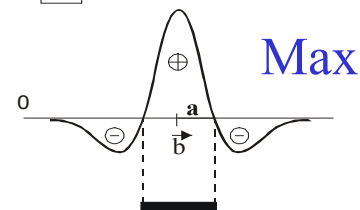
c



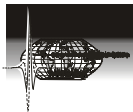
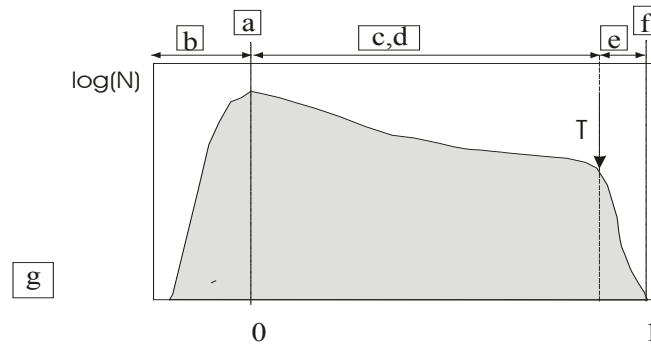
d



e



f



Méthode NOAWC

Méthode NOAWC

Pour chaque α

Pour chaque $\sigma.\alpha$

Pour chaque θ

- Calcul de la TO.

En chaque point (x,y)

Sélection du Coeff. Optimum et
sauvegarde des paramètres
associés (α , $\sigma.\alpha$, θ).

Comparaison de la valeur locale
présente à la valeur locale de la carte
OAWC précédemment sélectionnée.

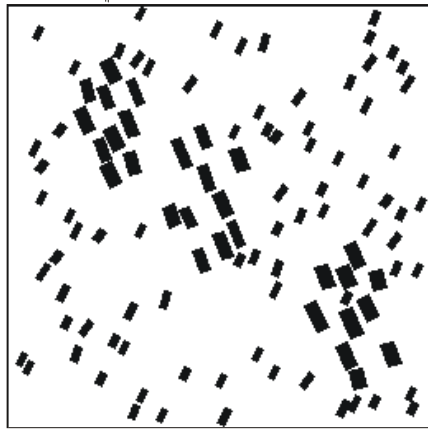
Seuillage - Extraction des structures significatives
=> "résumé optimisé" à l'échelle considérée.

Suivi des roses d'orientation
Reconnaissance des différents niveaux d'organisation.
Si nécessaire, analyse détaillée (dichotomie) pour
préciser l'échelle d'une transition.

Ouillon et al. 1995, 1996
Darrozes et al., 1997
Gaillot et al., 1997



Illustration



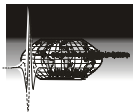
2 sous-populations

paramètres

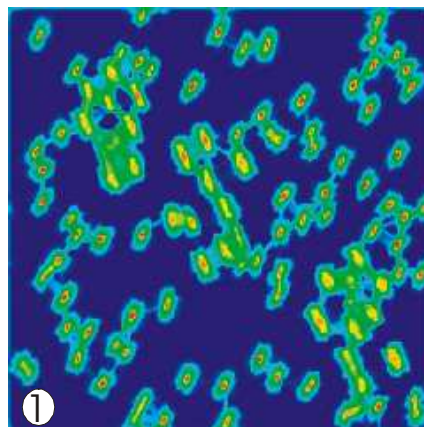
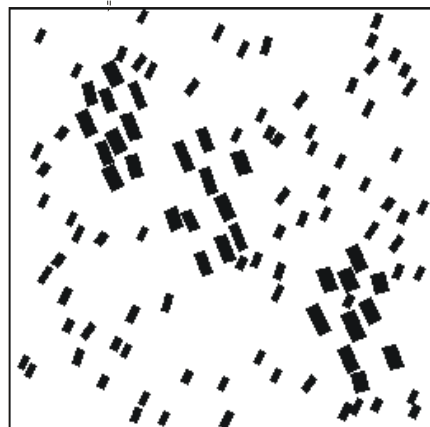
$$a = 2n \quad (n=1,2,\dots,10)$$

$$a \leq \sigma \cdot a \leq \text{Taille Image}$$

$$0^\circ \leq \theta \leq 180^\circ$$

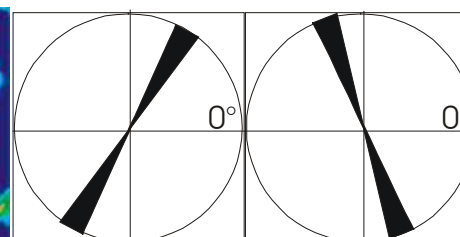


Illustration

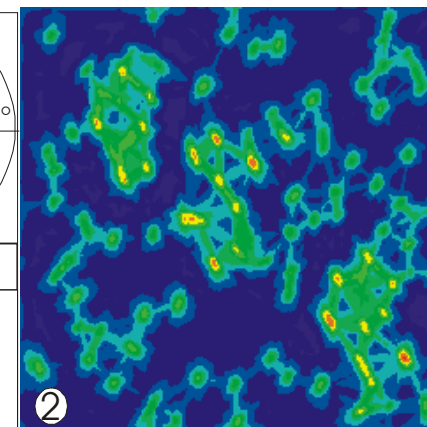


①

a= 2 pxl

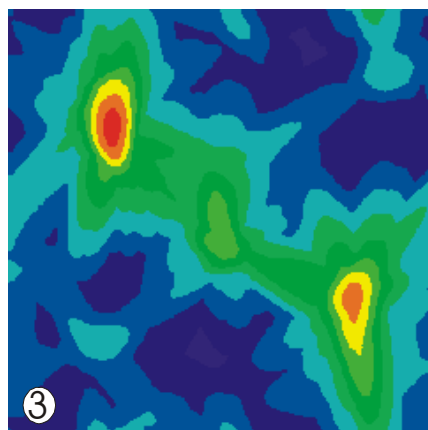


① Grains individuels	②
$\alpha = 2$	$\alpha = 4$
$\theta = 60^\circ \pm 5^\circ$	$\theta = 110^\circ \pm 5^\circ$
$\sigma = 1.86 \pm 0.35$	$\sigma = 1.63 \pm 0.32$



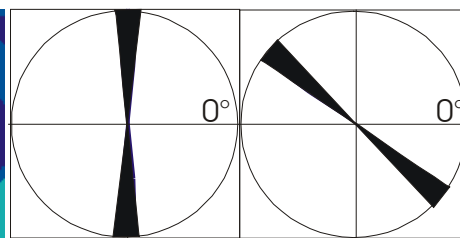
②

a= 4 pxl

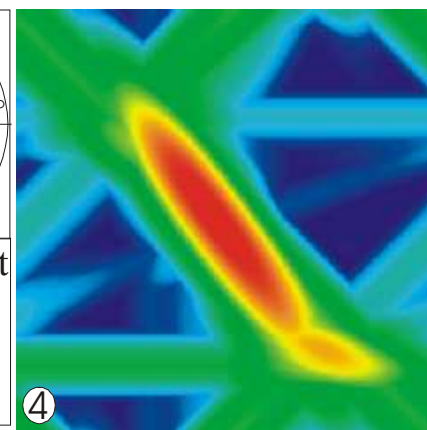


③

a= 12 pxl

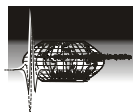


③ Amas	④ Alignement
$\alpha = 12$	$\alpha = 16$
$\theta = 88^\circ \pm 2.5^\circ$	$\theta = 140^\circ \pm 5^\circ$
$\sigma = 1.74 \pm 0.27$	$\sigma = 3$



④

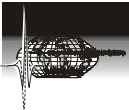
a= 16 pxl





Plan

- Problématique
- Formalisme
- ①D - Paléointensité relative du champ magnétique terrestre
- Pointés automatiques de phases sismiques
- ②D - **Analyse de la distribution spatiale des séismes**
- Analyse d'organisations minérales des roches magmatiques
- Conclusions et perspectives

