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EARTHQUAKE FORECASTING USING ACOUSTIC WAVES

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An earthquake generates seismic and acoustic waves. First you hear the noise of fracturing and then you feel the P wave. How is it possible that the speed of sound is less than the seismic P speed? What is the difference between acoustic and seismic waves? How could acoustic waves help in forecasting earthquakes? This article gives an answer for these questions.

An earthquake is the last part of a process where the elasticity of the rocks is broken. It produces waves that create fracturing and push the 'noise'. Basically the seismic wave generates and carries on the acoustics. Figures 1, 2 and 3 show the records of earthquakes using seismic equipment and a microphone. A seismometer is mechanically limited by an intense vibration as shown in the next picture.

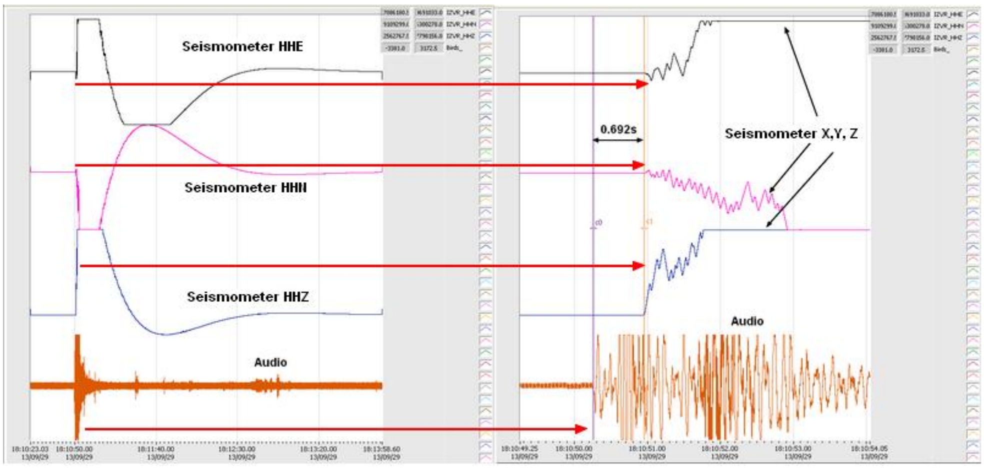

Figure 1. Earthquake acoustic record, 29.09.2013,05:01:57, ML=3.96R, H=5 Km, 45.49N, 27.84E

The acoustic record (Figure 1) is partially limited in amplitude but you can see the P and S waves.

The sounds generated by an earthquake contain high frequencies that are attenuated rapidly. So what we record must be generated in the vicinity. The sound depends on where you are registered (geological structure, seismic activity, soil, elasticity). Waves propagation through atmosphere depends on many conditions (temperature, pressure, humidity, wind).

We could have acoustic waves without earthquakes. The tectonic stress is continuouse and it is manifested by surface waves that produce fracturing. Figure 2 shows a case like this in a seismic area located next to an oil exploitation (Izvoarele, Romania). The sensor is a condenser microphone with

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electret. The seismic transducers do not detect the little oscilation that precedes the eathquake. The microphone is a pressure sensor specially designed to record sounds. The response type is important.

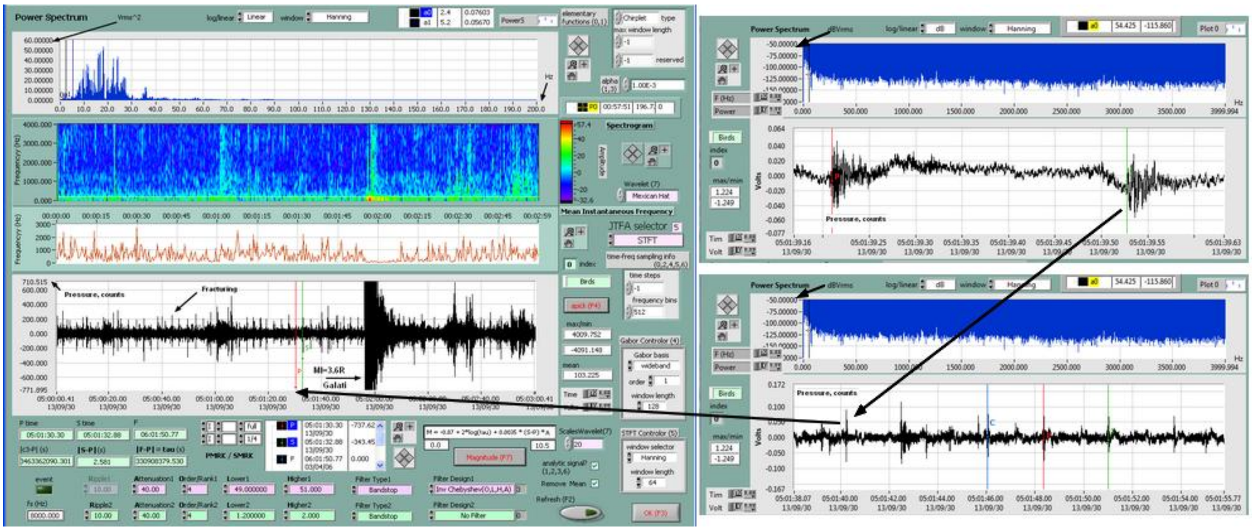
Figure 2.Earthquake acoustic record,30.09.2013,05:01:57,ML=3.6R,H=5Km,45.49N,27.79E,Izvoarele

