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Soil radon measurements as potential tracer of seismic and volcanic activity at Etna

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Radon is a radioactive noble gas present in all rocks of the Earth. It's used by the scientific community as a tracer of natural phenomena related to outgassing from the soil along faults, fractures and crustal discontinuity. Recently, radon has also been used on active volcanoes such as Etna, both as a precursor of volcanic phenomena as well as in the study of the dynamics of faults. The Istituto Nazionale di Geofisica e Vulcanologia (INGV) performs discrete and continuous measurements of radon from soil at Etna since 2002.
First studies concerned measurements of radon and thoron emissions from soil carried out on the E and SW flanks of Etna, in zones characterized by the presence of numerous seismogenic and aseismic faults. The statistical treatment of the geochemical data allowed recognizing anomaly thresholds, producing distribution maps that highlighted a significant spatial correlation between soil gas anomalies and tectonic lineaments. These studies confirmed that mapping the distribution of radon and thoron in soil gas can reveal hidden faults buried by recent soil cover.
INGV permanent radon monitoring network was installed in July 2005. First results were obtained during the July 2006 eruption. The radon signal recorded at Torre del Filosofo (TdF, $\sim$2950 m asl) was compared with volcanic tremor and thermal radiance data. The onset of explosive activity and a lava fountaining episode were preceded by some hours with increases in radon activity and more gradual increases in volcanic tremor. After 2006, Etna produced dozens of paroxysmal episodes from a new vent opened on the eastern flank of the Southeast Crater (summit area), that have built up a new, huge pyroclastic cone. In many cases we observed increase in radon activity some hours before the eruptive events. These observations suggest that radon emissions from the TdF zone are sensitive to the local geodynamic pressure induced by magma dynamics in the conduit systems.
Other promising results were obtained by the radon probe installed along the NE flank of Etna ($\sim$1800 m asl), nearby a seismogenic fault that is the westernmost segment of the Pernicana fault system. The probe is located also close to the North-East Rift, an important volcano-tectonic structure of Etna which is site of frequent lateral volcanic eruptions. The collected data (radon, temperature and atmospheric pressure) were statistically analyzed and compared with the main meteorological parameters. In two periods (28/Feb/2010-06/May/2010 and 01/Jan/2011- 18/Feb/2011) we observed major anomalies in the signal of radon. An earthquake swarm has affected the western portion of the Pernicana fault system on 2-3 April 2010. Moreover, the period under investigation was characterized by tree eruptive paroxysms occurred on 11-12 January, 18 February and 10 April 2011, respectively. The maximum release of seismic energy falls almost halfway through the first radon anomaly (28/Feb/2010-06/Maj/2010), after about 33 days from its inception. Regarding the second radon anomaly (01/Jan/2011-18/Feb/2011), two of the three paroxysmal eruptions (11-12 January and 18 February 2011) fall within that timeframe. In this case the radon anomaly begins $\sim$10 days before the 11-12 January paroxysm. The results show the possibility of using the anomalous variations of radon as potential tracers of seismic and volcanic activity.