The Ce/Yb vs. Ba/Ce Plot in Volcanic and Tectonic Classification

BRUCE R DOE

5508 Heming Ave., Springfield VA 22151-3220 USA
(brdoe@compuserve .com)

A plot of Ce/Yb vs. Ba/Ce average values is found to efficiently separate oceanic island/hotspot volcanics (OIV), MORB, and island arc volcanics (IAV) (Doe, 1997). Most OIV have average values of Ce/Yb >10, larger than MORB (<10) and many IAV (<20). On the other hand, IAV have average values of Ba/Ce >4.5 which is greater than MORB (<4.2) and most OIV. Some peralkaline volcanic rocks (e.g., the post-erosion nephelinitic Honolulu series of the Hawaiian Islands, carbonatites, and Type I kimberlites) can be especially high in Ce/Yb compared to MORB and IAV whether they are in the ocean basins or upon the continents. Other peralkaline rocks (e.g., the post-erosion nephelinitic Koloa series of the Hawaiian Islands, Type II kimberlites and ultra potassic lamproites) can be high in both Ce/Yb and Ba/Ce when compared to MORB and IAV whether they are in the ocean basins or upon the continents. Data trends suggest a unified hypothesis that carbonatites and/or kimberlites may exist at depth in the Hawaiian Islands where the post-erosion nephelinitic series exis,t as well as on the continents.

Some rifts are thought to be the result of hotspot action; however, other explanations have been proposed in recent years for a few rifts. The Antarctic rift system has values of Ce/Yb and Ba/Ce in the OIV field, compatible with a hotspot origin. The Rio Grande rift has values of Ce/Yb vs. Ba/Ce well into the IAV field with patterns not compatible with a hotspot origin as the least contaminated basalts do not approach the OIV field, a conclusion in agreement with other work by Davis and Hawkesworth (1995). Volcanics of the Yellowstone Plateau, Wyoming, have recently been proposed to be not of a hotspot origin (Humphreys et al., 2001). Least contaminated basalts from there, however, are close to the OIV field suggesting that a hotspot origin is more likely for the Yellowstone Plateau volcanic rocks.

References

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Study of water-soluble sulfates in tailings profiles from porphyry copper deposits by sulfur and oxygen isotopes

B. DOLD AND J. E. SPANGENBERG

Earth Sciences Department, University Lausanne, 1015
Lausanne, Switzerland (Bernhard.Dold@cam.unil.ch,
Jorge.Spangenberg@img.unil.ch)

The sources of water-soluble sulfate in the stratigraphy of three oxidizing sulfidic mine tailings impoundments from the El Teniente (ET), La Andina (LA), and El Salvador (ES) porphyry copper deposit in Chile were investigated by sulfur and oxygen isotopes. The water-soluble sulfate can have its origin by the dissolution of primary sulfates present in the ore mineralogy, or by the oxidation of sulfide minerals due to exposure to oxidizing conditions during mining activity. The $\delta^{34}S_{py}$ of pyrite of ET and LA deposit averages -1.0‰ and -1.1‰ CDT, respectively. The $\delta^{34}S_{anh}$ and $\delta^{18}O_{anh}$ for anhydrite in the primary ore assemblage of ET and LA average +10.2‰ and +11.9‰ CDT as well as +7.5‰ and +7.3‰ VSMOW, respectively. The calculated $\delta^{34}S$ values for total sulfur in the ore forming fluids is +4.5‰ for ET and +7.6‰ for LA. The mean of the $\delta^{34}S$ for hypogene sulfates (anhydrite, gypsum) is at the ES deposit +10.7‰, for the supergene sulfates (jarosite, alunite and gypsum) -0.7‰, and for the hydpogene sulfides (pyrite, chalcopyrite, chalcocite, bornite) -3.0. Our results show a clear different $\delta^{34}S_{SO4}$ and $\delta^{18}O_{SO4}$ values in the unsaturated zone of the tailings stratigraphy in relation to the underlying saturated primary zone in LA and ET. At ET the $\delta^{34}S_{SO4}$ values range from -0.4 to +1.4‰ in the unsaturated zone, indicating a major sulfate source from pyrite oxidation, whereas the values in the saturated zone range from +2.2 to +3.9‰. This ^{34}S-enrichment can be interpreted in two ways: 1) the result of a mixing between sulphate from oxidation of pyrite (-1.0‰) and sulfate from anhydrite (+10.2‰), or 2) the low pH (~ 4.5) of the tailings due to the applied acid circuit leads to (partial) dissolution of ore and supergene sulfides, resulting in $\delta^{34}S_{SO4}$ value close to the total S of the ore forming fluid (+4.5‰). At ES the $\delta^{34}S_{SO4}$ values average -0.9‰, suggesting dissolution of supergene sulfate minerals (mean -0.7‰) as the most probable source. The decrease of $\delta^{18}O_{SO4}$ values from the surface to the bottom of the unsaturated zone (LA: -4.5 to -10‰, ET: -1.3 to -4.7‰, ES: +2.7 to -3‰) indicates the increasingly importance of ferric iron as main electron acceptor in the pyrite oxidation. The effect of climate can be observed by lower $\delta^{18}O_{SO4}$ values in humid climate (LA), where more oxygen is derived from water ($\delta^{18}O$ = -10.9‰) over Mediterranean climate (ET) to hyper-arid climate (ES), where more atmospheric oxygen ($\delta^{18}O \approx$ +23‰) is involved in the pyrite oxidation.