Ore Geology Reviews 81 (2017) 296–308

Contents lists available at ScienceDirect

Ore Geology Reviews

journal homepage: www.elsevier.com/locate/oregeorev

Mineralogy, age and genesis of apatite-dolomite ores at the Seligdar apatite deposit (Central Aldan, Russia)

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ARTICLE INFO

Article history:
Received 28 July 2016
Accepted 12 October 2016
Available online 18 October 2016

Keywords:
Dolomite carbonatite
Aldan-Stanovoy shield
Apatite ore
Siberia
Genesis
Age
Mineralogy
Melt and fluid inclusion

ABSTRACT

The Seligdar apatite deposit is located in the Aldan-Stanovoy shield of the Siberian platform in Russia. This deposit is a typical ore deposit of the Nimnyrskaya approximately N-S apatite zone, which is about 400 km long. The genesis of the apatite-dolomite ores at the Seligdar deposit is a matter of debate. This article presents new evidence of the carbonatitic genesis of the apatite-dolomite rocks at the Seligdar deposit based on modern methods of mineralogical, geochronological, melt and fluid inclusion investigations. According to our data, the age of the apatite-dolomite ores is 1880 ± 13 Ma (U-Pb SHRIMP, zircon). Study of melt inclusions indicates that the ores were formed from a carbonate melt of dolomitic composition with alkali (sulphates, chlorides and fluorides of Na and K) and silica components (1–10 wt.%) at a temperature of >1100 °C. The dolomite carbonatites have been subsequently exposed to the intense processes of hydrothermal-metasomatic alteration and metamorphism. The evolution of mineral parageneses from the magmatic apatite-magnetite-dolomite carbonatite stage to the hydrothermal stages with quartz, calcite, monazite-Ce, xenotime-Y, haematite, thorite, thorianite, sulphates and sulphides mineralization agrees with the fluid inclusion regime evolution from the carbonate melt to the chloride brines, and the varying concentrations of the chloride solutions are also described in this article. The investigation of the apatite deposits within the Aldan shield not only allows us to take a new look at the question of their origin but also helps us to study the composition of the ancient mantle, as well as the specifics of apatite-dolomite carbonatite and related hydrothermal Fe and Th-REE mineralization in this region.

1. Introduction

The Seligdar apatite deposit is located in southeastern Russia (Fig. 1). The deposit is situated approximately 30 km southwest from Aldan town in the Central Aldan region of Yakutia (Sakha Republic, East Siberia). The Seligdar deposit is a typical part of the Nimnyrskaya apatite zone (Entin and Tyan, 1984). This zone is confined to the Hardagasky depression and controlled by the ancient Hatystyrsky approximately N-S deep fault. The host rocks of the apatite ore clusters are Archaean metamorphic rocks of the Aldan-Stanovoy shield and terrigenous platform sedimentary rocks. Granitoids and gabbro to plagiogranites from approximately 2000 Ma are spatially associated with the ore clusters.

Age estimates of the apatite-carbonate rocks at the Seligdar deposit range from 2600 to 1400 Ma (Tugarinov et al., 1976; Entin and Tyan, 1984). Dykes of dolerite (1200 Ma) and intrusions of diorite (age unknown) and syenite (Late Mesozoic) are found in the ore clusters of the Nymnyrskaya apatite zone. The complex history of tectonic processes and related magmatism leaves a number of geochronological questions. However, the main question is the origin of the apatite-carbonate ores in this region.

There are several hypotheses of origin for the apatite-carbonate ores of the Seligdar deposit. According to the sedimentary-metamorphic hypothesis, the deposit is confined to the productive carbonate horizon of the Fedorov Archaean suite (Egin and Kichigin, 1973). According to the metasomatic model, there is a potassium-alkaline mafic intrusion at depth, which served as a source of phosphorus for the formation of the hydrothermal-metasomatic apatite ore body (Boyarko, 1983). There is also the hypothesis that the Seligdar ores formed from mantle-crust carbonatites (Smirnov et al., 1976), but because of the lack of association of the apatite-dolomite carbonatites with any ultrabasic alkaline rocks in this region, the hypothesis has not found much support to date.

In this paper, we present new mineralogical, age, melt and fluid inclusion data, which suggest that the Seligdar ores are probably the product of a carbonatite melt.

