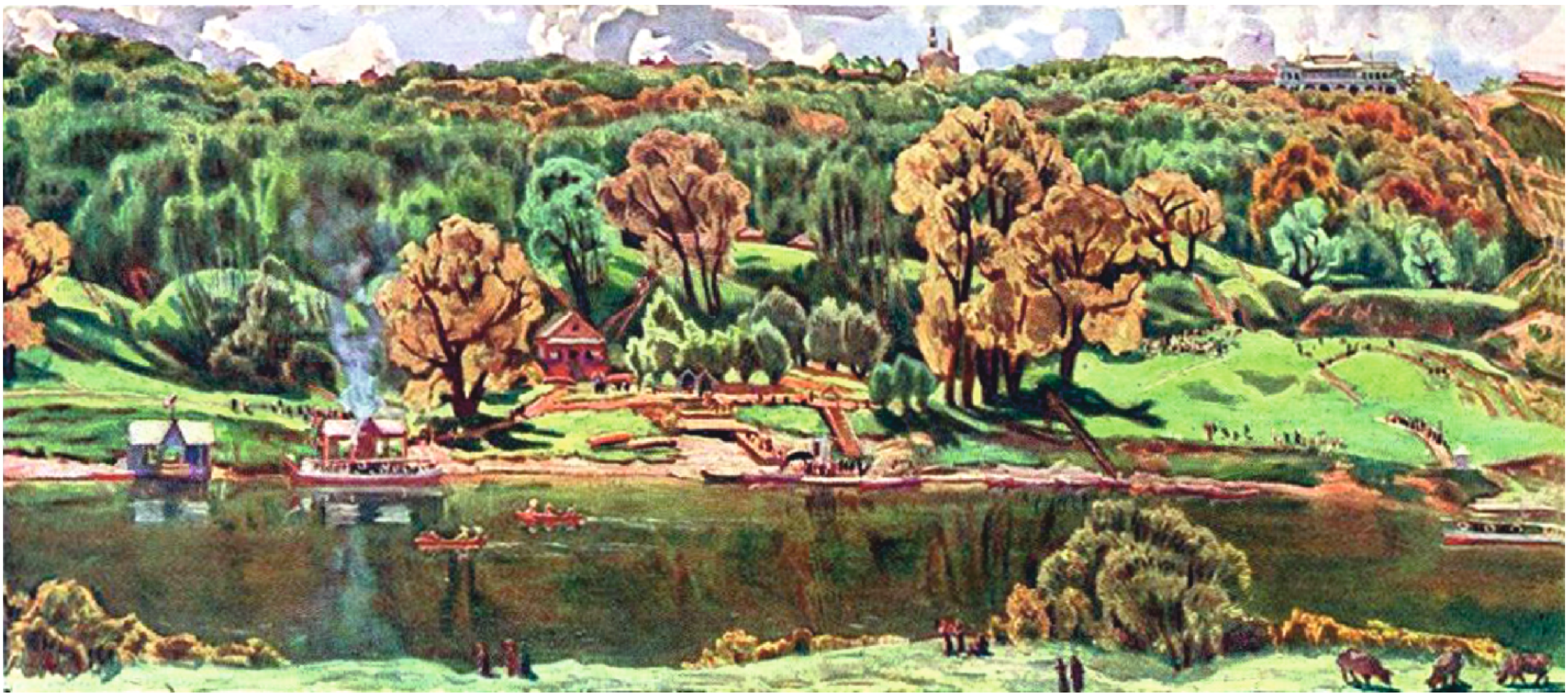
MAGMATISM OF THE EARTH AND RELATED STRATEGIC METAL DEPOSITS



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Magmatism of the Earth and related strategic metal deposits

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The mineral deposits of strategic metals are vulnerable to political and economic changes, and their availability is essential for high-technology, green energy, and other applications. The most of they are related to the deep – seated alkaline magmas.

This book offers a collection of papers presented at the 35th International Conference on Magmatism of the Earth and Related Strategic Metal Deposits held from September 3th to 7th 2018 in Moscow, Russia.

The conference articles are focused on the understanding of the geological processes that produce high concentrations of critical metals in geological systems such as the metal transport in the mantle (possibly from the core-mantle boundary) and crust and enrichment processes, hydrothermal and metasomatic processes leading to the formation of such significant deposits. Papers in this book give a representative overview including mineralogy, geochemistry and origin of strategic metals deposits.

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The cover pictures - Sparrow Hills, May. Konstantin Fedorovich Yuon, 1910.

