Formaterre 2014
Aléas et risques sismiques

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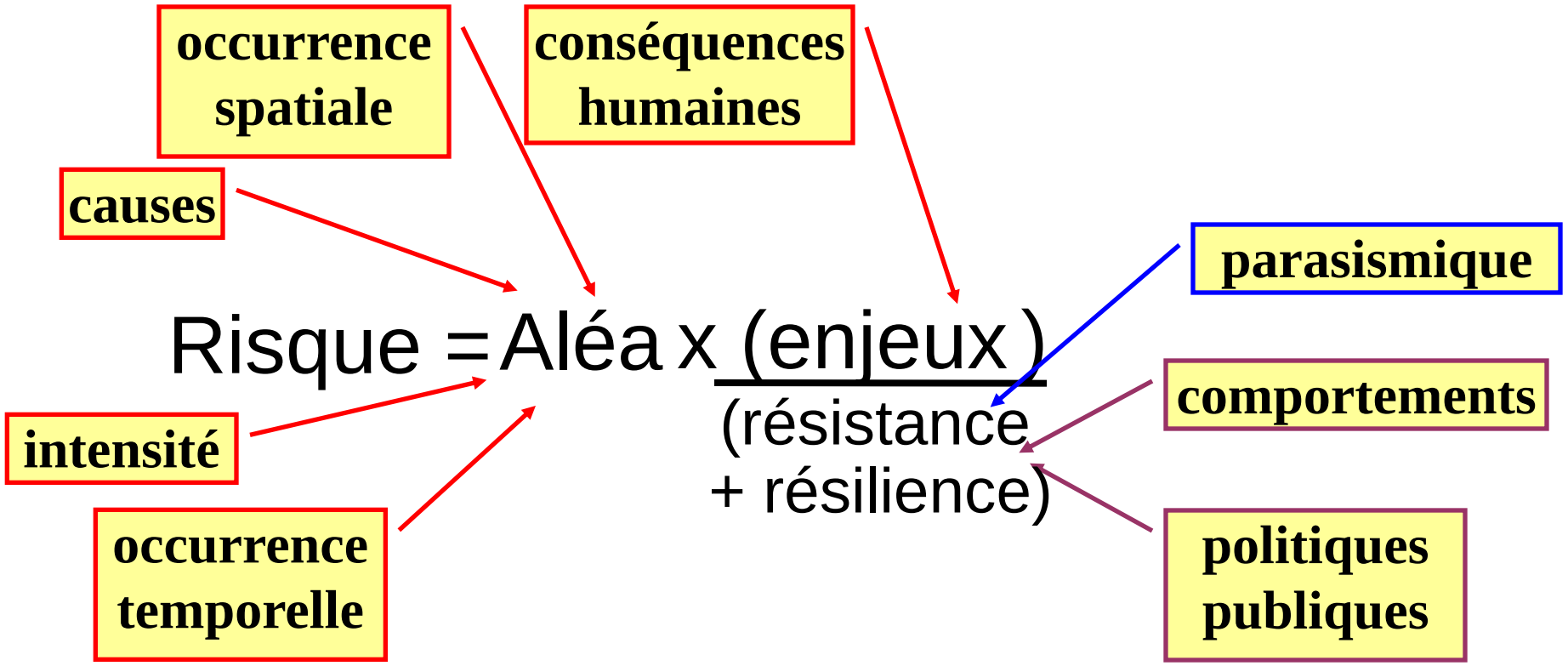
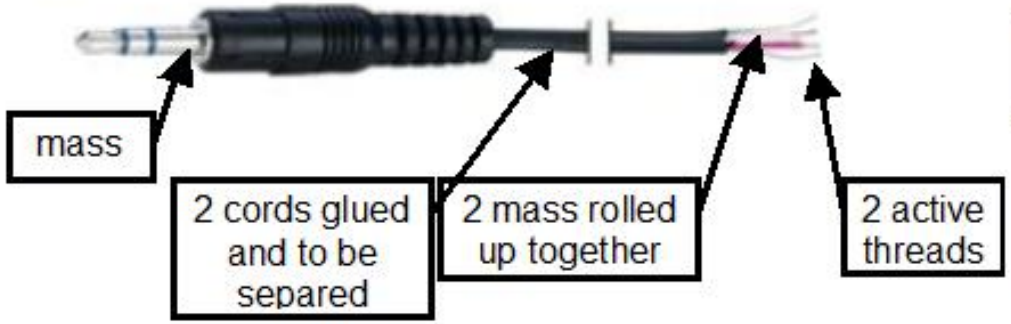
Aléa: *Hasard, événement imprévisible*

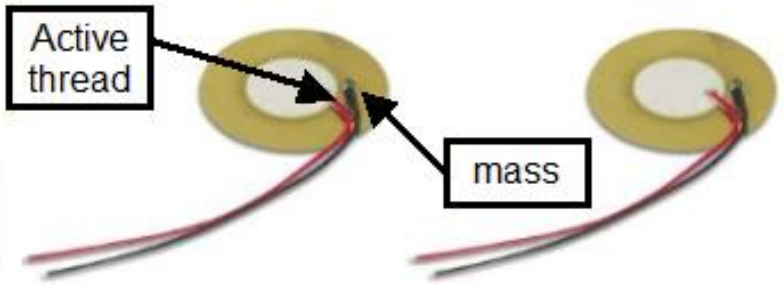
Risque: *Danger plus ou moins probable*

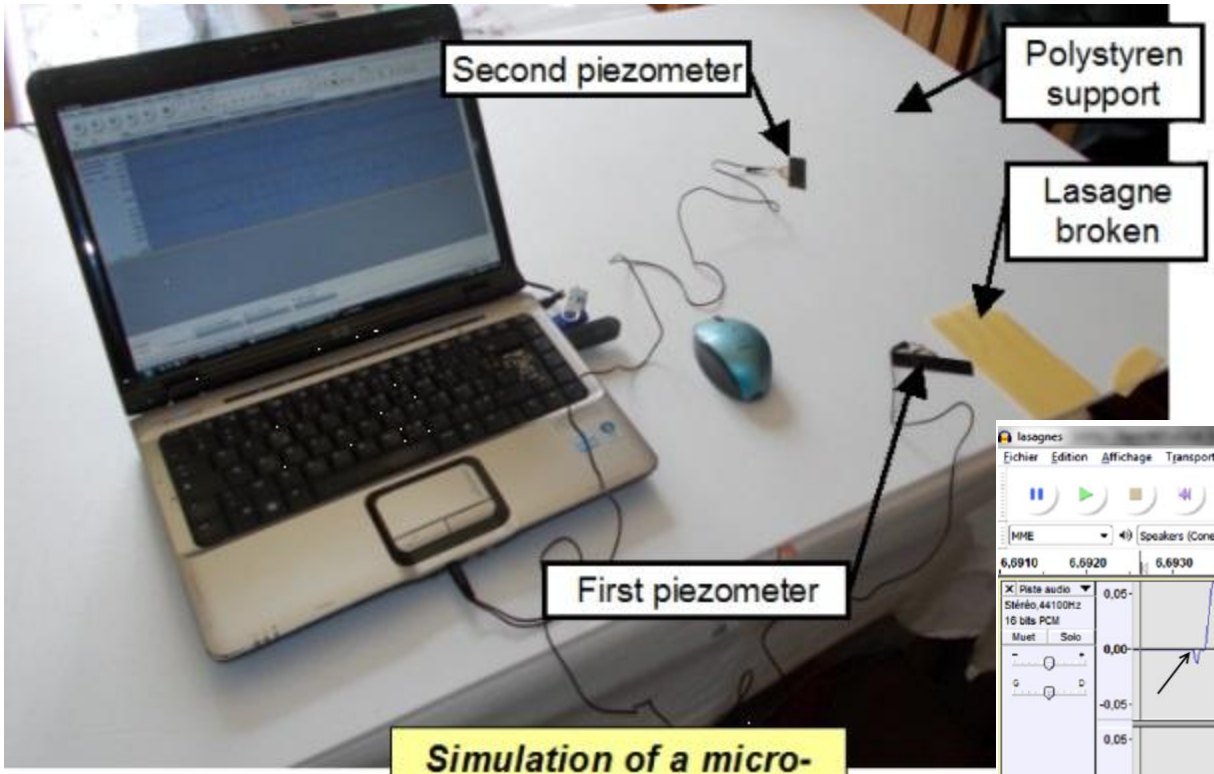


Causes

Sismomètre avec piézomètres

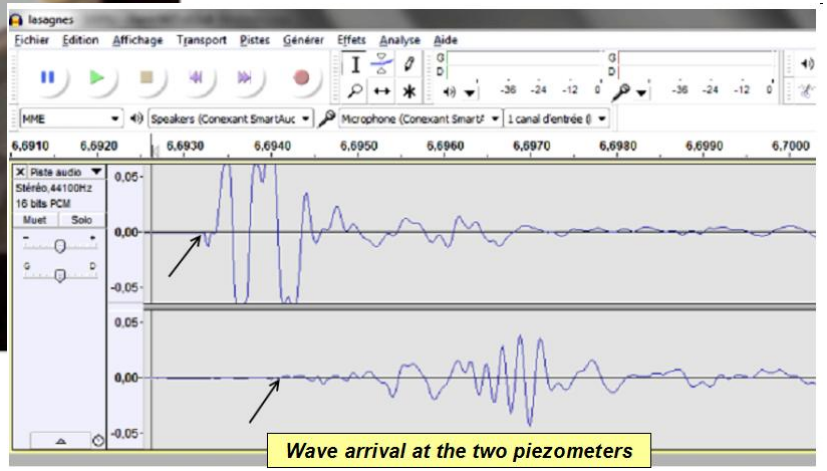






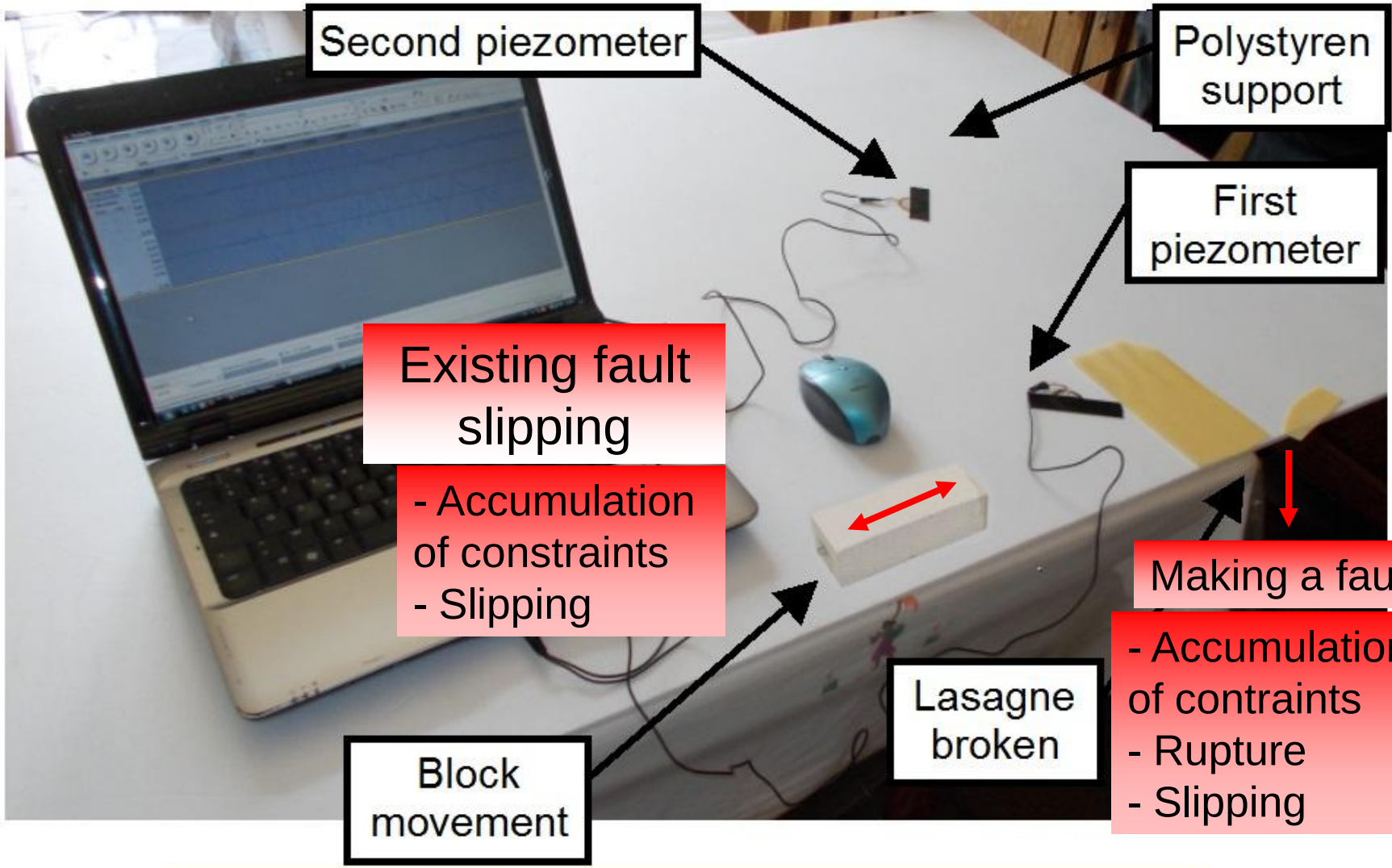
Simulation of a micro-earthquake

Carte son externe



Wave arrival at the two piezometers

Origine des séismes



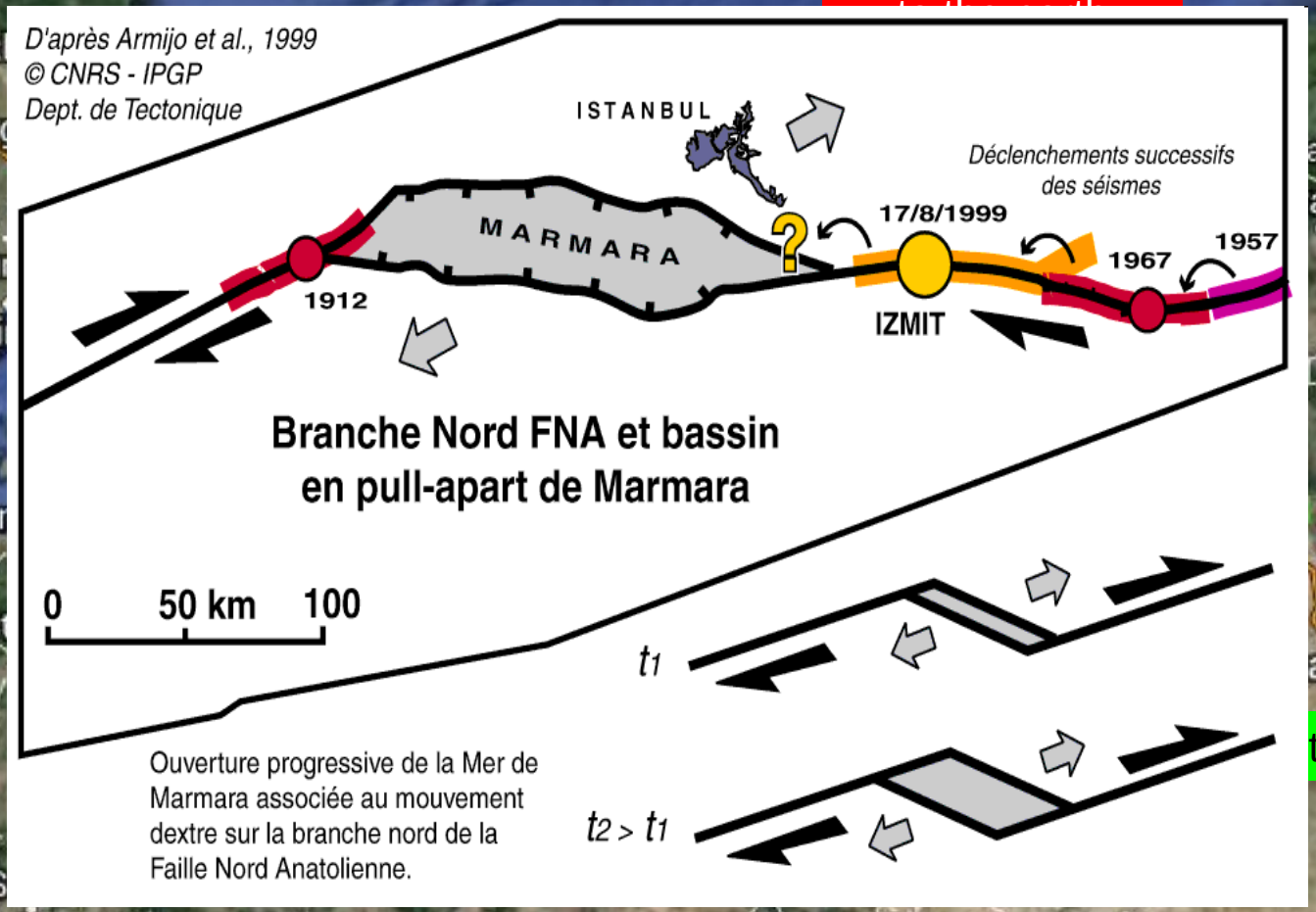
Simulation of a micro-earthquake

Accumulation de contraintes- Exercice avec GPS

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

[Google Earth]

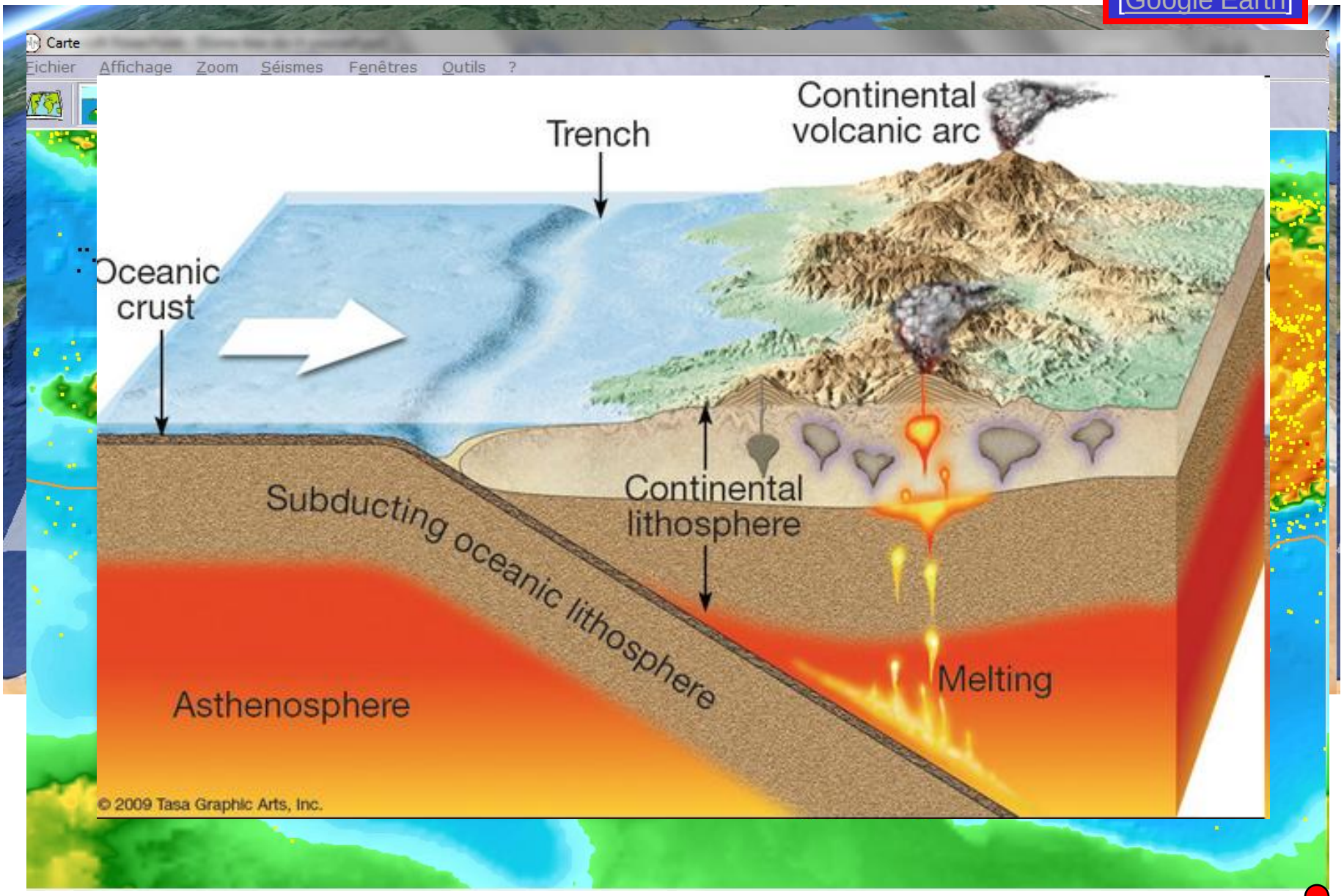
Same movement



t to the East

Accumulation of constraints- Local exercice with GPS

[Google Earth]

