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Mini Review

The Mystery of the Deep Earthquakes is Resolved

Rodkin MV[1,2]

[1]Institute of Earthquake Prediction Theory and Mathematical Geophysics, Russian Academy of Sciences, Russia

[2]Institute of Marine Geology and Geophysics, Far East Branch, Russian Academy of Sciences, Russia

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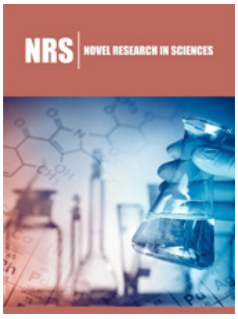

***Corresponding author:** Rodkin MV, Institute of Earthquake Prediction Theory and Mathematical Geophysics, Russian Academy of Sciences & Institute of Marine Geology and Geophysics, Far East Branch, Russian Academy of Sciences, Russia

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Deep-focus earthquakes were an enigma ever since their discovery [1]. It is well known that at the high pressures and temperatures of the Earth's interior, brittle failure is impossible, and the deformations will proceed in the plastic regime. Theoretically earthquakes should not occur at depths more than a few dozen kilometers; nevertheless, they do occur at depths up to 700 km. The paradox is explained by the presence of the deep fluid that decreases the effective friction in rocks and/or by metamorphic processes occurring in down-going slabs. The deep fluid mechanism is suggested as the main cause of the intermediate depth earthquakes, and the deep focus earthquakes are believed to be connected with the solid-state transformations.

If the physics of the different depth earthquake failure is different, the characteristics of earthquakes should differ also. However, no appreciable differences between the source characteristics of the shallow, intermediate-depth, and the deep earthquakes had been known so far. These expected changes were found in [2]. Firstly, a few examples are presented demonstrating that the stress and tectonic deformations are not sufficient for the occurrence of earthquakes deeper than 30-50 km. An additional factor associated with metamorphic transformations is required for the occurrence of deeper earthquakes. Factually earthquakes occur deeper than a few dozen kilometers only if the crustal block (the tectonic plate) sinks in the Earth's mantle, in this case the pressure and temperature in the block change, and the transformations of the block material are occurred. Thus, the intermediate depth and the deep earthquakes occur in the subduction zones, whereas the shear zones with only horizontal displacements are aseismic at greater depths, even in the case of high displacement velocities.

Data from the Global Centroid Moment Tensor Catalog (GCMT, http:/www.globalcmt.org/CMTsearch.html) since 1976 are suitable to estimate the apparent stress values associated with the earthquakes and the half-duration values of the earthquake process (half-duration of the seismic radiation process). When comparing the duration of earthquakes of different magnitude, they are norm by cubic root of the earthquake seismic moment value. Both the apparent stress values and the mean norm durations vary substantially with the depth. What is more, these changes are consistent with the theoretically suggested change in mechanism of earthquakes generation with the depth. The decrease in efficiency of the given mechanism of a brittle failure and the increase of role of the plastic deformation should be accompanied with the increase of brittle failure stresses and in the slowness of process of the seismic failure. Both these changes occur at the depth interval where the change of different modes of earthquakes origin are expected. "Normal" brittle earthquakes occur at depths less than 40-50 km [3-5]. The intermediate-depth earthquakes appear to be connected mainly with the dehydration embrittlement; this mechanism dominates in the depth interval from 30-50 km to 100-120 km (Figure 1); the deep earthquakes appear to be connected with the solid-state transformations.

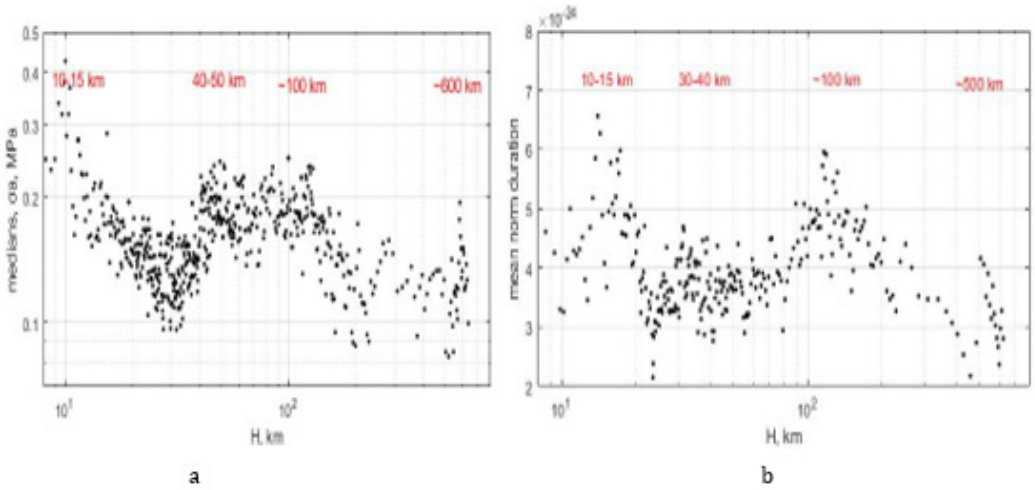

Figure 1: The change in medians of the apparent stress values (a) and of the norm duration of the earthquake processes (b) with the depth.

Confirming the change in earthquake physics with the depth is important for understanding the physics of earthquakes.

The difference in the physics of different depth earthquakes should be taken into account when carrying out algorithms of earthquake prediction.

References

1. Bridgman P W (1945) Polymorphic Transitions and Geological Phenomena. American Journal of Science A 243(1): 90-96.
2. Houston H (2015) Deep earthquakes. Treatise on Geophysics. 2nd Edition.
3. Rodkin MV (2022) The Variability of Earthquake Parameters with Depth: Evidence of Difference of Mechanisms of Generation of Shallow, Intermediate-Depth, and the Deep Earthquakes. Pure Appl Geophys.
4. Role of water in earthquake generation (2001).
5. Wadati K (1928) Shallow and deep earthquakes. Geophys Mag 1: 161-202.