



Formaterre 2014

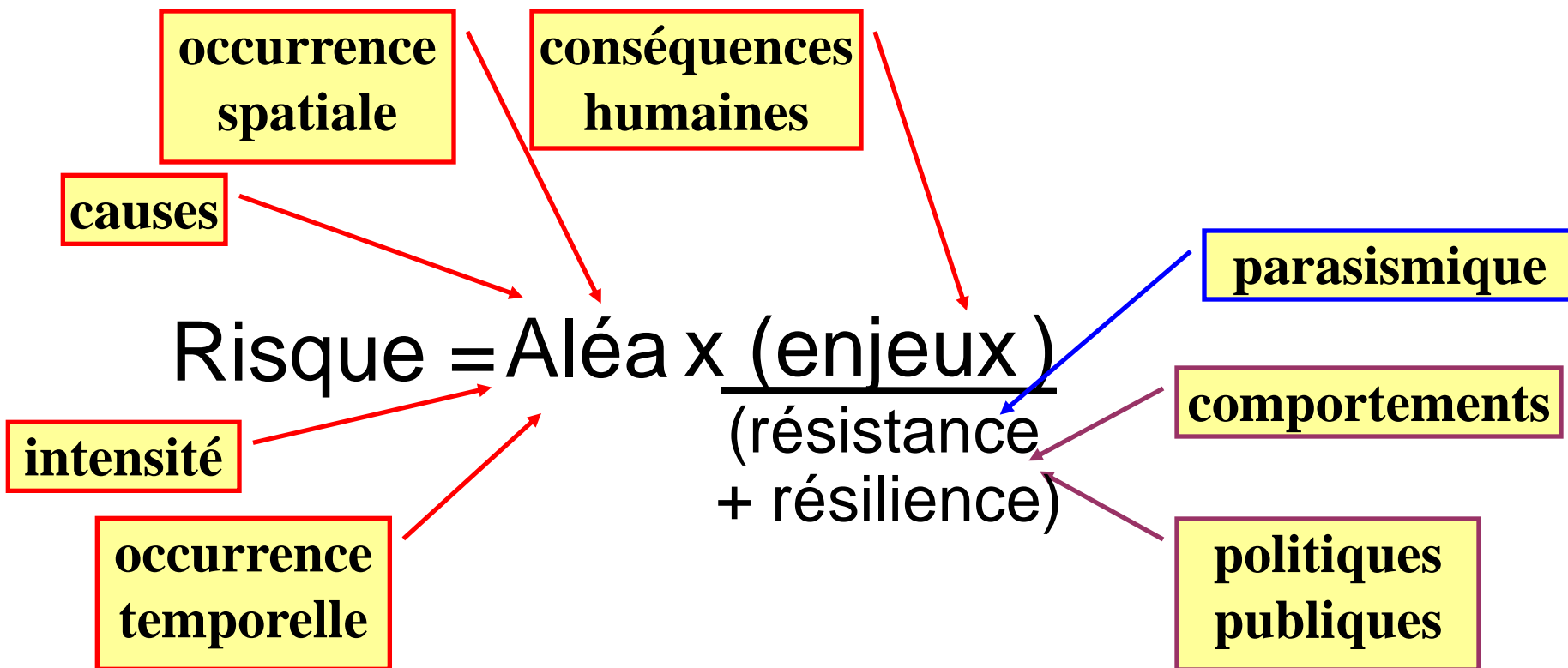
Aléas et risques sismiques



francois.tilquin@ac-grenoble.fr

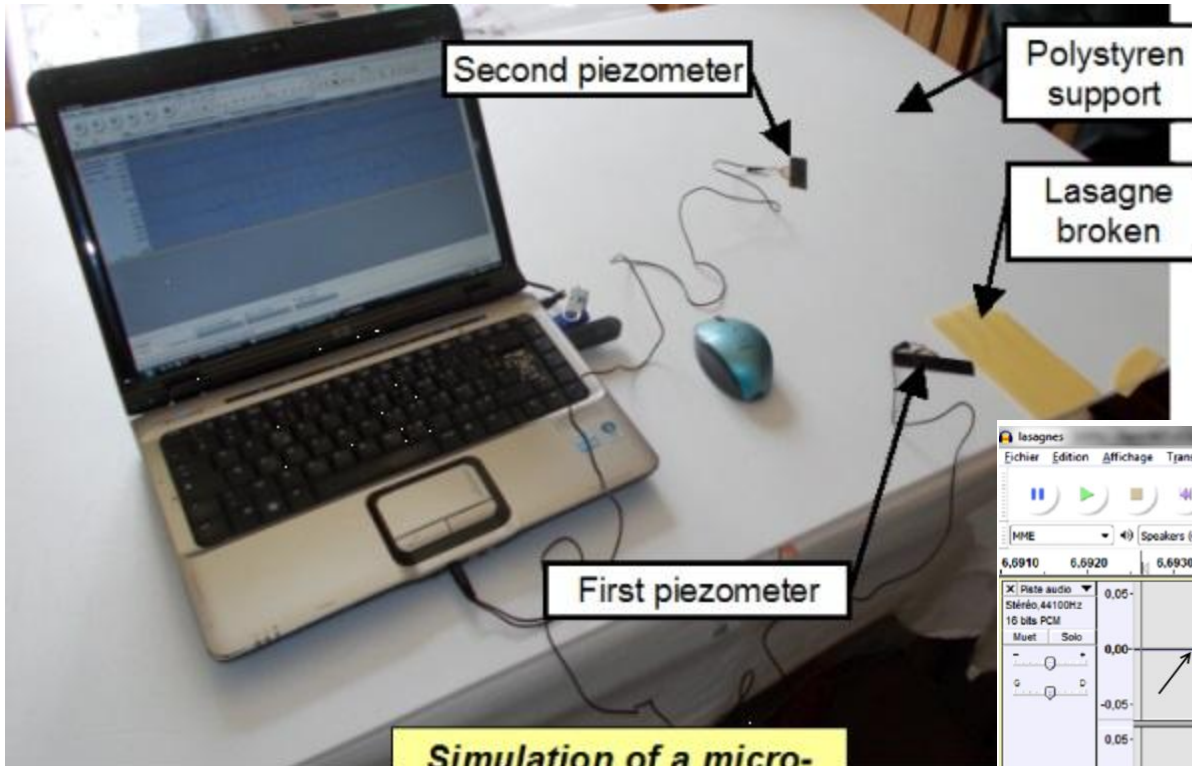
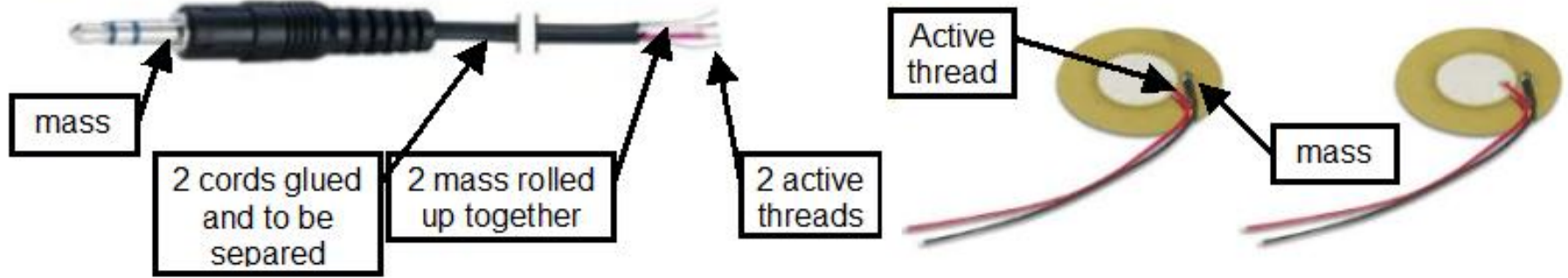
Aléa: *Hasard, événement imprévisible*

Risque: *Danger plus ou moins probable*



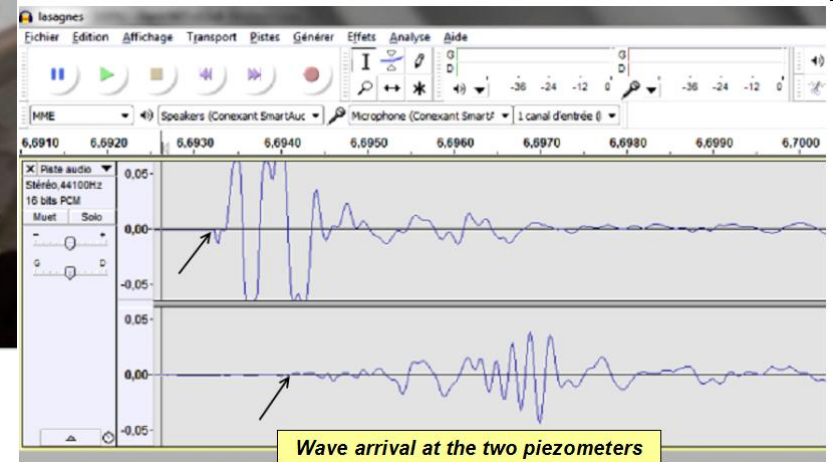
Causes

Sismomètre avec piézomètres



Carte son externe

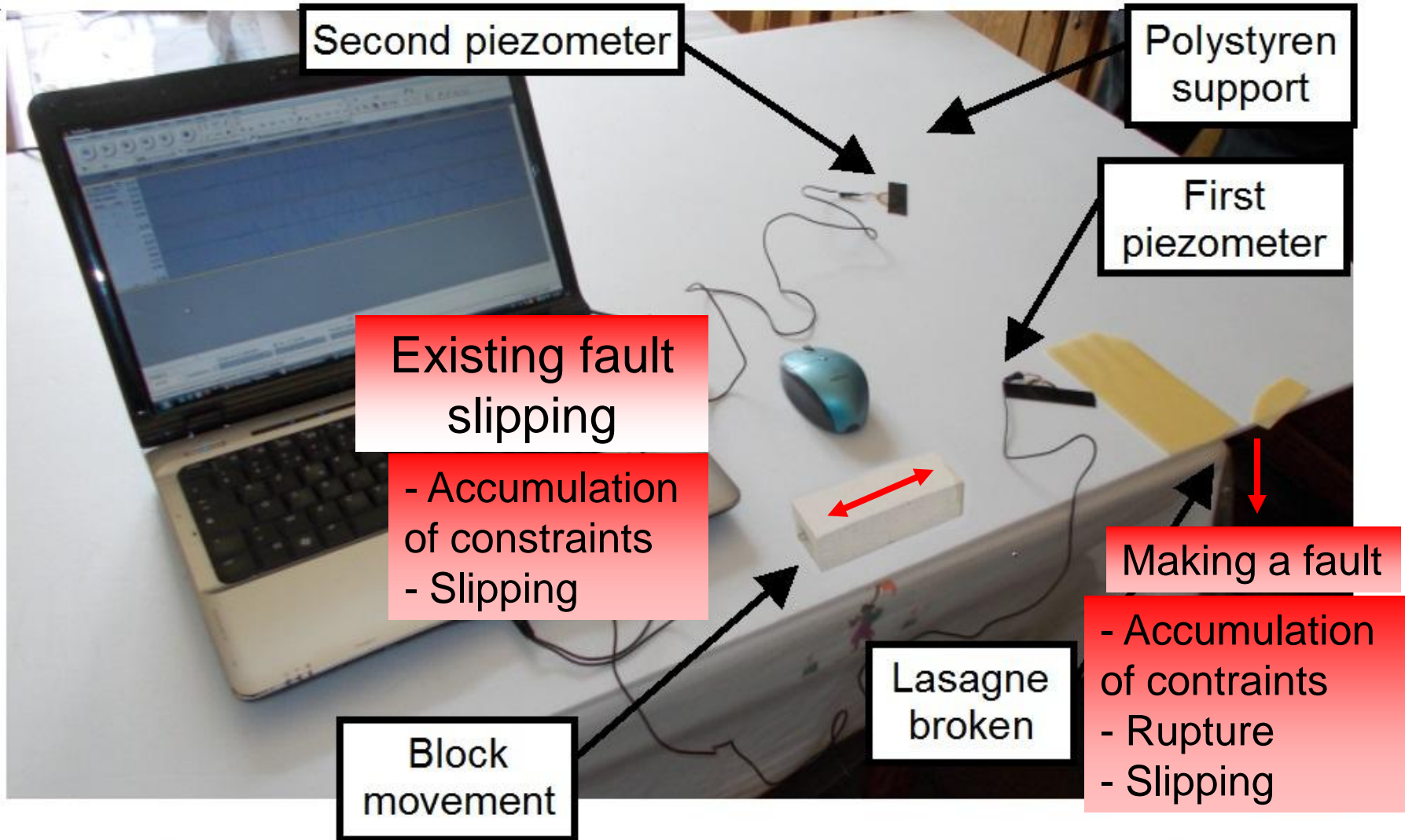
Simulation of a micro-earthquake



Wave arrival at the two piezometers



Origine des séismes

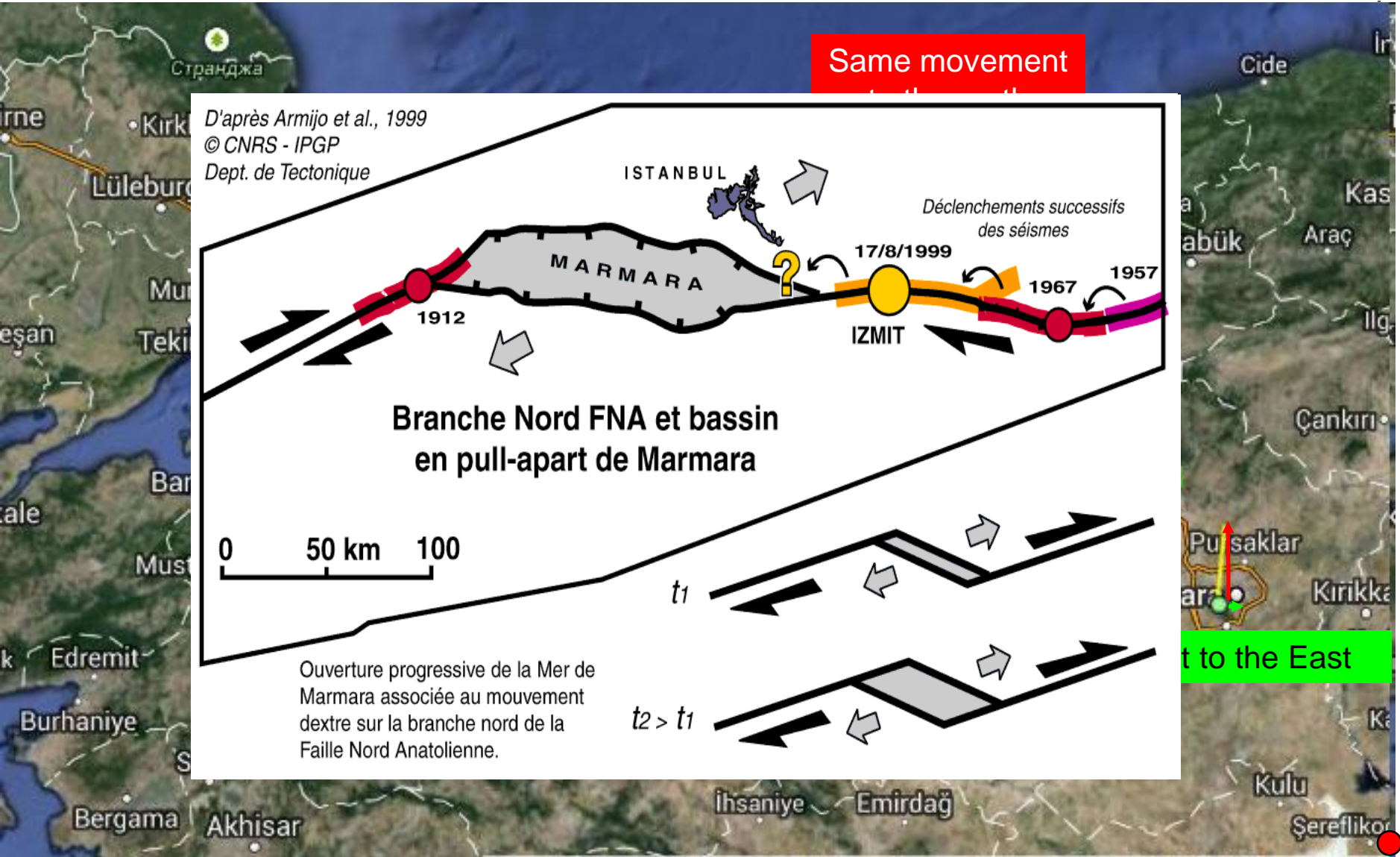


Simulation of a micro-earthquake

Accumulation de contraintes- Exercice avec GPS

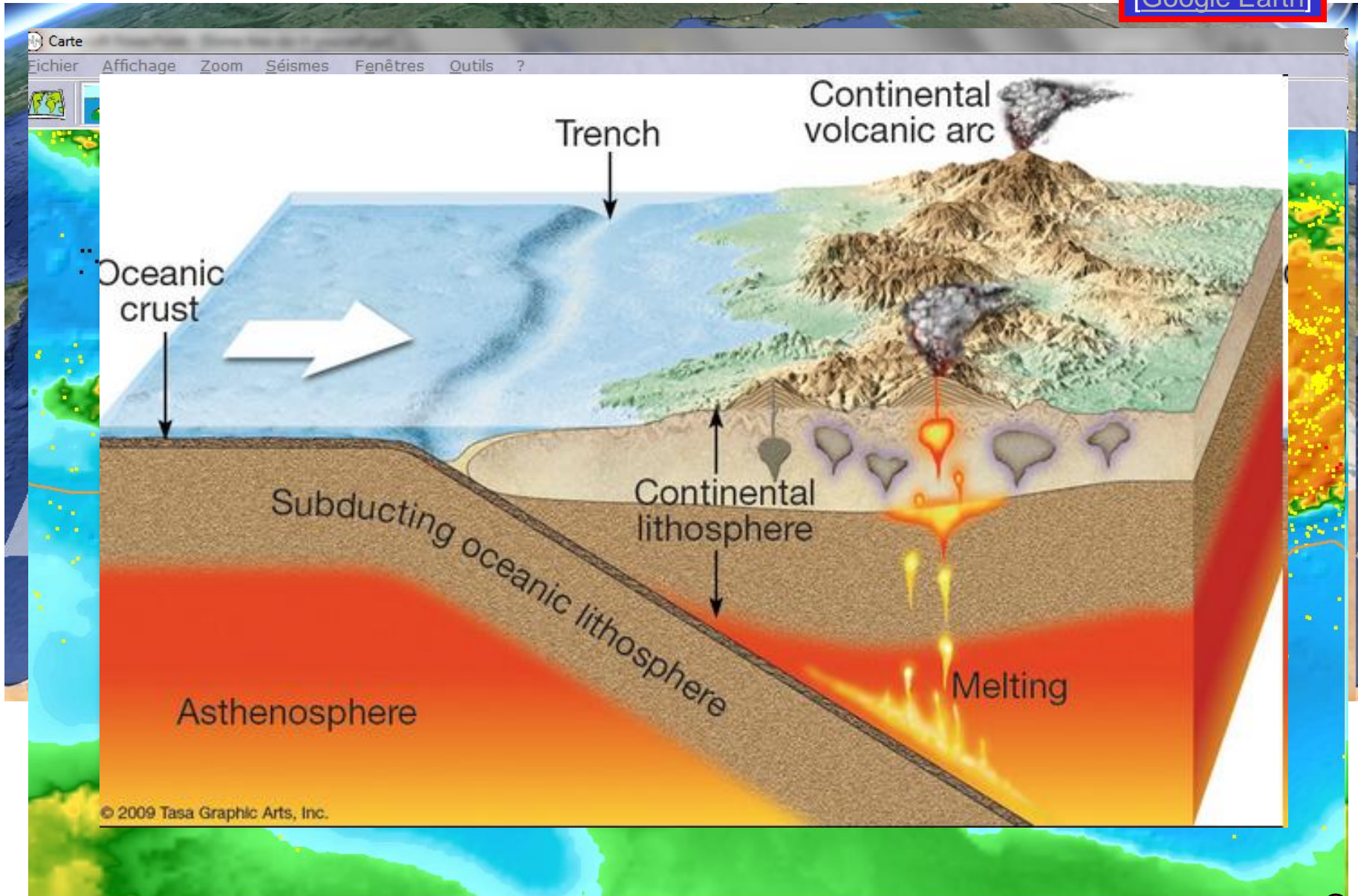
[\[http://sideshow.jpl.nasa.gov/post/series.html\]](http://sideshow.jpl.nasa.gov/post/series.html)

[Google Earth]



Accumulation of constraints- Local exercise with GPS

[Google Earth]



Occurrence spatiale

Localisation d'un séisme proche

With Seisgram software Read earthquakes, Select P & S waves **[Seisgram]** Distance

With Educarte software S-P circle earthquake location **[Educarte]** half-plan location

The screenshot displays the Educarte v3.3.0X14 software interface. The main window shows a topographic map of Europe with seismic stations marked. The cursor position is Lat=44,46° Lon=12,78° Elev=-21m. The interface includes a menu bar (Fichier, Langue), a toolbar (Version Imprimable, Grille Lat/Lon), and a list of seismic stations on the left. The station list is as follows:

AIXF	ANNE
BELF	BLOR
CAIF	CANE
CIVF	DRGF
EMCF	ESION
GRSF	LAUR
NICF	SAUV
SDTF	SJNF
SVLF	VINO
CARM	OSAS
VEMA	

The interface also features a scale bar (0, 100, 200 km) and a navigation panel on the right. A smaller window is open in the foreground, showing the same map and station list, with a scale bar (0, 100, 200, 300 km) and a vertical color scale (-10791, 0, 8440 m). The bottom of the interface has a toolbar with buttons for 'Saisie d'un point', 'Calcul d'une distance', 'Grille de distances', 'Tracer des cercles', 'Tracer des médiatrices', 'Effacer Tous', and 'Effacer Dernier'. A status bar at the bottom indicates: '1, Ai Sélectionnez (pour un couple de stations) la station où les ondes sismiques sont arrivées le plus tôt'.