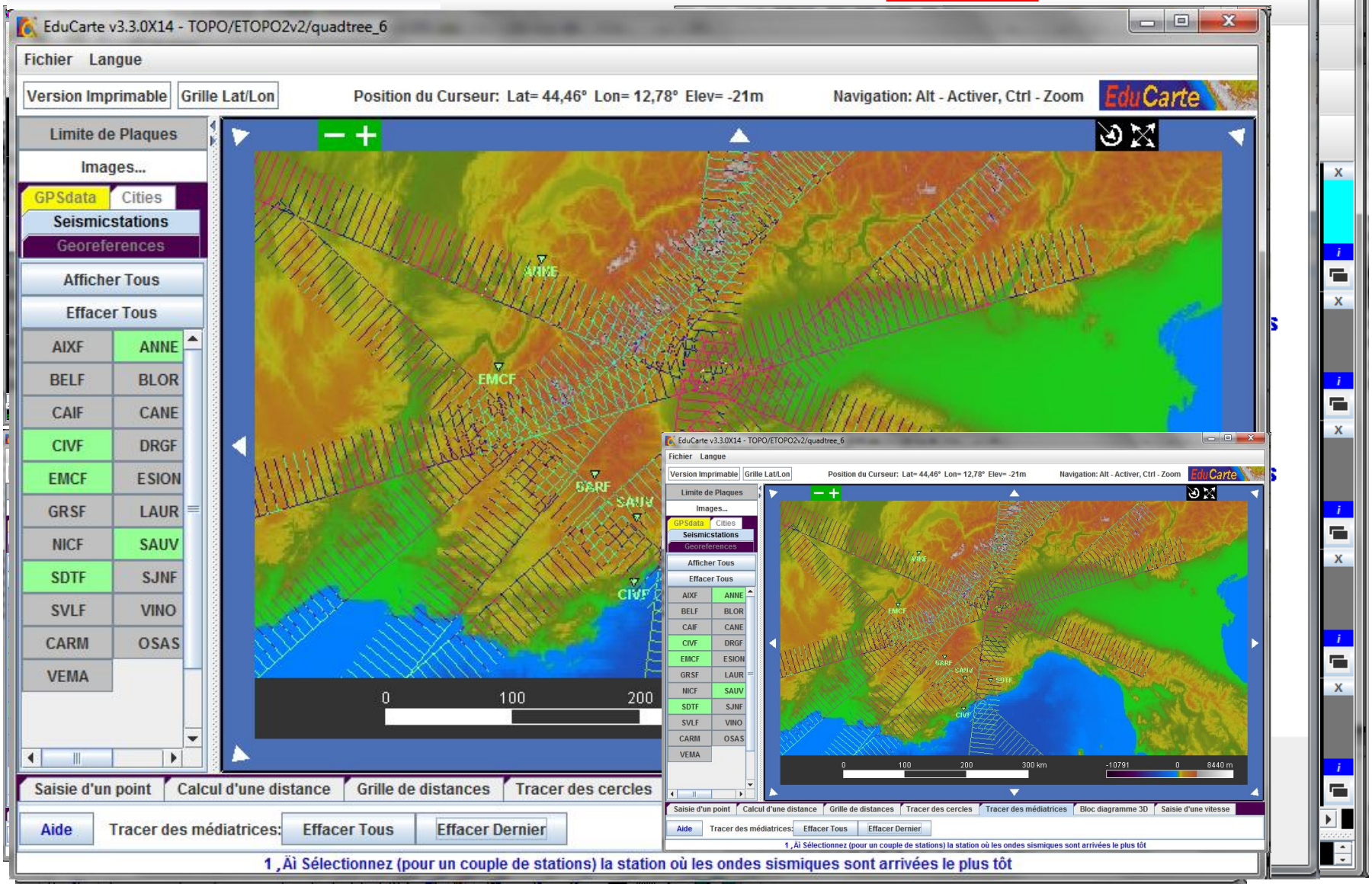


Occurrence spatiale

Localisation d'un séisme proche

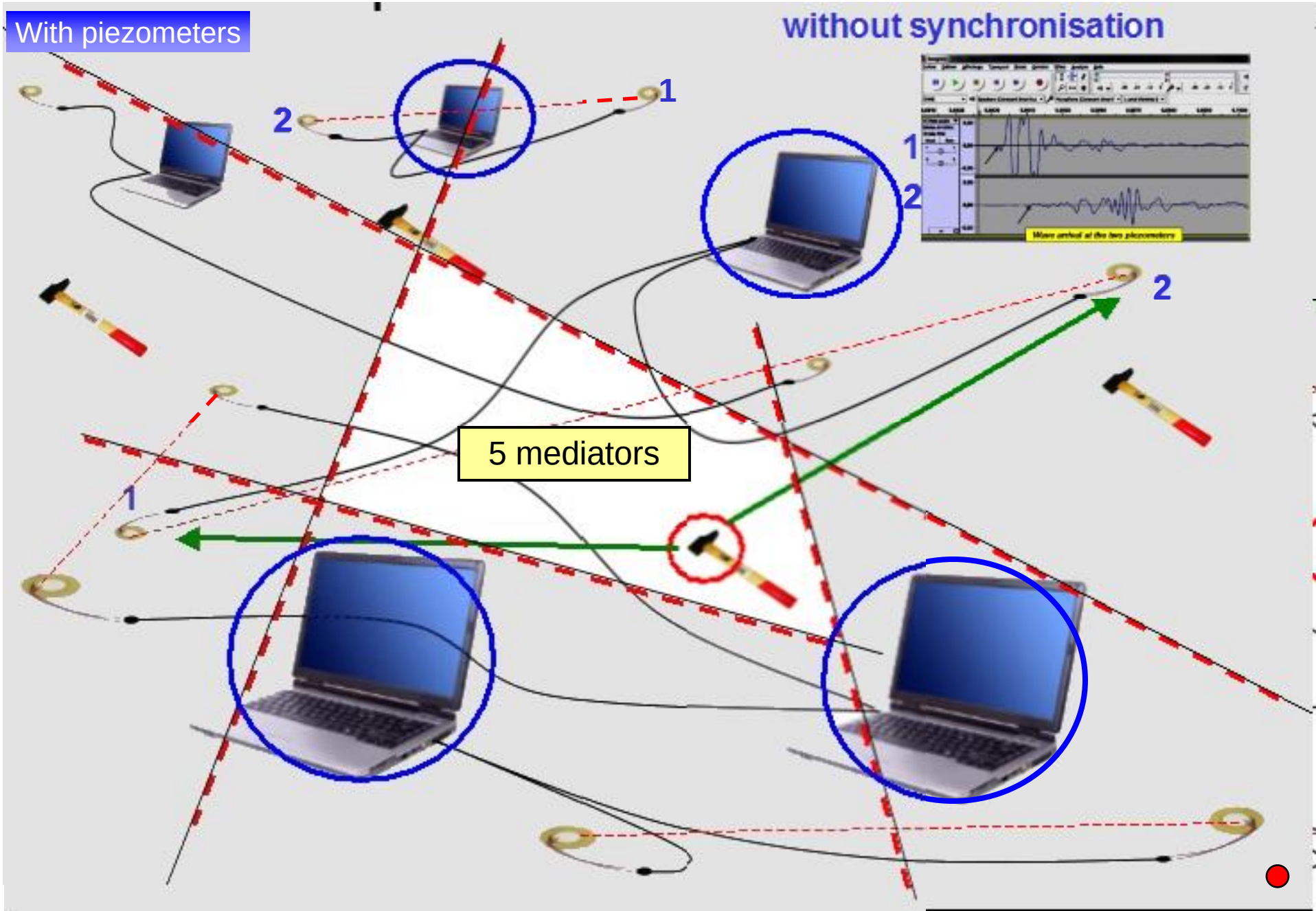
With Seisgram software | Read earthquakes, Select P & S waves | [Seisgram] | Distance

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



Localisation d'un séisme en classe

Localisation d'un séisme en classe

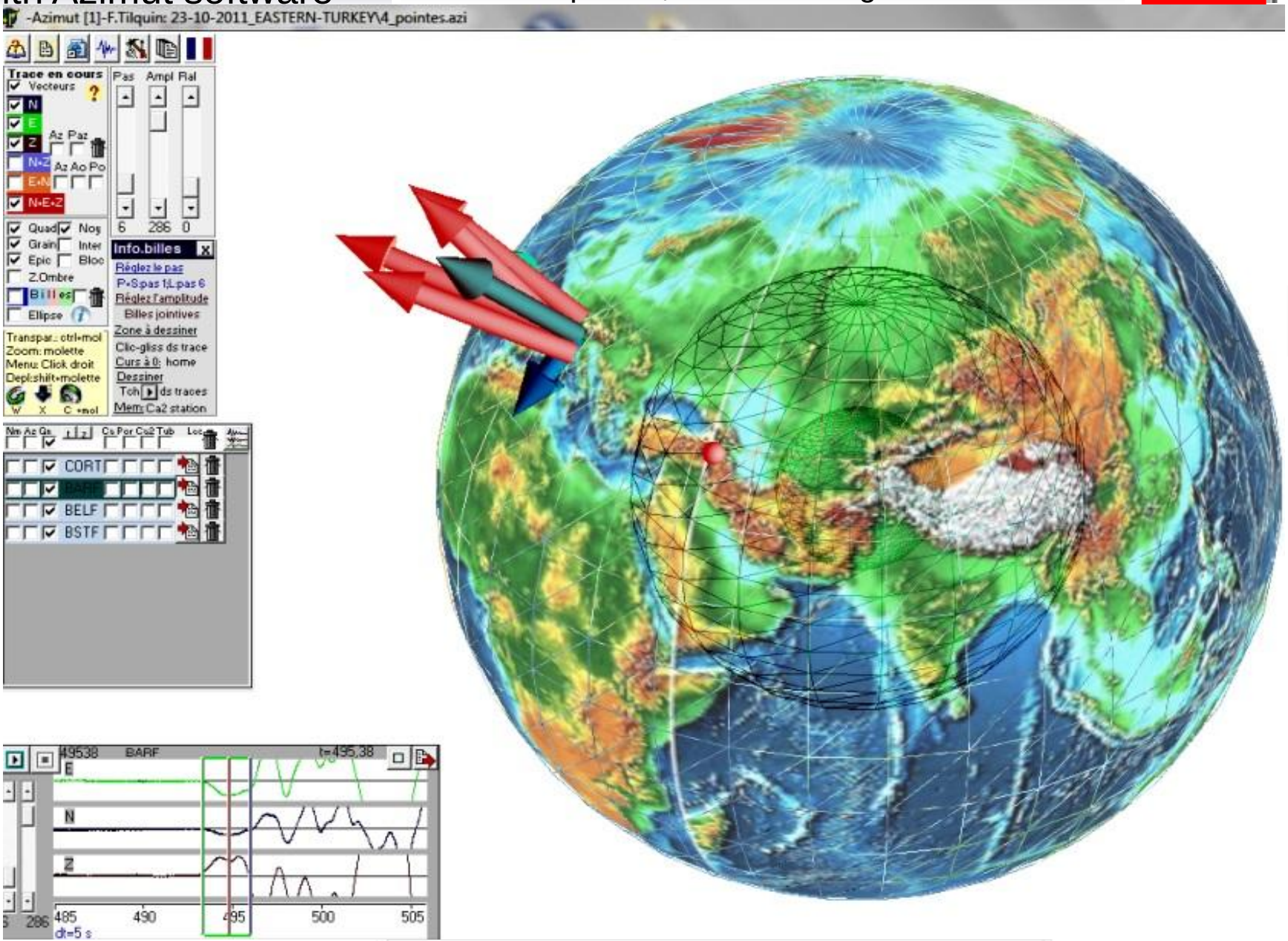


Localisation d’un télé-séisme

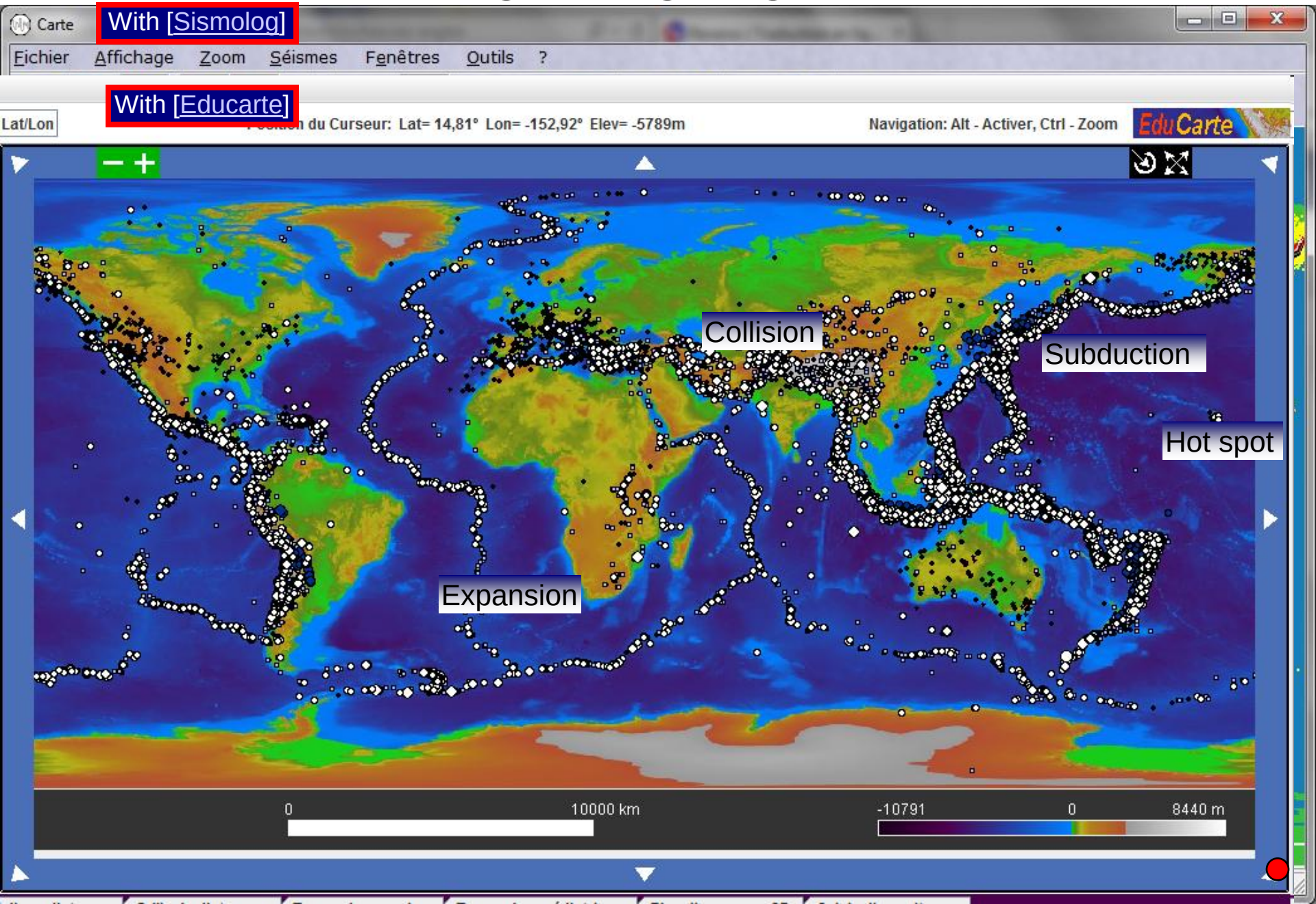
With Azimut software

Read earthquakes, draw the 3D ground movement

[Azimut]

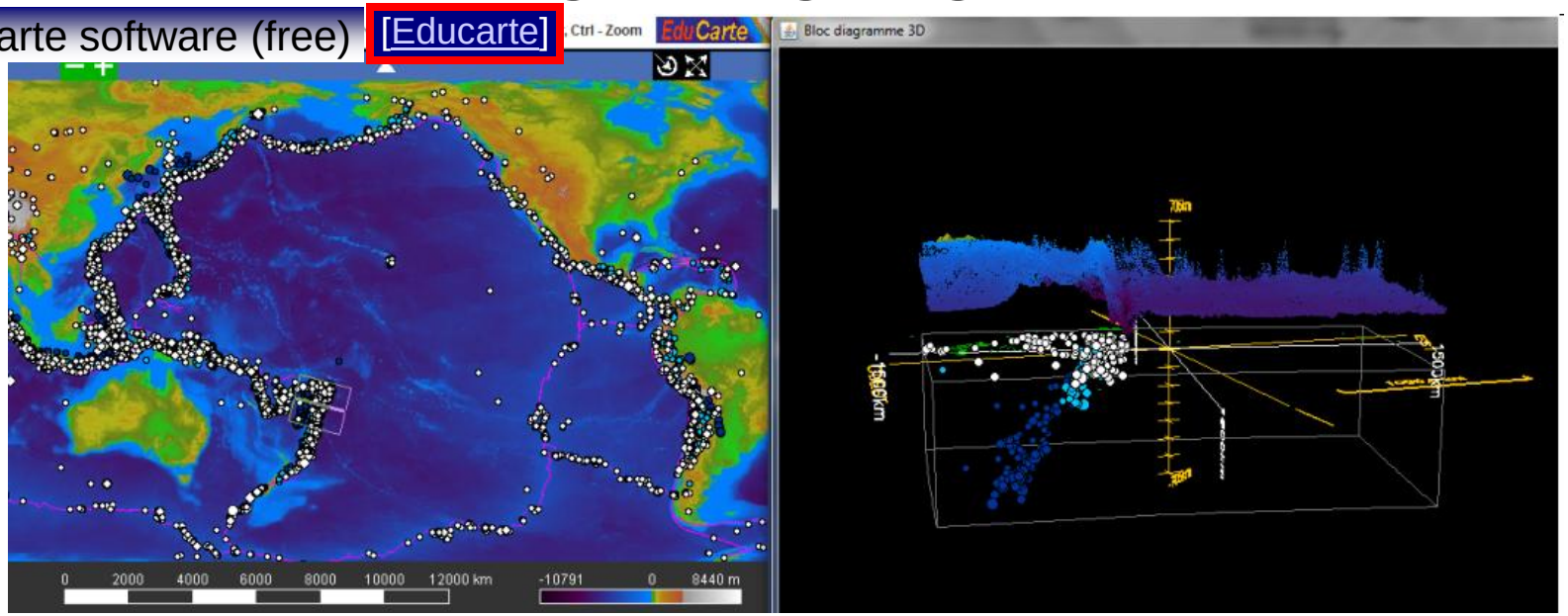


Séismes et géologie globale- distribution

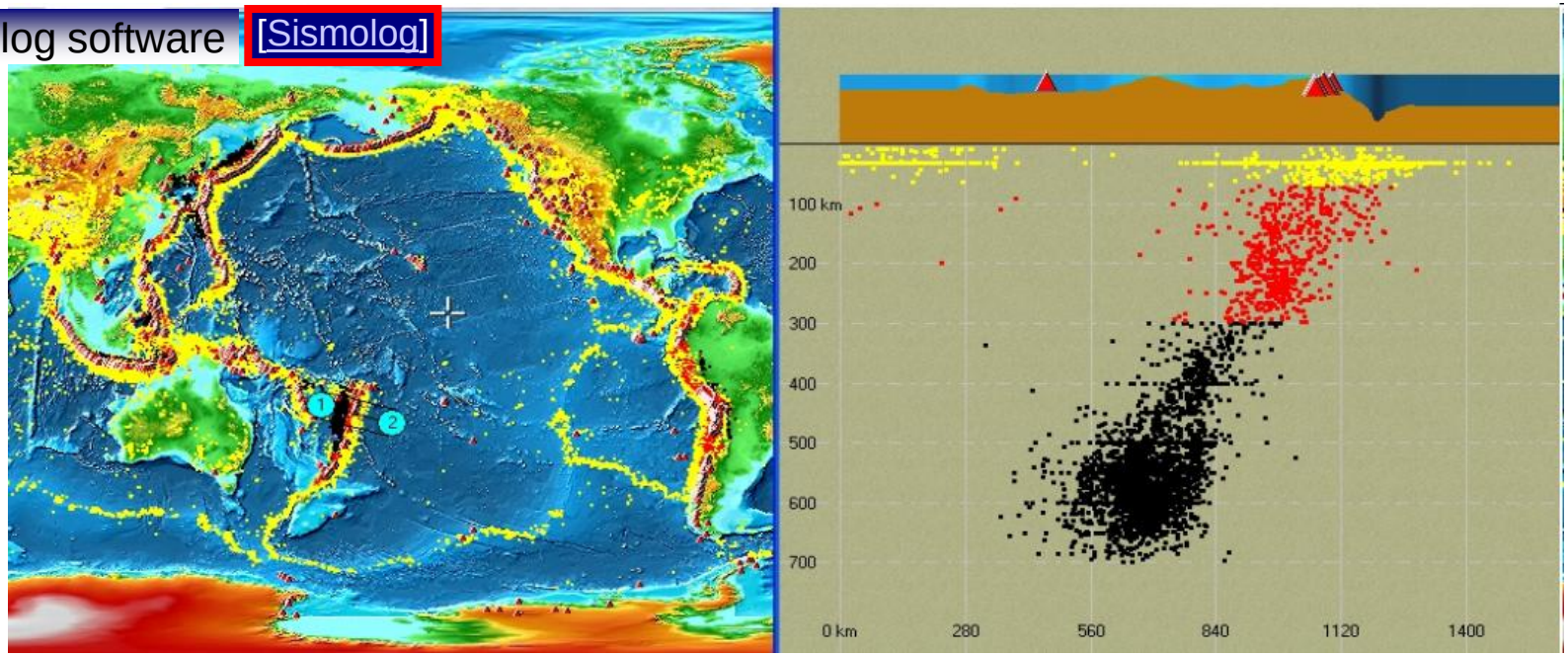


Séismes et géologie globale - cuttings

Educarte software (free) [Educarte]



