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Opinion

Review of Mineral Resources in Mongolia

Ochir Gerel*

Mongolian University of Science and Technology, Geoscience Center, Mongolia

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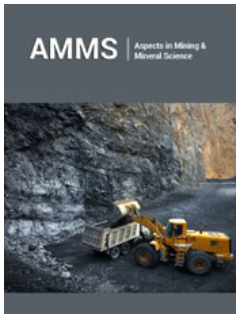

***Corresponding author:** Ochir Gerel, Mongolian University of Science and Technology, Geoscience Center, BagaToiruu 34, Ulaanbaatar, Mongolia

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Opinion

The position of Mongolia within the Central Asian Orogenic Belt, assembled by subduction-accretion is favorable for world-class deposits. The main types of economic metallic mineral deposits were formed from Neoproterozoic through Phanerozoic. Mongolia has high concertation of deposits and prospects of copper, base metals, gold, coal and uranium. The mining sector, a significant contributor to the economic development of Mongolia, accounts for 24% of the country's GDP, and 72% of the gross industrial output. Proven reserves include 69.9Mt of copper, 33.4Bt of coal, 34.2Mt of fluorspar, and iron ore of 1.84Bt. Mongolia produces and exports copper concentrate, coal, iron, fluorspar, gold, silver, uranium, and zinc. Total Mongolia's export of mineral products reached 70%, the export of coal is running at 98.9 percent, copper concentrate at 87.7%, iron ore at 59.8%, gold at 68.8%, and zinc at 103.8 percent, as reported by the Ministry of Mining and Heavy Industry in September 2022. There are several genetic types of copper deposits, and only the Cu-Au and Cu-Mo porphyry type is economic and includes two word-class Oyu Tolgoi (31Mt Cu, 1185t Au, 7809t Ag) and Erdenet (7.7Mt Cu and 362Kt Mo), major producers of copper concentrate [1]. Other deposits with economic importance are Tsagaan Suvarga (1.8Mt Cu), Kharmagtai, Oyut Ulaan, Saran Uul, and Shuteen porphyry systems formed in an island arc or continental arc environment associated with granodiorite, monzodiorite and monzonite. Mineralization is represented by bornite, chalcopyrite and chalcocite, and is associated with quartz-sericite (muscovite), potassium, argillic and propylitic alteration.

Molybdenum occurs in Mo porphyry type deposits or as by-products in Cu-Mo and W-Mo-Be greisen/stockwork and quartz vein mineral systems. There are about 50 Mo deposits and occurrences associated with granite, granodiorite and monzogranite. The highest annual molybdenum concentrate production was 5.5 thousand tons in 2018. Gold is mined from the hard rock related Boroo mine (40t Au) in north-central Mongolia and the Olon Ovoot mine in South Mongolia as well as the large placer deposits of Zaamar, Bayangol and Tolgoit in Central Mongolia. Representative primary gold mineralization types are gold-quartz, gold-quartz sulfide, gold-skarn, and gold-silver. Placer gold deposits are abundant and located along flood plains mined in large open-pit operations and contain 1 to 5 grams of gold/m3. Proven reserves are estimated at 448.1 tons. Polymetallic lead and zinc deposits in Mongolia occur in calcic skarn (Zn-Pb-Fe), hydrothermal vein (Cu-Pb-Zn), and epithermal vein (Ag-Pb-Zn) types, related to the Mesozoic volcano-plutonic rocks. The Tumurtiin Ovoo (885kt Zn) and Ulaan deposits are being actively, the Tsav, Dulaankhar Uul, and Uulbayan deposits are due to be mined, and other deposits are expected to have future economic potential. Zinc-proven reserves are estimated at 4.4Mt. Ferrous deposits in Mongolia are dominantly characterized by iron deposits with total proven reserves of 1.84Bt. The economic iron deposits are Fe and Fe-Zn skarns and metamorphosed ironstone types. Occurrences of Mn, Ti and V associated with mafic and ultramafic rocks are not presently economic.

