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Simulation and Interpretation of Low-Frequency Earthquakes Mechanism: Implications from Phase Diagrams

Xueting Wei (1,2), Xiaofei Chen (2), and Jiankuan Xu (2)

(1) School of Earth and Space Sciences, University of Science and Technology of China, Hefei, Anhui, China (wxt9588@mail.ustc.edu.cn), (2) Department of Earth and Space Sciences, Southern University of Science and Technology, ShenZhen, China

Low-frequency earthquakes (LFEs) are small repeating earthquakes that occur with deep slow slip and are considered as the components of tremor (Shelly et al., 2007). Further evidence shows that the stress drops and scaled energy of LFEs are orders of magnitude lower than those for ordinary earthquakes (Ide et al. 2008). Zhang et al. 2011 have found that tremor has earthquake-like high-frequency falloff. However, there is still a lack of explanation for the LFEs mechanism. Xu et al. (2015) obtained the phase diagram for rupture propagation styles based on the Boundary Integral Equation Methods (BIEMs) and defined 'self-arresting earthquake', for which the rupture process can be autonomously arrested by itself without any outside interference.

In this study, we carried out a vast number of numerical simulations using BIEMs to investigate the mechanism of LFEs. By changing the parameters of the slip-weakening frictional law, we find that the earthquakes with large frictional strength and large critical slip distance provide us good models for LFEs. These special kind of earthquakes are corresponding to the upper right part of the phase diagram obtained by Xu et al. (2015). Since the slip rate of this kind of earthquakes is much smaller than ordinary earthquakes and they can be arrested by themselves like self-arresting earthquakes, we named them 'slow self-arresting earthquakes'. According to our results, slow self-arresting earthquakes can satisfy most of the features of LFEs and are consistent with the source parameters measured from Thomas et al. (2015), Bostock et al. (2015) and Chestler et al. (2016). Since slow self-arresting earthquakes are quite easy to occur even with very small stress changes, the overlapped slow self-arresting earthquakes can explain the formation of tremor.