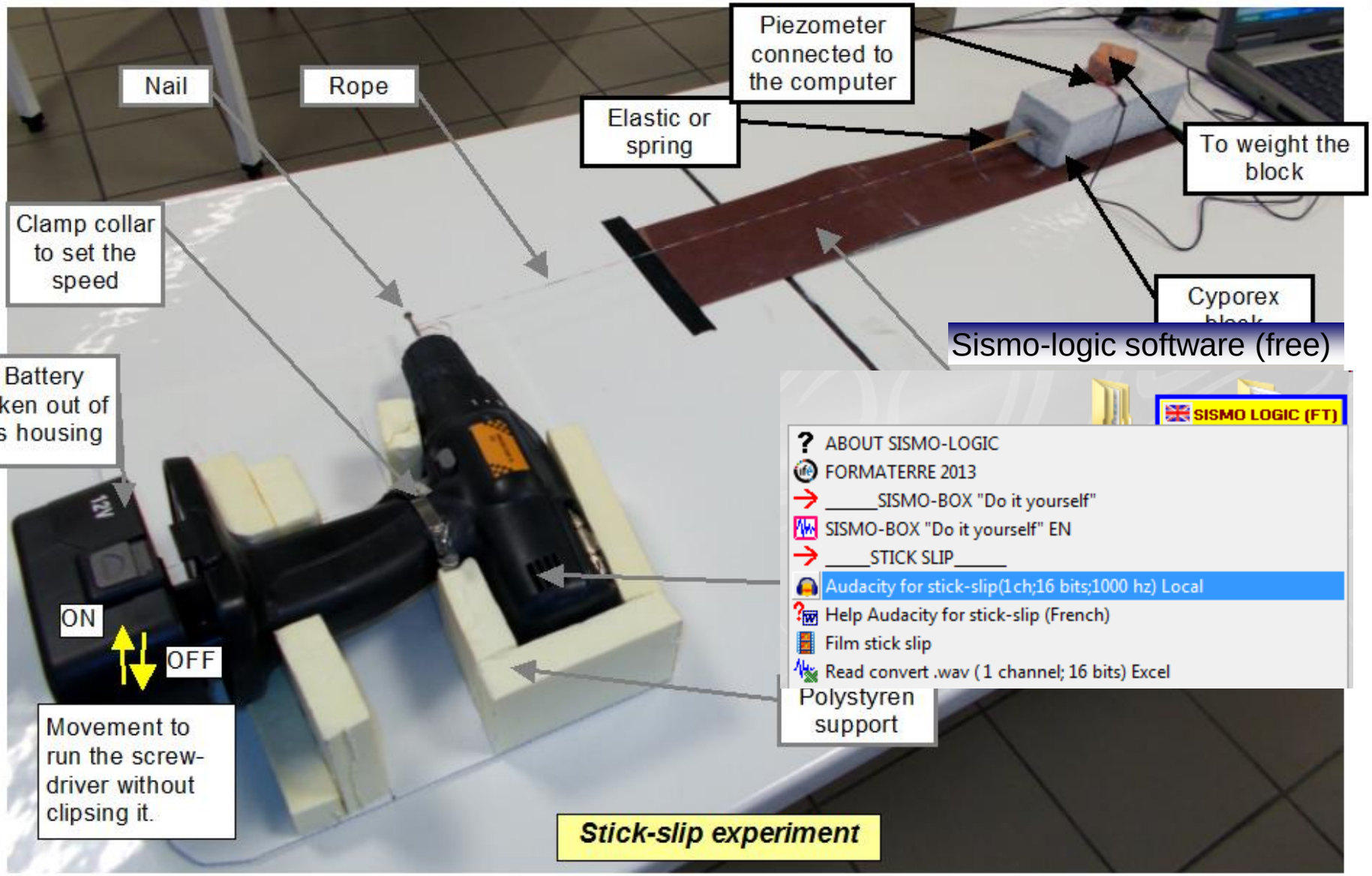
Sismolog software [Sismolog]



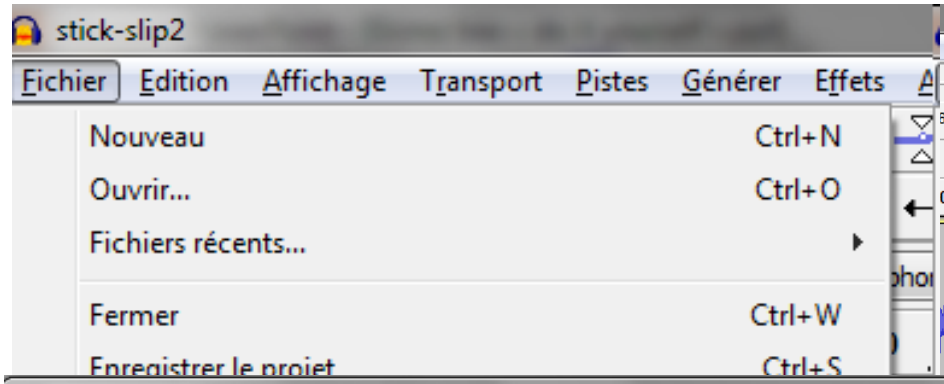
Occurrence temporelle

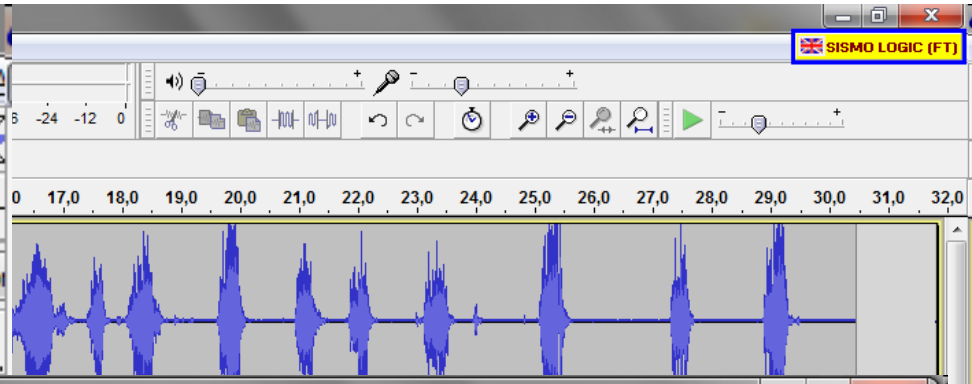
Prédiction des séismes ?

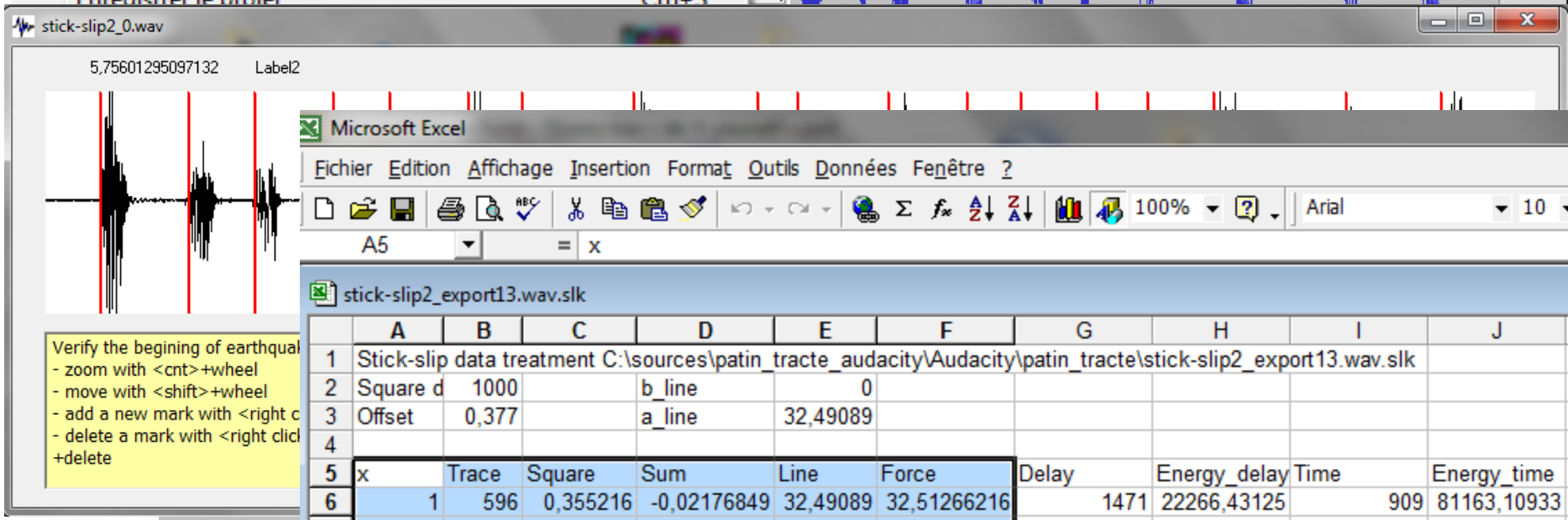
Protocole



Prédiction des séismes ? Logiciels







Microsoft Excel

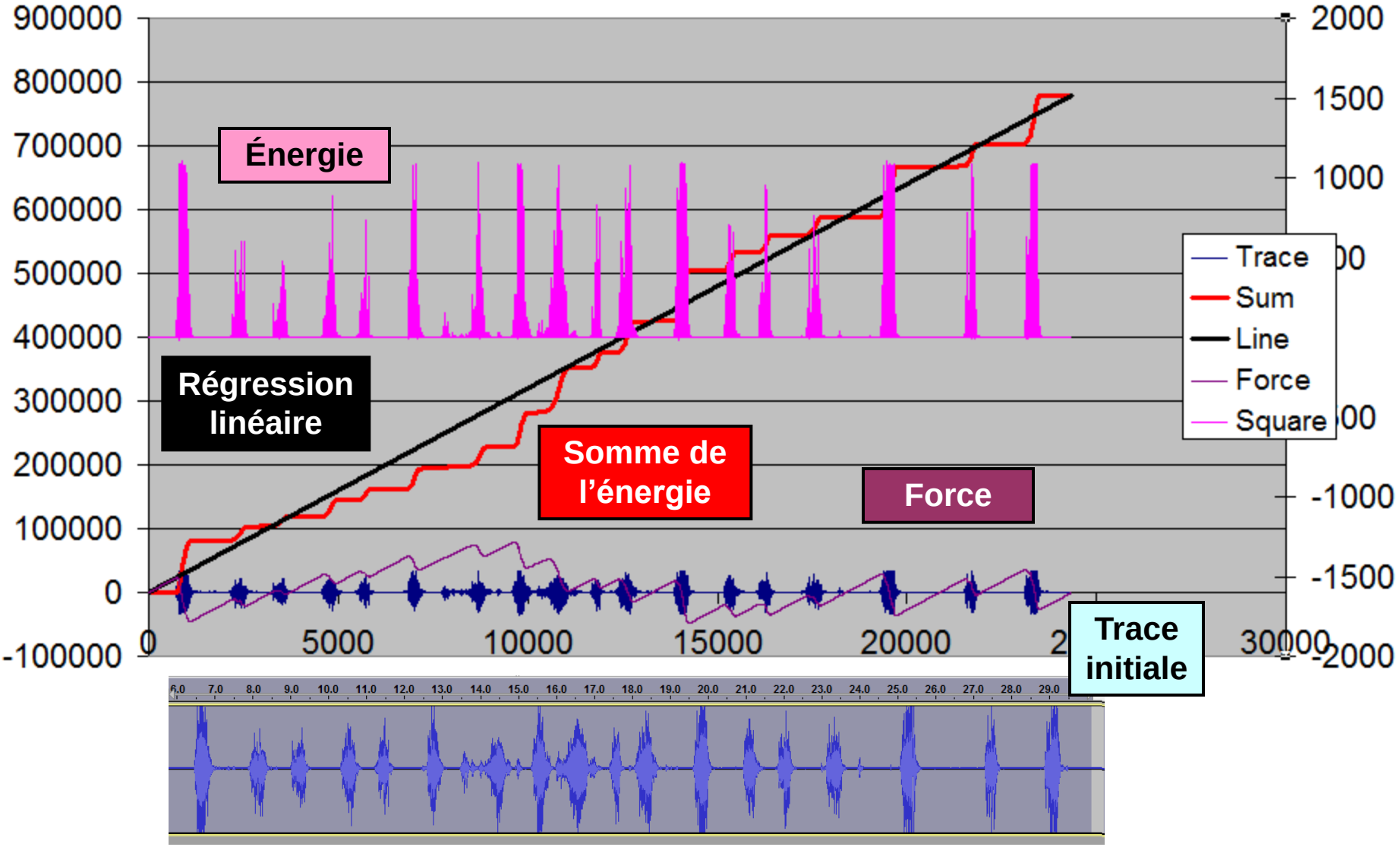
Fichier Edition Affichage Insertion Format Outils Données Fenêtre ?

A5 = x

stick-slip2_export13.wav.slk

	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

Résultats du patin tracté- Traitement



Résultats du patin tracté - Equilibre

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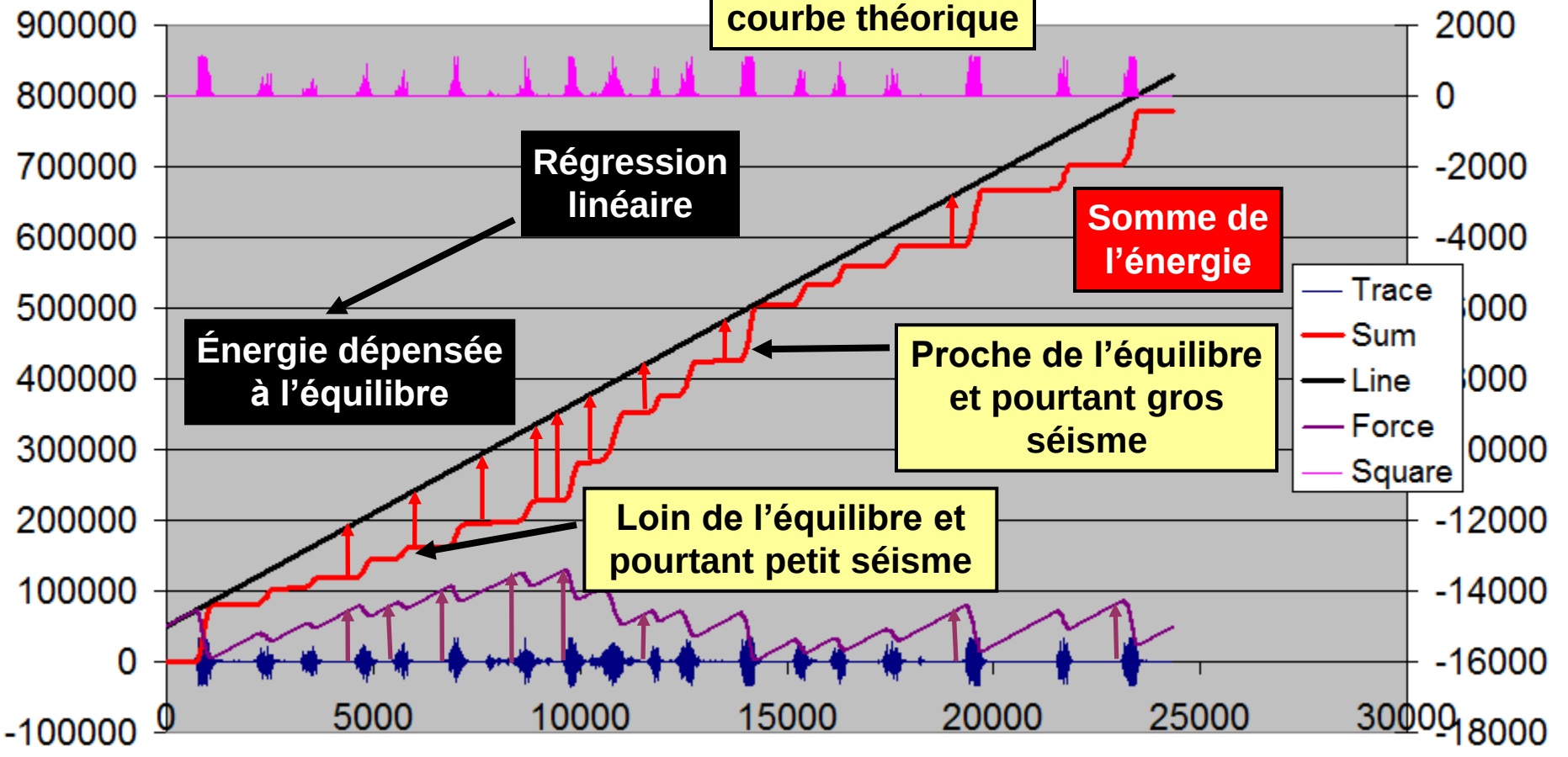
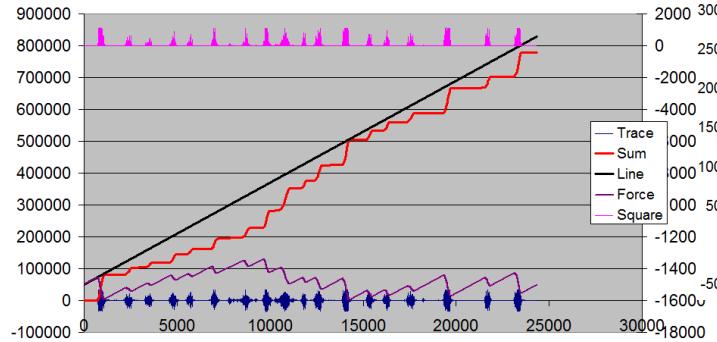
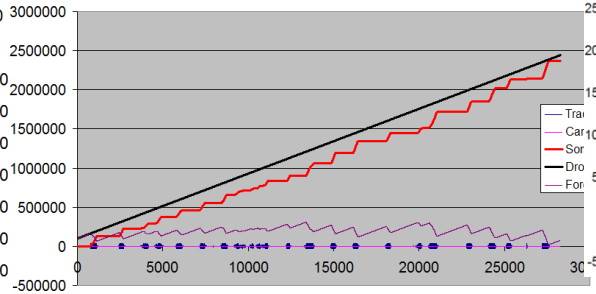
3	Offset	0,001		a_line	32			

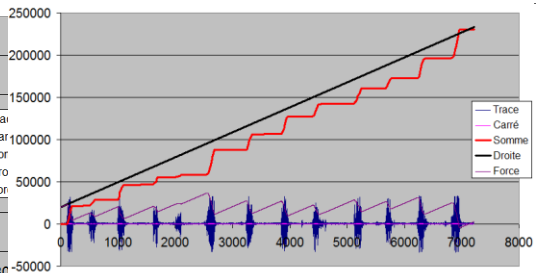


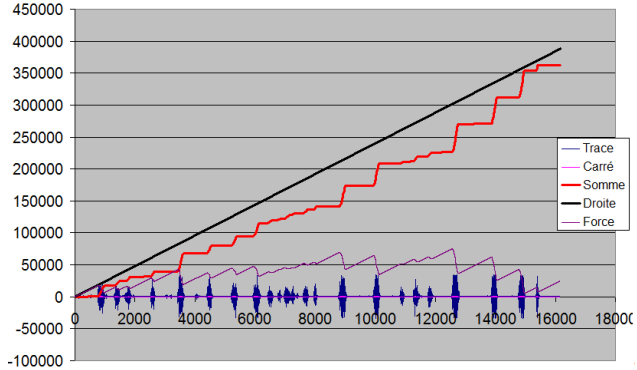
Il n'est pas possible de prévoir la magnitude

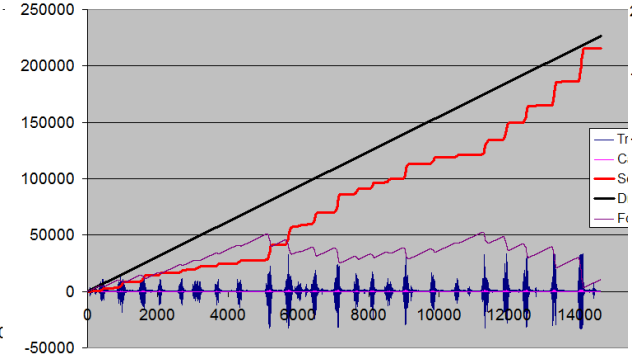
Résultats du patin tracté - Différents résultats