Localisation d'un séisme en classe



in
cation

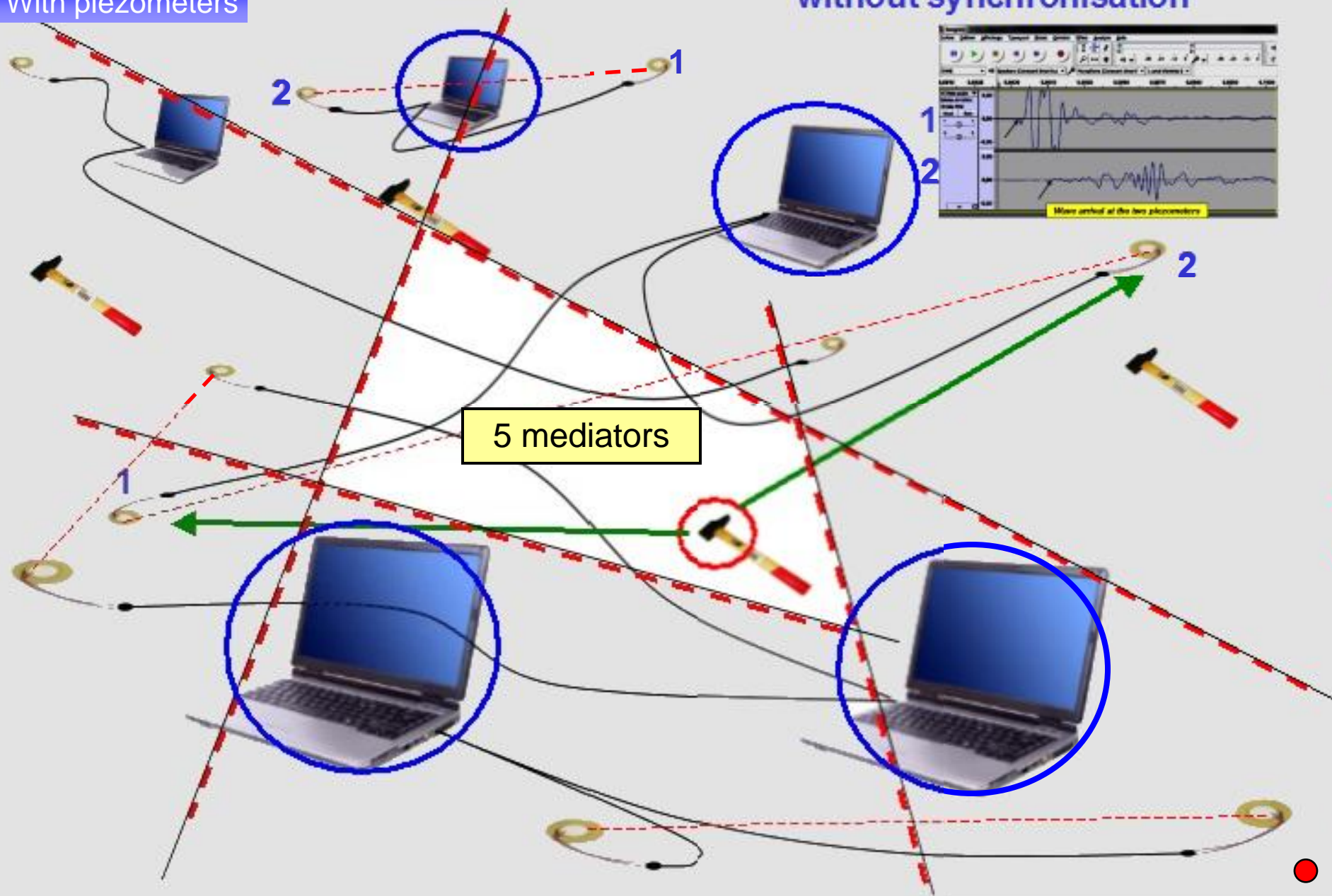
The sidebar contains a diagram of a seismic station with a vertical axis and a horizontal axis, and a screenshot of a software interface with a grid and text.



Localisation d'un séisme en classe

With piezometers

without synchronisation



Localisation d'un télé-séisme

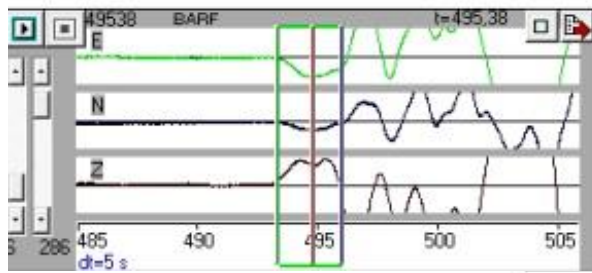
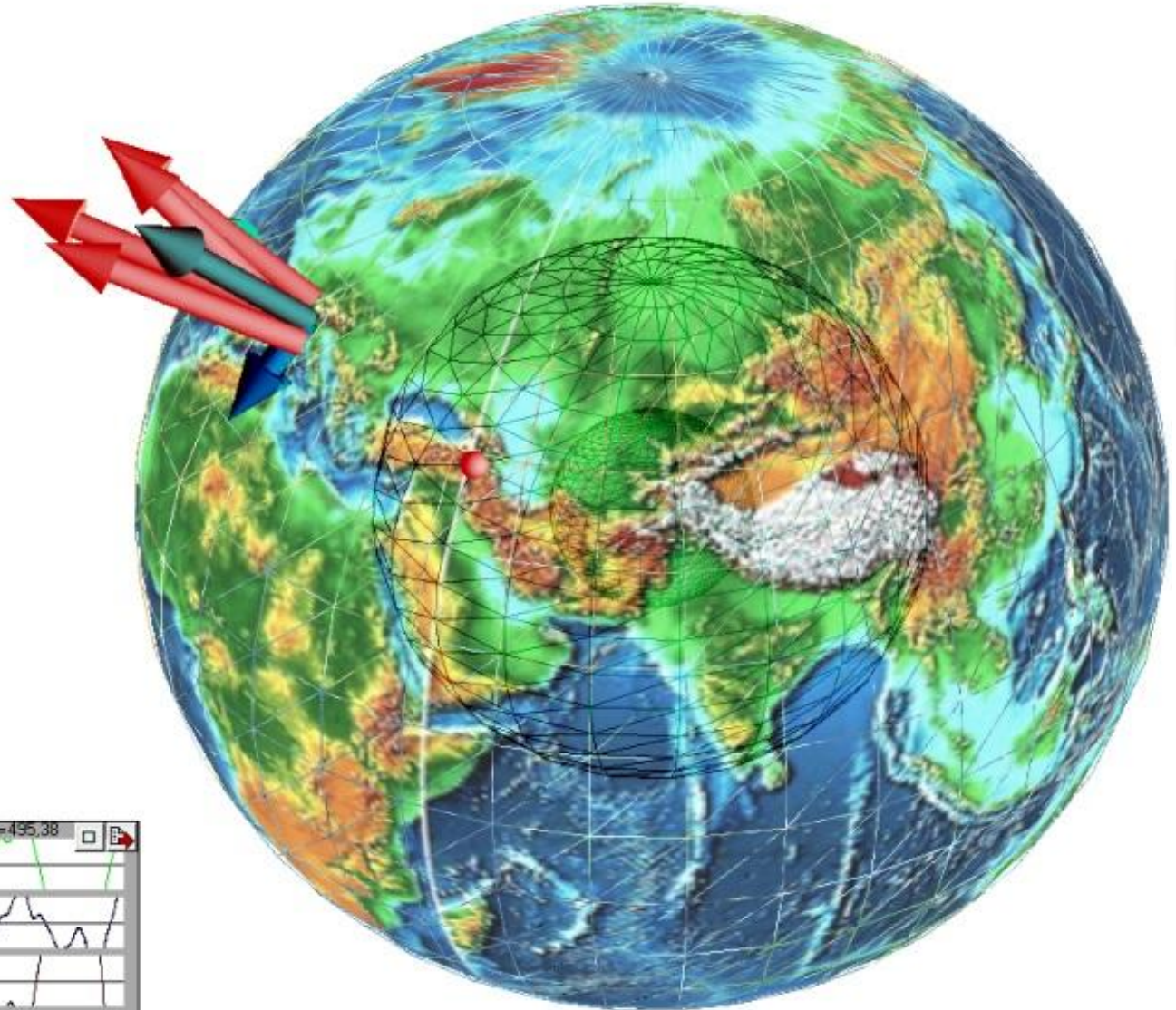
With Azimut software

Read earthquakes, draw the 3D ground movement

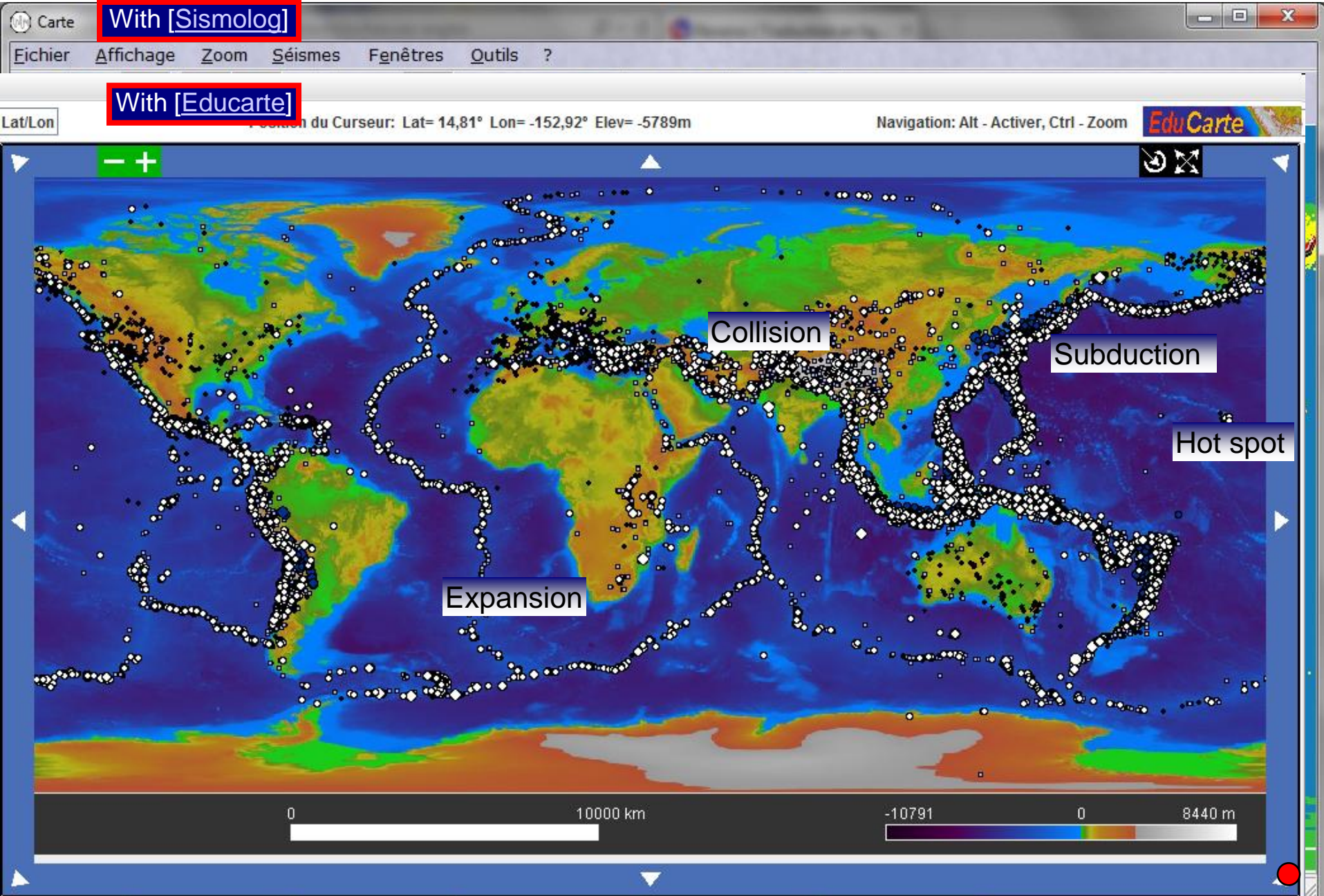
[Azimut]

-Azimut [1]-F.Tilquin: 23-10-2011_EASTERN-TURKEY4_pointes.azi

The interface includes a toolbar with icons for file operations and a main menu. The 'Trace en cours' section has checkboxes for 'Vecteurs', 'N', 'E', 'Z', 'N-E', and 'N-E-Z'. Below this are sliders for 'Pas' (set to 6) and 'Ampl' (set to 286), and a 'Fla' field (set to 0). The 'Info.billes' section contains options for 'Règlez le pas', 'Règlez l'amplitude', and 'Billes jointives'. A 'Zone à dessiner' section has a 'Clic-gliss ds trace' option. The bottom of the interface shows a list of stations: 'CORT', 'BELF', and 'BSTF', each with a checkbox and a trash icon.



Séismes et géologie globale - distribution



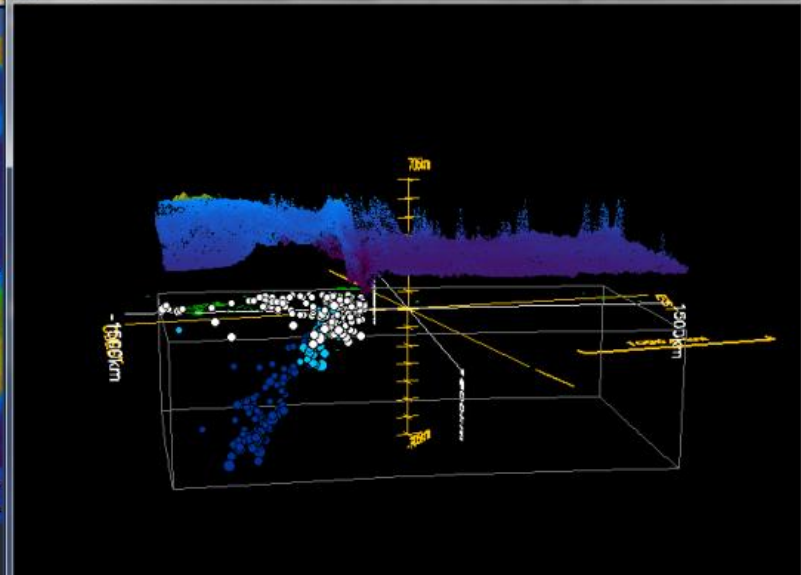
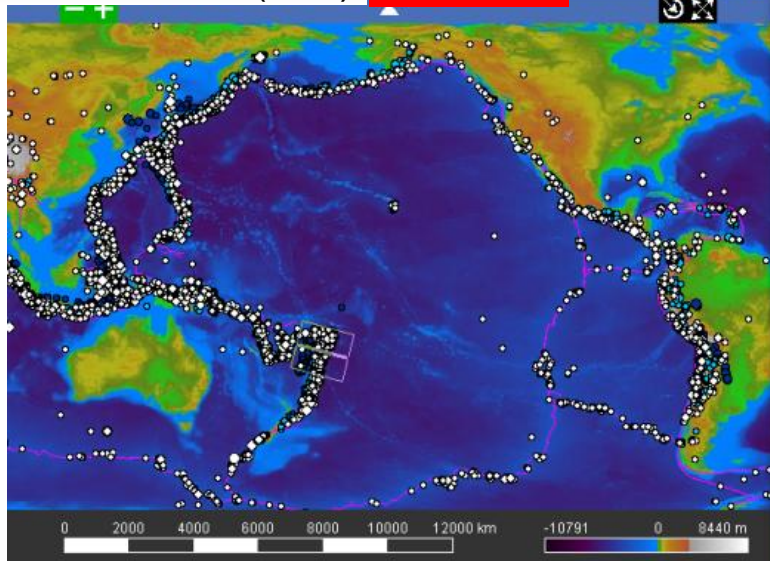
Séismes et géologie globale - cuttings

Educarte software (free)

[Educarte]

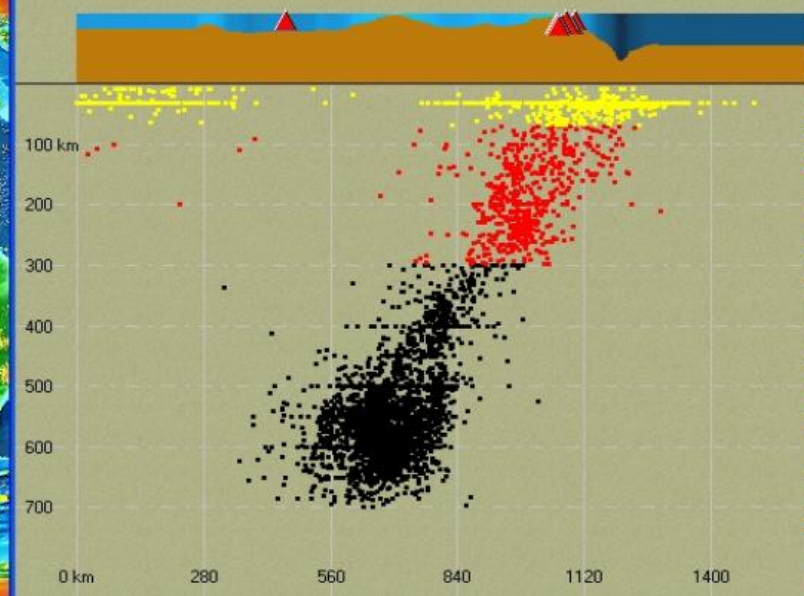
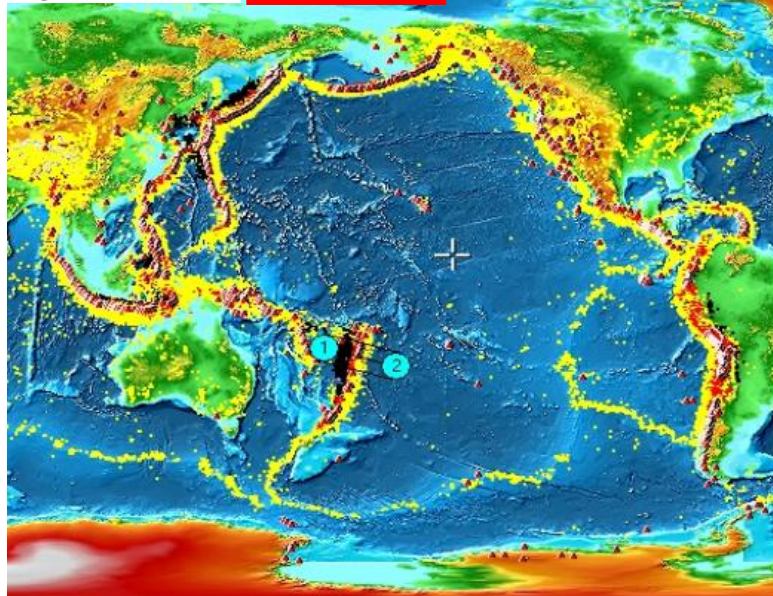
Ctrl - Zoom EduCarte

Bloc diagramme 3D



Sismolog software

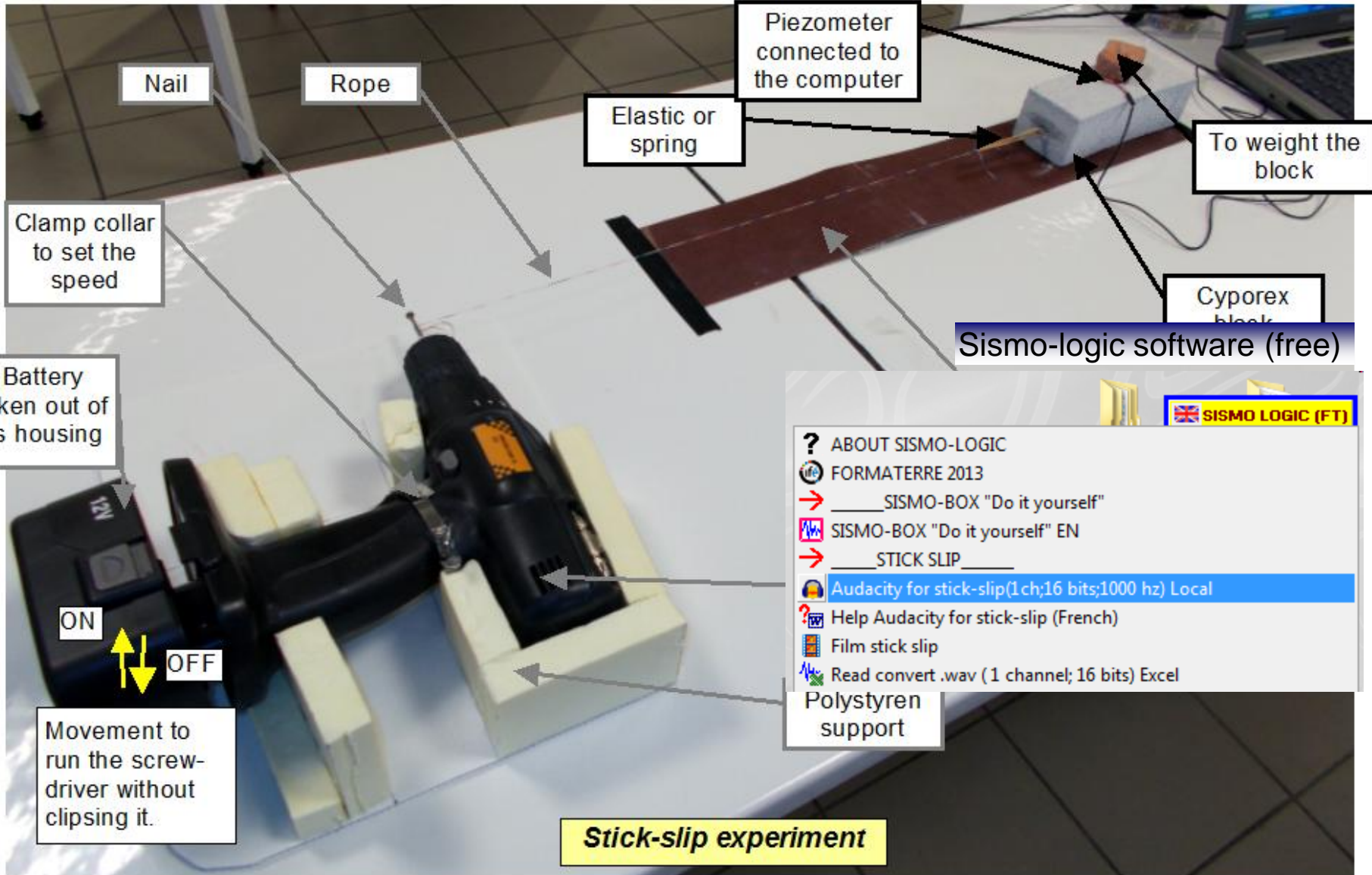
[Sismolog]



Occurrence
temporelle

Prédiction des séismes ?

