White Paper for Alaska Primary Site Planning Workshop

Impact of the Lithological Input into the Alaska/Aleutian Subduction Zone on Hydrology and Physical State of the Subducting Zone

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This white paper addresses some aspects of three of the key GeoPRISM SCD questions:

"How do volatile release and transfer affect the rheology and dynamics of the plate interface, from the incoming plate and trench through to the arc and backarc?"

" How are volatiles, fluids, and melts stored, transferred, and released through the subduction system?"

"What are the geochemical products of subduction zones and how do these influence the formation of new continental crust?"

It also addresses the 3rd SCD process-based theme on "Fore-arc to Back-arc Volatile Fluxes.

The lithological input into subduction zones (SZs) is an essential parameter that effects both the physical properties of the subducting slab and the volatiles budget of the system. The input of hydrous phases and thermal state constrain the dehydration reactions (e.g. Moore and Saffer 2001) and subsequent metamorphic reactions (e.g. Peacock 1990; Hyndman and Wang).

The Alaska SZ is unique in its incoming lithology, diatoms comprise a significant portion of the incoming sediments. Diatoms contain ~10 wt% structural water. Unlike clay minerals with 2 well defined types of water, one that dehydrates at <110 °C and the other at >350 °C, and mostly at 400-500 °C, diatoms have 5 types of water that are released step-wise (with minor overlapping) between 25 > 300 °C; the dehydration approximate temperatures were determined (Knauth and Epstein, 1982), hence, the release of water from diatoms has a distinct pattern: some of it overlaps with that of the 1st type of water in clays, and some precedes the 2nd type in clays, hence, should influence the hydrology and volatile cycling at this SZ. The transport and release of H_2O through the megathrust zone is a key question and the diatom input has an important impact on it.

Furthermore, the dehydration of diatoms and the high silica concentrations in pore waters in diatom-rich sediments, should effect clay dehydration and transformation reactions, they may be delayed to occur at higher temperatures than in the absence of diatoms. This topic is not well explored as yet, and should be addressed both experimentally and by modeling.

Diatoms, if at high concentration, also strongly effect the physical properties of sediments, in particular, the permeability and the porosity reductions with burial depth. Diatmaceous sediments even at shallow burial depths have high porosities but unusually low permeabilities controlled by the ultramorphology of diatoms, by the interlocking of the diatom frustules; this has been documented in such sediments, for example in the Monterey Formation, CA (Isaacs, 1981; Issacs et al., 1981). Diatom-rich sediments also do not follow the classic marine sediments porosity-depth reduction profiles (Hamilton, 1976), instead, the porosity reduction is a step function that is controlled by the transformation of opal-A opal-CT (e.g. Isaacs et al. 1981). The high dissolve silica in the pore water during the diagenesis to opal-CT may also impact the sediment strength by early cementation (e.g. Kastner, 1981).

All the above are strongly influenced by the thermal structure of the region, as yet only sparsely characterized.

The segmentation of this SZ, is most likely at least partially controlled by the differences in sediment type and thickness along-strike, (the eastern half of the megathrust is more sediment-rich and is associated with the largest megathrust evens), and the sediment composition in turn is influenced by the diatom content that varies along-strike. It influences both the amount of H_2O in the system at various temperatures and the Si concentration at the depth of magma generation, hence the composition and therefore viscosity of the magma. This may contribute to the along-strike variation in the composition of the volcanic rocks composition .

(The Bering Sea sediments were well characterized during DSDP Leg 19, Hein et al., 1978, and IODP Expedition 323).

For all the above, the incoming sediments must be fully characterized along-strike at representative sites that reflect the main variations in sedimentology-lithology (both composition and thickness) and thermal regimes. Also, new data on the pressure and temperature of clay dehydration and transformation reactions in diatom-rich, high Si and high volatile environments, must be determined, both experimentally and via modeling; also, the seismological consequences of the volatile cycling in diatom-rich sediments will need be considered.

(This white paper complements the White Papers by Spinelli and Harris and by Hallet Nittrouer.).

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