Mapping temperature gradients in hydrothermal vein systems with Raman spectroscopy

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The San Sebastian mine is located in eastern Durango State in the centre of the Mexican silver belt. The epithermal veins in the district are hosted in Mesozoic Caracol Formation carbonaceous shale. The district hosts a series of high-grade epithermal veins that span over three kilometres of strike length and a vertical extent of over 500 metres. The district hosts both shallow, lower temperature gold-silver dominant epithermal mineralization and deeper, higher temperature polymetallic (silver, copper, lead, and zinc with minor gold) epithermal mineralization, occurring concurrently within single veins.

The San Sebastian project was mined for precious metals from 2001 to 2005 and was one of the highest grade producers in Mexico. The mine returned to production in December of 2015 and operates at a rate of 370 tonnes/day from both open pit and underground operations. Since startup, the mine has produced 368,297 tonnes of ore containing 77,493 ounces of Au and 9.8M ounces of Ag with an average grade of 6.5 g/tonne Au and 830 g/tonne Ag.

Temperature, pressure and structure are the primary controls of mineralization in epithermal vein deposits. Mapping of temperature gradients at the vein or deposit scale can be useful to exploration drill hole targeting by: 1) identifying favorable temperature isotherms for the deposition of mineralization, 2) mapping potential up-flow/feeder zones, and 3) identifying metal zonation within a deposit.

Raman spectrometry of carbonaceous material is a geothermometric technique that measures the progressive, irreversible ordering that graphitic carbon undergoes during heating. The degree of order reached by the graphitic carbon molecules can be measured using Raman spectroscopy, then the maximum temperatures experienced by the host rock in a deposit are estimated using established calibration equations.

Four hundred and fifty-nine samples of carbonaceous shale host rock material located in direct contact with veins were taken from drill core at the San Sebastian project and analyzed at Western University. The focus of a master's level thesis was to develop a cost-effective protocol to prepare and analyze these samples and derive temperatures. The resulting data showed that temperatures from Raman analyses display clear temperature zonation on longitudinal sections and in three dimensional views. Potential fluid up-flow zones were identified, demonstrating that this technique is a viable, cost-effective exploration technique in deposits hosted by carbonaceous sedimentary rocks.

Keywords: Raman graphitic carbon geothermometer, carbonaceous material, temperature zonation, mineral exploration, epithermal, veins, precious metals, polymetallic.

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