Protocole



Prédiction des séismes ? Logiciels

The image displays a computer desktop with three main windows open:

- stick-slip2**: A software window with a menu bar (Fichier, Edition, Affichage, Transport, Pistes, Générer, Effets) and a waveform plot showing seismic data. The plot has a time axis from 17.0 to 32.0.
- stick-slip2_0.wav**: A smaller window showing a zoomed-in view of the seismic waveform with vertical red lines marking specific points.
- Microsoft Excel**: A spreadsheet window showing a data table for seismic data treatment. The table has columns A through J and rows 1 through 14.

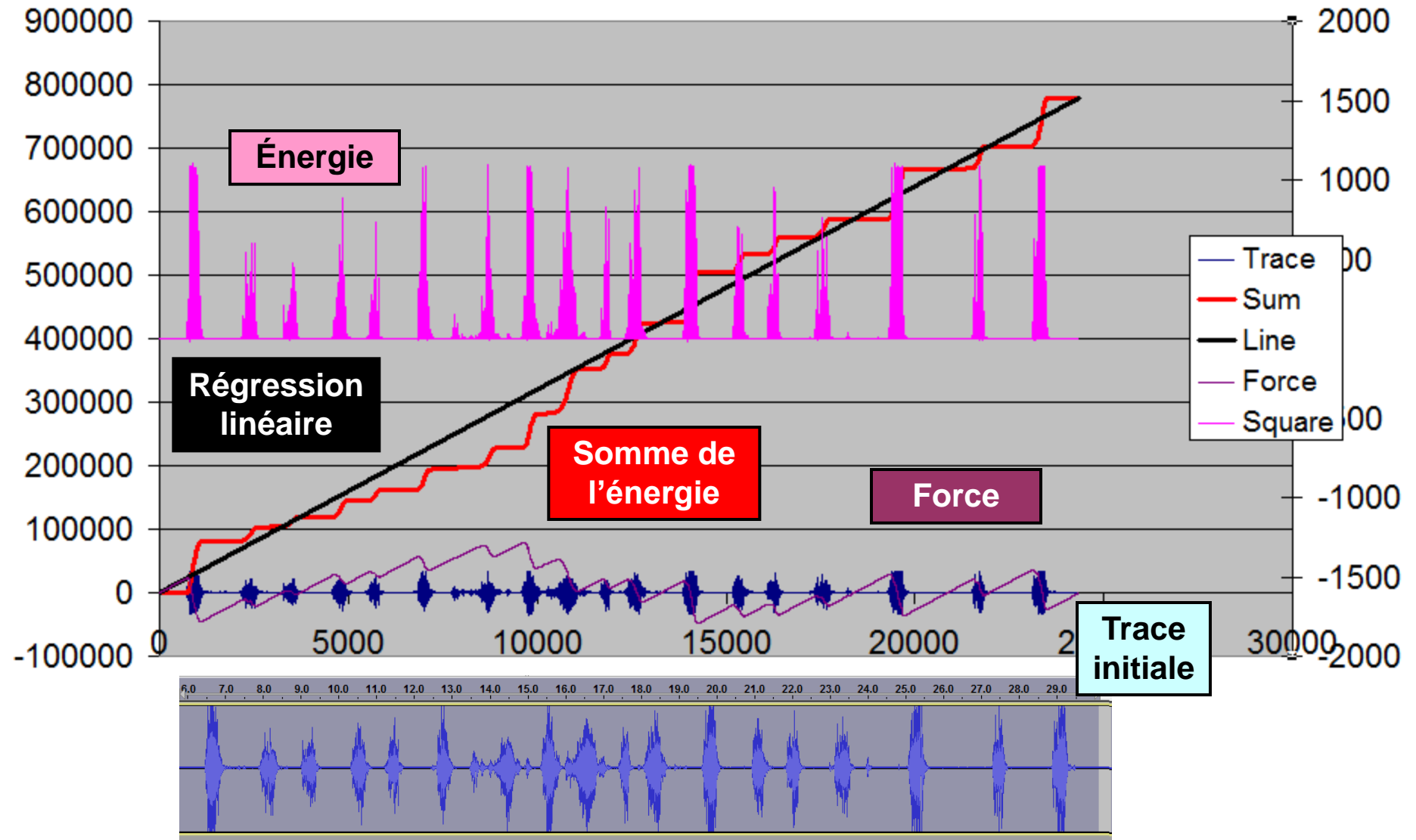
Excel Data Table:

	A	B	C	D	E	F	G	H	I	J
1	Stick-slip data treatment C:\sources\patin_tracte_audacity\Audacity\patin_tracte\stick-slip2_export13.wav.slk									
2	Square d	1000		b_line		0				
3	Offset	0,377		a_line		32,49089				
4										
5	x	Trace	Square	Sum	Line	Force	Delay	Energy_delay	Time	Energy_time
6	1	596	0,355216	-0,02176849	32,49089	32,51266216	1471	22266,43125	909	81163,10933
7	2	636	0,404496	0,005743021	64,98179	64,97604432	1073	15635,59127	2380	22266,43125
8	3	683	0,466489	0,095247532	97,47268	97,37743348	1314	25321,49311	3453	15635,59127
9	4	707	0,499849	0,218112043	129,9636	129,7454626	937	17660,57758	4767	25321,49311
10	5	693	0,480249	0,321376553	162,4545	162,1330918	1334	32272,94407	5704	17660,57758
11	6	652	0,425104	0,369496064	194,9454	194,575866	913	3477,817404	7038	32272,94407
12	7	619	0,383161	0,375672575	227,4363	227,0605831	635	29993,17741	7951	3477,817404
13	8	578	0,334084	0,332772085	259,9271	259,5943773	802	600,4320355	8586	29993,17741
14	9	549	0,301401	0,257188596	292,418	292,1608544	427	53470,38476	9388	600,4320355

Excel Help Text:

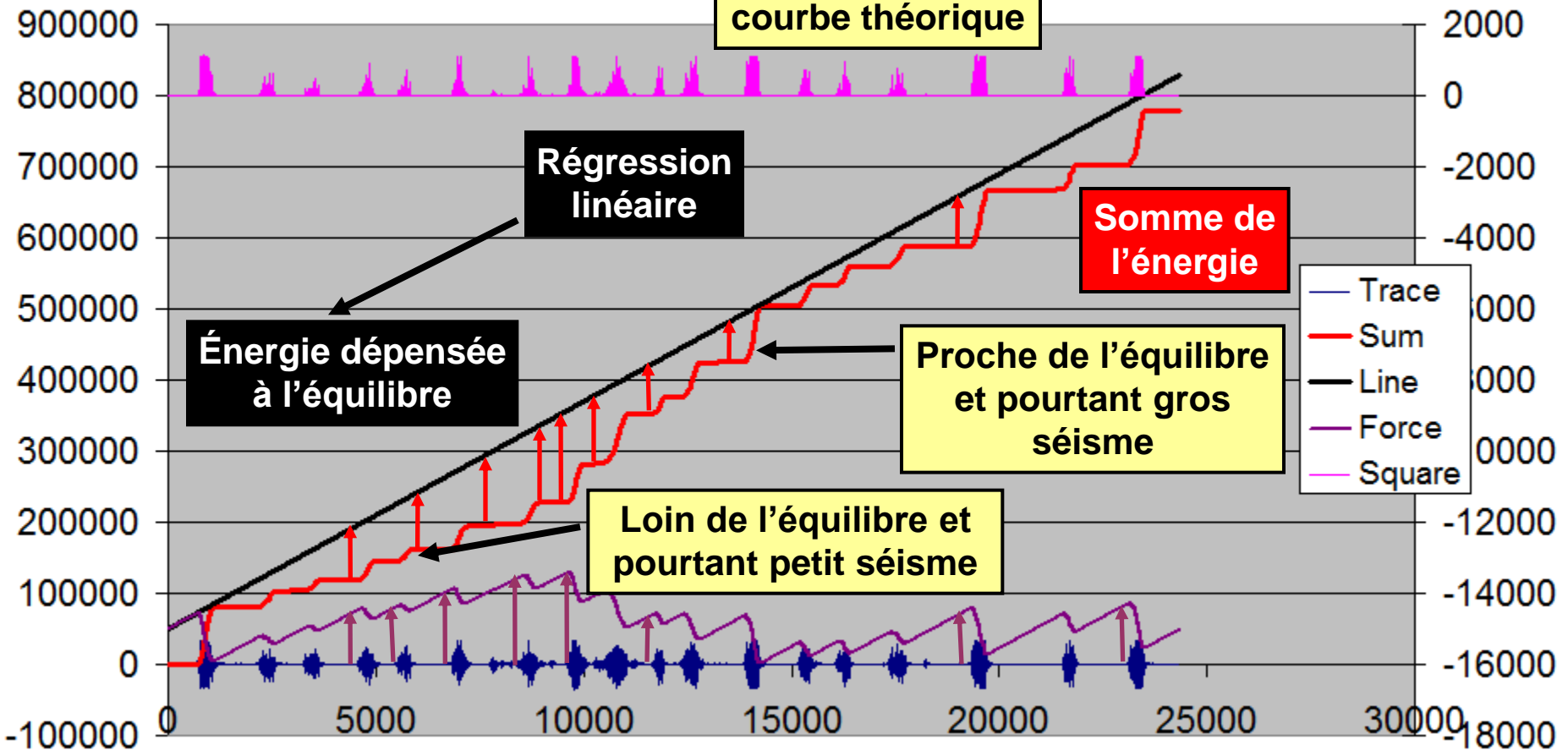
Verify the beginning of earthquake
 - zoom with <ctrl>+wheel
 - move with <shift>+wheel
 - add a new mark with <right click>
 - delete a mark with <right click>+delete

Résultats du patin tracté- Traitement



Résultats du patin tracté - Equilibre

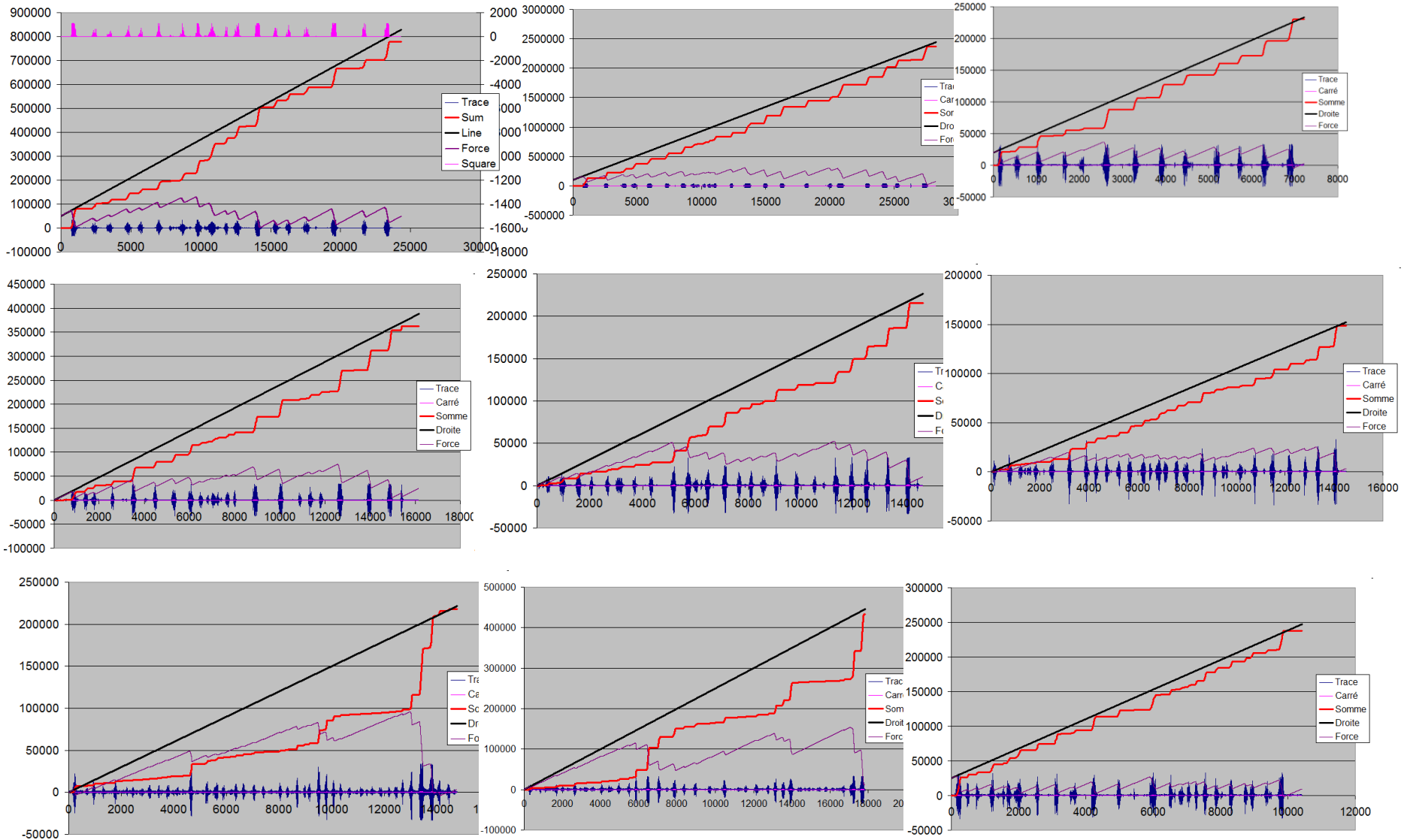
	A	B	C	D	E	F	G	H
1	Stick-slip data treatment d:\tilquin\fic_sismo_logic\audacity\patin_tracte\stick-slip2_0.wav.slk							
2	Square d	1000		b_line	50000			
3	Offset	0,001		a_line	32			



Il n'est pas possible de prévoir la magnitude

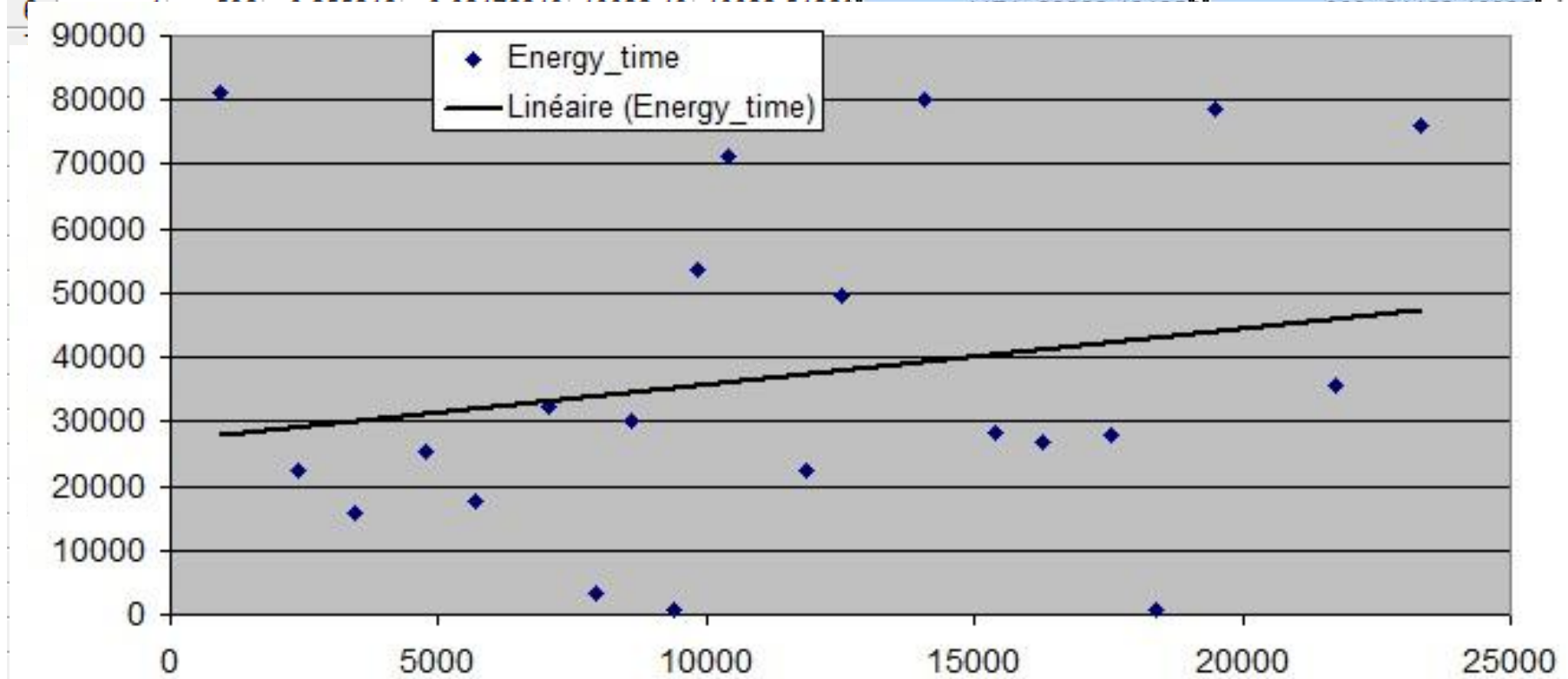


Résultats du patin tracté - Différents résultats



Résultats du patin tracté – Quand?

