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The pilot knob magnetite deposit in the Proterozoic St. Francois Mountains Terrane, southeast Missouri, USA: A magmatic and hydrothermal replacement iron deposit

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ABSTRACT

The Pilot Knob magnetite deposit is located in southeast Missouri within the 1380–1480 Ma St. Francois Mountains terrane rhyolitic/trachytic volcanic rocks. The deposit is tabular, dips about 45°, and is sill-like in nature, being approximately parallel to the bedding in the host tuffs. The deposit was uncovered by erosion and exposed to weathering in the late Proterozoic, and is overlain in angular unconformity by the Cambrian Lamotte Sandstone. This Proterozoic weathering cycle apparently had little effect on the deposit with only the updip edge being converted to hematite. Textural and mineralogical features of the deposit suggest a combined magmatic and hydrothermal replacement origin. The magnetite-rich ores that make up the bulk of the deposit are interpreted as having crystallized from an iron-rich magma, and a surrounding envelope of lower- to moderate-grade ores where magnetite has clearly replaced the tuffaceous host rocks are interpreted as hydrothermal in origin. After the development of the higher-grade magnetite ores and the envelope of lower- to moderate-grade ores, late hydrothermal minerals were deposited as cross-cutting veins and breccia fill. The two most abundant minerals in the higher-grade portions of the deposit are magnetite and albitic plagioclase, and petrologically the higher-grade ores could be described as a magnetite sodic syenite. The most abundant gangue mineral within the lower-grade impregnated envelope of ores around the higher-grade ores is K-feldspar, apparently relict from the rhyolites/trachytes. Thin lenses within the higher-grade ores contain calcite as a matrix mineral to the magnetite and are considered to indicate carbonatitic affinity. Rare earth elements are elevated in one of five whole rock chemical analyses of the ores and the REE-bearing mineral ferriallanite has been identified. Minor portions of the deposit, below the Proterozoic weathering cap, consist of high-grade hematite ores having equilibrium textures. At depth, the deposit is intruded by the Shepherd Mountain gabbro, a 120 m thick, near-horizontal dike, which resulted in minor contact metamorphism of the ore.

1. Introduction

The Pilot Knob magnetite deposit (PKM) is located in Iron County, Missouri, USA (Fig. 1), and was mined from 1968 to 1980, producing 20 million tons averaging 35–40% iron (Kisvarsanyi, 1990). The deposit consists of a series of tabular forms that strike northwest and dip about 45° southwest (Figs. 2 & 3), approximately parallel to layering within the host sequence of Proterozoic St. Francois Mountains terrane (SFMT) pink to gray rhyolitic pyroclastic rocks, dated between 1380 and 1480 Ma (Van Schmus and Bickford, 1981). The deposit does not crop out and was discovered by drilling of an aeromagnetic anomally in the 1950s and 60s, and because the deposit is covered by approximately 100 m of Cambrian sedimentary rocks, no geologic map of the local area exists. The orebody was exposed on the Precambrian unconformity and is angularly overlain by the basal Cambrian Lamotte Sandstone. The updip edge of the orebody was partially replaced by hematite during its erosional exposure (Wracher, 1976). The Shepherd Mountain gabbro, a 120 m thick near-horizontal and relatively unaltered dike that cuts the deposit (Fig. 2), yields a whole rock Sm–Nd isochron age of 1333 ± 56 Ma (Lowell and Rämö, 1999). The current study was conducted on the 18 surviving cores through the deposit.

The southeast Missouri iron deposits (PKM, Pea Ridge, and Iron Mountain) have been compared extensively with the Kiruna ores (Sweden), and there are numerous similarities. The Missouri ores are hosted by Proterozoic peralkaline rhyolites and trachytes and have been suggested to be genetically related to the development of this igneous suite (Kisvarsanyi, 1981). Frietsch and Perdahl (1994) suggested that at Kiruna, the iron ores were part of the same magma that formed the volcanic host rocks and evolved as a late differentiate. However, Geijer and Ödman (1974) noted that Kiruna is characterized by a distinct compositional gap between the ores and the associated igneous rocks, such that the ores are composed predominantly of magnetite–apatite whereas the host volcanic rocks are dominantly feldspathic.

