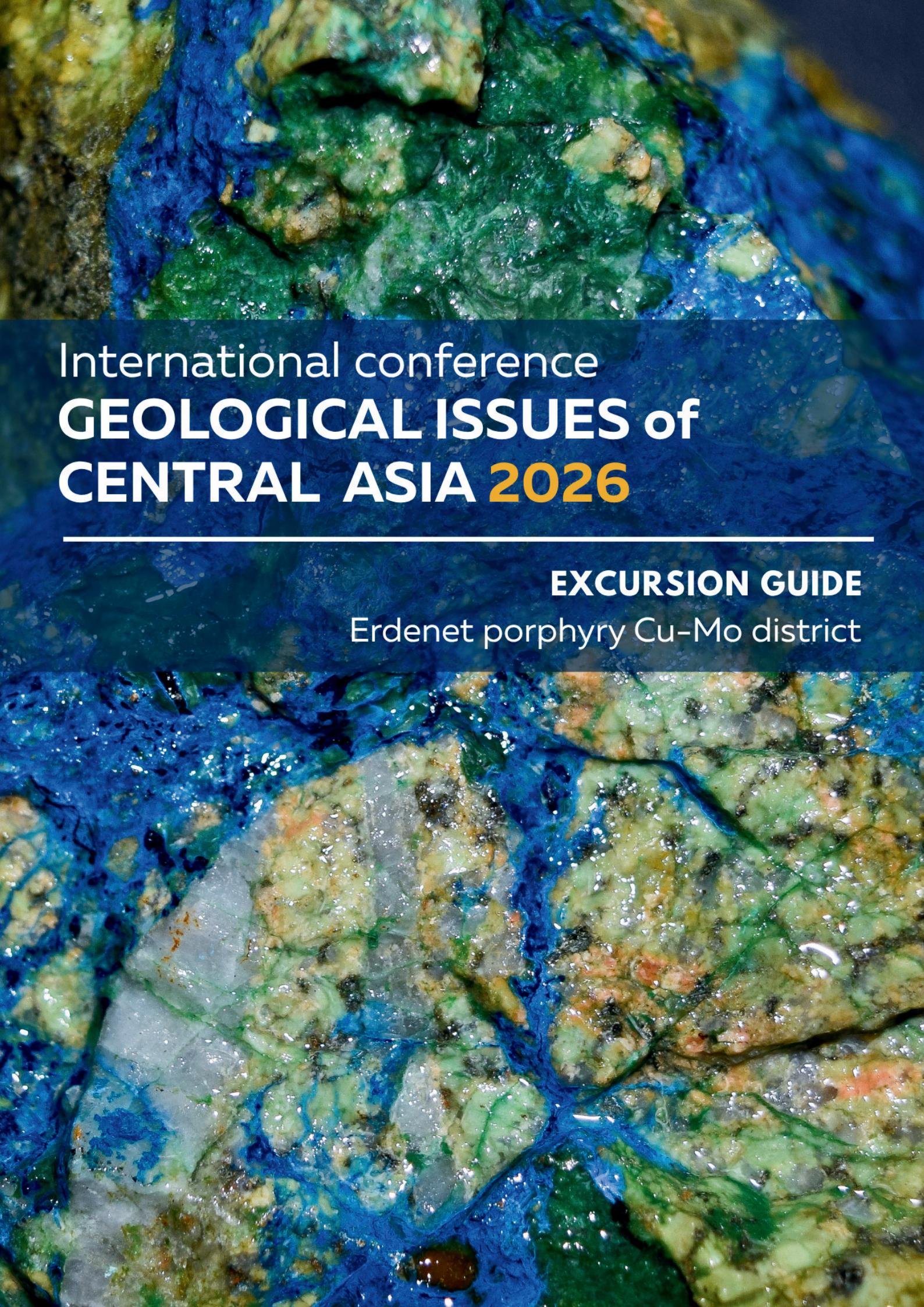


International conference

GEOLOGICAL ISSUES of CENTRAL ASIA 2026

EXCURSION GUIDE

Erdenet porphyry Cu-Mo district

GEOLOGICAL ISSUES OF CENTRAL ASIA 2026

Erdenet Cu-Mo Deposit Excursion

Geological setting, Metallogeny, and Mining Operations of
Asia's Premier Porphyry Deposit

A comprehensive two-day technical program examining regional geology, open-pit mining operations, museum, and deposit lithocaps.

13-14 September, 2026

Compiled by Gerel Ochir, Altankhuyag Dorjyunden, Turbold Sukhbaatar, and Ariunzaya Tsogoo

With the contributions of

Tungalag Nadiansuren, Sanchir Dorjgochoo, Damdinsuren Muunuu
and Oyunchimeg Tserentsegmid

Institute of Geology, Mongolian Academy of Sciences
Erdenet Mining Corporation, SOE

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Field Excursion Program

Day 1: September 13, 2026

Morning: Departure from Ulaanbaatar to Erdenet City (380 km paved road route).

Afternoon: Field inspection of regional geology of volcanic-plutonic belt

Evening: Arrival in Erdenet City, hotel registration, and technical networking session.

Day 2: September 14, 2026

Morning: Guided technical tour of Erdenet Mining Corporation (EMC) open-pit operations, museum, and Tsagaan Chuluut lithocap exposure, and primary mine overlook point.

- Erdenet Open Pit Mine: Active mining face observation showcasing high-grade quartz-muscovite alteration, D-veining, and structural faulting.
- Museum: Digital musuem.
- Tsagaan Chuluut Lithocap: Extensive 10 × 2.5 km advanced argillic alteration zone with residual quartz, K-alunite, diaspore, and pyrophyllite.

Afternoon: Departure from Erdenet back to Ulaanbaatar.

Evening: Arrival in Ulaanbaatar.

ERDENET DEPOSIT

Erdenet Mining Corporation

Erdenet Mining Corporation (EMC) is one of Mongolia's largest industrial enterprises and the country's leading copper-molybdenum producer. The company operates the Erdenetiin-Ovoo mining complex in Orkhon Province, integrating open-pit mining, ore processing, concentrate production, and analytical quality control within a single industrial complex. EMC is therefore not only a mining operation but an integrated mine-processing-laboratory-metallurgical control complex, in which analytical laboratories play an essential role in daily production decisions, concentrate quality assurance, and process optimization (Fig. 1).



Figure 1. Mineral processing operations at Erdenet Mining Corporation: (a) grinding circuit; (b) flotation and process monitoring; and (c) flotation circuit of the mineral processing plant.

The main activities of EMC include the open-pit extraction of copper-molybdenum ore, ore transportation, crushing and grinding, flotation processing, and production of copper and molybdenum concentrates. The company operates a large-scale mineral processing plant supported by continuous monitoring and quality-control procedures throughout the production cycle. Analytical data obtained at different stages of mining and processing are used to monitor ore characteristics, optimize processing parameters, and maintain the quality of the final concentrates.

EMC's production operations are supported by specialized laboratories equipped for the chemical analysis of ores, intermediate products, and final concentrates. Laboratory analyses include the determination of copper, molybdenum, and other chemical components and provide essential information for evaluating the efficiency of mineral processing and controlling product quality. The close integration of laboratory analyses with mining and processing operations enables EMC to make timely production decisions and maintain consistent concentrate quality.

Through the integration of mining, mineral processing, analytical control, and supporting industrial facilities, EMC represents a major example of Mongolia's modern mining and mineral-processing industry.

Through its integrated mining, processing, and laboratory infrastructure, Erdenet Mining Corporation represents a major example of a modern mining and mineral-processing enterprise in Mongolia. In 2019 copper metal recovery reached 89.3 percent, 37.2 million tons of ore was mined and 32.2 million tons of ore was processed, which is the highest indicators in the history of EMC, and for the first time the state and local budgets received 961.8 billion MNT.