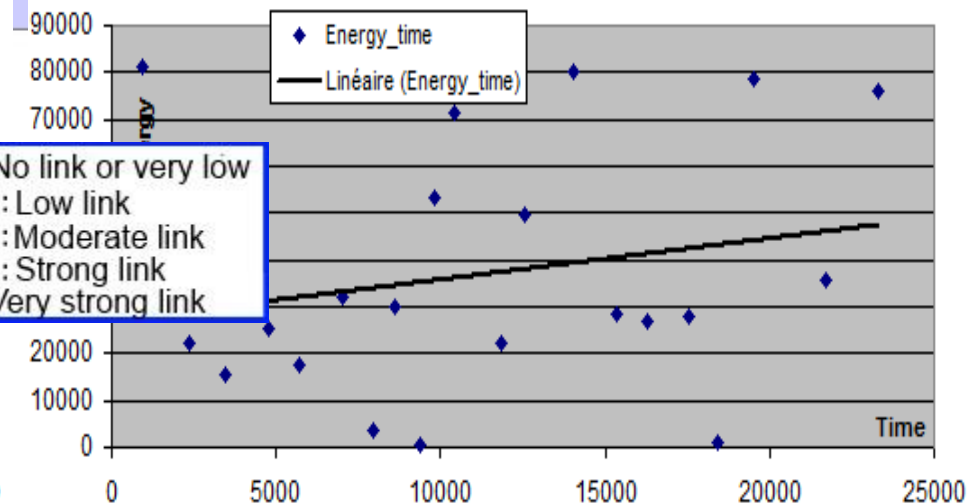
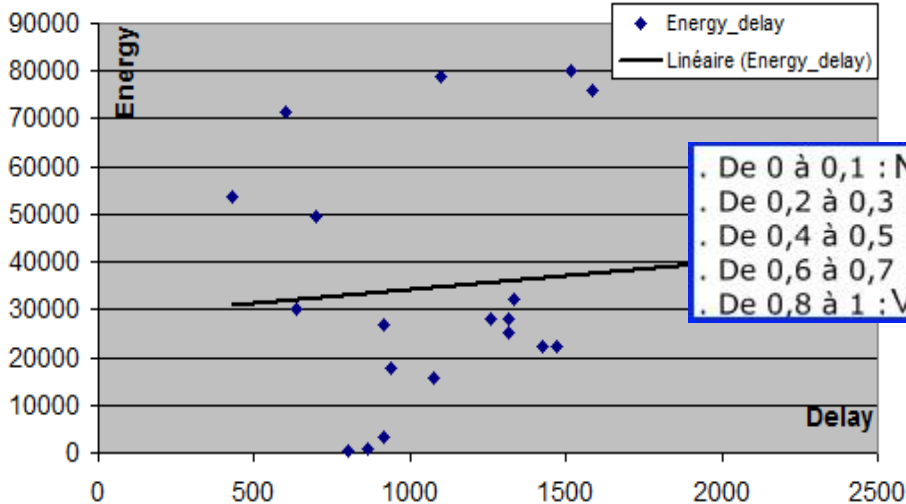
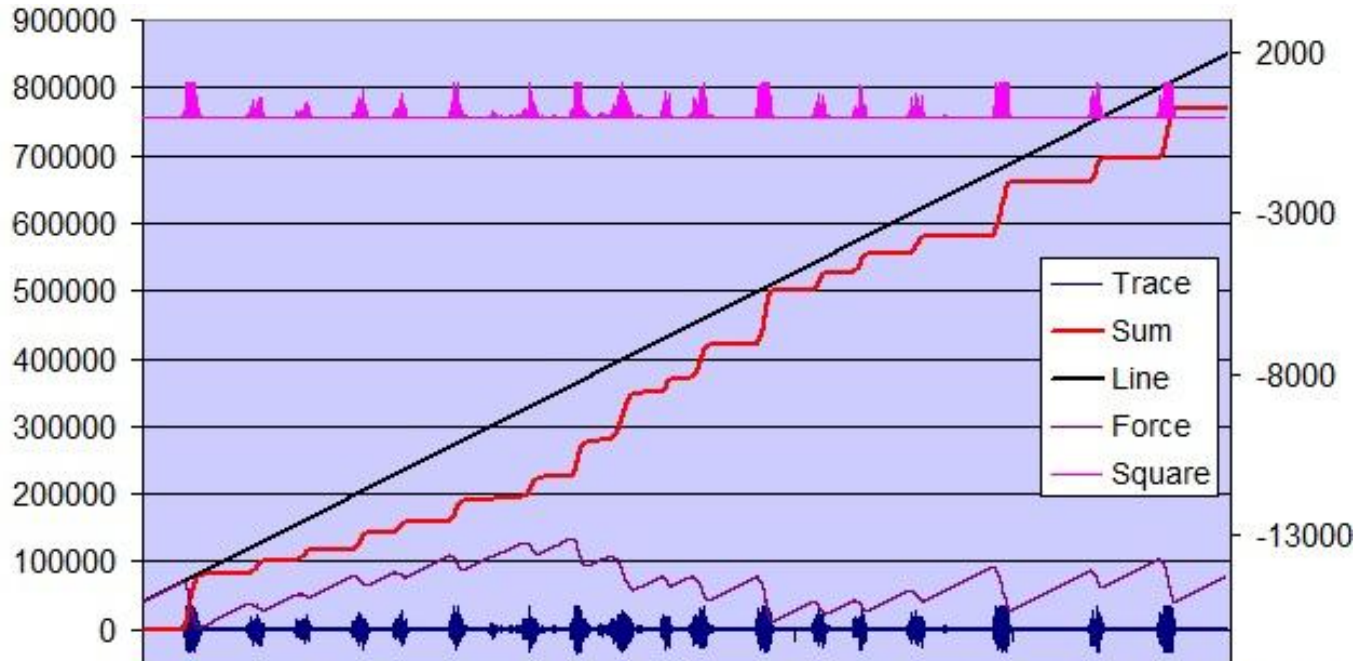
	A	B	C	D	E	F	G	H	I	J
1	Stick-slip data treatment C:\sources\patin_tracte_audacity\Audacity\patin_tracte\stick-slip2_export13.wav.slk									
2	Square d	1000		b_line	40000					
3	Offset	0,377		a_line	32,49089					
4										
5	x	Trace	Square	Sum	Line	Force	Delay	Energy_delay	Time	Energy_time



26	21	552	0,304704	0,365336724	40682,31	40681,94343	Correlation	0,099949775%	23305	76162,05004
27	22	562	0,315844	0,304196235	40714,8	40714,49546				
28	23	593	0,351649	0,278860746	40747,29	40747,01169				



Résultats du patin tracté – Quand ?



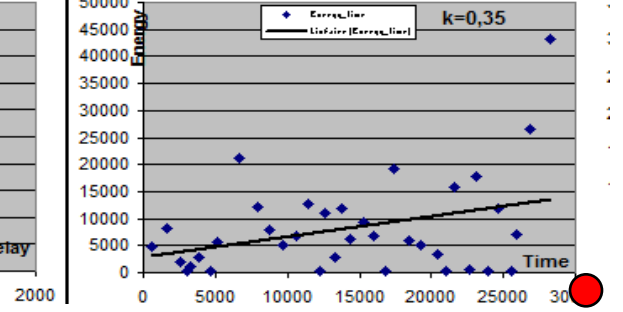
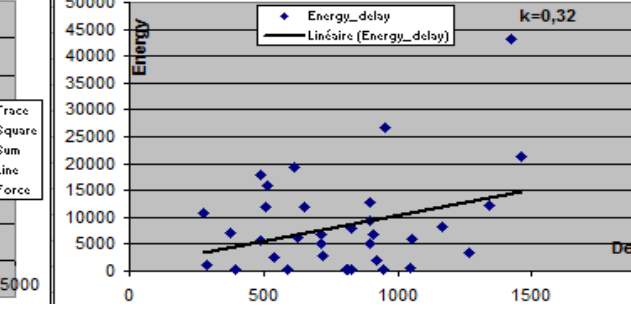
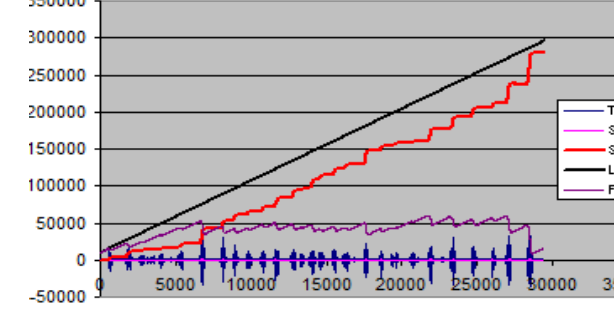
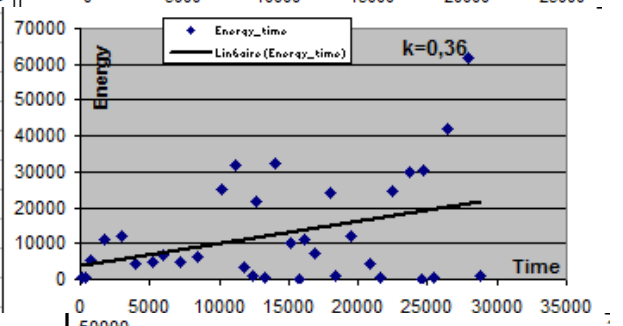
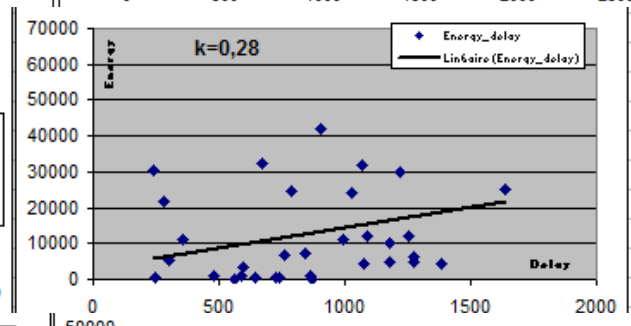
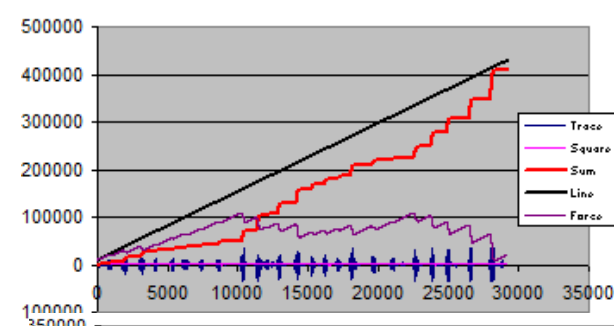
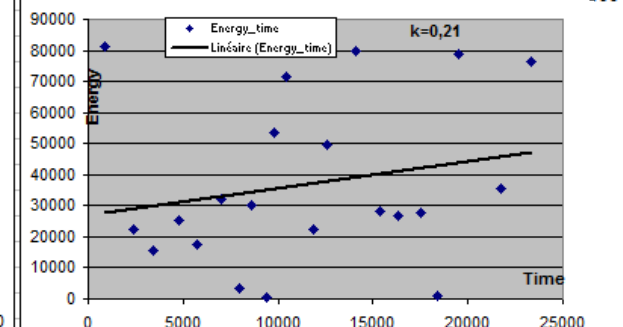
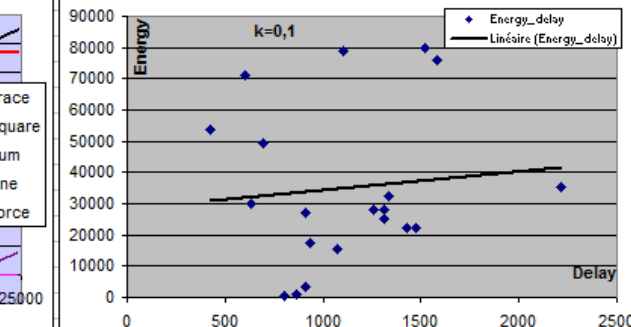
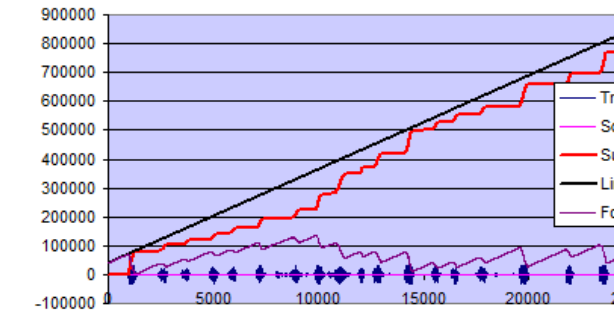
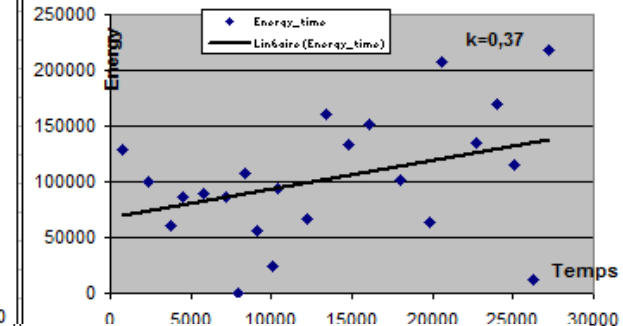
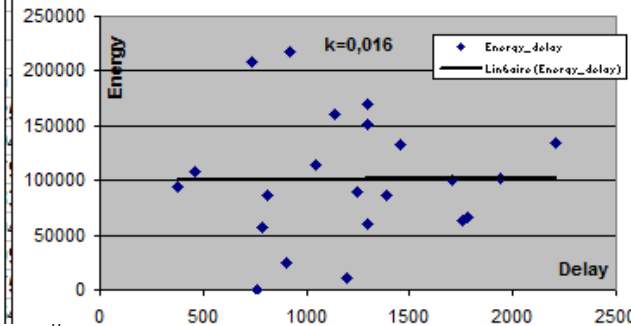
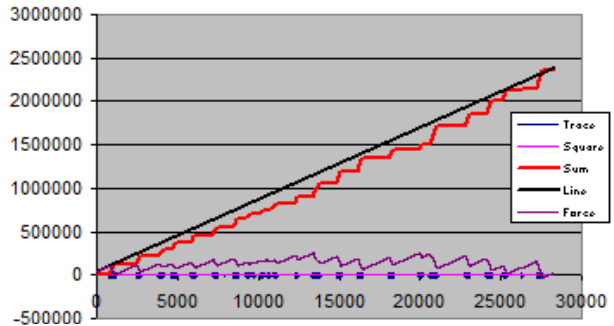
. De 0 à 0,1 : No link or very low
 . De 0,2 à 0,3 : Low link
 . De 0,4 à 0,5 : Moderate link
 . De 0,6 à 0,7 : Strong link
 . De 0,8 à 1 : Very strong link

r=0,099

r=0,208

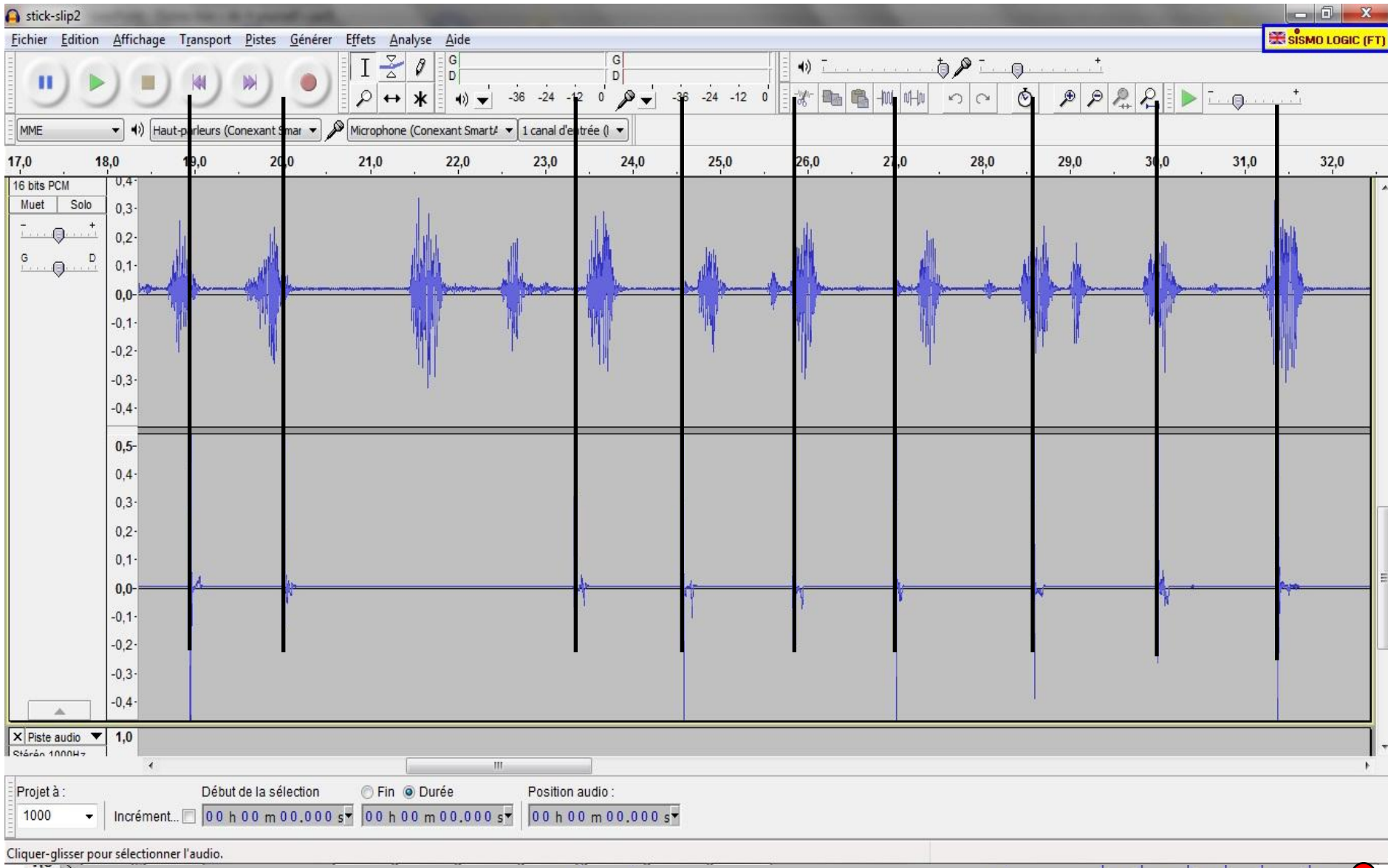


Résultats du patin tracté - Généraux



Résultats du patin tracté - Un test !

Qui veut prédire le séisme ?



Conséquences des séismes

Reproduce the same consequences to understand.



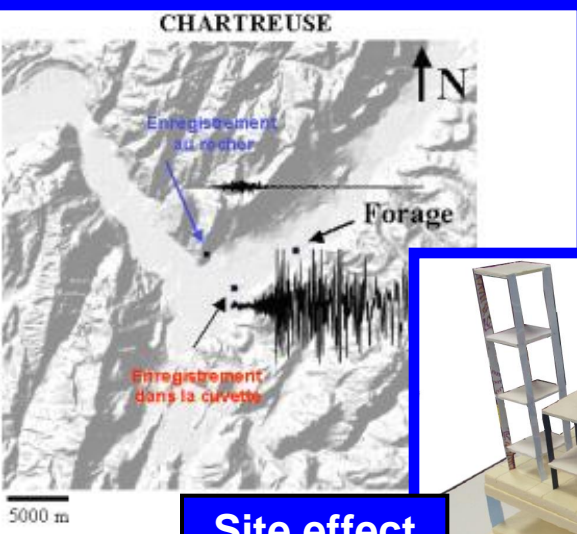
Thomas Picq Valbonne

Resonance

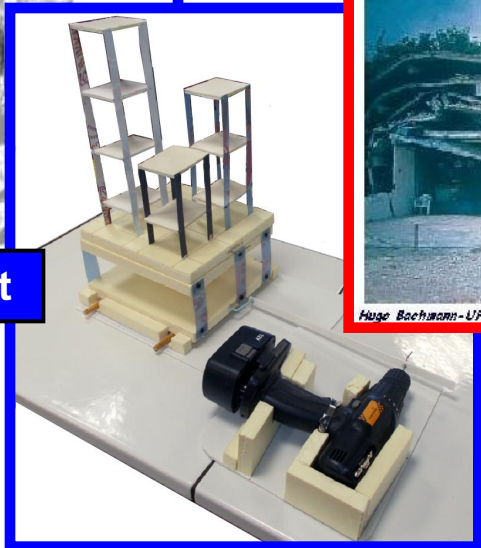


© DR Ersoz

Ground liquefaction

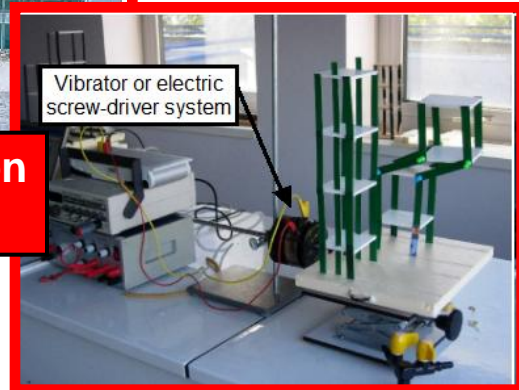


Site effect



Hugo Bachmann - UFAEG - Berno (Swiss, Eng)

