

Foreign cooperation of the Polish Geological Institute: critical raw materials reconnaissance project in Mongolia

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Abstract. Poland and Mongolia have established a geological partnership focusing on the recognition of critical raw materials. The cooperation is significant, given the urgent demand for minerals and metals necessary for advancing new technologies. The three-year joint project implemented in cooperation between the Polish Geological Institute – National Research Institute and the National Geological Survey of Mongolia involves geological reconnaissance of three areas in western Mongolia for exploration for tungsten, molybdenum and other strategic metals. The surveillance is mainly focused on outcrops of Permian granitoids and their metamorphic cover, located on the southwestern margin of the Khangai Mountains. The scope of work includes analysis of archival data, field geological and geochemical reconnaissance with sampling, laboratory testing and inter-

pretation of results. The project aims to identify the potential of research areas for critical and strategic raw materials occurrences, to develop research staff, and to increase bilateral relations between Poland and Mongolia.

Keywords: Mongolia, critical raw materials, international cooperation

The European Union must ensure access to a range of mining products known as Critical Raw Materials (CRMs) to safeguard its energy and raw material security. The escalating demand for CRMs within the EU is pivotal, underscoring the region's ambitious economic and environmental objectives. The CRM Act's regulation outlines a target for 2030, under which the EU must diversify imports of strategic raw materials. This means that the Union's annual consumption of each strategic raw material at any relevant stage of processing should rely on imports from several third countries or overseas countries or territories (OCTs), ensuring that no third country accounts for >65% of the Union's annual consumption of a particular strategic raw material (European Commission, 2024).

Currently, the EU is heavily dependent on imports for many CRMs, with some materials having nearly a 100% import reliance, often from just one country (European Commission, 2025). For instance, China supplies 100% of Heavy Rare Earth Elements (HREEs), 97% of magnesium, and 75% of Light Rare Earth Elements (LREEs). Additionally, Turkey supplies 99% of boron, Brazil 82% of niobium, and Chile 79% of lithium to the EU (European Commission, 2025). Although the volume of critical raw materials imported to the EU has decreased between 2019 and 2023 – except for natural graphite and rare earth metals (Eurostat, 2024) – it still remains at a high level. Opportunities to diversify supply chains should be sought by establishing trade relations with third countries and implementing exploration projects beyond the Alliance's borders. Both mining companies and research institutions can undertake these activities. In this regard, the Polish Geological Institute – National Research Institute (PGI-NRI) currently has 43 active Agreements with scientific institutions, research units and government bodies worldwide. Through cooperation with counterparts, PGI can implement research

projects and gain insights into identified and potential raw material resources in partner countries, whereas reconnaissance work brings mutual benefits to all parties involved.

Poland is Mongolia's third-most important trading partner among EU countries, following Germany and France, with a turnover of ~\$90 million (Serwis Rzeczypospolitej Polskiej, 2025). The largest share of exports from Poland consists of foodstuffs (about 30%), products of chemical or related industries, machinery and mechanical equipment, products of animal origin, plant-based products and plastics (Serwis Rzeczypospolitej Polskiej, 2025).

Mongolia actively supports foreign cooperation and investment through its "third neighbour strategy", which aims to foster partnerships, not only with neighbouring Russia and China, but also with institutions from the USA, the EU, Japan, South Korea and beyond. Under the current policy of the Government of Mongolia, mining and raw materials are key pillars of the national economy, making the country an important area of exploratory research. The country is five times larger than Poland and is characterized by a wide range of mineral deposits.

Mongolia stands as a treasure trove of mineral wealth, boasting significant deposits of copper, fluorite, uranium and other strategic resources that become the backbone of energy transformation. The Oyu Tolgoi mine, located in Umnugovi Province, exploits one of the largest known copper and gold deposits in the world, while the Tavan Tolgoi mine, situated 130 km to the north-west, is one of the world's largest untapped deposits of coking and thermal coal.

The Mongolian mining sector boasts one of the world's leading mineral resources, with over 10,000 deposits and occurrences of >80 types of minerals (Mongolian Government, 2025). According to Invest Mongolia, the country currently has 849 valid exploration licenses and 1,708 mining licenses, covering only 4.7% of the territory (Mongolian

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Government, 2025). This presents significant opportunities for exploration, documentation and exploitation of a major part of the critical raw material deposits listed by the European Commission's (European Commission, 2024).

