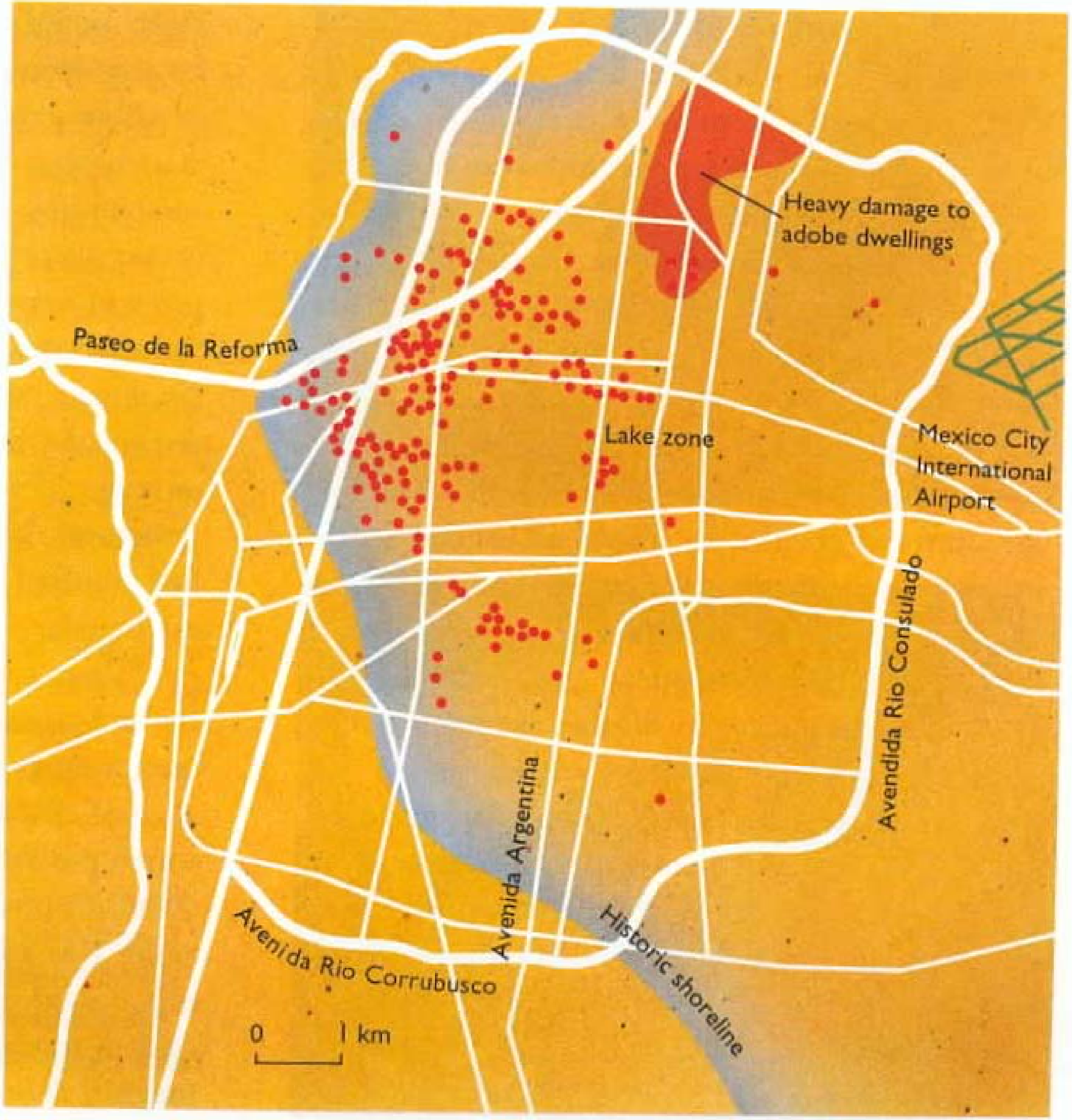
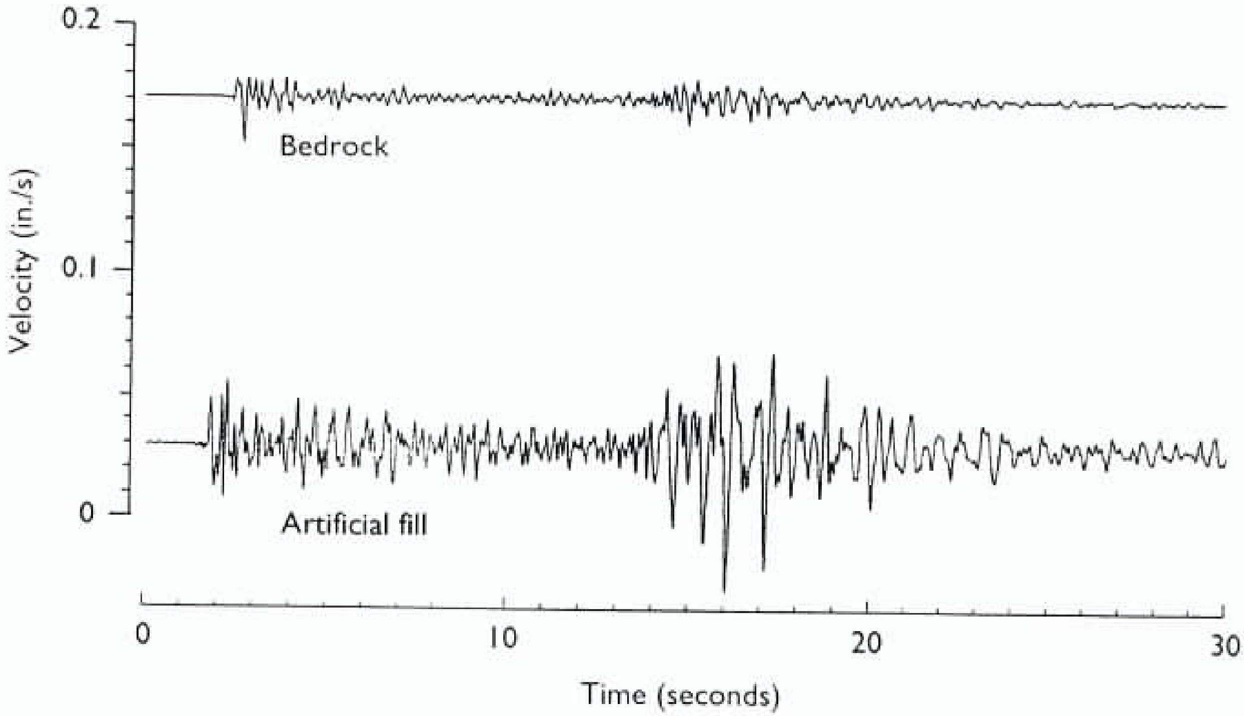
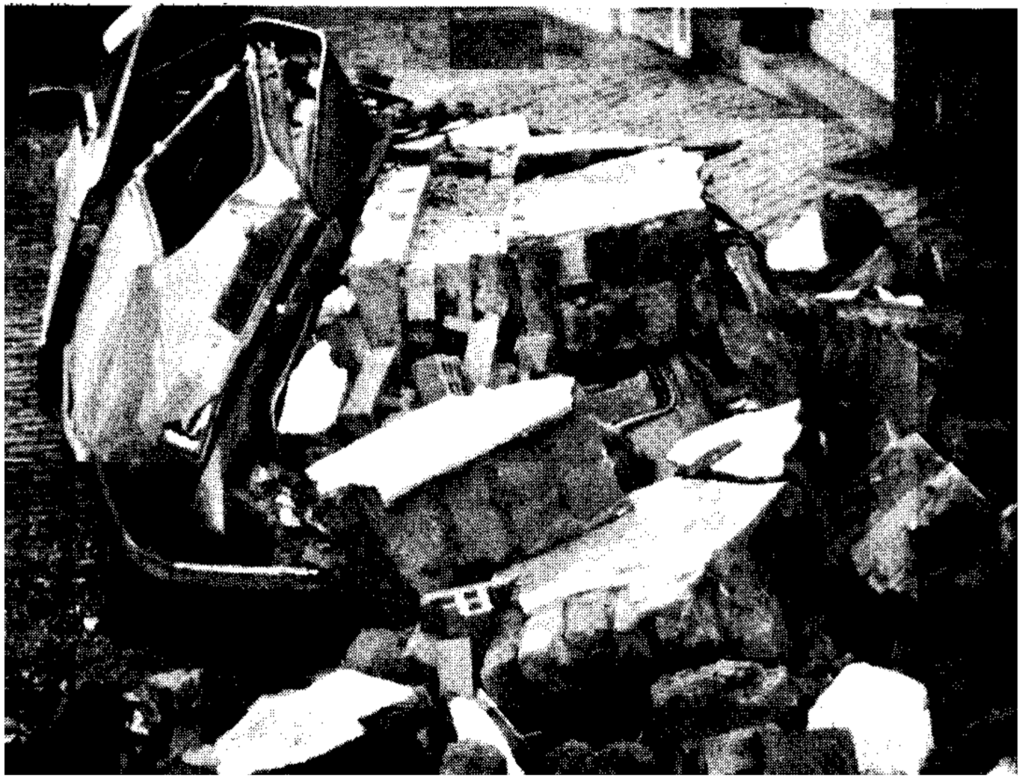
Effets de sites



Heavily damaged and collapsed major structures were concentrated in the old lake zone of Mexico City. Each dot represents a heavily damaged or collapsed building.



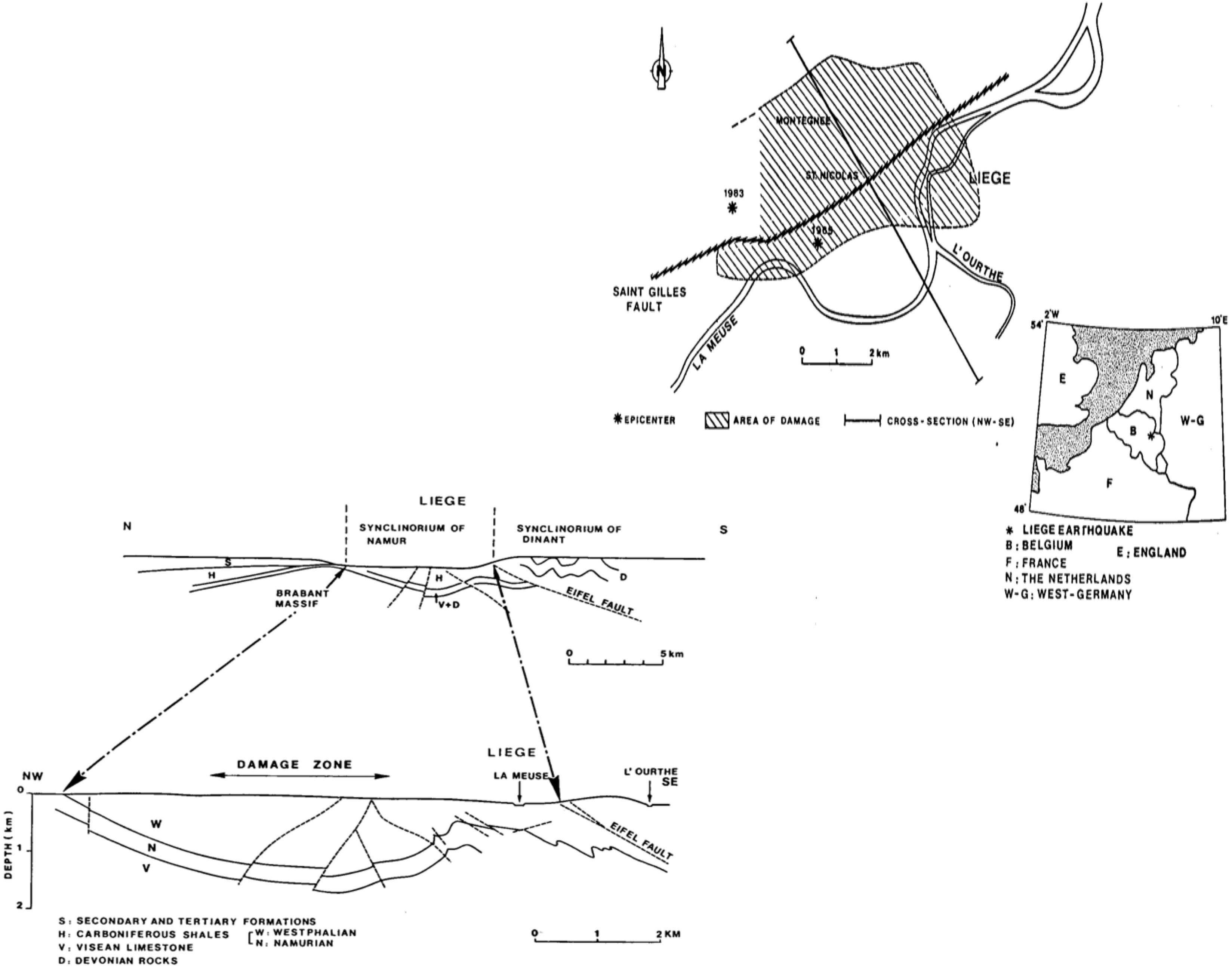
These two seismograms from temporary stations on bedrock and artificial fill were recorded during an aftershock of the 1989 Loma Prieta earthquake. The location of the station on artificial fill is indicated on the map on page 35.



