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Petrophysical properties of fossilized seismogenic megasplay fault

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To understand the evolution and fault mechanism of subduction zone megasplay fault branching from plate boundary, Nobeoka Thrust Drilling Project (NOBELL) was carried out in 2011. Nobeoka Thrust is known to be a fossilized megasplay fault (out-of-sequence thrust) in ancient accretionary complex, located onland in Kyushu, Japan. In this project, coring and wireline logging were conducted down to 255m in total depth across the Nobeoka Thrust. Continuous logs of resistivity, density neutron porosity, natural gamma ray, and optical/sonic images were successfully acquired along the borehole wall.

In this study, we focus on the interval of 20-60m, including the main fault core (at 41m), and compare the physical properties among hanging wall, footwall, and fault core, correlating logging datasets and core description. Structure of hanging wall is characterized by phyllite and relatively stable foliation. Stronger deformation and boudinage can be seen from ˜38m toward fault core. Random fabric cataclasite characterizes fault core, while cataclasite / foliated cataclasite are spread throughout footwall.

Footwall presents higher values of neutron porosity (4.6-10.5%) compared to hanging wall (2.3-8.7%), while porosity is lowest (3.2-10.2%) around fault core. Resistivity is higher at hanging wall (SN: 138-622 ohm-m), followed by drop near fault core (151-203 ohm-m) and stably lower footwall (163-323 ohm-m). P-wave velocity is highly fluctuated and slightly higher at hanging wall and higher values at fault core (3.3-5.0m/s) and values are stable at footwall (3.8-4.6m/s). Local decreases in natural gamma ray (91.9-134 API) and spontaneous potential (39.4-57mV) are characteristic around fault core, while values are nearly constant at hanging wall (81-158 API, 18.7-64.2mV) and footwall (91.1-152 API, 53.3-59.7mV). Density log is fluctuated and does not show significant changes throughout depth (2.4-2.9g/cc).

Crossplots of these logging data are useful to examine relationship between the logs and extract different responses with depth. A resistivity-porosity plot clearly illustrates that the fault core, hanging wall, and footwall show different trend. We also apply empirical formulas (such as Archie's formula and Wyllie's formula) to evaluate relationship between physical properties and internal structure and characterize hydrological properties. Permeability derived from porosity and resistivity show highest values around fault core, despite the lowest porosity value at the interval. These results provide important suggestions to understand structural and hydrological properties associated with fault activities and to connect modern and ancient seismogenic megasplay faults.