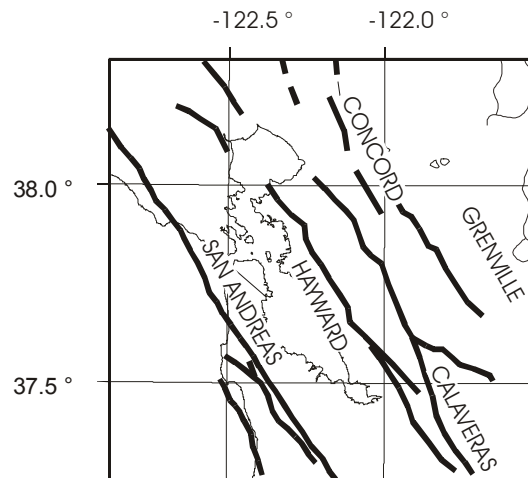


Failles et distribution spatiale des séismes

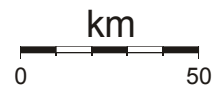
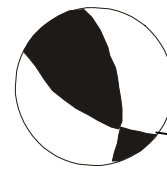
Caractérisation des failles

études tectoniques
risque sismique

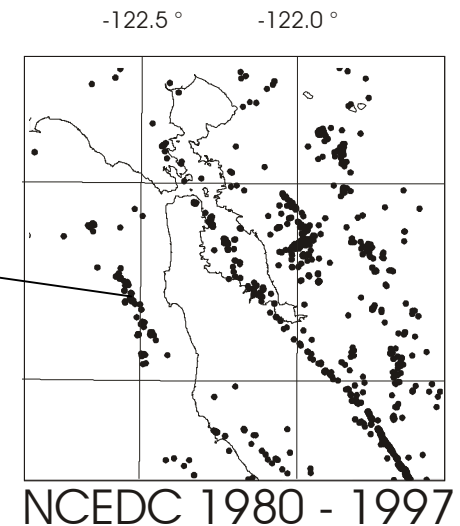
1) Terrain



2) Solutions focales

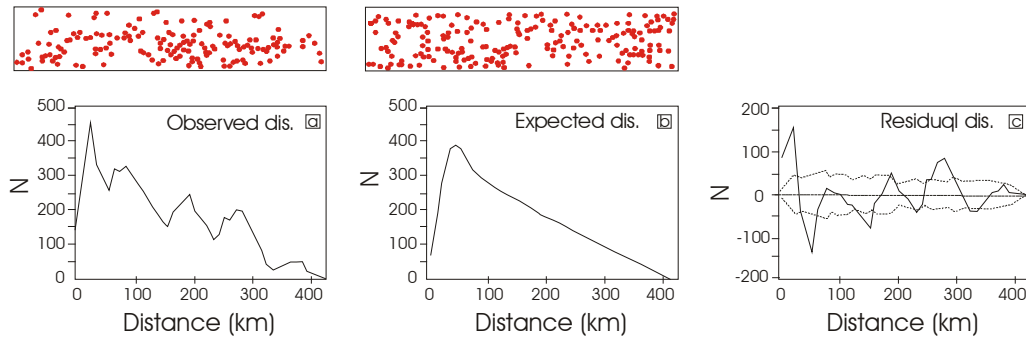


3) Distribution spatiale

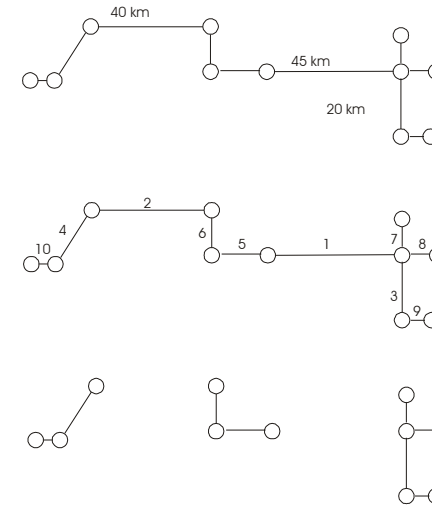


Analyse de la distribution spatiale: approches

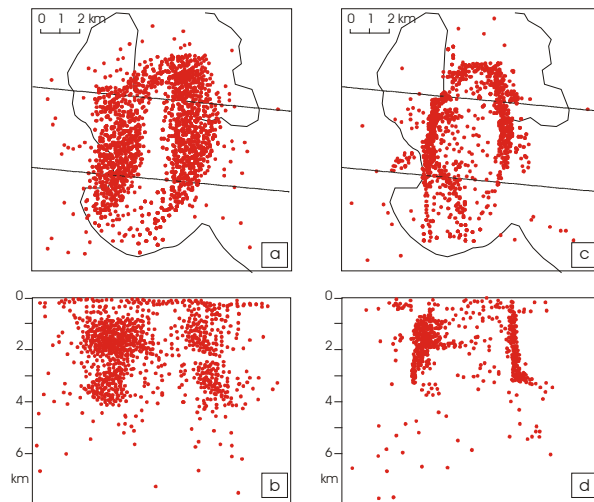
1) méthodes statistiques



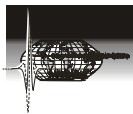
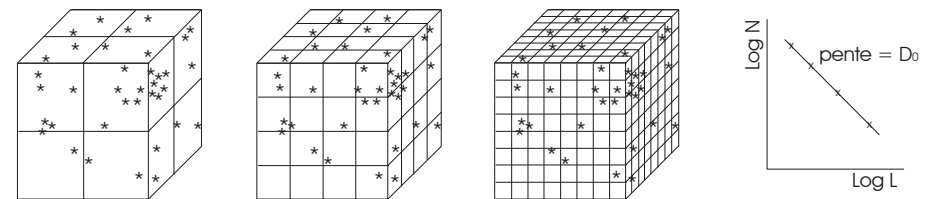
2) Analyse d'amas par lien unique



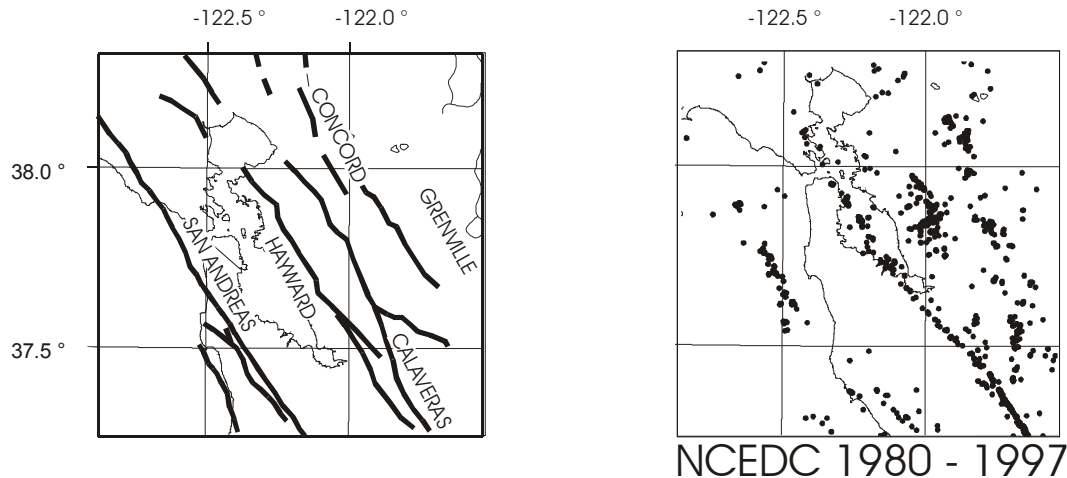
3) Méthode d'effondrement



4) Analyse fractal



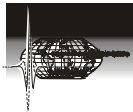
Nouvelle méthode



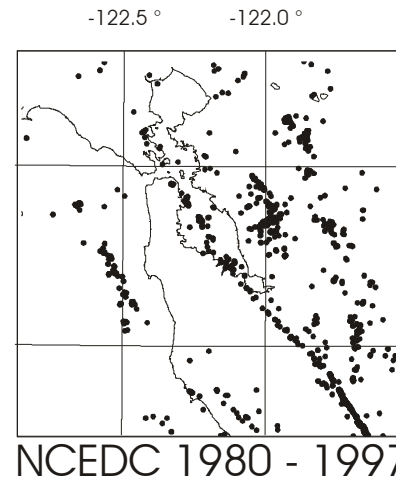
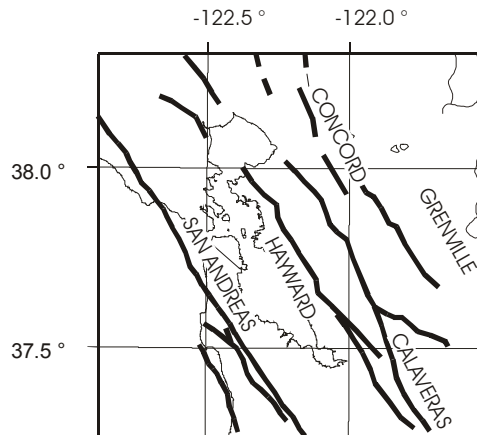
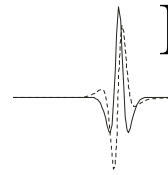
Détection objective d'alignement de sismicité

