such cases, further tests should be conducted in which modifications of the standard plate assay are used, such as preincubation or modification of the S9 preparation with regard to source, inducer, and cofactors.

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References and Notes

1. The meeting at which these recommendations were made was held in Arlington, Va., 28 to 30 August 1978. The meeting was organized by F. J. de Serres and M. D. Shelby under the auspices of the National Institute of Environmental Health Sciences and was sponsored in part by Imperial Chemical Industries, Ltd. The recommendations herein complement and extend those of I. E. Mattern and H. Greim [see *Mutat. Res.* **53**, 369 (1978)].
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Manganese Nodules on the Sea Floor: Are Economic Mining Operations Feasible?

Menard and Frazer deserve congratulations for making the first statement in what will undoubtedly be a long controversy over the magnitude of copper and nickel resource estimates in deep-ocean manganese nodules (*1*). By finally analyzing statistically all of the available data in the public domain, their statement neatly squashes the optimistic resource estimates of Mero (*2*), McKelvey and Wang (*3*), and others who first raised interest in the economic potential of the nodules, or does it? Menard and Frazer's report also helps to dispose of the myth that vast wealth is available from the nodules for the common heritage of mankind.

Menard and Frazer do not provide sufficient information or evidence to dispel the expectation that nodules may be mined economically for their nickel, copper, and manganese content. However, their conclusions may indeed add to the discouragement of investors and policymakers, who are already frustrated by the Law of the Sea Conference.

The negative correlation between nodule abundance and copper-nickel concentrations, the central conclusion of the report, supports the expectation that high concentrations of copper are rare in the oceans as on land. This fact has been pointed out by Skinner (*4*), among others. This makes economic concentrations of minerals (mineral deposits) on land distinct from ordinary rock. If replotted on a log-log scale, the data in figure 2 of (*1*) would be similar to a very noisy version of the plot of copper grade versus concentration in a region such as the copper province of the southwestern United States (the vertical component in the three-dimensional character of land deposits becomes negligible in an area the size of this province) (*5*).

The vast scale of the sample population to which Menard and Frazer's conclusions apply also deserves more attention. Perhaps it should be pointed out that the Scripps/International Decade of Oceanographic Exploration data bank contains only a few thousand samples to represent an ocean floor area of several tens of millions of square nautical miles, that this area can hardly be expected to be geologically homogeneous, and that most of the data were collected for other purposes than manganese nodule sampling. The data are thus not standardized.

According to the latest estimates, the area of potential mining sites will be of the order of 12,000 square nautical miles (1 square nautical mile = 3.4×10^6 m^2) (*6*). The 74 samples (apparently without concentration data in kilograms per square meter) referred to in (*1*) represent the most economically interesting part of the northwest equatorial Pacific Ocean, which covers approximately 6 million square nautical miles. This is roughly one uncontrolled sample for each of 74 areas the size of Nevada (85,600 nautical square miles). Are there no concentration data for this most important area? The negative correlation observed by Menard and Frazer [figure 2 in (*1*)] is either not present or is not statistically significant for the two smaller localities mentioned by Schatz (*7*) and Piper *et al.* (*8*) where potential economic deposits occur. As on land, economic concentrations of nodules on the ocean floor are expected to be anomalies. In figure 2 of (*1*), approximately 15 percent of the points are above a minable nickel and copper abundance of 0.25 kg/m^2 (*9*). Are we to conclude from this figure that 10 to 20 percent (95 percent confidence interval) of the area sampled consists of mineral deposits to be economically mined?

Although Menard and Frazer's report should sober some of the optimistic views of representatives of the lesser developed countries present at the March 1978 session of the Law of the Sea Conference, it should not deter ocean miners who are awaiting a U.S. go-ahead or a regime under which to proceed. A more thorough analysis based on geostatistical techniques (*10*) should be applied to the data to discover possible geographic trends or clusters. The unwarranted conclusion of Menard and Frazer serves only to point out the paucity of good data in the public domain and the need for more information so that matters of national and international interest can be debated more realistically.

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