Construction mode



Vibrator or electric screw-driver system

Conséquences des séismes - Resonance laws

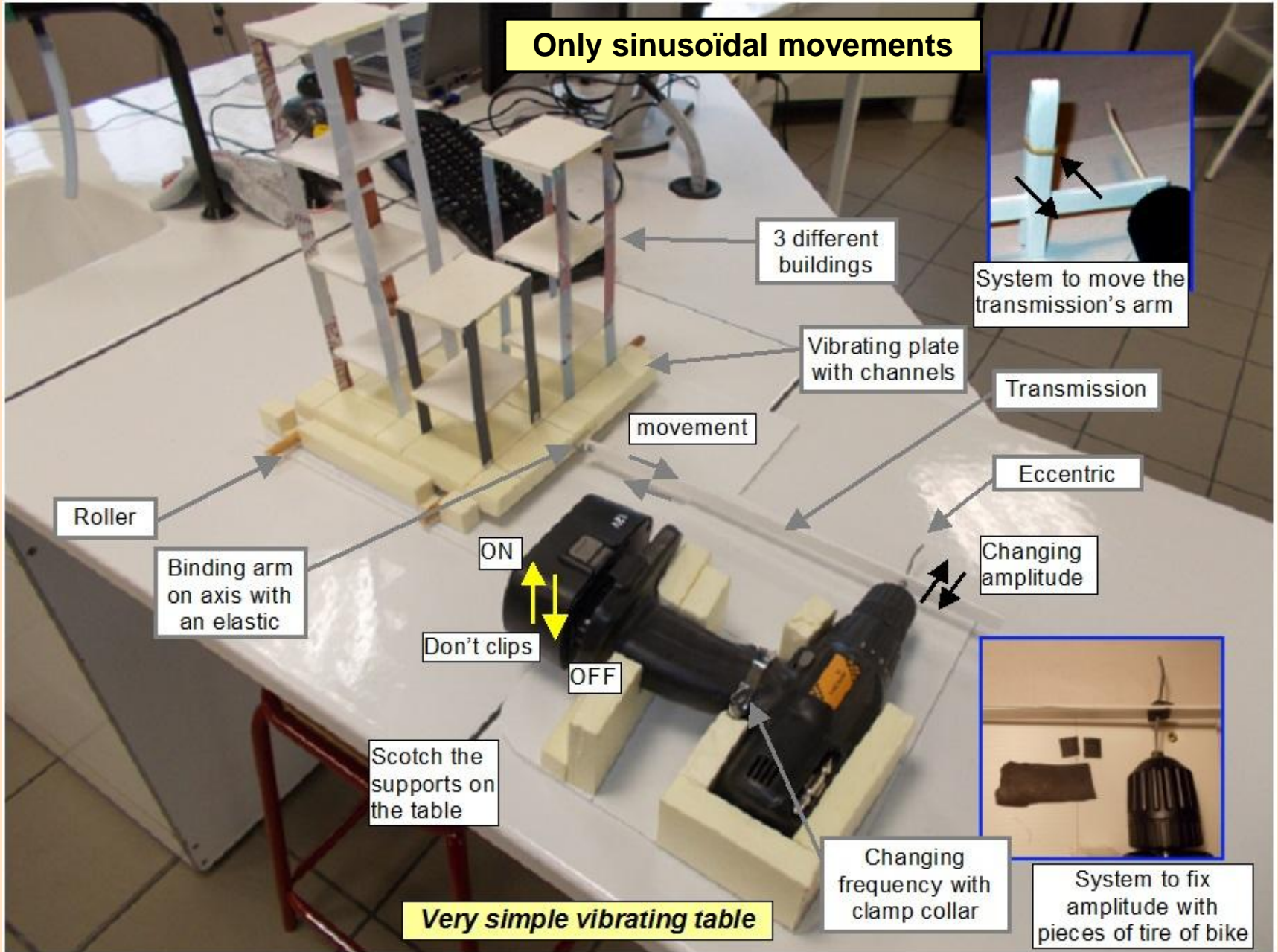


Thomas Picq Valbonne

Resonance



Conséquences des séismes - Simple-vibrating table



Conséquences des séismes - e- Vibrating table

An earthquake contains all frequencies

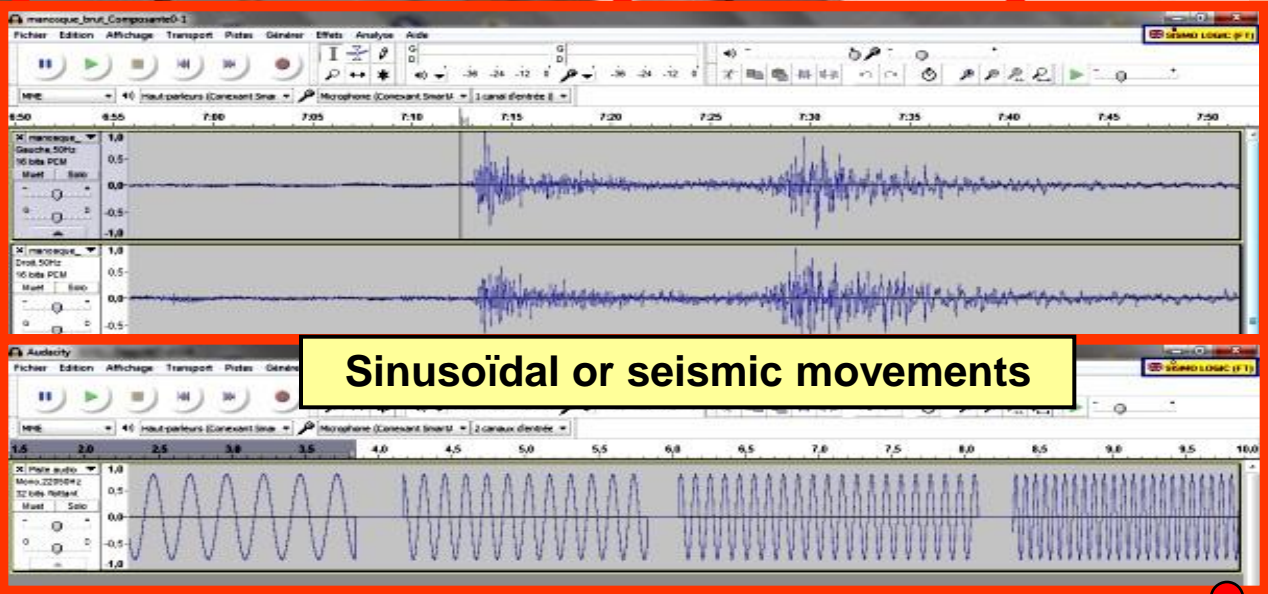
All buildings vibrate but some more than others

Mechanic connector

Old High - speaker

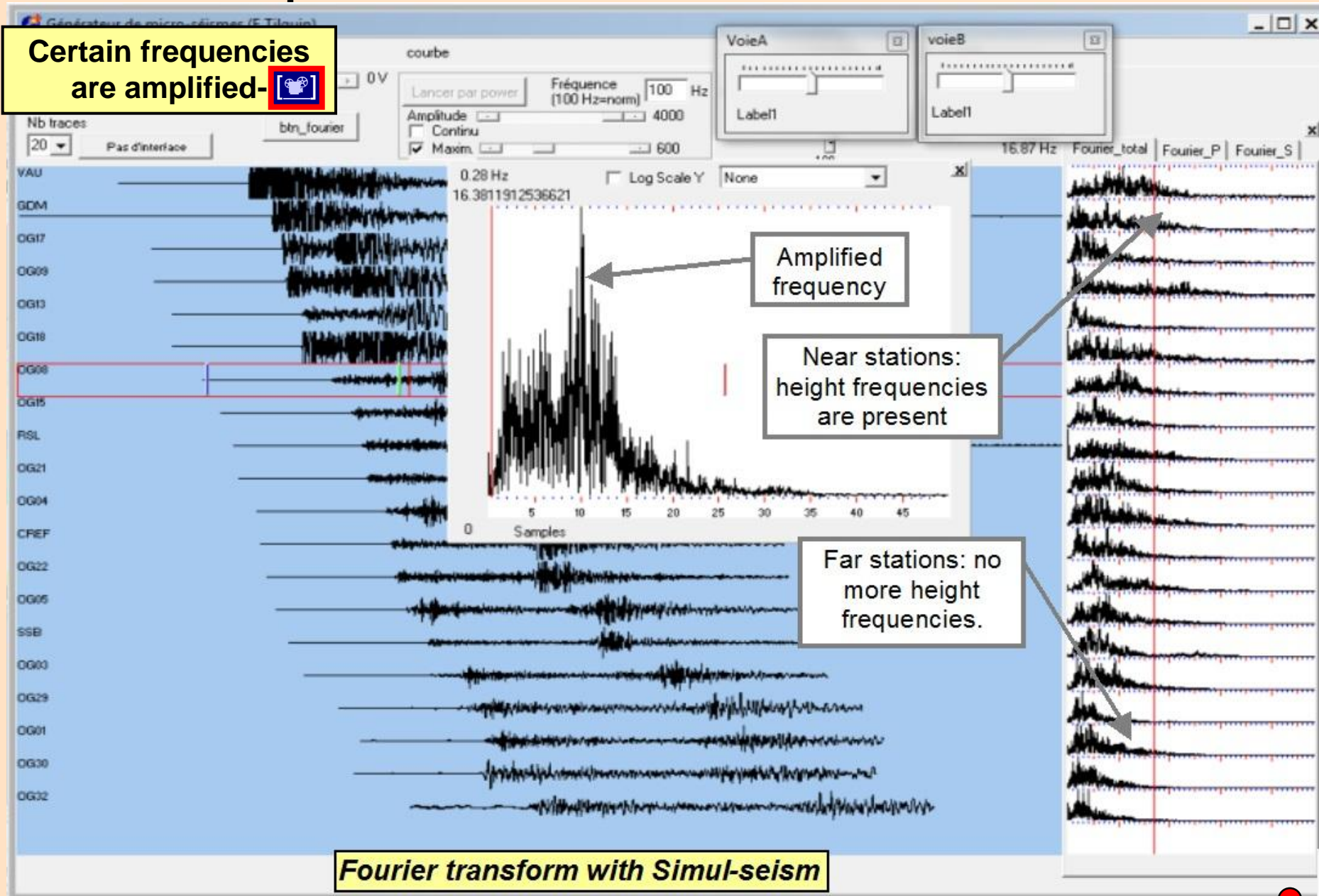
Audacity software

Springs or small balls



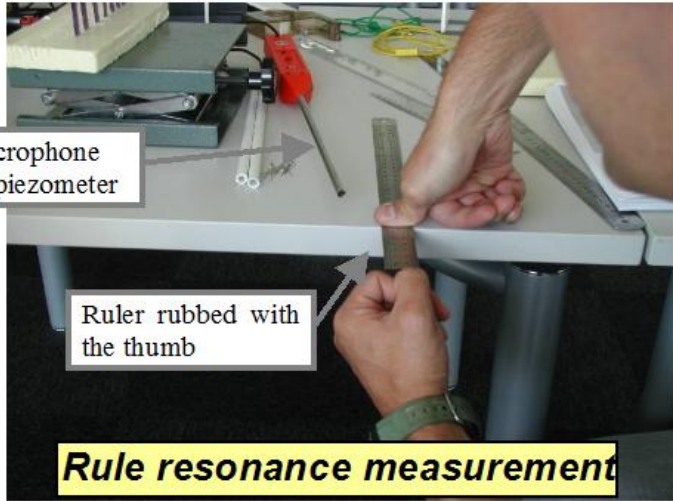
Conséquences des séismes - Fourier transform

Certain frequencies are amplified- 

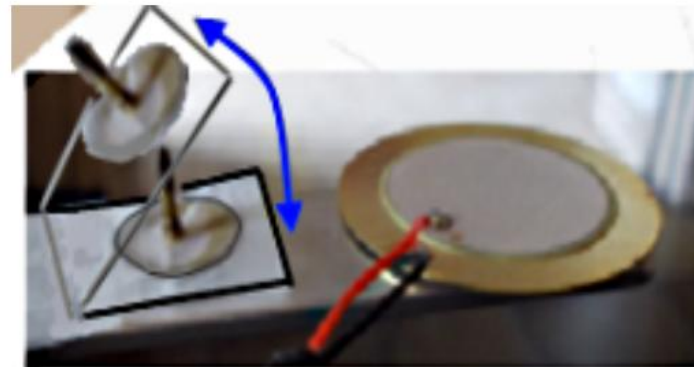
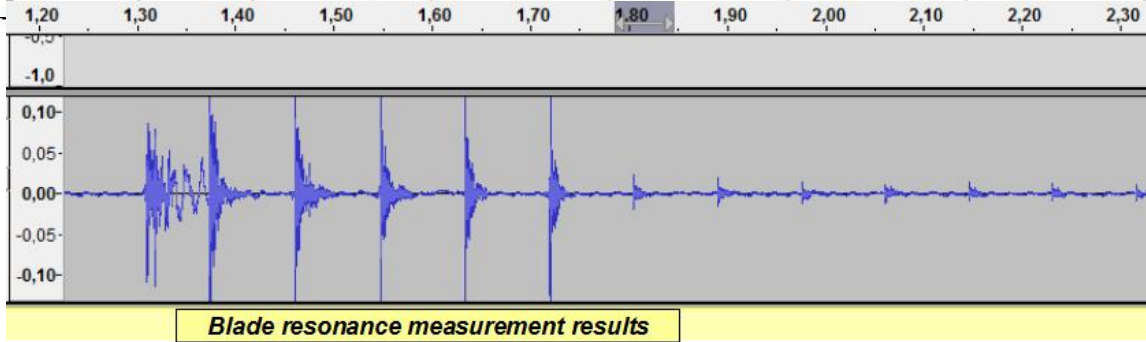
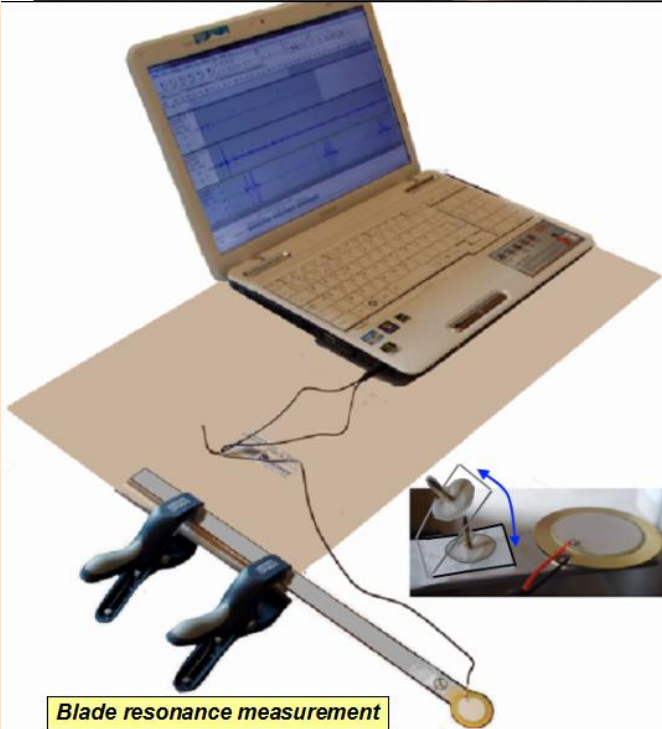
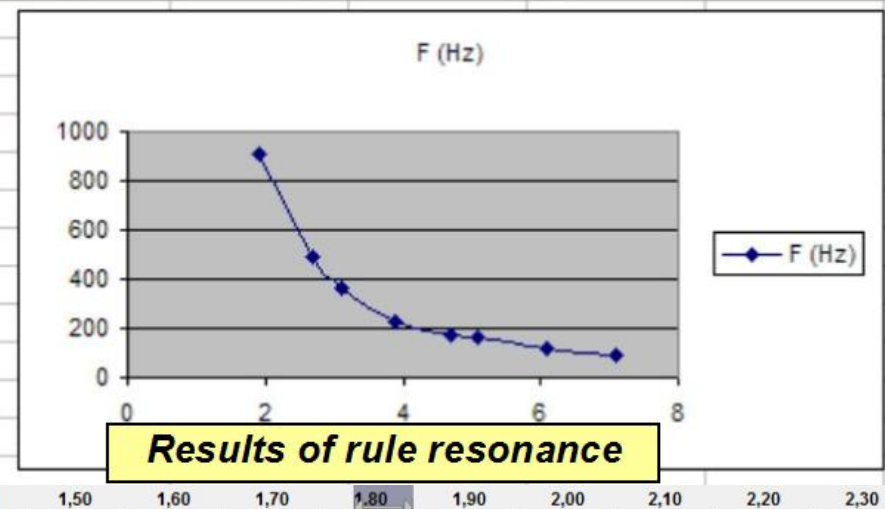


Fourier transform with Simul-seism

Conséquences des séismes - Resonance laws



L (cm)	F (Hz)
1,9	910
2,7	489
3,1	362
3,9	225
4,7	176
5,1	166
6,1	117
7,1	88



Conséquences des séismes - protection

The knowledge

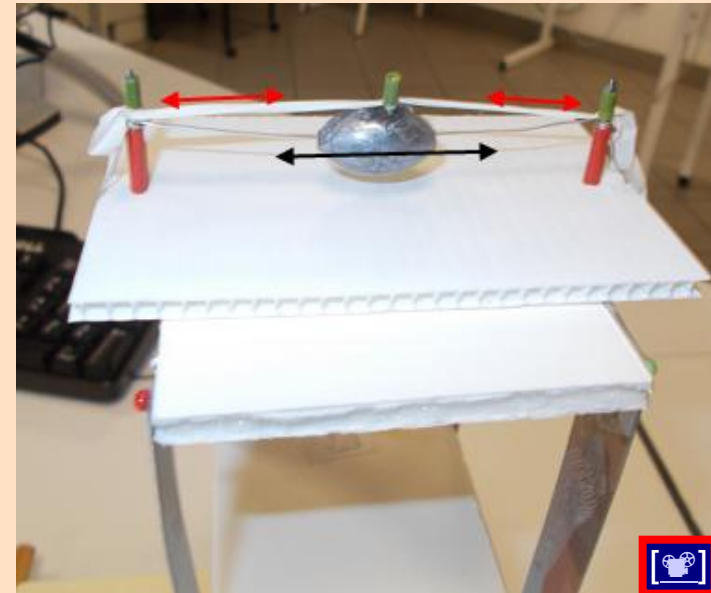
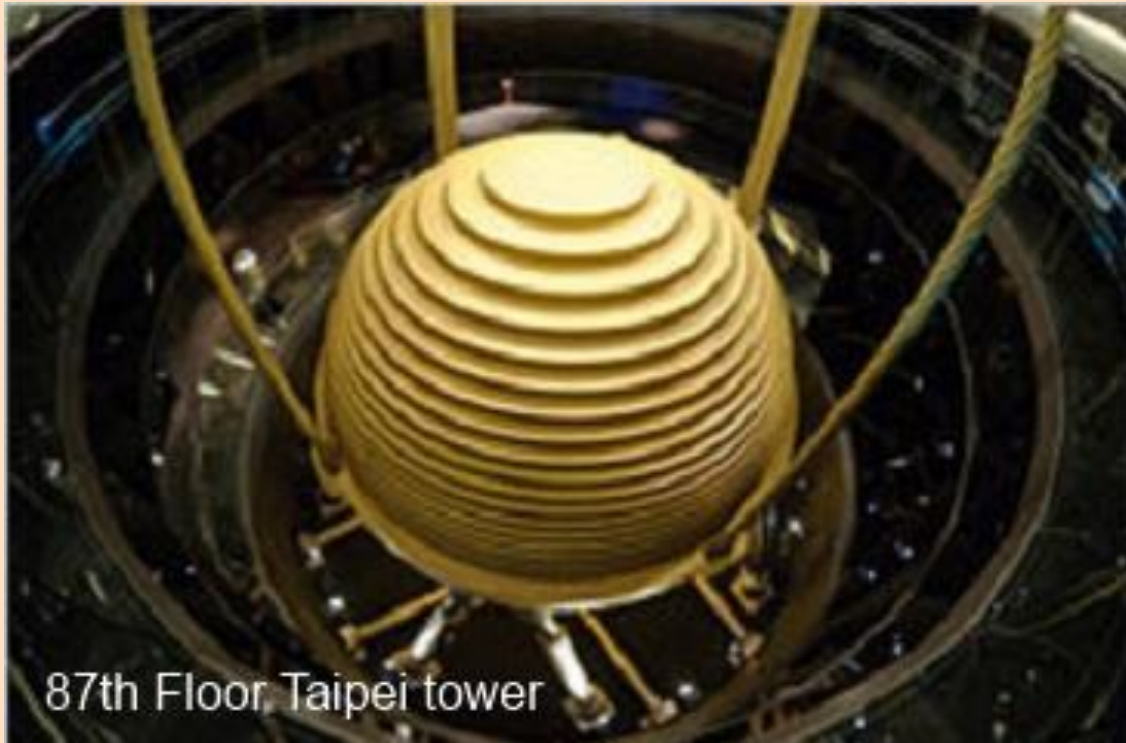
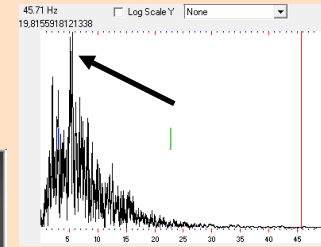
$$N = \frac{V}{\lambda} = \frac{V(2k+1)}{4L}$$

