

Lead isotope systematics in sulphides from modern hydrothermal vents: a comparison of mid ocean and back arc settings (Pacific)

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Introduction

Massive sulphide deposits on the modern ocean floor have been found recently in subduction - related back arc setting. The rock- and ore-forming processes responsible for the formation of this mineralization were suggested to reflect the contribution of subducted materials (e.g. Stackelberg, von, 1990). Our purpose here is to examine Pb isotope in modern sulphide deposits in back arc spreading zones and mid- ocean ridges and to attempt to identify the sources of lead.

Samples and methods

Pb isotope composition of samples from four modern sulphide deposits of Pacific ocean were analyzed. The 'Vienna Wood' vent occurs on MOR and BAB basalts within the central graben of the Manus back arc spreading center (Tufar, 1990). Two sites in the Lau back arc basin were sampled: first one is located in the northern part near triple junction of the spreading ridges (Lisitsyn *et al.*, 1992) and second one occurs on the spreading ridge in the central part of the basin (Lisitsyn *et al.*, 1992). Four major genetic rock types have been distinguished in the Lau Basin: tholeiitic and seamount basalts, and subordinate picritic and komatiitic basalts, island arc tholeiitic series (orogenic andesites), and locally dacites/andesites (Frenzel *et al.*, 1990). The fourth site is associated with MOR basalts hydrothermal 'smokers' on the East Pacific Rise at EPR 21.5°S, located in the axis graben of MOR ridge of ultrafast spreading (Tufar, 1992). Sulphide samples cleaned in 4N HCl at 80°C were dissolved in HCl + HNO₃. Lead was separated by the double ion exchange treatment using BIO-RAD 1 × 10, 200–400 mesh. An automatic mass-spectrometer MI 3306-IBM/PC was used to measure isotope composition. Reported values are the averages of two mass-spectrometer runs per dissolution by the silica gel technique. The

data are corrected to NBSRM 981 and are accurate to within 0.1 %.

Results and discussion

Bark arc basins. An examination of 10 samples of sulphide material from the 'Vienna Wood' hydrothermal field revealed the variations in ratios of ²⁰⁶Pb/²⁰⁴Pb from 18.264 to 18.347, ²⁰⁷Pb/²⁰⁴Pb from 15.460 to 15.537, ²⁰⁸Pb/²⁰⁴Pb from 37.941 to 38.228. These values lie within the field of Pb isotope ratios reported for MOR basalts (Fig. 1). Therefore basaltic sources as the primary contributor of Pb to sulphides can be inferred for the 'Vienna Wood'.

Six samples from the NL hydrothermal field gave the ²⁰⁶Pb/²⁰⁴Pb, ²⁰⁷Pb/²⁰⁴Pb and ²⁰⁸Pb/²⁰⁴Pb ratios ranging from 18.574 to 18.656, from 15.569 to 15.635, and from 38.596 to 38.777, respectively. The data points lie between Pb isotope ratios reported for LB basalts and pelagic sediments from the Mariana and Tonga troughs on the uranium diagram and fall partly into a field of Pb isotope values reported for the Tonga volcanogenic rocks and partly into a field of the Mariana pelagic sediments (Fig.3). The data points lie close to the 'orogen curve' of the plumbotectonic model on the uranium diagram. This trend of Pb isotope ratios in the hydrothermal sulphides may suggest a mixture of Pb from basaltic and sedimentary sources. Three samples from the CL hydrothermal field gave nearly identical values of ²⁰⁶Pb/²⁰⁴Pb, ²⁰⁷Pb/²⁰⁴Pb, and ²⁰⁸Pb/²⁰⁴Pb ranging from 18.168 to 18.174, from 15.521 to 15.511, and from 37.984 to 38.081. These data points are within or close to Pb isotope values, reported for LB basalts (Fig. 1). A calculated model lead age is about 150 Ma. The similar Pb isotopic ratios in LB basalts and sulphides demonstrate the coherency of local basalt and sulphide Pb isotope signatures. The more radiogenic compositions may infer the contribution of lead from ancient rocks.