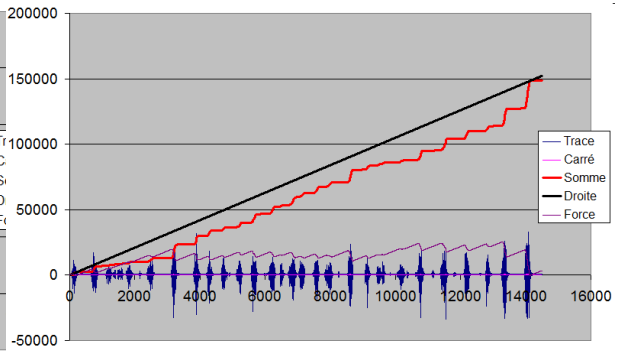


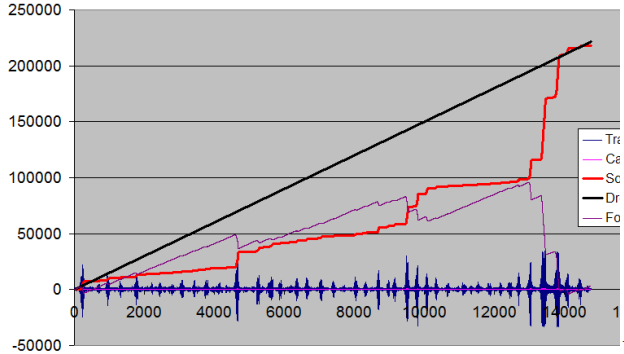


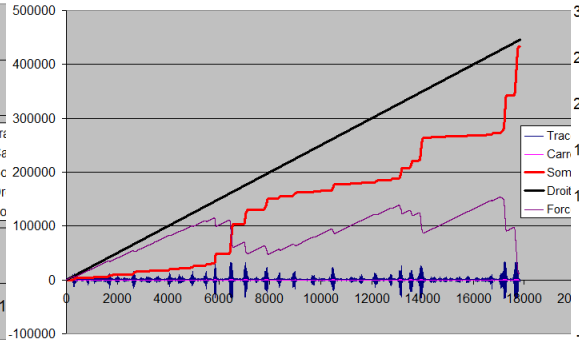


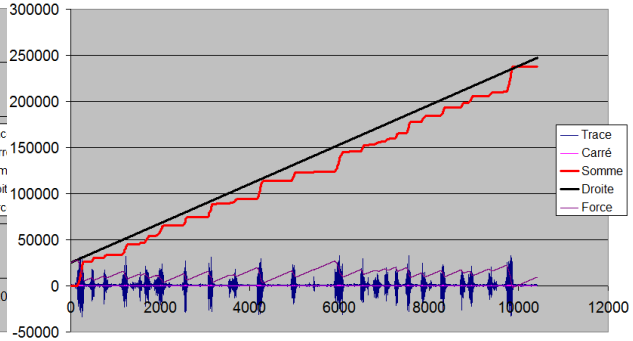






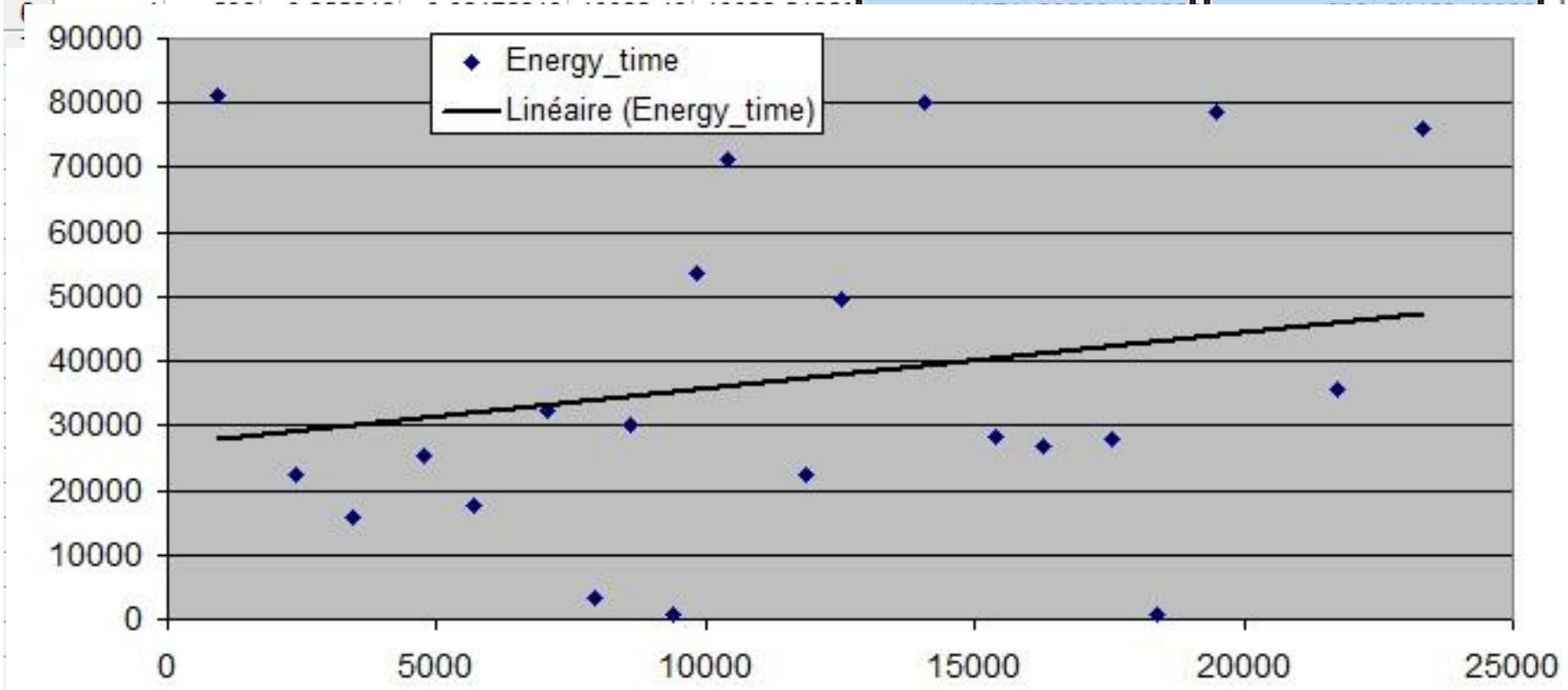






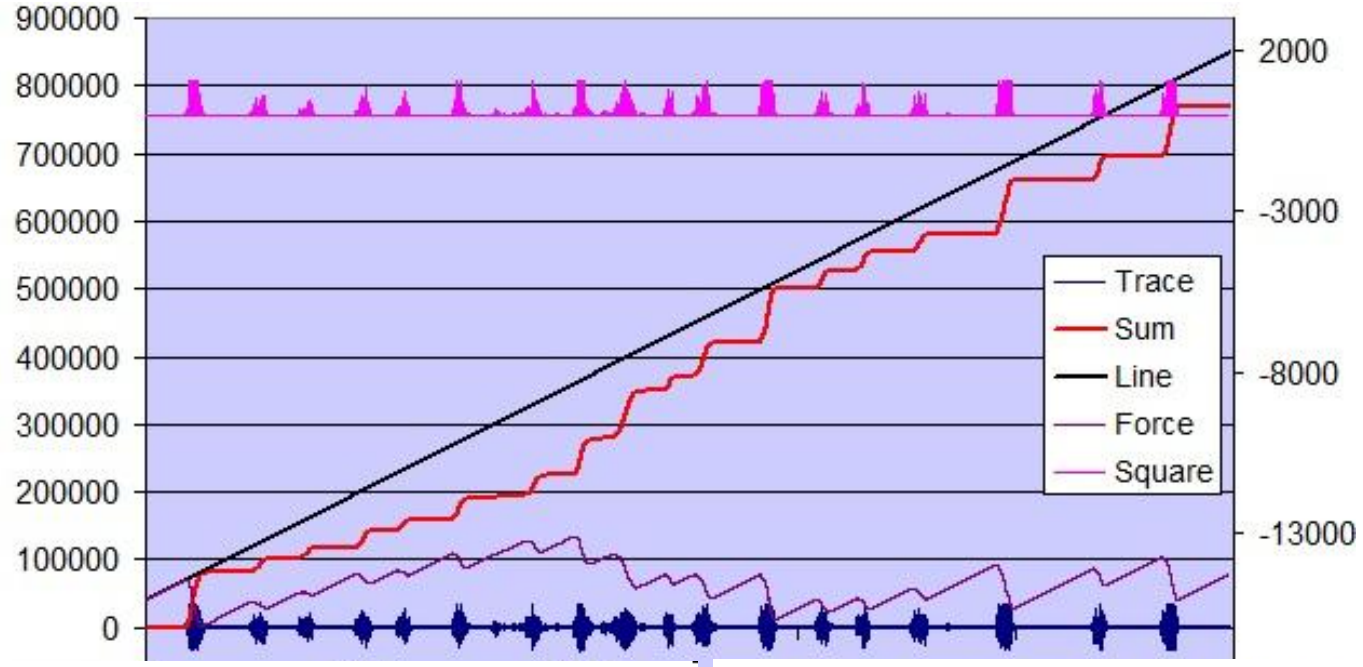
Résultats du patin tracté – Quand?

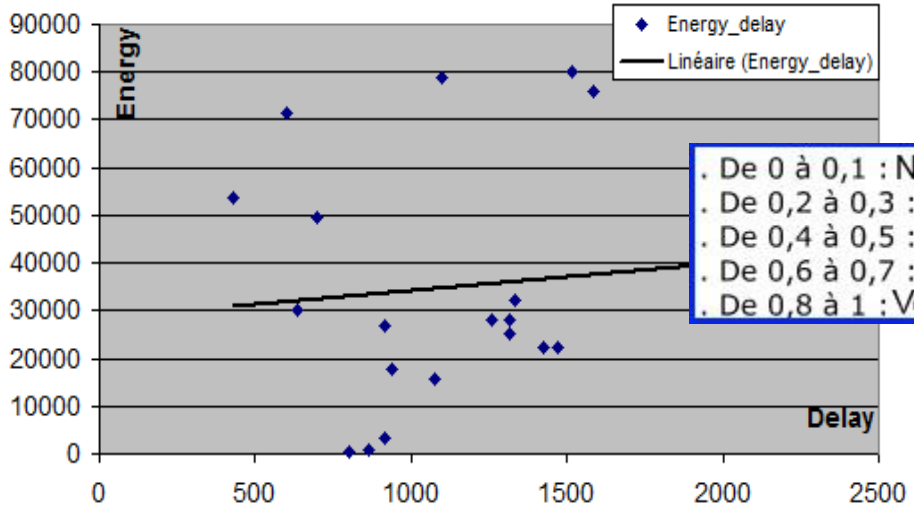
	A	B	C	D	E	F	G	H	I	J
1	Stick-slip data treatment C:\sources\patin_tracte_audacity\Audacity\patin_tracte\stick-slip2_export13.wav.slk									
2	Square d	1000		b_line	40000					
3	Offset	0,377		a_line	32,49089					
4										
5	x	Trace	Square	Sum	Line	Force	Delay	Energy_delay	Time	Energy_time



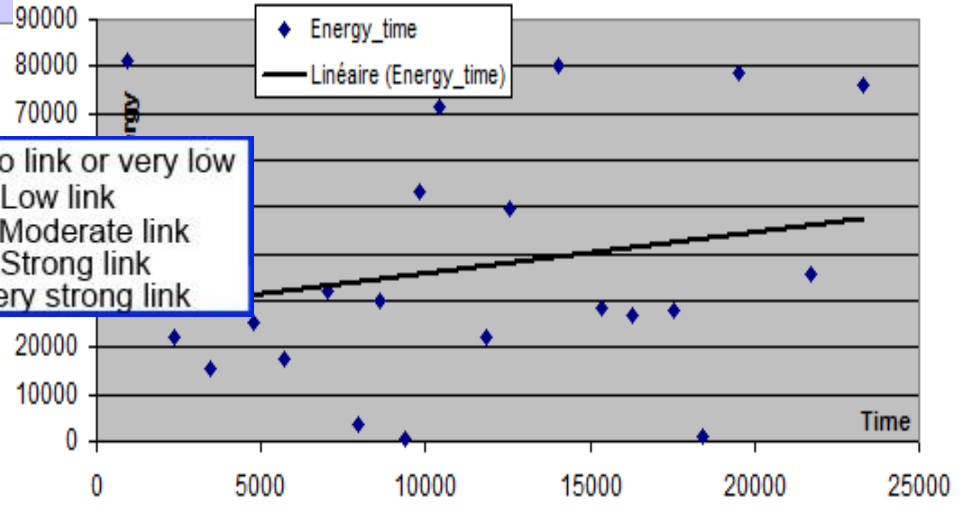
26	21	552	0,304704	0,365336724	40682,31	40681,94343	Correlation	0,099949775	23305	76162,05004
27	22	562	0,315844	0,304196235	40714,8	40714,49546			Correlation	0,208946398
28	23	593	0,351649	0,278860746	40747,29	40747,01169				

Résultats du patin tracté – Quand ?





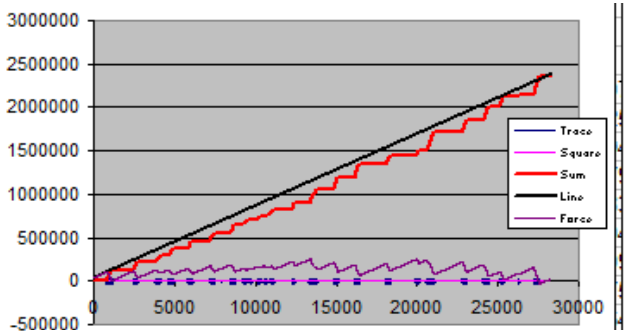
. De 0 à 0,1 : No link or very low
. De 0,2 à 0,3 : Low link
. De 0,4 à 0,5 : Moderate link
. De 0,6 à 0,7 : Strong link
. De 0,8 à 1 : Very strong link

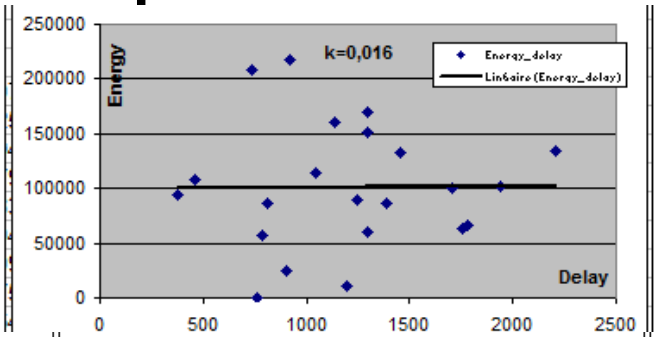


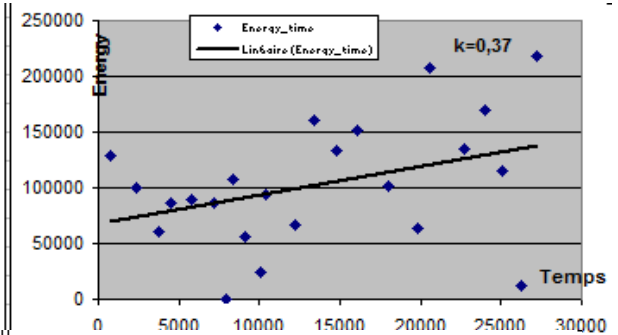
r=0,099

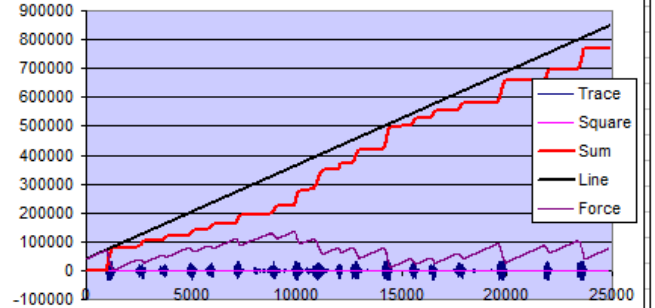
r=0,208

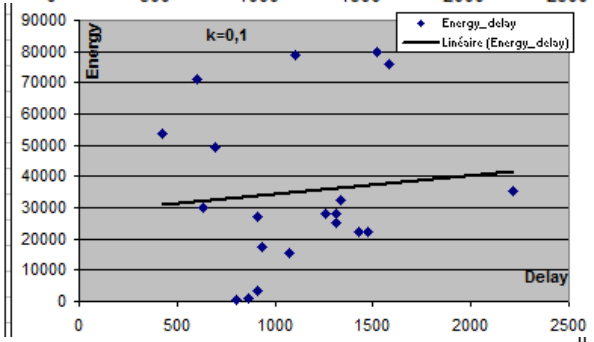
Résultats du patin tracté - Généraux

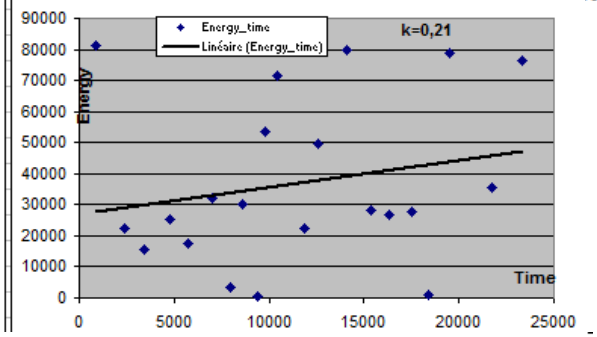


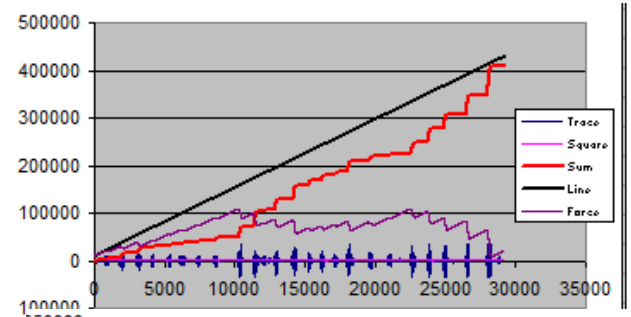


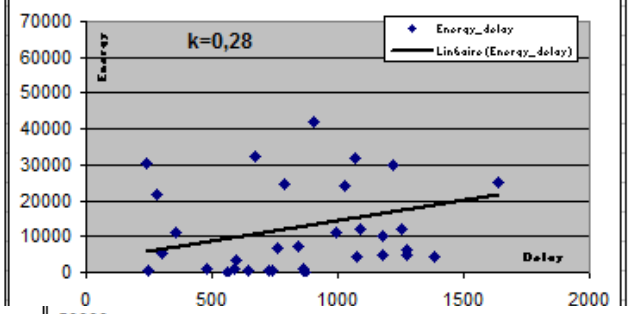


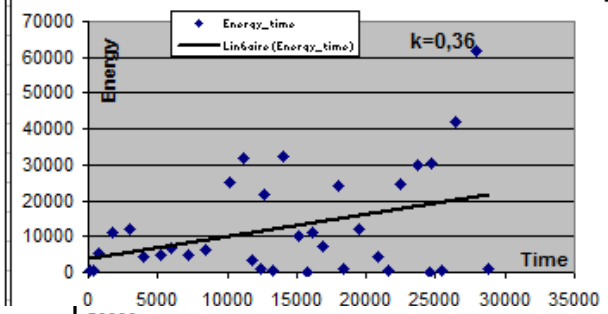


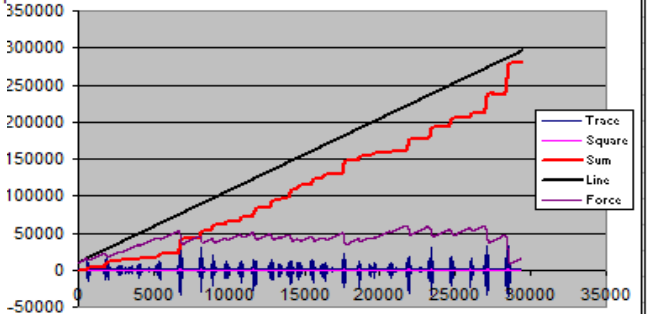


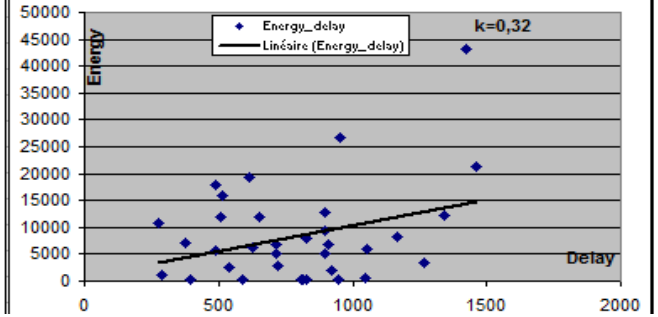


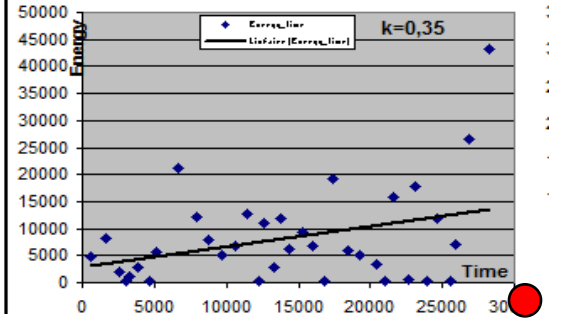






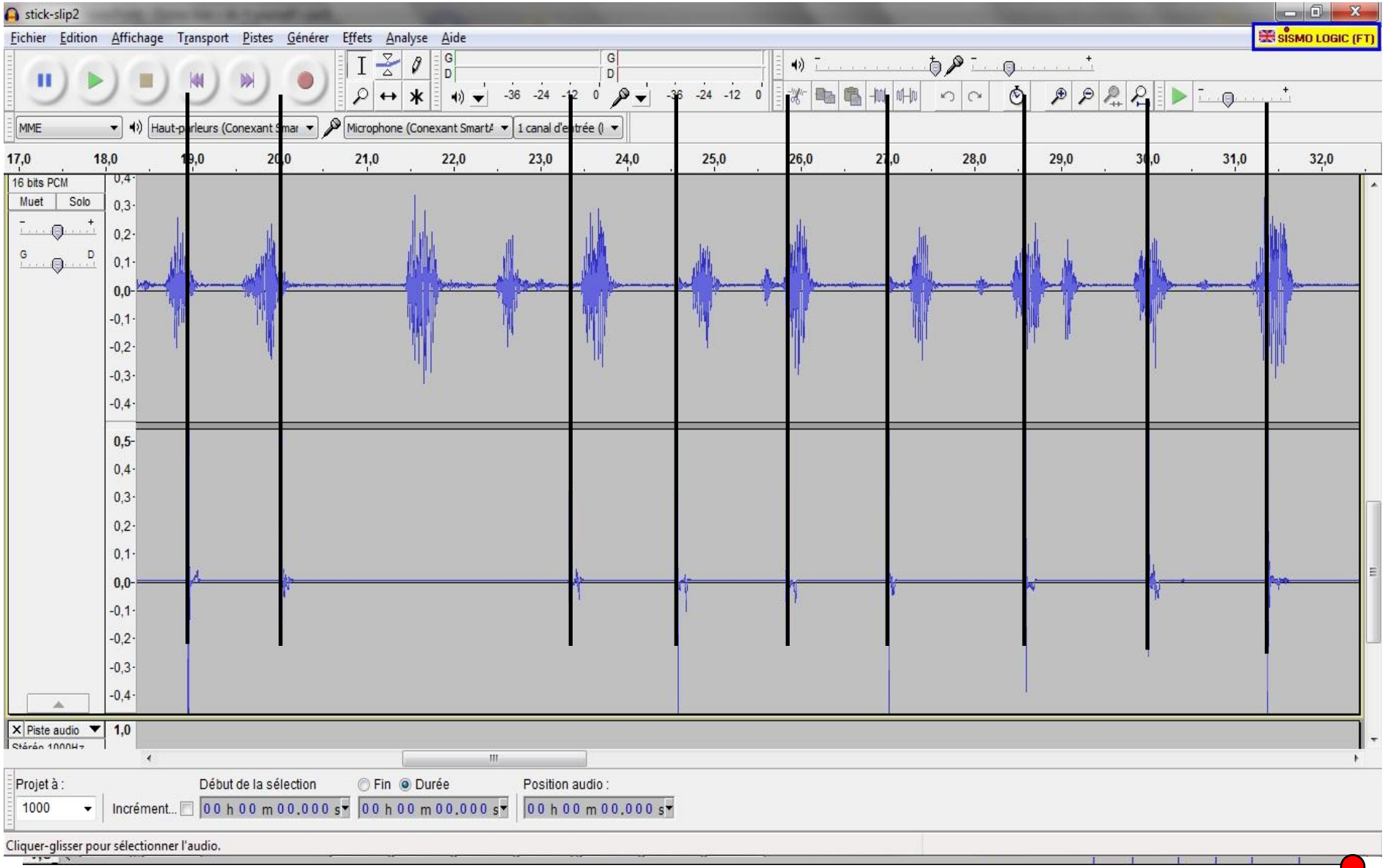






Résultats du patin tracté - Un test !

Qui veut prédire le séisme ?

