

Trace Elements at the Manus Basin, Papua New Guinea

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Introduction

Deep-sea hydrothermal systems play an important role as a significant source or sink of trace metals in the ocean, therefore hydrothermal activity has a major impact on the chemistry of the ocean. Many trace elements are extracted from the basalt by the vent fluid during hydrothermal circulation. Consequently, trace elements are introduced into deep sea via hydrothermal plume with high concentration. In order to estimate the flux of trace elements from deep-sea hydrothermal systems, we have been studying on the behavior and fate of trace elements discharged from hydrothermal vents at several hydrothermal areas. This paper will report the behavior of hydrothermal trace elements collected from the Manus Basin, Papua New Guinea.

Observations

Hydrothermal fluid samples were collected from three hydrothermal active sites (VIENNA WOODS, PACMANUS and DESMOS Site) in the Manus Basin using a manifold-pump sampling system (Sakai et al. 1990) attached to "Sinkai 6500" during the New STARMER ManusFlux Cruise from October to November 1995. Figure 1 shows geodynamic sketch of the Manus Basin and

the hydrothermal sites for sample collection by "Sinkai 6500". Unfiltered fluid samples for trace elements analysis were acidified to pH 1 with HNO_3 and kept until the samples analyzed on land. Total (dissolved plus particulate (acid leachable sulfide and hydroxide)) concentration of trace elements (Al, Mn, Fe, Ni, Co, Cu, Zn, Cd, Pb) were determined using graphite furnace atomic absorption spectrophotometry (Perkin-Elmer, Model 4100ZL) with Zeeman background correction by direct injection method of the 1/2 diluted samples, against standards made up in the same matrix with sample.

Results and Discussion

Manus Basin is a fast spreading ($>10\text{cm/y}$) back arc basin in the Bisnarck Sea, western Pacific Ocean, were the two major spreading axis (Martinez and Taylor 1996). The chemical characteristics of the Manus Basin hydrothermal fluid taken from the three sites are completely different (Gamo et al. in press). Figure 2 indicates Mg vs. pH, total carbonate and H_2S relationships for the hydrothermal fluid samples taken from three hydrothermal sites in the Manus Basin. The VIENNA WOODS fluids, erupting from anhydrite-sulfide chimneys on basaltic basement, have similar characteristics to

those from mid-ocean ridges. The PACMANUS fluids, erupting as black smokers from sulfide chimneys on dacite basement, have lower pH (4-2.5) and Ca concentration and higher concentrations of the other elements and total carbonate than those of the VIENNA WOODS. The DESMOS fluids show the unique chemical characteristics of extremely low pH (2.1) and high H_2S concentration (9.7mM) accompanied by native sulfur deposition around the vents, suggesting strong magmatic contributions.

Relationships between Mg and Al, Ni, Fe, Cu, Zn, Pb, Mn and Cd for hydrothermal fluids collected at PACMANUS, DESMOS and VIENNA WOODS hydrothermal sites during the cruise were shown in Figure 3. The DESMOS fluids have higher concentrations of Al and lower concentrations of other trace elements than those of the other two sites. In particular, the concentrations of Fe, Cu and Zn are extremely low. Chemical characteristics of the DESMOS fluids have extremely low pH and high H_2S concentration. In general, the solubility of trace elements increased under low pH conditions. Therefore, the concentration of trace elements in the DESMOS fluid are expected to be high. However the DESMOS fluid has low concentrations of all trace elements except Al. It is suggested that the reaction between trace elements and H_2S is a dominant pathway in the DESMOS fluid. If this is the case, Fe, Ni, Cu, Zn, Cd and Pb have been chiefly scavenged from the hydrothermal fluid as sulphide before discharged from the hydrothermal vent. The concentration of Mn

in the DESMOS fluid does not become low such as Fe, because Mn rarely forms a sulphide. Al are released in high concentration of from the hydrothermal vent without being scavenged from the hydrothermal fluid because aluminum sulfide (Al_2S_3) is water-soluble. In other words, the reason for the high Al concentration in the DESMOS fluid is that the formation of Al_2S_3 is predominant because the low pH limits the formation of the insoluble aluminum hydroxide. Therefore, it is suggest that the high concentrations of dissolved Al in hydrothermal plumes (Gamo et al. 1993) were attributed to the unique chemical characteristics of the DESMOS fluid.