Introduction

Erdenetiin Ovoo (Erdenet Mine) is one of the largest porphyry Cu–Mo deposits in Mongolia, with estimated resources of approximately 4.6 Gt at 0.29 wt.% Cu and 0.014 wt.% Mo (Feb. 2026). The deposit is located in northern Mongolia, approximately 240 km northwest of Ulaanbaatar. The Erdenetiin Ovoo deposit was discovered in 1964 by Czech and Mongolian research team and subsequently became the subject of extensive geological, mineralogical, geochemical, and metallogenic investigations (Fig. 2). Early studies were conducted by E. Kominek, G. Sanduijav, I. Popousek, V. S. Kalinin, L. I. Yakimov, I. D. Davydov, E. V. Mikhailov, and A. E. Shabolovsky (Geology of Mongolia, 1977), followed by investigations by Khasin et al. (1977), Sotnikov et al. (1974, 1981, 1984, 1985, 1995), Berzina and Sotnikov (1989), Sotnikov and Berzina (1985, 1989), Koval and Gerel (1986), Gerel et al. (1985), and Gavrilova et al. (1984, 1989). Subsequent studies by Gerel (1990), Dejidmaa and Naito (1998), Gerel and Munkhtsengel (2005), Munkhtsengel et al., (2007), and Kavalieris et al. (2017) further refined the geological, geochemical, and metallogenic understanding of the deposit. Much of the earlier geological information is preserved in exploration and institutional reports (e.g. Munhtsengel et al., 2019), complemented by more recent studies, including investigations of the Oyut deposit (Manzshir et al., 2026).

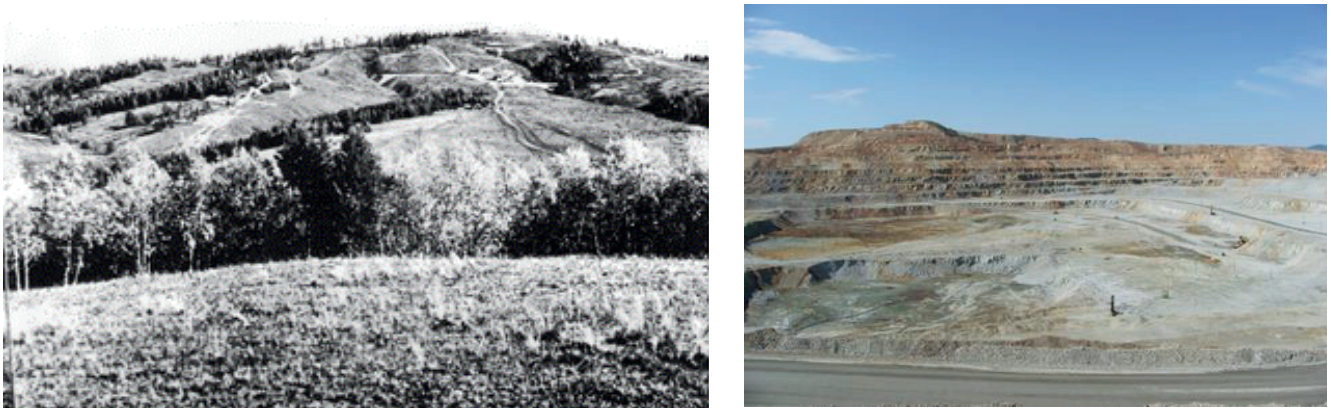


Figure 2. Erdenetiin Ovoo in 1963, before mining, and the Erdenet open-pit mine in its present state.

Regional Geology

The Erdenet deposit is situated within the Selenge terrane of the Mongol-Okhotsk Belt, the youngest orogenic system of the Central Asian Orogenic Belt (e.g. Zonenshain et al., 1990; Badarch et al., 2002). It occurs specifically within the Orkhon–Selenge volcano-sedimentary trough, a major tectono-magmatic domain of the terrane (Mossakovsky and Tomurtogoo, 1974). The trough records a prolonged Permian–Mesozoic history of volcanism, sedimentation, and intrusive magmatism and forms part of the broader Mongol–Okhotsk Orogenic Belt. Its stratigraphic and intrusive assemblages document successive stages of extension, volcanism, and later convergence associated with the evolution and final closure of the Mongol–Okhotsk Ocean (Fig. 3).

Recent regional tectonic and metallogenic studies provide a more detailed framework for the geological position of the Erdenet deposit within Mongolia.

In terms of metallogenic belt, the deposit belongs to the Erdenet ore district and the Erdenet ore-potential node of the Northern Mongolia Orkhon-Selenge metallogenic belt (Dejidmaa et al., 2021). According to the tectonic regionalization of Mongolia, the Erdenet deposit is located in the northwestern part of the Khulj-Yeroo zone of the Central Mongolian Massif within the Northern Mongolian Folded Province (Tumurtogoo, 2017).

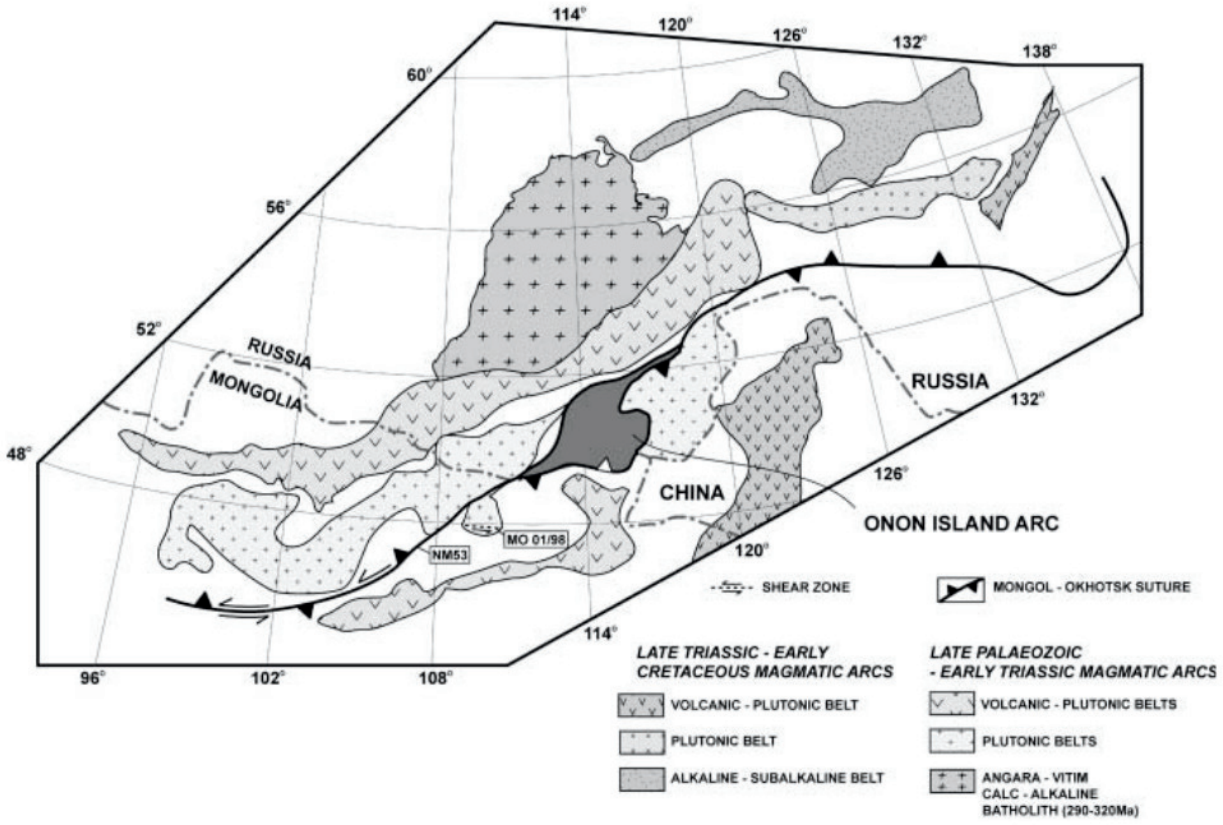


Figure 3. Schematic map of the Mongol-Okhotsk orogenic belt and the setting of the Erdenet ore deposit (Modified: Tomurtogoo et al., 2005).)