While the central and eastern regions of the country have been fairly well-surveyed for raw materials, the western provinces require more detailed field reconnaissance. Thus, they represent important areas for conducting scientific and exploratory research. The Mongolian Geological Survey, along with numerous mining companies, is conducting various reconnaissance projects, yet numerous locations with high ore potential remain unexplored.

Mongolia is one of the countries where the PGI actively engages in scientific and research cooperation. Official collaboration between Poland and Mongolia has been ongoing for over 60 years. In the second half of the 20th century, joint activities were mainly conducted within the framework of the Polish Geological Expeditions (1961–1964) and the International Geological Expedition (1976–1990) (Śliżewski *et al.*, 2005). During these research efforts, several raw materials, including tungsten, tin, copper and lithium, were discovered in eastern Mongolia. Two expeditions worked in the Gobi region to confirm the presence of rare earth elements (REEs) in the Lugin Gol and Mushgai Kuduk areas. From 2009 to 2015, under an agreement between the Polish and Mongolian governments, PGI conducted geological research focused on prospecting deposits in the Khasagt Mountains. Among the most celebrated Polish discoveries in Mongolia are those attributed to palaeontologist Zofia Kielan-Jaworowska, who led eight expeditions in the Gobi desert from 1963 to 1971. Her team made groundbreaking discoveries of many spectacular Late Cretaceous vertebrate fossils, including 20 species of dinosaurs, along with many lizards, crocodiles, turtles, and birds (Kielan-Jaworowska, 2005).

On November 24, 2021, the PGI and the National Geological Survey of Mongolia (NGS) signed a Memorandum of Understanding (MoU) to formalize their long-lasting partnership. This collaboration focuses on several key areas, including regional geology, tectonics, mineral resource assessment, geological mapping, geoinformation, databases, geohazards and geothermal research. According to the terms of the MoU, the Participants have decided to outline specific joint activities in the Project Agreement, signed on April 23, 2023. The contract between the entities established

a three-year project entitled “Reconnaissance of Critical Raw Materials in Mongolia: recognition of molybdenum and tungsten occurrences”.

SCOPE OF THE PROJECT

The project aims to identify mineral potential, evaluate geological data, detect critical/strategic resources, and interpret the information obtained from an ore perspective. The most direct ambition is to leverage the current expertise of PGI and NGS scientists to perform a geological reconnaissance of a designated study area, as agreed upon by the Parties. This area is believed to have the potential for critical material accumulations. Using archival data stored at the Archives of the Mongolian Geological Survey, Russian maps from the second half of the 20th century, and detailed satellite images from Pleiades and Sentinel-2, PGI and NGS designated three areas in the western part of the country, referred to as Beliin Bulag, Zadgai Bulag and Taishir, having preliminary potential for molybdenum (Mo) and tungsten (W) occurrences, both of which are part of the Govi-Altay Metallogenic Province. Based on the geological buildup and spot geochemical analyses from the Soviet era, both agencies postulate that the region may contain rock formations with minerals such as wolframite [(Fe,Mn)WO₄], scheelite [CaWO₄], molybdenite [MoS₂] and wulfenite [PbMoO₄].

Beliin Bulag is an area of ~57.4 km², located in the Bayanbulag sum of Bayankhongor province (Fig. 1). It lies along the southwestern margin of the Khangai Mountains. The terrain is characterized by mountainous landscape, with flattened ridges and peaks, that reach altitudes of up to 3,171 metres above sea level at Tost uul. The lowest recorded point, at 2285 m, is found at a stream that crosses the valley in a north-south direction. Archival NGS data indicate the potential for tungsten resources of about 8,000 tonnes and molybdenum deposits of around 2,000 tonnes. Additionally, there is a possibility of bismuth deposits totaling up to 2,000 tonnes. The average tungsten content is described as ranging from 10 to 200 parts per million (ppm) or 0.001 to 0.02%, with bismuth measured at ~70 ppm and beryllium ranging from 60 to 100 ppm.

Zadgai Bulag is also situated in the Bayanbulag somon of Bayankhongor province (Fig. 1), ~15 km south-west of Beliin Bulag (BB). It spans a mountainous area of 78.4 km², featuring sharper landforms compared to those in BB. It is crisscrossed by a series of deep, intermittent stream valleys and exhibits greater differences in altitude over a small area. Elevations range from 2,200 to 2,750 metres above sea level. Previous estimates suggest that the area contains 14,000 tonnes of tungsten resources and 460 tonnes of molybdenum. In the greisen zone, the average tungsten content is between 10 to 200 ppm, while molybdenum levels range from 10 to 50 ppm. In the skarn zone, tungsten concentrations vary from 200 to 7000 ppm, with additionally vanadium between 100 to 200 ppm and copper from 10 to 100 ppm.