V= speed
N number of nodes
 λ is the wave length
k= is an integer

Build by avoiding the most common frequencies

By changing the mass of building

By using a dynamic shock absorber



Conséquences des séismes – Mode de construction



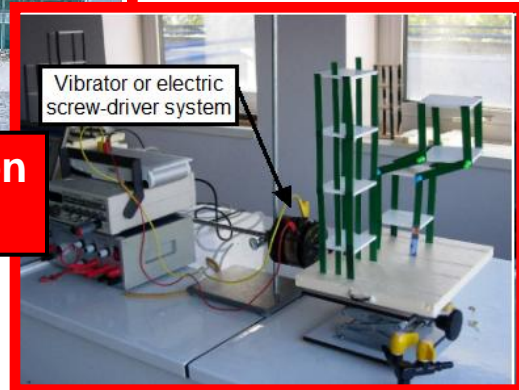
Thomas Picq Valbonne

Resonance

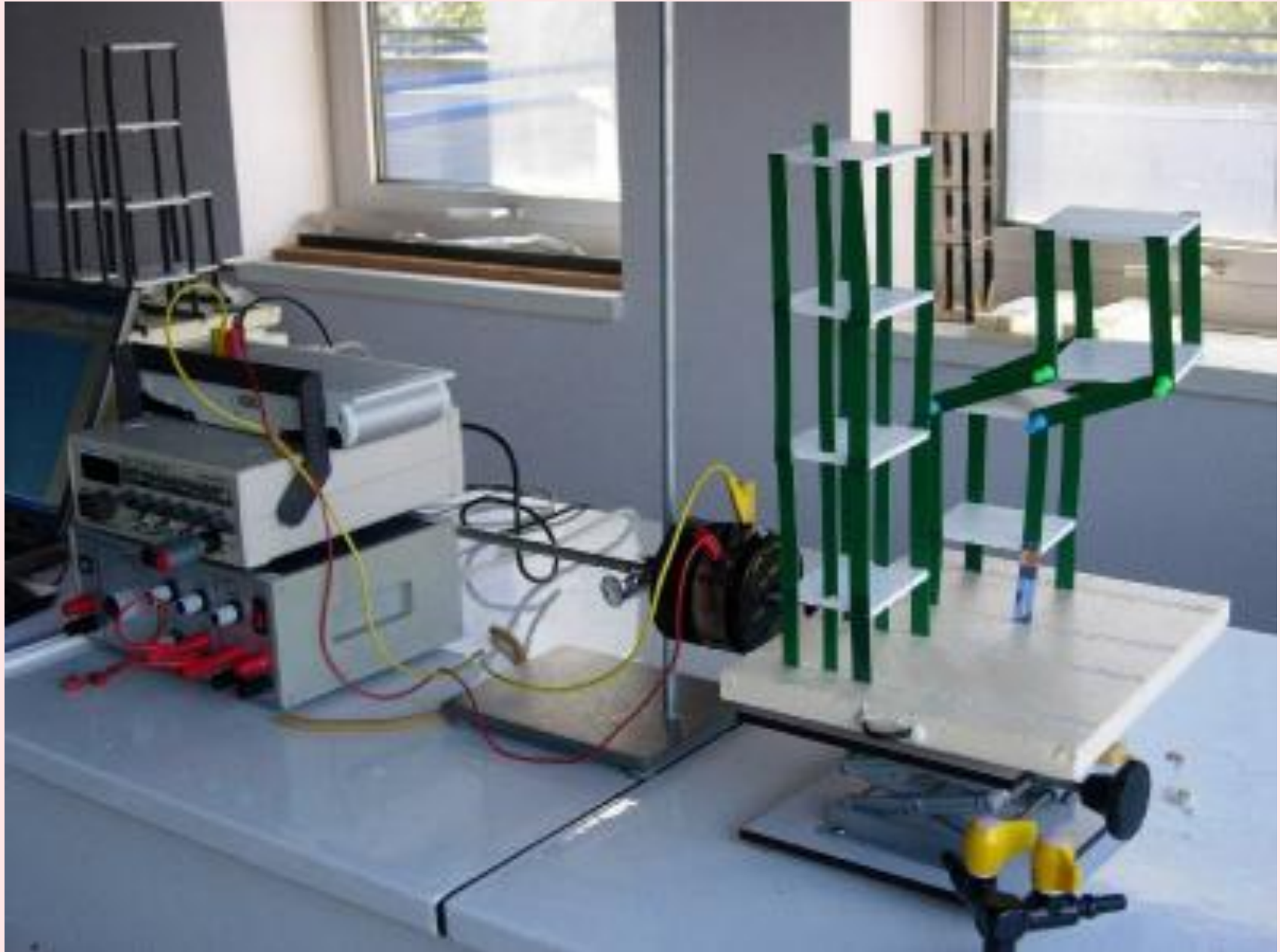


Hugo Bachmann - UFAEG - Berno

Construction mode



Effondrement des bâtiments- Murs porteurs



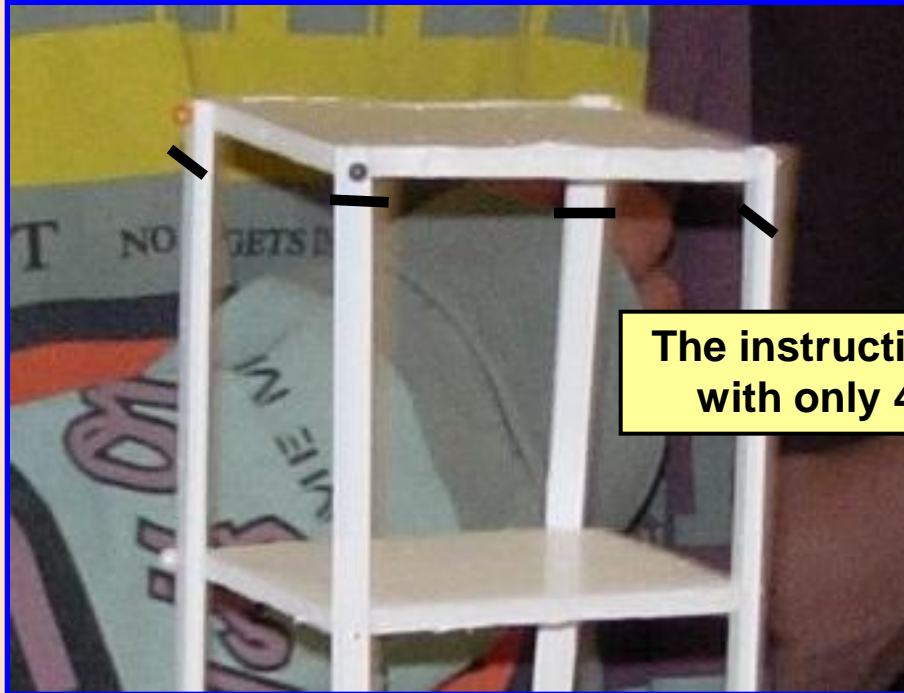
Effondrement des bâtiments position des murs porteurs



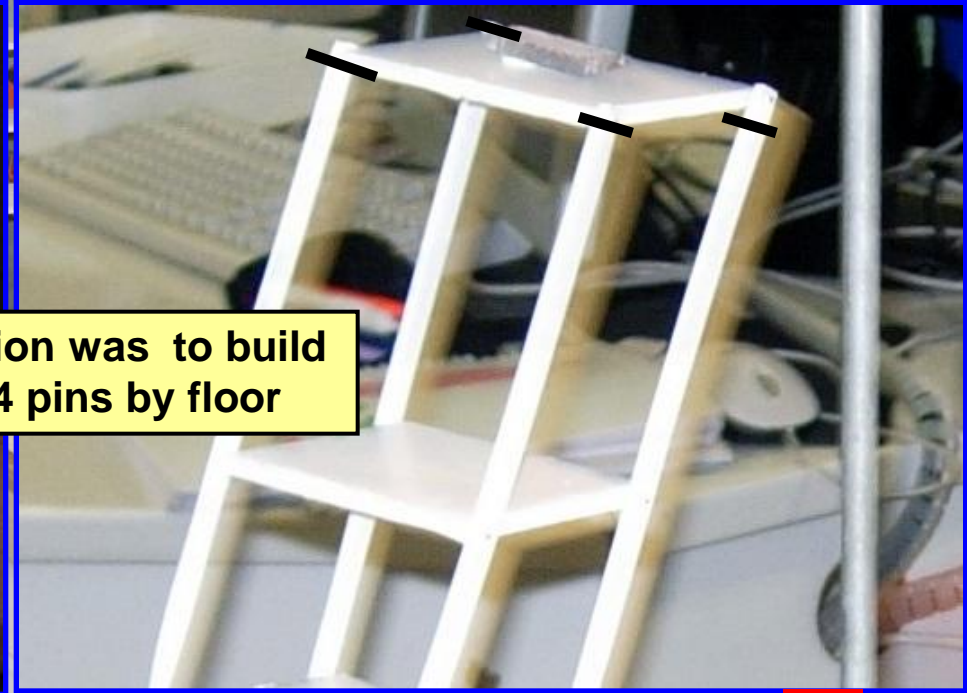
Effondrement des bâtiments Solutions des élèves



with perpendicular hanging wall



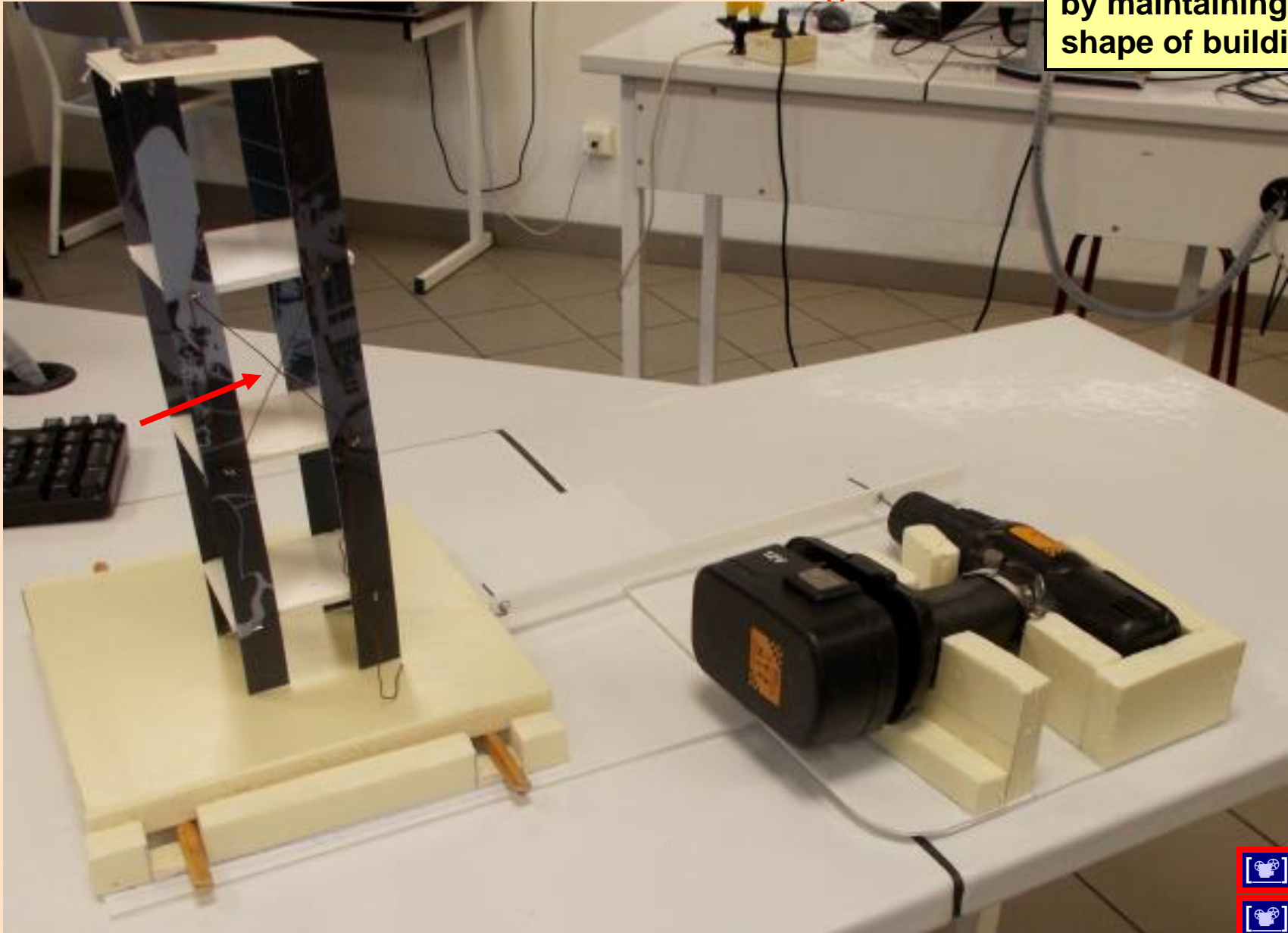
The instruction was to build with only 4 pins by floor



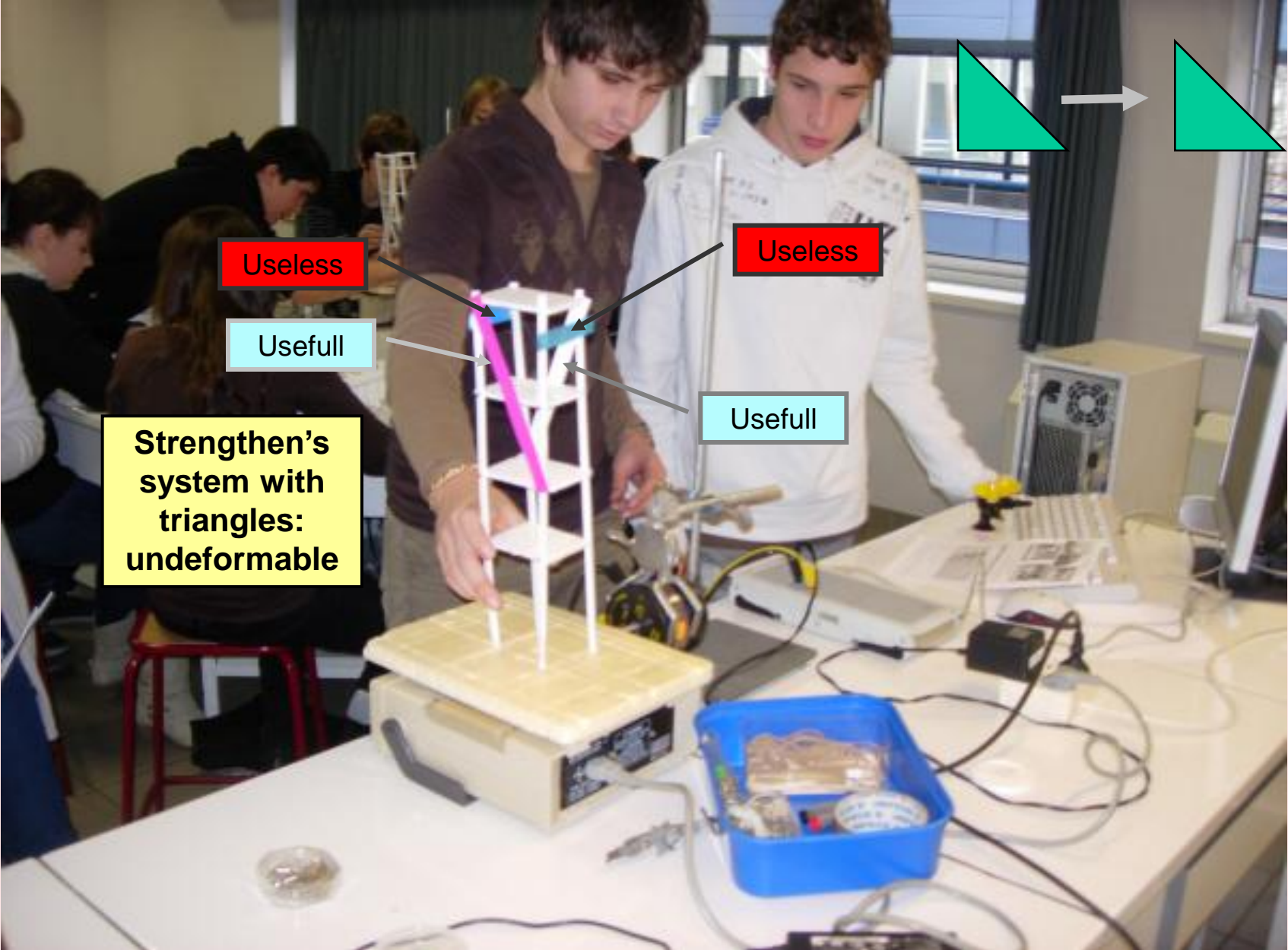
Effondrement des bâtiments

Contreventements triangulés

by maintaining the shape of buildings

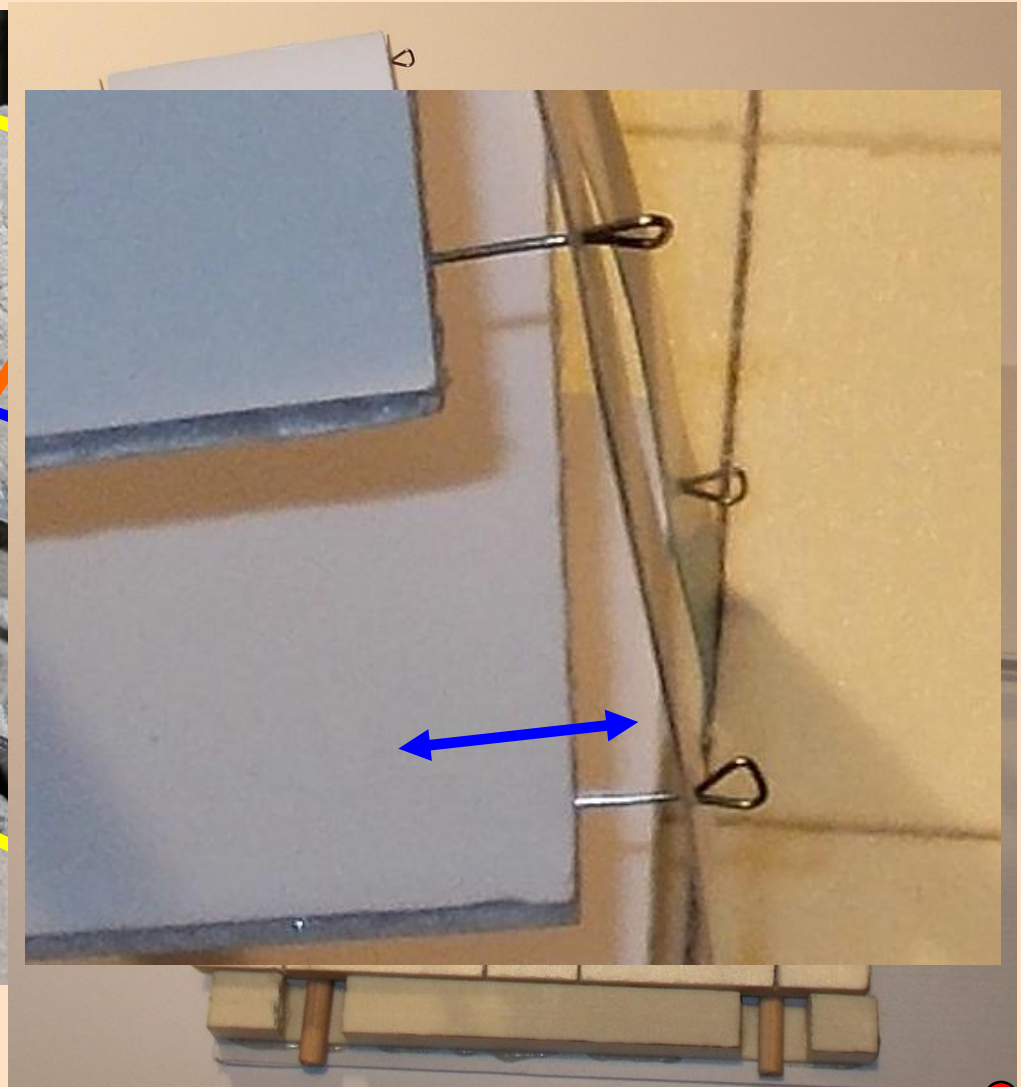
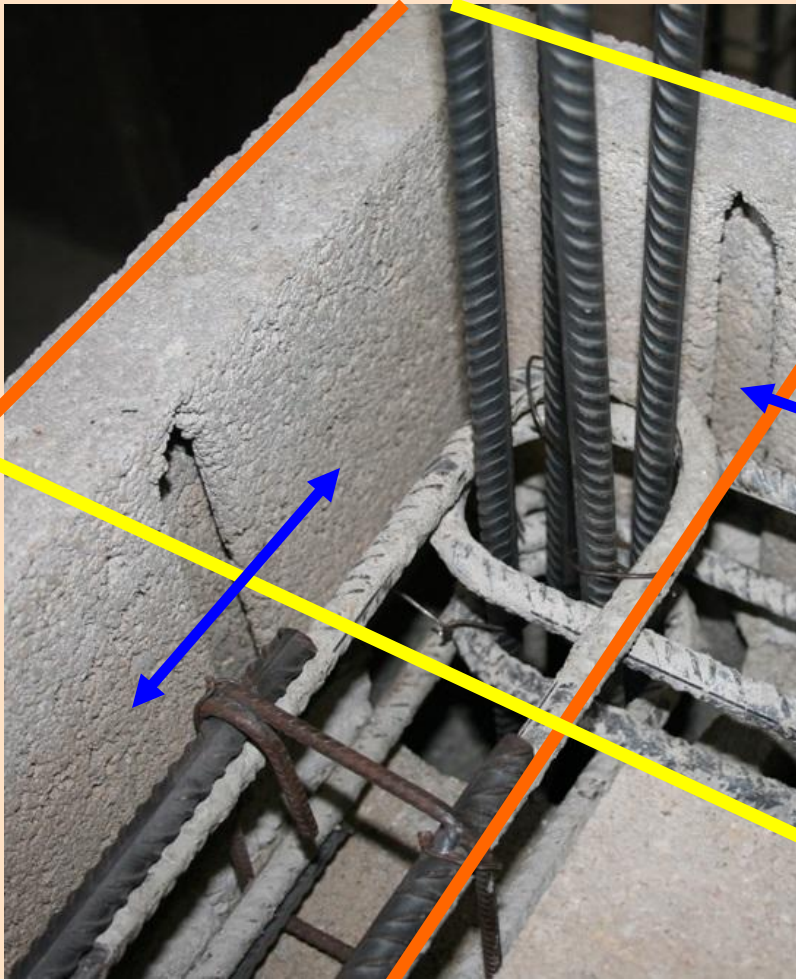


