

Re–Os ISOTOPE SYSTEMATICS APPLIED TO HYDROTHERMAL SULPHIDES

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Because rhenium and osmium are strongly chalcophile, the Re–Os isotope system has been lauded as uniquely suited to studying processes relating to hydrothermal sulphides. Rhenium and osmium in sulphides are at ppt–ppm levels, and are in the lower end of the range in sulphides associated with felsic magmatism. The exception is molybdenite, which is extremely enriched in Re and has been recognized as a potential geochronometer for over 30 years, but has met with mixed success. Deviations in Re–Os ages from molybdenite have been attributed to either problems with analytical techniques or post-crystallisation disturbances. Molybdenite Re–Os ages can be disturbed due to micro-inclusions of Re-enriched phases, or to alteration that can be identified using back-scattered electron and infrared imaging. Coupled with X-ray diffractometry, this improves the success of recognizing altered from unaltered molybdenites. For example, high 3R molybdenite from Potrerillos, Chile, has 8759 ppm Re and a Re–Os age of 38.1 ± 2.0 Ma, consistent with 38–34 Ma ages obtained by the K–Ar technique. In contrast, molybdenite from Cuajone, Peru is also high 3R (95–100 % 3R) but contains only 975 ppm Re, and has a disturbed Re–Os age (86.3 ± 3.4 Ma vs. 51–61 Ma). The Cuajone samples were collected well into the hypogene zone, but beneath an old palaeochannel, where meteoric fluids may have altered the molybdenite along existing fractures. No evidence at the macroscopic scale indicated that these samples were altered.

A variety of analytical techniques are adequate to obtain Re and Os from molybdenite, but the lower blank levels of the Carius tube/distillation technique make it most promising for the other sulphides associated with felsic igneous rocks due to their lower concentrations. Chalcopyrite, bornite, pyrite and sphalerite from the base metal porphyry deposit at El Teniente, Chile (~5 Ma) have Re contents of 0.053–0.180 ppb and Os contents of 0.042–0.9 ppb. $^{187}\text{Re}/^{188}\text{Os}$ ratios are from 0.3–21.8 and initial $^{187}\text{Os}/^{188}\text{Os}$ ratios range from 0.17 to 0.22. Paragenetically late pyrite with an initial $^{187}\text{Os}/^{188}\text{Os}$ of 0.88 indicates that the ore deposit was not isotopically homogeneous in Os throughout its formation. At Andacollo, Chile (~100 Ma) pyrites have $^{187}\text{Re}/^{188}\text{Os}$ ratios of 15–3600, and isochrons yield ages between 87 and 103 Ma, consistent with sericite K–Ar ages. Initial $^{187}\text{Os}/^{188}\text{Os}$ ratios of 0.2–1.1 are similar to El Teniente and suggest significant crustal involvement in the causal intrusives. The large range may be explained by a rapidly evolving fluid in which Re and Os concentrations change dramatically as minerals precipitate. This effect can be advantageous because large Re/Os variations can be obtained in separates of a single mineral from a hand specimen.

A final consideration in extending Re–Os isotope systematics to sulphides associated with felsic magmatism is that careful mineralogical examination prior to analysis is essential for the results to be geologically reasonable. Alteration of sulphides in the weathering environment is an established process that creates world-class ore deposits (e.g., supergene chalcocite) and outcrops used in exploration (i.e., gossans). Protocols have long been established for recognizing disturbed minerals in the lithophile radiogenic isotope systems (e.g., silicates in ^{40}Ar – ^{39}Ar , Sm–Nd, Rb–Sr). It is dangerous to assume that disturbance does not occur in chalcophile minerals simply because it is not easily detected. We have successfully applied criteria for evaluating molybdenite integrity prior to analysis, and extend these procedures to other base metal sulphides associated with felsic magmatism.