THE ORIGIN AND SEDIMENTOLOGY OF THE PUNA SUBMARINE CANYON, HAWAII

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Abstract

The Puna Submarine Canyon lies off the east coast of the island of Hawaii, the youngest island of the Hawaiian Chain. The canyon has a length of 75 km and a variable width, reaching a maximum of 35 km at a position about 25 km offshore. The canyon mouth attains a depth of 5400 m. This makes the Puna Canyon one of the world's deepest submarine canyons. The canyon has wall heights in excess of 1500 m.

The goals of this dissertation are to examine the origin, sedimentology, sediment transport and manganese nodule tailings dumpsite potential of the Puna Canyon. The canyon was investigated on four oceanographic cruises, by scuba divers, with the submersible MAKALI'I and by aerial color and infra-red photography. A total of 108 sediment samples and cores were taken. These were analyzed for grain size, carbonate content, mineralogy and major and trace element geochemical abundances.

The canyon is sandwiched between 4 unique physiographic features. The north wall of the canyon is formed by the Mauna Kea Ridge, an older volcanic rift which has undergone up to 1000 m of subsidence. The south wall of the canyon is formed by the volcanically active Puna Ridge. To the east of the canyon lies the Hawaiian Trough, a crustal depression of several hundred meters surrounding the Hawaiian Islands and caused by their weight on the crust. Off the city of Hilo lies a 320km^2 marine terrace at a depth of 385m.

The canyon is very young. Exposed rocks on the adjacent coast vary from 23 to 1500 years old. Calculations using the historic eruption rates of Kilauea show that its entire edifice could have been built in 400,000 years. The fully formed Puna Canyon is no older than this. Seismic surveys revealed exceptionally thin sediment cover over most of the canyon. Some areas of the mid-canyon have less than 10m of sediment. Only at the base of the steep canyon headwall and on the 385 m Hilo Marine Terrace do sediment thicknesses reach significant proportions, up to 220 m in the latter case. The low volume of sedimentary fill indicates a limit to turbidity current erosion. Major faulting is not present. The absence of sea level terraces on the Puna Ridge indicates that the canyon's south wall is younger than its north wall. The canyon was formed by volcanic growth along the Mauna Kea Ridge followed by volcanic growth along the Puna Ridge. Submarine sapping by large volumes of groundwater along the coastline in the canyon axis area may lead to significant headwall erosion.

The canyon's sedimentology was simplified by considering four distinct sedimentary end members which were distinquishable on the basis of mineralogy and geochemistry. The deep canyon is dominated by pelagic clay. The southern nearshore and rift areas are dominated by a volcanic, olivine-rich sand. The central and northern nearshore areas have a carbonate end member derived from coral, coralline algae, foraminifera and molluscs. Hilo Bay has an end member derived

from the weathering products of the adjacent sugar cane fields and lava flows. On the order of 60,000 m^3 of sediment are added to the Puna Canyon each year. In comparison with other large submarine canyons the Puna Canyon is sediment-starved.

The distribution paterns of 7 trace elements implies anthropogenic enrichment of two of these elements, Pb and Cd. Decreasing concentrations of Pb and Cd away from Hilo Bay, in conjunction with south-flowing currents, unstable sediment on slopes, and sediment mixing patterns suggests a southward transport of sediment out of Hilo Bay and into the Puna Canyon.

It appears that manganese nodule tailings are geochemically similar to volcanic sediment and that their main environmental hazard is their fine-grained nature. The sliding sediment, paucity of benthic life at depth, water column stability, weak currents and suggested sediment transport pathways lend support to the view that ocean disposal of nodule tailings may be both possible and environmentally benign. However, those factors affecting manganese nodule tailings disposal do not necessarily apply to other material.