Effondrement des bâtiments - Renforcements



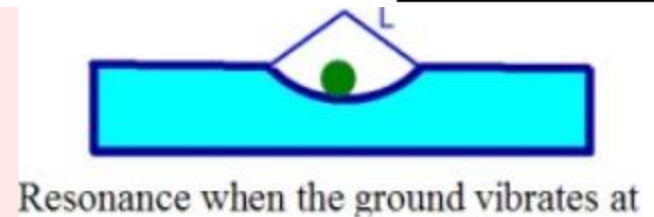
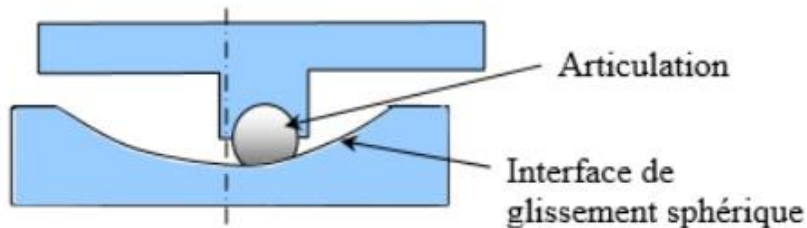
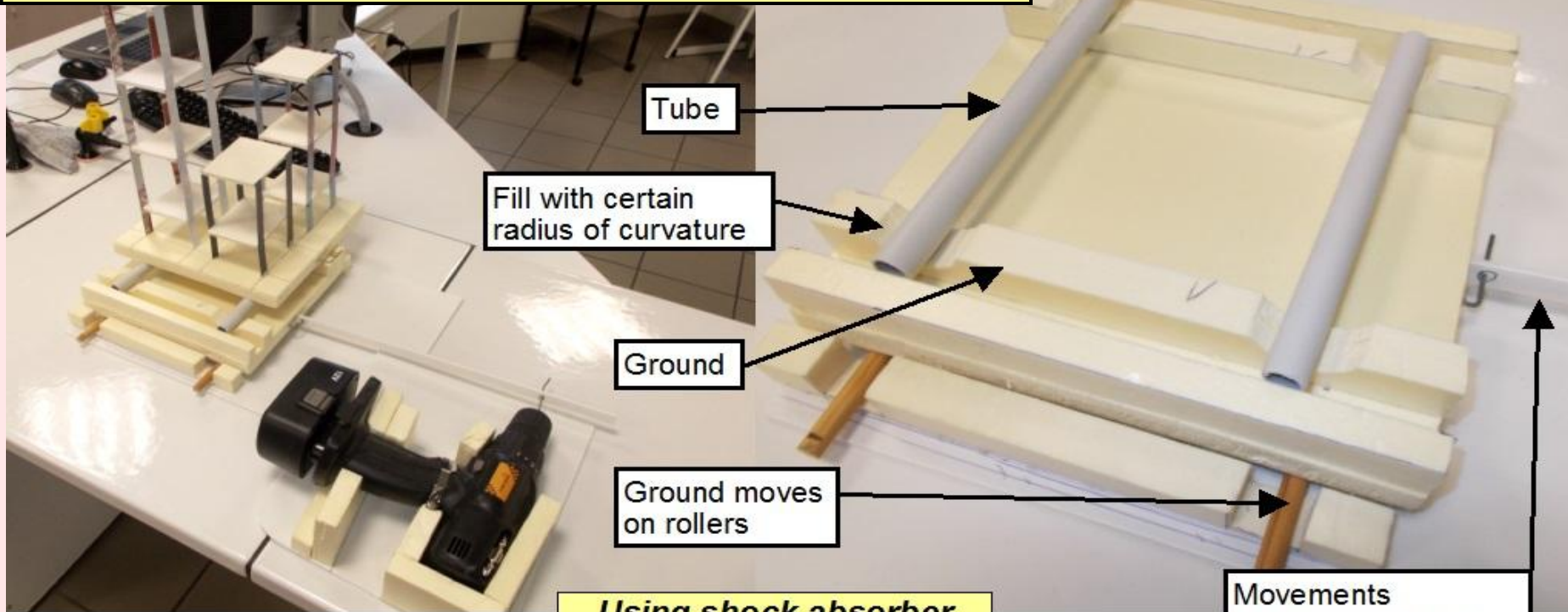
Effondrement des bâtiments - Chaînage

The chaining is a system which prevents the separation of buildings elements, walls and floors.



Effondrement des bâtiments - fondations roulantes

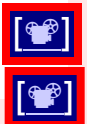
Disconnect buildings from ground with rolling foundations



$$T = 2 \times \pi \times \sqrt{\frac{L}{g}}$$

Denis DAVI CETE Méditerranée (p75)

System resonance



Conséquences des séismes- Liquéfaction du sol



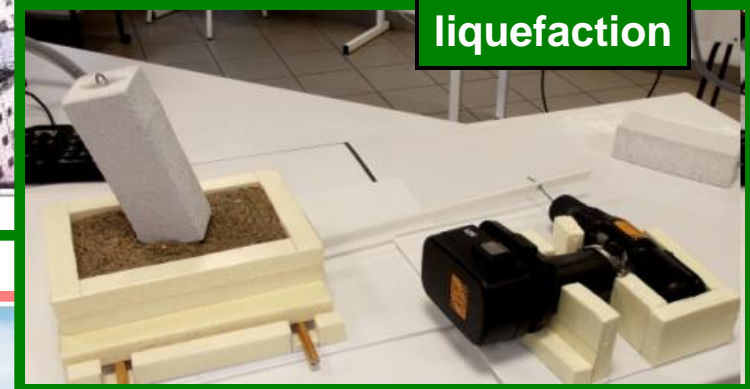
Thomas Picq Valbonne

Resonance



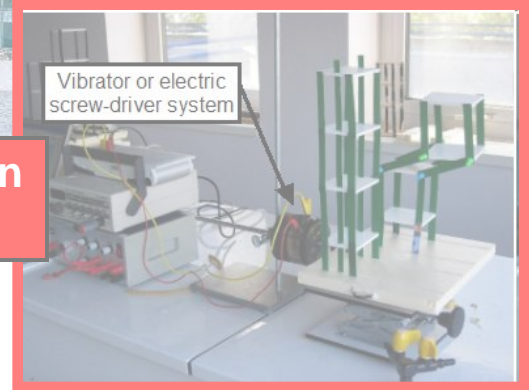
DR Essone

Ground liquefaction



Hugo Bachmann-UFABG-Berno (Swiss, Tokyo)

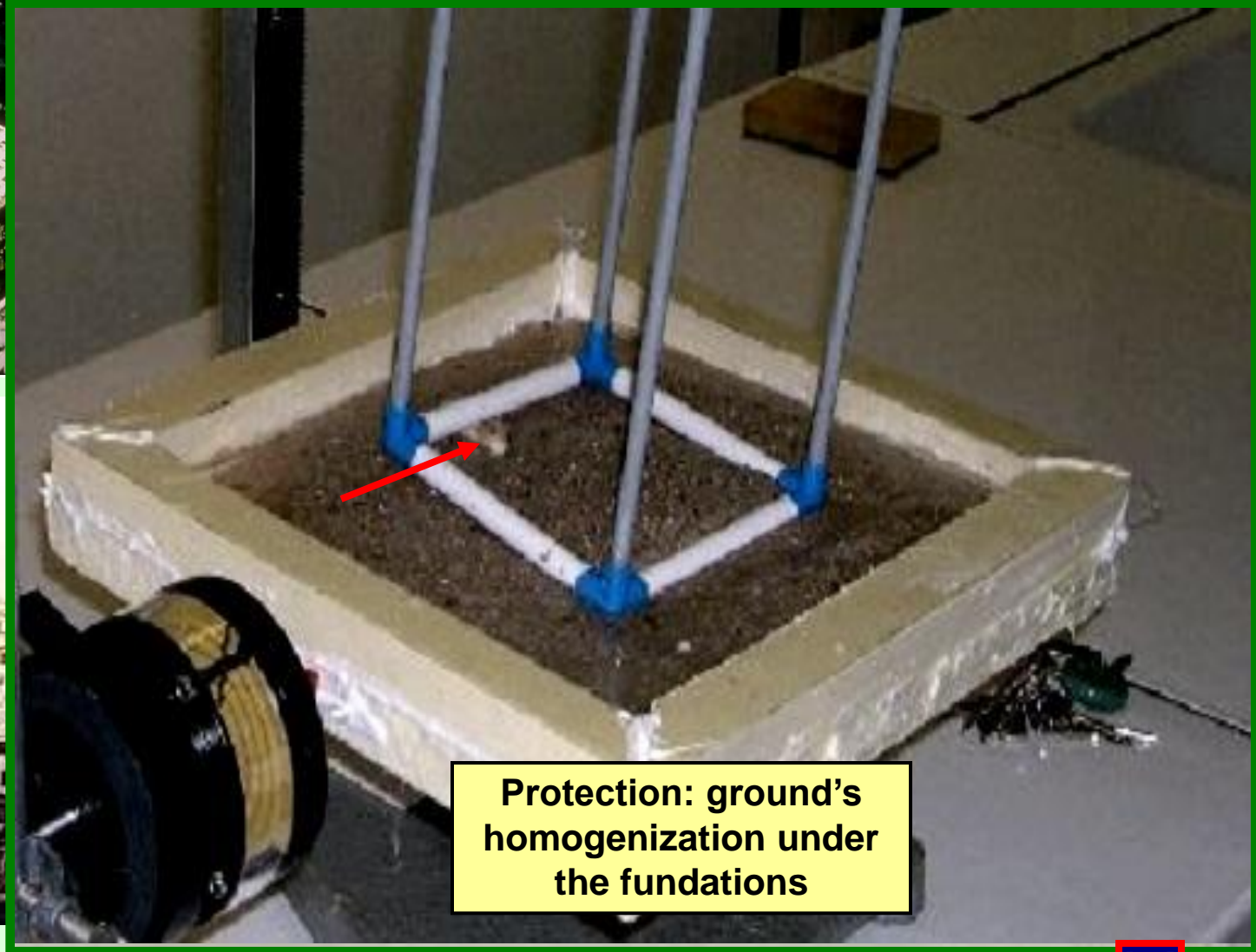
Construction mode



Vibrator or electric screw-driver system



Liquéfaction du sol- Conséquences et solutions



Conséquences des séismes – Effet de site

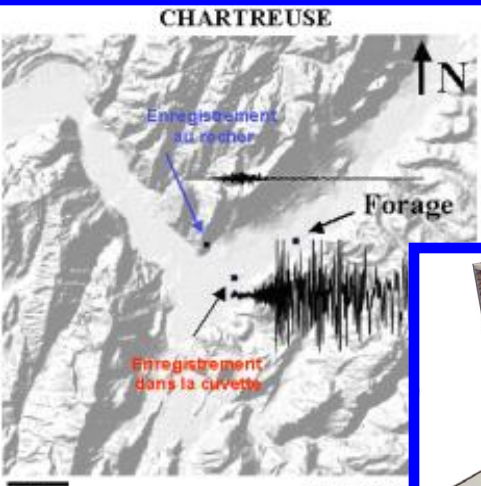
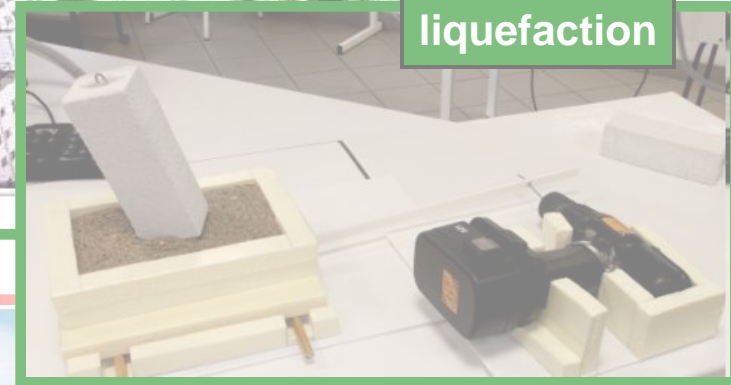


