Giuliano Panza on Earthquake Prediction and Risk

Speical Topics Interview: June 2010

According to our Special Topics analysis on earthquake research over the past decade, the work of Dr. Giuliano F. Panza ranks at #4 by papers, based on 74 papers cited a total of 434 times. In the Web of Science® from Thomson Reuters, Dr. Panza's record includes 109 original articles, reviews, and proceedings papers, cited 715 times between January 1, 2000 and May 6, 2010.

Panza is the Head of the Structure and Non-Linear Dynamics of the Earth (SAND) Group for the Abdus Salam International Centre for Theoretical Physics in Trieste, Italy. He is also Professor of Seismology at the University of Trieste.

ScienceWatch.com talks with Panza about his highly cited earthquake research.

SW: Please tell us about your educational background and early research experiences.

I received my Laurea in physics at the age of 22 from Bologna University. My early research experience culminated in the formulation of a gross model of the density distribution within the Moon using data on perturbations of the orbits of the Moon artificial satellites Luna 10 and Lunar Orbiter I, III, IV.

SW: What first drew your interest to earthquakes?

The impact they have on mankind and the possibility they offer to study the interior of our planet with the aim of understanding Earth geodynamics with a view towards earthquake prediction.

SW: Your most-cited paper in our analysis is the 2001 *Advances in Geophysics* paper, "Seismic wave propagation in laterally heterogeneous anelastic media: Theory and applications to seismic zonation," (Panza GF, Romanelli F, Vaccari F, 43: 1-95). Would you tell us about this paper?

It represents one of the main stages in the development of a pioneering procedure for the realistic modeling of seismic wave generation and propagation in laterally heterogeneous anelastic media.

The methodology described in the paper has been applied, within the framework of the international UNESCO-IUGS-IGCP projects 414, 457 and 487, to the seismic micro-zonation of urban areas like Bucharest, Rome, Beijing, Valparaiso, Sofia, Naples, to the seismic hazard assessment of countries like India, Romania, Cuba, Egypt, China and elsewhere.

"Earthquakes cannot be predicted with great accuracy."

The seismic ground motion modeling and damage earthquake scenarios establish a bridge between seismologists and earthquake engineers. These contributions have led in recent years to much better techniques for urban seismic microzonation, a critical component of urban earthquake risk assessment.

In the paper scientific rigor is effectively merged with production of practical results of general validity and combined with the unquestionable fascination to investigate and possibly understand the structure and geodynamic behavior of our planet.

SW: **Just this year, you and two coauthors published a paper in *Tectonophysics*, "Three-dimensional numerical modeling of contemporary mantle flow and tectonic stress beneath the Central Mediterranean" (Ismail-Zadeh A, Aoudia A, Panza GF, 482[1-4]: 226-36, Sp. Iss., 25 February 2010). What does this work have to say about the tectonics of the region?**

This paper is a natural outcome of very comprehensive international research started in the late '70s based on surface wave non-linear tomography, which led to the demonstration of the subduction of continental lithosphere beneath the Alps and collisional orogens in general, as clearly reported in the first map of the lithosphere-asthenosphere structure in the Mediterranean realm, where it is possible the recognition of relevant lateral heterogeneities in the upper mantle.

The modeled movement of the uppermost crust is consistent with the northeast-oriented motion of the lithosphere and is in an agreement with the geodetic measurements. The flow patterns of the lower crust and uppermost mantle are consistent with the regional observations.

The model predicts (i) northwest-oriented movements beneath the southeast part of the Adriatic Sea region, (ii) the northeastern subduction beneath the western part of the Adriatic Sea, (iii) the upwelling beneath the Tyrrhenian Sea and its eastern coast, (iv) the western movement of the Ionian Sea sub-plate, and (v) the subduction beneath the western Calabria region.

The model also predicts a distinct compressional regime along the northeast part of the Italian peninsula and to the east of Sicily, and a tensional regime beneath the Tyrrhenian Sea, Umbria–Marche region, and Ionian Sea. The predicted tectonic stress regimes in the northern and central Apennines are in agreement with stress regimes derived from earthquake fault-plane solutions.

Changes in the predicted crustal stress pattern and magnitude are likely to be caused by buoyancy-driven mantle circulation beneath the region rather than by gravitational potential energy differences in the crust itself. Based on the model, which is consistent with the global eastward mantle flow, the buoyancy forces play an important role in the contemporary tectonics of the region.

An integrated petrological, geochemical, and geophysical model explains the present-day anomalously high non-volcanic, mantle-derived CO2 emission in the Tyrrhenian region.