Phonolites are represented by the following species: phonolites, sodalite phonolites and calcite phonolites. Phenocrysts are represented by nepheline (40-65%), pyroxenes of the diopside-hedenbergite series, rarely with aegirine edging (10-50%), sanidine (15-40%), Mg-Fe mica (0-5%), titanite (1-10%), and apatite (0-8%). In these rocks a large number of macrophenic crystals of nepheline, pyroxene, and often sanidine are observed.

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PETROLOGY AND CONDITIONS OF FORMATION OF THE MADIAPALA SYENITES, CENTRAL ZONE OF THE LIMPOPO COMPLEX, SOUTH AFRICA

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The Madiapala syenite body is located in the western part of the Central Zone (CZ) of the high-grade Limpopo Complex, South Africa. It is situated within the Alldays TTG gneisses with an age 2610 - 2640 Ma. According to the SHRIMP geochronological data using the ^{207}Pb / ^{206}Pb ratio in titanites, Rigby et al. (2011) reported an age of the syenites 2010.3 ± 4.5 Ma. This age corresponds to the period of the Paleoproterozoic tectono-thermal activity (D3/M3) in the CZ, which was characterized by a massive fluid influx along regional and local shear-zones. Using pseudosection method (THERMOCALC), Rigby et al. (2008) estimated 6 kbar and 770°C as peak P-T parameters for the syenites and interpreted them as conditions of metamorphism of pre-existing syenites during the Paleoproterozoic metamorphic stage. Different model for the formation of the syenites within the TTG gneisses is suggested by Safonov et al. (Safonov, Aranovich, 2014; Safonov et al., 2014) on the basis on experiments on the interaction of biotite-amphibole tonalite gneiss with H_2O-CO_2-(K, Na) Cl fluids at 750 and 800ºC and 5.5 kbar (Safonov et al., 2012, 2014). These experiments demonstrated that the leading factor for formation of the syenite assemblages after tonalite gneiss is an increase of potassium activity in a fluid (associated with the salt component of the fluid). Thus, the Madiapala syenites could be a product of the syenitization of the TTG gneisses under influence of saline H_2O-CO_2 fluids.

The earliest assemblage in the syenites is potassium feldspar + clinopyroxene + titanite ± apatite. In order to estimate the conditions for formation of this assemblage, we used the PERPLE_X (Connolly, 2005) software, version 6.7.7 for Windows, to construct the P-T pseudosections for the dry syenite system, for the hydrous system and for the system saturated with an aqueous-carbonic fluid. These graphs showed that the observed association occurs in the water-bearing system (Fig. 1).

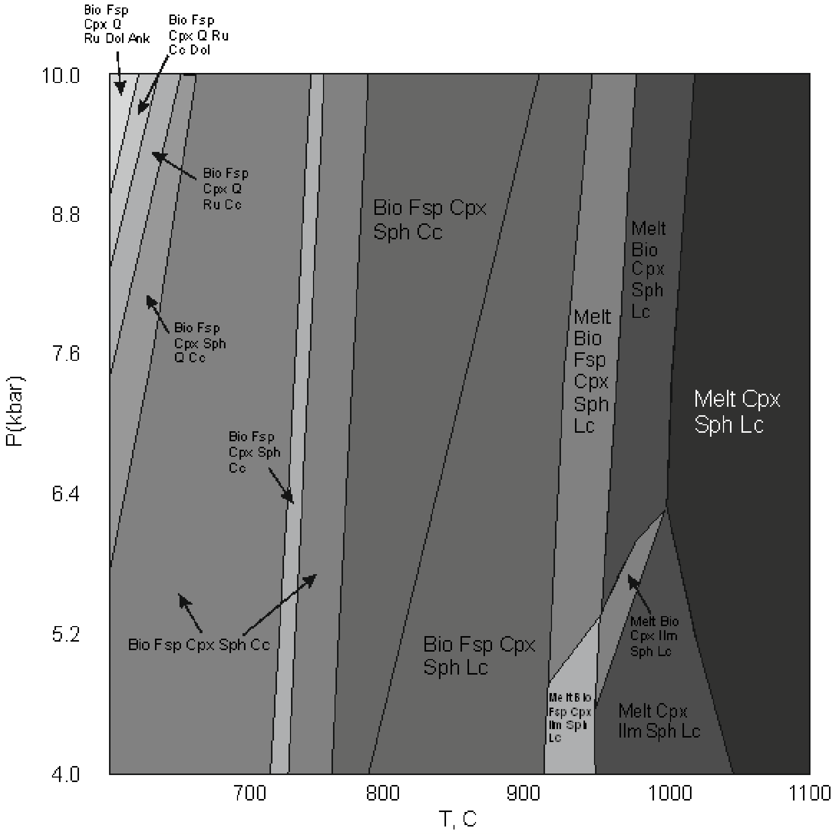

Fig. 1. P-T pseudosection for the syenite bulk composition in a system with a saturated H2O-CO2 fluid (mole fraction of CO2 is 0.5).

