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Progress in the study on the earthquake preparation process and its significance in the earthquake prediction research

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1. Introduction

In order to predict earthquakes, we have to know why and how earthquakes are generated. This is an important motivation for the New Earthquake Prediction Research Program that started in 1999. The 2nd 5-year program started in 2004 and its review was reported on January 15, 2007.

In my talk, I would like to summarize the results of the studies related to the earthquake preparation process, their significance in the earthquake prediction research, and prospects of the long- and mid-term prediction.

2. Earthquake preparation process

Recent studies have revealed that the fault strength is not so large and the stress drop at an earthquake amounts to a considerable portion of the shear stress on the fault prior to the earthquake. Therefore, it is hard to generate earthquakes just after the previous earthquakes at the same location. In other words, strain-energy accumulation is indispensable as an earthquake preparation process, and earthquakes are not occurring randomly by any means.

Earthquakes occur when the shear stress exceed the shear strength of the rock. Therefore, earthquake occurrence date and location can be roughly estimated if we have enough information on the satio-temporal distributions of stress and strength. Source size can be also roughly estimated in advance if we know the distributions of strength and strain energy.

The strength, stress, strain energy - it is very hard to estimate every single one of them, though. We have to rely on some models for the earthquake preparation process.

3. Interplate earthquakes

GPS observational studies have shown that aseismic slip frequently occur on some plate boundaries. Moreover, it has been revealed that there are many small seismic patches that cause similar earthquakes repeatedly on the plate boundaries. Based on these researches and studies on the source processes for old earthquakes, a model has been constructed as a revision of the traditional 'asperity model'. In the new asperity model, a plate boundary is composed of asperities (where seismic slip is dominant) and aseismic regions (where aseismic slip is dominant), and various phenomena can be explained by the interaction of slip on the asperities and aseismic regions.

On the other hand, the combination of asperities to be ruptured can vary from event to event. Therefore, it is difficult to estimate the rupture extent correctly in advance. Nevertheless, all we have to do is evaluate only few combinations of asperities.

4. Inland earthquakes

Active faults are thought to cause large earthquakes repeatedly, but is still unclear the reason why. Several models have been proposed to explain it. All these models are composed of elastic-brittle (seismic) parts and inelastic-plastic (aseismic) parts. The most realistic models are thought to be those in which inelastic-plastic portions are located beneath active faults. In these models, the stress and strain are concentrated above the inelastic-plastic portions and large strain energy can be accumulated there.

5. Intraslab earthquakes

Normal stress is very large below the depth of several tens of kilometers; very large shear stress is needed to generate earthquakes if the rock has ordinary strength. Therefore, many researchers proposed models in which fluids embrittle the rock. If such models are correct, it is expected that large intraslab earthquakes occur in the portion where microearthquake activity is higher and seismic-wave velocity is slower than the surrounding regions. Actually, some portions of slabs such characteristics.

6. Concluding remarks

The studies on the intraslab earthquakes are not explicitly included in the present project. The clues to evaluate the earthquake-generation potential have been obtained even for intraslab earthquakes. Therefore the evaluation of the earthquake-generation potential for the whole regions in and around Japan will be a major target of the next project.