

Marine Chemistry of the Permian Phosphoria Formation and Basin, Southeast Idaho

DAVID Z. PIPER[†]

U. S. Geological Survey, Mail Stop 902, Menlo Park, California 94025

Abstract

Major components in the Meade Peak Member of the Phosphoria Formation are apatite, dolomite, calcite, organic matter, and biogenic silica—a marine fraction; and aluminosilicate quartz debris—a terrigenous fraction. Samples from Enoch Valley, in southeast Idaho, have major element oxide abundances of Al_2O_3 , Fe_2O_3 , K_2O , and TiO_2 that closely approach the composition of the world shale average. Factor analysis further identifies the partitioning of several trace elements—Ba, Ga, Li, Sc, and Th and, at other sites in southeast Idaho and western Wyoming, B, Co, Cs, Hf, Rb, and Ta—totally into this fraction. Trace elements that fail to show such correlations or factor loadings include Ag, As, Cd, Cr, Cu, Mo, Ni, Se, the rare earth elements (REE), U, V, and Zn. Their terrigenous contribution is determined from minimum values of trace elements versus the terrigenous fraction. These minima too define trace element concentrations in the terrigenous fraction that approximately equal their concentrations in the world shale average.

The marine fraction of trace elements represents the difference between the bulk trace element content of a sample and the terrigenous contribution. Of the trace elements enriched above a terrigenous contribution, Ag, Cr, Cu, Mo, and Se show strong loadings on the factor with an organic matter loading and U and the REE on the factor with a strong apatite loading. Cd, Ni, V, and Zn do not show a strong correlation with any of the marine components but are, nonetheless, strongly enriched above a terrigenous contribution.

Interelement relationships between the trace elements identify two seawater sources—planktonic debris and basinal bottom water. Relationships between Cd, Cu, Mo, Zn, and possibly Ni and Se suggest a solely biogenic source. Their accumulation rates, and that of PO_4^{3-} , further identify the level of primary productivity as having been moderate and the residence time of water in the basin at 4.5 yr. Enrichments of Cr, U, V, and the REE, above both terrigenous and biogenic contributions, define bottom-water redox conditions as having been oxygen depleted, that is, denitrifying but not sulfate reducing.