Slip mechanism of a major out-of-sequence thrust in an accretionary complex

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In subduction zones, large out-of-sequence thrusts of accretionary prisms are primary source faults generating earthquake and tsunami, as well documented in Sumatra, Nankai, and Alaska. The out-of-sequence thrust (OOST) or splay fault in eastern Nankai Trough is characterized by a strong seismic reflector with negative polarity, which suggests existence of over-pressured fluid along the fault. On the other hand, geologic observations for co- and inter- seismic periods are quite important to understand the relationship between faulting and earthquake dynamics in the OOST. Therefore, we have examined a large fossilized out-of-sequence thrust, the Nobeoka thrust, in the ancient accretionary prism of the Shimanto Belt, Kyushu, SW Japan. The thrust is exhumed from the seismogenic depth of 7-10 km depth. The rocks in the Nobeoka thrust record a history of deformation in the past.

The hanging wall of the Nobeoka thrust is composed of phyllites. The phyllites record deformations from deep to shallow depth in the seismogenic zone because the maximum temperature (320 degree C) shows the deeper part of seismogenic zone. In the hanging wall, phyllite zone are developed from the Nobeoka thrust to about 1,600 m in thickness. The zone looks strongly deformed and is sandwiched between alternating beds of sandstone and shale and pelitic mélange. In this study, I researched the phyllite zone in terms of mesoscopic to microscopic observation, chemical analysis, and geometric analysis to reveal the deformation history of the Nobeoka thrust.

The evolving processes of the shear zone are classified into three stages:

First stage: Disseminated shear controlled by diffusive mass transfer and plastic shear. This process primarily developed phyllitic cleavages. Shear strain calculated from the angle between S and C-surfaces gradually decrease toward the Nobeoka thrust. The total value of displacement might be 1,500 m at a maximum.

Second stage: The displacement of type 1 veins along the discrete cleavage in phyllite. The slip mechanism of the shear shows diffusive mass transfer and grain boundary sliding. The displacement of type 1 vein is found from the Nobeoka thrust to about 200 m. The shear in this stage is localized compared to that in the first stage. The total shear strain suggests about 56 m shear displacement in the hanging wall.

Third stage: Seismic slip along the discrete subsidiary faults in the hanging wall during juxtaposition of the hanging and the foot walls. Considering from the temperature estimated from fluid inclusion analysis the seismic slip happened at the lower to middle seismogenic depth in the subduction zone.