Geophysical Research Abstracts
Vol. 20, EGU2018-6156-1, 2018
EGU General Assembly 2018

Seamount subduction and exhumation by serpentinite mud volcanism in the Mariana convergent margin system

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Geologic processes at convergent plate margins control geochemical cycling, seismicity, and deep biosphere activity in subduction zones. Determining unequivocally the composition of slab-derived fluids and their influences over the physical properties of the subduction zone or geochemical cycling in convergent margins requires direct sampling of the plate boundary subduction channel. The Mariana convergent margin provides the environment where a natural process brings materials from great depths directly to the surface. The Mariana subduction system is non-accretionary and the forearc is pervasively faulted. Here, active serpentinite mud volcanoes provide a window to the subduction channel between the subducting Pacific Plate and the Philippine Sea Plate. These mud volcanoes are composed principally of unconsolidated flows of serpentine muds containing clasts of serpentinized mantle peridotite and several other lithologies, including blueschist materials derived from the subducting slab via deep-seated faults.

IODP Expedition 366 recovered cores from three serpentinite mud volcanoes at increasing distances from the Mariana trench subduction zone along a south-to-north transect: Yinazao (Blue Moon), Fantangisña (Celestial), and Asùt Tesoru (Big Blue). These cores consist of serpentinite mud containing lithic clasts derived from the underlying forearc crust and mantle, as well as from the subducting Pacific Plate. Additionally, in situ pelagic sediments and volcanic ash deposits underlying the serpentinite mud volcanoes were recovered at Fantangisña. A thin cover of pelagic sediment was found at many sites.

A preliminary screening for micro- and nannofossils from Asùt Tesoru revealed assemblages of planktonic and benthic foraminifera and calcareous nannoplankton containing biostratigraphic marker species (e.g., Globigerinella calida, Globorotalia flexuosa, Gr. truncatulinoides Gr. tumida, Sphaeroidinella dehiscens amongst planktic foraminifera; Gephyrocapsa spp., Pseudoemiliania lacunosa, Reticulosfenestra asanoi amongst calcareous nannoplankton). This provides a robust stratigraphic framework and age assessment (from ca. 0.2 to 8.0 Ma from top to bottom) of distinct sediment and serpentinite mud flow layers.

Recycled materials from the subducted slab include fault rocks, metamorphosed pelagic sediments, diagenetic shallow water reef assemblages, and metavolcanic rocks. The recycled materials are found at all three mud volcanoes and are interpreted to be parts of subducted Pacific plate seamounts, presumably Cretaceous in age.

Core U1491C (Yinazao) recovered a Miogypsina rudstone cobble that could have derived from more than 10 km beneath the forearc sea floor, with lithoclasts and coralline, red-algal grainstone matrix, altogether showing diagenetic overprint. Although parts of subducted Pacific plate seamounts are assumed be Cretaceous in age, the presence of Miogypsina suggests a Miocene age, thus may represent the latest, uppermost part of a Pacific Plate seamount. The assemblage represents a shallow water (photic zone) environment.

Assuming a Pacific plate velocity of 100 mm per year the hypothetical Guyot was several hundred kilometers east of the trench at Late Miocene times (up to 1000 km), most likely outside the fore-trench bulge. Taking the recent Pacific plate WNW movement direction, and tracing back these 1000 or more kilometers, it would have been located in the area of today's Micronesia atolls where comparable shallow water conditions exist.