Pyroxenes from the Beaver Bay Gabbro Complex of Minnesota

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Abstract. Although the Beaver Bay ferrogabbro is a small-scale layered intrusion, Ca-rich pyroxenes show a strong iron enrichment during fractionation, ranging from augite (Mg$_{56}$Fe$_{24}$Ca$_{28}$) to ferrohedengergite (Mg$_{59}$Fe$_{24}$Ca$_{24}$). Ca-poor pyroxenes from intermediate pigeonite (Mg$_{52}$Fe$_{25}$Ca$_{23}$) to ferriferous pigeonite (Mg$_{57}$Fe$_{24}$Ca$_{29}$) occur as intercumulus minerals. The pyroxenes from the non-layered Beaver River gabbro are included in the overall pyroxene fractionation trend of the Beaver Bay gabbro complex. The pyroxene trend of the Beaver Bay gabbro complex is similar to those of the Skaergaard and Bushveld; however, there is a slight difference in that the Ca-rich pyroxenes of Beaver Bay (having Mg content over 30%) are slightly richer in Ca than either the Skaergaard or Bushveld augites.

Introduction

Muir (1954) made chemical analyses of one ferroaugite and the host ferrogabbro. He showed that ferrohortonolite ferrogabbro (iron rich diabase in Muir's nomenclature) contains ferroaugite (Mg$_{56}$Fe$_{24}$Ca$_{28}$), ferroppigeonite (Mg$_{52}$Fe$_{25}$Ca$_{23}$) and orthopyroxene. Gehman (1957) has summarized the pyroxene trend from Beaver Bay ferrogabbro with an additional analysis of one ferroaugite and five compositions of ferroaugite obtained by the optical method.

In the present paper, the overall trend in pyroxene crystallization from the Beaver Bay gabbro complex is presented, combining previously published data with new analyses of pyroxenes from Beaver Bay layered ferrogabbro and Beaver River non-layered gabbro. And also the pyroxene crystallization trend of the Beaver Bay gabbro complex is compared with those of the Skaergaard and Bushveld intrusion.

Chemical Composition of the Ca-Rich Pyroxenes

Eleven Ca-rich pyroxenes were separated by means of a Flantz Isodynamic separator and heavy liquid of cleriei solution, in order to establish the whole trend of pyroxene crystallization during fractionation in the magma of Beaver Bay gabbro complex. Fig. 1 shows a mineral assemblage in the Beaver Bay gabbro complex. Some augite from the lower half of the ferрогabbro has thin exsolution lamellae, but they were removed. Inverted pigeonite, hypersthene and primary pigeonite are almost impossible to separate, because these minerals are usually very fine-grained. The major component of the Ca-poor pyroxenes and olivines were determined by an electron microprobe. The bulk analysis of the Ca-rich pyroxenes were carried out by the wet chemical method. The results are shown in Table 1, together with previously published analyses to complete the sequence of pyroxene crystallization in the Beaver Bay gabbro complex.
Fig. 1. Columnar section of the Beaver Bay layered ferrogabbro. Thickness of the Beaver Bay layered ferrogabbro represents the structural height (meters). Numbers (1-14, A and B) in column are same in Table 1

The calculation of the atomic proportions of Ca-rich pyroxenes was made with the assumption that the tetrahedral position of Z is completely filled by Si and Al. Where Si and Al were deficient, Ti was added to Si and Al so as to make the atomic number in Z exactly equal to 2.00.

The minor elements, Al₂O₃, Fe₂O₃, Mn, TiO₂ and K₂O constitute about 4% of each of the analyses, but do not effect on the trend of pyroxene crystallization. The Na content is not variable, on the whole, throughout the Beaver Bay gabbro complex. The variation trend of Mn is quite similar to that seen in the Skaergaard,