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PARTIAL MELTING OF THE ASSEMBLAGE SPHALERITE + GALENA + PYRRHOTITE + CHALCOPYRITE + SULFUR: IMPLICATIONS FOR HIGH-GRADE METAMORPHOSED MASSIVE SULFIDE DEPOSITS

Gary Stevens,† Sebastian Prinz, and Abraham Rozendaal

Department of Geology, Stellenbosch University, Private Bag X1, Stellenbosch, 7602, South Africa

Abstract

The role of Cu, added as $CuFeS_2$, and S, added as FeS_2 that decomposed to FeS + S during heating, on the melting behavior of Fe-Pb-Zn massive sulfide deposits has been investigated at 2 MPa. The solidus of the assemblage $CuFeS_2$-PbS-FeS-ZnS-S is located at a temperature between 700° and 730°C, at least 70°C below that of the galena-pyrrhotite-sphalerite system. The lowest temperature melt that was present in an analyzable volume in this study (at 750°C) had the average composition of 68.8 at. percent Fe, 6.5 at. percent Cu, 1.7 at. percent Zn, and 23 at. percent Pb. The experimental charges underwent gravity-driven differentiation into two density-stratified crystal-rich zones (sphalerite- and pyrrhotite-rich, respectively) floating on a melt-rich zone. Vesiculation textures developed near the top of the melt-rich portion of the quenched charges, suggesting that the melts produced in this study contained sulfur at a concentration greater than the 1:1 ratio of sulfur to metal cations that typifies the sulfides that crystallized from the melt (pyrrhotite + galena + chalcopyrite). This study demonstrates that the assemblage $CuFeS_2$-PbS-FeS-ZnS-S will melt close to the second sillimanite isograd in metapelites, within the upper amphibolite facies, and will produce initial melts that crystallize approximately equal proportions (wt %) of pyrrhotite and galena, with relatively little chalcopyrite and very little sphalerite. The apparent excess sulfur in the melts, in conjunction with the relatively low copper concentrations in the melts developed close to the solidus, suggests that the depression of the solidus relative to that of the galena-pyrrhotite-sphalerite system can be attributed to the solubility of a pyrite component in the melt. These findings indicate that sulfide mobility in a melt phase should be considered in the evolution of all massive sulfide bodies metamorphosed to upper amphibolite facies conditions or higher, and that the presence of a sulfur-rich fluid phase may promote melting during high-grade metamorphism.

† Corresponding author: e-mail, gs@sun.ac.za

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