SW: **A few of your papers have examined the history of seismic activity at Mt. Vesuvius and the possibility of future volcanic earthquake activity at this site. How likely is this to happen?**

"The seismic ground motion modeling and damage earthquake scenarios establish a bridge between seismologists and earthquake engineers."

At the Somma-Vesuvius volcano, the seismicity in the past three decades (1972–2000) can be described as composed of a background level, characterized by a low and rather uniform rate of energy release and by sporadic periods of increased seismic activity. Such relatively intense seismicity periods are characterized by energy rates and magnitudes progressively increasing in the critical periods.

The steady variation indicates an increasing dynamics in the volcanic system. The analysis of the source moment tensor of the largest earthquakes shows that the processes at the seismic source are generally not consistent with simple double-couples, typical of tectonic events, but that they are compatible with isotropic components, mostly indicating volumetric expansion and fluid motion.

Such focal mechanisms can be interpreted as the effect of explosion phenomena, possibly related to volatile exsolution from the crystallizing magma.

The availability of a reduced amount of high-quality data necessary for the inversion of the source moment tensor, the still-limited period of systematic observation of Vesuvius micro-earthquakes and, above all, the absence of eruptive events during such interval of time, cannot obviously permit the outlining of any formal premonitory signal.

Nevertheless, the progressively evolving dynamics, characterized by a generally increasing trend in the seismic activity in the volcanic system and by a significant volumetric component of recent major events, poses serious concern for a future evolution towards eruptive activity, even if the present behavior of the volcano seems to belong to a period of relative quiescence.

SW: **How much have we learned about earthquakes in the past decade? What advances would you like to see in the future of earthquake research? How reliable do you think current prediction algorithms are?**

Earthquakes cannot be predicted with great accuracy. Reduction of time-space uncertainty of earthquake prediction could be achieved by combining the most advanced geophysical modeling methods with Earth observations.

Short-term predictions might appear the most useful at first glance; nevertheless, considering the problems related with the short-term prevention measures, such predictions should be provided with an extremely high precision, which is probably impossible to attain.

At present, earthquake prediction is routinely possible with uncertainties of several hundreds of km in space and up to a few years in time, not sufficiently accurate for red alert, but fully consistent with low-key actions that, if properly applied, can mitigate earthquake risk. ■

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PROPAGATION, GENERATION, MODELING, LATERALLY HETEROGENOUS ANELASTIC MEDIA, URBAN SEISMIC MICROZONATION, URBAN EARTHQUAKE RISK ASSESSMENT, CONTEMPORARY MANTLE FLOW, TECTONIC STRESS, CENTRAL MEDITERRANEAN, SOMMA-VESUVIUS VOLCANO.

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Photo 1:

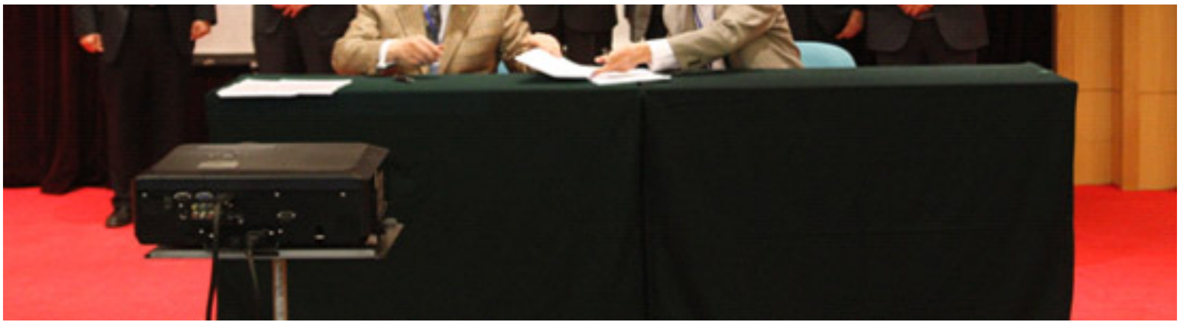
Photo 1 description:

40th Anniversary of Diplomatic Relations between Italy and the People's Republic of China. Prof. Zhu Rixiang for the Institut of Geology and Geophysics of the China Academy of Sciences and Prof. Panza for the Department of Geosciences of Trieste University sign the Memorandum of understanding about the collaboration between the two Institutions during the First Sino Italian Conference on: "Advanced Methodologies and Technologies in Geophysics, Geodynamics and Seismic Hazard Assessment" (Beijing, March 30, 2010).

Photo 2:

Photo 2 description:

40th Anniversary of Diplomatic Relations between Italy and the People's Republic of



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