ACTA VULCANOLOGICA

Journal of the National Volcanic Group of Italy

Data Related to Eruptive Activity, Unrest Phenomena and Other Observations on the Italian Active Volcanoes 1992

L. Villari, Editor

VOLUME 6 · 1994

GIARDINI

4.2. Seismic propagative effects and waveform composition

F. Bianco, M. Castellano

Osservatorio Vesuviano, via Manzoni 249, 80123 Napoli, Italy

The seismicity recorded on Mt. Etna by Osservatorio Vesuviano network during 1992 was analysed by means of polarization parameters. The aim was that of evaluating both anisotropic characteristics of the volcano and possible variation in stress field without using seismic source models. Unfortunately the recorded seismicity was out of shear waves window making very difficult the anisotropy revealibility, so our study has been aimed, until now, to the propagative effects of structural heterogeneity on waveform composition.

4.2.1. Instrumental and methodological approach

From April 1992 the Osservatorio Vesuviano installed a seismic network on the eastern slope of Mt. Etna (Fig. 4.2.1) composed of two three-components analogical stations and two one-component analogical stations transmitted on a trigger digital system located in Acireale. These seismic signals are elaborated by a fifteen-channels digital system using an STA/LTA algorithm to identify the events onset. From December 1992 the eastern seismic network has been also supported by a three-component digital station in local acquisition, located on Piano Pernicana structure (Fig. 4.2.1).

In September 1992 we have installed a seismic network on Mt. Etna western slope too. This network is composed of three three-components digital stations transmitting in PCM code on a Mixer PCM5800 located in Centuripe (Fig. 4.2.1). All the stations are equiped with short-period (1Hz) Mark L4-C and L4C-3D seismometers. We have chosen the localization of all the seismic stations in agreement with the information acquired from our analyses of 1988-1989 seismic data-set.

During the period 1988-1989 the Osservatorio Vesuviano, in collaboration with the Institut de Physique du Globe of Paris, installed on Mt. Etna a temporary seismic network composed by digital three-components stations in local acquisition (Castellano et al., 1988). The

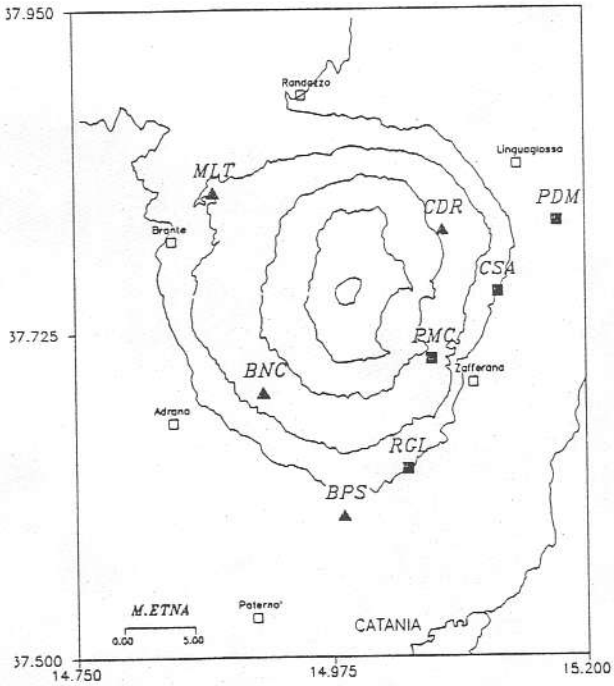

Fig. 4.2.1. – Seismic network of Osservatorio Vesuviano at Mt. Etna. Squares and triangles indicate analogical and digital stations respectively.

instruments were high-dynamic (120 db) Lennartz PCM5800 digital stations in trigger configuration, recording on magnetic tape with 125 Hz sampling rate. Seismometers used were short period 1Hz Mark L4C-3D and 2Hz Mark L4A-3D, with longitudinal component in N-S direction and the transverse one in E-W direction. A set of selected data from the recorded seismicity of that period was analyzed to reveal seismic anisotropy on Mt. Etna from shear wavetrain analyses (Bianco et al., 1992).

