# THE EXPERIMENTAL DETERMINATION OF PARTITION COEFFICIENTS FOR Cr BETWEEN ORTHOPYROXENE AND A SYNTHETIC BUSHVELD / STILLWATER PARENT MELT, AS A FUNCTION OF OXYGEN FUGACITY AND TEMPERATURE: IMPLICATIONS FOR THE DISTRIBUTION OF CHROMITE IN LAYERED INTRUSIONS.

Stephen J. Barnes, SN4
NASA Johnson Space Center, Houston Tx. 77058.

Chrome contents of orthopyroxene have been determined for all the spinel - opx saturated experiments described in the accompanying abstract (Barnes, this volume). Orthopyroxenes in these experiments are bronzites having mol. % En between 76 and 90. The Cr content of opx coexisting with spinel varies between oxygen buffer curves from 0.5-0.6 wt.% $Cr_2O_3$ at NNO and QFM, to 1.0-1.2% at IW, and is independent of temperature along each buffer curve. Opx/melt partition coefficients for Cr (expressed as ratio of wt. %) are presented in figure 1. $D_{Cr}$ increases with falling temperature and increasing oxygen fugacity, from about 1 at 1330 and IW to 12 at 1160 and QFM. As in the case of the solubility data, the oxygen fugacity dependence is attributable to changing Cr(III) to Cr(II) ratio. D values for Cr(III) have been calculated after correcting for this effect, using the results of the spinel - melt exchange calculation given in [1]. The regression of log D for Cr(III) vs. reciprocal temperature is shown in figure 2.

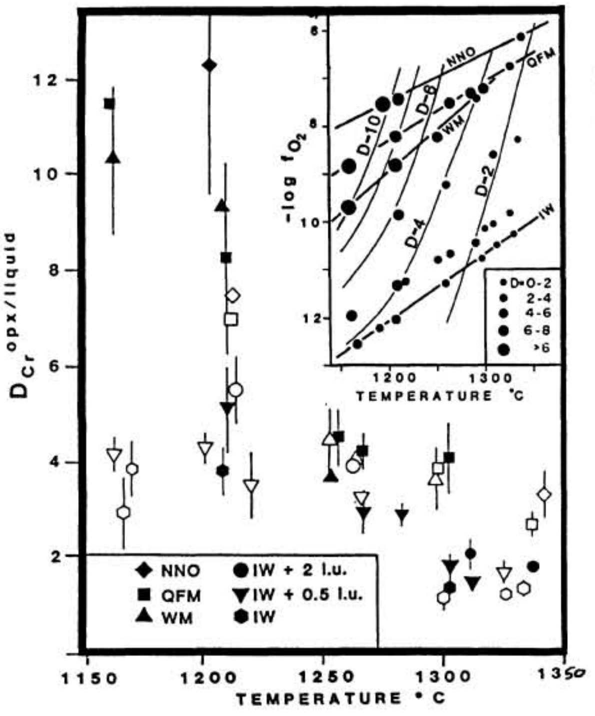
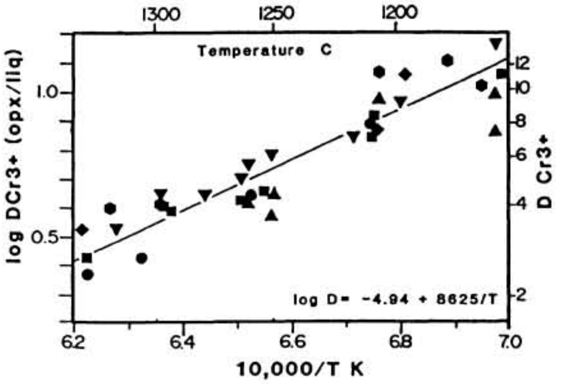


FIGURE 1. Experimental determinations of $D_{Cr}$ vs. temperature along and between various oxygen buffer curves. Open symbols: isothermal runs, closed symbols: runs cooled from liquidus. Error bars = 2 X std. error of mean probe determination (some error bars have been omitted for clarity). Inset shows contours on D in log $fO_2$ - T space.

FIGURE 2. Regression of log D for Cr3+ vs. reciprocal temperature, after correction for Cr(III)/Cr(II) ratio in silicate melt as described in [1].



Application to layered intrusions. In the Stillwater Complex, chromite seams are restricted to the olivine - rich lower 20% of the cumulate stratigraphy. Chromite is rare to absent in pyroxenitic cumulates, and absent altogether in the overlying gabbros and norites of the Lower Banded Series. In the Bushveld Complex, in contrast, chromite seams commonly occur within orthopyroxenite layers, and extend well up into the noritic and anorthositic Upper Critical Zone. Hill and Roeder [2] observed a peritectic reaction

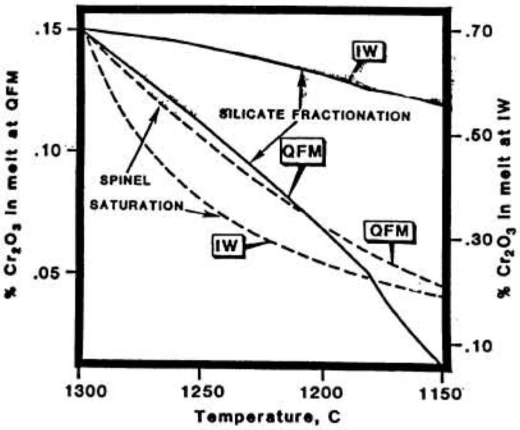


FIGURE 3. Model curves for variation in Cr in melt (total Cr expressed as $Cr_2O_3$) at QFM (left axis) and IW (right axis). Solid curve for fractionation of opx ± plag. (to right of inflection) alone. Dashed curve is experimental chromite saturation surface from [1].

relationship between chromite and pyroxene; this accounts for the distribution of chromite in the Stillwater, but not in the Bushveld.

Figure 3 shows model curves for variation of Cr (total Cr expressed as $Cr_2O_3$) in a hypothetical silicate melt, calculated from the regressed experimental data at QFM and IW. In both cases, the melt is assumed to be initially saturated with both opx and chromite. Solid curves show the trend of Cr in the liquid due to crystallization of silicates alone (opx, joined by plagioclase at the point of inflection). At IW, the silicate fractionation trend plots well above the chromite saturation surface. The melt must follow the lower of the two paths; therefore, at IW, the melt follows the chromite saturation surface, and chromite and opx continue to crystallize together throughout. At QFM, however, the spinel saturation surface and the silicate fractionation trend are almost coincident, such that minor fluctuations in conditions may determine whether or not chromite will crystallize along with opx. Below about 1200°, continuing pyroxene fractionation pulls the melt below the spinel saturation surface, and chromite ceases to crystallize. The latter case corresponds to the Stillwater Complex, where chromite disappears below the top of the ultramafic cumulates. The Bushveld Complex may have crystallized under somewhat more reducing conditions, such that co-precipitation of chromite and opx extends over a wider range, and chromite saturation persists to a higher stratigraphic level.

The experimental data indicate that Cr contents of pyroxenes crystallizing along the spinel saturation surface should remain constant along a given oxygen buffer curve. At Cr contents below chromite saturation, opx becomes progressively depleted in Cr for oxygen fugacities at or above the WM buffer, while at IW pyroxene Cr contents increase slightly with fractionation in the absence of spinel. This is due to the combination of low D values under reducing conditions with the temperature dependence of Cr partitioning. The model QFM trends closely match the observed trend of Cr in Stillwater bronzite.

References: [1] Barnes, (1985), this volume. [2] Hill and Roeder (1975), J.Geol. 82, 709-729.