An example of seismic and acoustic waves recorded in the same place are shown in Figure 3. The STFT spectogram indicates high energy after the P wave. The acoustic wave is an amount of sounds from air. The microphone was fixed on a wall and it records the wave only from one side (response type is pressure field). The earthquake shakes the building, including the sensor. Therefore, the wave "seen" by the microphone also includes the ground effect.

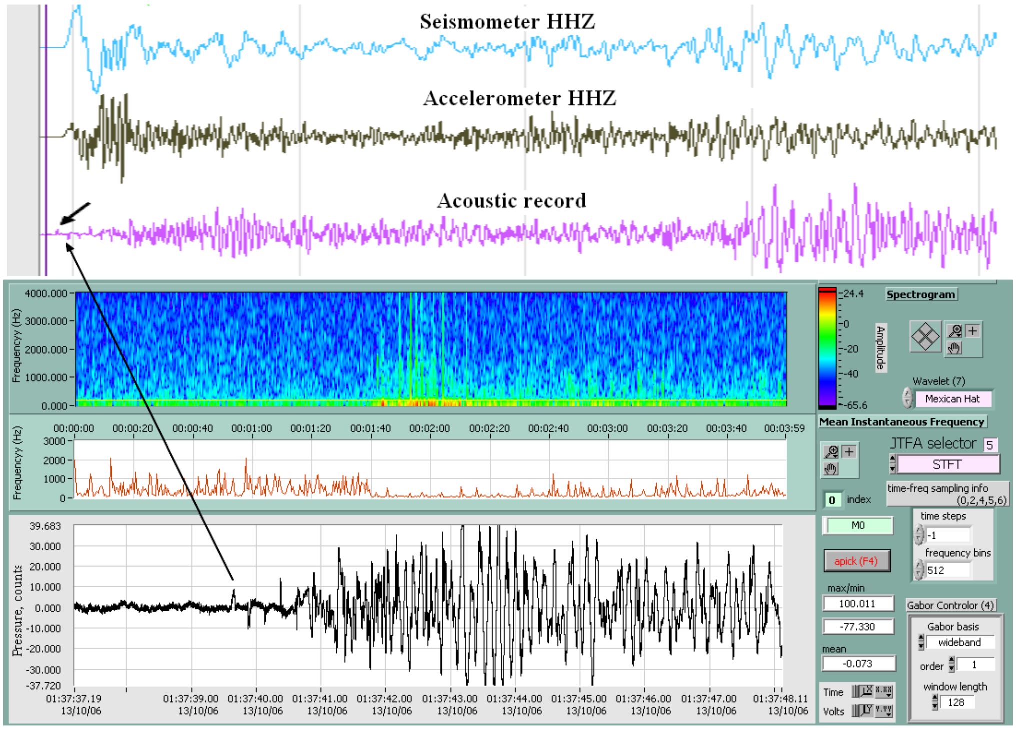

Figure 3. Fracturing from acoustic record, Vrancioaia station, ML=5.5R, H=134 Km

Noises can be heard by sticking the "ear" along the ground or in the air. We use a phonic isolated sensor fixed on a concrete block next to a seismometer-accelerometer, and another one in the air with a wall behind it. Figure 4 showes both cases. We analise the sounds before a seismic period in order to find a connection between the tectonic stress manifested by sounds and seismic activity. Many examples indicate that we have more 'spikes' at high frequencies before an active seismic period.

The records from air measurements include animal behavior. Dogs feel very well fragmentation such as the one in figures 2, 3 and 4. They are accustomed to noise of the surroundings and react when there is a change.