Mid-ocean ridge hydrothermal setting. Five samples of sulphide materials from the EPR hydrothermal field gave the following pattern: $^{206}\text{Pb}/^{204}\text{Pb}$ ratios are of 18.202 to 18.241, $^{207}\text{Pb}/^{204}\text{Pb}$ ratios are of 15.463 to 15.486, $^{208}\text{Pb}/^{204}\text{Pb}$ ratios are of 37.651 to 37.700. These data points consistent with the Pb isotope characteristics of EPR 20 to 23oS basalts with the reduced fraction of ^{208}Pb and ^{206}Pb as compared with MOR basalts of NE Pacific (Fig. 2). A sample of fresh MOR basalt from EPR 21.5oS gave values $^{206}\text{Pb}/^{204}\text{Pb} = 18.210$, $^{207}\text{Pb}/^{204}\text{Pb} = 15.481$, and $^{208}\text{Pb}/^{204}\text{Pb} = 37.655$, corresponding to those of sulphides and MORB from given segment of EPR.

Conclusion

The results obtained show evidence of provinciality in the lead isotope data. Sulphides in hydrothermal deposits from Manus and CL back arc basins and EPR contain Pb with isotope ratios identical to their local basaltic sources. Lead in NL sulphide materials is a mixture of basaltic and sedimentary components. Lead in LB hydrothermal fields infers the contribution of subducted materials to ore fluids responsible for formation of modern sulphide ores.

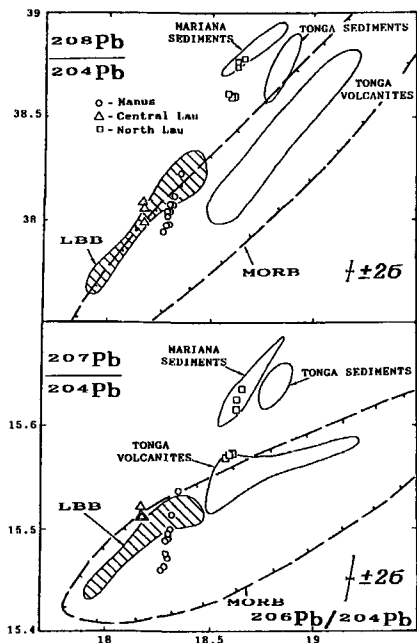


FIG. 1. Lead isotope ratio diagrams showing data for back arc hydrothermal sulphides in comparison to the volcanics and sediments data (after comparison in Jenner *et al.*, 1987 and Vallier *et al.*, 1991).

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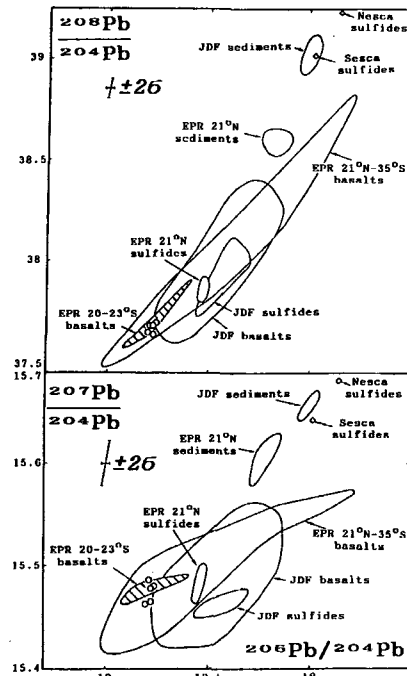


FIG. 2. Lead isotope ratio diagrams showing data for 21.5°S EPR sulphides (circles) and local basalts (ruled) in comparison to other MOR hydrothermal sulphides. MORB and sediments data from Hegner, Tatsumoto (1987); Le Huray *et al.*(1988); White *et al.* (1987)