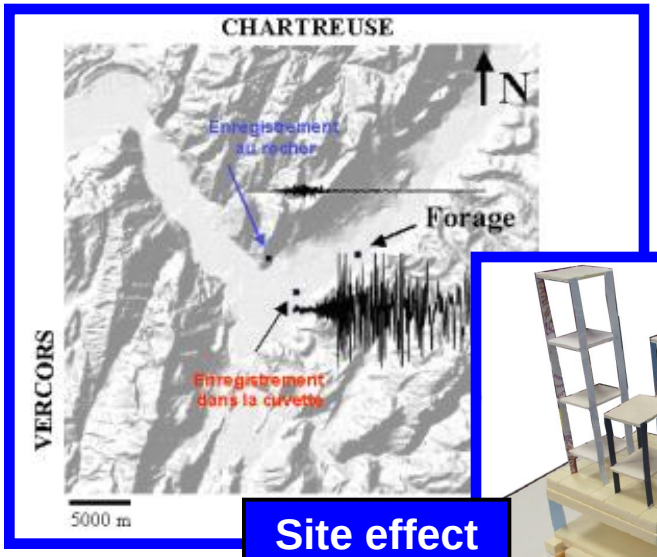


Conséquences des séismes

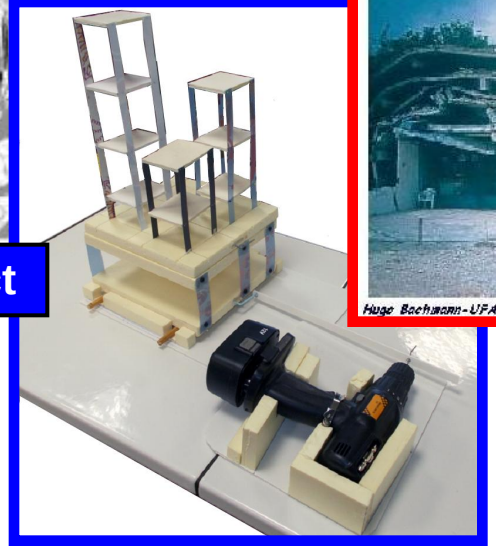
Reproduce the same consequences to understand.

Resonance

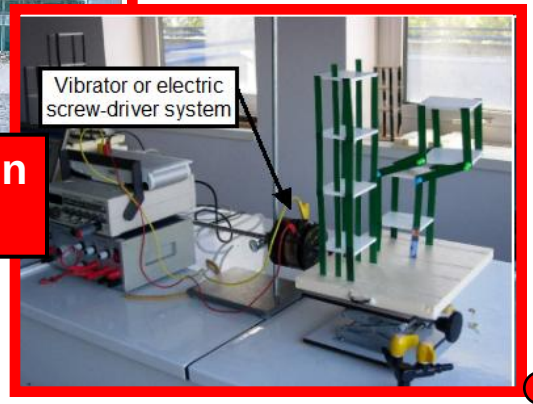
Ground liquefaction



Site effect

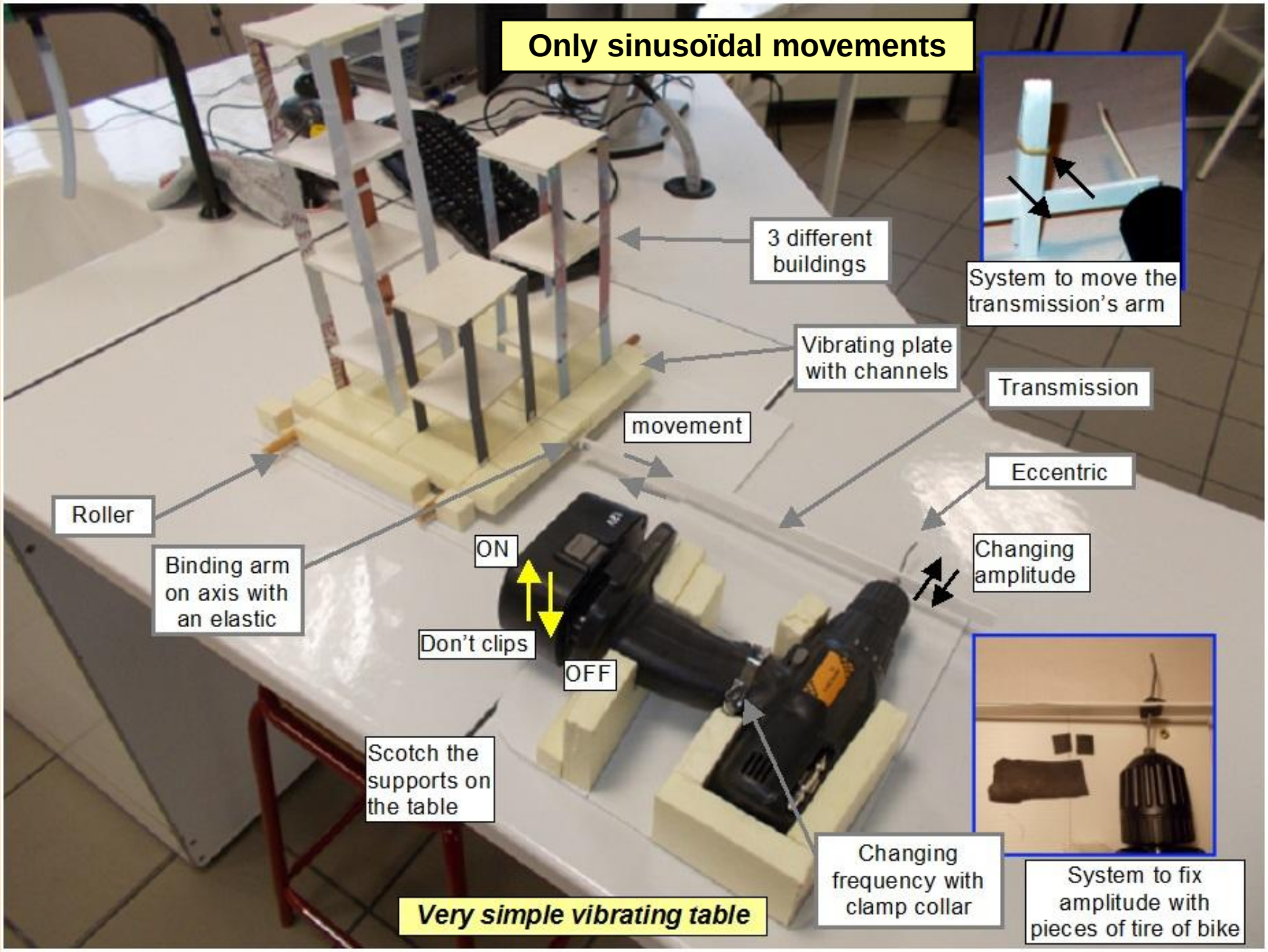


Construction mode

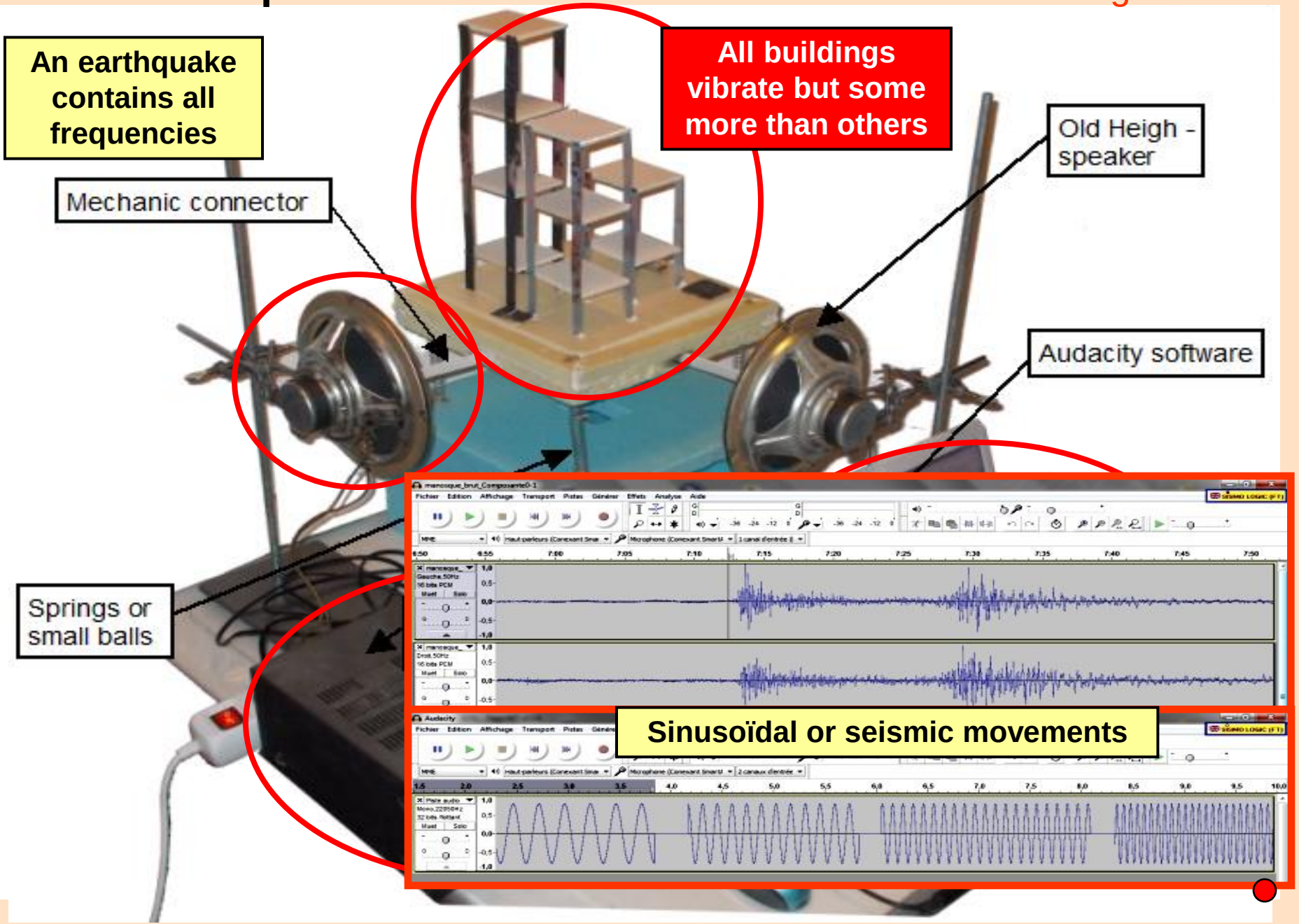


Conséquences des séismes - Resonance laws

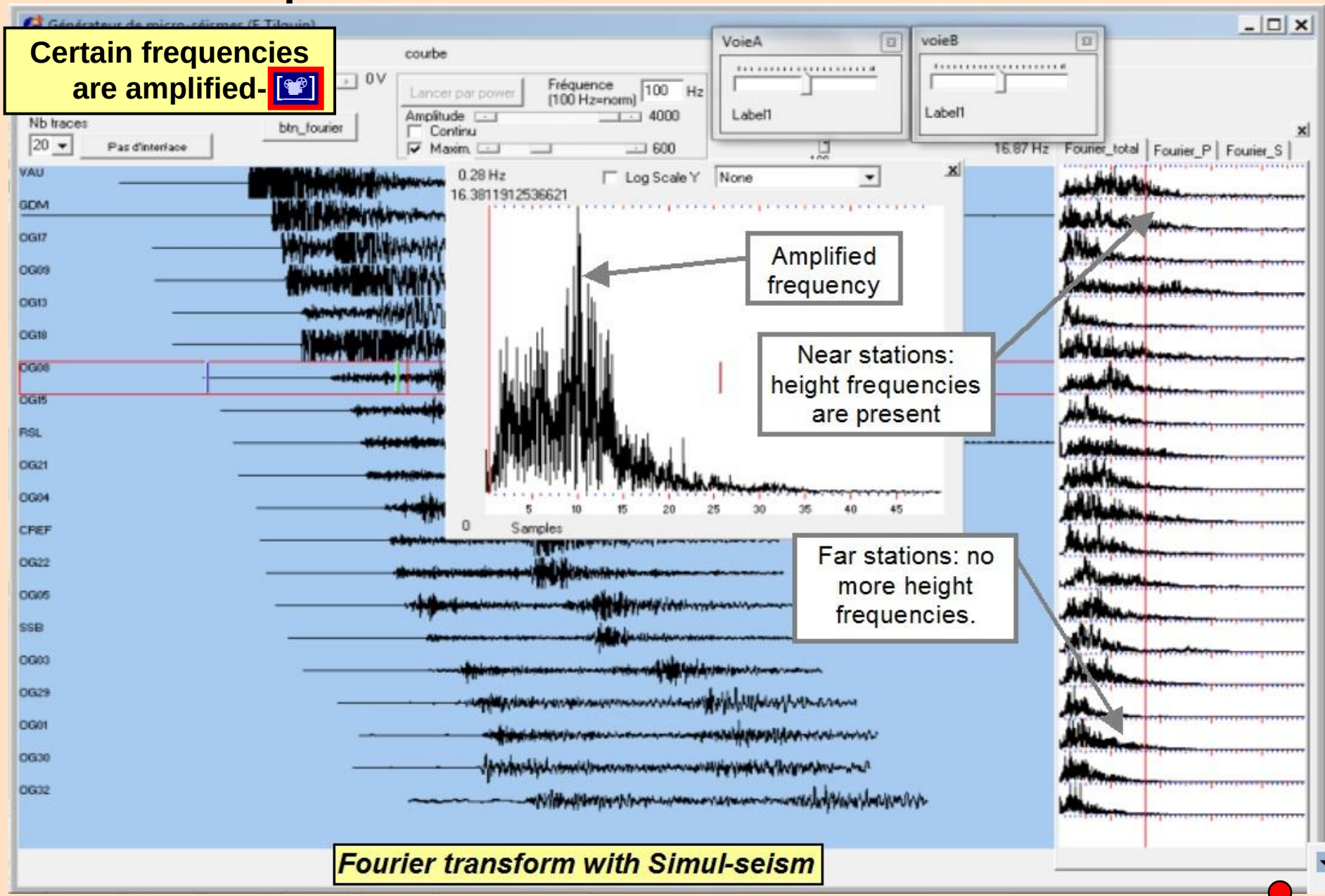
Conséquences des séismes - Simple-vibrating table



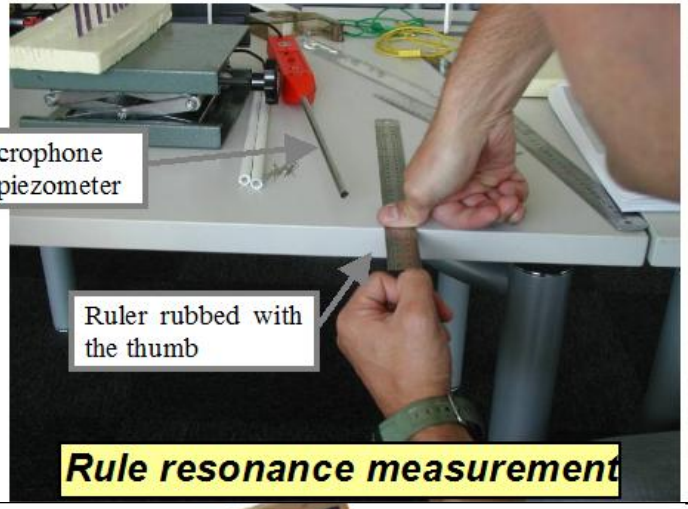
Conséquences des séismes - e- Vibrating table



Conséquences des séismes - Fourier transform

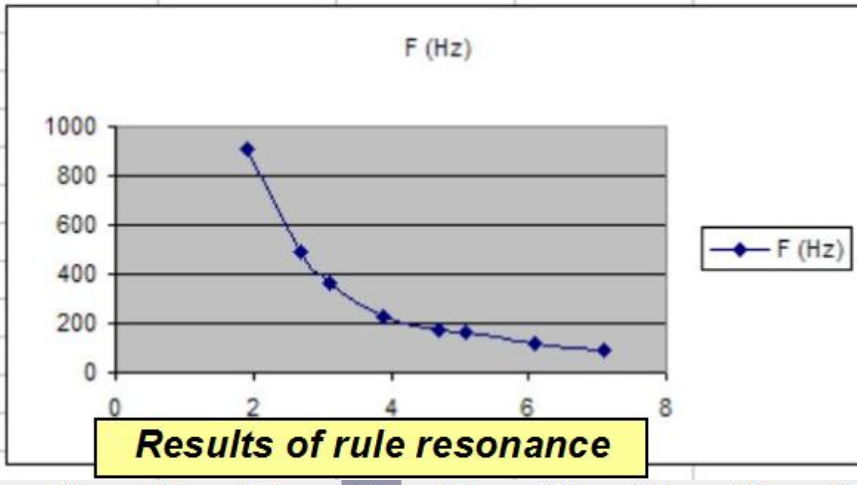


Conséquences des séismes - Resonance laws



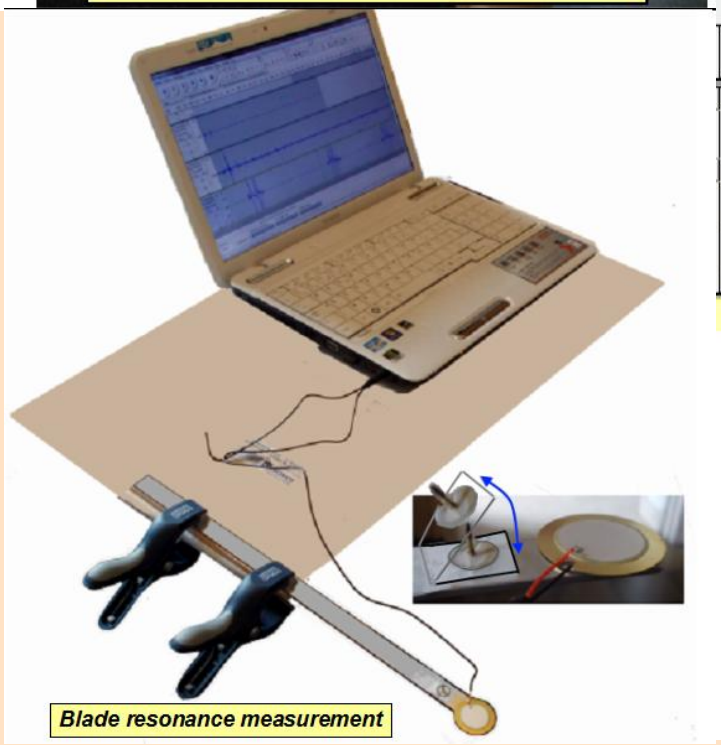
Rule resonance measurement

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

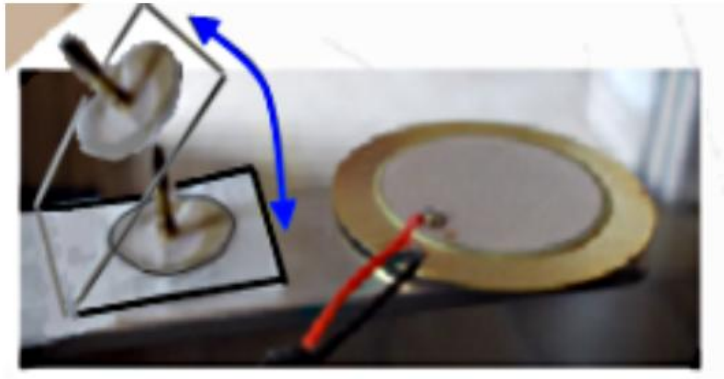


Results of rule resonance

Blade resonance measurement results



Blade resonance measurement



Conséquences des séismes - protection

The knowledge

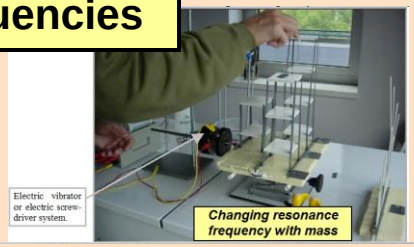
$$N = \frac{V}{\lambda} = \frac{V(2k+1)}{4L}$$

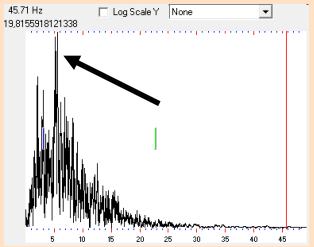
V=speed
N number of nodes
λ is the wave length
k=is an integer

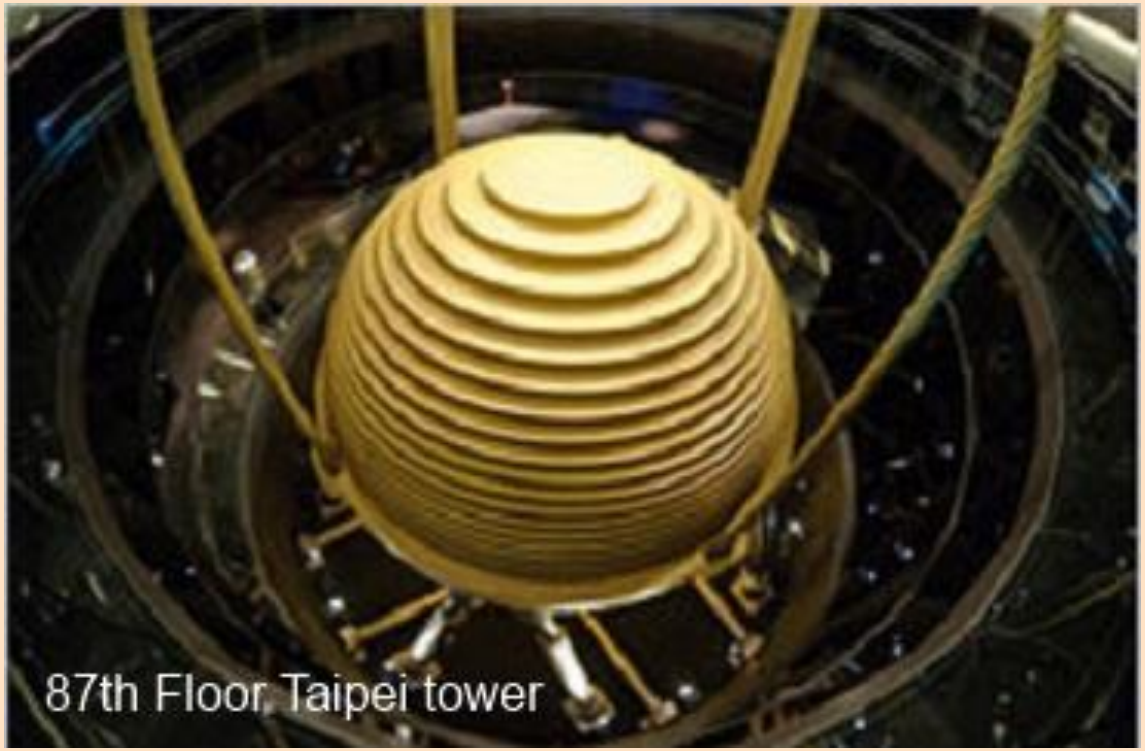
Build by avoiding the most common frequencies

