Explosive volcanism from the galapagos hotspot: evidence from Miocene marine tephras found during IODP Expedition 334 and 344

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The Central American Volcanic Arc (CAVA) has generated numerous Plinian eruptions along its 1200 km NW-SE extension, evident as ash layers in marine sediments of the Pacific, downwind from the eruption centers. Such deposits are not known to exist from the Galapagos Hotspot. During IODP expeditions 334 and 344, offshore and near Costa Rica, a total of 81 and 37 tephra layers have been recovered at Sites U1381 and U1414, on top of and at the rim of the Cocos Ridge, respectively.

Within the first 56 (meters below seafloor) at Site U1381, eighteen tephra layers are intercalated with hemipelagic Pleistocene sediments of Unit I, associated with a near trench depositional environment. In contrast, the 63 tephra layers recovered from Unit II (>56 mbsf) are embedded, after a >9 my hiatus, in a succession of Miocene silicic and calcareous ooze dominated sediments. Plate reconstruction shows that these sediments may have been deposited in proximity to the Galapagos Islands.

Individual tephra layers range in thickness from 1 to 41 cm. The 81 tephra layers are compositionally variable. Gray to whitish layers show dacitic and rhyolitic compositions (predominantly Unit I; fresh, transparent glass shards, common plagioclase, amphibole and pyroxene) and gray to brown black layers show basaltic compositions (predominantly Unit II; dark to light brown sideromelane glass shards, rare tachylitic particles, and minor plagioclase and traces of pyroxene). Dark black tephra beds account for ca. 27% of the total tephra bed assemblage of Unit I, but are more abundant in Unit II (ca. 72%). Grain sizes range from fine to medium ash, getting coarser in Miocene Unit II (up to mm size). Generally, tephras from the older Miocene sequence have a lower crystal content than the tephras of the younger ones.

At Site U1414 a continuous sedimentary succession was recovered that encompasses the whole Holocene to the Middle Miocene. Tephra layers from U1414 are predominantly felsic in composition (>90%) and mafic tephras are less abundant than at Site U1381. Despite this difference, the appearance of the individual tephra layers and their glass shard and mineral inventory reflect the same variability as at Site U1381.

A first provenance analysis based on major and trace elements suggests that most of the tephra layers within the Pleistocene unit of Sites U1381 and U1414 are derived from Central American volcanic arc eruptions. In contrast, Miocene mafic and felsic tephras of Sites U1381 and U1414, respectively, show a Hotspot signature (Nb,Ta enrichment in spider diagrams and high Nb/La).

Both IODP sites constrain the occurrence of an important amount of large explosive volcanism at the Galapagos Hotspot, which is not evident from onshore data. How, where, when and to what extent this volcanism took place in the Miocene will be investigated in the future with more trace element analyses and Ar/Ar ages.