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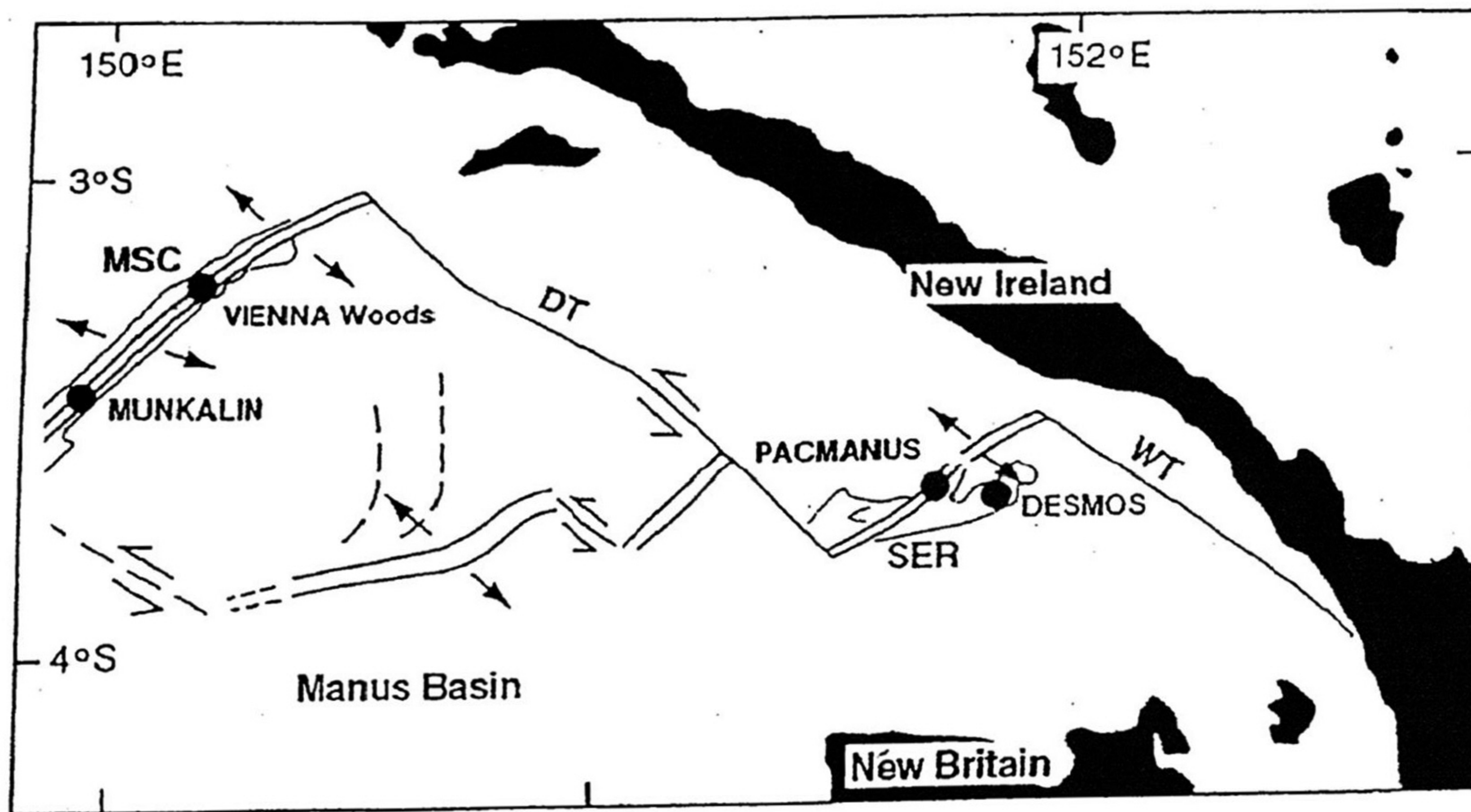


Figure-1: Geodynamic sketch of the Manus Basin as well as locations of PACMANUS, DESMOS and VIENNA WOODS hydrothermal sites.

