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沈み込み帯のレオロジーにおける現状と課題
Subduction-zone rheology: current status and future tasks

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I have re-evaluated Subduction-zone rheology and seismicity and have listed the following 7 major tasks (Shimamoto, 2010, JpGU; Shimamoto, 2010, GRC). This review talk will focus on task 1 and task 4 which will be important with respect to the seismogenic-zone drilling and slow slip, respectively. Task 1: High-velocity (HV) friction of faults to evaluate the response of shallow accretionary prism to earthquake rupture coming from depths. Task 2: Friction and fracture experiments to determine velocity dependence of faults and post-failure curve for understanding low-frequency earthquakes in shallow subduction zones. Task 3: Reexamination of exhumed accretionary prism such as Shimanto belt with a renewed view that background deformation of accretionary prism itself is overprinted by impulse-like deformation due to rupture propagation from depths. Task 4: High-temperature and ultralow effective-pressure (Pe) friction experiments to understand slow slip and nonvolcanic low-frequency tremors in the transitional regime. Task 5: Deformation mechanisms along megathrust faults, particularly evaluation of the significance of pressure solution. Task 6: Studies on hydrofractures, permeability and fracture seal in metamorphic environments which are needed to analyze pore-pressure (Pp) evolution in subduction zones. How unusually high Pp can be maintained in slow slip regime is a difficult but an exciting problem. Pp may be the most important factor in delineating the megathrust and slow-slip regimes. Task 7: Dynamic analysis of slow slip and megathrust earthquake cycles using realistic fault properties are needed to understand how a megathrust earthquake initiates. Recent modeling of Matsuzawa et al. (2009, AGU; 2010, JpGU) brought about changes in frequency of slow slip prior to a megathrust earthquake. Earthquake forecast might become possible by exploring interactions between megathrust and slow slip regimes.

One of the central issues in the Nankai drilling project is to explain the updip limit of seismogenic zone. A fashionable view for the aseismic to seismic transition is the change from velocity weakening at shallow depths to velocity strengthening at the updip limit. Despite nearly 10 years efforts of PennState group, it was not easy to get velocity weakening behavior for clayey fault gouge. I proposed that high-velocity friction is important to study the response of shallow accretionary prism to the megathrust rupture coming from depths (Shimamoto, 2009, AGU). Faulkner at al. (2010, Padova workshop) went one step further; they showed that fault gouge composed of several clay minerals has very low friction without clear peak friction (drained high-velocity experiments) and proposed that the earthquake rupture can propagate through the shallow accretionary prism without much resistance. A new low to high-velocity machine at Institute of Geology, CEA, Beijing was designed to study this problem and has a velocity jump capability up to six orders of magnitude. I would like to summarize the current status on this issue including some new experimental results.

Another issue I will address is fault rheology in the slow slip regime. Recent modeling of slow slip by several groups strongly suggests that Pe is on the order of several MPa or lower in the slow-slip regime. Seismicity has been reported at estimated temperatures even over 500 degrees Celsius. Shimamoto and Noda (2101, AGU) proposed an empirical law linking the rate-and-state fault constitutive law and rate-and-state flow law (Noda and Shimamoto, 2010, GRL). This will be useful for modeling slow slip and low-frequency tremors and will give insight on designing experiments to cover the brittle to fully plastic fault motion using realistic rocks. The law predicts how brittle frictional properties remains to higher-temperature condition with increasing pore pressure.

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