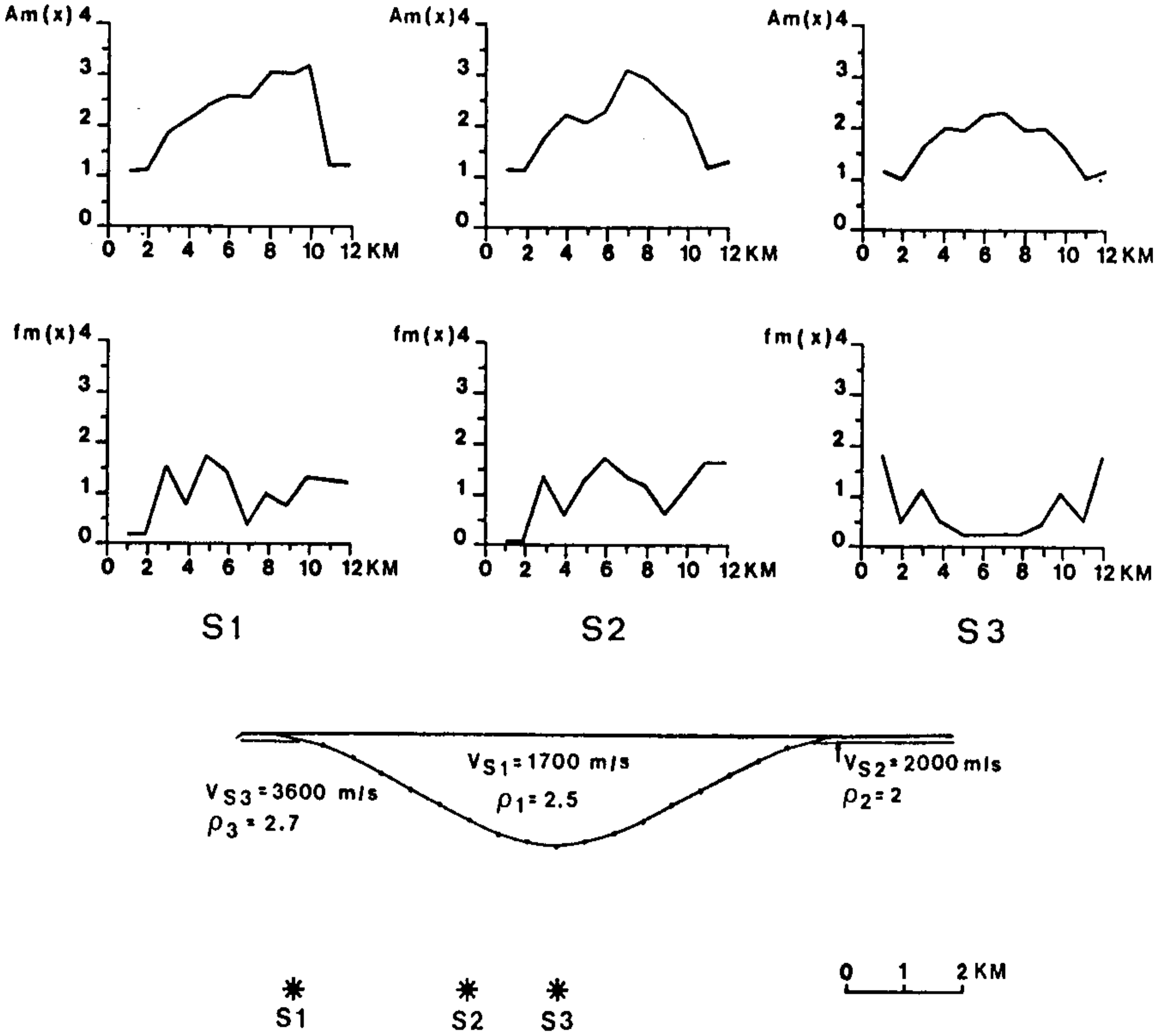
Liège, 1983   M=4.9

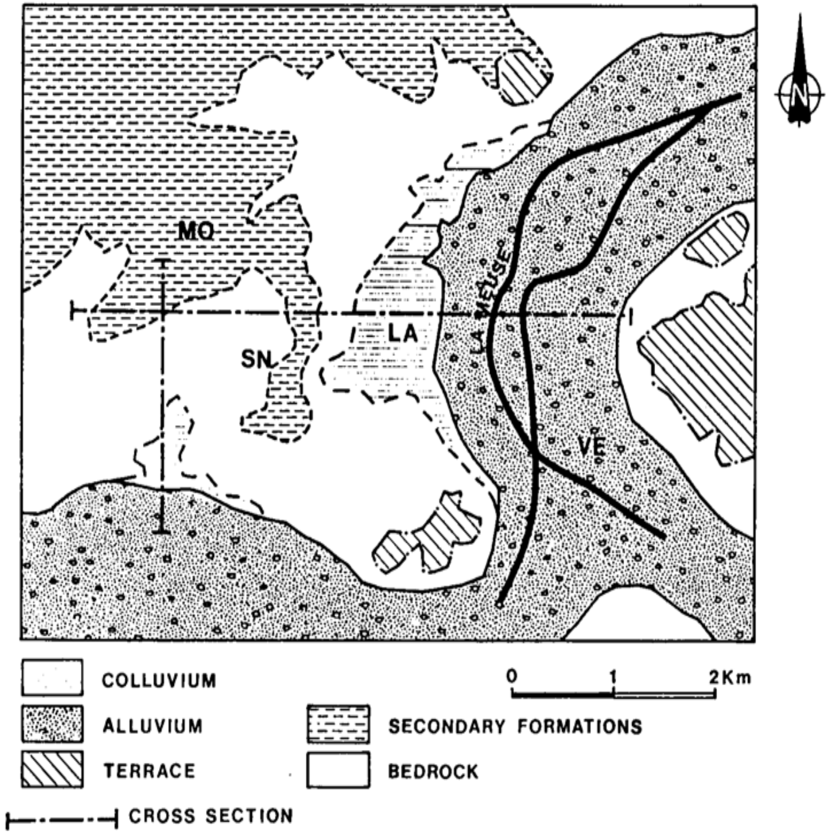
Figure 8 - Displacement of building front.

Figure 9 - Partially collapsed masonry building.

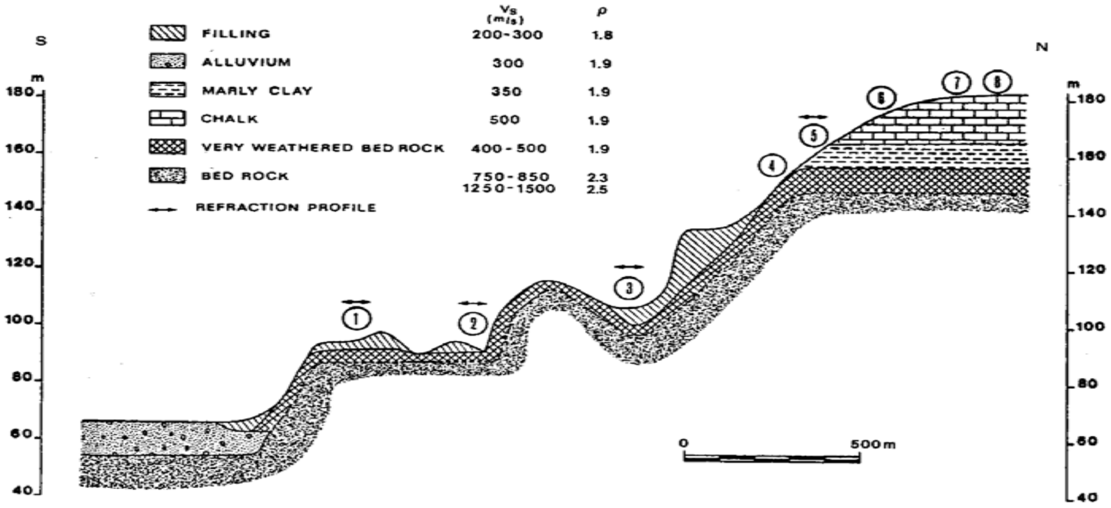


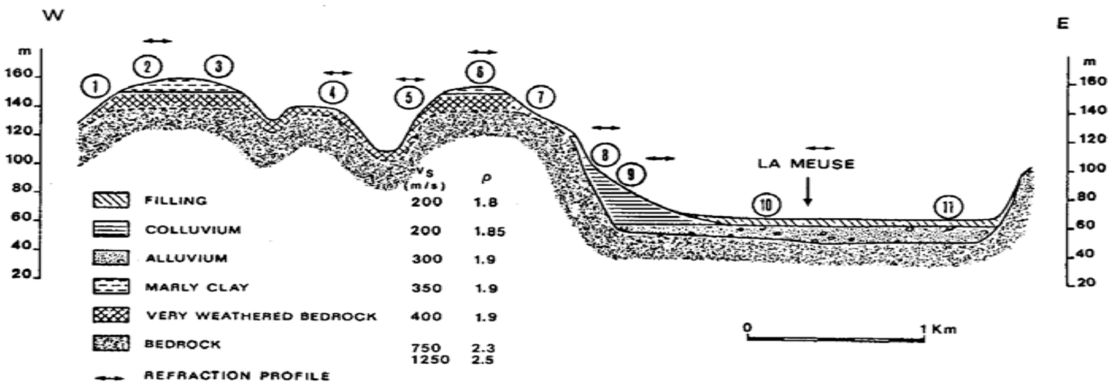
N
MONTEGNEE
ST NICOLAS
LIEGE
1983
1985
SAINT GILLES
FAULT
LA MEUSE
L' OURTHE
0 1 2 km
EPICENTER
AREA OF DAMAGE
CROSS-SECTION (NW-SE)
2°W
10°E
54°
48°
E
N
B
W-G
F
LIEGE EARTHQUAKE
B: BELGIUM
E: ENGLAND
F: FRANCE
N: THE NETHERLANDS
W-G: WEST-GERMANY
LIEGE
N
SYNCLINORIUM OF NAMUR
SYNCLINORIUM OF DINANT
S
S
H
H
D
BRABANT MASSIF
V+D
EIFEL FAULT
0 5 km
DAMAGE ZONE
LIEGE
NW
LA MEUSE
L' OURTHE
SE
0
1
2
DEPTH (km)
W
N
V
EIFEL FAULT
S: SECONDARY AND TERTIARY FORMATIONS
H: CARBONIFEROUS SHALES [W: WESTPHALIAN, N: NAMURIAN]
V: VISEAN LIMESTONE
D: DEVONIAN ROCKS
0 1 2 KM


Am(x) 4
3
2
1
0
0 2 4 6 8 10 12 KM
fm(x) 4
S1
S2
S3
V_{S1} = 1700 m/s
ρ_1 = 2.5
V_{S3} = 3600 m/s
ρ_3 = 2.7
V_{S2} = 2000 m/s
ρ_2 = 2
0 1 2 KM



MO
SN
LA
LA MEUSE
VE
COLLUVIUM
ALLUVIUM
TERRACE
SECONDARY FORMATIONS
BEDROCK
CROSS SECTION
0
1
2Km
N


S
N
FILLING 200-300 1.8
ALLUVIUM 300 1.9
MARLY CLAY 350 1.9
CHALK 500 1.9
VERY WEATHERED BED ROCK 400-500 1.9
BED ROCK 750-850 2.3
1250-1500 2.5
REFRACTION PROFILE
Vs (m/s)
ρ
m
180
160
140
120
100
80
60
40
0
500m


W
E
LA MEUSE
FILLING 200 1.8
COLLUVIUM 200 1.85
ALLUVIUM 300 1.9
MARLY CLAY 350 1.9
VERY WEATHERED BEDROCK 400 1.9
BEDROCK 750 2.3
1250 2.5
REFRACTION PROFILE
Vs (m/s)
ρ
m
160
140
120
100
80
60
40
20
0
1 Km

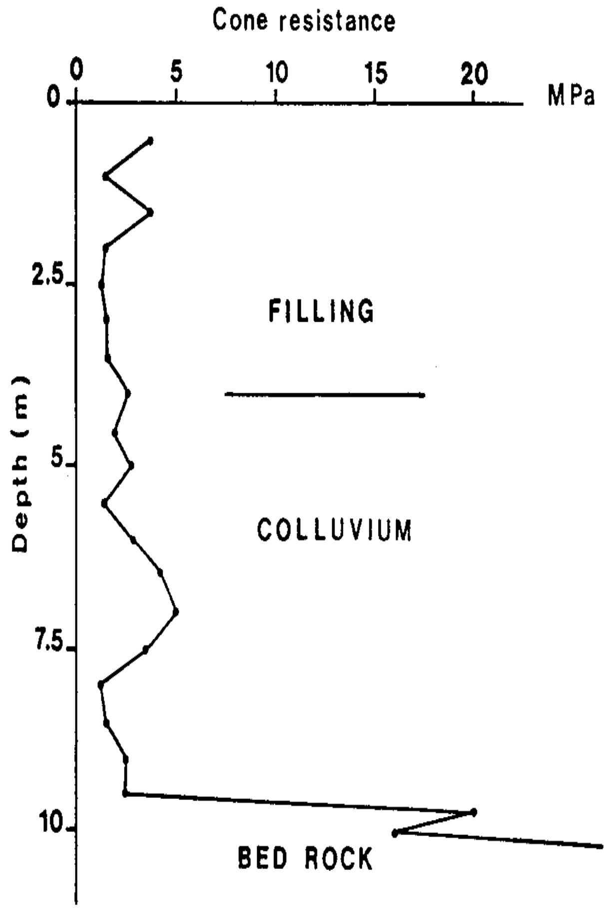
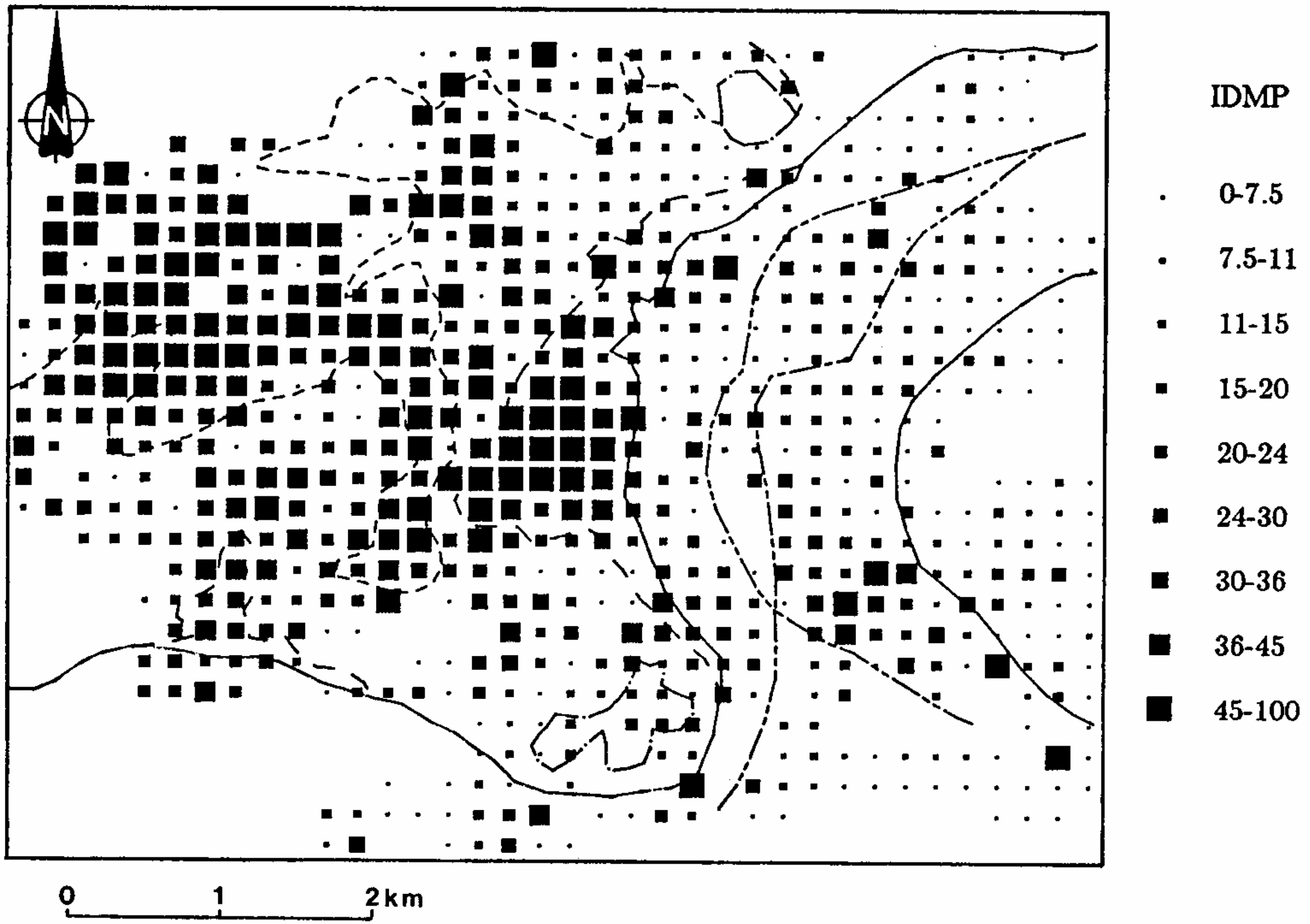


Figure 6 - Cone penetration test diagram.