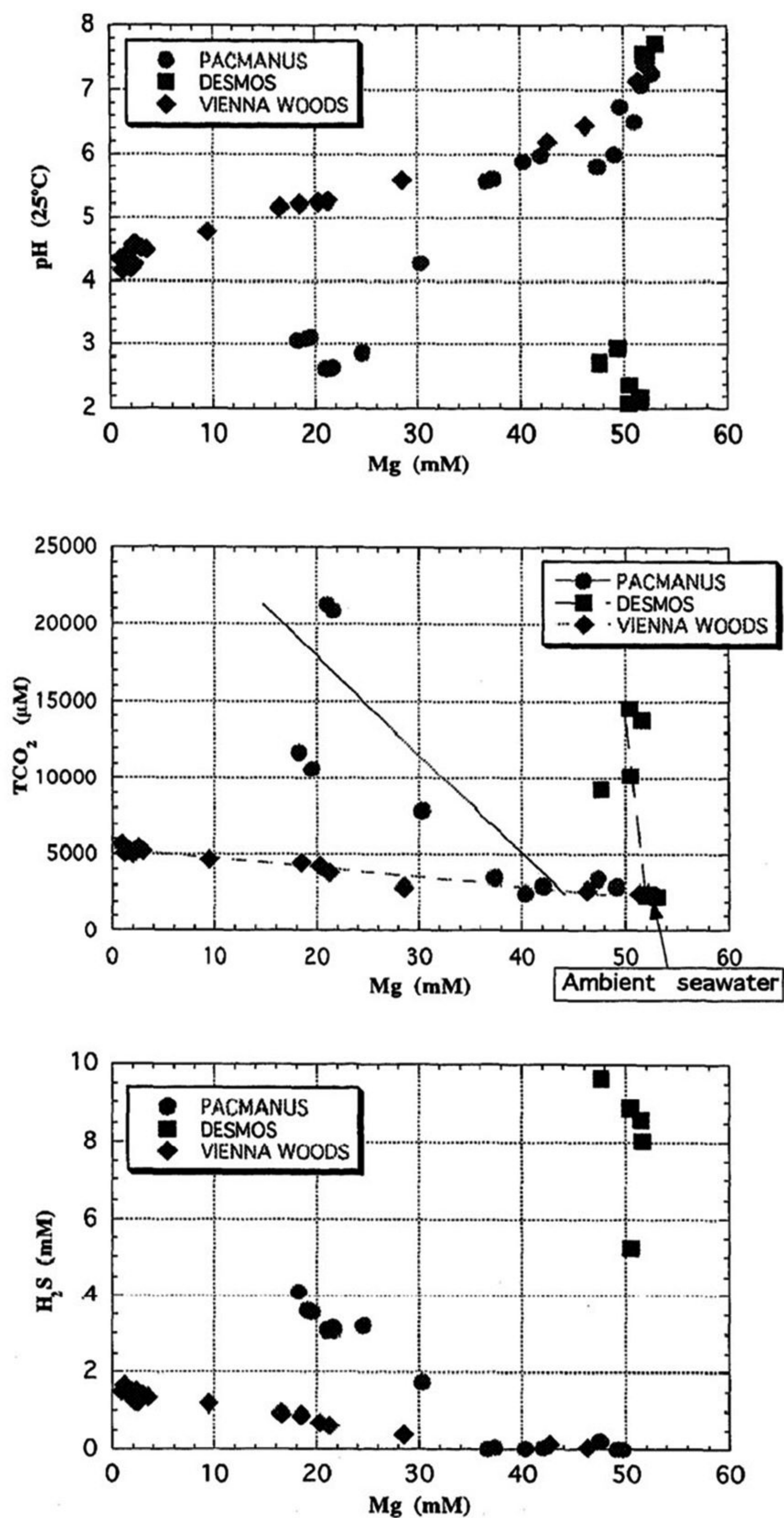


Figure-2: Mg vs. pH, total carbonate and H₂S relationships for the hydrothermal fluid samples taken from three hydrothermal sites in the Manus Basin.