Hyp: alignements \longleftrightarrow plans de faille

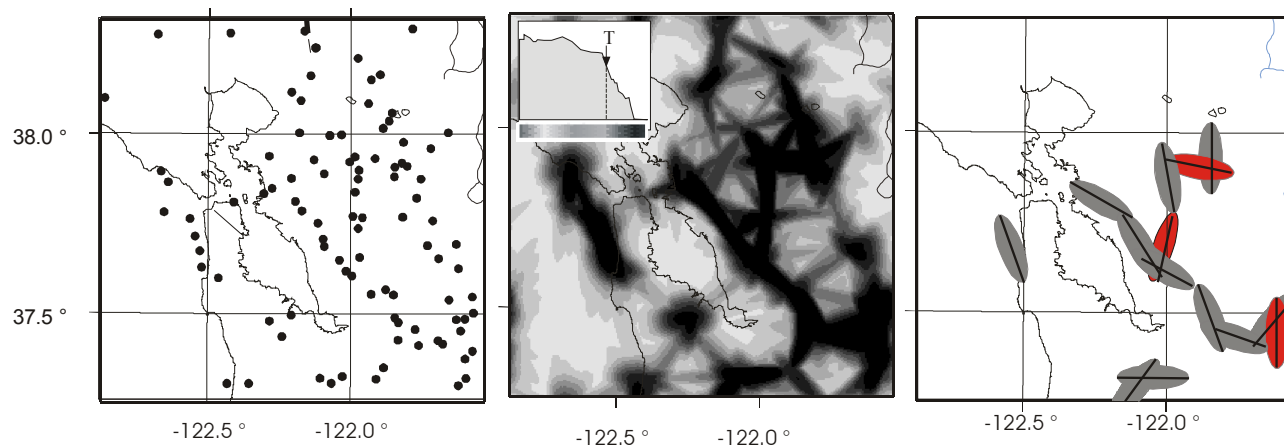
Ondelettes anisotropes : filtres locaux directionnels multi-échelles



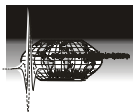
Illustration



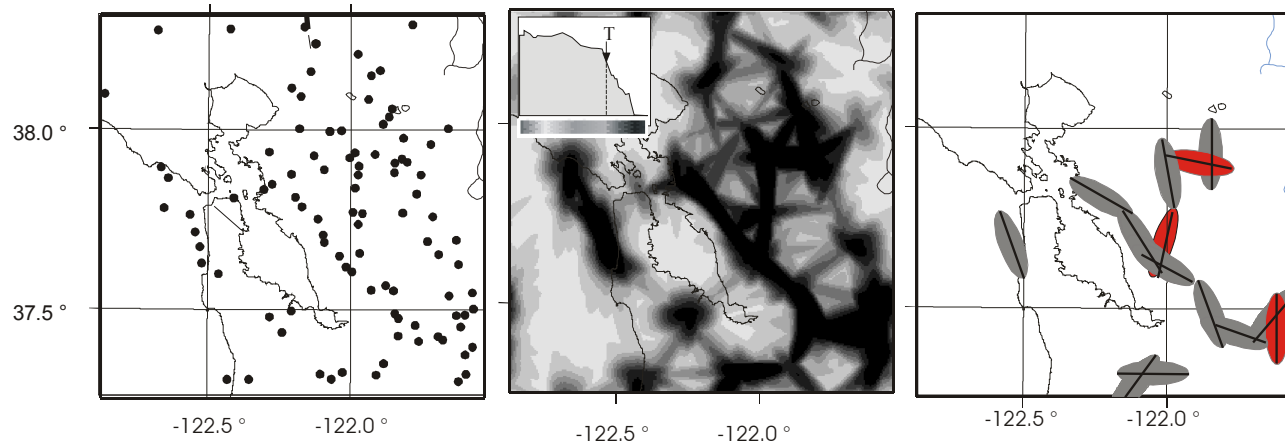
$a \sim 4 \text{ km}$
 $10 < \sigma.a < 150 \text{ km}$
 $0^\circ < \theta < 180^\circ$



100 événements



Interprétation



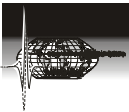
Alignements

failles cartographiées
"extra lignes"

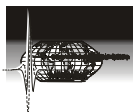
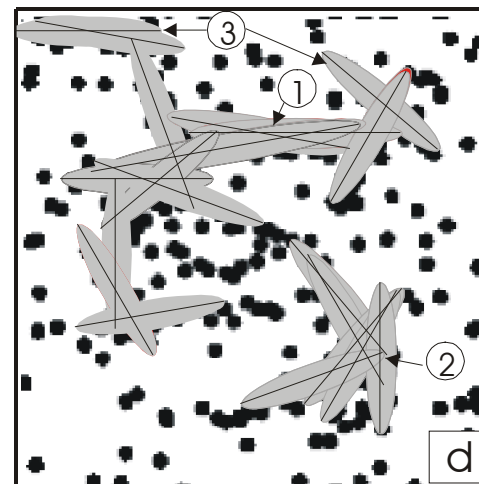
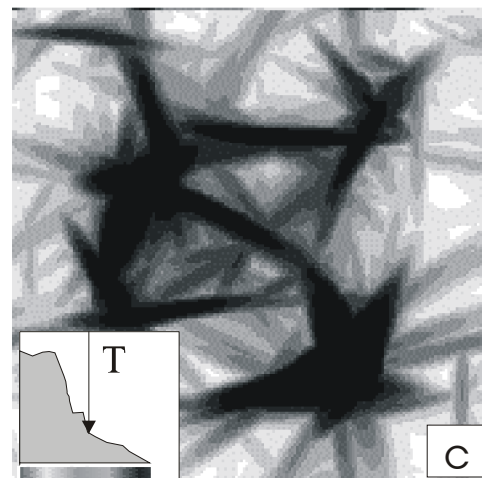
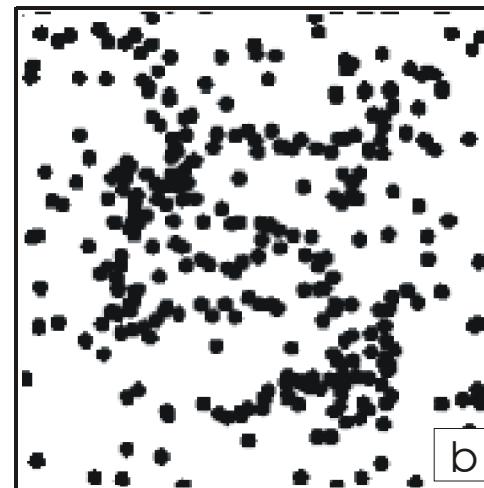
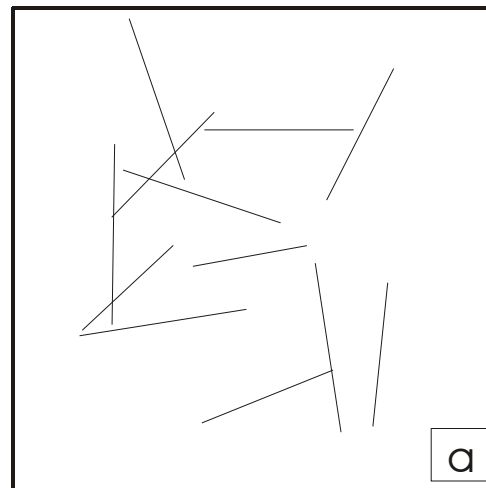
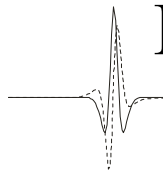
structures tectoniques?
artefacts mathématiques?