IDMP
0-7.5
7.5-11
11-15
15-20
20-24
24-30
30-36
36-45
45-100
0
1
2 km

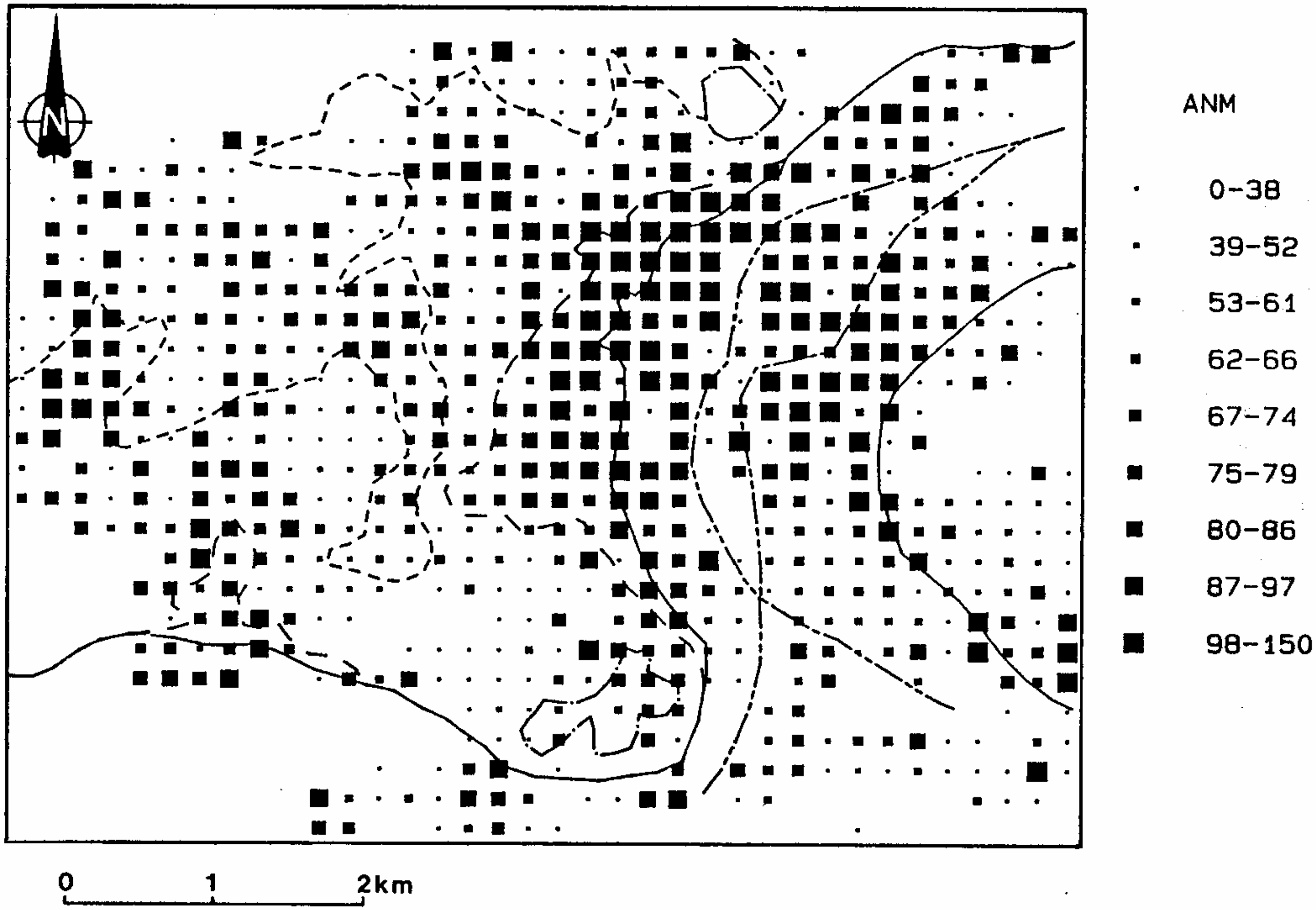
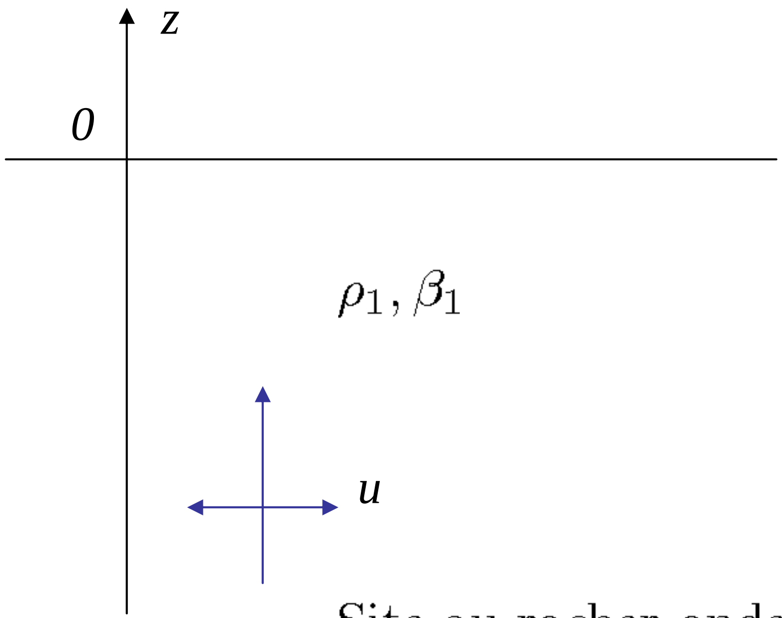


Figure 11: Mean building age map. The black squares represent equal occurrence classes of the age.



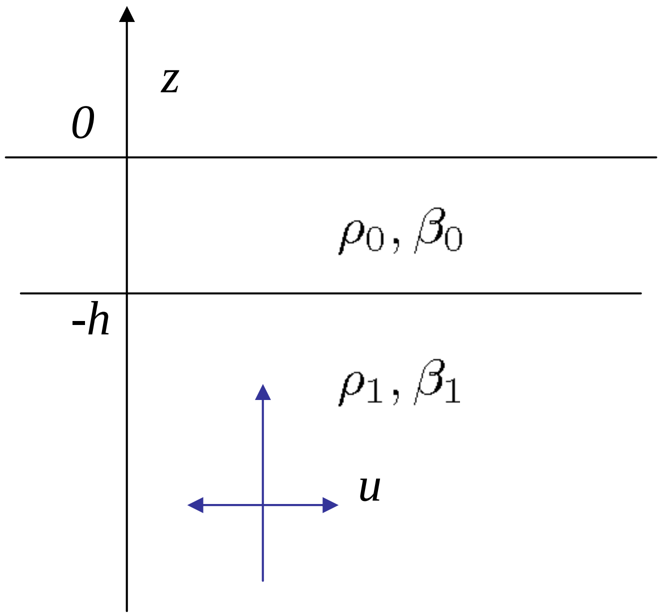
Site au rocher onde SH harmonique incidente verticalement

$$u_i = u_0 exp(-ikz) \quad ((exp(i\omega t)))$$

$$k = \omega/\beta_1 = 2\pi/\lambda$$

A la surface: onde incidente + onde réfléchie
$R_s = 1$

$$|u(z=0)| = 2u_0$$



Effet des sédiments

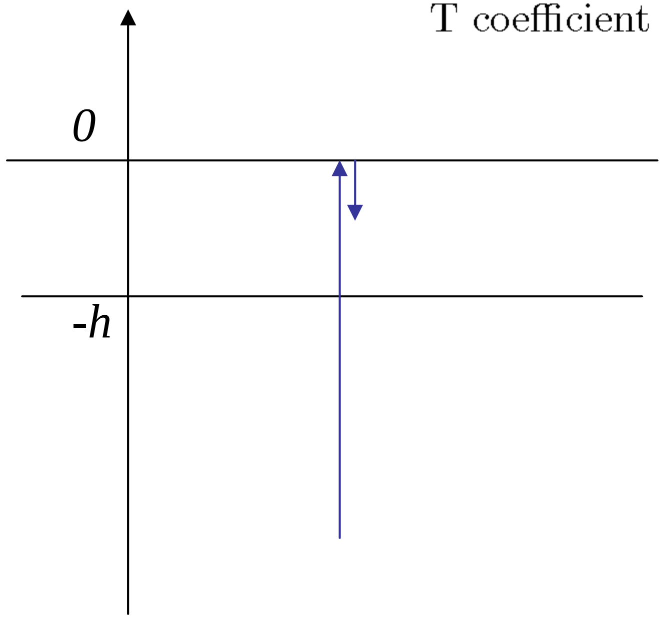
En présence d'une couche d'épaisseur h:

- onde transmise primaire à la surface:

$$u(z=0) = (u_0 \; T \; exp(ikh) \; exp(-ik'h) \times 2$$

$$k' = \omega/\beta_0 = 2\pi/\lambda'$$

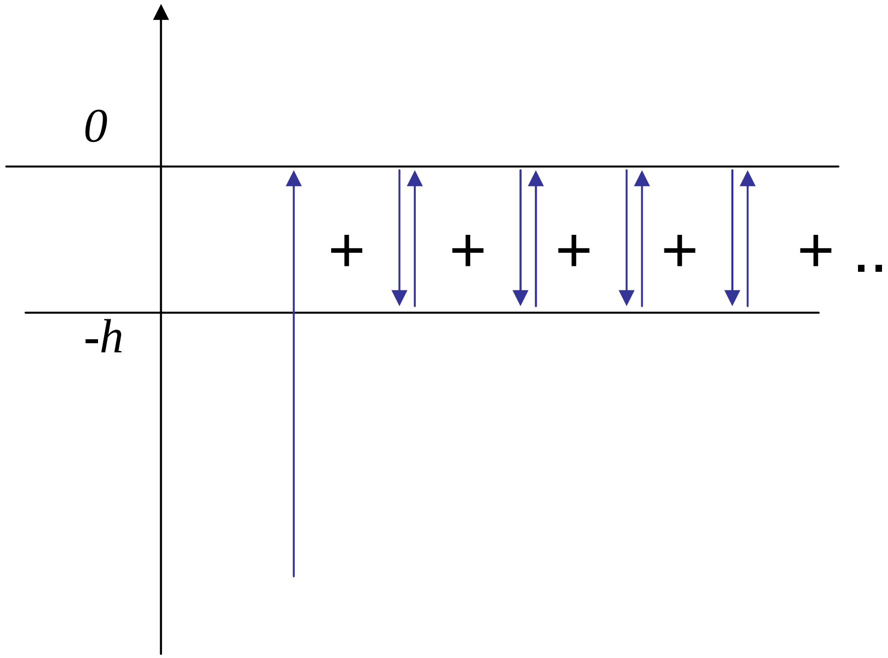
T coefficient de transmission $T = \frac{2\rho_1\beta_1}{\rho_0\beta_0+\rho_1\beta_1}$



- avec les multiples:

R coefficient de réflexion $R = \frac{\rho_0\beta_0 - \rho_1\beta_1}{\rho_0\beta_0 + \rho_1\beta_1}$

$$u(z=0) = (2\ u_0\ T\ exp(i(k-k')h))(\ 1 + Rexp(-ik'2h) + (Rexp(-ik'2h))^2 + (Rexp(-ik'2h))^3 + \ldots\ldots)$$



On reconnait une série de la forme:

$$1 + X + X^2 + X^3 + ...$$

avec $X = R\ exp(-ik'2h)$ donc $|X| < 1$

on a alors:

$$1 + X + X^2 + X^3 + ... = \frac{1}{1 - X}$$

u en surface est de la forme:

$$u(z = 0) = (2\ u_0\ T\ exp(i(k - k')h))\frac{1}{1 - X}$$

avec $X = R\ exp(-ik'2h)$

$$u(z=0) = (2\ u_0\ T\ exp(i(k-k')h))\frac{1}{1 - R\ exp(-ik'2h)}$$

$|u|$ est maximum quand $1 - R\ exp(-ik'2h)$ est minimal.

$$R < 0 \Rightarrow exp(-ik'2h) = -1 \rightarrow k'2h = (2N+1)\pi$$

$$\Rightarrow \frac{2\pi f\ 2h}{\beta_0} = (2N+1)\pi$$

$$4h/\lambda = 2N+1 \rightarrow h = (2N+1)\lambda/4$$

ou

$$f = (2N+1)\frac{\beta_0}{4h}$$

Aux fréquences de résonance:

$$|u| = 2u_0 T \frac{1}{1+R}$$

$$|u| = 2u_0 \frac{2\rho_1\beta_1}{\rho_0\beta_0 + \rho_1\beta_1} \frac{1}{1 + \frac{\rho_0\beta_0 - \rho_1\beta_1}{\rho_0\beta_0 + \rho_1\beta_1}}$$

$$|u| = 2u_0 \frac{\rho_1\beta_1}{\rho_0\beta_0}$$

En comparant avec le cas du site au rocher, le coefficient d'amplification du site vaut:

$$A_{max} = \frac{\rho_1\beta_1}{\rho_0\beta_0}$$

Les effets de site

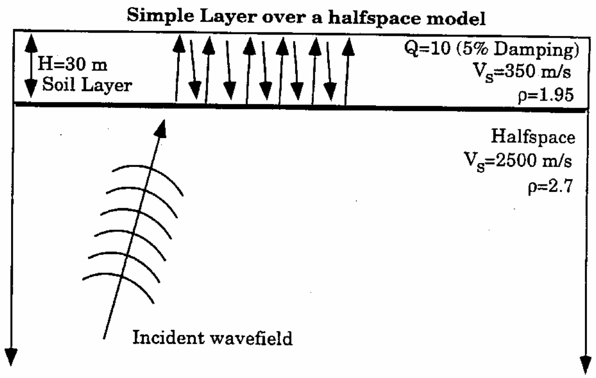


Figure 1). Simple layer over a halfspace model used in numerical calculation of transfer functions. Energy is trapped in the near-surface soil layer and reverberates causing resonance amplification.