The Taishir area is located ~80 km west of Zadgai Bulag (Fig. 1), 45 km north-north-east of the city of Altai, and 5 km north-west of Lake



Fig. 1. Location of the project on the administrative map of Mongolia divided into aimags (provinces)

Gegeen. It is the largest of the areas surveyed, covering about 120 km². The predominant terrain features mountainous relief with flattened peaks, ranging in elevation from 1630 to 2220 metres above sea level. The lowest point is along the bank of the Zavkhan River, while the highest point is on a hill in the central part of the area. Maps provided by NGS suggest the possibility for mineralization of tungsten, molybdenum, tin, zinc, silver, lead and copper, with the greatest potential in the tungsten occurrence. South of the Zavkhan River, in the Govi-Altay Metallogenic Province, several molybdenum deposits have been described by NGS, with average values ranging from 35 to 1500 ppm Mo. These nine deposits are expected to contain reserves of 1.09 million tonnes of molybdenum and 4.57 million tonnes of copper.

All research areas are located far from major urban settlements, which necessitates setting up encampments for field teams (Fig. 2). The research is being conducted in areas inhabited by Mongolian nomads, who, regardless of arrangements with authorities in Ulaanbaatar, must provide agreement for the fieldwork to take place. These nomads have a profound spiritual connection to the steppe, viewing it as a living entity infused with sacred energy. They believe in the concept of Tengri, a god who governs nature and the universe, reflecting their deep reverence for the natural world. Consequently, they generally prohibit deep digging and systematic drilling. Any shallow trenches must be thoroughly backfilled and compacted to prevent problems for moving livestock. For these reasons, the project had to limit the amount of exploratory works that would involve excessive surface transformation.

GEOLOGY

The areas selected are located in the southwestern part of the Khangai Mountains and the margin of the range (Fig. 3A, C). Tectonically, these regions fall within the cratonic, Proterozoic terranes of the Central Asian Orogenic Belt (CAOB, Fig. 3B), which include Tarvataganay, Baidrag and Zavkhan, situated to the north of the main Main Mongolian Lineament (Badarch *et al.*, 2002). Terrane accretion in this section of CAOB occurred during the early Paleozoic, though subsequent tectonic events have also been recorded (Cunningham, 2001; Badarch *et al.*, 2002). The lithologies in the region exhibit a complex structure shaped by multiphase evolution, underlined by tectonometamorphic changes, plutonism and vertical movements of the tectonically active interior of Central Asia.

The reconnaissance is primarily focused on outcrops of Permian granitoids and their metamorphic cover. In the Bayanbulag area, particularly at Belii Bulag and Zadgai Bulag, the main analyses were concentrated on the Bugatyn Nuruu massif and the Khangai intrusion (Tomor *et al.*, 2016). In the Zadgai

Bulag, where exposures of Neoproterozoic cover are prevalent, several occurrences of Cambrian granites have also been recorded (Smirnov *et al.*, 1987; Davaa *et al.*, 1989). Among the granitoids, mafic (gabbroic, dioritic) enclaves, as well as aplites and pegmatites (Davaa *et al.*, 1989; Tomor *et al.*, 2016) occur. Younger basalt intrusions are present in both the granitoids and the metamorphic cover. Quartz veins occasionally occur in fault zones. The cover over the granitoids is mostly composed of metasedimentary rocks with low to medium degrees of metamorphism. However, in the Bayanbulag area, gneisses and granitogneisses can also be found. The degree of metamorphism is higher in the contact zones with granitoid intrusions, where greisens, hornfelses and skarns occur.

The metamorphism of the cover rocks proceeded as a result of regional extensional movements that followed the Baikal orogenesis in the early Paleozoic (Stipska *et al.*, 2023). Meanwhile, the distribution of Permian granitoids is associated with the closure of the Mongolian-Okhotsk Ocean at the end of the Paleozoic and in the early Mesozoic (Wang *et al.*, 2022; Ling *et al.*, 2024).

RESEARCH METHODS

The prescribed scope of work includes the following stages of implementation: (1) preparation period; (2) fieldwork; (3) laboratory analyses; (4) assessment and mapping works; (5) processing and interpretation of results; and (6) drafting reports.

