The serious side effects of suicidal sulphide segregation systems

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The metal contents of sulphide liquids largely depend upon the amount of silicate magma that they are able to "process" for metals. Some high-grade magmatic Ni-Cu (± PGE) deposits and many magmatic PGE (± Ni-Cu) deposits require very high magma: sulphide ratios that are hard to visualize. Recent models for some base-metal-dominated deposits suggest "multistage upgrading" processes, in which an early-formed sulphide liquid reacts with subsequent batches of silicate magma. Such models circumvent the requirement for small amounts of sulphide liquid to react with vast amounts of silicate magma in a single step. However, any later magmatic flux is likely to be sulphur-undersaturated, and will thus partially redissolve any pre-existing sulphide liquids as it enriches them. Empirical computer models and mathematical analyses of this combined process yield identical results, which suggest that it may be important in the genesis of high-grade magmatic sulphide deposits.

Multistage upgrading combined with sulphide liquid dissolution is a very efficient process, and could reduce the amount of silicate magma that must be processed by as much as two orders of magnitude. It also permits development of sulphide liquids that have metal contents above those attainable via single-stage, closed-system reaction between sulphide liquid and magma. Furthermore, the behaviour of base metals and PGE during advanced dissolution of sulphide liquids is fundamentally different. The base-metal contents of the sulphide liquids will generally stabilize, whereas their PGE contents will generally continue to increase. Mathematical analysis demonstrates that contrasting element behaviour is largely governed by the relative magnitudes of the sulphide/magma partition coefficient and the dissolution rate of the sulphide liquid. This "decoupling" effect provides a possible explanation for the unusually high grades and high PGE: base metal ratios exhibited by many PGE-dominated deposits.

However, every silver lining is surrounded by a cloud. If sulphide liquids can be partially dissolved during multistage upgrading, it is also possible that they could be *completely* dissolved, and all previously-extracted metals returned to later batches of magma. Should this occur, metal-depletion signatures characteristic of sulphide liquid segregation would still be preserved in the geological record, even though the sulphides themselves had been destroyed. Complementary metal-enrichment signatures in magmas would likely be very difficult to detect, particularly for the base metals. Caution is therefore dictated in the use of magmatic depletion signatures to infer overall mineral potential, or to estimate the possible size of undiscovered magmatic sulphide deposits.