Sans absorption: $A_{max} = 9.9$

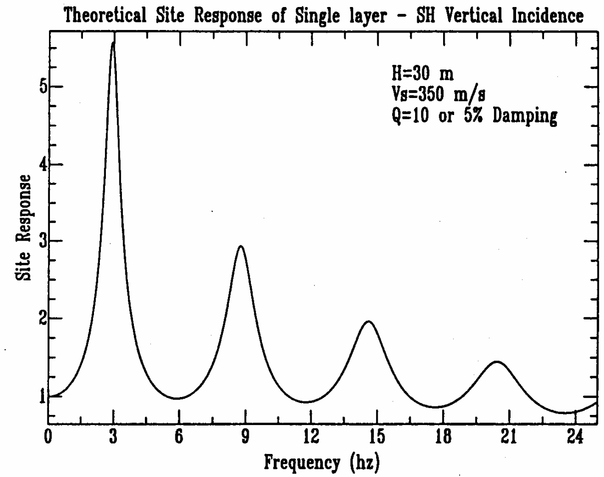


Figure 2). Theoretical example of amplification vs. frequency calculated using simple 1-dimensional geometry shown in Figure 1. Resonance amplification, seen as peaks in the transfer function is caused by trapped energy reverberating in the near-surface soil layer.

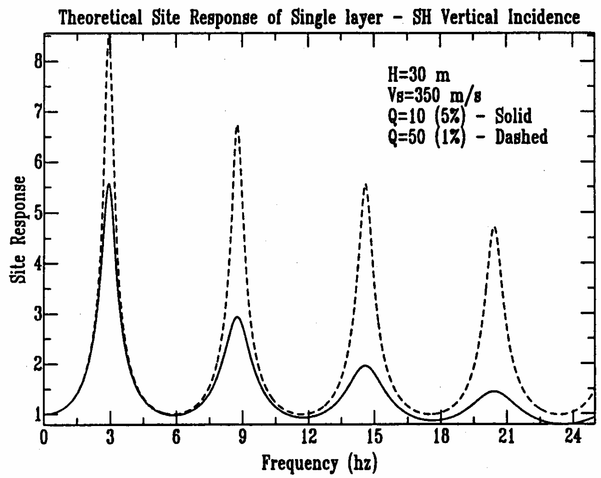


Figure 3). Theoretical example showing the effect of different attenuation (material damping) in the near-surface soil layer. Solid curve is the same as shown in Figure 2 (Q=10), dotted curve is for a Q=50.

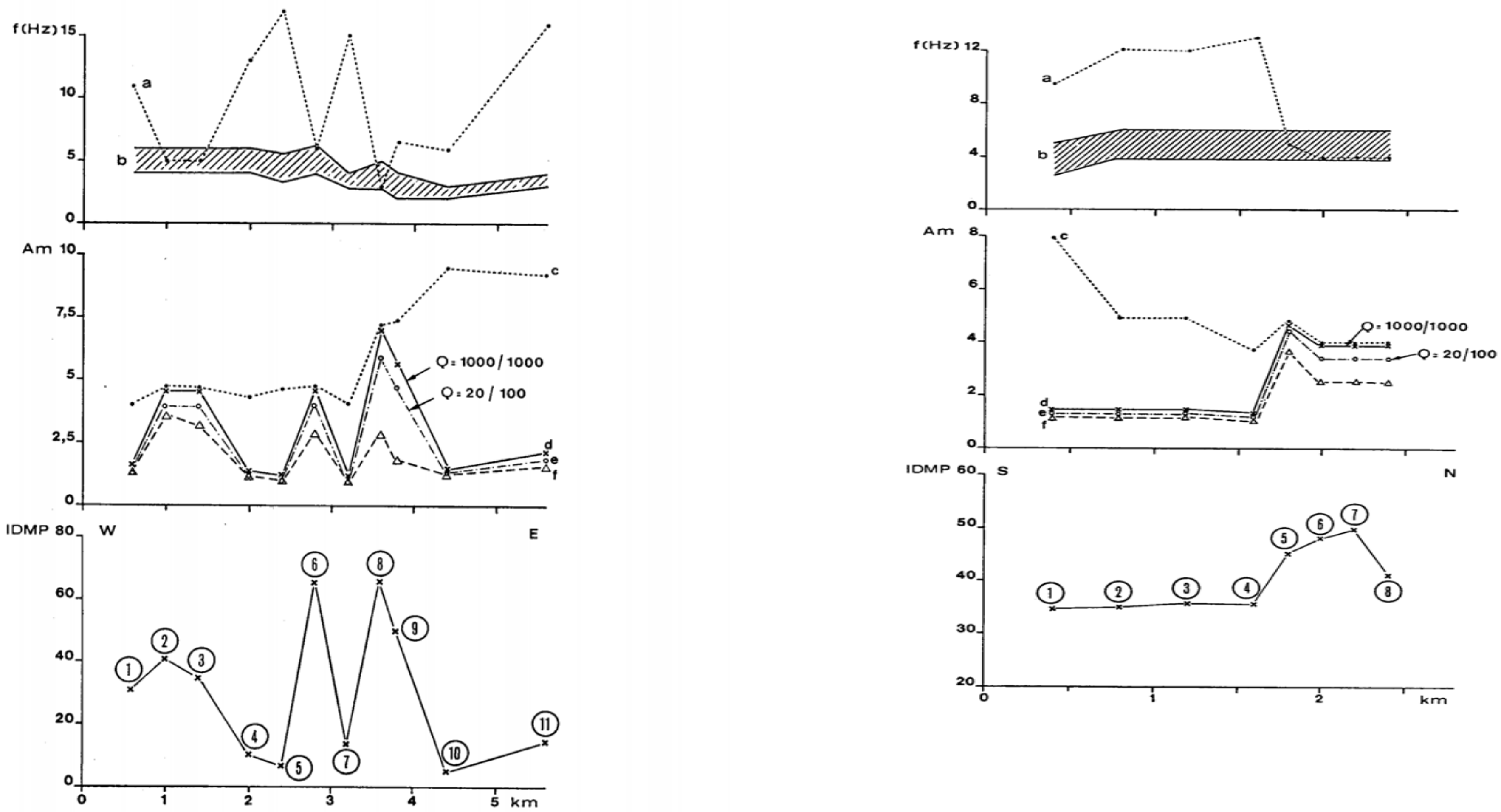
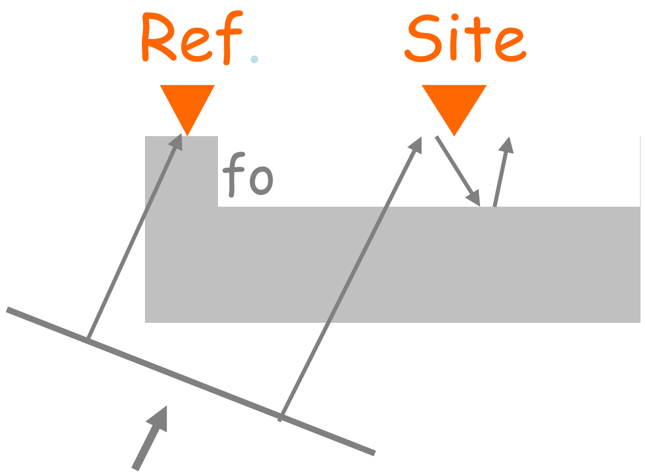
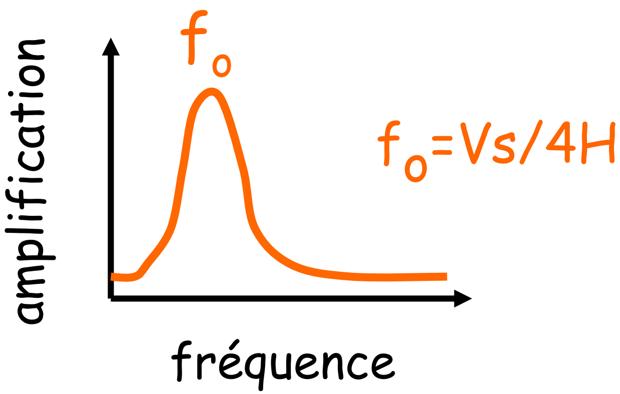


Figure 12 - Up: Frequency of maximum 1D amplification and mean value of the natural frequency of building along E-W cross-section. Middle: Amplification curves (see text for description). Bottom: Damage parameter. The horizontal scale is the same for all curves.