The Erdenetiin Ovoo deposit is hosted by the Late Permian-Early Triassic Selenge Intrusive Complex (Fig. 4), which forms part of the extensional volcano-plutonic belt developed within the Orkhon–Selenge trough. The trough is the largest Late Paleozoic–Early Mesozoic tectonic structure in northern Mongolia, extending for more than 200 km in an east-northeast direction and measuring approximately 30–40 km in width. It is dominated by Permian volcano-sedimentary sequences (Khanui Group), whereas Late Triassic and Jurassic volcanic rocks occur mainly within tectonic grabens and unconformably overlie the Late Paleozoic succession (Mogod Formation) The Selenge Intrusive Complex and Erdenet Porphyry Complex constitute the magmatic framework of the Erdenetiin Ovoo deposit.

1.1 Permian Khanui Group

The Permian Khanui Group volcanics consist predominantly of alkali-rich trachyandesites occurring as interlayered lava flows and pyroclastic rocks. They overlie a Late Neoproterozoic to Early Cambrian basement intruded by Paleozoic, including Devonian, granitoids and locally overlain by Carboniferous sedimentary rocks. Late Permian-Triassic intrusive rocks, ranging in composition from diorite and granodiorite to quartz syenite and leucogranite, intrude the Permian volcanic succession and show compositional affinities with the host volcanics, suggesting a genetic relationship and broadly coeval magmatic activity (Table 1). The oldest age obtained is 292±14 Ma (K–Ar, hornblende), while zircon U–Pb ages from andesite range between 258–256 Ma (Tsukada et al., 2018).

1.2 Selenge Intrusive Complex

The intrusive magmatism of the Orkhon–Selenge zone is represented by the Selenge Intrusive Complex, which covers approximately 2,800 km² and comprises three main intrusive phases (Gerel and Munkhtsengel, 2005). The first (early) phase comprises gabbrodiorites, diorites, syenodiorites, monzonites and quartz-monzonites which have either fine-grained or mainly porphyritic textures within a mono-crystalline groundmass. Phenocrysts are composed of plagioclase (An50-65 to An35) and K feldspar, as well as hornblende and rare biotite, and clinopyroxene in the gabbrodiorites. Accessory minerals include magnetite, apatite and sphene. The association of plagioclase and hornblende, sometimes with clinopyroxene, K feldspar and biotite is characteristic of these rocks. The second (main) phase is dominated by granodiorites, granosyenites with limited syenites and alkaline granites. These granitoids are characterized by miarolic structures, and hypidiomorphic and micrographic textures. They are composed of K feldspar, plagioclase (An10-15 to An25-35), hornblende, biotite, accessory magnetite, sphene, apatite and zircon. Dykes and stocks of the third (last) phase leucogranites and granites form small bodies of up to 5-10 km2, and dyke sets which are widespread throughout the Orkhon-Selenge trough.

The second phase comprises granodiorite, syenogranite and syenite, characterized by hypidiomorphic to locally micrographic textures and composed mainly of K-feldspar, plagioclase, amphibole, and biotite, with accessory magnetite, titanite, apatite, and zircon.

The third phase consists of leucogranite and alkali-feldspar granite occurring as stocks and dykes, generally covering 5–10 km², and locally cut by rhyodacite dykes. The Erdenet Pluton, which surrounds the Erdenetiin Ovoo deposit, is part of the Selenge Intrusive Complex. Like the other plutons of the complex, it is composed of a series of intrusive masses which range in composition from gabbrodiorite to granodiorite and granite. A series of minearalized dykes and plugs, which are widespread within the Erdenet district were distinguished as the "Porphyry Association" by Koval et al., (1985), or as the "Porphyry Complex" (Sotnikov and Berzina, 1985).

Table 1. Magmatism of Erdenet area (Age data from report of Munhktsengel et al., 2019)

U-Pb age, Ma	U-Pb age, Ma	U-Pb age, Ma	U-Pb age, Ma	U-Pb age, Ma
195-200?	T3-J1	Trachyte-trachyandesite		Mogod Fm
218±1.9 (Munkhtsengel et al., 2019)	T3-J1		Alkali granite, syenite Subvolcanic rocks	Orkhon Complex
235.6±4 245.2±4.7 (Munkhtsengel et al., 2007	P3-T1		Granodiorite and granite porphyry	Erdenet Complex (Erdenet association
243.3±4.6 249.7±4.0 (Munkhtsengel et al., 2007)	P3-T1		Gabbro-granodiorte-granite-syenite	Selenge Complex
256.9±2.2 Ma (Tsukada et al., 2018)	P3	Trachybasalt-trachyandesite		Khanui Group Tulbur Fm
231.1±0.91-225.3±1.1 (Munkhtsengel et al., 2007)	P2	Basalt-trachybasalt-trachyandesite		Khanui group (Khargana Fm)
283.5±4.6 277.5±5.1 (Munkhtsengel et al., 2019)	P1	Basalt-trachybasalt-trachyandesite		Khanui group (Khustai Fm)
243.9±17 258.0±17	P1-2	Trachyandesite-trachydacite-rhyolite		Khanui Group (Unnamed Lower Fm)
251.9±1.6 258.1±1.6 (Orgil et al., 2026)	P3-T1		Granodiorite and biotite granite	Selenge Complex

The Selenge Intrusive Complex granitoids are medium- to high-K calc-alkaline, metaluminous I-type granitoids. U-Pb ages vary from 243.3±4.6 to 258.1±1.6 (Munkhtsengel et al., 2019; Orgil et al., 2026). They display typical subduction-related geochemical characteristics, including enrichment in LILE (Ba, Sr, and Pb) and LREE, together with depletion in Nb, Ta, P, and Ti, weak Eu anomaly, volcanic arc granites with Sr/Y ratio of normal arc, some with adakitic signature, moderately to highly oxidized (Fig. 4). Their isotopic compositions are characterized by εNd(t) values of +1.5 to +4.1 and initial 87Sr/86Sr ratios of 0.7041–0.7047 (Gerel and Munkhtsengel, 2005).