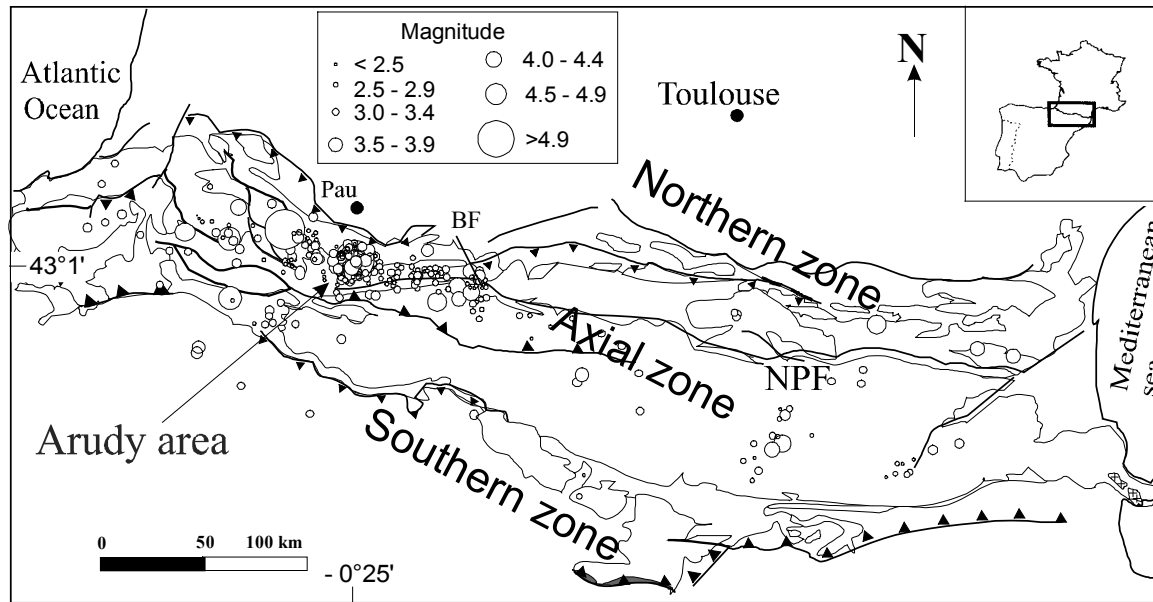
Etudes complémentaires



Exemples d'artefacts mathématiques



Application



Darrozes et al., 1998
Gaillot et al., in print

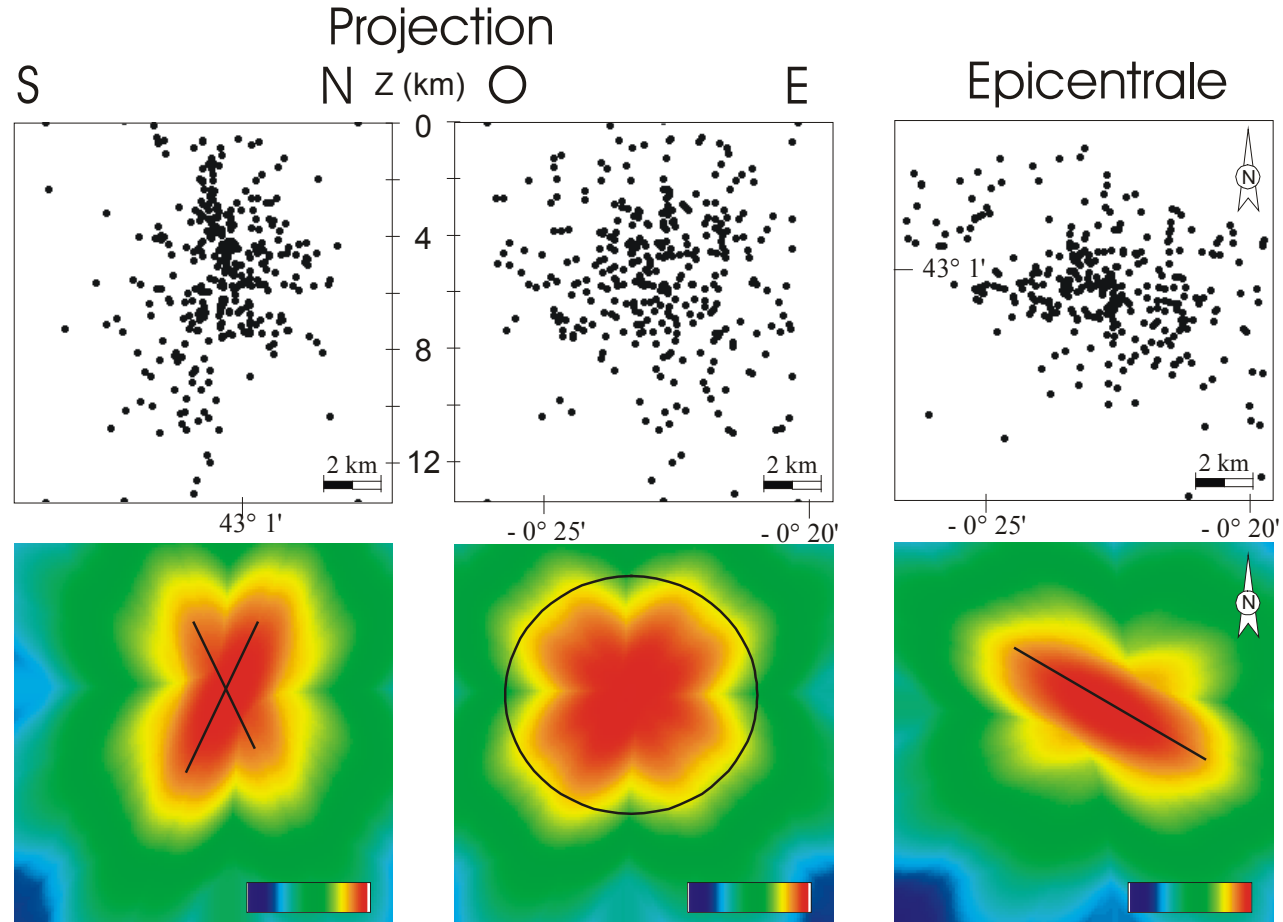
Arudy, $M = 5.1$
29/02/1980

Pas de rupture de surface
Pas ou peu de failles cartographiées

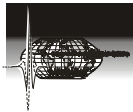
Solutions focales
Distribution des événements sismiques
Err Z ~ 2 km Err X, Y ~ 400 m
Gagnepain-Beyneix et al., 1982

3D → 2D

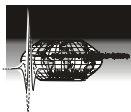
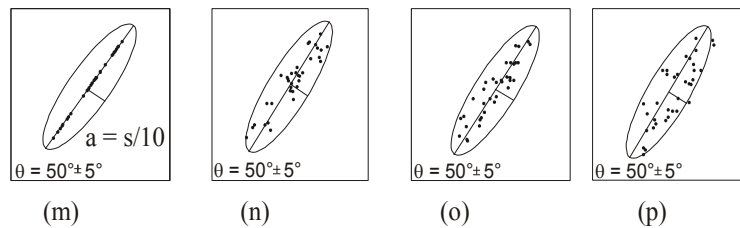
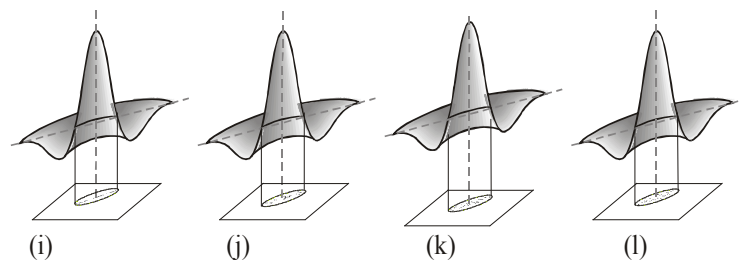
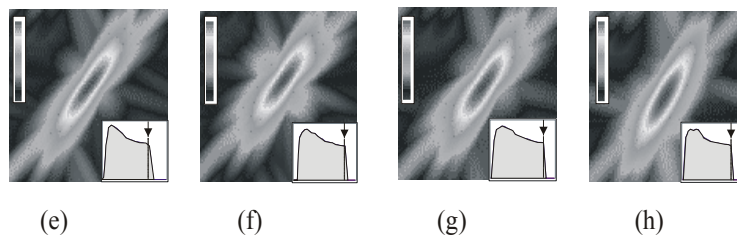
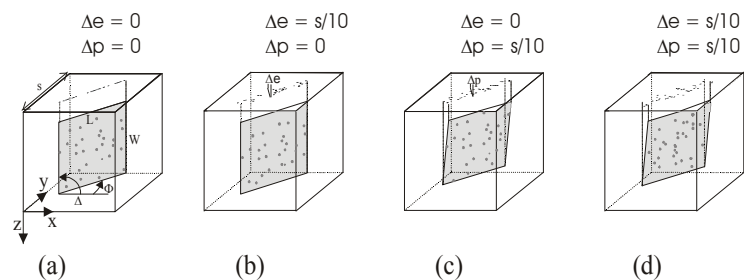
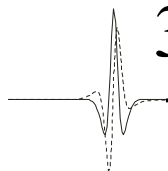
Analyse Grande échelle



