



An active footwall shortcut thrust revealed by seismic reflection profiling: a case study of the Futaba fault, northern Honshu, Japan

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The Futaba fault is located along the Pacific coast of southern part of Northern Honshu and continues at least 100 km. Based on tectonic morphological research, its central part show the active tectonic features. Due to the effect of M9 Tohoku Oki earthquake 2011, the evaluation of Coulomb stress changes on the fault surface is concerned for the assess of seismic hazards. To investigate the deep geometry of seismogenic source fault and basic crustal structure, we performed deep seismic reflection profiling along the 58-km-long seismic line across the Futaba fault. The seismic data were obtained using four vibroseis trucks and 1164 channel recorders. The seismic section portrays the half graben filled by 1000-m-thick lower Miocene fluvial sediments, suggesting that the Futaba fault reactivated as a west dipping normal fault during the early Miocene associated with opening of the Sea of Japan. On the hanging wall of the Miocene normal fault, Mesozoic metamorphic rocks are cropping out forming a narrow range parallel to the fault. On the footwall of this range, footwall shortcut thrust is clearly identified by the deformation of Plio-Pleistocene sediments on the seismic section. The deeper extension of the Futaba fault can be traced down to 4.5 seconds (TWT) and sub-horizontal reflectors are developed around 6-7 seconds (TWT). The dip angle of the Futaba fault in the seismogenic zone is about 45 degrees. The footwall shortcut thrust was formed at the shallow high-angle part of the Futaba fault as a low-angle (30 degrees) reverse fault. The formation of half graben is limited along the northern part of this fault system. The footwall shortcut thrust was developed along a 40-km-long segment only accompanied with the Miocene half graben. The southern segment of the surface trace of the Futaba fault suggests a straight geometry may represent a change in dip angle.