A simple experiment on seismic precursors

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Abstract This work describes a simple and cheap experiment to inquire into seismic precursors .The experiment is similar to others carried out in Italy . It consist of stressing some block of rocks till breaking point and of searching for emission of radio signal , more precisely of Very Low Frequencies (VLF) signals The apparatus required for experiment is so simple that also people of an high school (both teachers and students) can execute it and then the experiment can be a useful tool to teach how a " real " scientific activity has made ..

Key-words : Earthquake precursors , teaching physics , high schools , VLF radio signals , " Nature " radio , didactic tools

1 Introduction

In the last years detection of seismic precursors has been one of most important topic in seismology. In literature several kinds of seismic precursors have been reported [1],[2],[3],[4] (bright lights in the sky , variations of local magnetic field , little earthquakes , infrared emission and so on) but the First experiment , by Mognaschi , was performed applying an uniaxial stress which increased uniformly from zero to rock failure in about 90 s. A magnetic antenna of 107 turns, wound on a ferrite rod, was placed near the gneiss block under stress. The antenna, shielded from external noise sources, was connected to a radio receiver tuned at 500 kHz. The audio output was recorded on a tape and then analysed with a dynamic signal analyser . The block of rock was a cube of dimension 10×10×10 centimetres. and , for this cube , a rock failure occurs to a 10^3 kg/cm^2 pressure

In other experiment , by Nardi , a similar arrangement was utilised but the observation was in VLF range and then a receiver not tuned but sensible to range of frequencies 1 – 22 Khz was used.

Really radio signals have been detected in both experiments but these have had some limits .
First of all they have been made in laboratories located in big city or rather in places full of electromagnetic noise (downtown of Pavia and Rome)...

most frequently reported precursors are electromagnetic precursors or rather emissions of radio signals before earthquake .
In the last years two experiments have been performed in Italy to verify rocks under mechanical stress emit radio signals [5].
Besides the stresses applied rose from zero to rock failure in a time much shorter then typical times involved in preparation of an earthquake.
Last but not least rocks used were dry while there is always water in the underground and this fact can change the electrical characteristics of rocks.

In this paper an experiment is presented to verify radio signals emission by stressed rocks. This experiment is done in countryside or rather in a place where there is little electrical noise and it is so simple to be made also by high school students and then it is a teaching method to introduce students into a "real "scientific experiment
In experiment below described VLF (Very Low Frequencies) radio signals emission will be searched but the showed apparatus can be easily modified such a way to detect signals in other frequencies bands

2 The apparatus

Let's image to be in a field that is some kilometres far by electrical noise sources .as : electrical lines , railways , factories (or rather any place with

electrical motors) , towns , roads (or rather busy roads) and similar . Let's suppose experimenters don't carry metal objects , for example keys , whose movement can disturb receiver apparatus and let's suppose metallic objects being able to move (for example fences made by wire nets) there aren't near apparatus .
We put on ground four blocks of volcanic tufa (typical rock of seismic zones of Central Italy) of dimension 1×1×1 centimetres. Previously blocks have been immersed in water for some days; we do this to avoid one of limits above citied...We put a sideboard on blocks and fill it with non metallic objects, for example books... By this way pressure on blocks will rise until to reach breaking point that , in this case , is 400 kilograms .(100 for every block) .
Let's note that, by this way, pressure on the rocks rises much slowly then in previous experiments
If the hypotheses about seismic precursors are right, electromagnetic waves would be emitted by blocks. To detect these an apparatus like that used by amateur radio astronomers can be used.
Taking reference to literature let's imagine an apparatus [6] made by following components:

An antenna made by a square wooden frame 60 centimetres side with 36 turns on it, practically a big coil whose axis points at blocks. The numbers are a compromise solution between the necessity to have a large coil (to collect more signal possible) and the necessity to not rise numbers of turns (many turns make things difficult for us because their parasitical capacities are a short circuit for signal)

A receiver circuit as that showed in Fig. 1 It's a circuit [7] based on a low noise and stable operational amplifier that is both a booster for signal and a virtual short circuit for input current because the passive components of circuit keep the input pins of amplifier to the same potential. Input capacitors and the 330pF one limit the frequency response of this loop to about 22 kHz, and stop MF and HF interferences