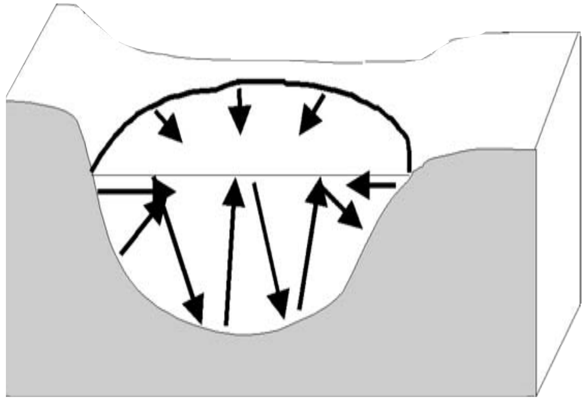
Effets de site en zone alluviale

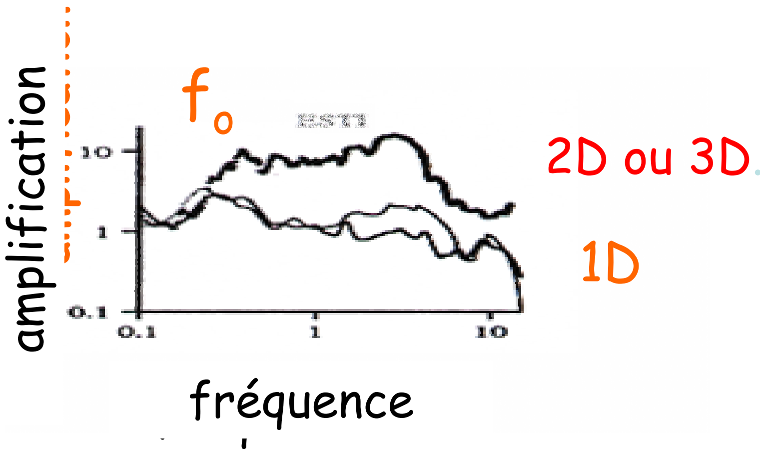
1) Cas 1D : réverbérations verticales





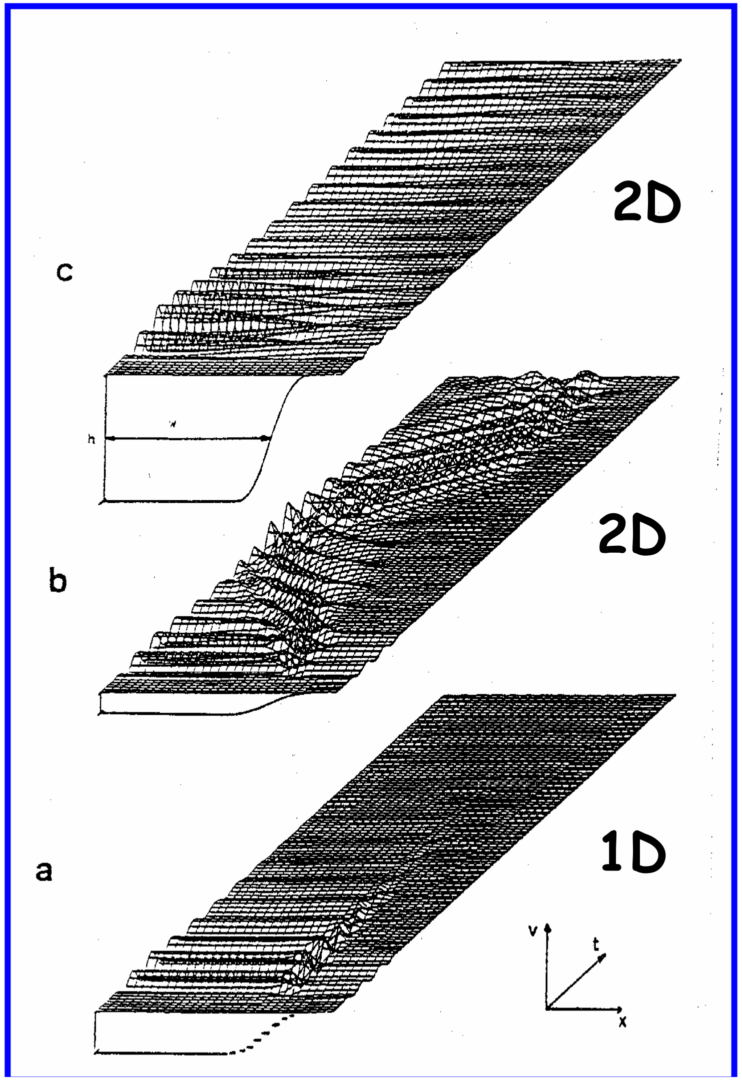
2) Cas 2D / 3D Réverbérations latérales

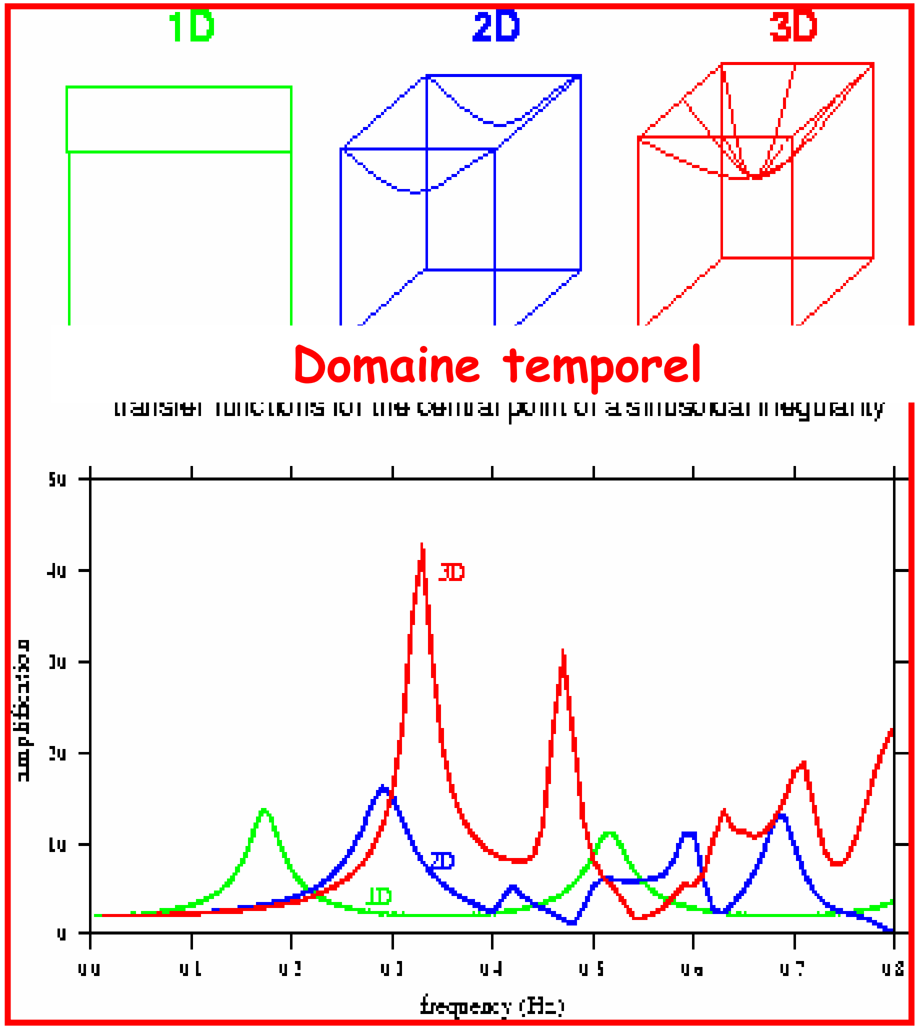




Effets de site : intérieur de vallée

Domaine temporel





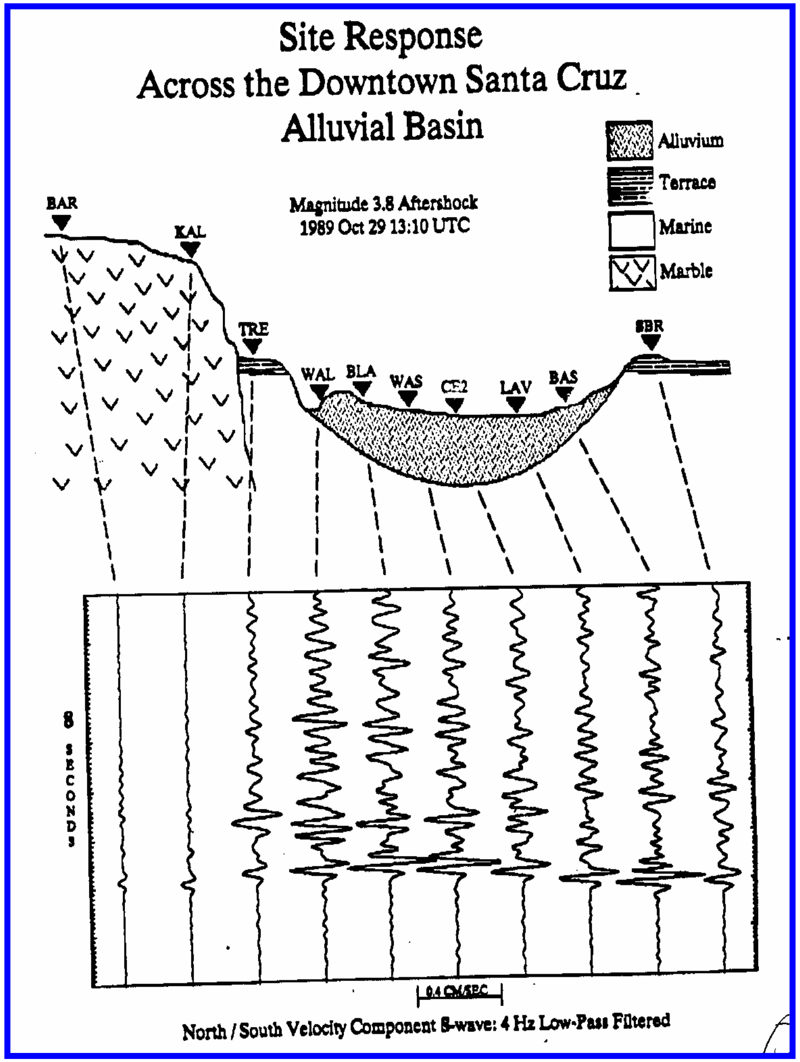
Effets de site : intérieur de vallée

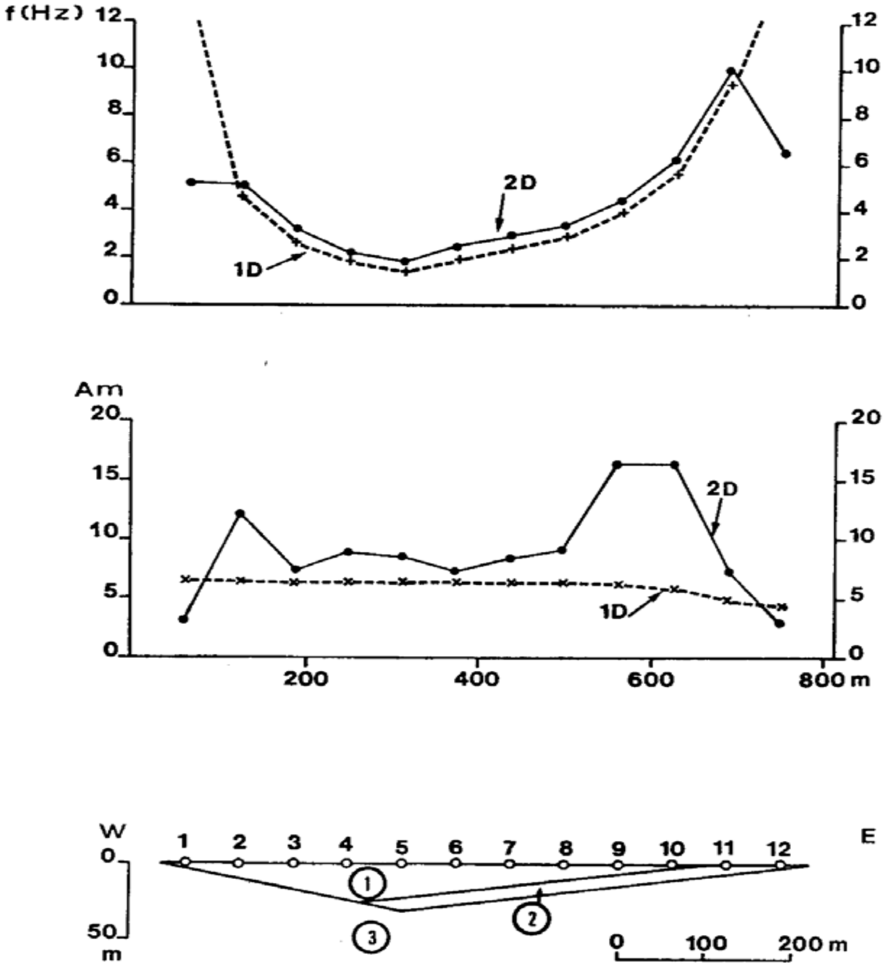
•Diffraction d'ondes

– Réverbérations verticales et latérales
– Transformation ondes de volume en ondes de surface
– Piégeage plus efficace

•Conséquences

– Augmentation de durée
– Augmentation de l'amplification





	V_S (m/s)	Q_S	ρ
①	200	20	1.85
②	300	50	1.9
③	1250	100	2.5

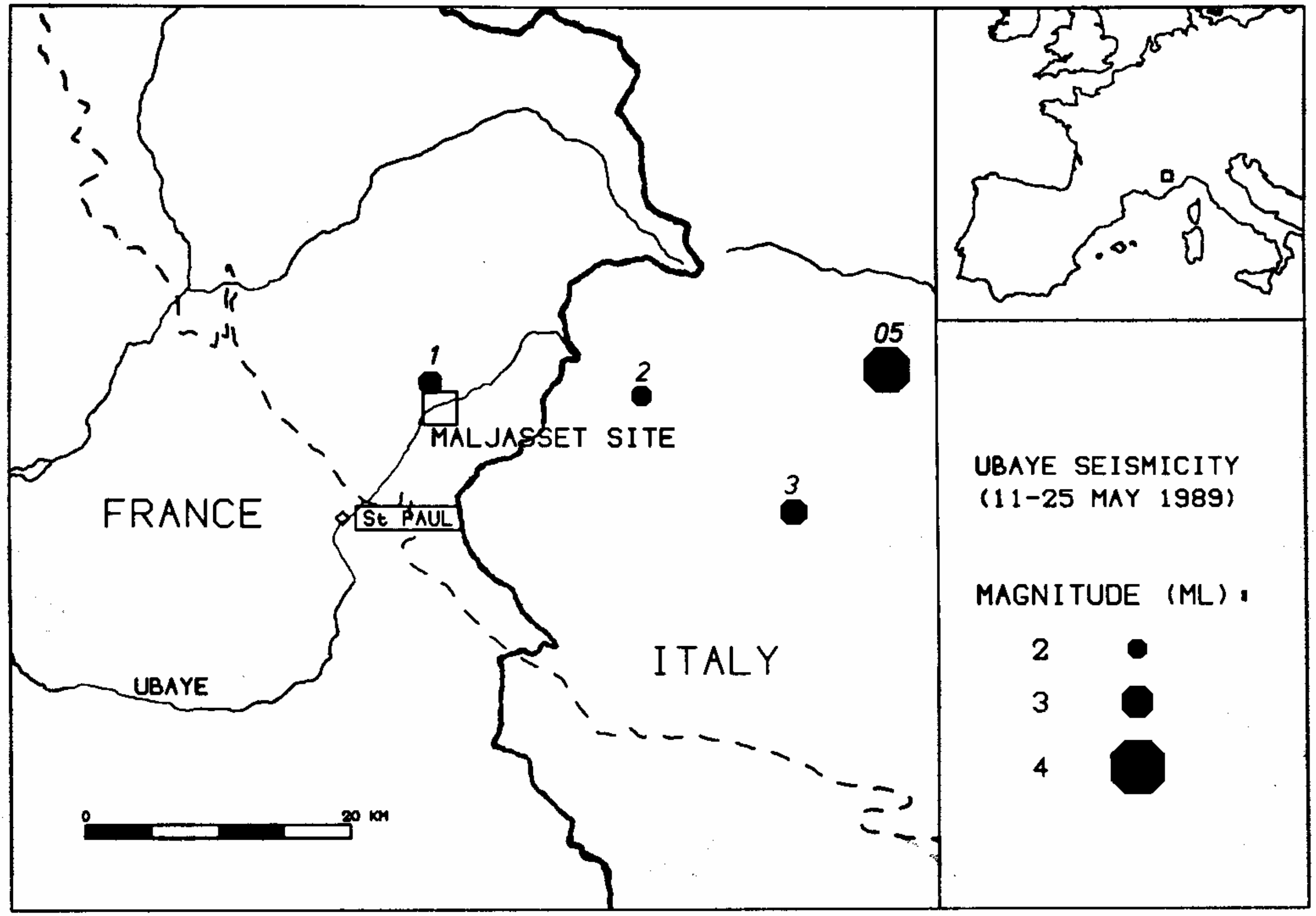
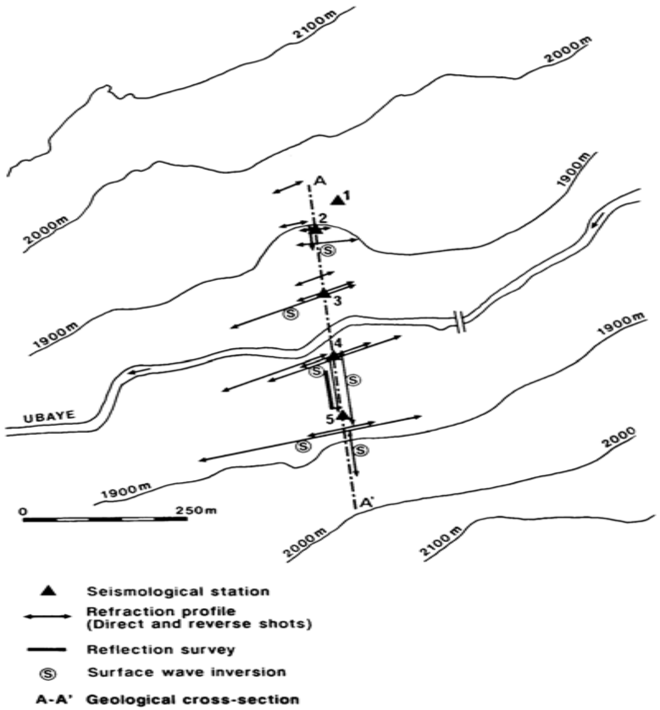


FIG. 1. Map of the Ubaye Valley showing the Maljasset site (square symbol) and the epicenter locations (numbered 1, 2, 3, and 05) of the different earthquake groups. The dashed line represents the Pennine front.