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http://dx.doi.org/10.1016/j.oregeorev.2016.10.012
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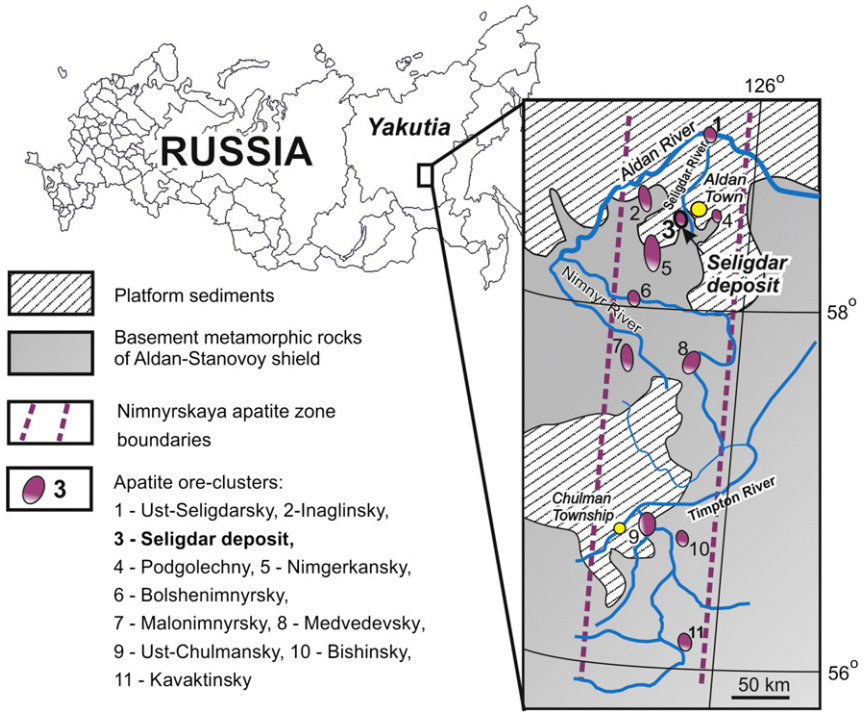

Fig. 1. Position of the Seligdar deposit within the Nimnyrskaya apatite zone in south-east of Russia. (after Entin and Tyan, 1984)

2. Geology

The discovery of the Seligdar apatite deposit occurred during 1972–1982. It was established that the deposit consists of a single round ore body with output parameters of 1.6 × 2.2 km at the surface and estimated total reserves of P_2O_5 of approximately 110–112 Mt (Boyarko, 1983, Fig. 2). The apatite mineralization was traced by drilling as deep as 1660 m. According to the geophysical data, the interpreted depth of the ore body is no less than 3 km. According to morphology, the ore body is a vertically bedded stock-work that is divided into a series of lenses at the periphery. The northern part of the ore body reaches the surface; the southern part is covered by overlying Lower Cambrian carbonate sediments and intrusions of syenite porphyries of Late Mesozoic age (Entin and Tyan, 1984).

The tectonic position of the ore body is determined by the location of the intersecting Tommotsky and Yuhtinsky regional faults trending northeast and northwest, respectively. Faults and cracks within the ore body are filled with brecciated and haematitized apatite-carbonate ores, as well as dykes of trachyte and kersantite. The host rocks in the Seligdar ore field are composed of metamorphosed Archaean deep crystalline rocks, represented by various compositions of gneisses and marbles with minor calc-silicate rocks (Egin and Kichigin, 1973). Gneisses

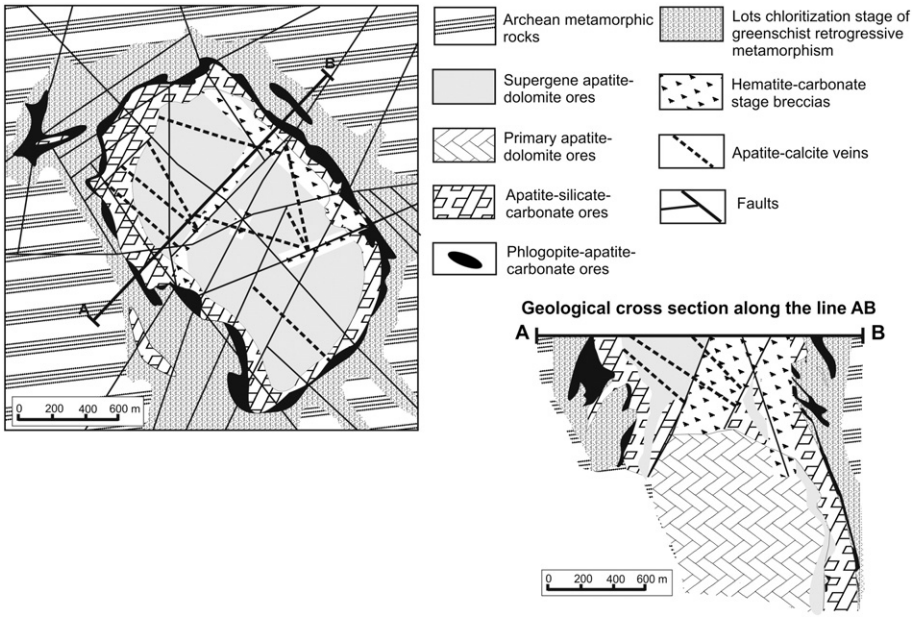

Fig. 2. Schematic geological map and a cross-section through the ore body of the Seligdar deposit. (after Boyarko, 1983)