

PENELOPE computer simulations of secondary fluorescence in EPMA

J. KELLY, J. GOSSES, C. WEBBER, K. STAFFIER
AND J. FOURNELLE

Dept. of Geology and Geophysics, 1215 W. Dayton, Madison,
WI 53706, USA (jkelly@geology.wisc.edu)

Researchers are aware that primary electron interaction volumes in EPMA span a few microns in geologic materials. X-rays can travel farther and result in secondary fluorescence (SF) across phase boundaries. In the past, this SF was rarely corrected. Excess x-rays result in inaccurate measurements, particularly at trace element levels. PENELOPE is a new computer modeling program designed to simulate SF across phase boundaries [1]. PENELOPE modeled several situations in which SF was a probable source of error; in particular the goal was to reproduce experimental SF where possible.

Fe in Cu grains (Meteorites): PENELOPE showed that at 10 μ m away from a pure iron phase there was 1 wt.% apparent Fe due to SF, which decreased to 0.2 wt.% at 30 μ m. Our data was in excellent agreement with recent experimental work [1], but did not coincide with older experimental work.

Al (Trace element) in Quartz: PENELOPE generated Al values are similar (100-200ppm) to data collected by Müller et al. [2] and do not represent a significant SF effect.

Ti (Trace element) in Quartz: PENELOPE data suggested 10ppm Ti at 100 μ m from the phase boundary. No SF was experienced at distances greater than 200 μ m away from the boundary. The Ti ppm data could reflect SF in quartz and not necessarily Ti ppm levels present in the quartz [2].

Ca from CPX in OPX: The SF error in the 2 pyroxene geothermometry method of Taylor [3] and Brey and Kohler [4] was estimated with PENELOPE for Red Hills samples (New Zealand). The effect was found to be minimal. In 5 μ m opx exsolution lamella, 0.11 wt% Ca was due to SF.

Ca in olivine Fo90, Fe in plagioclase An60: PENELOPE shows that Fo90 at 10 μ m from An80 will have 0.03 wt.% Ca from SF, and drops to near zero (.001 wt.%) at 100 μ m. Fe SF in plagioclase from adjacent Fe-rich glass or Fe-bearing phases was studied experimentally [5, 6]. PENELOPE SF data is slightly greater than, but generally matches, previous work.

References

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SR-XRF analyses of trace elements in electrum from several epithermal gold deposits, Japan

T. SAKAMOTO¹, N. SHIMADA¹, D. ABE¹, T. NAKAMURA¹,
W. NOZAKI¹, K. SHIMADA¹ AND A. IIDA²

¹Dep. Earth and Planetary Sci., Kyushu Univ., Fukuoka, 812-8881, Japan (takeaki@geo.kyushu-u.ac.jp)

²Photon Factory, KEK, Tsukuba, 305-0801, Japan
(atsuo.iida@kek.jp)

Auriferous quartz is a major source for gold, and occurs in hydrothermal veins, especially in epithermal vein-type deposits in Japan. The most important mineral in such deposits is electrum, native metal alloy with silver, which occurs as very fine grains less than several ten μ m in diameter in quartz together with minor amount of sulfide, selenide and telluride minerals. Although EPMA is a common instrument of non-destructive elemental analysis and is useful to analyze quantitatively the contents of Au and Ag in electrum, few realize those of trace elements. This study aims to clarify the contents of trace elements in the electrum by means of SR-XRF analyses, in order to discuss the formation environments of the epithermal gold deposits.

The samples of high-grade auriferous quartz were collected from three representative gold deposits of the Hishikari, Ohkuchi and Kushikino mines in Kyushu, Japan. We extracted electrum grains from the samples by treating with HF and then HCl, HNO₃ and H₂SO₄ solutions. The analysis was performed at the High Energy Accelerator Research Organization (KEK), Japan. The SR-XRF spectra were obtained for individual electrum grains using an X-ray microbeam of 5 μ m x 6.5 μ m at the energy of 10.5 keV. An energy dispersive spectrometer was used to analyze X-ray fluorescence.

It is obvious that the electrum contains Cu, Fe, Zn, Cr, Ba, Te and/or Sb as trace elements less than 1,000 ppm. Electrum from Hishikari and Ohkuchi is characterized with high Cu and Fe, together with Zn, Cr and Ba. The electrum is divided into two types, Te-rich one associated with Se-bearing minerals (e.g., naumannite), and Te-poor one with Te-bearing minerals (e.g., hessite). While, electrum from Kushikino contains higher contents of Cu, similar of Fe, Zn, Cr and Ba, lower of Te, and subordinate amounts of Sb. This electrum is intergrown with Sb-bearing minerals (e.g., tetrahedrite). It appears that differences of trace element concentrations in electrum among the epithermal deposits are closely related with paragenetic minerals, and also reflect the chemical features of ore forming hydrothermal solution.