A shear wave, that enters into an anisotropic region, splits into two phases, commonly named qS1 and qS2, which can propagate having different polarizations and velocities (qS1 is the faster). Since on re-entering an isotropic medium the original waveform cannot be reconstructed, the information about the anisotropy of a region are acquired by studing both the delay between the arrival time of qS1 and qS2 phases, and the polarization anomaly of S-wavetrain that become elliptical. These phenomena are revealable if the incidence is in the shear waves window (Evans, 1984). We have calculated the time delay between the qS1 and qS2 onsets by means of cross-correlation tecniques (Bowman & Ando, 1987), and polarization anomaly studying the behaviour of the eigenvector related to the greater eigenvalue of the covariance matrix representing the seismic signal (Born & Wolf, 1965; Bianco et al., 1992). The distribution of time delay signs and the polarizations vector chaoticity behaviour suggest us to divide the eastern slope of Mt. Etna in three sectors characterized by a variable degree of anisotropy (Fig. 4.2.2).

We have interpreted shear wave velocity anisotropy on the eastern Mt. Etna slope as due to the presence of cracks or aligned fractures. In an anisotropic area time variations of shear waves splitting could monitor time variations in stress field because the polarization direction of qS1 wave is strictly connected to the stress field direction and the splitting dimension is related to the stress field intensity (Crampin, 1987). To analyse time variations in shear waves splitting we have decided to install the eastern seismic network in places with anisotropic characteristics as revealed from analyses of 1988-1989 dat-set (Bianco et al., 1992). Moreover, we had no sufficient previous informations to delineate correctly

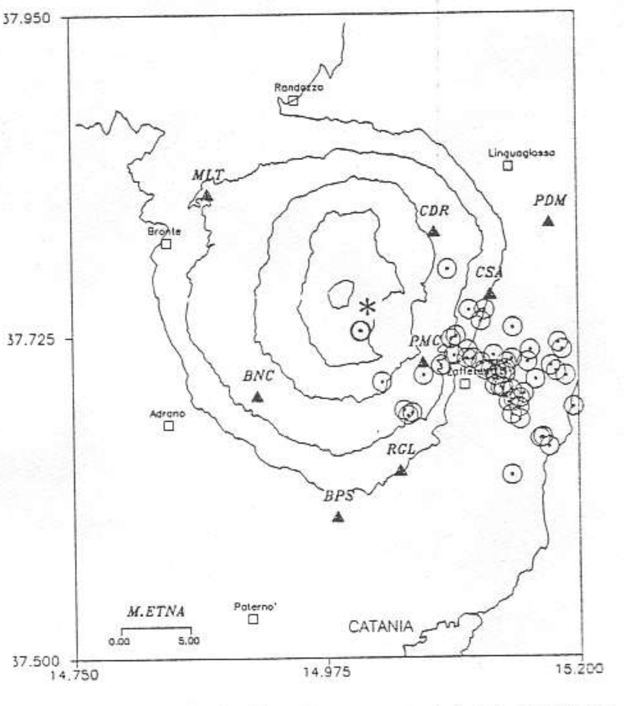

Fig. 4.2.3. – Epicentral distribution of events recorded at least at four stations in the period April-December 1992. Star indicates the event shown in figure 4.2.5.

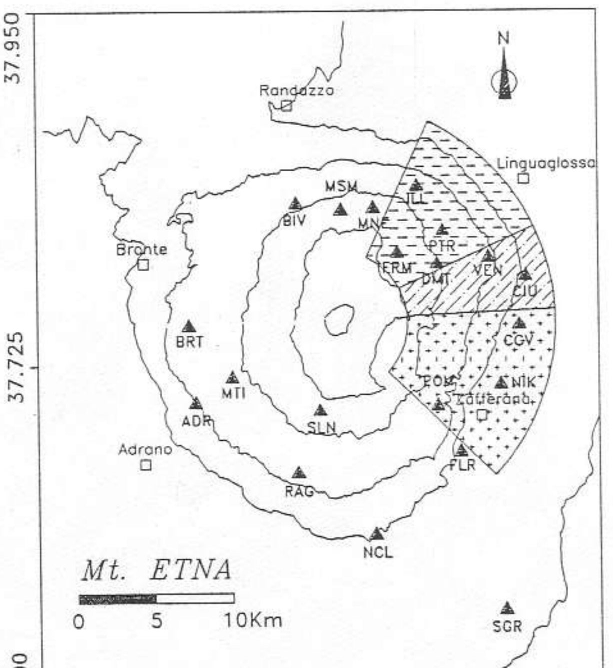

Fig. 4.2.2. – Zonation of the eastern side of Mt. Etna inferred by anisotropic characteristics. Chaoticy degree of the polarization vectors is used as parameter for the classification of the areas.