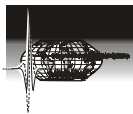
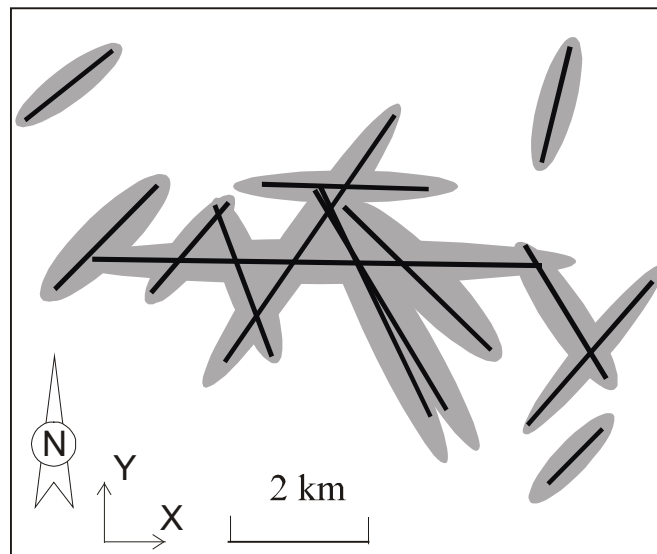
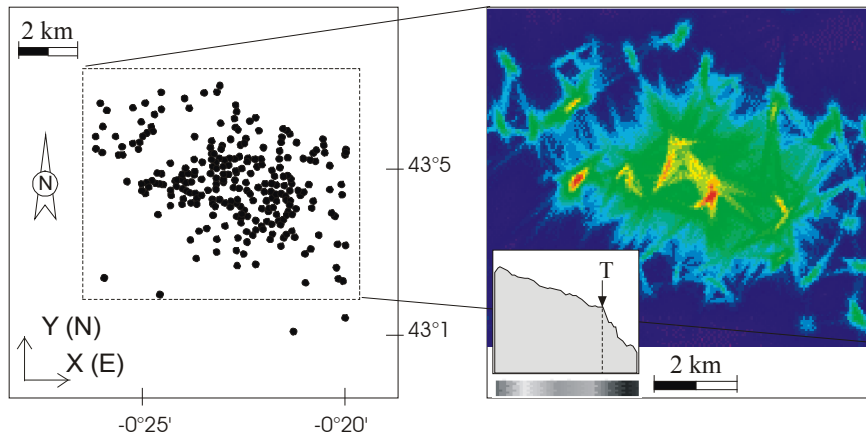
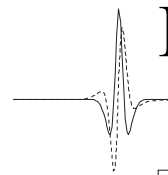
Structures sub-verticales → Analyse de la distribution épiscopentrale



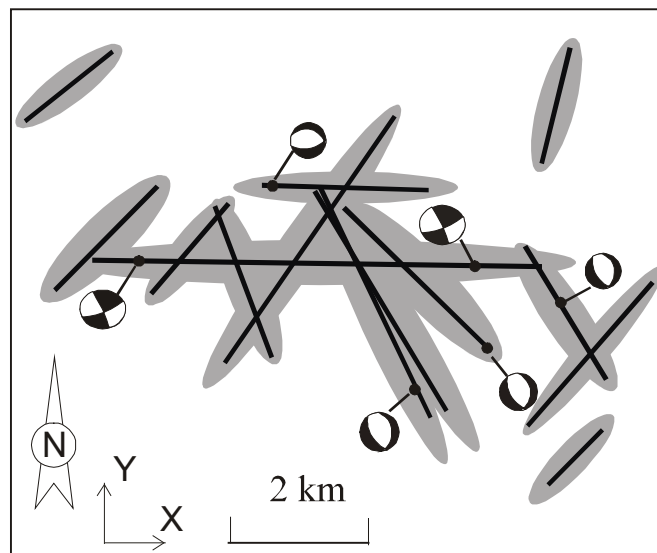
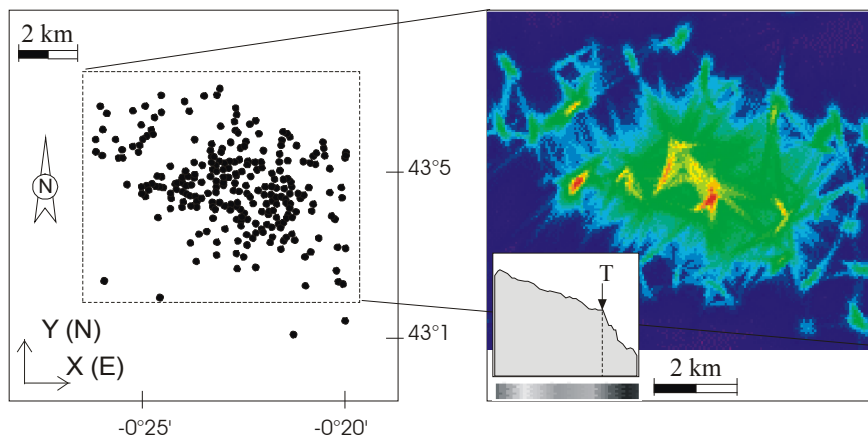
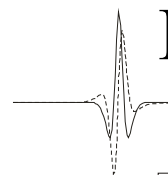
3D → 2D - cas théoriques



Distribution épicentrale



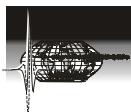
Distribution épacentrale



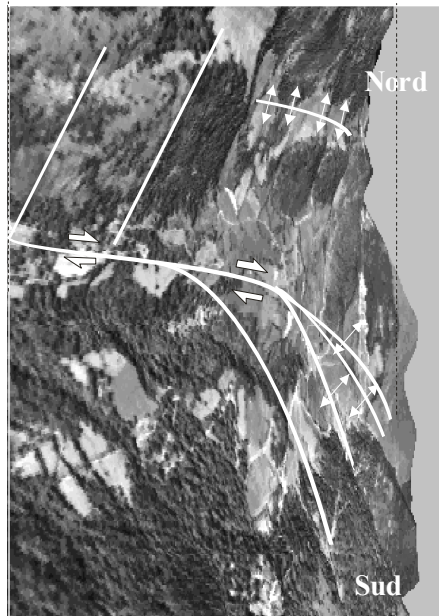
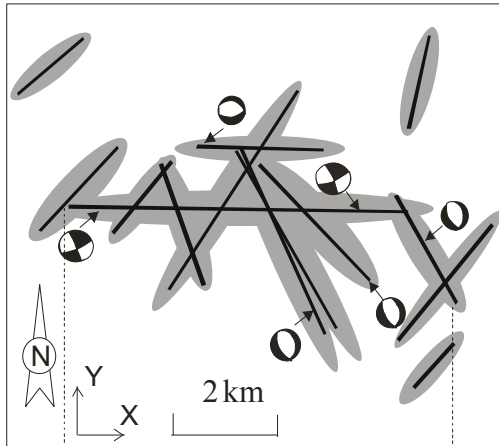
Solutions focales
Arguments mécaniques