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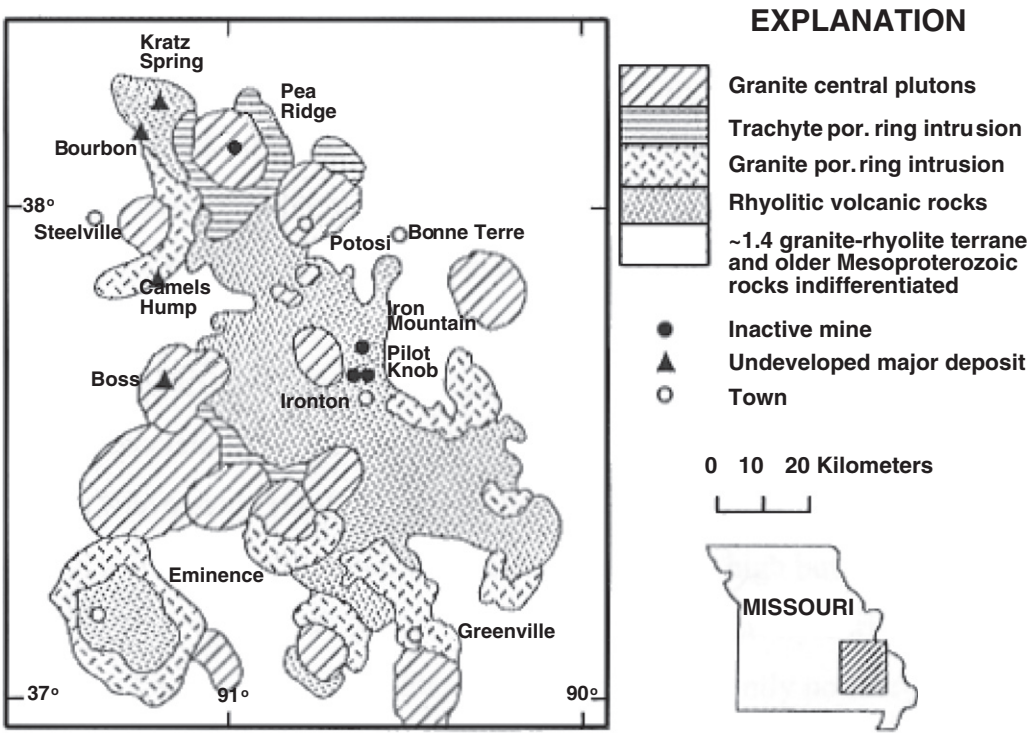

Fig. 1. Geologic map of the St. Francois Mountains igneous terrane, showing surface and subsurface features, with known and inferred plutons and ring-dike complexes (modified from Kisvarsanyi, 1981). The most westerly of the two black dots near Pilot Knob is the Pilot Knob magnetite deposit.

This is not the case at PKM; where PKM has minor apatite in most of the ores, mostly as traces, the most important minerals accompanying the magnetite are albite, quartz, K-feldspar, and chlorite. Although it is true that PKM has considerable dissimilarities to the main Kiruna magnetite–apatite orebody, PKM is very similar to the magnetite syenite porphyries that lie within the footwall of the main Kiruna orebody.

The genesis of "Kiruna-type" magnetite deposits is still controversial despite over a hundred years of discussion. Although many authors

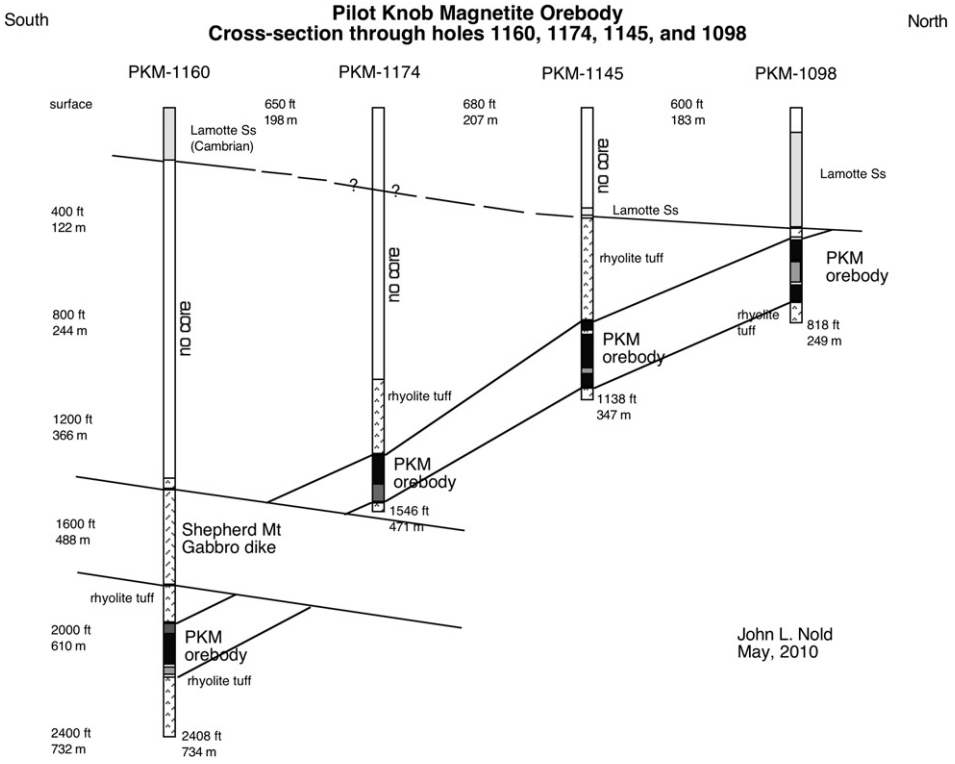

Fig. 2. Cross-section down the dip of the PKM orebody through core holes 1098, 1145, 1174, and 1160. The orebody is overlain in angular unconformity by the Cambrian Lamotte Sandstone and is cut by the 120 m thick Shepherd Mountain Gabbro dike at depth. In the cross-section, black and gray refer to higher and lower-grade portions of the orebody, respectively. The orebody is shown in more detail in Fig. 3.