2100m
2000m
2000m
1900m
A
1
2
3
4
5
A'
UBAYE
1900m
1900m
1900m
2000
2000m
2100m
0
250m
Seismological station
Refraction profile
(Direct and reverse shots)
Reflection survey
Surface wave inversion
A-A' Geological cross-section

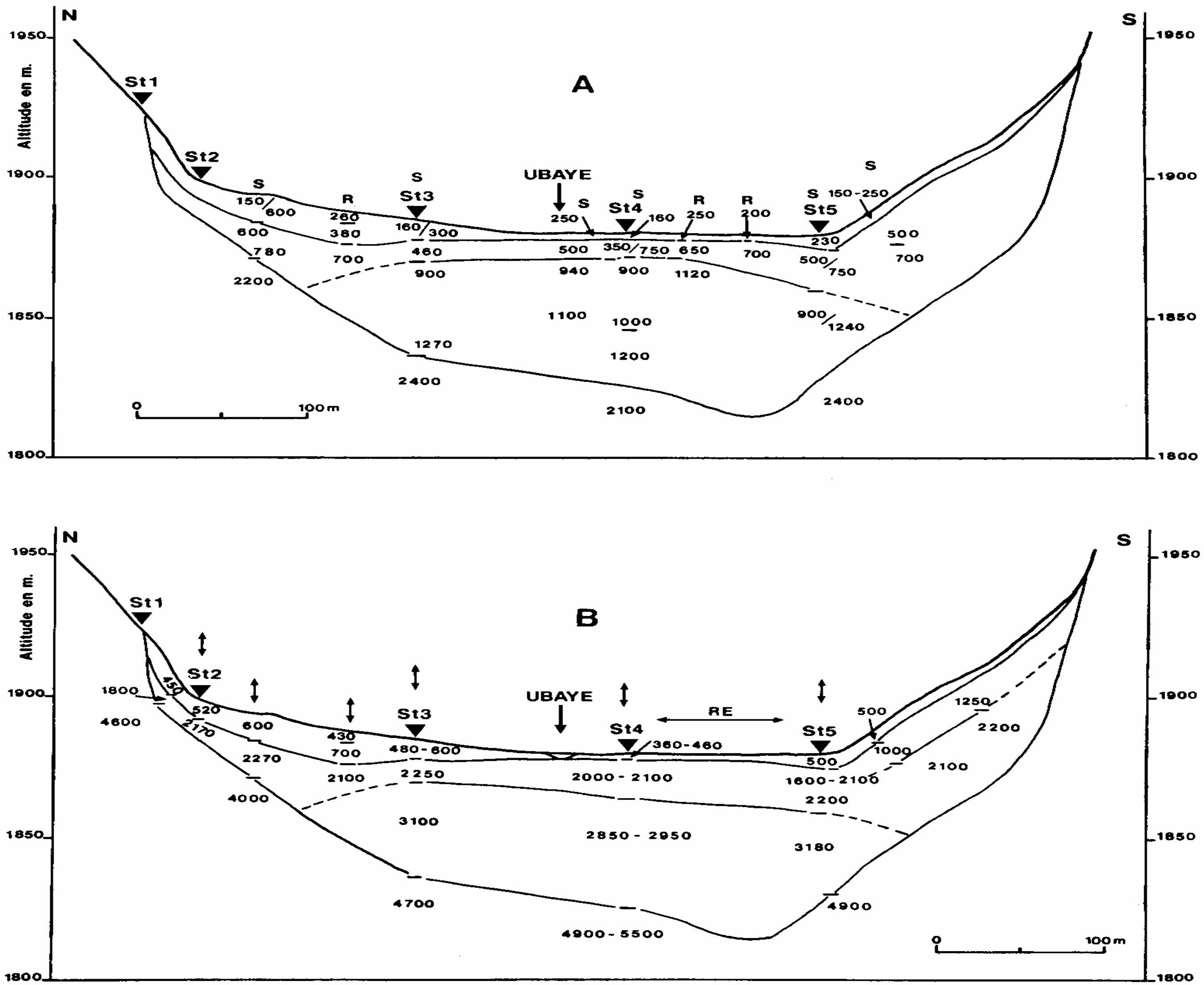
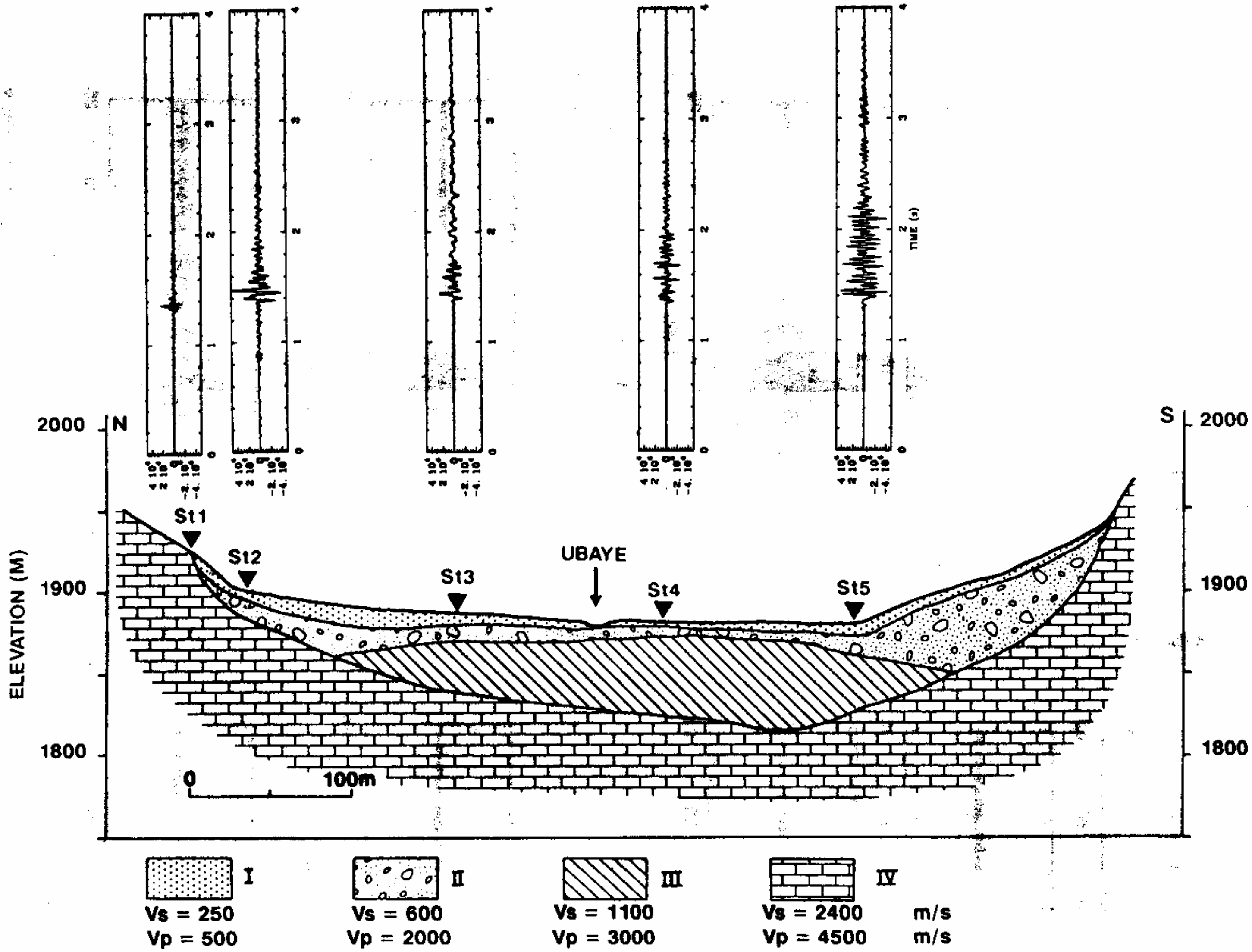
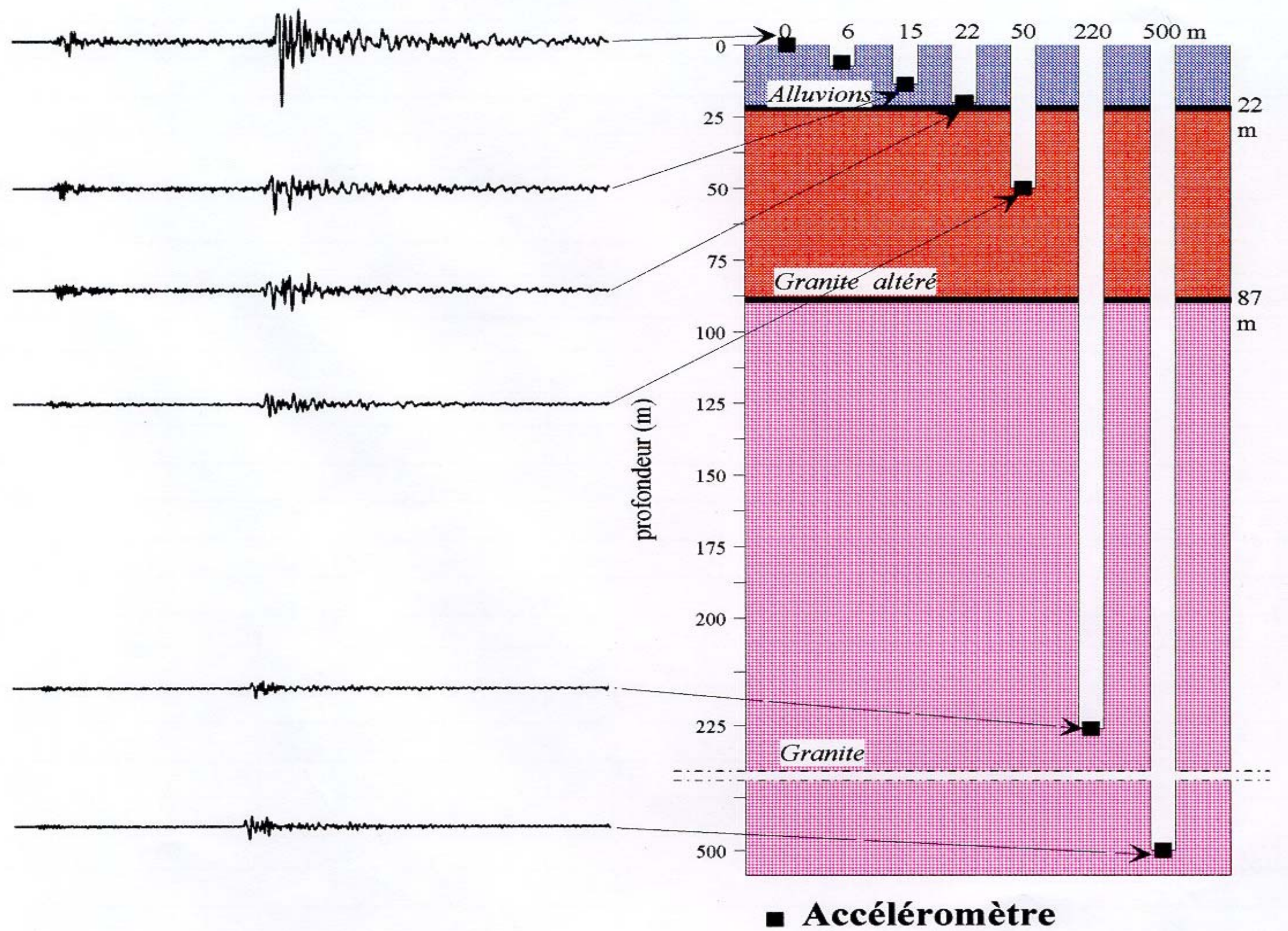


FIG. 3. Cross sections along the profile AA′ (Fig. 2) perpendicular to the valley axis. (*A*) *S*-wave velocity values deduced from *SH* refraction profiles (*R*) and surface wave inversion (*S*). The notation 500/750 means that the velocity ranges from 500 to 750 m/sec from the top to the bottom. (*B*) *P*-wave velocity values inferred from refraction tests.

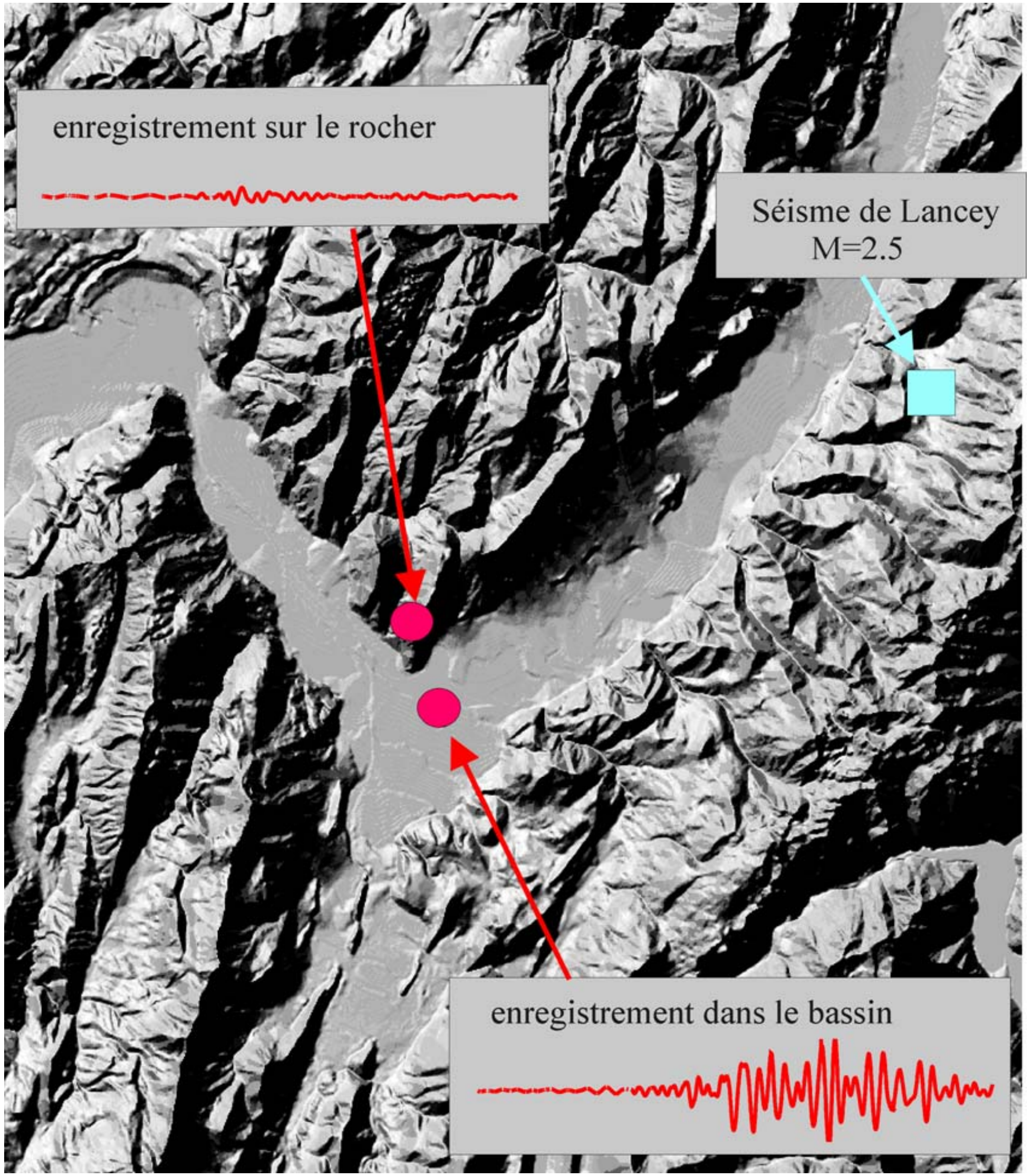


N
S
2000
1900
1800
ELEVATION (M)
St1
St2
St3
UBAYE
St4
St5
0
100m
I
II
III
IV
Vs = 250
Vp = 500
Vs = 600
Vp = 2000
Vs = 1100
Vp = 3000
Vs = 2400
Vp = 4500
m/s
m/s