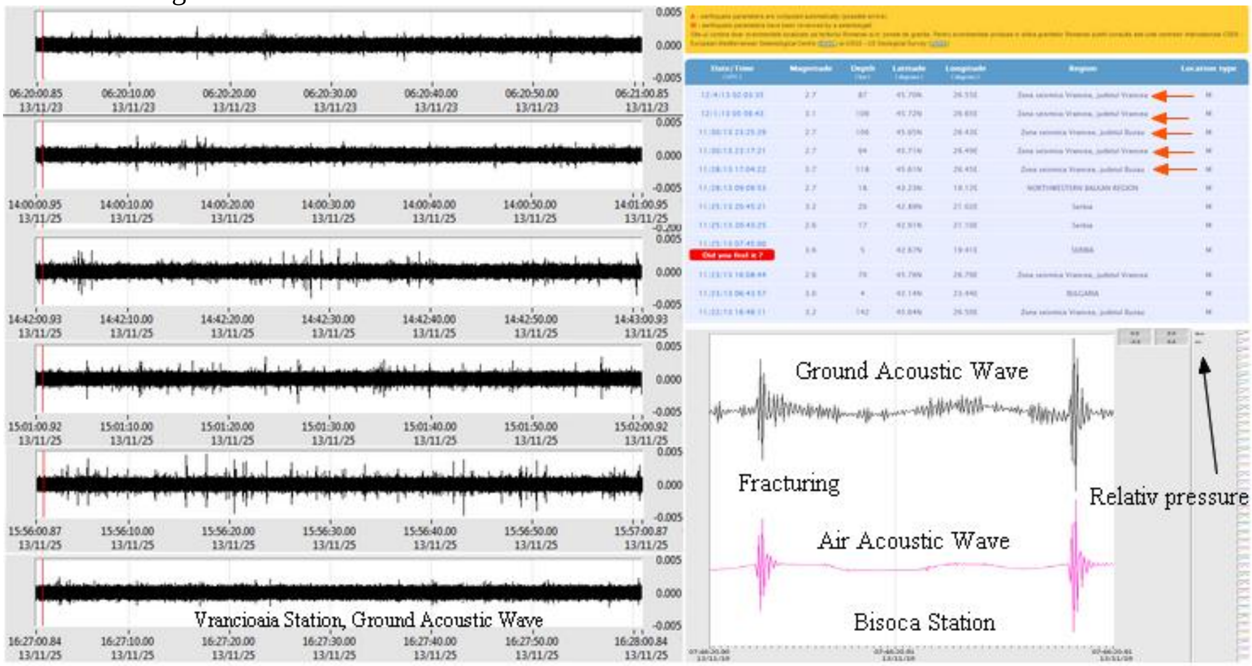

Figure 4. Acoustic waves from ground and air, http://www.infp.ro/realtime-archivel/local-earthquakes

The seismic waves interact with the cracks from the crust. The dynamic deformation of cracks produces sounds. The tests on concrete and other materials prove this hypothesis. An example is in Figure 5. A light concrete has many cracks for a good thermal isolation.

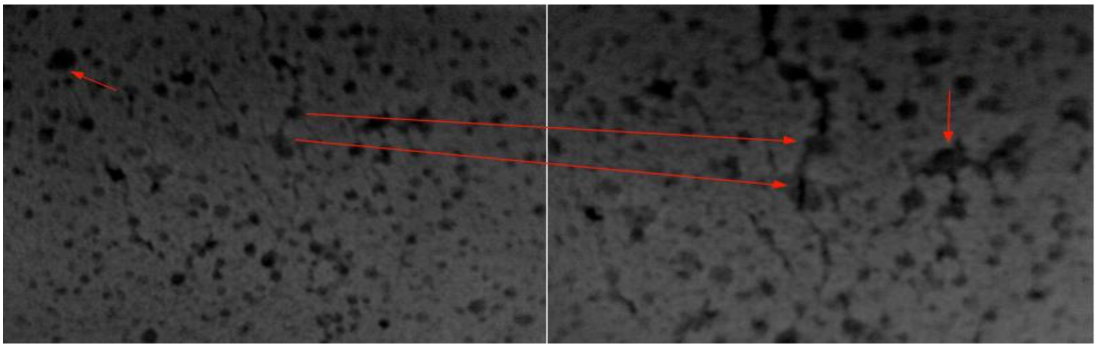

Figure 5a,b Crack deformation generates sound waves

A compression force causes deformations of the cracks and produces a noise that changes when exceeding the elastic domain. These sounds precede the rupture of the material and indicate the initial phase of destruction. An earthquake has similar effects and generates precursor sounds.

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