During the preparation period, the Parties review the available literature, query available data and analyse all documentation stored at the Central Geological Archives of the National Geological Survey in Ulaanbaatar. This analysis includes documented occurrences of critical raw materials, occurrence of deposits, regional geology, analysis of maps and satellite images, and gathering information from published works. Additionally, this phase involves preparations for conducting field research.



Fig. 2. Field camp located in the Zadgai Bulag area. Photo by Radomir Pachytel

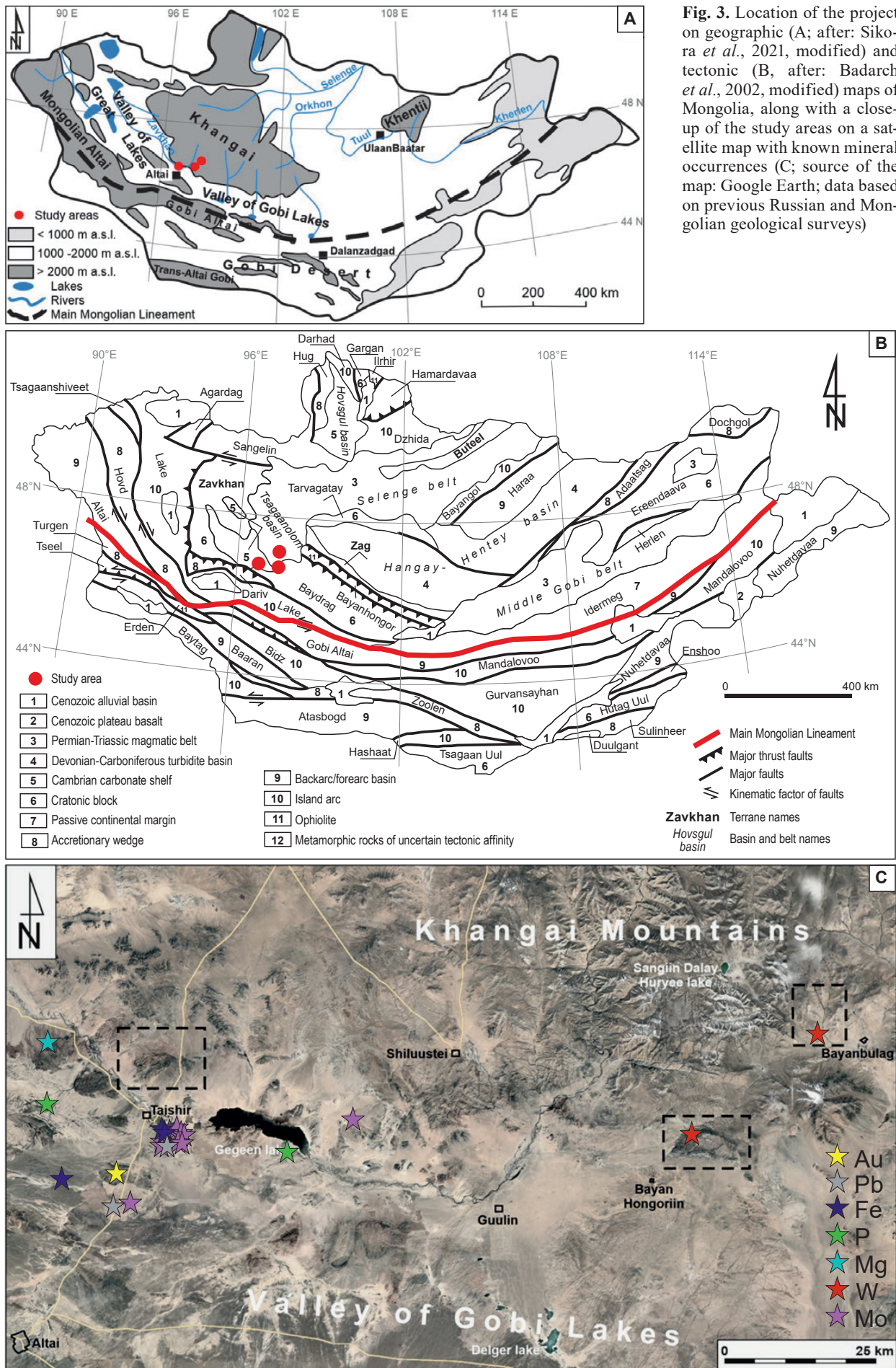


Fig. 3. Location of the project on geographic (A; after: Sikora *et al.*, 2021, modified) and tectonic (B, after: Badarch *et al.*, 2002, modified) maps of Mongolia, along with a close-up of the study areas on a satellite map with known mineral occurrences (C; source of the map: Google Earth; data based on previous Russian and Mongolian geological surveys)