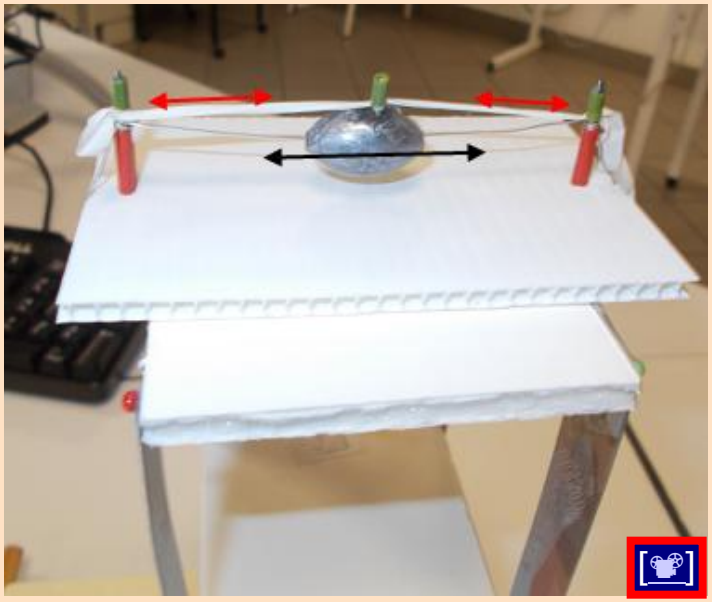
By changing the mass of building

By using a dynamic shock absorber



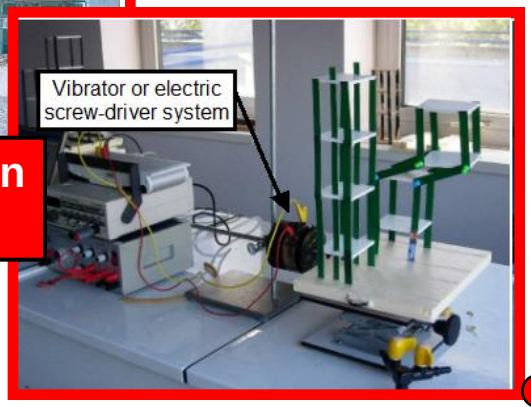






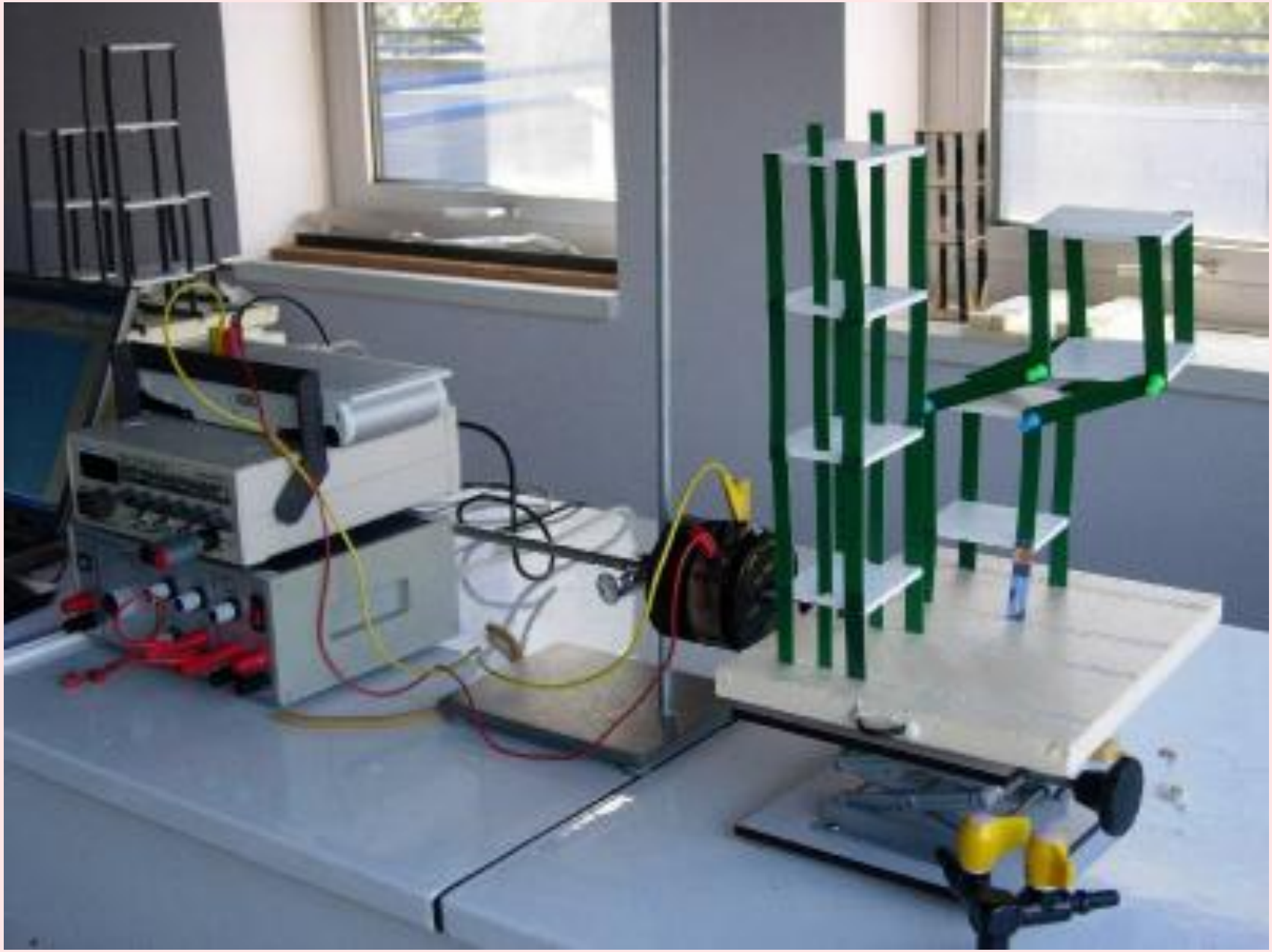
Conséquences des séismes – Mode de construction

Resonance

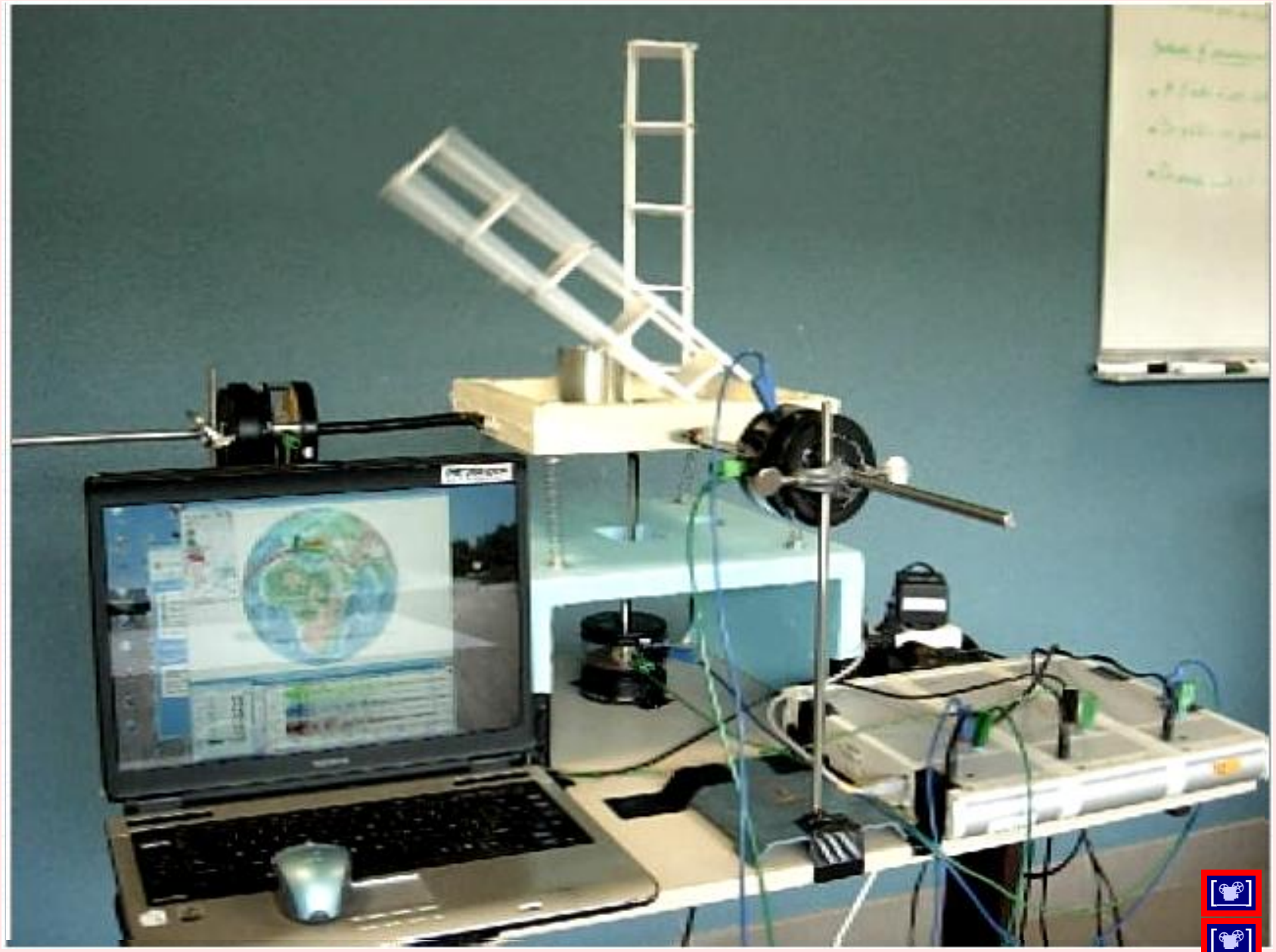


Construction mode

Effondrement des bâtiments- Murs porteurs



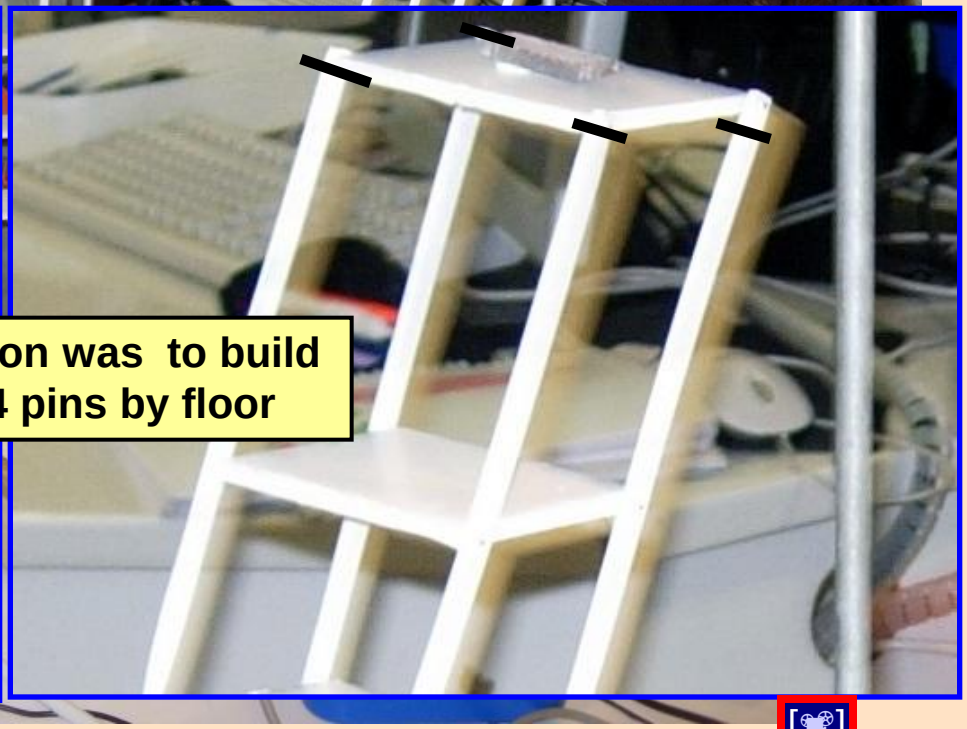
Effondrement des bâtiments position des murs porteurs



Effondrement des bâtiments Solutions des élèves

with perpendiculary hanging wall

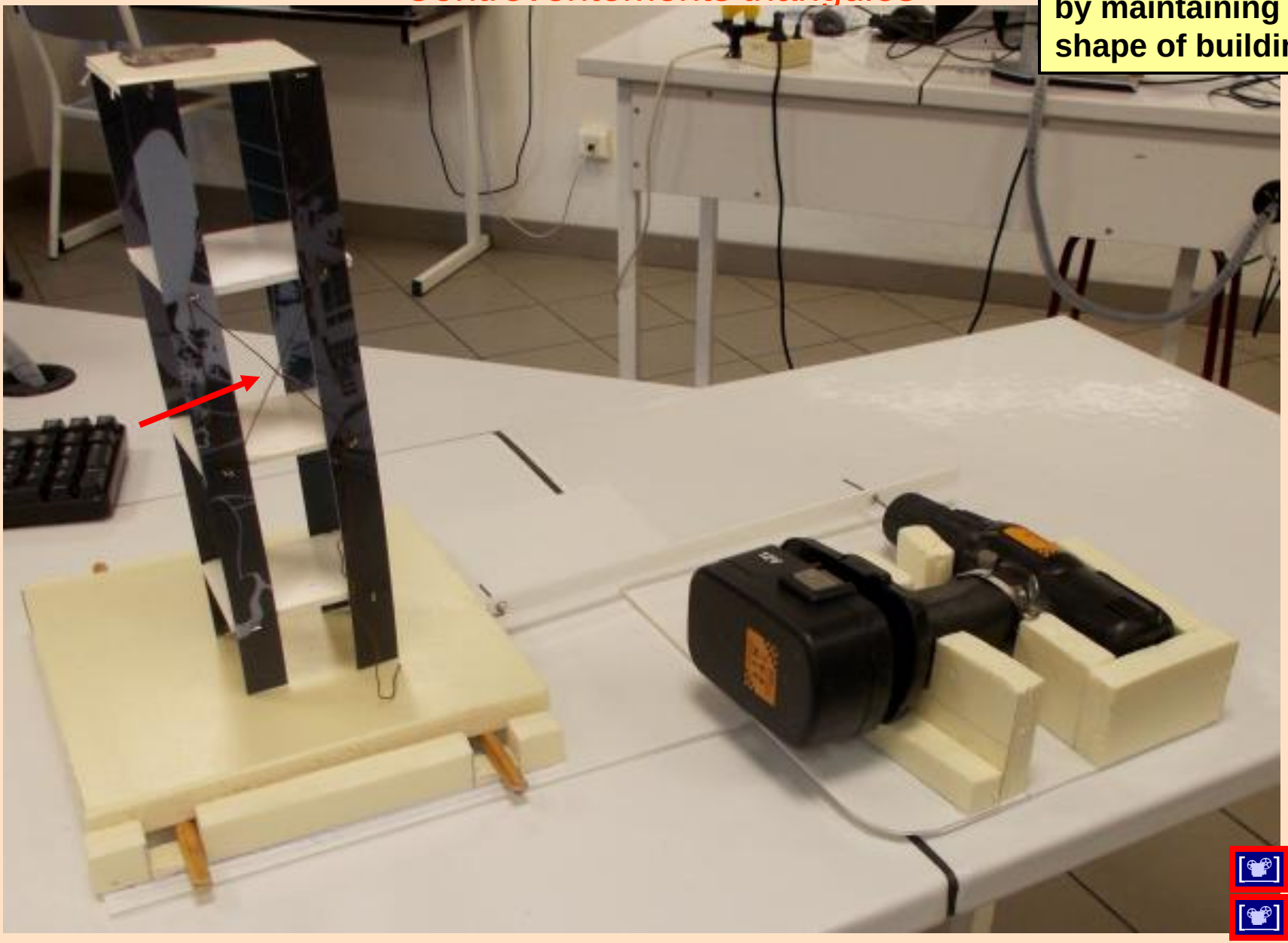
The instruction was to build with only 4 pins by floor



