Deciphering the significance of hopanoids in the marine geologic record

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Hopanoids are pentacyclic triterpenoids produced by some bacteria that have been dubbed bacterial 'sterol surrogates.' Hopanoids have been broadly applied in the marine sedimentary record as taxonomic markers for certain groups of bacteria and their associated biogeochemical processes. However, our ability to rigorously interpret the significance of hopanoids in the geologic record has been greatly limited by a dearth of knowledge surrounding the sources of hopanoids in marine environments. Despite the ubiquity of hopanoids in modern and ancient marine sediments, their precise provenance in the modern oceans is largely unknown. In this study, we present a survey of bacteriohopanepolyols (BHPs) in a diverse selection of marine and proximal marine environments. Our work establishes the presence and ubiquity of hopanoids in the oceans, and provides fresh insight on the environmental sources and biogeochemical significance of hopanoids in marine sediments. We observe pronounced heterogeneity in the spatial and temporal distribution of BHPs, indicating the potential for the application of hopanoids as biomarkers for biological processes in the upper ocean and as tracers for organic matter input to sediments. In particular, BHPs appear to be relatively abundant and structurally diverse in low oxygen and oligotrophic environments and in particulate organic matter (OM) transported by rivers from terrestrial environments. Given the rich structural diversity of BHPs in terrigenous OM, interpretations of the sedimentary record of hopanoids in coastal marine settings must resolve inputs from marine pelagic and terrestrial sources. Furthermore, BHPs produced in suboxic and anoxic pelagic environments likely represent an important input to the sedimentary hopanoid inventory in upwelling environments and anoxic marine basins.

The Shatsky Rise supervolcano

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Oceanic plateaus are igneous mountains constructed by massive eruptions of basalt and related igneous rocks. Because they are hidden beneath remote parts of the oceans, the structure and evolution of these mountains are poorly known. Shatsky Rise, in the northwest Pacific, is an oceanic plateau that formed during the Late Jurassic and Early Cretacous (˜145-125 Ma) near a triple junction of spreading ridges. It consists of three large volcanic massifs and a narrow volcanic ridge. It is inferred that eruptions began with the largest massif (Tamu Massif) and waned through time through the formation of the other massifs. Tamu Massif is a supervolcano, i.e. a single volcanic edifice, like a seamount, but much bigger. It has an area similar to Olympus Mons on Mars, the largest volcano in the solar system. Geophysical data show that Tamu Massif has a central summit, and a shape that is symmetric across its axis. Volcanic slopes are low, implying long, low viscosity lava flows. A seismic profile across the volcano axis shows lava flows flowed outward from the axis. Seismic profiles in some spots over these axes show normal faulting that imply volcanic rift zones. Coring on Integrated Ocean Drilling Program (IODP) Expedition 324 recovered basalt flows of two types: pillows and massive flows. Pillows are indicative of normal seamount volcanism at low effusion rates whereas the massive flows imply high volume lava flows with high effusion rates. Massive flows are typical of continental flood basalts and are also found on other large plateaus. On Shatsky Rise, thick massive flows are found on Tamu Massif, whereas pillows and thin massive flows characterize the other massifs. This trend supports the idea that Tamu Massif was formed by an initial massive eruptive event and afterwards volcanism waned as other massifs were erupted. Shallow water fossils and depth-diagnostic rocks and sediments indicate that the summits of Shatsky Rise massifs were near sea level at the time of formation. Expedition 324 cores recovered hyalo-clastites and volcanic sedimentary rocks implying that explosive volcanism was significant near the volcano summit. Heavy alteration of rocks from the shallower parts of the volcanoes suggests that warm fluids flowed through the volcano summit rocks. In sum, the structure and evolution of Tamu Massif appears much like that of a typical seamount, except that it is much bigger and was built by correspondingly larger and widespread eruptions.