The rare metals occurring as Sn-W and W-Mo-Be greisen/stockwork and vein type deposits associated with Mesozoic highly differentiated granitic rocks form a few large but mainly medium to small size deposits and abundant placers which occur in Eastern Mongolia, Mongolian Altai and Southwest Mongolia. Commercial Sn-W greisen/stockwork and quartz

vein and placer deposits were mined in the last century. Presently only a few W deposits produce tungsten concentrate. Li, Nb and Ta mineralization is associated with peralkaline rocks, peraluminous Li-F granites and pegmatites. Beryllium is mainly a by-product of W-Mo deposits and is common in pegmatites. Other Be resources could be Be-bearing tuffs in Cretaceous volcanic rocks. Rare earth element (REE) mineralization of economic significance is related to the Mesozoic carbonatites or to the Paleozoic peralkaline granitoid rocks. Carbonatite deposits are formed in continental rift zones in South Mongolia and have complex mineralization, e.g., REE-P-Sr-Ba-F-Pb and Fe- REE. The mineralization associated with peralkaline granitic rocks contains significant concentrations of Zr, Nb, Th and U in western Mongolia. Although Mongolia is rich in rare earth occurrences, many of them are small in size and have low grades. Only Late Mesozoic carbonatite-related Mushgai Khudag (34Mt), Khtogor(40Mt) and Permian Lugiin Gol (0.5Mt) deposits in South Mongolia and peralkaline granite and syenite-related Khalzan Buregtei (49Mt) deposit in Western Mongolia are economically important. Silver mineralization occurs in hydrothermal polymetallic Ag-Zn-Pb deposits associated with Mesozoic volcano-plutonic rocks as a hydrothermal deposit in Eastern Mongolia. One of the largest silver deposits is Asgat (2.24Kt) in western Mongolia near the border with Russia. Economically important PGE deposits and occurrences have not yet been discovered in Mongolia. PGE mineralization is known from three deposit types: podiform chromite associated with the ultramafic part of ophiolite complexes, PGE associated with layered gabbro intrusions, and PGE-Au placer. The major type is ophiolite-related podiform chromite. Mongolia is one of the leading producers of fluorite in the world with proven reserves of 34.2Mt. Major deposits of economic importance are of Jurassic and Cretaceous ages in central and eastern Mongolia. Most of the fluorite deposits in Mongolia are hydrothermal or epithermal. The epithermal fluorite deposits occur as veins, irregular and lens-shaped, and in brecciated and disseminated shear zones. The vein deposits are dominant. Major minerals of the epithermal type are quartz and fluorite. The large mining and ore processing complex is located at the Bor Undur deposit, and many deposits are in production.

A major phosphate resource is known from the early Paleozoic Khuvsgul phosphorite basin in Northern Mongolia and Zavkhan basin in Western Mongolia. The Khuvsgul phosphorite basin includes about 30 deposits and occurrences that constitute a major phosphate resource of Mongolia. The Burenkhaan (40Mt) and Khuvsgul deposits are economic. However, these deposits are not mined because they are lying within Khuvsgul National Park. The grades in these deposits vary from 10 to 38% of P2O5. The Zavkhan basin may contain some phosphate deposits of economic interest. There are several types of uranium deposits with proven reserves of 197 thousand tons with the dominat volcanic-related type in Eastern Mongolia associated with Late Mesozoic bimodal volcanic rocks. Sandstone-hosted roll-front and basal channel or paleo valley uranium deposits occur in Mesozoic basins in southeastern Mongolia. The uranium mineralization is accumulated in the medium to coarse-grained sandy, lacustrine sediments. Recently, sandstone uranium-type deposits closely associated with hydrocarbon-bearing basins have been identified in eastern and south Mongolia. The largest epithermal deposits are Mardai, Dornod and Guurvanbulag in Eastern Mongolia with 41Kt U reserves. Coal reserves are calculated at 33.4Bt, of which 66% are lignite, located mostly in Eastern Mongolia. The largest Permian coal deposit of Tavantolgoi with reserves of 5.263.7Mt and Nariin Sukhait (616.22Mt of cooking coal) deposits are the main exporter of cooking and thermal coal. Lower Cretaceous oil shales are distributed in Central Mongolia. Crude oil proven reserves are 332.6Mt.

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