Effets de site mis en évidence sur l'instrumentation de Garner Valley

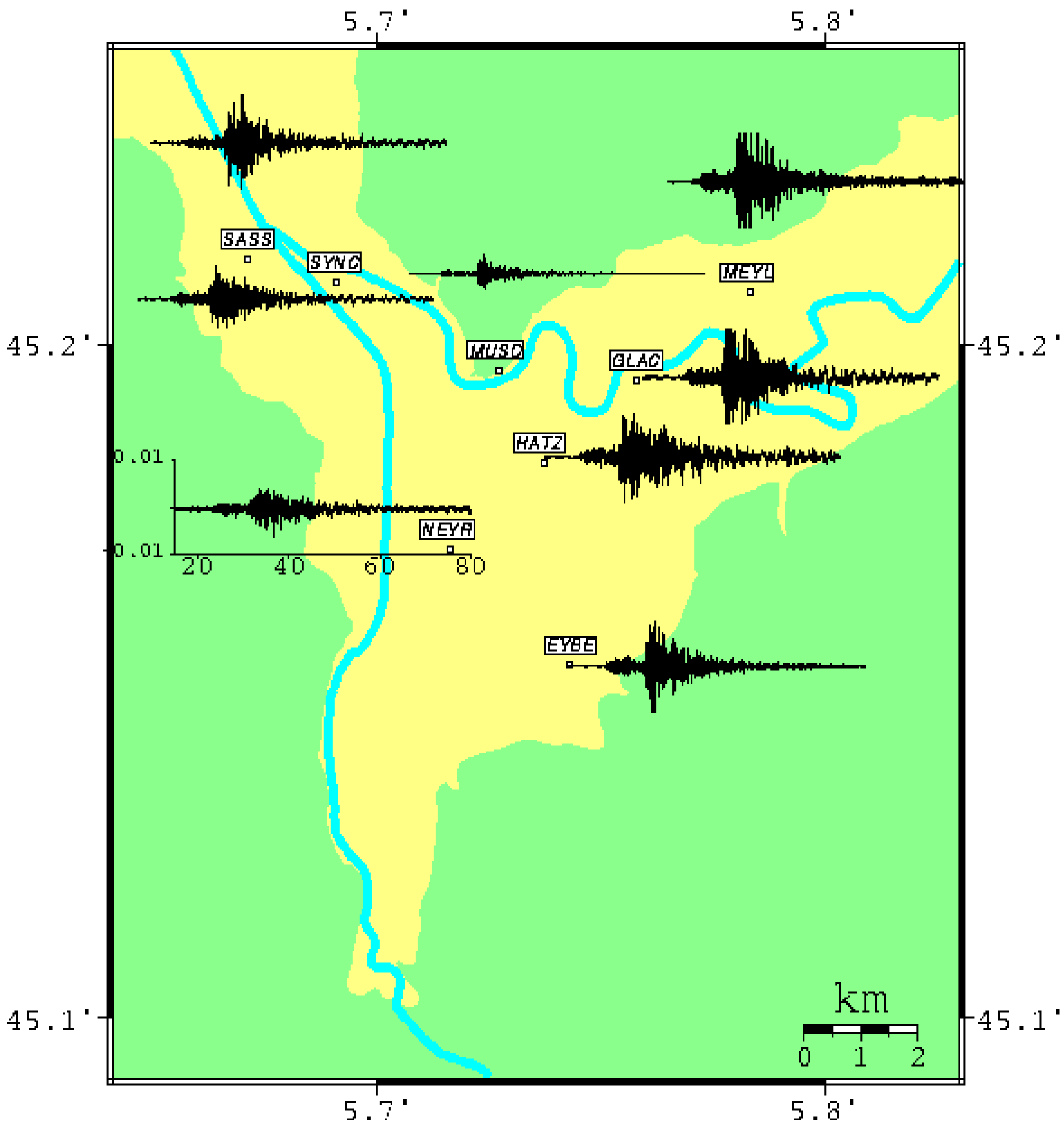


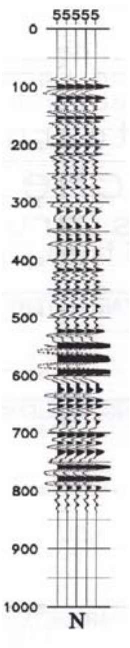
Un effet de site particulier : le cas de la cuvette grenobloise

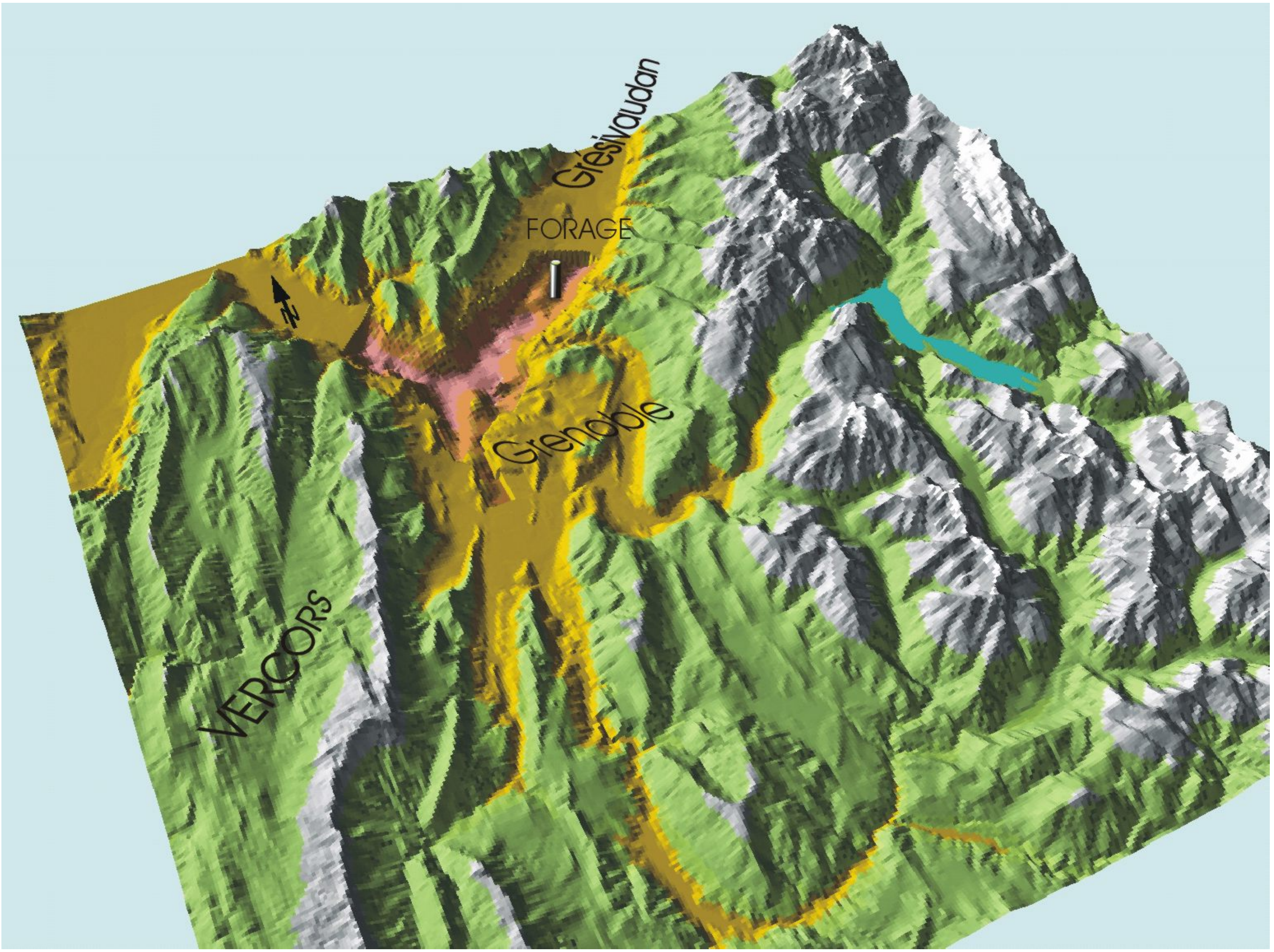


Example of site effects in Grenoble from local events

- Event
  - Baz = N10
  - D=40 km, ML = 2.2
  - EW Component
- Observations
  - Larger amplitude
  - Longer duration
  - Long duration for small events

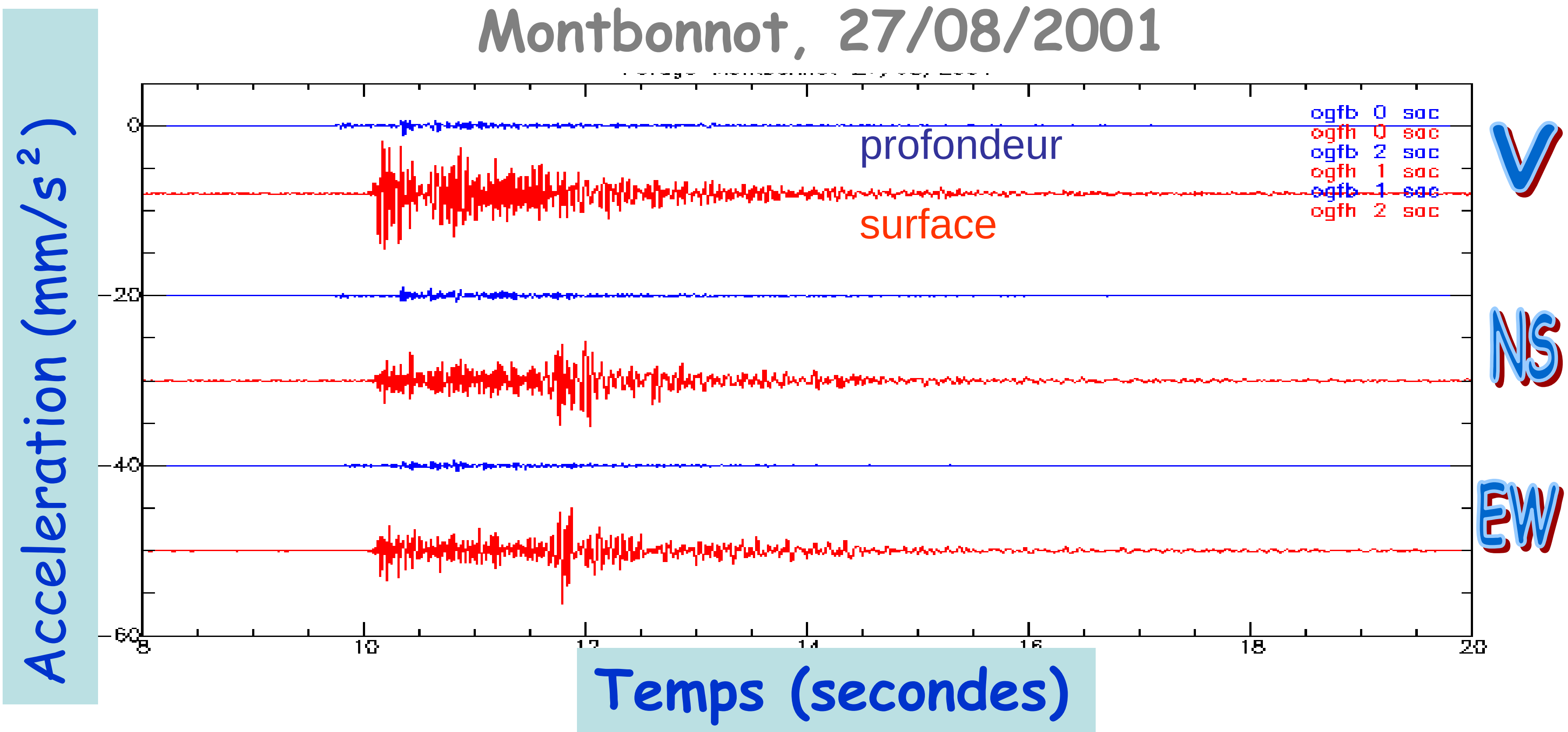




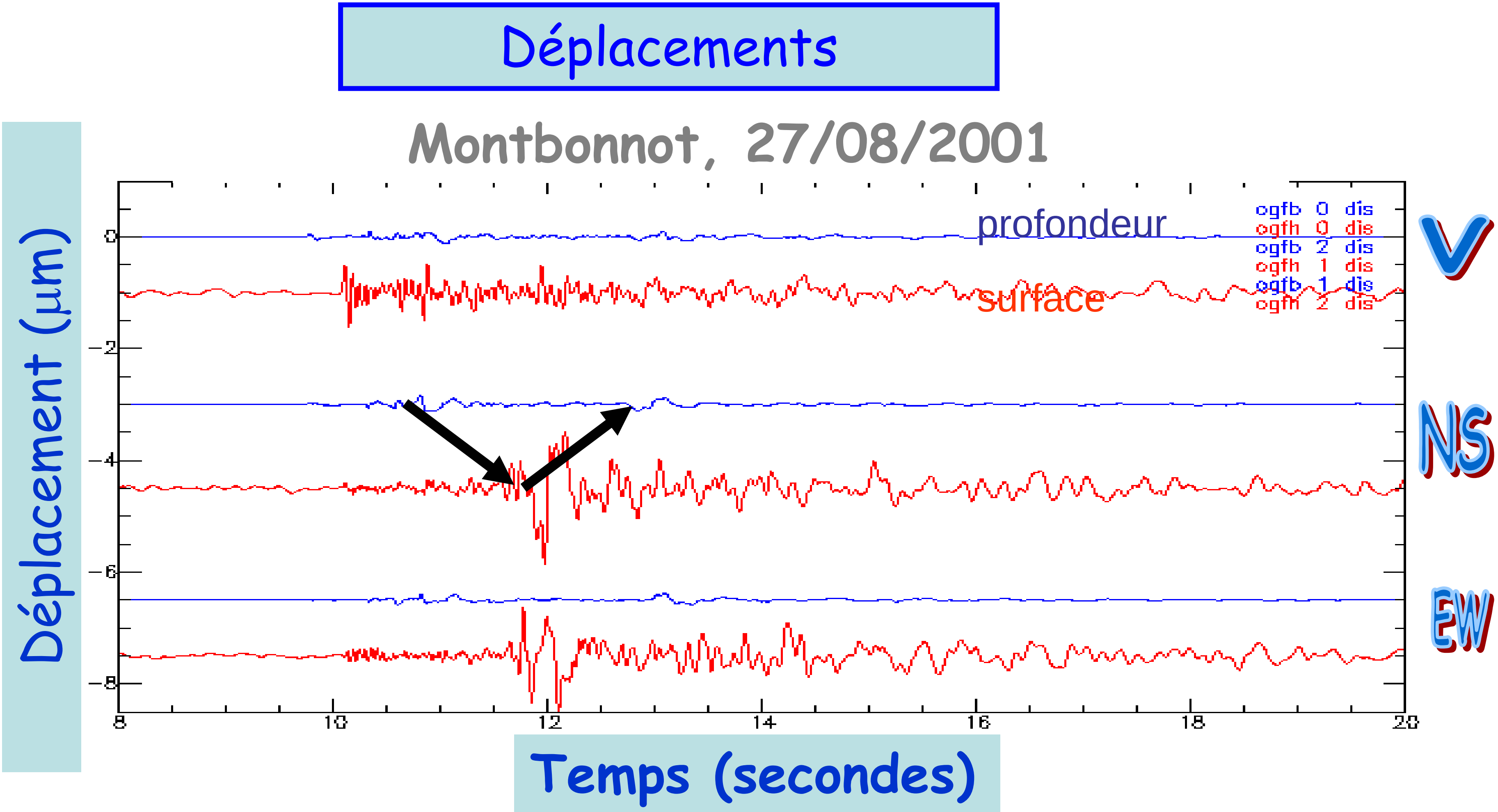


Forage IPSN, novembre 1999.

