ACOUSTIC, ELECTROMAGNETIC, NEUTRON EMISSIONS AS SEISMIC PRECURSORS

A. Carpinteri, G. Lacidogna, O. Borla and M. Costantino

Politecnico di Torino, Department of Structural, Geotechnical and Building Engineering,
Corso Duca degli Abruzzi 24, 10129 Torino, Italy

Abstract: Three different forms of emission might be used as earthquake precursors for environmental protection against seismicity. At the tectonic scale, Acoustic Emission (AE) prevails, as well as Electro-Magnetic Emission (EME) at the intermediate scales, and Neutron Emission (NE) at the nanoscale. TeraHertz pressure waves are in fact produced at the last extremely small scale, and fracture experiments on natural rocks have recently demonstrated that these high-frequency waves are able to induce nuclear fission reactions with neutron emissions. The authors present the results they are obtaining at a gypsum mine located in Northern Italy. The observations reveal a strong correlation between AE/NE events and the major earthquakes in the closest area.

1. Introduction

Solids that break in a brittle way are subjected to a rapid release of energy involving the generation of pressure waves that travel at a characteristic speed with an order of magnitude of 10^3 metre/second. We consider the relation $\lambda = v/f$ between the wavelength, λ, and the frequency, f, by assuming a constant pressure wave speed, v, and the wavelengths at the same size scale of the forming cracks: from nanometre (10^{-9} metre) for defects in crystal lattices, up to kilometre (10^3 metre) in the case of faults in the Earth's crust.

Before an earthquake, as deformation increases through tectonic movements, it appears that the Earth's crust surrounding the fault begins to crack as manifested by the increased level of observed AE. This is the reason why AEs (frequency > 20 kiloHertz) generated by cracks at the metre scale are identified as seismic precursor [1]. In the Mega- and GigaHertz range, pressure waves produce electromagnetic emissions through cracks between the micron and the millimetre scale, which turn out to be even a more anticipated seismic precursor (up to a few days before) [2]. When phonons show frequencies between Giga- and TeraHertz, created by cracks below the micron scale, a phenomenon in part unexpected is observed: phonons resonate with the crystal lattices and, through a complex cascade of events, may induce nuclear fission reactions [3]. It can be shown experimentally how such fission reactions emit neutrons [4], which therefore appear to be as the most anticipated earthquake precursor (up to three weeks before) [5].

2. Experimental results

The preliminary results obtained during a dedicated in-situ monitoring at a gypsum quarry located in Murisengo (AL), Northern Italy, revealed a strong correlation between AE/EME/NE events and the major earthquakes in the surrounding area.

The three different emissions anticipate the seismic event by about one day, 2-3 days, one week, respectively. They should be considered precursors of the next earthquake rather than aftershocks of the previous one, on the basis of the different temporal distances (Table 1). The AE hourly rate (Fig. 1a) and the neutron fluence rate (Fig. 1b) vs. the estimated local magnitude in Murisengo are reported. In both cases a power law is obtained. By increasing the perceived magnitude also AE and NE increase. For small earthquakes of magnitude less than 2.5 a decrease in acoustic emissions is monitored, whereas in the case of neutron emissions a sort of plateau of about $(1.84 \pm 0.51)\times10^{-3}$ n cm^{-2} s^{-1} is observed. On the other hand, as conjectured in [3], considering the results described in [6], for higher magnitudes a rapid increment is verified and the expected value of 10^{10} n cm^{-2} s^{-1} for seismic events of the 9th degree in the Richter scale is extrapolated.

	PRECURSORS Time to the next earthquake (days)	**AFTERSHOCKS Time after the previous earthquake (days)**	**Standard deviation (days)**
Acoustic Emissions	1.73	13.32	± 0.65
Electromagnetic Emissions	2.40	12.86	± 0.38
Neutron Emissions	6.95	8.24	± 1.94

Table 1. Acoustic, Electromagnetic and Neutron emissions as seismic precursors

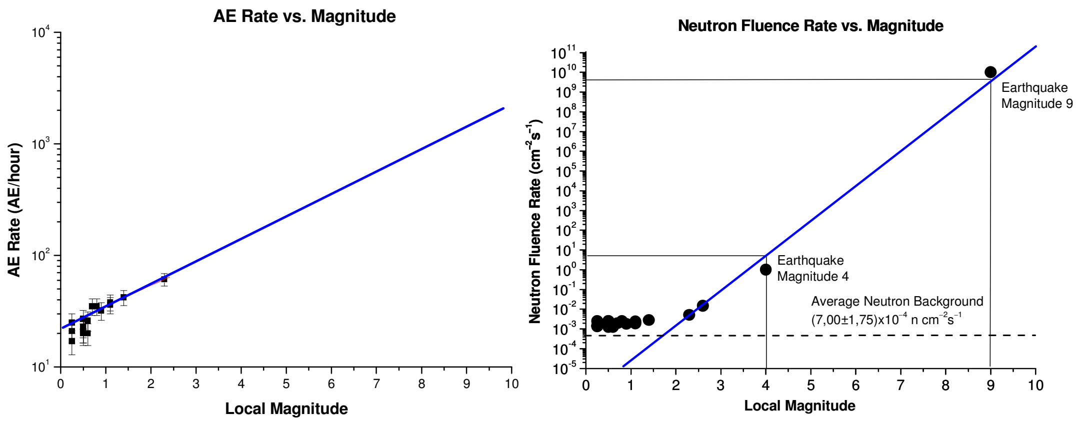

Figure 1. (a) AE Hourly Rate vs. Local Magnitude and (b) Neutron Fluence rate vs. Local Magnitude

3. Conclusions

Preliminary results acquired at a gypsum mine and related to the evaluation of acoustic, electromagnetic and neutron emissions are reported. The experimental data emphasize the close correlation between AE/EME/NE events and seismic activity. By integrating all these signals, it will be possible to set up a sort of territorial database station that combines acoustic, electromagnetic, neutron emissions with radon and CO_2 concentrations, temperature variations, etc.

References

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