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DETERMINATION OF SULFIDE AGES FROM LOWER SILESIA USING THE Re-Os METHOD

Abstract: Molybdenite from quartz veins in a late Variscan Strzegom-Sobótka granite massif from the Fore-Sudetic block yield ages of 309 to 304 Ma with the Re-Os method. The ages of the molybdenite reflect post-magmatic hydrothermal activity associated with leucogranite (aplogranite) related to regional uplift and shear deformation during Westphalian time within this part of the Saxothuringian zone of the European Variscan belt. A six-point Re-Os isochron age of 317 ± 17 Ma has been obtained for auriferous sulfides from sheeted quartz veins representing the first stage of ore precipitation at the Radzimowice Au-As-Cu deposit. A Co-arsenopyrite sample from the Klecza Au deposit – analysed as a low level highly radiogenic (LLHR) sulfide – yields a precise age of 316.6 ± 0.4 Ma. The Re-Os ages indicate refractory gold mineralization in the Late Namurian during post-orogenic extension and regional uplift of the Kaczawa Mountains.

Keywords: molybdenite, refractory gold, rhenium, osmium, low level highly radiogenic sulfides (LLHR), Lower Silesia, Kaczawa Mountains, SW Poland.

INTRODUCTION

Re and ^{187}Os concentrations in selected sulfides were determined at AIRIE, Colorado State University, using procedures and techniques outlined in Stein *et al.* (2001) and Markey *et al.* (2003). The Re-Os method has been successfully applied to molybdenite age determination, as well as analysis of sulfides with much lower concentrations of Re and Os, including samples with very high Re to Os ratios (so-called low level highly radiogenic sulfides – LLHR, Stein *et al.* 2000). We present the results of high precision Re-Os age determinations for molybdenite samples using a mixed double Os spike (^{185}Re , ^{188}Os - ^{190}Os). Analysis of samples with extremely low levels of Re and/or Os requires careful monitoring of blanks, and a full blank correction including adjustment of the $^{187}\text{Os}/^{188}\text{Os}$ ratio. Very low-level samples cannot be expected to deliver the same uncertainty in their age as high level molybdenite. The first Re-Os isotopic ages for LLHR sulfides closely associated with gold mineralization were reported for the Bendigo goldfield in Australia (Arne *et al.* 2001). Since then additional studies have successfully dated arsenopyrite and pyrite (*e.g.* Morelli, *et al.* 2004). This work provides the first Re-Os data for sulfides from the Sudetes of southwest Poland.

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AGE OF MOLYBDENITE FROM THE PASZOWICE QUARRY ON THE FORE-SUDETIC BLOCK

In the NW part of the Strzegom-Sobótka granitoid massif, numerous occurrences of molybdenite mineralization have been documented (Pendias, Walenczak 1956; Sałaciński 1973, 1978; Kanasiewicz, Mikulski 1989; Ilnicki 1998). Among other localities, Mo mineralization is found in the abandoned aplogranite quarry near the Paszowice village. Molybdenite is a major sulfide present in quartz veinlets forming either monomineral concentrations or may occur in paragenetic association with other sulfides (chalcopyrite, pyrite), native bismuth, or rarely with oxides such as wolframite and cassiterite (Pendias, Walenczak 1956; Sałaciński 1973). Molybdenite samples for Re-Os dating were collected from the lowest level in the central part of the quarry within the Strzegom-Sobótka granitoid massif (Mikulski *et al.* 2005a). Euhedral molybdenite was selected from fine-crystalline gray quartz veins (up to 2 cm thick) cutting fine-grained leucogranite porphyry (aplogranite). The low Re contents of these molybdenites, all below 1 ppm, are typical of molybdenites associated with crustal metamorphic processes (Stein, *in press*). Ages range from 309 to 304 Ma (Table 1).

Table 1. Re-Os data for molybdenite from quartz veins, Paszowice quarry *after* Mikulski *et al.* 2005a

(Sample)	Re, ppm	¹⁸⁷ Os, ppb	Age, Ma
MDID-311	0.6847 (6)	2.219 (2)	309 ± 1
MDID-304	0.932 (1)	2.975 (4)	304 ± 1
MDID-315	0.5428 (1)	1.744 (3)	306 ± 1