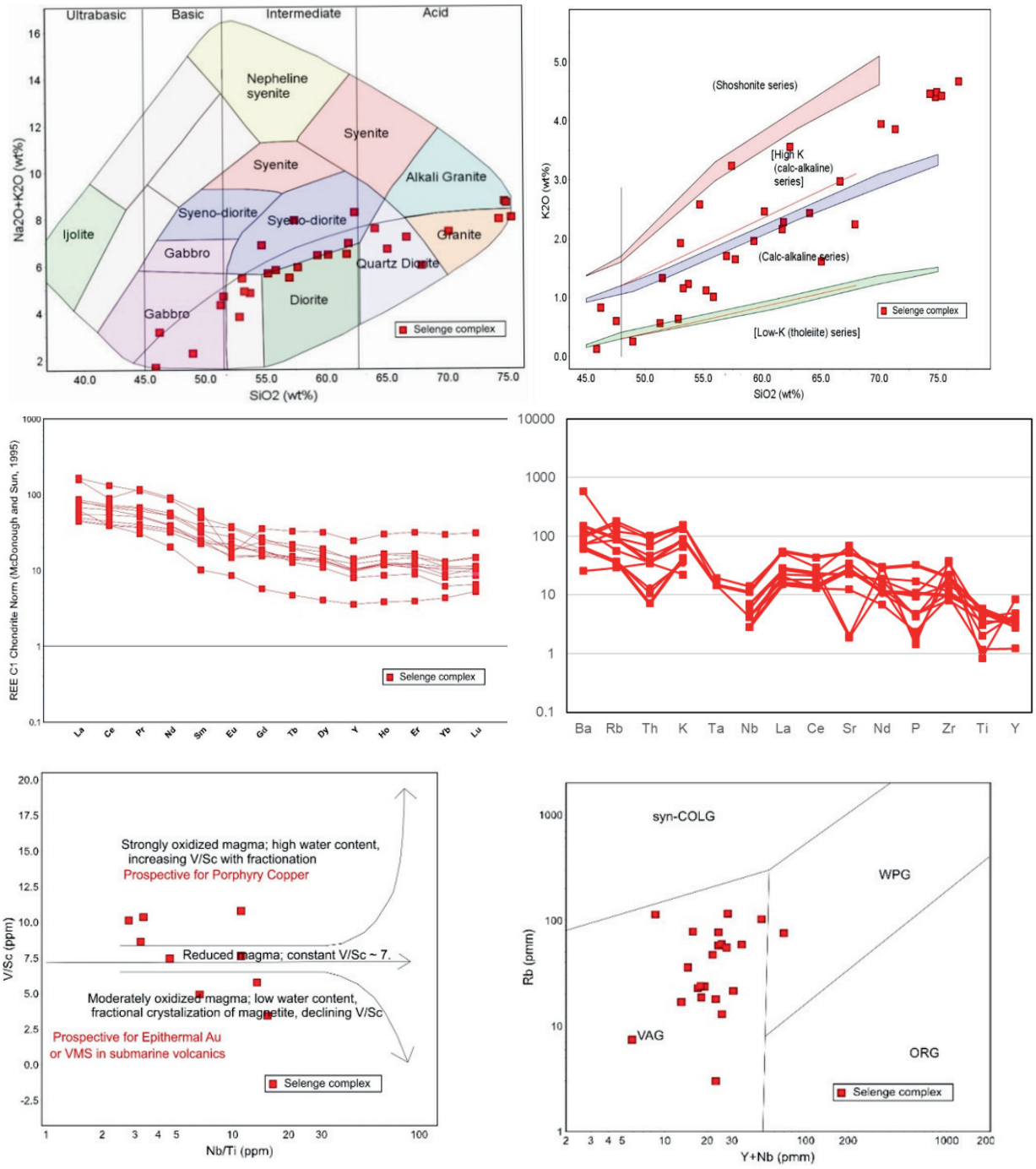


Figure 4. Geochemical characteristics of the Selenge Complex granitoids based on data from Munkhtsengel et al. (2019; 2026).

1.3. Erdenet Complex (Porphyry Association)

The Erdenet Porphyry Complex comprises diorite, granodiorite, and granite porphyries, as well as dacitic rocks. These intrusions yield ages of approximately 245–220 Ma, including a Re–Os age of ~240 Ma (Watanabe and Stein, 2000), and 40Ar/39Ar ages of 234–225 Ma (Kavalieris et al., 2017). Initial 87Sr/86Sr ratios range from 0.703 to 0.704, whereas εNd(t) values range from +1.5 to +4.0, with depleted-mantle model ages (TNd(DM)) of approximately 0.67–0.98 Ga. (Fig. 5). The porphyries range in composition from diorite to granite and belong to the medium- to high-K calc-alkaline series. They are metaluminous with the peraluminous character likely enhanced by hydrothermal alteration. They are enriched in LILE and depleted in HFSE, with absent to weak Eu anomalies.

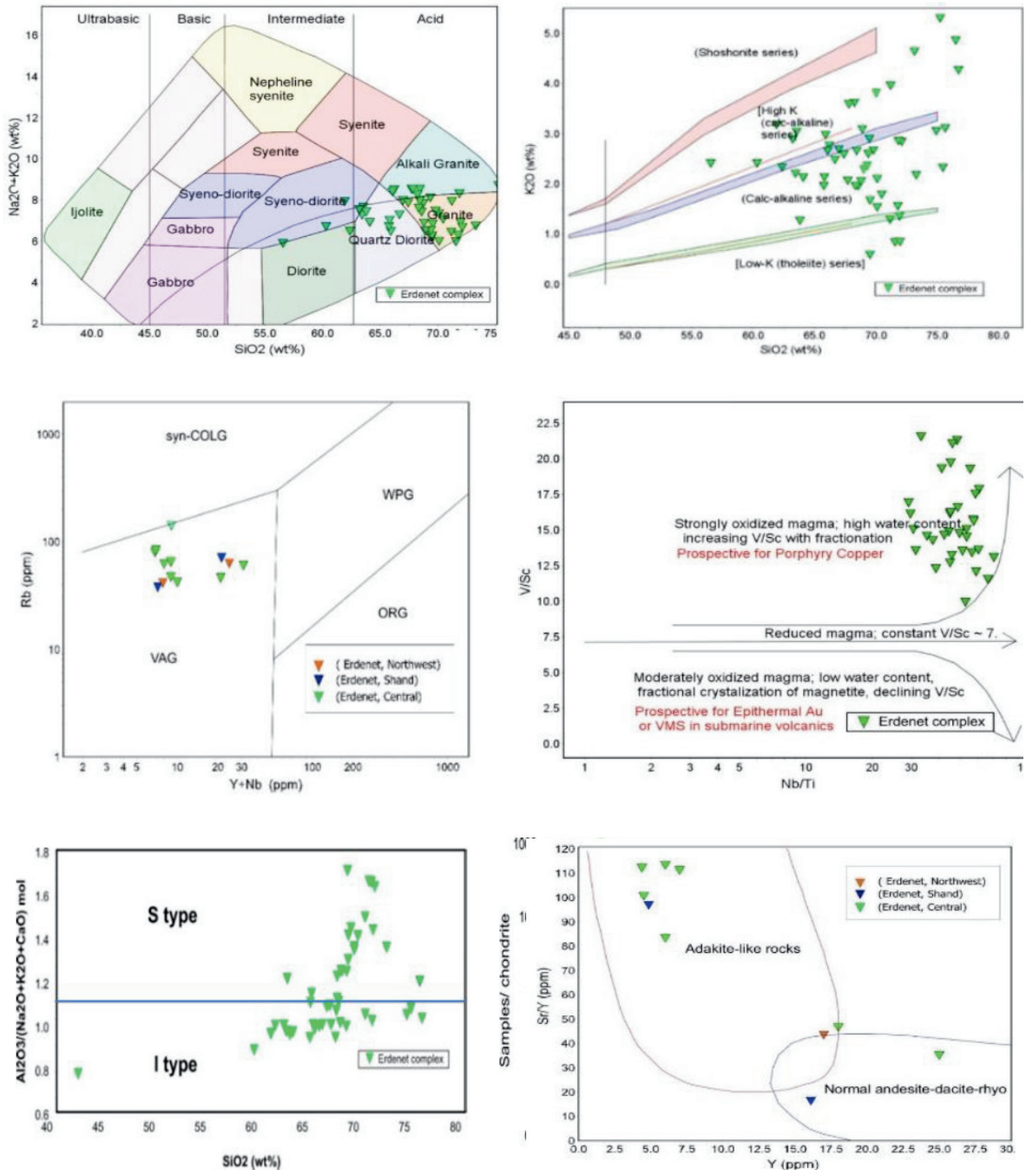


Figure 5. Geochemical characteristics of the Erdenet porphyry Complex granitoids based on data from Munkhtsengel et al. (2019).

