Memorable mathematical models of suicidal sulphide segregation

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Economic sulphide deposits rely on segregation of metals from a silicate magma into an immiscible sulphide liquid phase. In equilibrium, the ratio of the metal concentrations in the sulphide liquid and silicate magma is given by the distribution coefficient D, which is about 500 for Nickel and 1000 to 100 000 for PGE. However, that does not mean that sulphide Ni content is upgraded 500 times relative to the initial magma, because as the sulphide becomes upgraded the silicate magma becomes more metal-depleted: the sulphide metal contents depend on the relative quantities of silicate and sulphide (the "R" factor) as well as D. For a single batch of magma, this can be expressed as a very simple mathematical equation. When several batches of sulphur-saturated magma equilibrate with one batch of sulphide, e.g. in a magma conduit, a different equation results. This "multistage" upgrading actually requires less total silicate magma but, as in the single batch system, upgrading is limited to a maximum value of D. However, when the batches of magma are sulphur-undersaturated, as would normally be the case, the equations allow for radically different results. As the sulphide phase dissolves, upgrading of base metals in the remaining sulphide becomes greater than D, and PGE can experience "upgrading runaway". A valuable deposit may result if solidification occurs before the sulphide is entirely consumed.