Measuring relative volatilities and activities of trace components in silicate melts

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Knowledge of the activities of trace components in silicate melts is extremely important for addressing such problems as (a) degassing in volcanic systems (b) volatilities in protoplanetary systems and (c) the effect of melt composition on trace element partitioning. Nevertheless these activities are very difficult to measure by conventional phase equilibrium techniques except under circumstances where the metallic element is stable in a readily accessible fO_2 range[1].

We have modified the "metal-saturation" approach by measuring the partitioning of a large number of elements (V, Cr, Cu, Zn, Ga, Ge, Mo, Ag, Cd, In, Sn, Sb, W, Tl, Pb, and Bi) between liquid Fe alloys and liquid silicate at 1.5 GPa and 1923K. These data provide activity coefficients for oxide components relative to the activity of FeO, whose partitioning between metal and silicate is also measured. These activities enable prediction of the relative volatilities of these elements[2].

To validate the volatility estimates a one-atmosphere gas-mixing stirring furnace has been constructed (see schematic). Volatile-loss experiments have been conducted to directly measure volatile loss of these trace elements from a melt of basaltic composition.

At 1573K and a $\log(fO_2)$ of -13, thermodynamically calculated vapour pressures predict that In should be more volatile than Pb, Ge, Cu and Sb, by factors of 10^2, 10^4, 10^7, and 10^{10} respectively. Our results show that In is actually less volatile than all of these elements by the factors given here: Cu, 1.3; Pb, 1.3; Tl 2.3; Sn, 4.8; Ag, 9.1; Zn, 10.1; Cd, 15.9; Ge, 19.4; Bi, 42.3; Sb, 97.

These results have implications concerning volatile degassing of molten planetissimals and their associated trace element budgets.

[1] O'Neill, H. S. C. & Eggins, S. M. (2002) *Chem Geol* 186: 151-181 [2] Wood, B. and J. Wade (2013). *Contrib Mineral Petrol* 166(3): 911-921.