Osservatorio Vesuviano

Istituto Nazionale di Geofisica e Vulcanologia

Osservatorio Vesuviano – INGV

SEMINARI DI SISMOLOGIA SPERIMENTALE

Presentazione delle recenti attività
del Laboratorio Rete Sismica Mobile

27 Ottobre 2004 – ore 14:30
Sala Mercalli dell' Osservatorio Vesuviano
Via Diocleziano 328, 4° piano
Napoli

PROGRAMMA

Mercoledì 27 Ottobre 2004

Ore 14.30 Apertura lavori

Ore 14.45 Edoardo Del Pezzo, *"Elastic scattering and numerical simulation of the seismogram envelopes in non uniform media"*

Ore 15.10 Mario La Rocca, *"Array Analysis of Cascadia Deep Tremor and Earthquakes in Pacific Northwest"*

Ore 15.35 Vincenzo Nisii, "A*rray analysis of air-gun sea-shots records for imaging the heterogeneous crust beneath the Campi Flegrei caldera"*

Ore 16.00 Simona Petrosino, *"Shallow velocity structures at volcanic sites from inversion of surface-wave dispersion functions"*

Ore 16.25 Pausa

Ore 17.00 Paola Cusano, *"A quadripartite array for seismic monitoring of Mt. Vesuvius"*

Ore 17.25 Danilo Galluzzo, *"Peak ground acceleration produced by local earthquakes in volcanic areas of Campi Flegrei and Mt. Vesuvius"*

Ore 17.50 Gilberto Saccorotti, *"The Noisy Breathing of a Volcano: the 2002-2003 Eruption of Mt. Etna, Italy"*

Ore 18.15 Mariateresa Bonagura, "S*eismotectonic interpretation of seismicity in Sao Miguel Is. (Azores). Contributions from hypocenter relative relocations and others techniques"*

ABSTRACTS

Elastic scattering and numerical simulation of the seismogram envelopes in non uniform media

Edoardo Del Pezzo

The scattering wavefield in inhomogeneous media is described through numerical simulation of the energy envelopes for seismograms of local earthquakes. Results indicate the need of a substantial revision of the attenuation parameters calculated with coda wave analysis.

Array Analysis of Cascadia Deep Tremor and Earthquakes in Pacific Northwest

Mario La Rocca

The July 8-24, 2004 Cascadia Episodic Tremor and Slip (ETS) event was observed using three small aperture seismic arrays located near Sooke, BC, Sequim, WA, and on Lopez Island, WA. Each array was composed of six or seven 3-component, short-period seismometers. Besides recording two weeks of strong, deep tremor many earthquakes with a range of magnitudes, distances and azimuths were also recorded. Earthquake signals have been used to test the resolving ability of the arrays for subsequent analysis of the deep tremor signals. Analysis techniques tested were "Zero Lag Cross-Correlation" in time domain and classical "Beam Forming" and "High Resolution" array methods in the frequency domain. Calculated backazimuth and slowness values of P and S direct phases were compared with those calculated based on the hypocenters determined by the regional network (Pacific Northwest Seismograph Network , PNSN) and the regional velocity structure to give an estimate of the error associated with array techniques. The time domain analysis results show good agreement with the real earthquake locations. The resolution capability associated with the Zero Lag Cross-Correlation method is between 0.01 and 0.02 s/km for slowness and 5-10 degrees in backazimuth, depending mostly on the signal to noise ratio. On the contrary, the results of spectral techniques are less reliable and generally differ more than expected from the true values. This is probably due to the small number of stations composing the arrays which affects the spectral techniques more than the time domain techniques. As a further test, synthetic waveforms were calculated for a variety of parameters including backazimuth, slowness, array geometry and noise level. The synthetic tests results are comparable with those obtained by the analysis of earthquakes.
Array analysis in time domain of strong deep tremor has been applied to both vertical and horizontal components. Results for each array yield consistent estimates of back azimuth and slowness. Among the arrays, the backazimuths give a reasonable estimate of the tremor epicenter that is consistent with the network determined epicentral locations. Polarization analysis in time domain indicates that the deep tremor wavefield is composed mostly by shear waves.