1.4 Mogod Formation

The Late Triassic–Early Jurassic Mogod Formation comprises predominantly intermediate to mafic volcanic rocks, including basaltic trachyandesite and trachyandesite, with subordinate trachyte. The volcanic rocks occur mainly as lava flows, together with associated tuff breccias and volcaniclastic rocks, and form part of the Late Triassic-Early Jurassic volcanic succession of the Orkhon–Selenge region. Geochemically, they are characterized by alkaline to shoshonitic, high-K compositions, strong enrichment in LILE and LREE, and pronounced depletion in Nb, Ta, Ti, and P. These features indicate derivation from an enriched mantle source modified by a subduction-related component (Fig. 6). The predominance of samples in the OIA field in the TiO_2–MnO/10–P_2O_5×10 discrimination diagram, together with their subduction-related trace-element signature, suggests a subduction-influenced intraplate to back-arc setting rather than a typical volcanic-arc environment (Koval and Gerel, 1986).

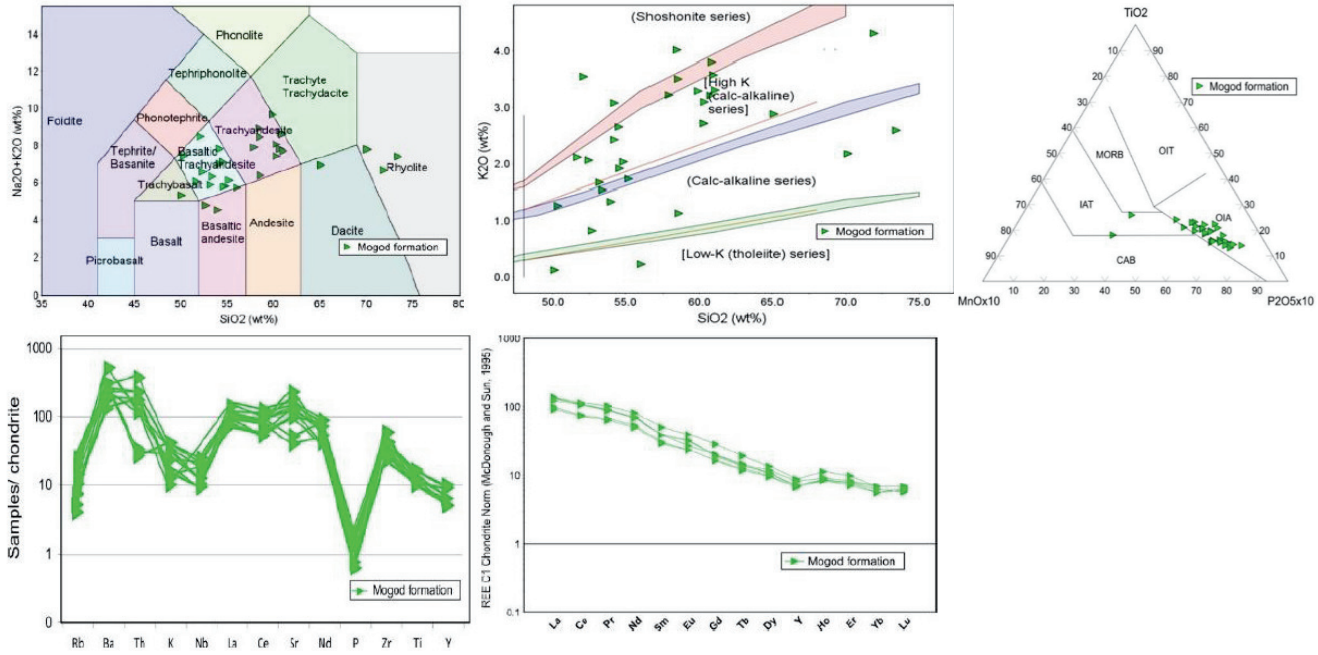


Figure 6. Geochemical characteristics of Mogod Formation

2. Erdenet ore district

The Erdenet ore district is centered on a local circular structure approximately 20–25 km in diameter that encompasses several subvolcanic intrusive centers, each approximately 2–2.5 km in diameter. These centers are represented mainly by altered granodiorite dykes and stocks. Four aligned intrusive centers form a northwest-trending range of low hills, whereas a fifth is inferred from geophysical data beneath Quaternary sediments of the Erdenetiin Gol River. Northwest-trending, approximately 10-km-long belt of porphyry-style Cu–Mo mineralization incudes Tsagaan Chuluut, Erdenet (NW), Central, Oyut, Tourmaline deposits and occurrences. (Fig. 7)

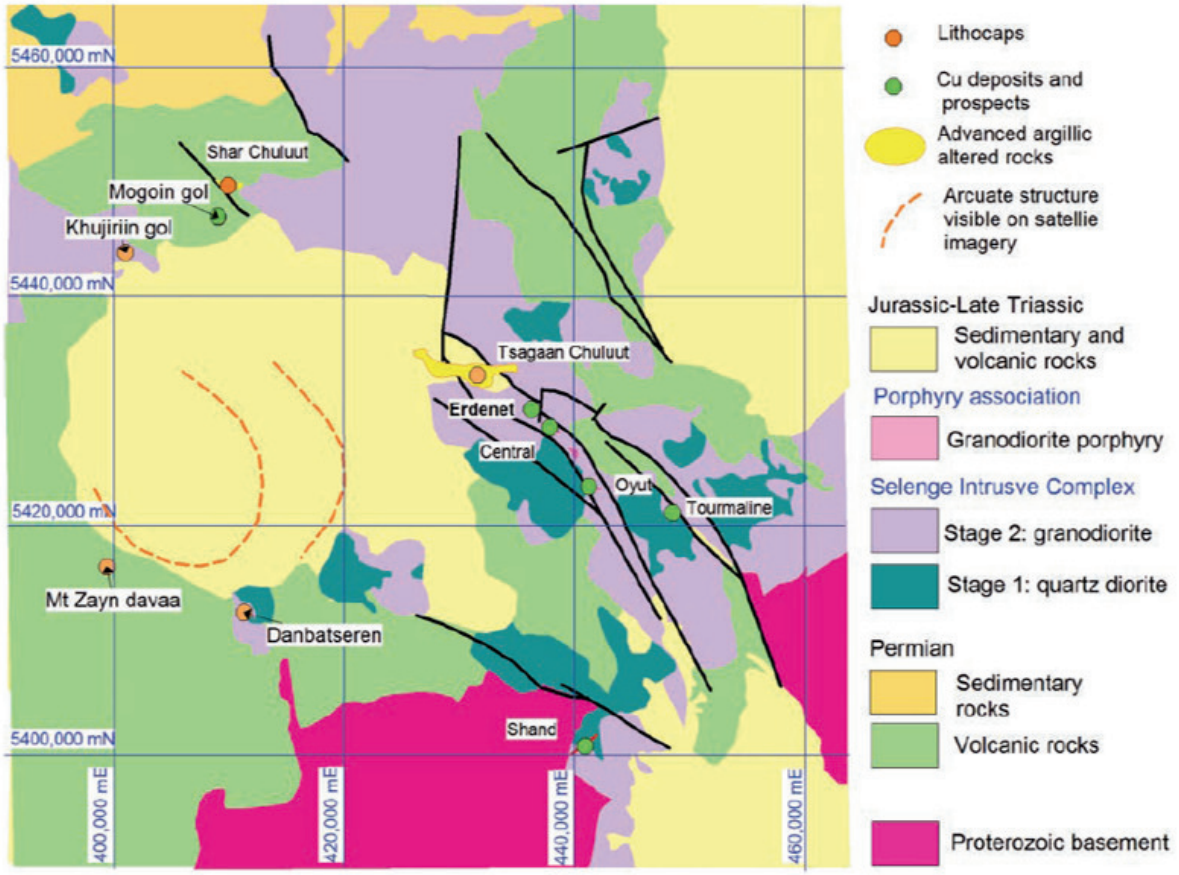


Figure 7. Simplified map of the Erdenet cluster deposits and occurrences (Kavalieris et al., 2017)

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Stop 1. Erdenetiin Ovoo deposit

