CHIKYU IODP Full proposal for Bend-Fault Hydrology in the Old Incoming Plate (H-ODIN): Scientific objectives and drilling strategy

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The oceanic plate has played a main role in global deep water circulation within the Earth. It has been considered that the main water reservoir of the subducting plate is the upper crust. Crustal hydration at mid-ocean ridges by hydrothermal circulation has been considered to be the first-order control on the degree of the oceanic plate hydration. Previous ocean drilling projects have aimed to reveal hydration processes and their extent of oceanic crust at spreading centers (e.g., Alt et al., Proc. ODP Sci. Res., 1996; Bach et al., G-cubed, 2003; Wilson et al., Science, 2006). In the last two decades, it has been, however, generally accepted that extensive hydration due to plate bending-induced normal faults (bend-faults) occurs in the region between trench and outer rise (outer rise) (e.g, Ranero et al., Nature, 2003; Key et al., EPSL, 2012, Fujie et al., GRL, 2013). It is emphasized that little is yet known about the degree and style of hydration in the oceanic plate at outer rises. Bend-fault hydration processes depend on thermal conditions and stress state. Investigating several subduction zones with various conditions is crucial to expand our knowledge of bend-fault hydration processes. The northwest Pacific (NW Pacific) region is one of the world oldest, thus coldest, and most studied oceanic plates, and is therefore a high priority region to study bend-fault hydration. Water circulation (deep penetration and deep upwelling) and hydration through the bend-faults in the NW Pacific region is supported by results from extensive recent geophysical survey: (1) Horst and graben structures formed by bend-faulting are the best developed in the world (Nakanishi, Springer, 2011) (2) Large bend-fault earthquakes (M>7) have repeatedly occurred and been well recorded, (3) Detailed Vp/Vs variations within the incoming plate have been determined (Fujie et al., 2013, Nature Comm, 2018), (4) The local stress state is likely to have changed significantly after the 2011 Tohoku Earthquake (Obana et al., Geophys. Jour. Inst., 2019), and (5) Anomalously high heat flow suggests heat transport by water circulation (Yamano et al., EPSL, 2014; Kawada et al, G-cubed, 2014). In addition, the NW Pacific Plate is the best place to comprehensively study relationships between subduction inputs, subduction tectonics, and subduction zone processes because one successful drilling project (JFAST) and a newly planned drilling project (JTRACK) will further augment the research goals of this proposal and because geochemical compositions of volcanic rocks and their quantitative modeling has also been extensively studied in the northeastern Japan Arc. Moreover, intraplate normal-faulting (i.e., bend-fault) earthquake in the outer rise occurred within a day to 37 years after the plate-interface earthquakes. Both types of earthquakes caused tsunamis that caused massive damage along the coast of northeastern Japan Although there have been several outer-rise earthquakes (M7 class) along the Japan Trench since the 2011 Tohoku-Oki earthquake (e.g. Asano et al. EPS, 2011), we must be aware of the possibility of the future outer rise earthquake (e.g. Lay et al. EPS, 2011). We are likely be in a rare phase between a giant megathrust event and its potential outer-rise doublet. It is imperative to understand the nature of the outer rise normal-fault earthquake and assess tsunami hazards.
In order to address (a) hydration processes and their extents along bend-faults, (b) geophysical, chemical and structural properties of the bend-faults, (c) outer rise earthquake and development of horst-graben structure, and (d) lithospheric biosphere: its living conditions and sustainability, we will analyze in-situ physical properties and lithofacies that will be best obtained by ocean drilling in the NW Pacific region.

Two drill sites are absolute minimum requirement (fault along sediment and basement, fault within basement).

Keywords: Oceanic Plate, Outer rise, Subduction zone, Earthquake