Queue de cheval



Validation géomorphologique



MNT

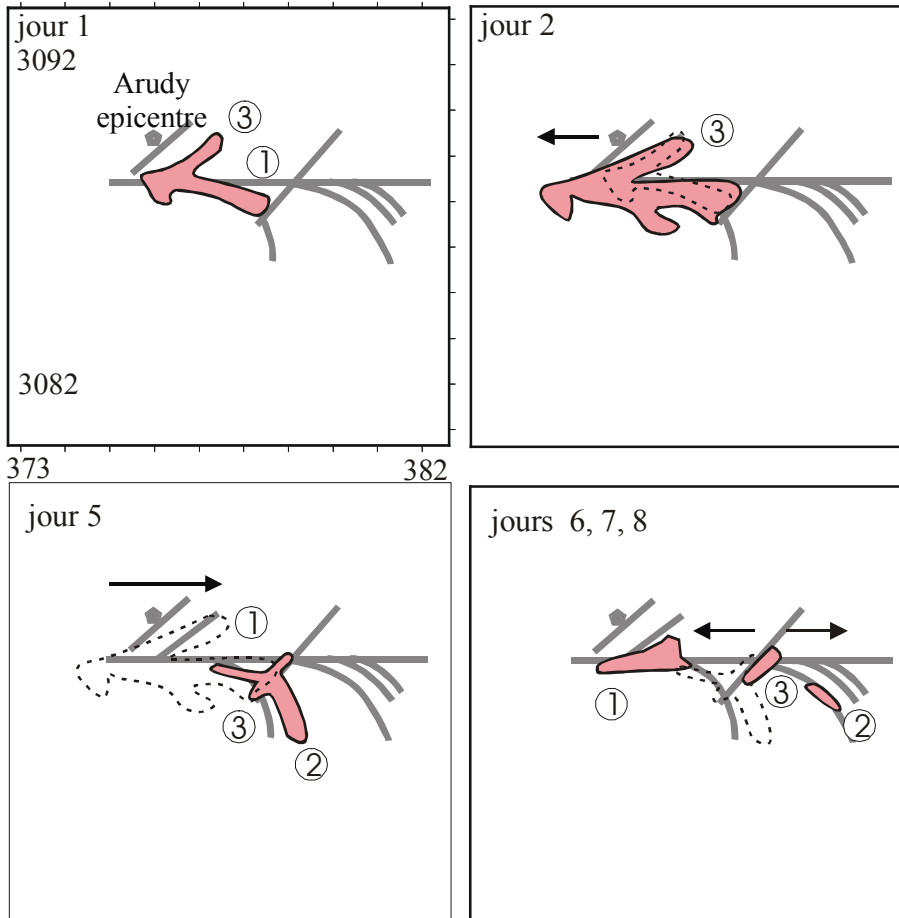
Argument géomorphologiques



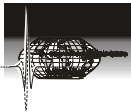
Validation

Propagation de la rupture

Reconstruction temporelle



Jour 1: concentrée
Jour 2: migration vers l'Ouest - Blocage
Jours 3 - 4: relaxation
Jour 5: activité à l'Est
Jour 6 et +: rebond à l'Ouest -
réajustement à l'Est



Résumé et conclusion

Nouvelle méthode

Spécification

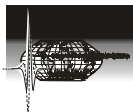
a: résolution = incertitude sur les données

Seuil ← Histogramme de coefficients d'ondelette

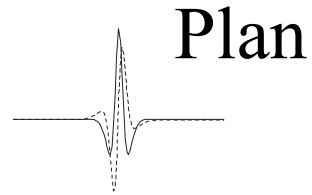
Ondelettes

base d'une approche quantitative, objective et pluri-outils

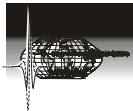
→ reconstruction de la géométrie de la zone de rupture

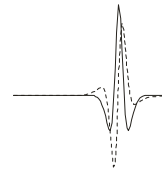


Plan



- Problématique
- Formalisme
- ① - Paléointensité relative du champ magnétique terrestre
- Pointés automatiques de phases sismiques
- ② - Analyse de la distribution spatiale des séismes
- **Analyse d'organisations minérales des roches magmatiques**
- Conclusions et perspectives





Problématique

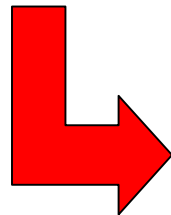
Analyse des fabriques

Processus

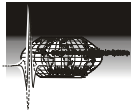
déformation des roches magmatiques
| cristallisation - refroidissement
| transition liquide-solide

Fabrique (=taille, forme, orientation et distribution spatiale)

| signification à l'échelle du grain
| mécanismes d'acquisition



Etudes cinématique et tectoniques de la croûte sup.



Approches classiques

Terrain

ASM

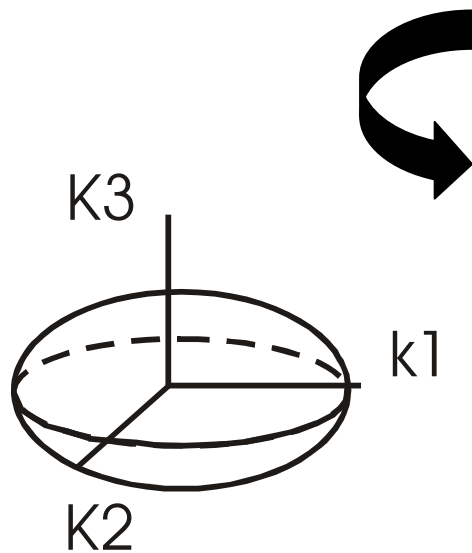
3D

Phases magnétiques

Analyse d'image

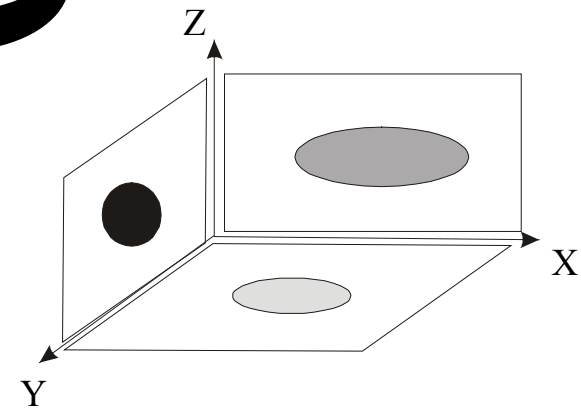
2D

Toutes les phases

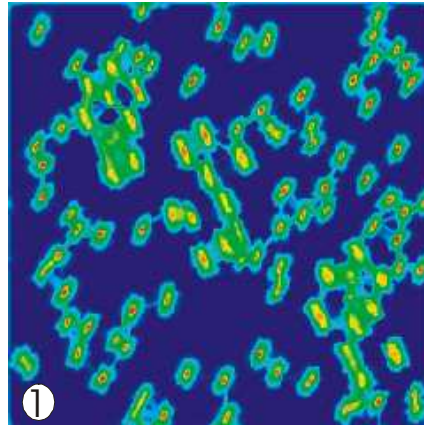
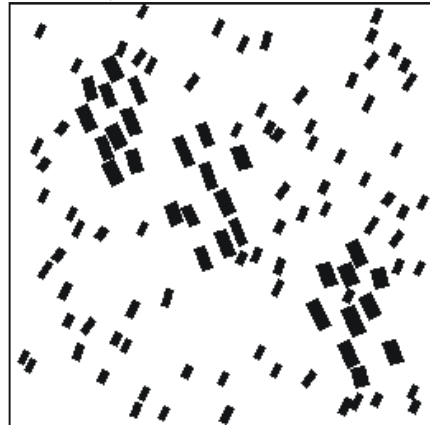


composition
taille
forme
orientation
distribution spatiale

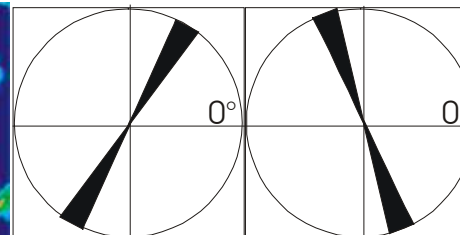
TENSEURS



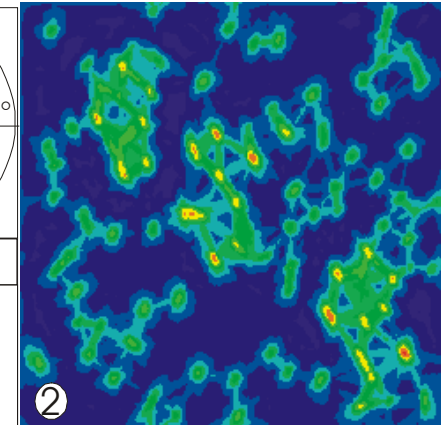
Méthode



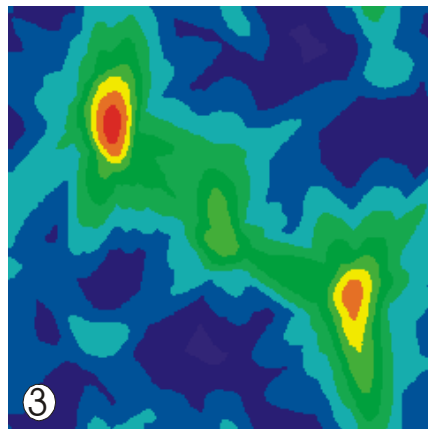
①
a= 2 pxl



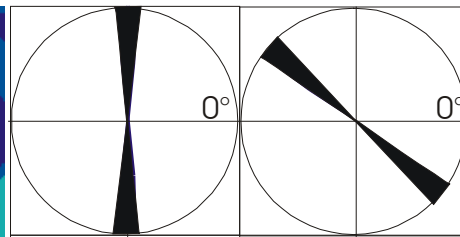
① Grains individuels	②
$\alpha = 2$	$\alpha = 4$
$\theta = 60^\circ \pm 5^\circ$	$\theta = 110^\circ \pm 5^\circ$
$\sigma = 1.86 \pm 0.35$	$\sigma = 1.63 \pm 0.32$