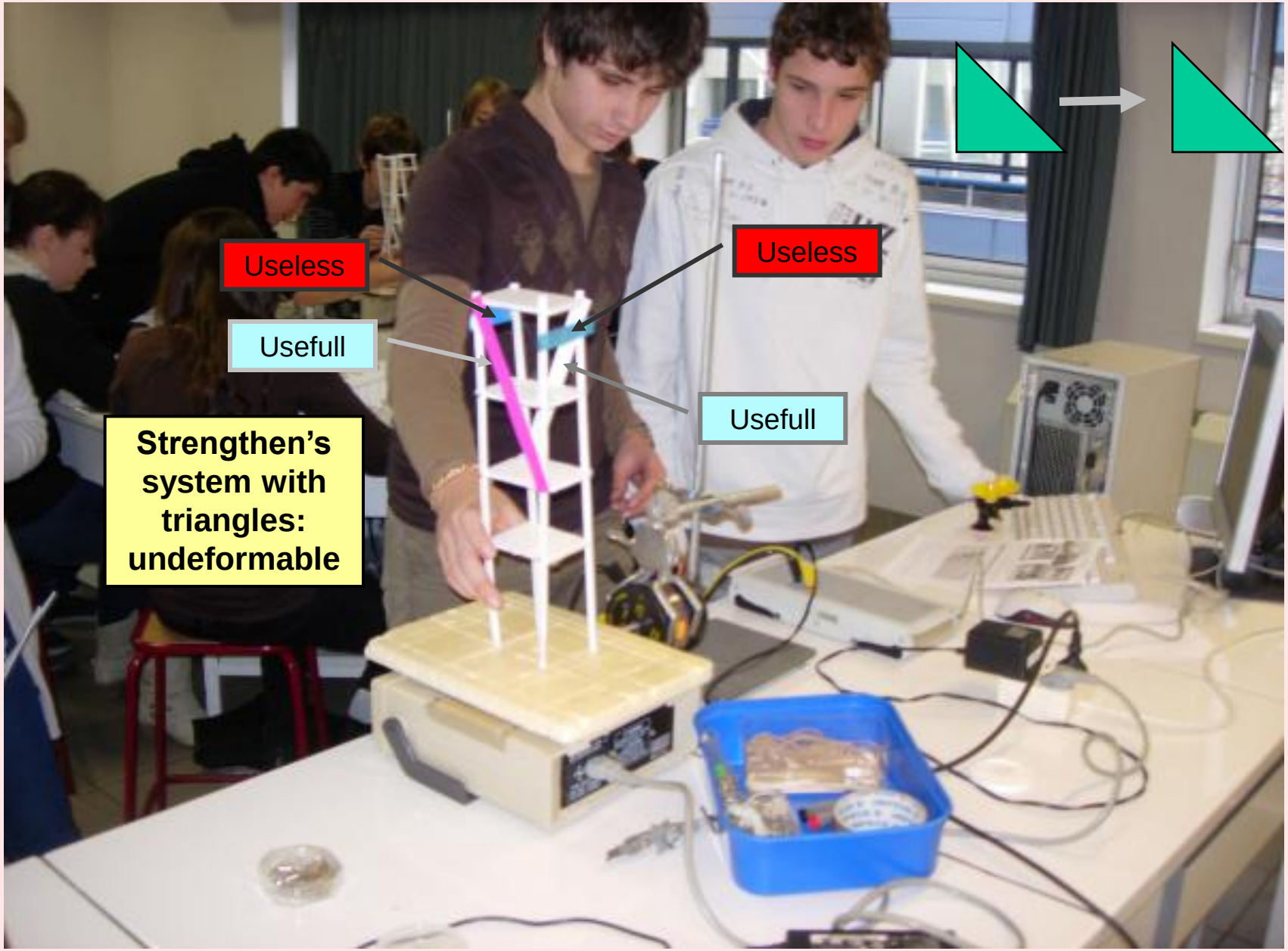
Effondrement des bâtiments

Contreventements triangulés

by maintaining the shape of buildings

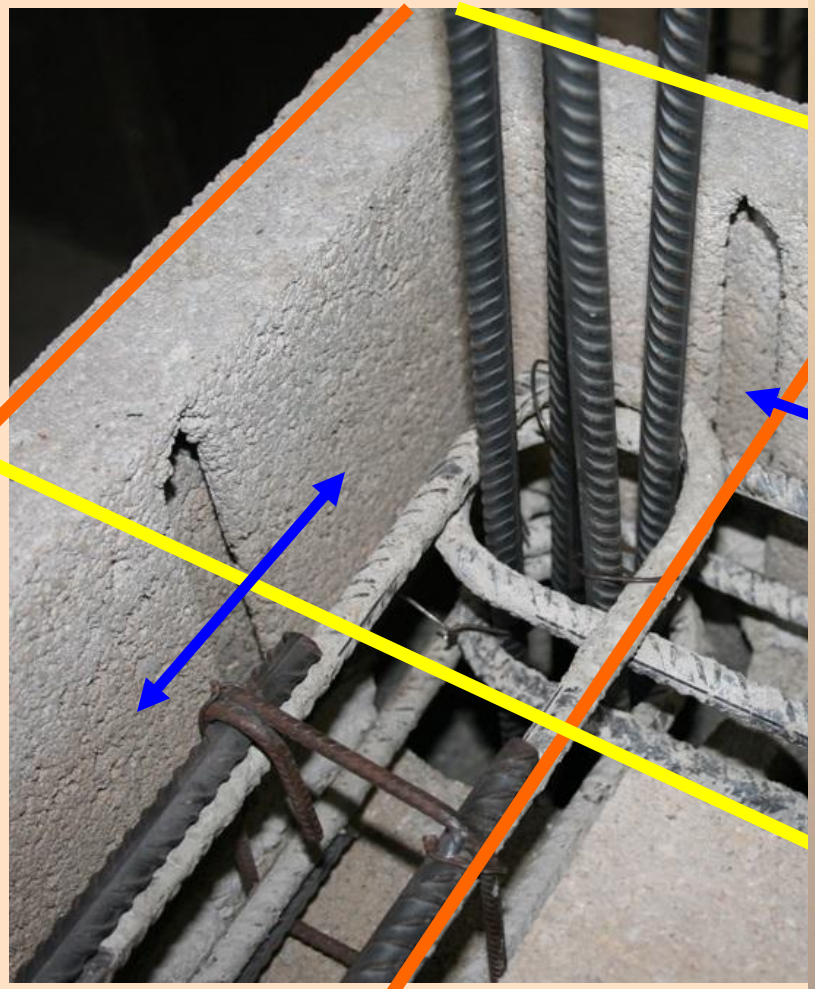


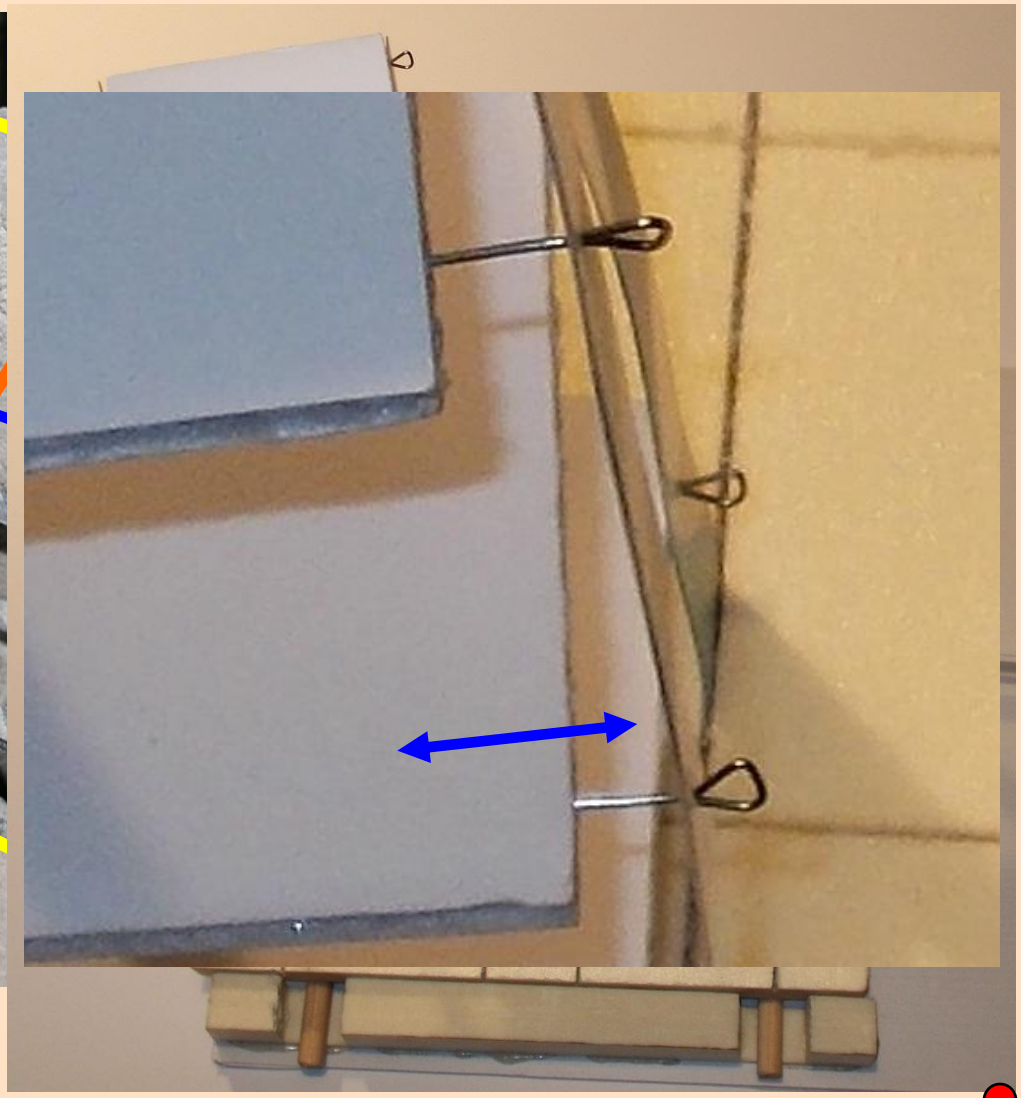
Effondrement des bâtiments - Renforcements



Effondrement des bâtiments - Chaînage

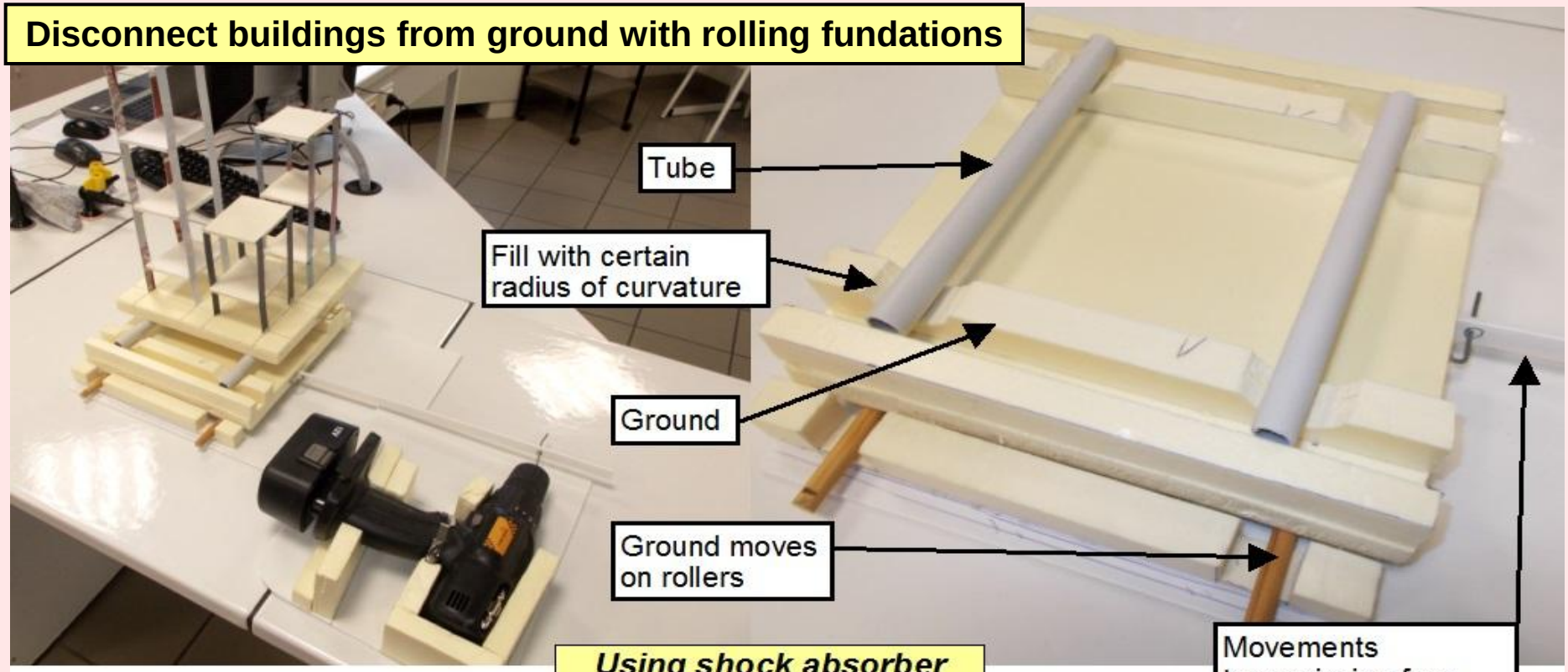
The chaining is a system which prevents the separation of buildings elements, walls and floors.



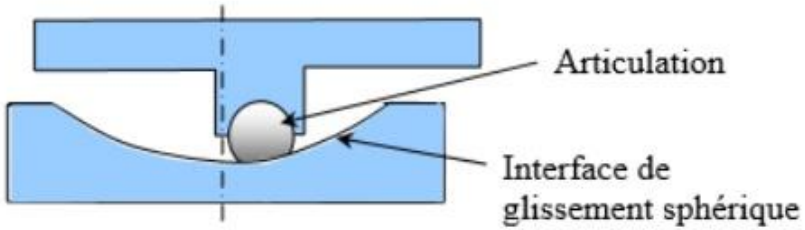


Effondrement des bâtiments - fondations roulantes

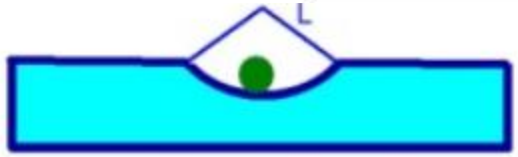
Disconnect buildings from ground with rolling fundations



Using shock absorber



Denis DAVI CETE Méditerranée (p75)



Resonance when the ground vibrates at

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

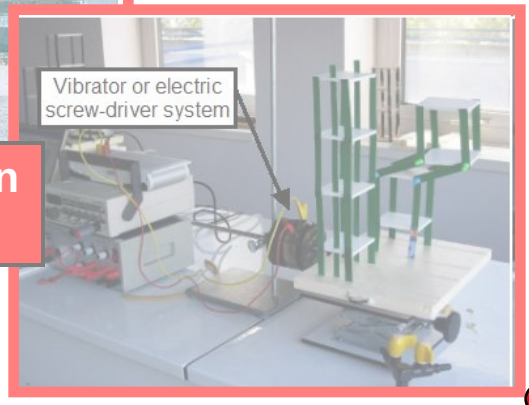
System resonance

Conséquences des séismes- Liquéfaction du sol

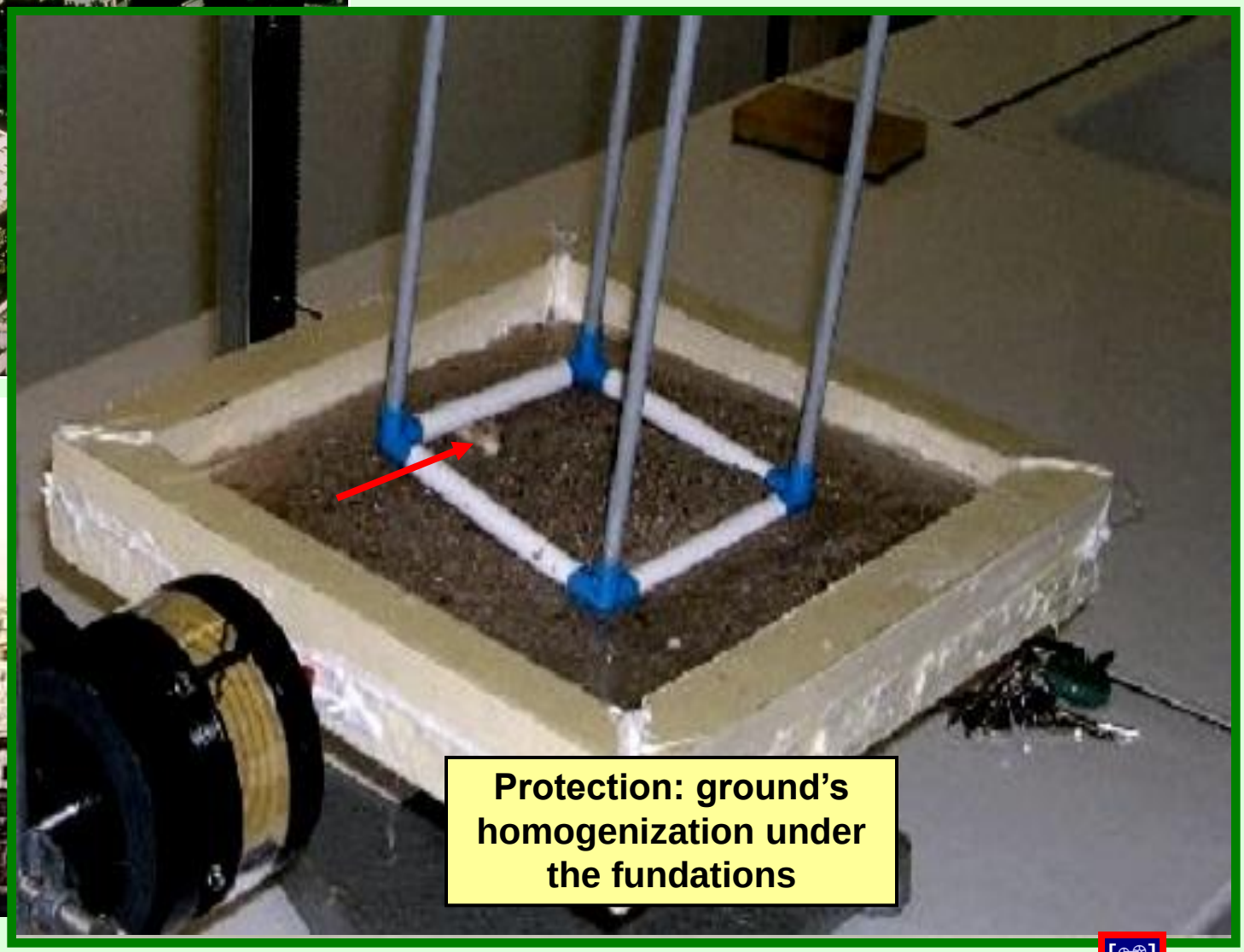
Resonance

Ground liquefaction

Construction mode



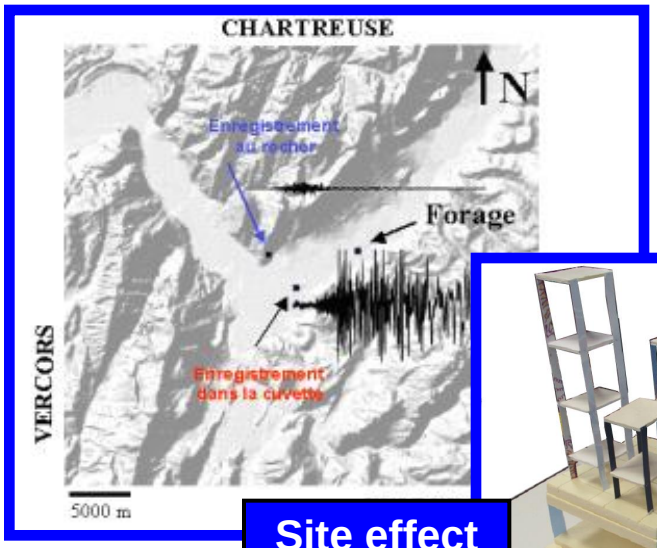
Liquéfaction du sol- Conséquences et solutions



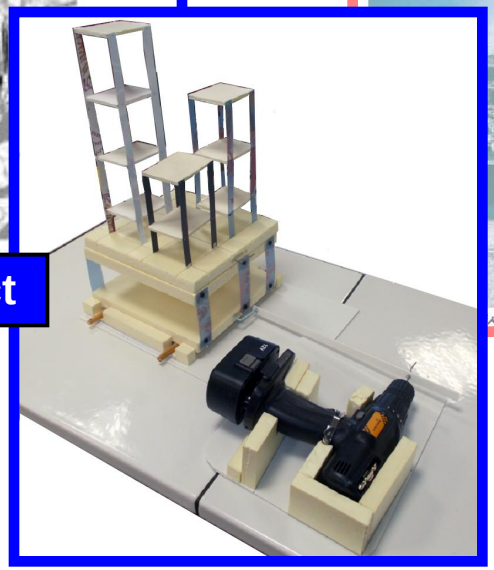
Conséquences des séismes – Effet de site

Resonance

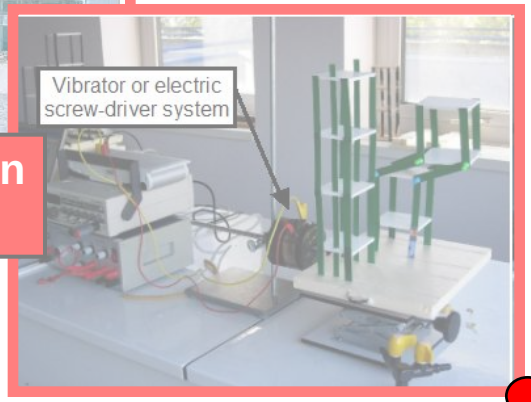
Ground liquefaction



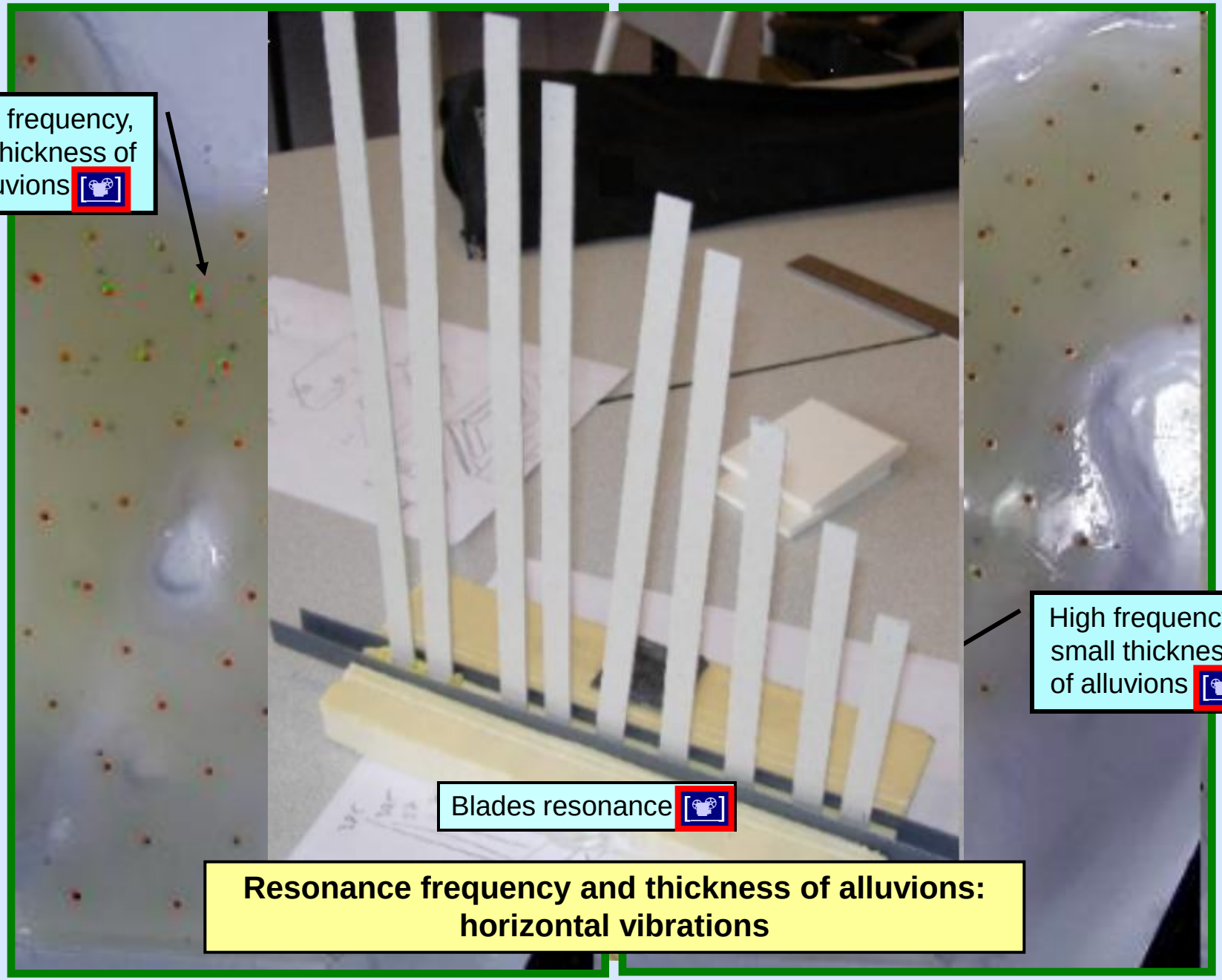
Site effect



Construction mode



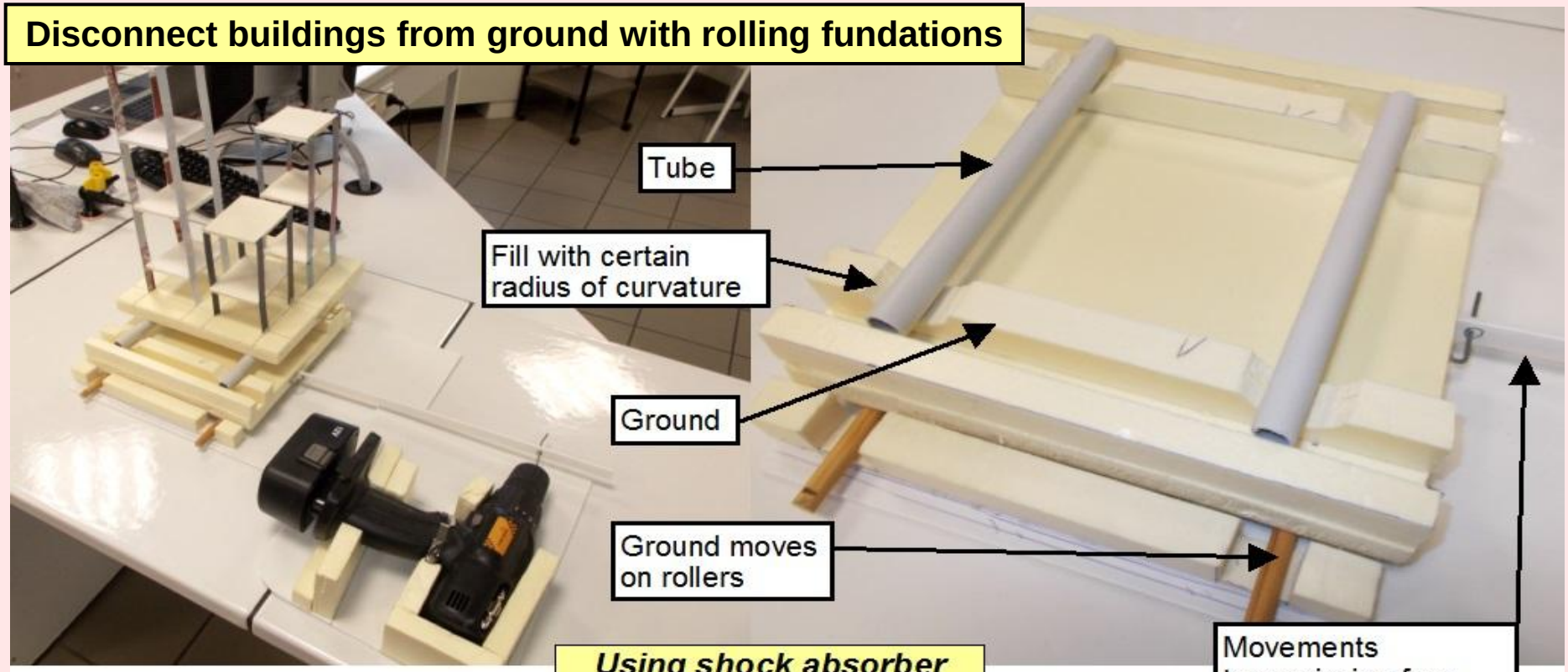
Effet de site- conséquences de 2 fréquences différentes