The Erdenet ore-field porphyries and associated ore-bearing stockwork intrude biotite–hornblende granite, granodiorite, and quartz syenite of the Selenge Intrusive Complex. The porphyries crosscut the third-phase granites of the Selenge Complex, which in turn intrude the Permian volcanic succession, including its uppermost mafic volcanic unit. The Erdenet porphyries show close geochemical affinities with the Selenge granitoids and were therefore initially interpreted as a late intrusive phase of the Selenge Complex. However, Koval and Gerel (1985) and Sotnikov et al. (1985) distinguished these rocks as a separate Erdenet Porphyry Complex. Koval and Gerel, (1985)also grouped the widespread porphyritic subvolcanic and volcanic rocks of the Erdenet district into a broader porphyry association.
The ore-bearing porphyries are hosted by granodiorites of the Selenge Complex, which have zircon U–Pb ages ranging from 258 to 240 Ma, consistent with previously reported Rb–Sr ages. The Erdenet Porphyry Complex in the southwestern part of the deposit consists predominantly of granodiorite porphyry and granite porphyry (Fig. 8). The porphyry bodies comprise one large intrusion, approximately 1,500 × 500 m in size, in the central part of the deposit area, and two smaller bodies, each approximately 500–600 m long, in the southeastern part of the area (Figs. 8 and 9).

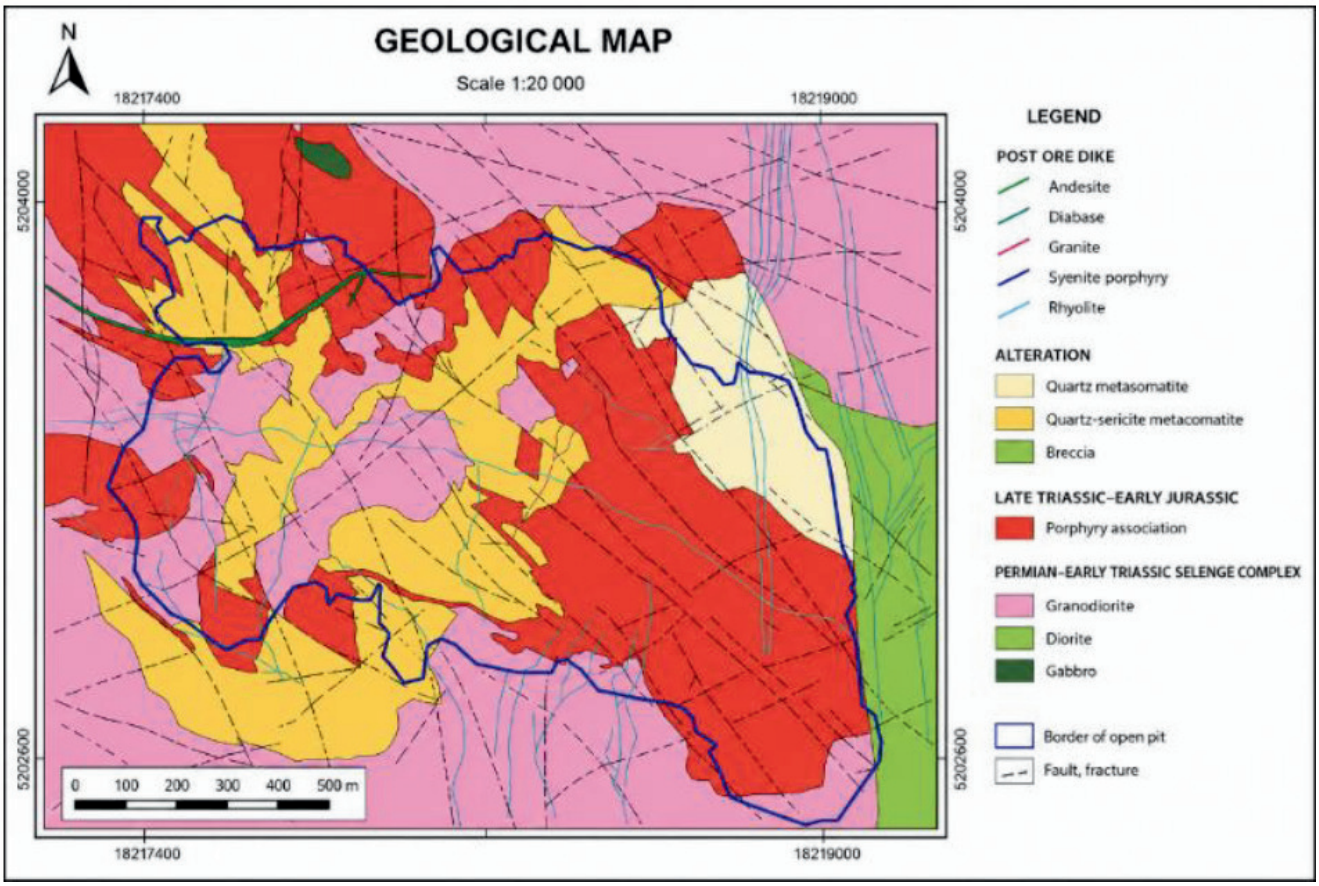


Figure 8. Simplified geological map of the Erdenetiin Ovoo deposit (after Erdenekhuyag et al., 2002)

The younger porphyry intrusions cut the Selenge Complex granodiorites, indicating that the Selenge Complex represents the pre-existing magmatic host to the ore-bearing porphyries. Late-stage NE–SW-trending dykes, ranging in composition from andesite to rhyolite, cut both the Selenge Complex and the ore-bearing porphyry intrusions. Supergene processes have produced three principal vertical zones, from top to bottom: a leached and oxidized zone, a secondary sulfide-enrichment zone, and a primary ore zone.

Re–Os dating of molybdenite from the Erdenetiin Ovoo Cu–Mo porphyry deposit yields ages of 240.4±0.8 and 240.7±0.8 Ma (Watanabe and Stein, 2000), while U–Pb zircon dating of granodiorite gives an age of 240±3 Ma (Jiang et al., 2010). These ages are consistent with a 40Ar/39Ar sericite age of 235.8±1.9 Ma (Sotnikov et al., 2005). However, other Ar–Ar sericite ages are significantly younger, around 207±2.5 Ma (Lamb and Cox, 1999). More recent studies report 40Ar/39Ar ages of 239.7±1.6 and 240±2.5 Ma, and a K–alunite age of 223.5±1.9 Ma (Kavalieris et al., 2017).

Ore-related porphyries

The ore-related porphyry intrusions comprise several stages, of which the first-stage porphyries represent the principal syn-mineral intrusive phase. They are dominated by hornblende–biotite granodiorite porphyry, with subordinate dacite. The granodiorite porphyry contains up to 40% phenocrysts of plagioclase (An_{28}), hornblende, and biotite set in a fine-grained groundmass of quartz, K-feldspar, and plagioclase ($An_{14–8}$). Dacite occurs as plagioclase-phyric to aphyric veinlets and injections, as matrix material in breccias, and within boudinaged granodiorite.