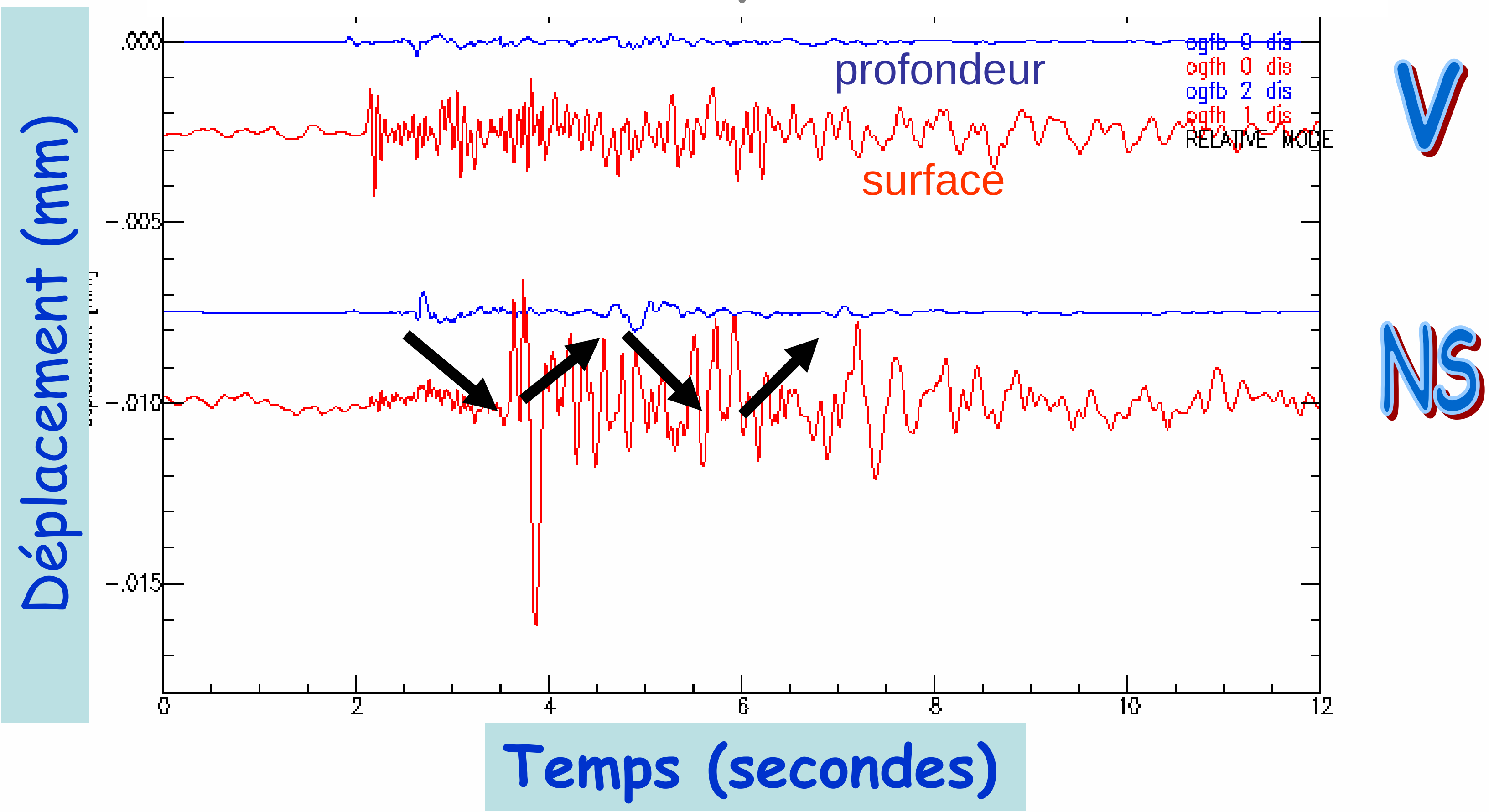
Exemple d'enregistrement en fond de puits



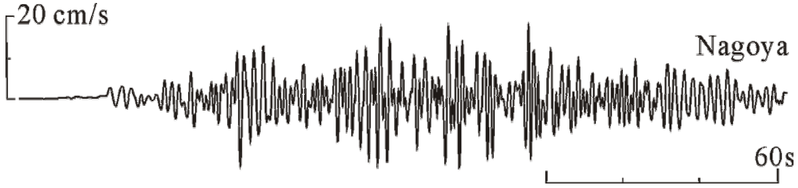
Exemple d'enregistrement en fond de puits

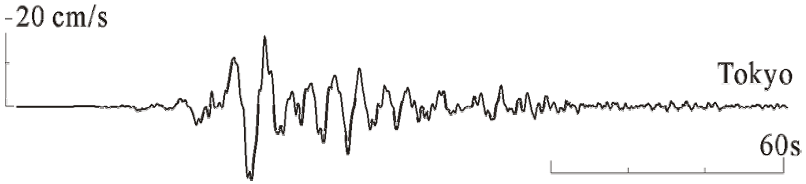


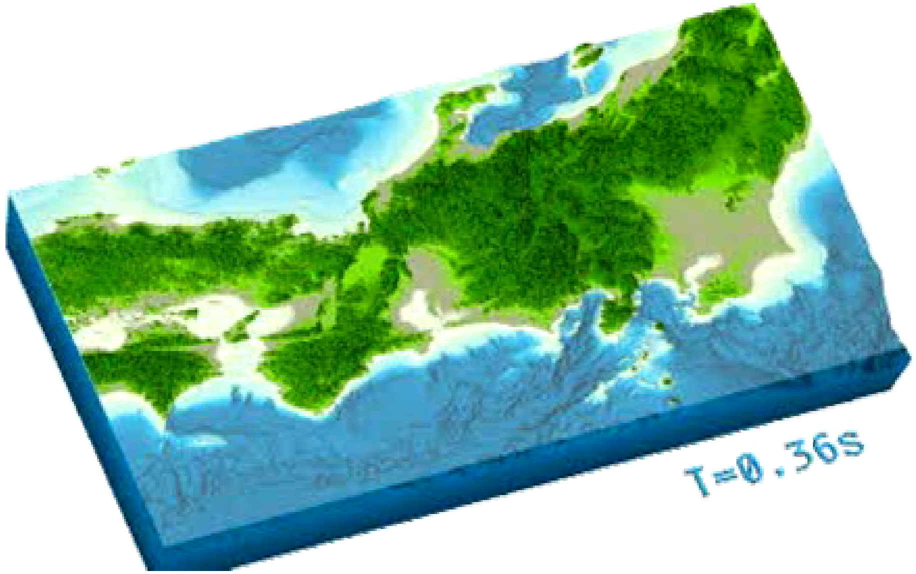
Montbonnot, 11/01/2001

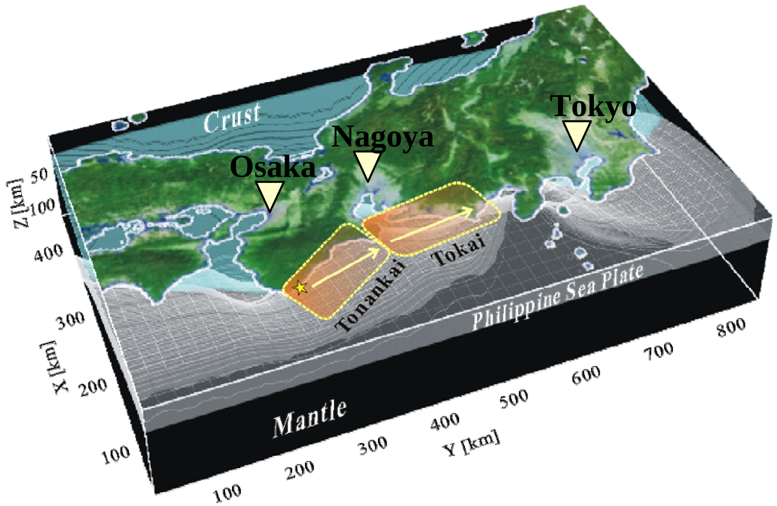


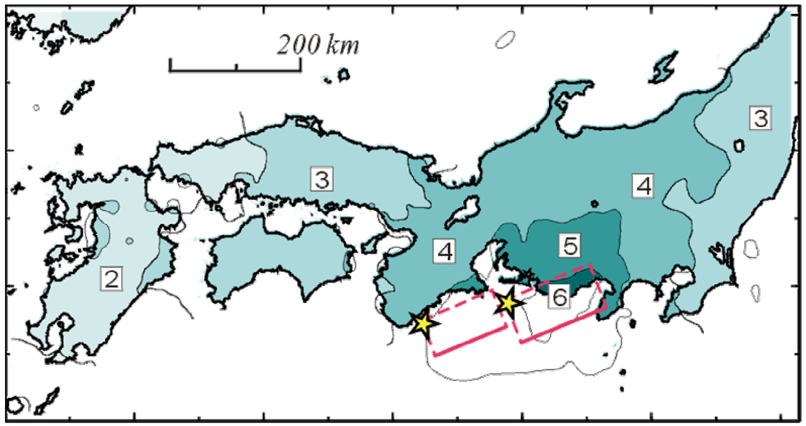
Scenario de mouvements forts pour un séisme dans la zone de Tokai







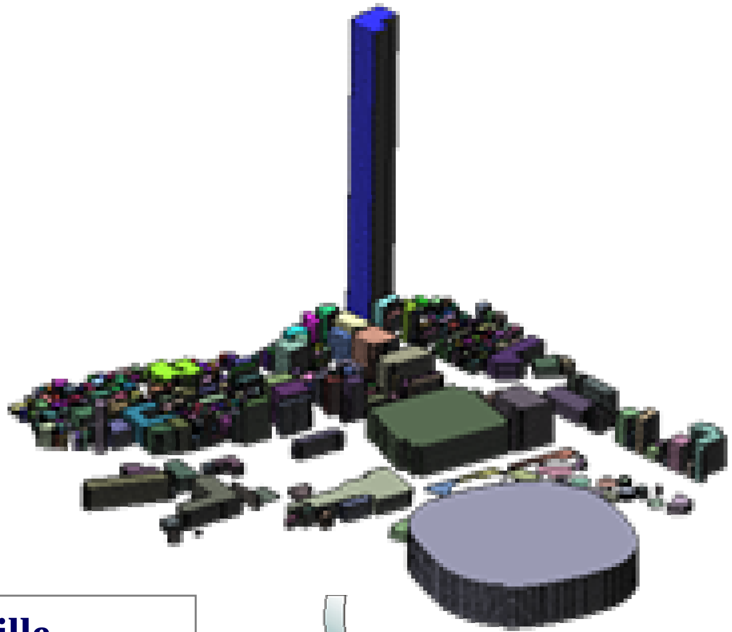




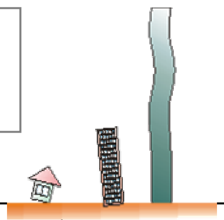
Les mouvements dans le bassin de Tokyo sont importants seulement à basse fréquence

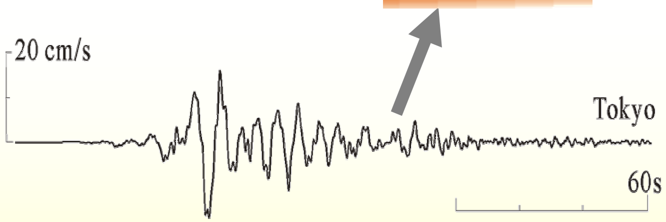
Mouvements basse fréquence

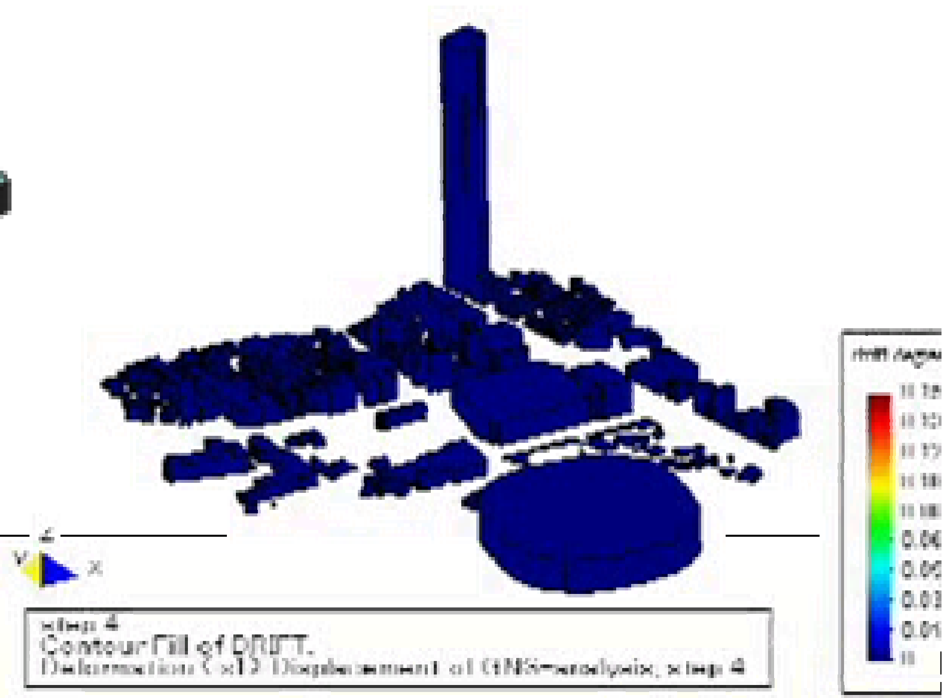
Résonance des batiments élevés (>60 étages) amplitudes (>1.5m) et durées (>10min)



Ville virtuelle







Mouvements simulés

Courtesy from Prof. Ichimura, TIT

計算：　東京工業大学 市村強 助教授による