Array analysis of air-gun sea-shots records for imaging the heterogeneous crust beneath the Campi Flegrei caldera

Vincenzo Nisii

The Campi Flegrei caldera structure, southern Italy, is investigated through analysis of multi-channel recordings of sea-shots. The receivers were deployed in the Solfatara crater. The sources consists of about 600 air-gun explotions shots in the Gulf of Pozzuoli at offset ranging between 1 and 4 km, and spanning an azimuthal range of 40°. The array consisted of 24 vertical-component and 4 three-component short period sensors with a maximum aperture of about 250m. The Zero-Lag-Correlation technique was adopted to estimate horizontal slowness and backazimuth of the coherent wavefield crossing the array. The ray parameters and backazimuth obtained by recordings of sea-shots in the northern sector of Gulf, with maximum offset 3 km, show values which are in agreement with those predicted for the 1-D velocity model used for routine locations. For explosion recordings located more than 3 km offset, the coherence curves show a secondary maxima associated to a secondary phases propagating with a lower velocity than the first-arrival P wave. Finite-difference synthetic seismograms, generated with a 2D velocity model, were calculated to explain the observation.
The late arrivals are compatible with waves diffracted from a high velocity body located at about 1 km depth. This evidence concords with the discontinuity observed by 3D tomographic image obtained by Zollo et al. (2003), and interpreted as the collapsed southern rim of Campi Flegrei caldera collapsed during the explosive eruption of 12 Ky b.p. The small spacing among adjacent shotpoints allowed contemporaneous wavefield decomposition at the source and receiver arrays. Using a modified version of the double-beam method, we obtain further constrain about position and geometry of the inferred high velocity boby. A 3D scattering tomography image of caldera, currently performed using recordings of local earthquakes associated to the 1982-1984 bradyseismic crisis, show evidences of structural complexities which are consistent with our results.

Shallow velocity structures at volcanic sites from inversion of surface-wave dispersion functions.

Simona Petrosino

We investigate the dispersion characteristics of surface waves to retrieve the shallow velocity structures at two volcanic areas located at Campi Flegrei (Italy) and Nisyros (Greece). At Solfatara Crater (Campi Flegrei), single-station recordings of surface-waves associated to air-gun shots are analyzed using the Multiple Filter Technique (MFT) to determine the group-velocity dispersion curves of Rayleigh waves. Seismic signals are filtered in different frequency bands and the

dispersion curves are obtained by evaluating the arrival time of the envelope maxima of the filtered signal in each frequency band. Fundamental and higher modes are carefully recognized and separated by using a Phase Matched Filter (PMF). The obtained dispersion curves indicate Rayleigh-wave fundamental mode group velocities ranging from about 0.8 to 0.6 km/sec in the 1-13 Hz frequency band. Phase velocities ranging from 1.5 km/s to 0.3 km/s over the 1-10 Hz frequency band are instead derived from application of Aki's correlation technique applied to data from a dense array operated in neighbour site. The group velocity dispersion curves are inverted to infer a shallow shear-wave velocity model down to a depth of about 250 m. The obtained values of the S-wave velocity are compatible with those derived from cross- and down-hole measurements in neighbour wells. These data are eventually intepreted in light of the geological constraints given by borehole drillings in the surrounding areas.

At Nisyros volcano, we use recordings of ambient noise collected by a dense seismic array deployed in the central part of the summit caldera. We use the correlation method to retrieve the dispersion characteristics of Rayleigh waves over the 4-20 Hz frequency range. The results show that phase velocities range from 0.8 km/s to 0.2 km/s. These data are inverted for a shallow velocity structure, which is characterized by a main discontinuity at a depth of about 70 m.

A quadripartite array for seismic monitoring of Mt. Vesuvius

Paola Cusano.

A small aperture quadripartite seismic array was installed on the South-East flanks of Mt. Vesuvius about 1 km far from the crater axis, with the purpose of improving the seismic monitoring of this active volcano. In order to test the ability of the array to resolve the azimuthal direction of the source of transient signals and hence to discriminate between volcanic events coming from the crater area and artificial blasts occurring in the densely urbanized area surrouding Mt. Vesuvius, we analysed the seismic events by using two techniques MUSIC and ZLCC. These methods work in frequency and time domain respectively. Both techniques retrieve the components of the vector slowness from the dominant peak of the slowness spectrum, allowing the estimation of the apparent velocity and the azimuth of the signal.
The data set used for the array analyses consisted of both sea shots related to illegal fisherman activity and mine blasts recorded during December 2003. The retrieved backazimuth vectors of the sea shots point toward south and south-west, indicating that these blasts generally occur in the Gulf of Naples, mainly along the coast-line between Torre del Greco and Torre Annunziata.
Conversely the mine blasts show backazimuth directions pointing southeastward, where the mine is located.
Moreover, we checked the ability of the array to retrieve the kinematic properties of the noise wavefield by analysing some noise samples at a focusing frequency of 2.5 Hz. For all the analysed samples, the backazimuths values show a great variability and it is not possible to identify a predominant direction of propagation of the noise wavefield.

Peak ground acceleration produced by local earthquakes in volcanic areas of Campi Flegrei and Mt. Vesuvius.