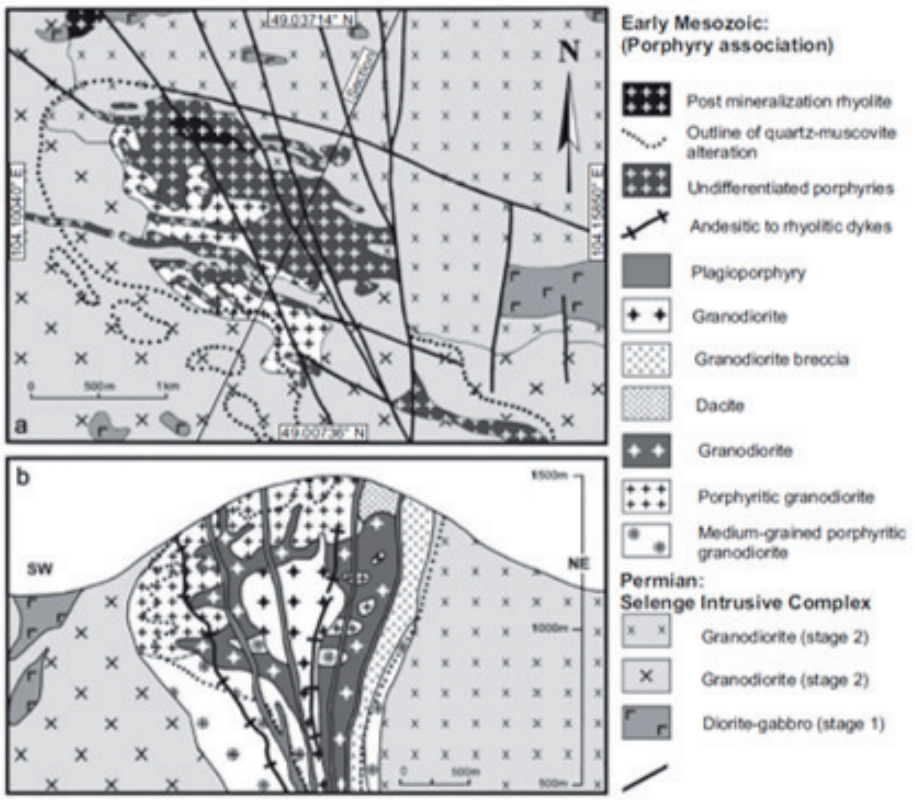


Figure 9. Geological map (a) and cross section (b) of the
Erdenetiin Ovoo deposit (simplified after Gavrilova et al.,1989)

Emplacement of the first-stage porphyries was accompanied by explosive activity and brecciation, producing eruptive breccias containing granodiorite fragments cemented successively by granodiorite porphyry and dacite (Gerel and Munkhtsengel, 2005).

The first-stage porphyries form two interconnected mineralized stocks. The southeastern stock is approximately 1.0 × 0.8 km and has an inverted-pear-shaped geometry in vertical section, whereas the northwestern body is approximately 0.9 × 0.85 km and has a horseshoe-shaped plan view. At shallow to intermediate depths, the northwestern body is stock-like but divides at depths of approximately 300–400 m into two steeply dipping, dyke-like bodies (Gavrilova and Maksimyuk, 1990) (Fig. 9).

Hydrothermal alteration and mineralization

Mineralization in the Erdenet porphyry system is closely associated with the shallow emplacement of the Early Mesozoic porphyritic intrusions. The hydrothermal system comprises three principal alteration assemblages: (1) potassic alteration, (2) quartz–sericite (phyllic) alteration with peripheral chlorite–sericite alteration, and (3) propylitic alteration, together with locally intense silicification. The alteration is broadly zoned from the deeper and central parts of the porphyry intrusions toward shallower and peripheral zones.

Early biotite–K-feldspar alteration with chalcopyrite mineralization occurs in the deeper parts of the system. Quartz–sericite alteration is closely associated with disseminated Cu mineralization and is locally overprinted by intense silicification, brecciation, and quartz–molybdenite veining. Propylitic alteration extends outward beyond the quartz–sericite zone and commonly affects the peripheral parts of the system.

Gavrilova and Maksimyuk (1990) proposed a two-level hydrothermal model for the Erdenet deposit. The lower level, below approximately 1,100 m elevation, comprises steep, fracture-controlled structural conduits that facilitated the upward migration of ore-bearing hydrothermal fluids. The upper level, between approximately 1,100 and 1,160 m elevation, envelops the porphyry stocks, satellite bodies, and dykes and hosts the main ore body. It consists of a lower weakly silicified zone and an upper strongly silicified zone characterized by porphyroblastic quartz, quartz veinlets, and silica-cemented breccias. The model suggests that the intensely fractured upper zone provided the principal environment for hydrothermal fluid accumulation, alteration, and ore deposition. The lower boundary of the quartz-rich zone approximately coincides with the base of the secondary sulfide-enrichment zone.

Hypogene mineralization and vein paragenesis

Gavrilova and Maksimyuk (1990) distinguished one pre-ore and five ore-related stages. The early mineralization is dominated by quartz–pyrite, quartz–chalcopyrite–pyrite, and quartz–molybdenite veinlets, followed by quartz–molybdenite and quartz–chalcopyrite–tennantite assemblages. Later stages are characterized by quartz–galena–sphalerite assemblages and by superimposed bornite–chalcocite–covellite mineralization. The first two mineralizing stages formed the main stockwork ore body, whereas the later stages are more closely associated with renewed fracturing and dyke emplacement. Stages IV and V are comparatively weakly mineralized.

The early quartz–sulfide stockwork veins are broadly comparable to A-type veins, whereas quartz–molybdenite±Cu-sulfide veins correspond to B-type veins. Later quartz–pyrite±Cu-sulfide veins associated with sericitic alteration are comparable to D-type veins in the classification of Gustafson and Hunt (1975). However, these vein types should be assigned on the basis of their mineral assemblages, alteration halos, textures, and cross-cutting relationships rather than solely by mineral composition (Fig. 10 and 11).

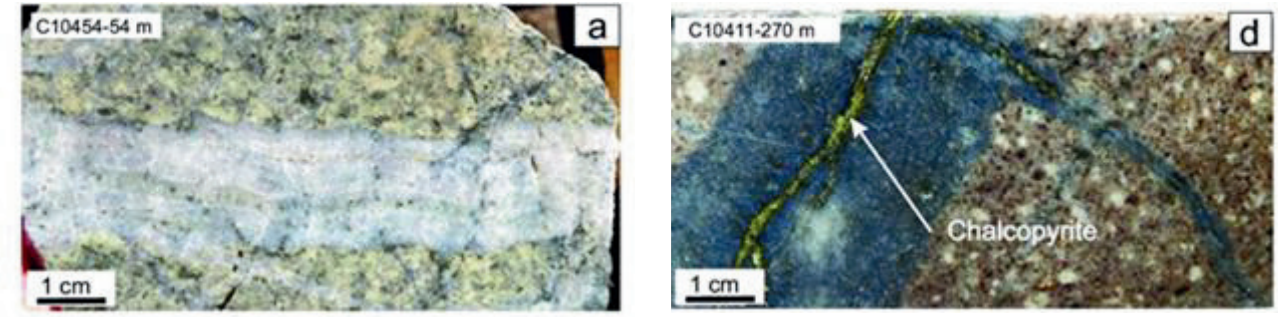


Figure 10. a) quartz-molybdenite vein; d) D-type vein, with chalcopyrite-pyrite filling fracture and broad muscovite selvage (Kavalieris et al., 2019)

Pyrite is the most abundant hypogene sulfide and occurs in several paragenetic associations: (i) early quartz veinlets; (ii) quartz–molybdenite veinlets; (iii) association with chalcopyrite, tennantite, and sphalerite; (iv) euhedral to porphyroblastic crystals; and (v) association with galena, sphalerite, and tennantite. Molybdenite occurs mainly with quartz and pyrite and locally with chalcopyrite. Chalcopyrite occurs principally in quartz–chalcopyrite–tennantite assemblages and as an overprinted phase associated with bornite–chalcocite–covellite. Tennantite occurs with pyrite, chalcopyrite, and sphalerite and in later sphalerite–galena assemblages. Enargite is rare and occurs mainly with pyrite and quartz. Galena forms disseminations, monomineralic aggregates, and veinlets, locally replacing sphalerite and tennantite. Sphalerite occurs as marmatite and cleiophane.

