

Editorial

Editorial for Special Issue “Ore Genesis and Metamorphism: Geochemistry, Mineralogy, and Isotopes”

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Magmatism, ore genesis and metamorphism are commonly associated processes that define fundamental features of the Earth’s crustal evolution from the earliest Precambrian to Phanerozoic. Basically, the need and importance of studying the role of metamorphic processes in formation and transformation of deposits is of great value when discussing the origin of deposits confined to varied geological settings. In synthesis, the signatures imprinted by metamorphic episodes during the evolution largely indicate complicated and multistage patterns of ore-forming processes, as well as the polygenic nature of the mineralization generated by magmatic, postmagmatic, and metamorphic processes.

Rapid industrialization and expanding demand for various types of mineral raw materials require increasing rates of mining operations. The current Special Issue is dedicated to the latest achievements in geochemistry, mineralogy, and geochronology of ore and metamorphic complexes, their interrelation, and the potential for further prospecting. The issue contains six practical and theoretical studies that provide for a better understanding of the age and nature of metamorphic and metasomatic transformations, as well as their contribution to mineralization in various geological complexes.

The first article, by Jiang et al. [1], reports results of the first mineralogical–geochemical studies of gem-quality nephrite from the major Yinggelike deposit (Xinjiang, NW China). The authors used a set of advanced analytical techniques, that is, electron probe microanalysis, X-ray fluorescence (XRF) spectrometry, inductively coupled plasma mass spectrometry (ICP-MS), and isotope (O, H) mass spectrometry, to obtain important evidence for formation of nephrite bodies associated with dolomites. Three main stages were established: (1) diopside formed by prograde metasomatism; (2) nephrite formed by retrograde metasomatism and replacement of anhydrous minerals of the first stage; (3) hydrothermal alteration after the nephrite formation. The new mineralogical–geochemical data on Yinggelike nephrites allow for a new interpretation of formation settings for such objects. Moreover, the new results can facilitate further prospecting for nephrite occurrences in the region.

The article by Li et al. [2] discusses the ore genesis of the Kuergasheng Pb-Zn deposit (Xinjiang Province, NW China) based on a detailed study of fluid inclusions in quartz and application of a range of isotope techniques (H–O–C–S–Pb isotopes). Three paragenetic stages are defined: early pyrite–chalcopyrite–quartz veins; middle-stage galena–sphalerite–quartz veins; and late sulfide–poor calcite–quartz veins. The authors provide evidence to support a hypothesis in which ore-forming fluids had a hybrid origin and formed under the impact of meteoric waters at late stages. New S- and Pb-isotope data for galena showed that the ore-forming matter was mainly obtained from the Beidabate intrusive body and the Tuosikuertawu Formation. Thus, a tight link between magmatism and fluid-metasomatic processes in the ore genesis of major deposits is justified.

The article by Ding et al. [3] provides interesting conclusions about the association of carbonaceous matter with gold mineralization in the Bumo Deposit (Hainan Province, South China). Although the carbonaceous material is a product of the metasedimentary genesis and is commonly associated with the gold mineralization, its genesis and the nature of its relationship with gold are still unclear. The authors establish two types of



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carbonaceous matter in the deposit, that is, layered and veinlet. The former type dominates and has an important feature: areas of gold-bearing sulfide mineralization are concentrated along boundaries between quartz veins and the layered carbonaceous material. Temperature measurements using the Raman carbonaceous material geothermometer demonstrate convincingly that the layered carbonaceous matter was formed at 400–550 °C. In contrast, the veinlet-hosted carbonaceous matter occurred at the temperatures typical of gold mineralization, that is, 200–350 °C. The authors make an interesting conclusion that the layered carbonaceous matter was generated during Caledonian pre-ore metamorphism and its presence promoted subsequent deposition of gold. The veinlet type has a hydrothermal origin, and its deposition changed chemical environment of ore fluids, which provided for destabilization of Au complexes favoring mineralization.

Geochemical features of zircon from tourmaline-muscovite granites of the Archaean Kolmozero–Voronya greenstone belt (NW Russia) and new U-Pb geochronological data are discussed in the paper by Kudryashov et al. [4]. Although thoroughly studied, the sources of ore components within the pegmatites are poorly constrained. The age and genesis of rare metal Li-Cs-Ta mineralization in pegmatite deposits of the Kolmozero–Voronya greenstone belt are also still debated. The age of pegmatites in the framework of the belt is dated at 2.7–2.6 Ga. Pegmatites can be linked to many types of granitoids in the region, for example, plagiogranites, tonalites, amphibole-biotite granodiorites, microcline granites, alkaline granites or muscovite-tourmaline granites. The authors dated cores of zircon crystals at 2802 ± 13 Ma and the rims of zircon crystals at 2728 ± 14 Ma, using high resolution analytical equipment for precise dating (SHRIMP-RG microprobe). Based on new isotope-geochronological data, tourmaline-muscovite granites close to veins of rare-metal pegmatites were suggested to be the most probable source for the components of the pegmatites.

