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ICP-AE and cluster analysis investigation of the distribution of major and trace element in manganese nodules, micronodules and abyssal clay collected from the Clarion-Clipperton abyssal plain, Northeast Pacific

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The concentrations of seven major components (Ti, Fe, Mg, Ca, Na, K and P as oxides) and 15 trace elements (Sc, V, Cr, Ni, Cu, Sr, Y, Zr, Ba, La, Ce, Nd, Eu, Yb and Th) were determined by ICP-AE spectrometry in 27 samples of manganese nodules, micronodules and abyssal clay collected by dredging during the 1984 cruise of the R/V Akademik Alexandr Karpinski in the Clarion-Clipperton Province of the North Pacific (12° N-12° 40' N and 137° 40' W-138° 50' W) at a depth of about 4,500 m. Cluster analysis was used to compare among individual as well as pooled datasets, in addition to different indicators such as La/Th, Ni/Cu and LREE/HREE ratios for the Clarion-Clipperton samples, as well as between these and corresponding values for the upper continental crust (UCC), North America Shale Composite (NASC), and igneous Indian and Pacific Mid-Ocean Ridge Basalts (MORBs).

The results evidenced the existence of significant positive correlations between major components in the Clarion-Clipperton samples and Pacific Ocean MORB, whereas trace elements (excepting Ni and Cu) correlate better with the UCC and NASC. There was also evidenced a depletion in LREEs which, together with a Ce negative anomaly for all Clarion-Clipperton samples, pointed towards a hydrothermal origin of the all REE, this fact being sustained by a La/Th ratio between 5 and 7, different from UCC (2.80) and NASC (2.50), but closer to Pacific (8.8) and Indian (11.25) Oceans MORBs.

On the other hand, on a Sc-La-Th ternary diagram, all Clarion-Clipperton samples grouped together closer UCC and NASC and far away from both Pacific and Indian Oceans MORBs.

At the same time, all investigated samples showed more significant clusters such as phosphorous pentoxide and all REE excepting Ce, or Ni and Cu. Compared to abyssal clay, the nodule as well as micronodules show significant enrichment in Ni and Cu while a constant Ni/Cu ratio indicated that all samples come from the sediment surface.

In this way, the distributions of major components as well as trace elements for the Clarion-Clipperton samples present, to different degrees, characteristics common to both the upper continental crust and Mid-Ocean Ridge Basalt, strongly implying a hydrothermal origin, most probably from East Pacific Rise material transported by the Pacific North Equatorial Current.