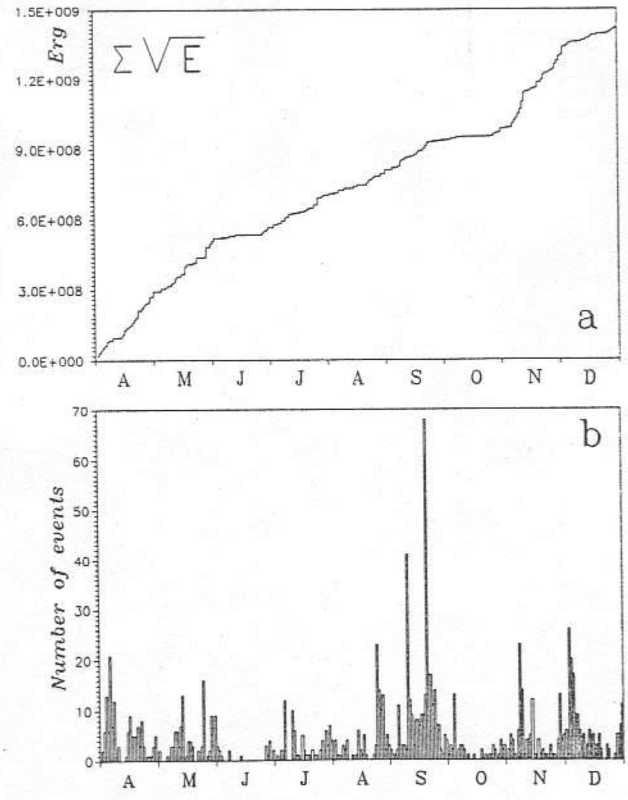

Fig. 4.2.4. – Strain-release (a) and daily frequency of seismic events recorded at least at two station (b) in the period April-December 1992. Note that energy release is very low during the entire period and the abrupt increase in November is linked to few events of more high magnitude (Mmax = 3.0).

