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Paradox of seismicity in subduction zones: Background seismicity and mega-earthquakes

Satoshi Ide[1*]

[1]Dept. EPS, Univ of Tokyo

Since earthquakes release elastic strain accumulated by long-term plate motion, we expect that fast plate subduction yields frequent occurrence of earthquakes. This intuitive expectation is supported by observation. A background seismicity rate estimated by applying the ETAS model in a finite area of subduction zone correlates with the velocity of relative plate motion. Especially a strong correlation exists for subduction zones in the south western Pacific including the Mariana and Tonga-Kermadec subduction zones. Despite high seismicity, no earthquake larger than M9 has been known in these regions and the Mariana subduction zone was considered as a representative region where no mega-earthquake occur in early comparative subductology. In total, these regions have a potential to yield one M9 earthquake every decade, if we assume the complete coupling and the independent occurrence of large earthquakes. On the other hand, there are many regions where seismicity is extraordinary lower than the expectation by the above proportionality. These include the Nankai, Ryukyu, Cascadia, and southern Chile subduction zones, all of which are also known as the area of ”slow earthquake”, i.e., tectonic tremor and slow slip events, and as the high-risk area of mega-earthquakes. Therefore, apparently high seismicity implies low risk of mega-earthquakes, and vice versa. Slow aseismic process seems to be a key to reconcile this paradox. Actually, the above fact is not new, and vaguely and regionally recognized by many researchers. However, I emphasis that it is an important paradox in earthquake science, that should be considered globally and quantitatively.

Keywords: subduction zone, seismicity, ETAS, slow earthquake