

VARIATION IN SULFUR AND OXYGEN FUGACITY ASSOCIATED WITH PGE-SULFIDE MINERALIZATION, STILLWATER COMPLEX. Alan E. Boudreau and I. Stewart McCallum, Department of Geological Sciences, AJ-20, University of Washington, Seattle, WA 98195.

Recent work on platinum-group element (PGE) mineralization within the Stillwater and Bushveld complexes has led to the suggestion that these ore zones are characterized by localized changes in sulfur and oxygen fugacities (1,2). Within OB I of the Stillwater Complex (the lowermost olivine-bearing zone of the Banded series), PGE-sulfide is found with a variety of mineral assemblages. The evidence for variation in sulfur and oxygen fugacity is consistent with reactions involving increasing interaction between the rocks of OB I and a volatile component.

Sulfide within OB I occurs in all rock types of this mineralogically variable unit, from normal cumulate (gabbro)norite, to pegmatitic olivine + biotite assemblages. Phase assemblages are as follows:

- A) pl + opx + po + py + cpx
- B) pl + opx + ol + po + cpx + py
- C) pl + ol + chromite + po + opx + cpx + py
- D) ol + biotite + po + pl + hb + opx + cpx

Primary pyrite (present as exsolved blebs in pyrrhotite) is common only in olivine-free mineral assemblages. A reaction involving chromite and biotite is evident in biotite rimming chromite, and the absence of chromite in olivine-rich rocks (>60% olivine) which contain abundant biotite. Fig. 1 shows a path of sulfur fugacity vs. oxygen fugacity variation that is consistent with the above mineral assemblages, and fig. 2 shows possible paths in a sulfur fugacity vs. $1/T$ diagram. For both figures, mt refers to the magnetite component of chromite and ksp refers to potassium feldspar component of plagioclase. It is apparent that assemblage A (unbuffered by the silicate/oxide assemblage) will intersect the pyrite solvus on cooling, whereas the other assemblages will not. Furthermore, the lowest sulfur and oxygen fugacity is associated with the more olivine-rich rock types.

Additional evidence that the above sequence is accompanied by a change in oxygen fugacity is seen in microprobe analyses of iron in plagioclase (fig. 3). Two compositional fields for iron in plagioclase are defined: A) "cumulus" plagioclase, typically medium grained, in samples which may or may not contain olivine. B) Interstitial "recrystallized" plagioclase, typically coarse-grained to pegmatitic, with the most albitic plagioclase being associated with biotite. The lowest iron content occurs in recrystallized plagioclase which coexists with relatively iron-rich mafic phases, especially the biotite-bearing assemblages, which have the highest $Fe/(Fe + Mg)$ ratio observed within OB I. As terrestrial plagioclase may contain from 2/3 to 3/4 ferric iron (3), the lower total iron content of the biotite-bearing assemblages is consistent with lower oxygen fugacity and resulting lower ferric iron content of the plagioclase.

It has been shown by Kinloch (1) that ferroplatinum alloy dominates in the potholes of the Merensky Reef of the Bushveld Complex, whereas PGE-sulfide mineralization is more typical of the reef away from the potholes. Furthermore, Buntin et al. (4) have shown that the potholes are characterized by a lower intrinsic oxygen fugacity. Both authors have suggested that the potholes represent zones of volatile streaming, and hence can be interpreted as regions of high fluid/rock interaction leading to lower oxygen and sulfur fugacities of these rocks. The olivine-rich rocks of OB I also contain anomalous Cl-rich biotite and apatite (5), providing additional evidence for the

VARIATION IN SULFUR AND OXYGEN FUGACITY
Boudreau, A.E. and McCallum, I. S.

presence of Cl-rich fluids at this level in the intrusion. Olivine may also be a secondary mineral which resulted from incongruent dissolution of pyroxene with silica undersaturated fluid (6,7). The results to date are consistent with a high fluid/rock ratio associated with the olivine-rich rocks of OB I, and with increasing fluid/rock interaction leading to progressively lower fugacities of both sulfur and oxygen.

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References: (1) Kinlock (1982) *Econ. Geol.* 77:1328-1347. (2) Elliot et al. (1982) *Econ. Geol.* 77:1493-1510. (3) Longhi, J., et al. (1976) *Proc. Lunar Sci. Conf 7th*, p. 1281-1300. (4) Buntin, T. J. et al. (in press). (5) Boudreau and McCallum LPSC XVI, this volume. (6) McCallum et al. (1977) *Trans. Am. Geophys Union* 58:1245. (7) Boudreau (1982) *Lunar and Planet. Inst. Tch Rpt 82-01*, p. 59-61.

Figure captions: (1) Plot of log sulfur fugacity vs. log oxygen fugacity for mineral assemblages of OB I. (2) Plot of log sulfur fugacity vs. $1/T$. Points A, B, C, and D refer to those in figure 1. (3) Total iron in plagioclase (as FeO) vs. An content of plagioclase.