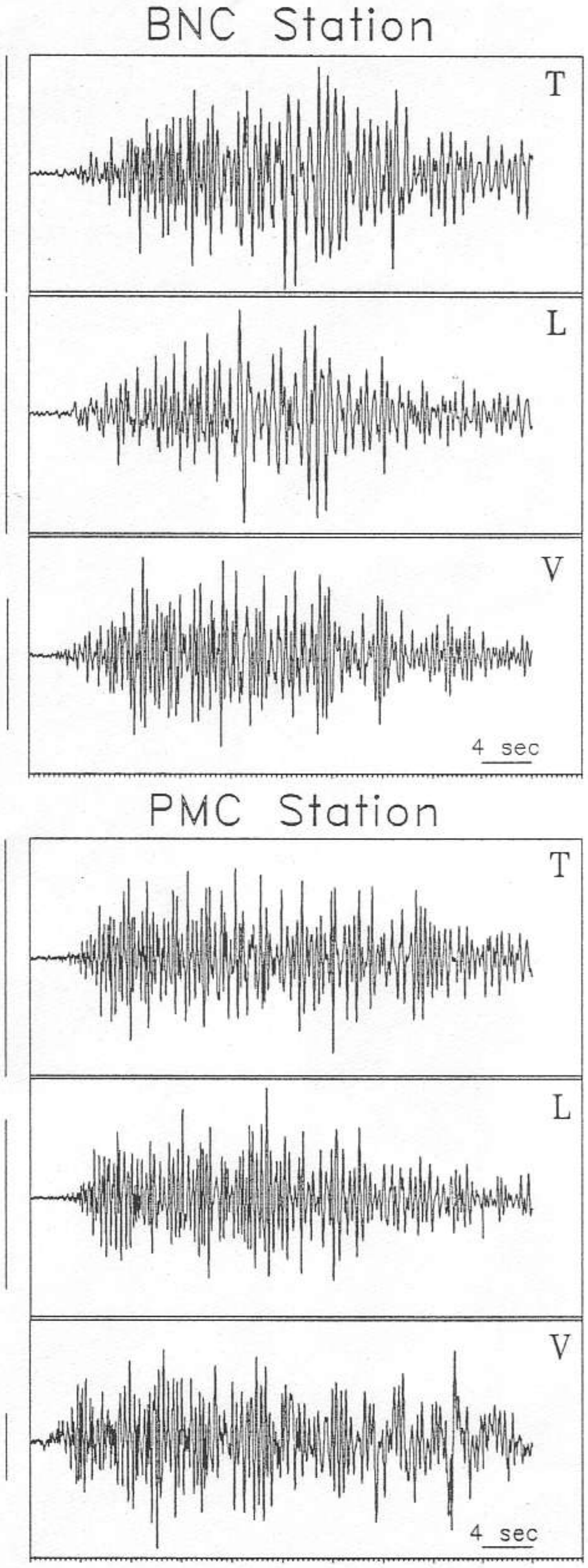

Fig. 4.2.5. – This event (07/11/1992 at 02:57) is indicated by a star in figure 4.2.3. and it is characterized by low frequency and not clear S-phase onset. It is, on the other hand, one of the most energetic events recorded during 1992 (M = 2.8).

the anisotropic characteristics of Mt. Etna western slope, and this is the reason of the western seismic network, besides the importance of the area structural dynamics (Castellano et al., 1991a, b).

4.2.2. Collected data and previous results

In 1992 seismic activity at Mt. Etna, recorded from the Osservatorio Vesuviano seismic network, has been characterized by the presence of low frequency events (1-6 Hz), localized in the summit craters area, and by seismicity connected to the seismogenetic areas of the eastern slope. In figure 4.2.3 are shown the epicentral distribution and in figure 4.2.4 the seismic frequency and the strain-release of the recorded seismicity.

Note that in the examinated period the 1991-1993 eruption was in course. The low seismical energy level of the recorded events has often made difficult to individuate correctly the phases onset, especially for stations a few kilometers far from the sources. Both the network distribution and the not impulsive onsets of the most recorded seismicity have made not easy an analytical localization of the events in the summit area. The most part of the localized seismicity seems to be connected to the dynamics of the eastern slope of Mt. Etna and show well defined localizations with:

RMS < 0.20 sec
ERH < 0,8 km
ERZ < 1.0 km

The hypocentral distribution of these events is concentrated in the upper 5 km of the structure.