AGE DETERMINATION OF AURIFEROUS SULFIDES FROM THE RADZIMOWICE AND KLECZA DEPOSITS IN THE KACZAWA MOUNTAINS

At Radzimowice, gold-bearing polymetallic sulfide mineralization is found in quartz-sulfide ± carbonates veins that cut the Żeleźniak intrusion and its metamorphic cover (Maneck 1965; Zimnoch 1965; Paulo, Salamon 1974; Mikulski 1999, 2005). Six representative main stage vein samples were acquired. Analyses of auriferous Co-arsenopyrites from the Radzimowice Au-As-Cu deposit yield Re concentrations of 0.13-3.5 ppb with total Os in the ppt range (Mikulski *et al.* 2005b, c). The LLHR arsenopyrite (LL-99) from Radzimowice with the highest Re contents yields a Re-Os model age of 317 Ma that is fairly insensitive to the assumed ¹⁸⁷Os/¹⁸⁸Os initial ratio (¹⁸⁷Re/¹⁸⁸Os > 10⁵). There is general agreement between model ages for these samples when an Os initial ratio of 0.2 is used. Additional analyses of Re and Os concentrations in pyrite and chalcopyrite samples from the Radzimowice deposit were also made. Unfortunately, these sulfides had extremely low contents of Re and Os, in the low ppt range. Nonetheless, these results were used to construct a six-point isochron that yields a Re-Os age of 317 ± 17 Ma (Fig. 1). The relatively large uncertainty is due to the very low Os concentrations for most of the samples (<5 ppt total Os in all cases but one). Re concentrations are a few tens of ppt.

At Klecza-Radomice, gold-bearing sulphide mineralization occurs in quartz lodes, veins and vein arrays in folds (saddle reefs), faults and brittle-ductile shear zones, all

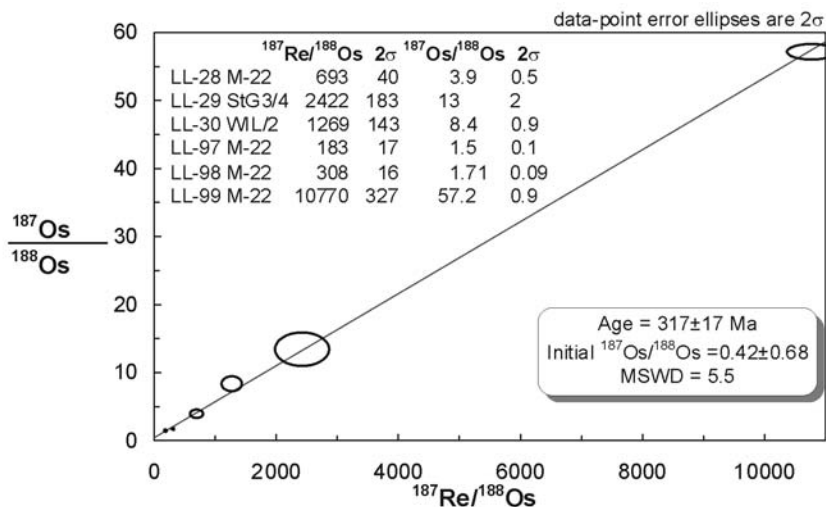


Fig. 1. Six-point isochron for auriferous sulfides from Radzimowice (Mikulski *et al.* 2005c)

hosted in flysch sequences, deformed and metamorphosed to lower greenschist facies (Mikulski 2003). Nearly all analyzed auriferous sulfide samples from the Klecza-Radomice ore district were characterized by extremely low Re concentrations (near blank level), so age information based on those samples, with the exception of one, is not well-constrained. Co-arsenopyrite sample G-4 from Klecza, however, analyzed as a LLHR sample, provides a highly precise 2-sigma age of 316.6 ± 0.4 Ma, assuming an initial $^{187}\text{Os}/^{188}\text{Os}$ ratio of 0.2.

DISCUSSION AND CONCLUSIONS

Quartz vein-hosted molybdenum mineralization in the Paszowice quarry clearly postdates emplacement of leucogranite (aplogranite), but is considered as related to either (1) post-magmatic processes associated with the emplacement of evolved and Mo-specialized leucogranite magma (Kanasiewicz, Mikulski 1989), or (2) metamorphic processes and the development of shear zones. Field relationships permit an interpretation whereby the Paszowice leucogranite and mineralized quartz veins were emplaced during shear deformation in late Variscan time. Re-Os dating of molybdenite constrains the age for this deformation to about 310-303 Ma. Thus, the Mo mineralization formed during uplift of the Variscan orogen in Westphalian time (Mikulski *et al.* 2005a).

At the Radzimowice Au-As-Cu deposit, gold-bearing sulfide veins cut dacite porphyries and post-date lamprophyre dykes, but also appear to be spatially associated with the dykes. A Re-Os model age of *ca.* 317 Ma for LLHR arsenopyrite sample LL-99 agrees with SHRIMP ages for zircon from fine-grained rhyolite and microgranites from the Źeleźniak intrusion (316.7 ± 1.2 Ma; Muszynski *et al.* 2002) and may indicate a genetic relationship between auriferous Co-arsenopyrite and post-orogenic felsic magmatism (Mikulski *et al.* 2005c). The occurrence of quartz-sulfide veins spatially associated with lamprophyre dykes may indicate that deep-seated structures controlled both alkaline lamprophyric magmatism and channelways for post-magmatic hydrothermal fluids (Mikulski 2005). Within uncertainty, the Re-Os age for our isochron overlaps our much more precise model age of 316.6 ± 0.4 Ma for Co-arsenopyrite sample G-4 from the Klecza deposit. In summary, Re-Os ages indicate that refractory gold mineralization in the

Kaczawa Mountains took place at ca. 317 Ma (Late Namurian), during post-orogenic extension and regional uplift.

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