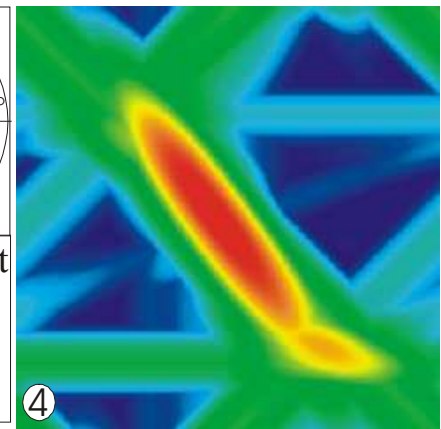
②
a= 4 pxl



③
a= 12 pxl

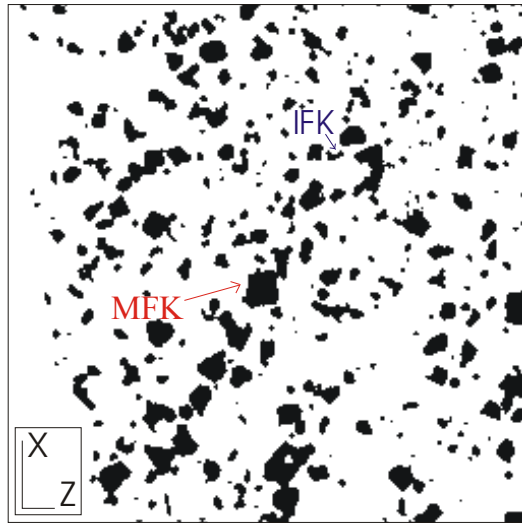


③ Amas	④ Alignement
$\alpha = 12$	$\alpha = 16$
$\theta = 88^\circ \pm 2.5^\circ$	$\theta = 140^\circ \pm 5^\circ$
$\sigma = 1.74 \pm 0.27$	$\sigma = 3$



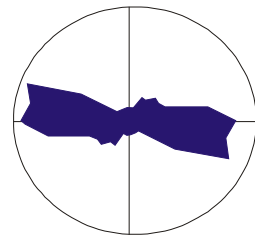
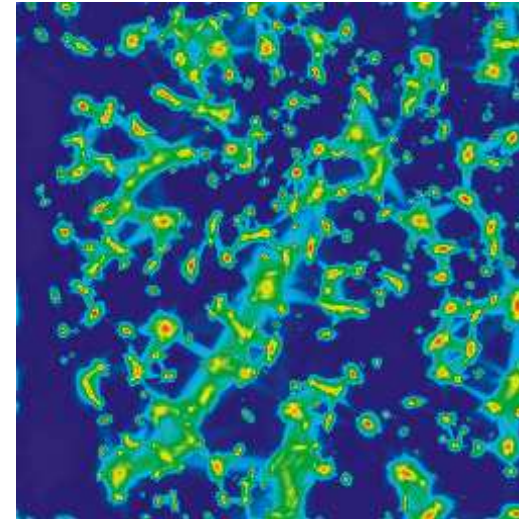
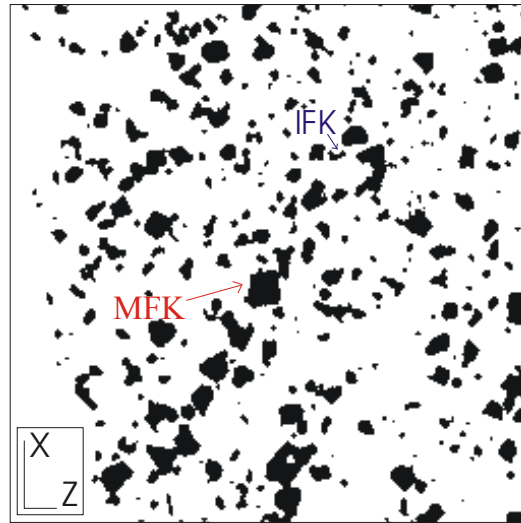
④
a= 16 pxl

Application

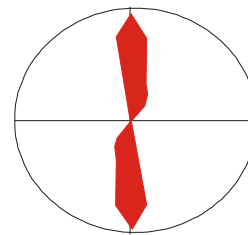


Granite (Sidobre, France)
section XZ
20 cm x 20 cm
Feldspath Potassique

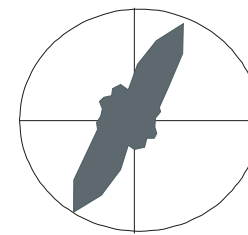
Résultats



FP interstitiel:
 $a = 2 \text{ pxl}$
 $SR = 1.3 \pm 0.3$
 $\Theta = -10^\circ \pm 5$

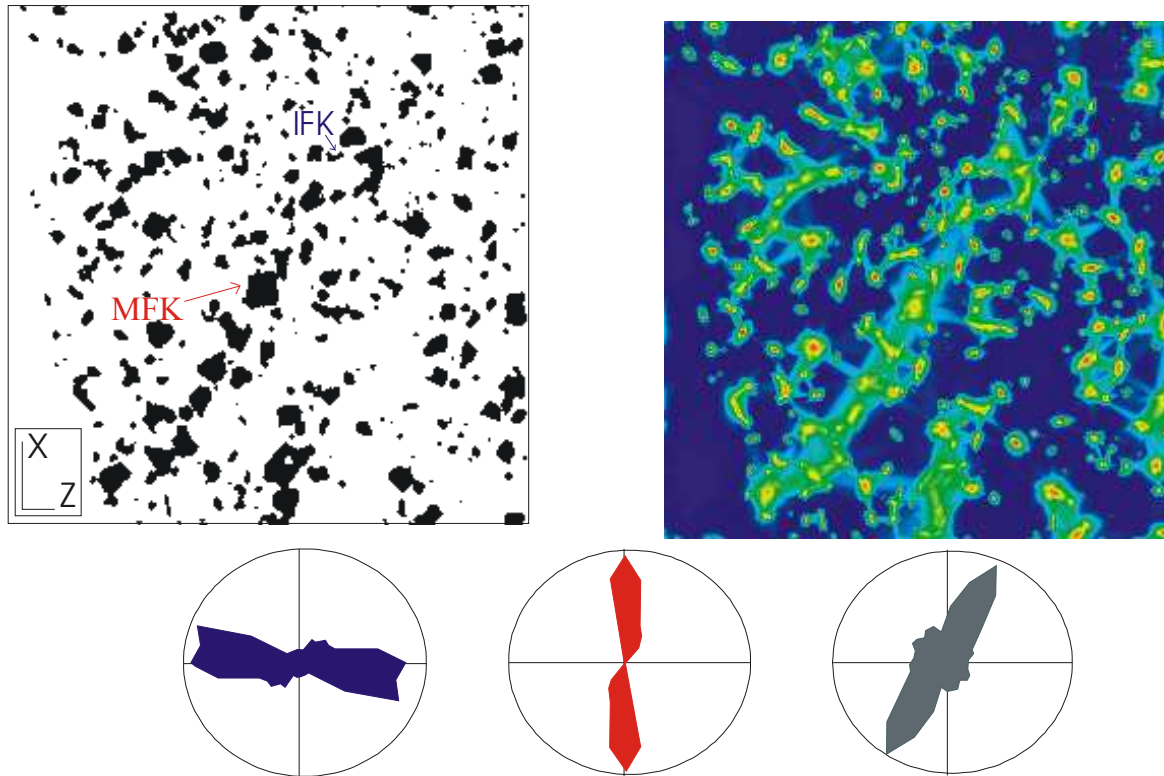


FP Megacristaux:
 $a = 4 \text{ and } 6 \text{ pxl}$
 $SR = 1.2 \pm 0.2$
 $\Theta = 90^\circ \pm 5$