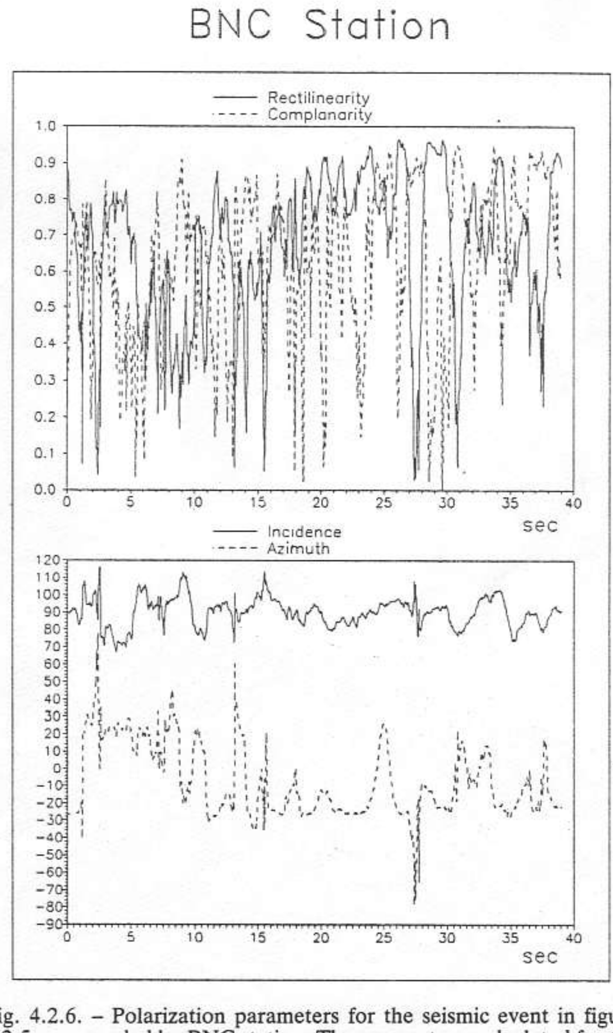

Fig. 4.2.6. – Polarization parameters for the seismic event in figure 4.2.5, as recorded by BNC station. The parameters, calculated for the first 40 seconds of the signal, show a very complex wavefield probably due to the amount of heterogeneity encountered in the complex wavefield probably due to the amount of heterogeneity encountered in the wavefront propagation. The S phase is not clearly recognizable.

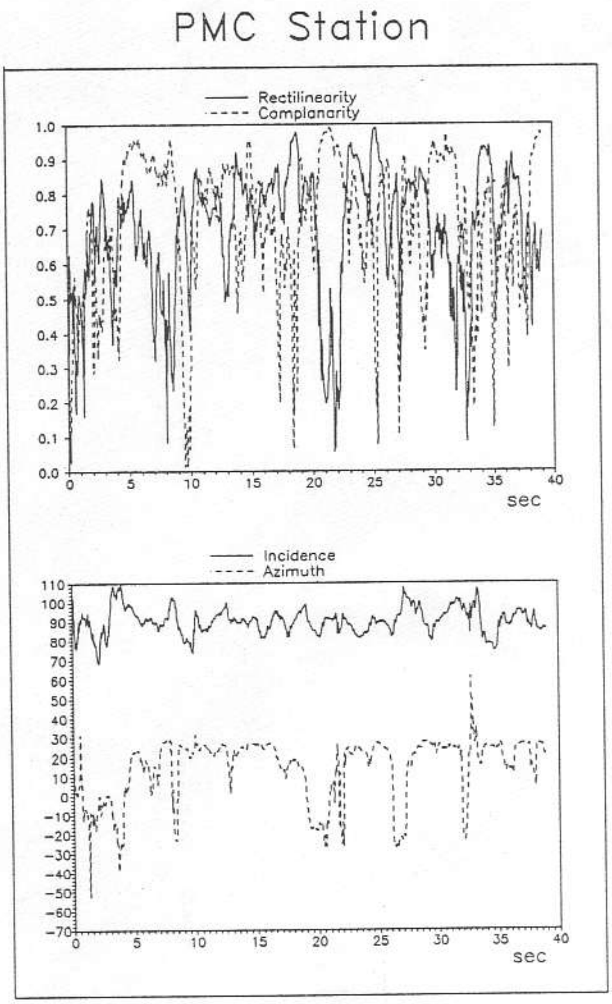

Fig. 4.2.7. – The same as in figure 4.2.6 for PMC station. The level of noise for the parameters calculated at this station seems to be lower, even if the recognition of the S-phase is still difficult.

