Geophysical Research Abstracts
Vol. 21, EGU2019-13034, 2019
EGU General Assembly 2019

Geogenic radon for the mapping of active faults in the Fucino basin (central Italy)

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In geosciences, the analysis of the spatial distribution of radon (222Rn) concentrations in the shallow environment provides insights into a range of primary spatial geochemical/geophysical processes. Among the soil gases, 222Rn is considered a convenient fault tracer, because of its ability to migrate to long distances from host rocks, as well as the efficiency of detecting it at very low levels. In the scientific literature, many papers are focused on Rn as tracer of hidden faults, and reported evidences suggest that Rn anomalies are significantly higher than background levels along active faults thus providing reliable information about the fault location and the shallow geometry of the associated fracture zones (Annunziatellis et al., 2008; Ciotoli et al., 2007, 2014; Seminsky et al., 2014; Davidson et al., 2016).

In this work, 1200 soil gas radon measurements were carried out at different scales across exposed and buried structural discontinuities in the Fucino plain (central Italy). Linear radon anomalies along the fault strike constitute the main distribution pattern suggesting the extension of the fault domain. Geostatistical analysis of radon data provided a correlation between the anisotropic shape and the orientation of radon anomalies, and the different fault geometry: broader anomalies linked to a wider and low permeability buried fracture zone in the western sector of the plain; high values and more sharp anomalies along the high permeability fractured zone of the active San Benedetto-Gioia dei Marsi Fault (SBGMF) bordering the eastern side of the plain. However, the intensity of radon anomalies can vary along the fault strike due to permeability and/or porosity changes (i.e. geometry and maturity).

A re-interpretation of the dataset in the light of new seismic data interpretation (Cara et al., 2011) provides new hypotheses regarding the link between radon migration and the process of fault evolution during the progressive linkage mechanism of several fault segments. In particular, radon distribution appears to be controlled by the highest offsets in the case of early stage of the fault and by presence of highly fractured transfer zones at the tips of the fault segments during the linkage process. Furthermore, the cyclicity of the spatial distribution of offsets and radon peaks along the fault strike may confirm the presence of distinct segments of the SBMF with a typical geometry, e.g. relay ramps, suggesting that the linkage process is not completed. The double cyclicity of the cover thickness with respect to the radon values can be interpreted in terms of the evolution of the faults. In fact, as the most fractured area is usually located at the fault tip where relay ramps and secondary faults can be developed, this would result in a symmetrical and opposite distribution of the radon anomalies with respect to the progress of the offset (Fossen and Rotevatn, 2016). This strict link between Rn and fault processes suggests the relation between the stress-strain changes along seismogenic faults and the anomalous signals in geogenic Rn time series.