
Rheological properties and earthquake depth distribution : application to the 2016-2018 central Italy earthquake sequence

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Résumé

The 2016-2018 Amatrice seismic sequence occurred along northwest-southeast trending normal faults, accommodating the present-day extensional deformation in the central Apennine intermontane basins (Falcucci, 2016). To investigate whether the crustal rheological properties control the depth distribution of earthquakes, we first divided the dataset into background events (i.e. independent events) and triggered events (i.e. clustered events related to mainshocks or swarms) using the high-quality catalogue distributed by Chiaraluce (2022). The catalogue contains 81,662 events recorded during the Amatrice seismic sequence. To perform the catalogue declustering, we developed a new technique using a self-organising map (SOM), an unsupervised machine learning clustering approach based on an artificial neural network (Septier et al., 2023). The SOM neural network was trained to cluster the catalogue data into two classes based on a set of 22 seismic features calculated for each event. We used a probabilistic approach to classify the resulting SOM clusters, which achieved a balanced accuracy of 90% on synthetic evaluation. Applied to the central Italy catalogue we obtained 25,402 background earthquakes with magnitudes between 0 and 5.4, evenly distributed across the study area.

We then compared the depth distribution of background events to a predicted yield strength envelope that we constructed using published constraints on heat flow (Vedova & al 1995), crustal structure and composition (Barachi 2021, Carafa 2020, Ispra Institute), Moho depth (Agostinetti & al 2022) and strain rates. We defined 3 zones based on their respective geological settings, in which we detected significant changes in the distribution of events at depth. For each zone, we performed a quantitative analysis of the agreement between the predicted and "observed" curves and their spatial variability. Through our analysis, we examine whether (and to what extent) short-term deformation expressed by seismicity reflects the long-term mechanical properties of the lithosphere, and what control might be exerted by other parameters such as tectonic inheritance or the level of decoupling between basement and Meso-Cenozoic sedimentary sequences.

Mots-Clés: deformation, lithosphere, yield strength, mechanical properties, rheologie, earthquakes, Amatrice, machine learning, seismicity

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