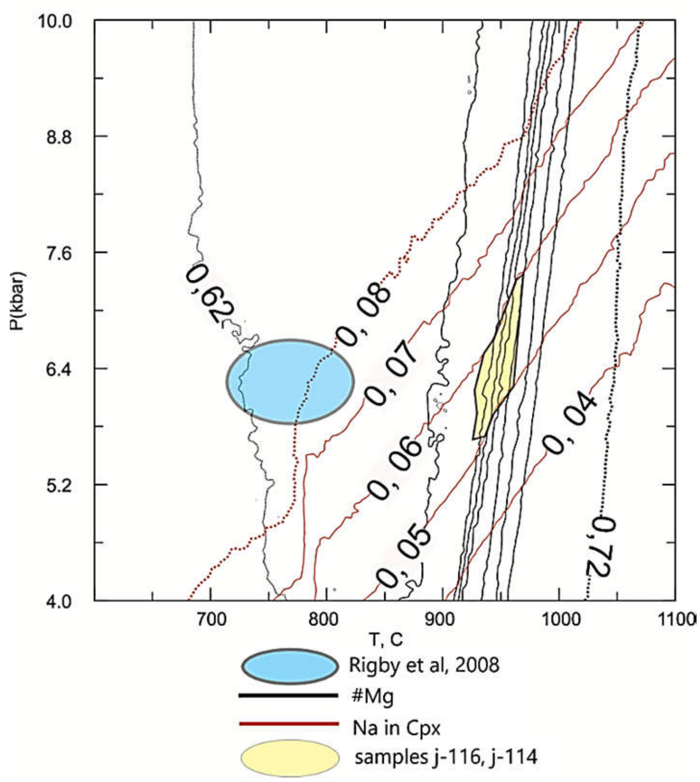

Fig. 2. Isopleths for Mg-number and Na content in clinopyroxene for the Madiapala syenites.

Following to the pseudosection, isopleths X_{Mg} = 0.64 – 0.67 и 0.05 – 0.06 a.p.f.u. Na in clinopyroxene, characteristic for the syenites, converge at temperatures 930-960°C and pressures 5.6 - 7.4 kbar.

At similar pressure, the calculated temperatures are much higher than the temperatures estimated by Rigby et al. (2008) (Fig. 2) for amphibole-bearing metasomatic veins in the syenite body (6.4 ± 0.6 kbar, 770 ° C). We suggest that temperatures > 900 ° C correspond to crystallization of the primary magmatic assemblage Cpx + Kfs + Sph ± Ap, whereas amphibole-bearing assemblages recorded the cooling of the syenite magma. Pseudosection in terms of lg(a_{H2O}) and lg(a_{K2O}) show that the Alldays gneiss can be transformed to the syenite via increase of the potassium activity at constant P and T.

Thus, the formation of the primary syenite assemblage occurred at pressures of about 6.4 kbar and temperatures of 950°C in the study of Alldays tonalite gneisses with a H_2O-CO_2-salt fluid, in which a potassium-salt component played an important role. The formation of amphibole-bearing assemblages, studied by Rigby et al. (2008), occurred during cooling of the syenite magma at the middle-crustal level 18-20 km.

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REGULARITIES IN THE LOCATION OF VOLCANOGENIC PYRITE-POLYMETALLIC DEPOSITS IN SIBERIA

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The most important factor in the formation of large reserves of pyrite ores is the connection with contrast or successively differentiated volcanogenic formations, the proximity of the ore source, the presence of structures that favored the accumulation and rapid burial of large ore bodies, and the long duration of ore formation processes against the background of the paleovolcanic regime (Dergachev, 2010; Kuznetsov, 2014). The most promising regions of the Russian Federation for the development of mineral resource base of polymetallic ores are: Rudnoaltay, Salair, Kyzyltashtyg and Priargun mineragenic zones. Polymetallic and pyrite-polymetallic deposits in volcanogenic associations (VHMS) and sedimentary rocks (SEDEX) have been identified within these zones. The pyrite-polymetallic deposits of the Rudnoaltay, Salair, Kyzyltashtyg and Priargun mineragenic zones are formed synchronously with volcanism.

The Rudnoaltay mineragenic zone includes Zyryanovsky, Leninogorsky, Zmeinogorsky, Rubtsovsky, Zolotushinsky and Priirtyshsky ore zones, which are confined to volcanogenic-sedimentary rocks. According to the composition, age and ratio of the volcanogenic and sedimentary components, these rocks are divided into two formations related to the potassium-sodium series and corresponding to two cycles of volcanism: the lower (ems-eifel-early givet) - successively