The paper by Pripachkin et al. [5] provides comparative analysis of diorites observed in the Monchegorsk pluton (Kola Peninsula) and its basement. The Monchegorsk complex is primarily known for its complex Cu-Ni-PGE-Cr-Fe-Ti-V mineralization. It is also interesting from the viewpoint of geology and petrology for the multiphase igneous (including rhythmic) layering and availability of features confirming the multiphase nature of its emplacement with several genetic types of ore mineralization (contact, vein, and reef). Two types of diorites are known in this ore area, that is, the Archaean basement diorites widespread all over the Fennoscandian Shield, and metadiorites of the Gabbro-10 massif, which is a structural unit of the Monchegorsk pluton. According to U-Pb isotope data, the age of the diorite-gneisses in the DW block is 2736.0 ± 4.6 Ma. The Sm-Nd mineral (garnet, biotite, and tourmaline) isochron for the DW rocks yielded an age of 1806 ± 23 Ma (related to the processes of the Svecofennian orogeny). The DW diorite-gneisses are compared with the metadiorites of the Gabbro-10 massif. The latter is a part of the Monchegorsk complex, with U-Pb crystallization age of 2498 ± 6 Ma. Geological and isotope-geochemical data suggest that the DW rocks belong to the Archaean basement, whereas the Gabbro-10 metadiorites probably represent one of the late-magmatic phases of the Monchegorsk complex.

The successful synthesis of geological-petrographic, isotope-geochemical and geophysical methods is described in the article by Mustafaeu et al. [6]. This paper provides a consistent view at the formation of the University Foidolite–Gabbro Pluton (Kuznetsk Alatau Ridge, Siberia) and a potential source of its nepheline ores. The behavior of REE and HFSE in rocks of the massif suggests that sources of contained materials were heterogeneous. Despite a varied differentiation degree, geochemical parameters reflect joint involvement of both OIB and IAB components in melt genesis. It is emphasized that they were formed in a complex geodynamic environment that combines features of island arc, continental margin and intraplate magmatism, while mantle magmas were strongly contaminated by components derived from the continental crust. Based on the obtained age dates, the massif was likely emplaced at 494–491 Ma. The wide range of isotopic compositions of strontium and neodymium ($\epsilon_{\text{Sr}}(\text{T}) +3.13$ – $+28.31$ and $\epsilon_{\text{Nd}}(\text{T}) +3.2$ – $+8.7$) for the studied association indicates that initial magmas were generated from a plume

source of the moderately depleted PREMA mantle, from which derivatives were subject to selective crustal contamination.

In summary, the six papers show that use of advanced techniques for precise study jointly with world practices in scientific research allows unique results to be obtained both for individual geological objects, and for global geodynamic areas. Laboratory studies across the world provide a new perspective on the evolution of ore-magmatic systems and provide valuable clues to understanding the spatial, temporal, and genetic links between metamorphic processes, magmatism, and ore genesis. These interrelated studies carry great potential and will contribute to a better understanding of the Earth and the long-term history of the deep mantle.

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References

1. Jiang, Y.; Shi, G.; Xu, L.; Li, X. Mineralogy and geochemistry of nephrite jade from Yinggelike deposit, Altyn Tagh (Xinjiang, NW China). *Minerals* **2020**, *10*, 418. [[CrossRef](#)]
2. Li, S.; Chen, C.; Gao, L.; Xia, F.; Zhang, X.; Wang, K.; Arkin, K. Ore genesis of the Kuergasheng Pb–Zn deposit, Xinjiang Province, Northwest China: Constraints from geology, fluid inclusions, and H–O–C–S–Pb isotopes. *Minerals* **2020**, *10*, 592. [[CrossRef](#)]
3. Ding, Z.; Deng, T.; Xu, D.; Li, Z.; Zou, S.; Li, L.; Xu, K.; Hai, Y.; Ma, W. Genesis of two types of carbonaceous material associated with gold mineralization in the Bumo deposit, Hainan Province, South China. *Minerals* **2020**, *10*, 708. [[CrossRef](#)]
4. Kudryashov, N.M.; Udoratina, O.V.; Coble, M.A.; Steshenko, E.N. Geochronological and geochemical study of zircon from tourmaline-muscovite granites of the Archaean Kolmozero–Voronya greenstone belt: Insights into sources of the rare-metal pegmatites. *Minerals* **2020**, *10*, 760. [[CrossRef](#)]
5. Pripachkin, P.; Rundkvist, T.; Groshev, N.; Bazai, A.; Serov, P. Archean rocks of the diorite window block in the southern framing of the Monchegorsk (2.5 Ga) layered mafic-ultramafic complex (Kola Peninsula, Russia). *Minerals* **2020**, *10*, 848. [[CrossRef](#)]
6. Mustafaev, A.A.; Gertner, I.F.; Ernst, R.E.; Serov, P.A.; Kolmakov, Y.V. The Paleozoic-aged University foidolite-gabbro pluton of the northeastern part of the Kuznetsk Alatau Ridge, Siberia: Geochemical characterization, geochronology, petrography and geophysical indication of potential high-grade nepheline ore. *Minerals* **2020**, *10*, 1128. [[CrossRef](#)]