

Boström K & Peterson M N A. Precipitates from hydrothermal exhalations on the East Pacific Rise. *Econ. Geol.* **61**:1258-65, 1966.
[Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA]

On the East Pacific Rise the sediments are exceptionally rich in Fe, Mn, Cu, Cr, Ni, and Pb, depositing from solutions of deepseated origin. The deposits are related to local high heat flows and could represent the initial enrichment in some ore-forming processes. [The SC¹® indicates that this paper has been cited over 115 times since 1966.]

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"This paper had its beginnings in the late 1950s. I then studied the origin and rock-water interactions of hydrothermal veins in some 2,000 million-years-old Swedish manganese ores, using a thermodynamic approach in the discussion of complex redox-equilibria.

"In early 1962, I got my PhD. By that time I had planned a study of the geochemistry of hot springs in Iceland. However, no funds were available for this work—in hindsight that appears fortunate; it is doubtful that there were sufficient thermodynamic data at that time for an adequate discussion of these problems. Another project I considered was to study groundwaters as geochemical prospecting tools—but, alas, again no funds!

"In late 1962, G. Arrhenius offered me a position as research oceanographer at Scripps—I gladly accepted. At that time several pioneering studies took place at Scripps. Von Herzen and Uyeda¹ discovered high heat flows on the East Pacific Rise, Menard² pointed out the enormous mass of basic rocks that poured out on the ocean

floor, and Peterson and Goldberg³ and Arrhenius and Bonatti⁴ suggested volcanic origins for feldspars and barite on the East Pacific Rise.

"What struck me then was that the high oceanic heat flows continued on land in southern California, where mineralizing hot springs and wells occur.⁵ Should not then mineralizing hot springs occur also on the ocean floor? These hunches were reinforced by field studies of hot springs in Italy, California, and Yellowstone.

"This became a highly controversial hypothesis. Some researchers accepted such 'heresies,' but most objected and favored the concept of settling terrigenous and biogenous detritus as the only major sources besides seawater for metals in the deep ocean.

"This polarisation lasted until 1971 and was occasionally frustrating for me and my colleagues, but it also had its benefits. We had to sharpen our observations, produce synoptic maps of these metalliferous sediments, their compositions, and the accumulation rates of various components, particularly for Fe and Mn. These results lent additional support to the theory that volcanism delivers mineralizing solutions to the ocean floor. Much of these developments are summarized in my recent work.⁶

"Why has this paper become a *Citation Classic*? I think a good reason is that it presented evidence based on a large number of elemental analyses, indicating a new source of metals in the ocean. Also, many ores with strong indications of a submarine volcanic origin called for an actualistic example; hence it is not surprising that economic geologists were among the first to accept the concept of submarine mineralizing hot springs.

"This story also offers an amusing lesson—a grant rejection may occasionally be a blessing!"

1. von Herzen R P & Uyeda S. Heat flow through the eastern Pacific Ocean floor. *J. Geophys. Res.* **68**:4219-50, 1963.

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3. Peterson M N A & Goldberg E D. Feldspar distributions in South Pacific pelagic sediments.

J. Geophys. Res. **67**:3477-92, 1962.

4. Arrhenius G O S & Bonatti E. Neptunism and volcanism in the ocean. (Sears M, ed.) *Progress in oceanography*. London: Pergamon Press, 1965. Vol. 3. p. 7-22.

5. White D E, Anderson E T & Grubbs D K. Geothermal brine well: mile-deep drill hole may tap ore-bearing magmatic water and rocks undergoing metamorphism. *Science* **139**:919-22, 1963.

6. Boström K. The origin of ferromanganese active ridge sediments. (Rona P A & Lowell R P, eds.) *Sea floor spreading centers: hydrothermal systems*. Stroudsburg, PA: Dowden, Hutchinson & Ross, 1980. p. 288-332.