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A SIMPLIFIED SLAB PULL MODEL: AN EXAMINATION INTO THE OCCURRENCE AND RECURRENCE OF GREAT INTERPLATE SUBDUCTION EARTHQUAKES

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ABSTRACT

In the current subduction paradigm the principal force is that due to the cold, dense plate sinking into the less dense hot mantle. This force is resisted by viscous forces in the mantle and by frictional forces in the "trench" region where large subduction earthquakes occur. In our simplified model this process is represented by a mass (m_2) resting on a horizontal plate, with the mass (m_2) being pulled by a spring (of constant k) connected to another mass (m_1) sinking into a fluid of viscosity η. The mass m_2 on the plate has a static coefficient of friction f_s and a dynamic coefficient f_d. Both physical and mathematical realizations of this model produce periodic slipping of the mass m_2, that represents the stick-slip process of subduction.

Viscosity η is the dominant factor controlling the subduction rate, Young's modulus E (k of the spring) determines the displacement of slipping, and to first order the ratio η/E controls the recurrence rate of slipping.

Application of this model to a system with earth-like properties gives estimates of earthquake recurrence times that are in reasonable agreement with actual subduction zones. The model also gives insight into the critical factors controlling recurrence rates.

INTRODUCTION

Large interplate thrust earthquakes occur due to accumulation of strain associated with subduction processes in the trench region. That the stress associated with this strain is released by large earthquakes with a statistically characterizable recurrence rate, is itself an indication that subduction is episodic or stick-slip. It is also evidence that for long periods during the subduction process the subducting slab can be viewed as sinking into the mantle under its own weight while suspended from the locked zone at the trench.

This research is motivated by a desire to understand the general phenomenon of subduction and the recurrence rates of great subduction earthquakes. Great subduction earthquakes are the cause of the largest natural disasters and this knowledge can be of use in the Taiwan-arc "region" where has been classified as one of the highly potential areas for these great earthquakes (McCann *et al.*, 1979).

The negative buoyancy force of the cold and dense subducted slab is a key factor in driving the plates. From the thermal model of McKenize (1969), this force, called slab pull, can be estimated by integrating over the slab forces caused by the density contrast between the denser subducting material and the density of "normal" surrounding mantle material. Slab pull (as large as 10^{13} N/m) contributes the major stresses inside the slab (Richardson, *et al.*, 1979; Turcotte, *et al.*

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