Alignements:
 $a = 8 \text{ and } 10 \text{ pxl}$
 $SR = 8 \pm 2.4$
 $\Theta = 30 \pm 5$

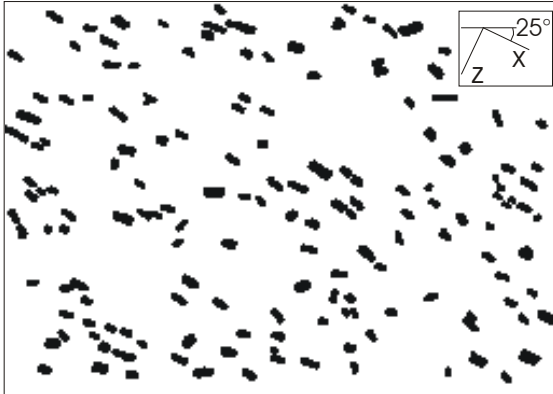
Interprétation



Reconnaissance de 2 sous-fabrique perpendiculaires ← cristallisation tardive
Avec remplissage de microfractures par les derniers liquides feldspathiques



Application

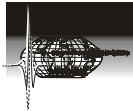


Granite (Sidobre, France)

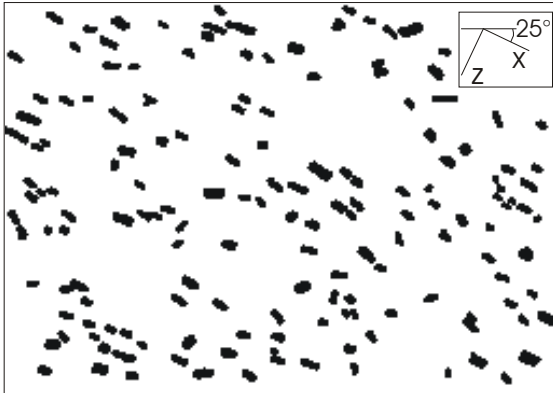
XZ section

70 cm x 100 cm

Feldspath Potassique

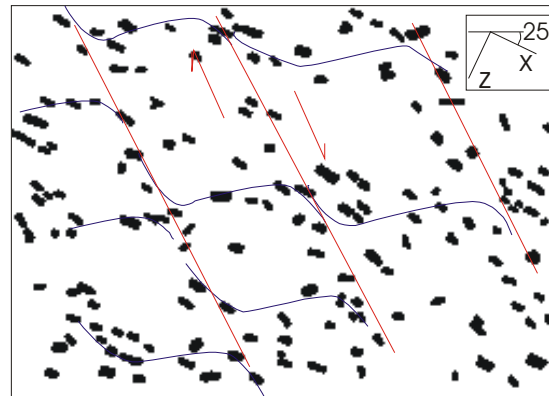
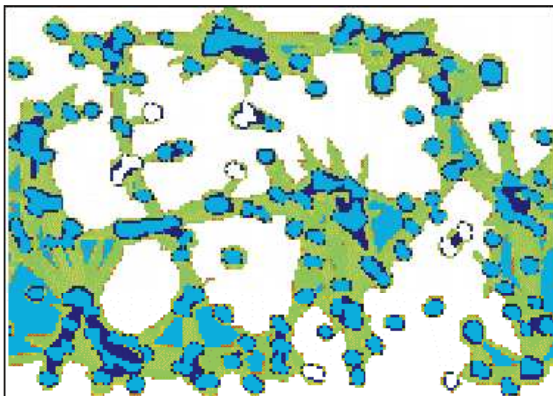


Résultats



distribution spatiale périodique

glissement à l'interface grains/matrice
interactions mécaniques entre grains



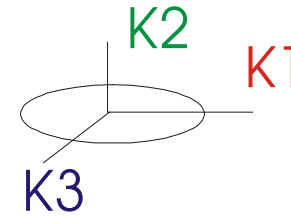
Cisaillement avant cristallisation complète du massif

Distribution spatiale des magnétites et ASM

2 grains isolés



forme
orientation
taille



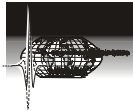
Distribution spatiale et ASM? Théorie

Stephenson, 1991
Canon-Tapia, 1995

Expériences

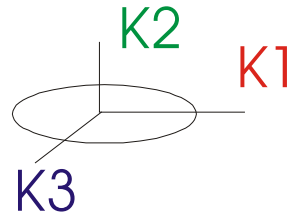
Hargraves, 1991
Grégoire et al., 1995

Interactions magnétiques

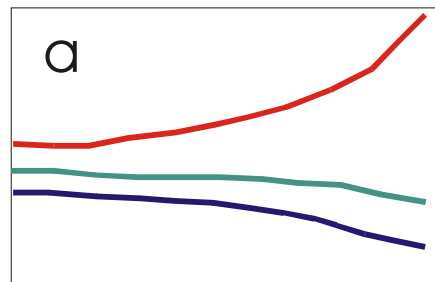
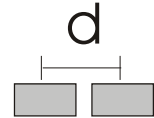


Interaction magnétique

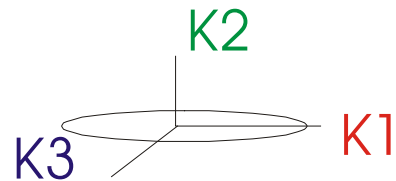
Grains isolés



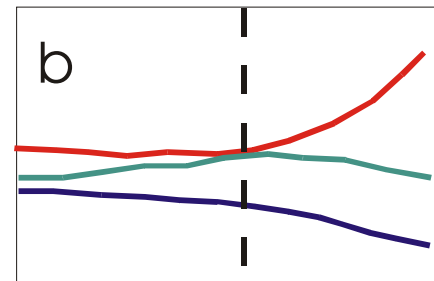
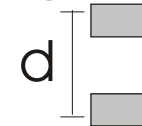
configuration a



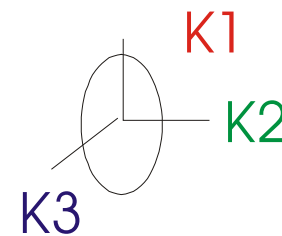
1/d



configuration b

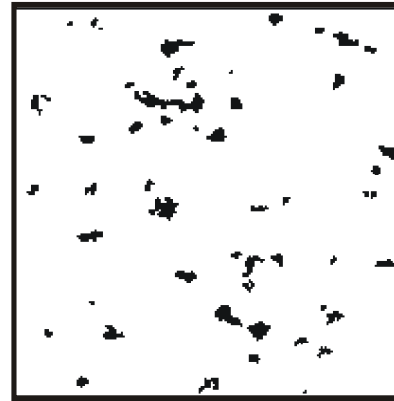


1/d



Cas naturel

Syénite (Madagascar)
3% magnétite



2 cm x 2 cm

6 K1K2 sections

6 K2K3 sections

6 K1K3 sections

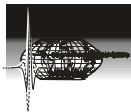
600 grains

Analyse et résultats

Ondelettes = | filtres directionnels locaux
 | détecter et caractériser les amas interagissant
 | distance inter-grains
 | orientation de l'alignement

		K_1K_3	K_2K_3	K_1K_2
Interactions faibles	$C \geq 0.22$			
	θ (°) n (%)	5 ± 22 20.1	14 ± 22 19.3	11 ± 22 18.7
Interactions fortes	$C \geq 0.42$			
	θ (°) n (%)	28 ± 11 3.8	46 ± 11 2.7	-3 ± 6 5.5

ASM = OPF





Résumé et Conclusion

Processus de déformation des roches magmatiques

Résultats

Méthode développée

Quantifier

OPF

distribution spatiale des grains

Détecter différentes sous-fabriques

Détecter des structures d'échelles variées

processus de cristallisation tardive

glissement à l'interface grains/matrice

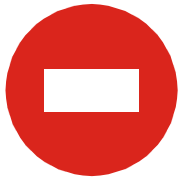
interactions mécaniques entre grains

valider ASM pour les roches ferromagnétiques



Conclusion : point de vue méthodologique

Propriétés d'analyse locale et multi-échelle
Pas d'hypothèse - Flexibilité

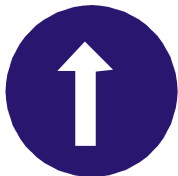


Considérations théoriques

formalisme

restrictions mathématiques

connaissance du système



Explique rien - éclate l'information

Description quantitative

hétérogénéités, singularités et interactions
à différentes échelles



PROCESSUS