An audio card receiving the output of previous circuit and sending it to a PC Let's remind we operate in audio frequencies band

A spectral analysis software (it's possible to download freely software of this kind from several Internet sites) producing a spectrogram or rather a time – frequency plot .of received signal
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Fig. 2 is an example of such plot in which there are both typical noise present in these frequencies and a possible true signal.
More precisely there are: a signal produced by underwater communications done by two near and intermittent frequencies, signal of electrical lines (50 Hz and its multiple because this signal isn't exactly sinusoidal) and vertical lines corresponding to emissions produced by lightings, also .several hundreds kilometers far
The "true" signal is that starting at time t1 and ending to time t2 and evidently this has to be the interval of time in which pressure on the blocks is near breaking point
The intensity of line is proportional to the intensity of signal

It's to note that whole experiment can be performed in the space of a morning taking reference to Italian schools where lessons are only in the morning.
It's to note also that solar cells can supply power to components of apparatus because we have supposed to be far from electrical lines

3 Considerations and conclusions

This experiment can have several and interesting improvements, even suggested by students too.

First of all two antennas instead of one can be used. Because of the coil is a directional antenna sensitive to signal coming from the direction of its axis. . Then we can use two coils, the first with axis towards blocks and other with axis perpendicular to first. Only the first antenna will receive the "true "signal.

Another improvement can be the use of a single block of bigger dimension (for example 10×10×10 cm) using an hydraulic press .to weigh the blocks

Besides signals in other bands of frequencies can be searched utilising other types of antennas and of receivers (always simple and cheap) as TV parabolic antenna for searching UHF emission
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References

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[5] for a description of two experiments let's see in http://www.anisn.it/geologia2000
[6] a description of several of these apparatus is in R.Romero *Radio Natura (Nature Radio)* , Ed. Sandit , 2006
[7] A detailed description of this circuit is in R.Romero and M.Bruno in An easy VLF loop 200Hz-20kHz reception without transformers in www.vlf.it

Fig 1 Signal receiver circuit used in the experiment . Values of components are purely as an indication

Fig.2 Example of spectrogram , or rather time frequency plot of received signal (" true " signal and noise)

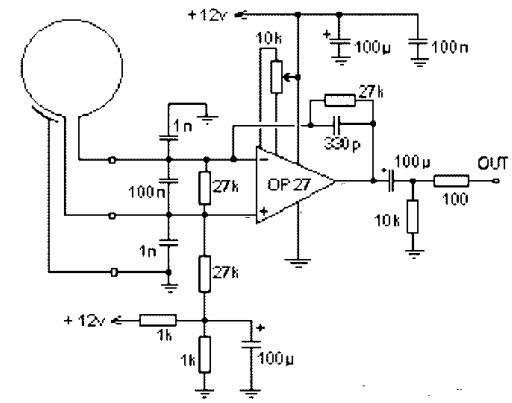

FIG. 1

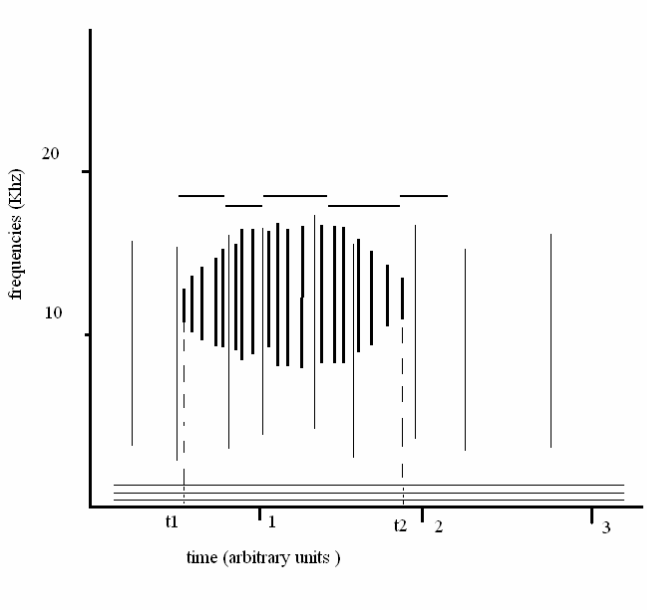

FIG. 2