Danilo Galluzzo

The scaling law of the seismic spectrum experimentally calculated at Mt. Vesuvius and Campi Flegrei is used to constrain the estimate of the maximum expected peak acceleration of ground motion. The scaling law was calculated for earthquakes recorded at BKE and OVO stations in the period 1997-2000 for Mt. Vesuvius and for earthquakes occurred during the 1983-84 bradyseismic crises at Campi Flegrei. For Mt. Vesuvius the scaling law clearly deviates from a constant stress drop relation in the whole range of magnitude ($0.4 < M_D < 3.6$) whilst constant stress-drop is found for Campi Flegrei data ($0.7 < M_D < 3.4$). These results are used to give a first estimate of the maximum ground motion corresponding to the largest magnitude (M_{max}) inferred in the two investigated areas by the Gutenberg-Richter formula. The values of the seismic moment M_0 and the characteristic source radius corresponding to M_{max} are used to evaluate the peak ground acceleration PGA. This parameter is determined by stochastic simulation of ground motion.

The Noisy Breathing of a Volcano: the 2002-2003 Eruption of Mt. Etna, Italy.

Gilberto Saccorotti

One of the most powerful and voluminous eruptions of Etna's recent history began on late October, 2002. During the first 16 days of eruption, the activity consisted of sustained ash emissions from a crater located at 2750 m elevation on the S flank of the volcano, accompained by lava outpouring from events located on both the N and S sectors. Eruptive activity suddenly stopped at around 12 GMT on November 12, 2002. During the following 12 hours, the activity at the 2750-m vent evolved to energetic, pulsating Strombolian explosions and strong ash emissions. During this transition, contemporaneous seismic, gravimetric and geochemical measurements provide unprecedented observations of oscillatory phenomena characterising the eruptive dynamics at different time scale. The entire, 12-hour long transition period is associated to a saw-tooth variation of the energy of 1-2 Hz volcanic tremor, to which are superimposed large-amplitude, 24-minute-period oscillations.
Both these changes are markedly anti-correlated with the signal recorded by a gravimetric station located about 4 km from the active vent. Noticeably, such

anticorrelation is not observed either before or after the 12-hour-long transition period. Location of tremor activity is retrieved through inversion of seismic amplitudes observed at a 6-element broad-band network, and shows a complicate migration of the source occurring at time scale of a few hours. The dynamics of the transition activity is furtherly parameterised through data from a Fourier Transform Infrared spectrometer (FTIR) that recorded the intensity of infrared radiation and the SO2/HCl ratios of emitted gas. Intensity depicts a pulsating behaviour occurring at cycles of about 28 minutes, which are significantly correlated with tremor cycles, lagging, by about 5 minutes. Moreover, intensity and SO2/HCl ratios are almost perfectly anti-correlated throughout the whole transition period. These data offer unprecedented insights into the complex mechanisms governing eruptive dynamics at Etna Volcano.

Seismotectonic interpretation of seismicity in Sao Miguel is. (Azores). Contributions from hypocenter relative relocations and others techniques

Mariateresa Bonagura

In this study we analyze the seismo-tectonic implications of the recent seismicity at Sao Miguel Island (Azores).The main tectonic lineaments of Sao Miguel strike:

- NW-SE, in accordance with both the pattern observed in the Azores Plateau and the direction depicted by the Terceira Rift;
- E-W, following the general orientation of the island.

Most of the recorded seismicity is clustered in the central sector of the island and includes the Fogo and Furnas volcanoes and a rift zone, mainly basaltic, which links those central volcanoes. This rift is known as the Achada das Furnas complex and is 5 km long; it consists of cinder cones and lavas, and includes a small, young trachytic centre known as Congro. Observations of recent seismicity are from a large-scale seismic deployment which operated on Sao Miguel from April 2003 through June 2003. Given the low energy of the recorded events (Mmax=3), hypocenters and fault plane solutions from first-arrival polarities are poorly vinculated, therefore hindering any direct correlation with the aforementioned tectonic lineaments. In order to better constrain the location and geometry of the seismogenetic structures, we apply several methods, including Principal Component Analysis of hypocenter data and the Best Estimate Method, which collapses hypocentral clouds on the base of individual location errors.

Moreover, we benefit from waveform similarities of a seismic swarm (160 earthquakes occurred in a few hours) to perform a precise relative relocation through coss-correlation techniques. The results indicate that most of the swarm earthquakes align along minor E-W striking faults, intersecting a maior NW_SE fault on the eastern side of the Fogo edifice. A more widespread distribution of epicentres also occurs within the rift zone. The spatio-temporal evolution of the seismicity suggests that the recorded earthquakes are due to the movement of hydrothermal fluids within a pre-existing tectonic fault. We conclude that the fault segments associated to hydrothermal zones could represent possible sites of hydrothermal explosions.