

## **Metamorphic amphiboles in the Ironwood Iron-Formation, Gogebic Iron Range, Wisconsin: Implications for potential resource development**

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### **ABSTRACT**

The Paleoproterozoic Ironwood Iron-Formation, a Superior-type banded iron formation located in the western Gogebic Iron Range in Wisconsin, is one of the largest undeveloped iron ore resources in the United States. Interest in the development of this resource is complicated by potential environmental and health effects related to the presence of amphibole minerals in the Ironwood, a consequence of Mesoproterozoic contact metamorphism. The presence of these amphiboles and their contact metamorphic origin have long been recognized; however, recent interest in this resource has highlighted the lack of detailed knowledge on their distribution, mineral chemistry, and morphology. Optical microscopy, X-ray diffraction, scanning electron microscopy, and electron microprobe analysis were utilized to investigate the origin, distribution, morphology, and chemistry of amphiboles in the Ironwood.

Amphibole is present in the western portion of the study area due to regional-scale contact metamorphism associated with the intrusion of the 1.1 Ga Mellen Intrusive Complex. Locally amphibole is also present, adjacent to diabase and/or gabbro dikes and sills in the lower-grade Ironwood in the eastern portion of the study area. In both localities, amphiboles in the Ironwood most commonly developed in massive and prismatic habits, and locally assumed a fibrous habit. Fibrous amphiboles were recognized locally in the two potential ore zones of the Ironwood but were not observed in the portion likely to be waste rock. Massive and prismatic amphiboles show a wide range of Mg# [molar Mg/(Mg+Fe<sup>2+</sup>)] values (0.06 to 0.87), whereas Mg# values of fibrous amphiboles are restricted from 0.14 to 0.35. Factors that influenced the compositional variability of amphiboles in the Ironwood may have included temperature of formation, morphology, bulk chemistry of the iron formation, and variations in prograde and retrograde metamorphism. The presence of amphiboles in the Ironwood is a known issue that will need to be factored into any future mine plans. This study provides an objective assessment of the distribution and character of amphiboles in the Ironwood to aid all decision-makers in any future resource development scenarios.

**Keywords:** Amphibole, banded iron formation, Ironwood Iron-Formation, metamorphism