Thomas Picq Valbonne

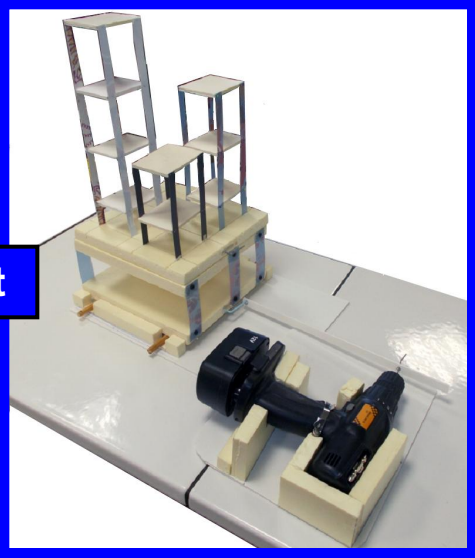
Resonance



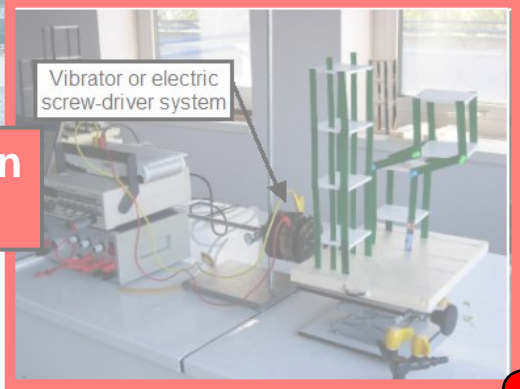
Ground liquefaction



Site effect



Construction mode

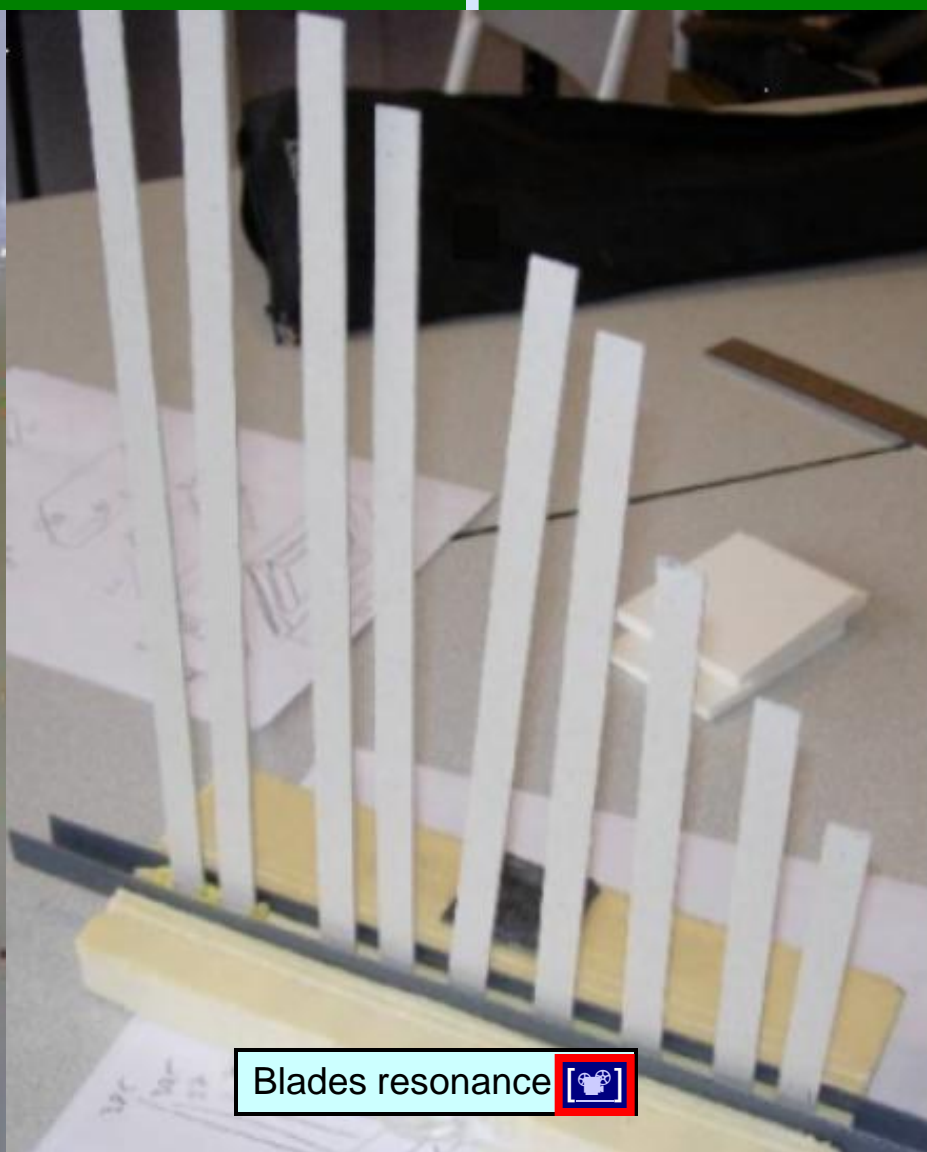


Vibrator or electric screw-driver system



Effet de site- conséquences de 2 fréquences différentes

Low frequency,
big thickness of
alluvions



Blades resonance



High frequency,
small thickness of
alluvions

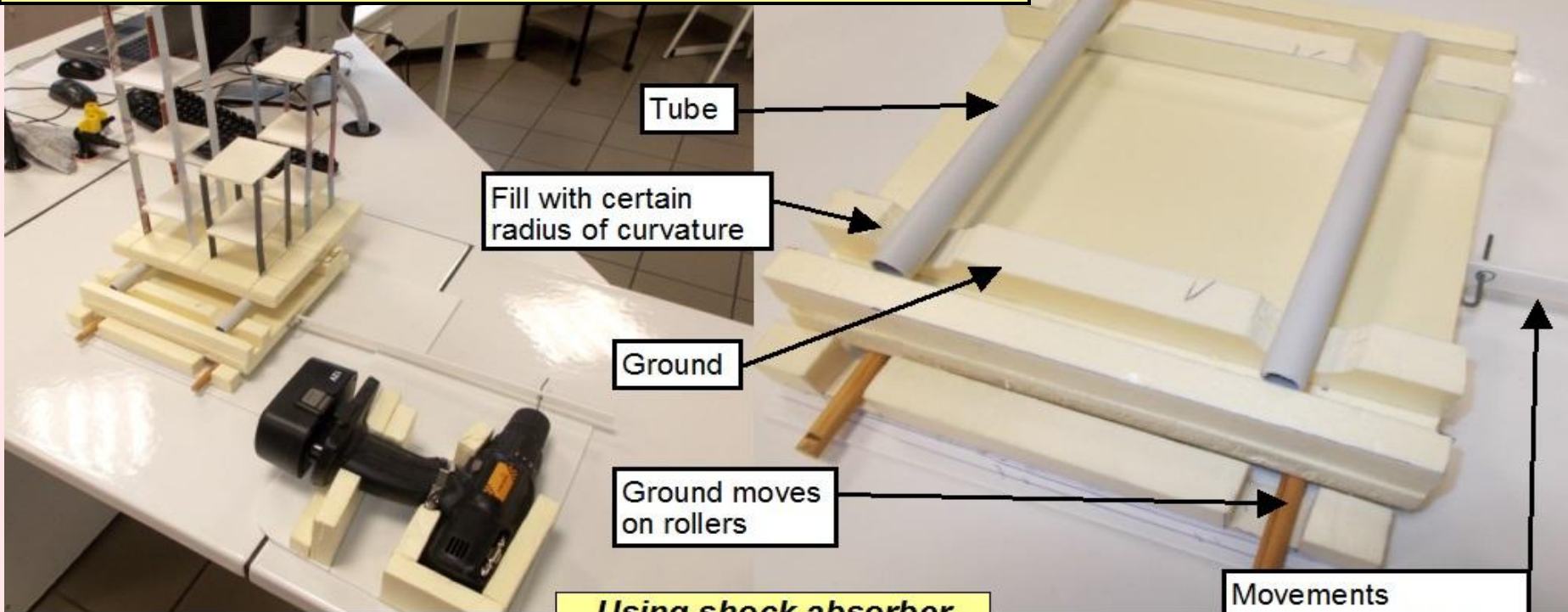


**Resonance frequency and thickness of alluvions:
horizontal vibrations**

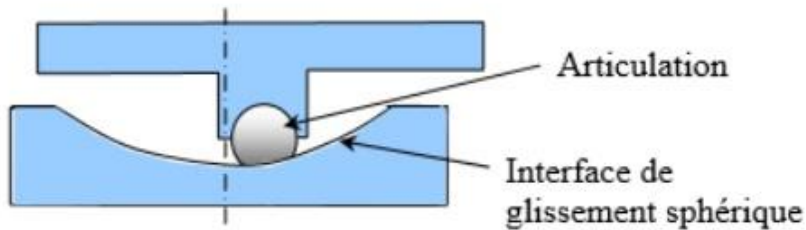


Dommages sur les bâtiments : Fondations roulantes

Disconnect buildings from ground with rolling foundations

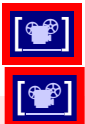


Using shock absorber



Resonance when the ground vibrates at

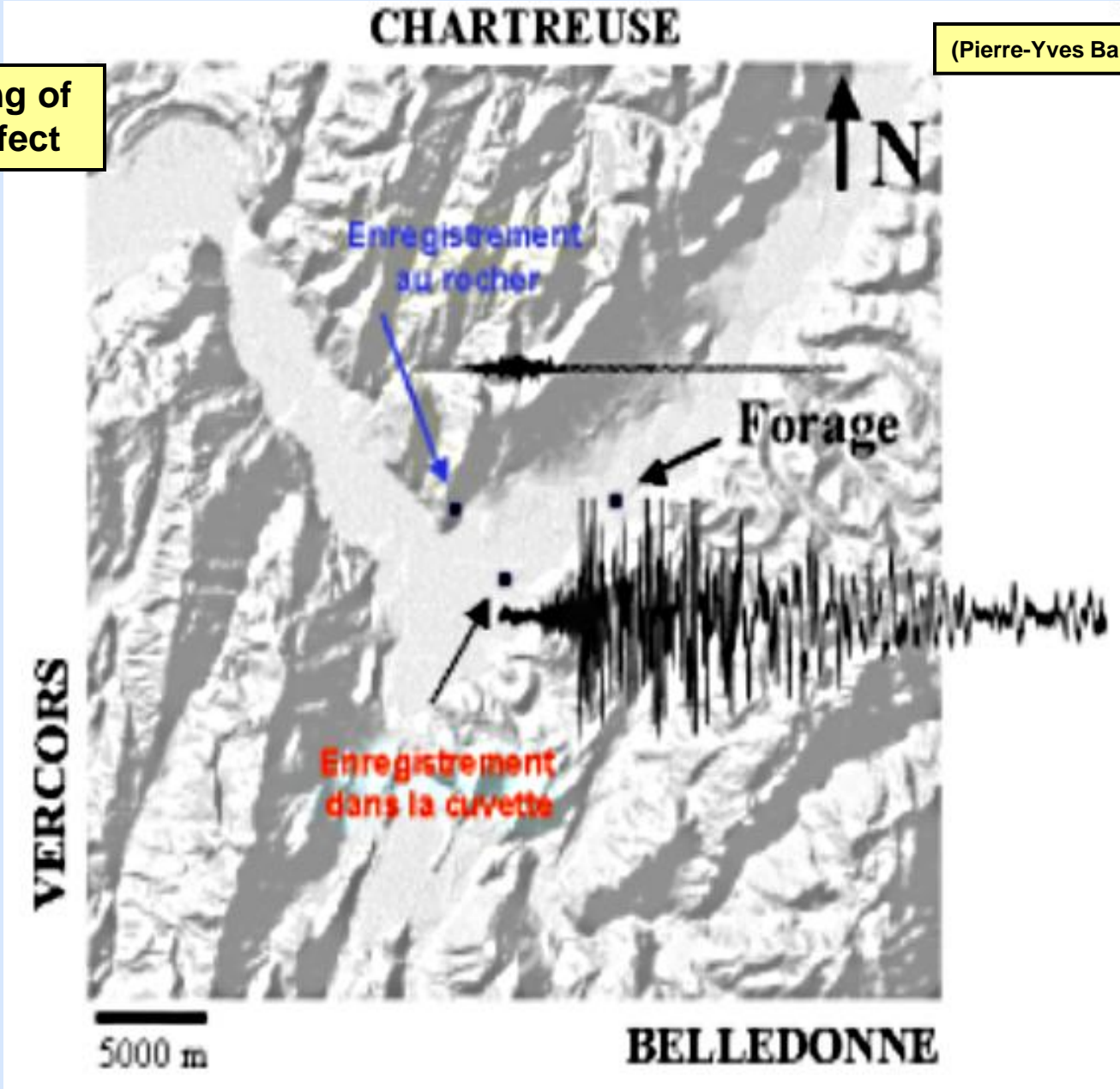
$$T = 2 * \pi \sqrt{L / g}$$



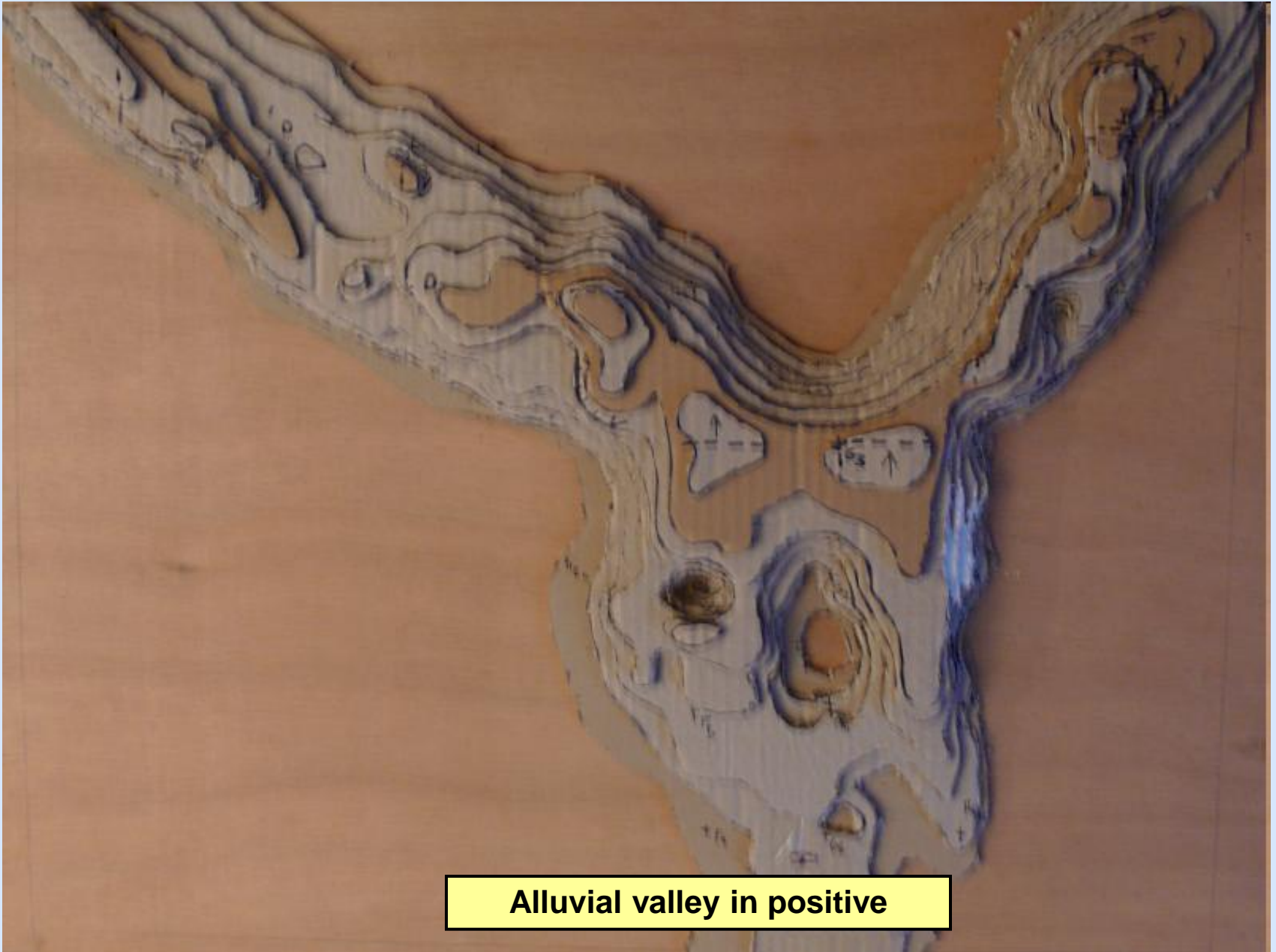
Site effect- Map of Grenoble

Highlighting of the site effect

(Pierre-Yves Bard, ISTERre)



Effet de site- **Modèle en carton**



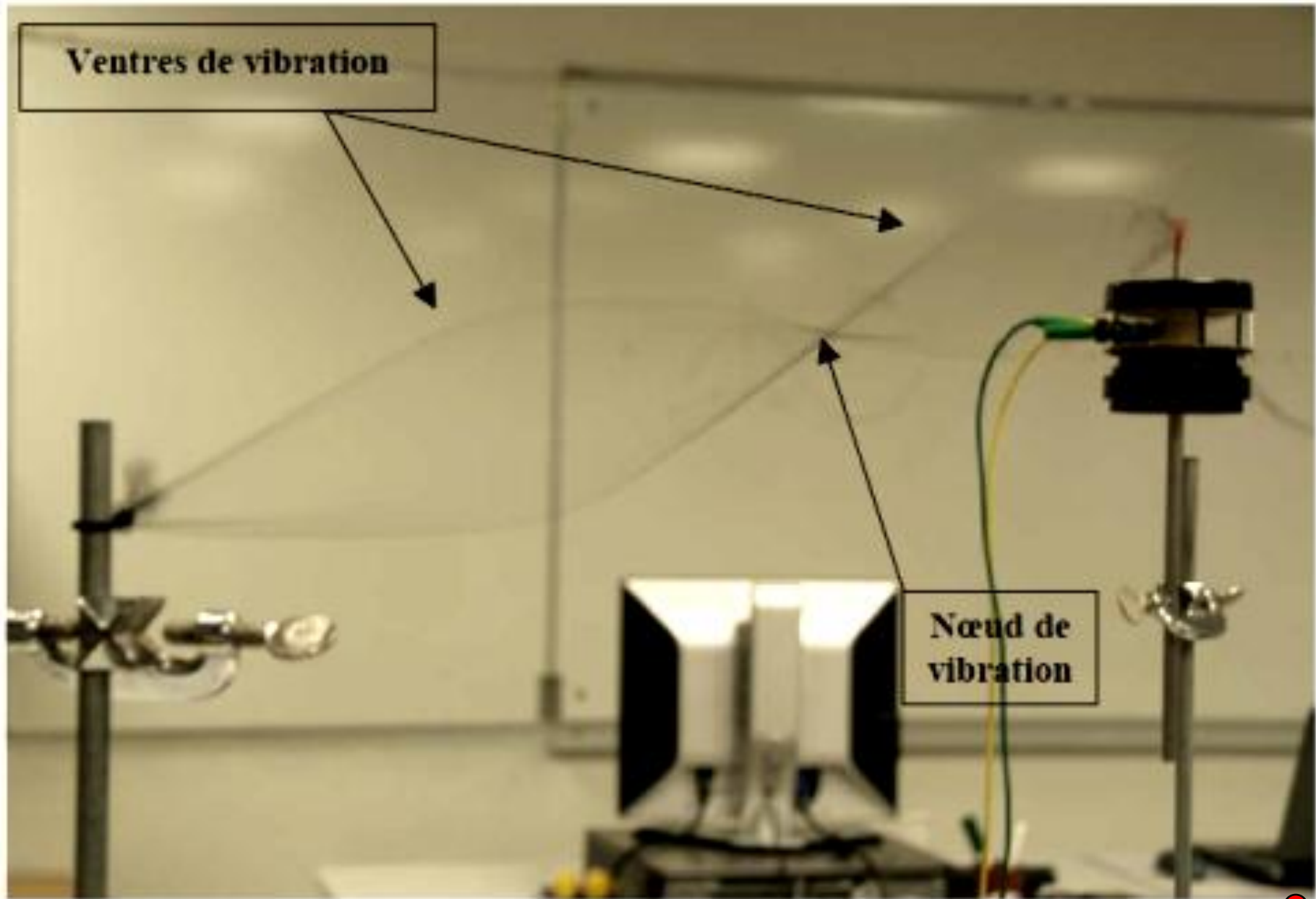
Alluvial valley in positive



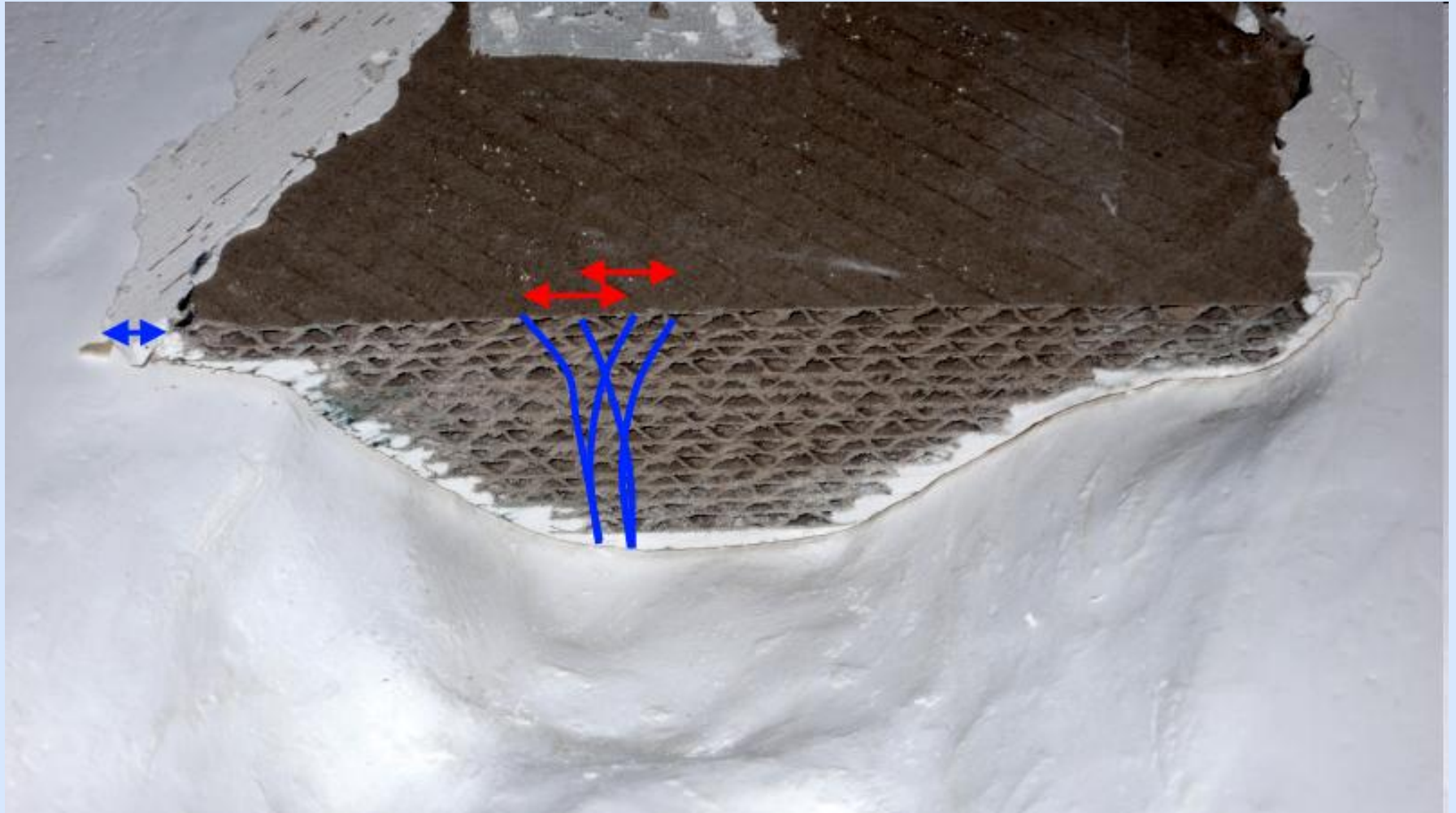
Effet de site – Modèle en résine



Effet de site – Nœuds et ventres de vibrations sur une corde

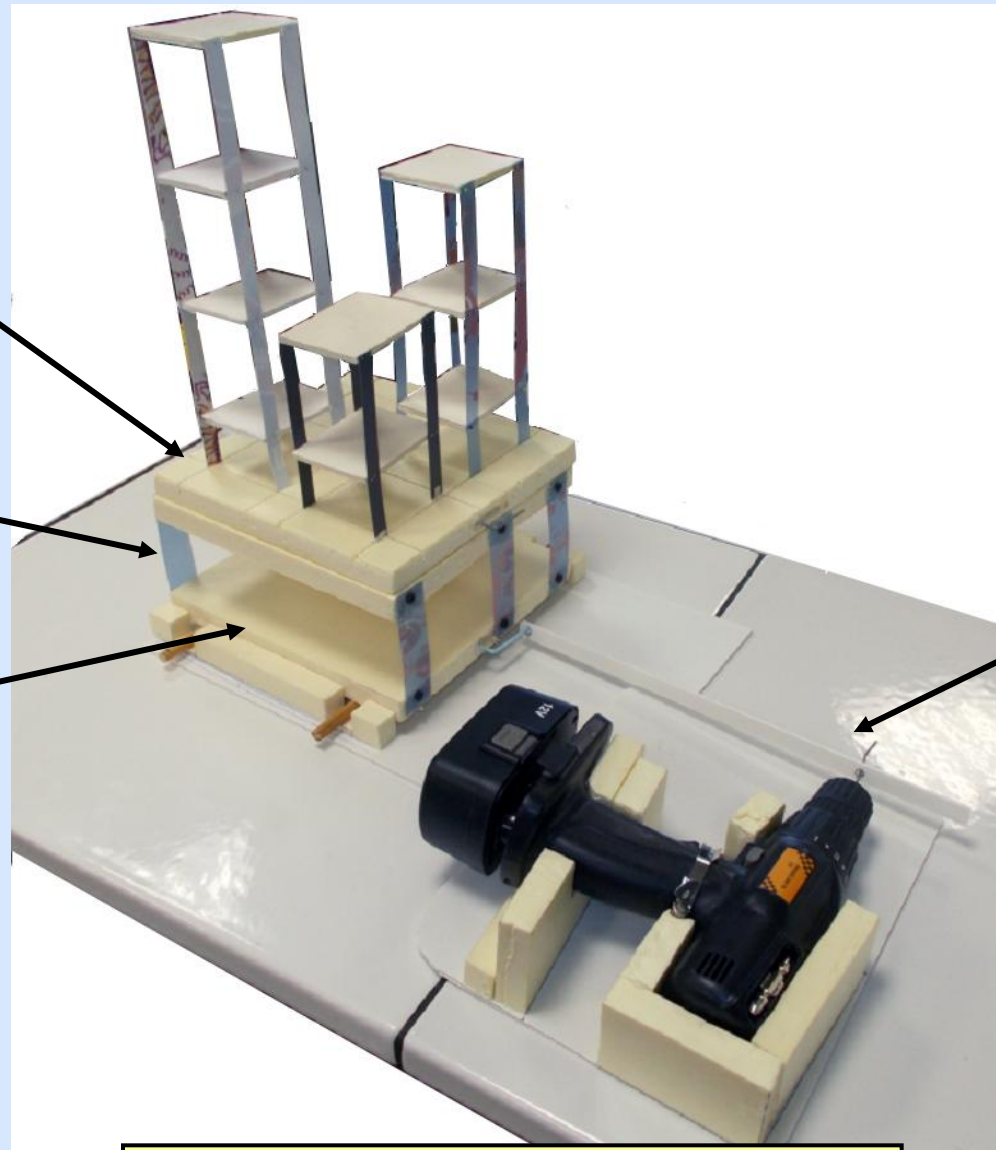


Effet de site - 2 modèles de vibrations



Resonance like blades or rope

Effet de site – *Modèle avec des lames en plastique*



Ground and buildings

Alluviums (plastic blades)

Bedrock

Vibrator with different frequencies

Site effect: alluviums resonance



Équation du risque

occurrence spatiale

conséquences

causes

Risque = Aléa x (enjeux)
(résistance + résilience)

intensité

parasismique

occurrence temporelle

**politiques publiques
comportements**