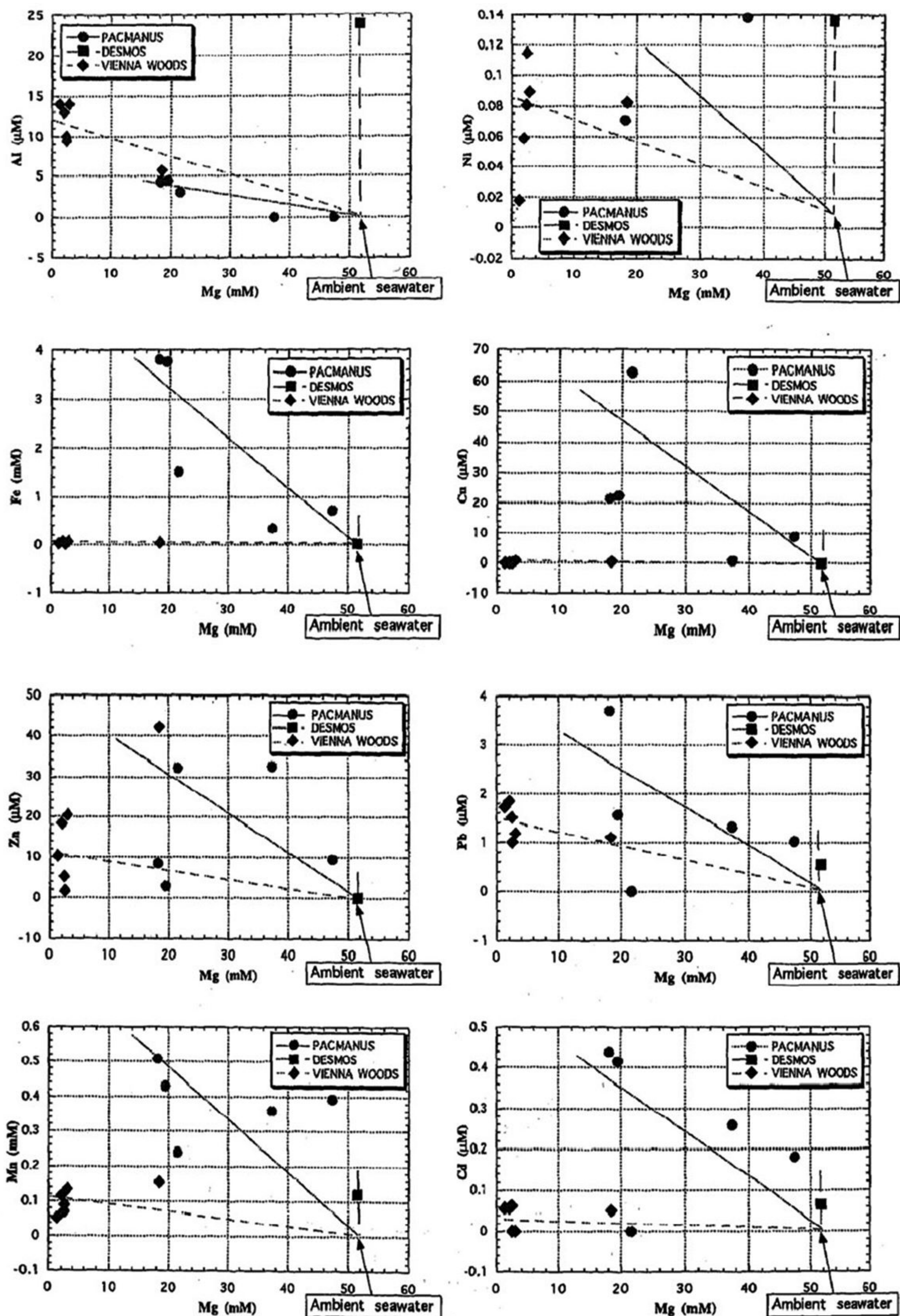


Figure-3: Relationships between Mg and Al, Ni, Fe, Cu, Zn, Pb, Mn and Cd for hydrothermal fluids collected at PACMANUS, DESMOS and VIENNA WOODS hydrothermal sites during the cruise.