



Specific suites of earthquakes occurring at shallow and intermediate depths - a signature of major lithospheric deformation episodes in Vrancea seismic zone

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At the southeast Carpathians bend, in Vrancea seismic zone, strong and very strong earthquakes ($M_w \geq 6$) frequently occur at intermediate (subcrustal) depths (70-160 km), in a highly confined (30 x 60 km) epicentral area. Investigations addressing regularities in those earthquakes recurrence periods have so far been concerned just with the actual subcrustal seismogenic volume: possibly existing relationships with the shallower ($h < 60$ km) and less strong ($M_w < 5$) crustal earthquakes which were recorded in an adjacent, broader area, have not been considered. A Na-K-Mg geothermometer anomaly, which we managed to monitor for more than 1 ½ year prior to the occurrence of a strong intermediate-depth Vrancea earthquake, provided a first suggestion that such a major shock could be somehow related also to smaller magnitude crustal events.

The present search for coherence patterns has taken into account main seismic events recorded since 1975 till now in three distinct domains: (i) in the very domain of intermediate-depth seismicity (all the events with $M_w \geq 6.0$); (ii) in a previously outlined crustal lineament of seismic sensitivity, extending between the cities Marasesti and Galati (all the events with $M_w \geq 3.3$); (iii) in another previously outlined crustal lineament of seismic sensitivity, designated as “Vrancioaia region” (events with $M_w \geq 2.6$). The two indicated lineaments of crustal seismicity converge, to delineate an obtuse angle which closely bounds the narrow epicentral domain of the subcrustal earthquakes.

Over the indicated time-period, the considered seismic events series developed as a succession of 4 distinct “episodes”, each episode displaying a highly similar evolution pattern: it started with one of the main crustal events ($2.6 \leq M_w \leq 4.5$) recorded in Vrancioaia region; there followed, 9-23 months afterwards, one or two strong ($6.0 \leq M_w \leq 7.4$), intermediate-depth earthquakes; finally, 5-42 months after the intermediate-depth earthquakes, there was recorded one of the main crustal events ($3.3 \leq M_w \leq 4.4$) of the Marasesti-Galati lineament.

The above-indicated time-lags provided obvious evidence that the considered crustal earthquakes were neither foreshocks, nor aftershocks of the strong intermediate-depth events. Instead, each succession of “Vrancioaia crustal - strong subcrustal – Marasesti-Galati crustal” events appeared to define a major lithospheric deformation episode. In the case of the last recorded episode (“centered” on the strong subcrustal earthquake of 27 October 2004), corroborating evidence that some kind of long-range lithospheric deformation indeed took place has been provided by Na-K-Mg geothermometry anomalies recorded at a deep-origin groundwater discharge (Slanic Moldova): while the corresponding “forerunning” crustal earthquake of Vrancioaia region had occurred on 10 February 2003, the hydrogeochemically anomalous behavior has been continuously manifest from April 2003 until October 2004.

The previously-discussed results revealed that some kind of long-range interdependence seemed to exist between various phenomena (subcrustal and crustal seismicity, groundwater chemistry fluctuations) that occurred in a broad region associated to the Vrancea “nest” of strong earthquakes. Integrated monitoring of the indicated phenomena might further provide precursor signatures of impending catastrophic Vrancea earthquakes. At the same time, there can be assessed possible influences that major lithospheric deformation episodes, related to Vrancea zone, might exert on the seismicity of apparently remote areas (that of the major city of Galati, for instance).