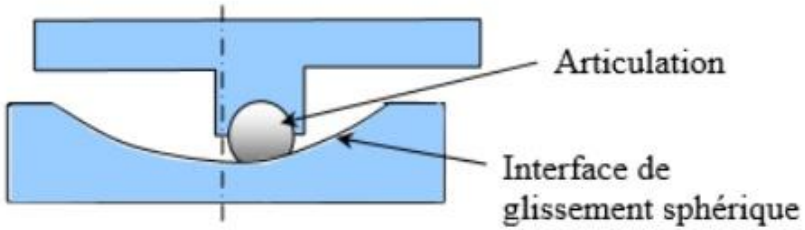
Resonance frequency and thickness of alluvions: horizontal vibrations

Dommages sur les bâtiments : Fondations roulantes

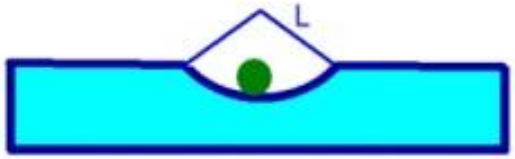
Disconnect buildings from ground with rolling fundations



Using shock absorber



Denis DAVI CETE Méditerranée (p75)



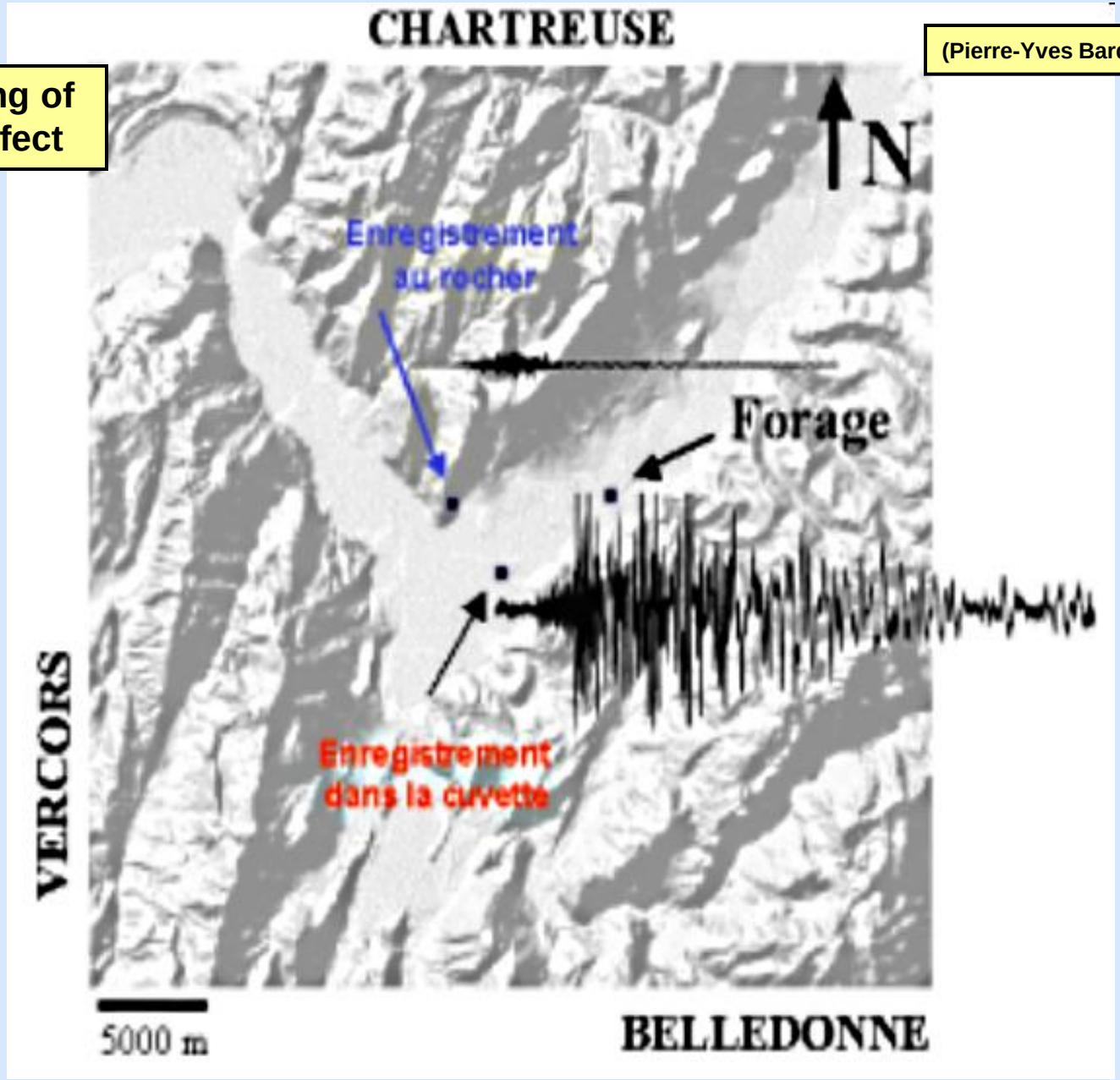
Resonance when the ground vibrates at

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

System resonance

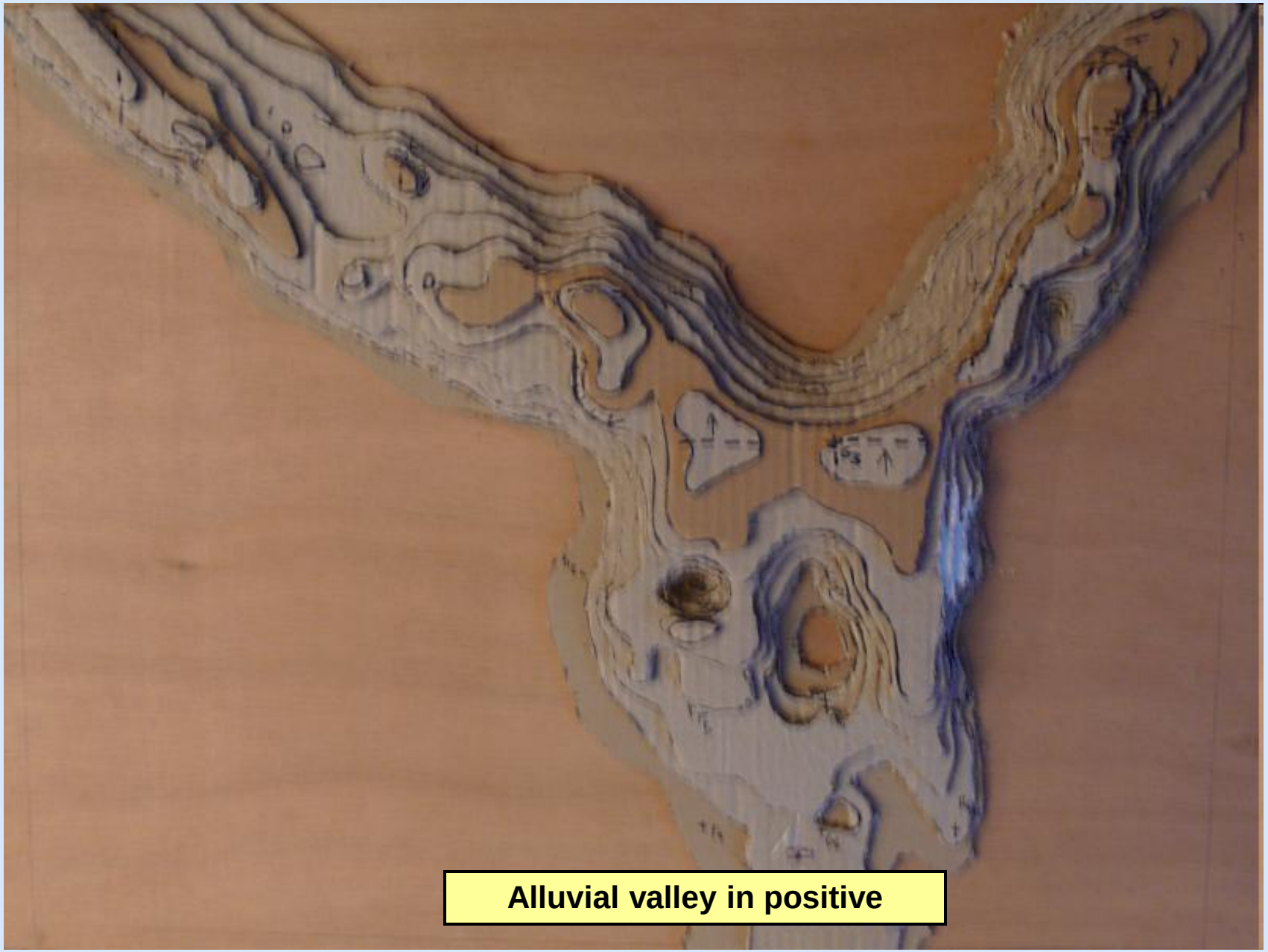
Site effect- Map of Grenoble

Highlighting of the site effect



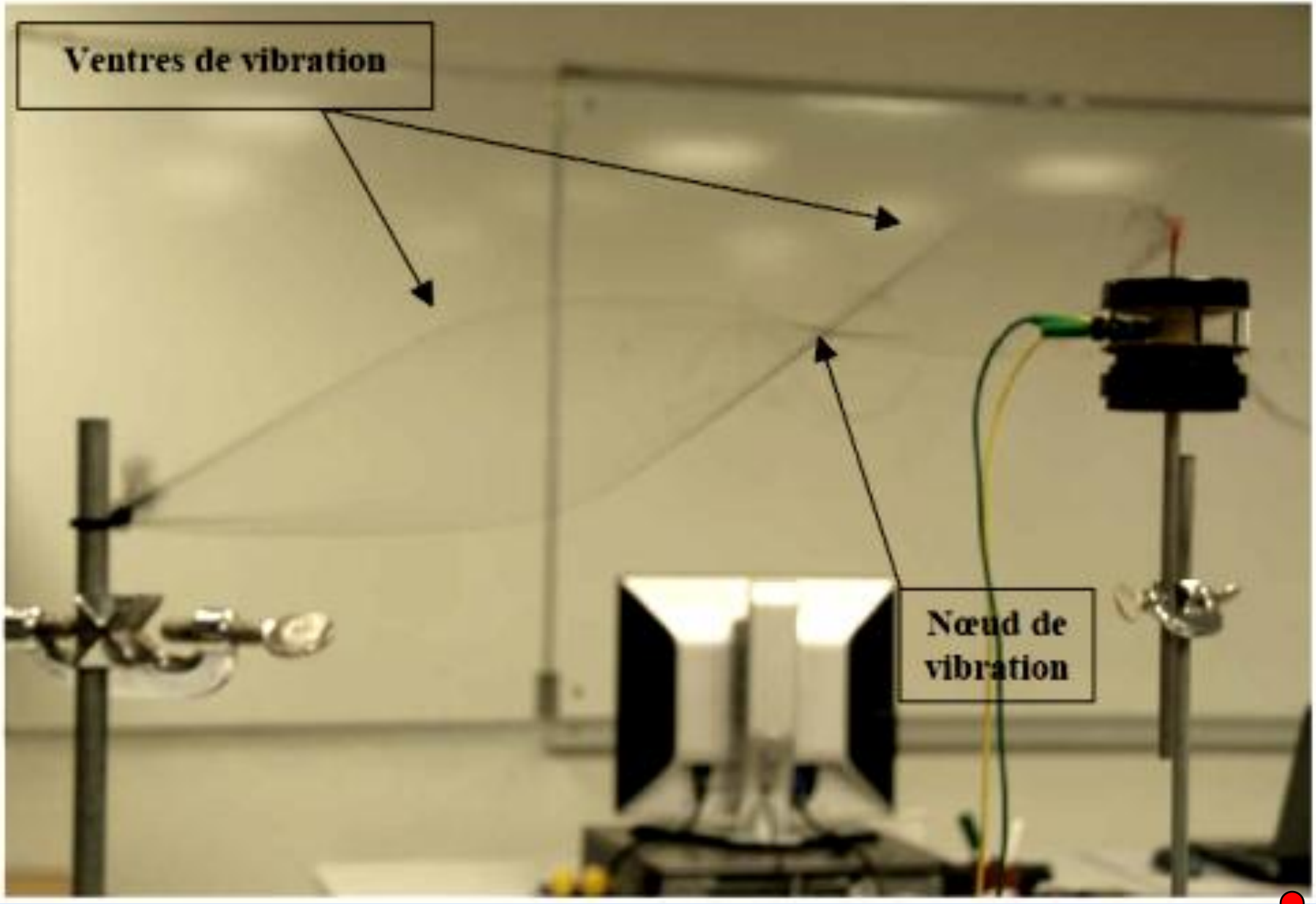
(Pierre-Yves Bard, ISTerre)

Effet de site- Modèle en carton

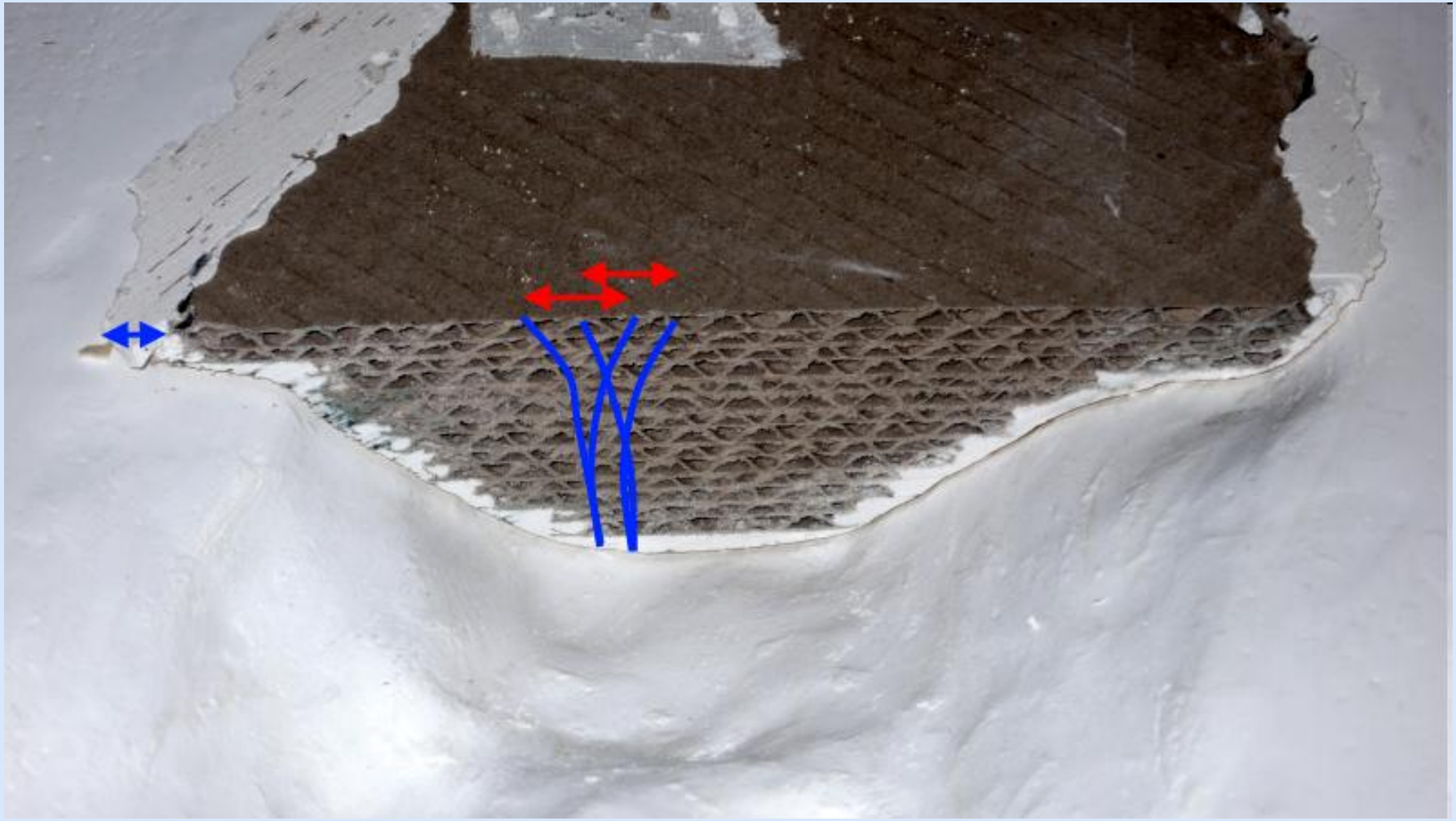


Effet de site – Modèle en résine

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

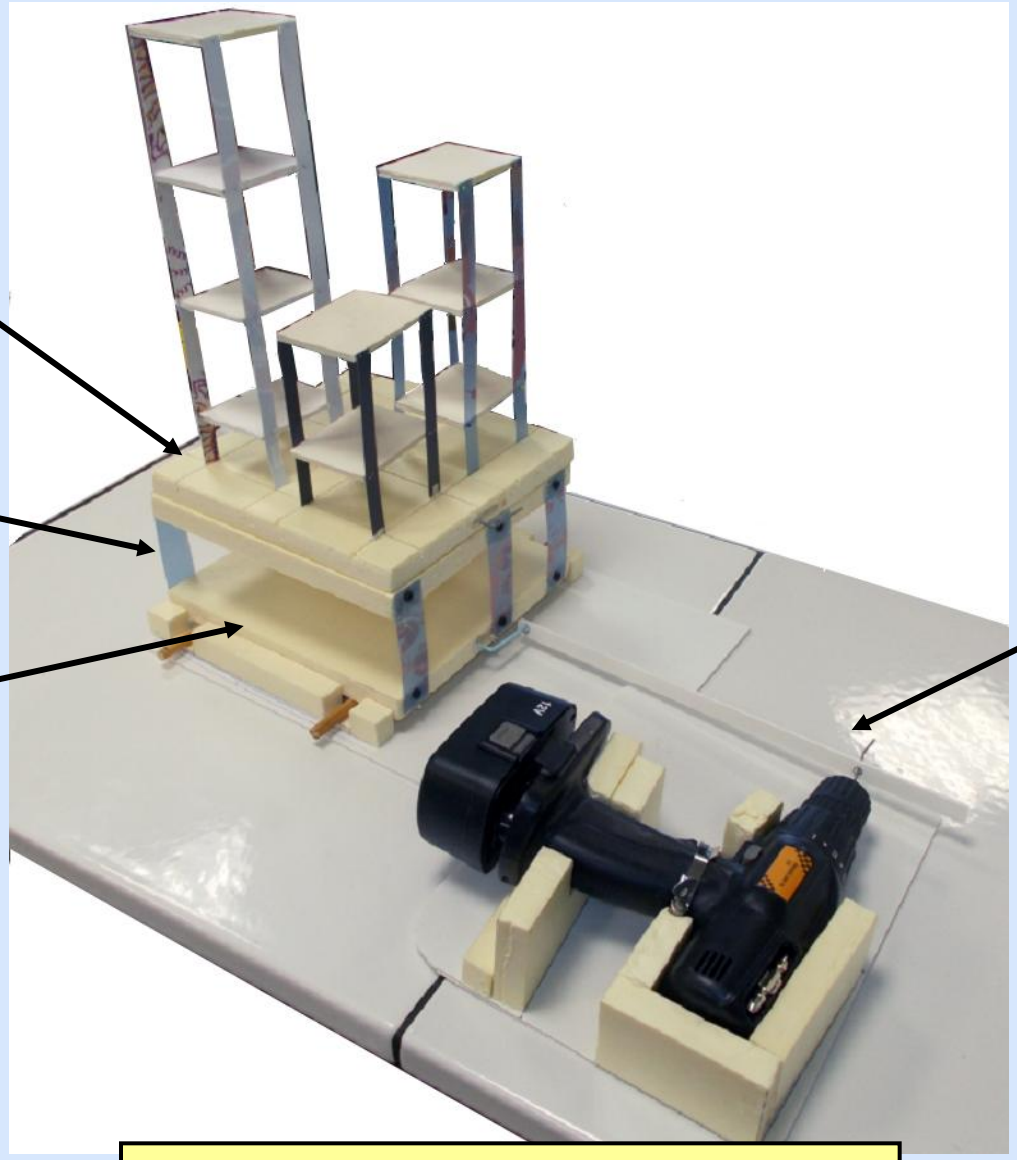


Effet de site - 2 modèles de vibrations



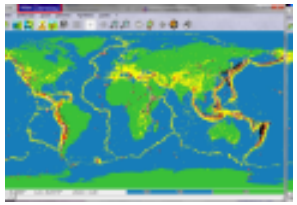
Resonance like blades or rope

Effet de site – Modèle avec des lames en plastique



Site effect: alluviums resonance

Équation du risque



occurrence spatiale

causes

Effondrements!!

Effet de site

Liquéfaction

conséquences

Murs porteurs

Amortisseur de toit

intensité

$$\text{Risque} = \text{Aléa} \times \frac{\text{(enjeux)}}{\text{(résistance + résilience)}}$$

parasismique

occurrence temporelle

politiques publiques comportements

Amortisseur de sol

Contreventement triangulé

Chaînage