Devolatilization and Geochemical Cycling along Deep Seated Faults off Japan

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ODP Leg drilling (Sacks et al) recently targeted the Japan Trench forearc offshore Honshu Island where a million year old (Ma) Pacific Plate is subducted beneath Eurasia Previous geophysical investigation (e g von Huene and Culotta) and scientific drilling (DSDP Legs) documented a history of complex tectonic forearc dynamics Whereas little accretion has occurred during the Neogene subduction erosion removed considerable volumes of forearc strata and has subsequently caused subsidence of the continental margin off northern Japan (von Huene and Lallemand) Two holes were drilled into the forearc to install downhole instruments However the meters of sediment recovered from each of these sites also revealed some interesting details concerning the rock structure their state of deformation and deep seated fluid flow in the area

The sedimentary section drilled recovered dominantly silty clays and claystones of middle Miocene (Ma; Site) and upper Miocene (Ma; Site) to Recent age Although the sediments show a strong increase in hardening with increasing depth porosities are anomalously high ( ) at the base of both holes This pore volume together with secondary porosity from brittle failure in the deeper consolidated sediments at both sites (below meters below seafloor) allow fluid migration in the forearc Some of the fracture networks can be directly related to major shear zones which hydraulically connect to deep seated out of sequence thrusts in the underlying Cretaceous forearc wedge

Pore water geochemistry of the Leg drill cores represents the most profound freshening reported in ODP convergent margins drilling (Sacks et al) exceeding that observed along deep seated faults like the Barbados or Nankai accretionary wedges (e g Moore and Vrolijk) Chlorinity potassium (K) and sodium (Na) contents (see figure) but also salinity and magnesium (Mg) show a strong downhole decrease to values about half their seawater concentration On the other hand enrichment of mobile elements like strontium (Sr) boron (B) calcium (Ca) (see figure) as well as lithium (Li) has been measured in the pore fluids some of which reach x to x seawater concentration Also stable B and chlorine (Cl) isotope ratios of the pore fluids show characteristic decreases with depth (Deyhle and Kopf) Devolatilization due to temperature and pressure driven processes in the deep forearc is further attested by an increase in hydrocarbon concentrations in gas samples from the Leg cores (Sacks et al) Gas from cores taken in the fractured sheared intervals (see gray areas in figure) show the highest abundance of higher hydrocarbons

Given the high porosities in the deep portion of the sedimentary successions drilled at Sites and and the permeability of the shear zones (see figure) fluids may be conducted efficiently to the seafloor via deep seated faluts cross cutting the entire forearc Given further that these fluids are strongly enriched in certain mobile elements and hydrocarbon gases these thrusts are crucial pathways for geochemical cycling and devolatilization and are essentially shortcuts for backflux into the hydrosphere in addition to the décollement zone at the base of accretionary prisms

References

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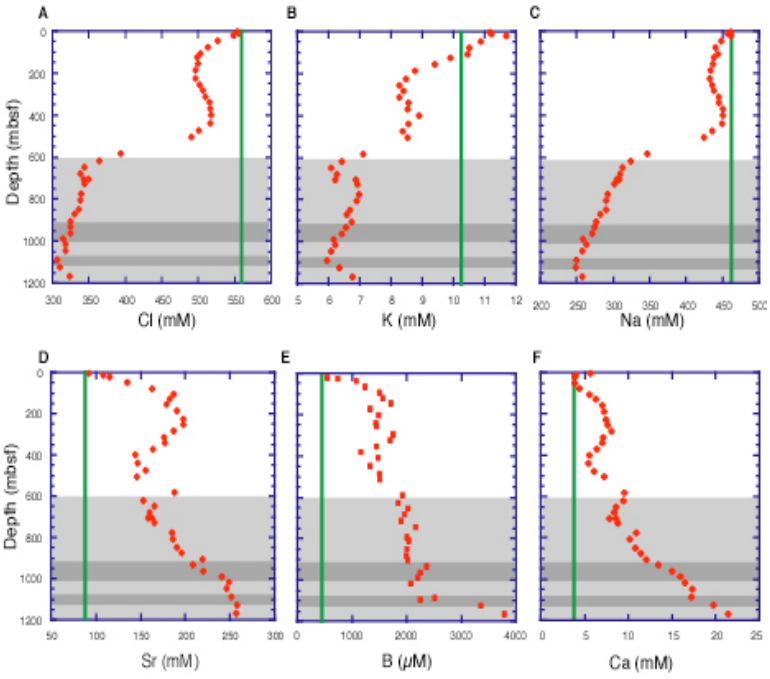

Pore water concentration of selected constituents in interstitial water samples from ODP Site 1150, Japan trench forearc. Light gray area is fractured; dark gray zones are shear zones. Green bars represent seawater concentrations.