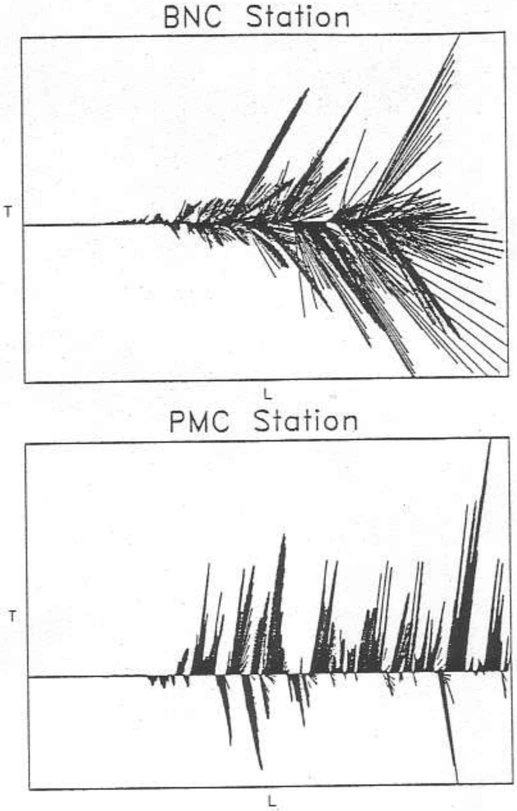

Fig. 4.2.8. – Eigen vector of the greatest eigenvalue of the covariance matrix, on the horizontal plane, representative of the first 15 seconds of the event in figure 4.2.5. Both the stations show a polarization direction prevailing on the trasversal component.

On the data-set we have analysed the composition of the wave-field by making polarization analysis, studying the temporal behaviour of polarization parameters such as rectilinearity, complanarity, incidence and azimuth related to the polarization eigenvector. Moreover we have analysed the temporal behaviour of both particles motion and polarization vector. Examples of this kind of analysis and the related seismograms are in figures 4.2.5 to 4.2.9. The wavefield inferred from the comparative analysis of rectilinearity, complanarity, azimuth, incidence, polarization vectors and particle motions seems to be composed principally by compressional and surface waves, while the shear phase, which onset can be distinguished by the variation of polarization parameters, results contaminated by various phenomena such as scattering, absorption and diffraction. The chaotical behaviour of polarization parameters is in agreement to the distance source-receiver and is related to the interaction between wavefront and free surface too.

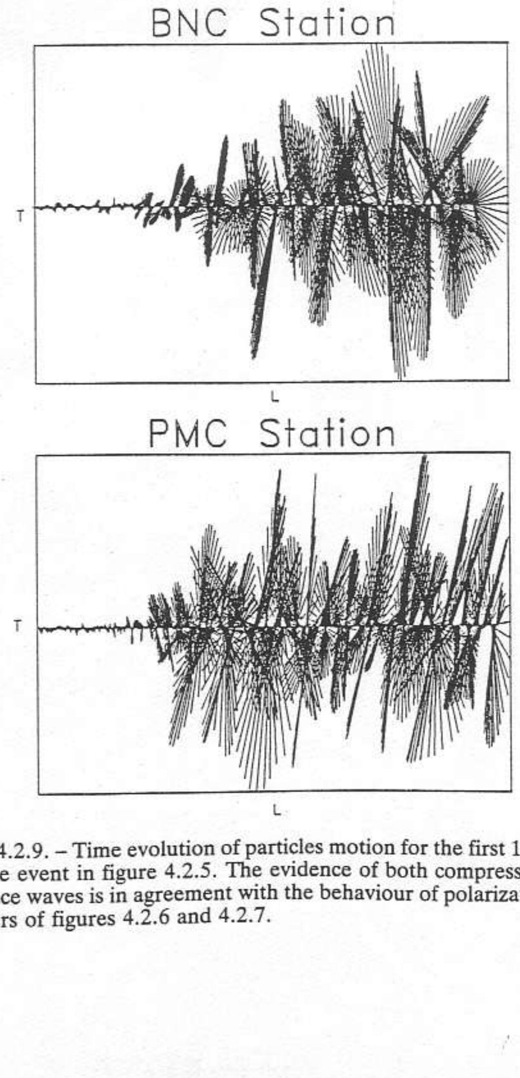

Fig. 4.2.9. – Time evolution of particles motion for the first 15 seconds of the event in figure 4.2.5. The evidence of both compressional and surface waves is in agreement with the behaviour of polarization parameters of figures 4.2.6 and 4.2.7.

4.2.3. Conclusions

The methodological approach, previously described, has allowed to individuate anisotropic characteristics at

Mt. Etna volcano. This type of information is only from 1988-1989 seismic data. In fact the seismic events occurred during 1992 have not the required characteristics for this kind of analyses, having no clear evidence of S-phase and being out of shear waves window. In this condition is impossible to evaluate possible variation of stress field too. The recorded seismicity is actually investigated to a better knowledge of the propagative effects related to the structural complexity of the volcano by means of the waveform analyses.