Fig. 4. Project field research: **A** – landform with a dried-up stream; **B** – analysis with portable X-ray spectrometer (pXRF); **C** – exposure of pink granite; **D** – sieving of schlich (placer) samples. Photos by R. Pachytel

The nomadic tribes living in the country's western areas cultivate their land, a larder for livestock, without granting permission for digging or drilling. Hence, recognition must rely on the study of surface exposures and non-invasive analyses.

The fieldwork phase concentrates on conducting geological observations and descriptions, recognizing rock types, and performing chemical studies with a portable X-ray spectrometer (pXRF). The team also samples rocks for laboratory testing, conducts UV light observations, collects schlich (placer) samples from intermittent streams, photographs and catalogues the exposures and rocks analysed (Fig. 4). Field research teams follow marching paths determined from satellite image analyses, adjusting their routes to the on-site conditions. All lithologies identified in rock exposures are described, chemically tested and sampled for laboratory tests. If higher concentrations of elements targeted for project analysis are observed, teams make more analyses in the zone. The project's objectives include sampling at least 1,000 rock specimens of various mineral compositions for further laboratory analysis. The fieldwork is conducted in challenging, arid terrain, with significant topographic variation and a lack of infrastructure. Both scientists from PGI and NGS participate in the fieldwork.

Samples collected from the study area are delivered for laboratory analysis in both Mongolia and Poland. These analyses aim to enhance the information gained during field investigations by accurately determining the rock compositions and identifying zones with higher ore potential.

The tests conducted include geochemical testing using Inductively Coupled Plasma Mass Spectrometry (ICP-MS), mineralogical analyses through X-ray diffraction (XRD), gold testing via Graphite Furnace Atomic Absorption Spectrometry (GFAAS), and the preparation of thin-sections along with their petrographic descriptions. Furthermore, selected lithologies are submitted for geochronological studies using the Sensitive High Resolution Ion MicroProbe (SHRIMP), while schlich samples undergo mineralogical composition analysis.

Based on the results of the field survey and laboratory analysis, the perspectives for the occurrence of strategic metals in the study area will be estimated. Maps illustrating the variability of individual elemental content at each site will be created. The interpretation of these results will help determine whether detailed surface geological surveys indicate a deposit's occurrence. All activities applied during the implementation of the project will be included in the final report. PGI will forward the conclusions to the Polish Ministry of Climate and Environment as well as to other relevant entities.

CONCLUSIONS

The Polish Geological Institute and the National Geological Survey of Mongolia are developing bilateral cooperation through a joint project aimed at identifying critical and strategic raw materials in western Mongolia. This project

encompasses three sites covering over 250 km². The research targets magmatic and metamorphic rocks that may contain deposits of tungsten, molybdenum and other strategic metals. It includes a thorough chemical, mineralogical and petrographic reconnaissance of the rock units located on the south-western margin of the Khangai Mountains. The project's results, according to the agreement between the Surveys, will be published upon its completion in 2026.

The exploration of critical raw materials in non-EU countries constitutes a key element of the alliance countries' foreign policy. Ensuring a continuous supply chain of strategic metals from outside the EU necessitates international cooperation and strengthening ties between importing and exporting countries. Mongolia has been Poland's trading partner for many years, and good relations between the nations have been cultivated at various levels. Conducting extensive reconnaissance, identification and exploration work enhances the mutual scientific efforts of the Polish and Mongolian geological surveys, thereby increasing bilateral cooperation between the countries. The implementation of this reconnaissance project will enable the development of the scientific expertise of both surveys, facilitate robust knowledge transfer, and build their capacity. In the future, it may allow increased investment and trade relations between Poland and Mongolia. Through the application of advanced geological mapping, detailed mineral analysis, and state-of-the-art research technologies, both nations are committing to responsible resource management.

Through its partnership with Mongolia, Poland aims to secure a steady supply chain for several critical raw materials, enhancing its position in the global market while contributing to the sustainable development of Mongolia's vast resources. In an evolving geopolitical landscape, this collaborative effort represents a strategic partnership.

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Beryllium, Sudetes. From the collections of the PGI-NRI Geological Museum.
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