Seamount and Cobalt-Platinum rich Fe-Mn Crust Resources in the Indian Ocean

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ABSTRACT

Ferromanganese encrustations of hydrothermal types have been known together with manganese nodule for their Ni-Cu metal content. However, ferromanganese crust formed on ancient volcanoes have a chemistry quite different than those associated with nodules. They have a high level of cobalt (1-1.5%) and platinum (~1g/ton) in addition to a series of other elements such as, cerium and titanium, which are of strategic significance in terms of “new metals”. Based on the criteria of exploration, potential areas within the Indian Ocean most ideally suitable for the development of the crust have been suggested. The substrata rocks over which the cobalt rich crust have been formed are volcanic breccias, hydroclastic basalts, phosphorite, limestone, volcanoclastic sandstone, mudstone and chert.

Several areas in the Indian Ocean have a geological environment which is favourable for the formation of thick ferromanganese crusts. These areas could be grouped into:

a. Old seamounts (More than 20 million years of age).

b. Areas with a well developed oxygen minimum zone.

c. Areas of strong, oxygen-rich, near-bottom currents, and

d. Areas where seamount flanks are ideally between 500 to 1500m water depth, in the equatorial zone (between 15-20° latitude each side of the equator).

In such exploration campaign, one has to

a. Avoid areas with atolls and coral reefs.

b. Avoid areas near continents.

c. Select area with flat top of the seamounts for better picking/sampling and eventual detailed exploration to mining prospects.

d. Select areas with an average crust thickness of more than 4 cm and a cobalt grade of more than 0.8%.

e. Select microphotographic areas with the wide-spread occurrence of crust, and eliminate areas of slumps, talus deposits and sediment cover.

Based on these criteria, in the Indian Ocean, areas close to India worth considering for exploration are (1). Lakshadweep islands, only seamounts without reefs, (2) Southern tip of Kerala state, (3) Seamounts between 93°-96°E and 10°-13°N. The area could be extended to the south of the Ninety-East Ridge, as well as other potential areas well within the EEZ of India.

INTRODUCTION

Although ferromanganese crusts were obtained first during the famous HMS Challenger Expedition (1872-1986), a cruise dedicated to their study was not forthcoming until 1981. Scientists on-board Germany's RV Sonne studied ferromanganese encrustations from the Mid-Pacific Mountain (MPM) and Line Islands in 1981, 1983, 1984 (Halbach et. al., 1982; Halbach, 1983).

In 1983 and 1984, scientists on board USGS's RV S.P.Lee studied crusts from the Nector Ridge (near Hawaii Islands;Hein et. al., 1985 a and b; Schwab et. al., 1985). About this time the University of Hawaii conducted several cruises around the Hawaiian Islands (within EEZ limits).

Ferromanganese crusts collected prior to these specific cruises were incidental to the other studies. However several publications have been devoted to analysis and interpretation of data pertaining to crusts collected prior to 1981 (see Glasby, 1977; Cronan, 1980; Roonwal, 1986 et.al.; Bischoff et. al., 1984).

Ferromanganese crusts or encrustations contain three strategic and economically important metals in abundance: Mn, Co, and Pt. In addition, Ni, Ph, Ti, Cc, and Te are significantly enriched in crusts.

Ocean floor ferromanganese nodules are enriched in Cu, Ni and Co in that order. However, in ferromanganese crusts, cobalt is 3 to 6 times more abundant than in the nodules or even in ores mined on land (Foose, 1984).

Several papers however have been published prior to 1981, in which data concerning the ferromanganese encrustation, analysis and their interpretation have been incorporated (Craig, Andrews and Meylan, 1982; Aplin and Cronan, 1985). This contrasts to the extensive literature dealing with ocean floor ferromanganese nodules which have been reviewed several times (Glasby, 1977 - Bibliography on Nodules).

MINERALOGY OF THE CRUSTS

The dominant minerals in the vast majority of crust is Fe-rich δ-MnO2 (Fe-Vernadite) with only two X-ray reflections at 2.42Å and 1.42 Å. Todorokite has been found on average in one sample per seamount studied. Carbonate fluorapatite has been found to be abundant in the older layers of several crusts. X-ray amorphous FeO-OH X H 2O is the other dominant phase present along with δ-MnO2 in all crusts. Delta-MnO2 forms epitaxial intergrowth with FeO-OH.xH2O (Burns, 1976). Other common minerals include plagioclase, quartz, geothite and minor minerals include barite, potash feldspars, calcite, manjiroite (= Na analog of cryptomelane with the formula [Na, K] 1-2 Mn8O16 x H2O), zeolites, and clay minerals (Table 1).