Hypogene Cu mineralization is dominated by chalcopyrite and bornite, with widespread late covellite and locally chalcocite intergrown with bornite. In addition to Cu and Mo, the ores contain Se, Re, Au, Ag, W, Sn, Ga, Tl, Ge, Bi, Zn, Co, Ni, As, and Sb, which occur mainly as trace constituents in pyrite, chalcopyrite, molybdenite, tennantite, galena, and chalcocite (Gavrilova et al., 1984). Quartz is the dominant gangue mineral. The $\delta^{34}S$ values of primary sulfides, including pyrite, molybdenite, and chalcopyrite, cluster near 0‰, consistent with a predominantly magmatic sulfur source. In contrast, secondary Cu sulfides have $\delta^{34}S$ values ranging from –3.2‰ to –0.3‰, with an average of –1.6‰ (Kim et al., 2018).

Supergene mineralization

Supergene processes produced an upper oxidized zone up to approximately 70 m thick, characterized by cuprite, malachite, azurite, turquoise, brochantite, native copper, delafossite, and antlerite. Copper grades within the oxidized zone are highly variable, and a well-developed leached cap has not been identified at Erdenet. A lithocap has, however, been documented at Tsagaan Chuluut (Kavalieris et al., 2017).

Where developed, a 30–300 m-thick supergene enrichment blanket is characterized by structurally controlled sheeted veinlets containing supergene chalcocite. Chalcocite occurs as crystalline, amorphous, and collomorphic forms and commonly replaces hypogene covellite and bornite. Supergene chalcocite also replaces chalcopyrite within the stockwork zones.

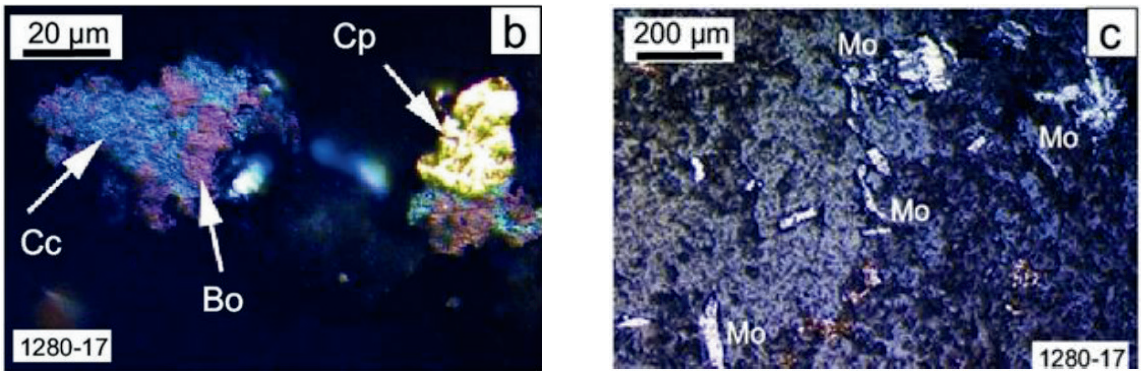


Figure 11. (b) polished section, shows chalcocite intergrown with bornite, partly rimming pyrite, (c) fine-grained disseminated molybdenite and chalcopyrite in strongly altered granodiorite (Kavalieris et al., 2019)

The genetic model proposed by Kavalieris et al. (2017) illustrates the spatial and temporal relationship between the Erdenet porphyry Cu–Mo system, its associated alteration zones, and the overlying advanced argillic–high-sulfidation epithermal environment (Fig. 12). Tungalag et al. (2023) classified the porphyry intrusions associated with the Central and Oyut mineralizatio of the Erdenet Ovoo deposit as high-silica adakite (HSA) based on the geochemical characteristics of the host granitoids, and suggested that they were derived from the partial melting of subducted oceanic crust.

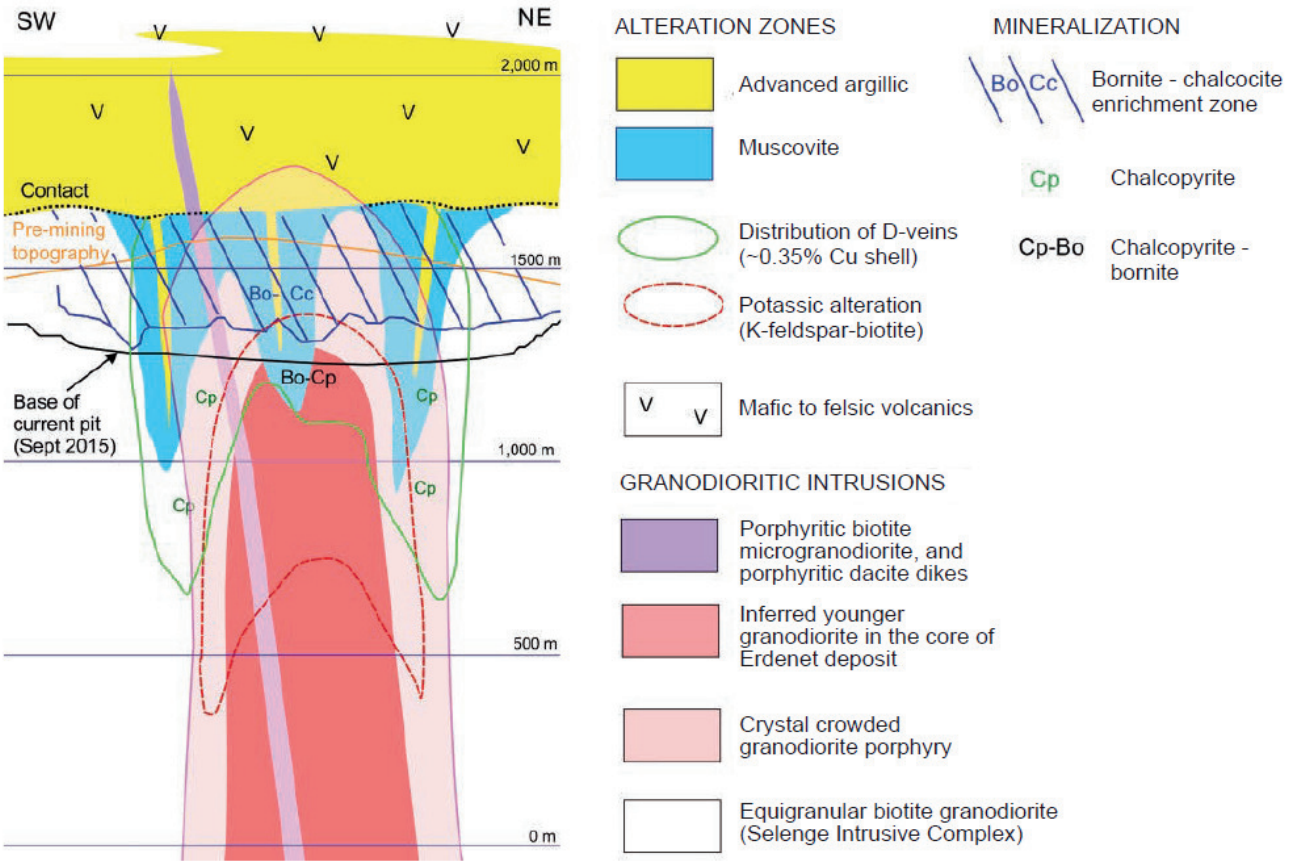


Figure 12. Model for the Erdenet porphyry deposit (Kavalieris et al., 2017)

Stop 2. EMC Digital Museum

The EMC Digital Museum presents the 40-year history and development of Erdenet Mining Corporation, documenting the transformation of the enterprise from the establishment of the Erdenetiin-Ovoo mine into one of Mongolia's major mining and mineral-processing companies. The museum's exhibition halls preserve and present both tangible and intangible cultural heritage associated with the corporation and its workforce. The collections include more than 1,000 exhibits, over 200 videos, and 160 published works, together providing a comprehensive record of the corporation's industrial, technological, cultural, and social development.

Through digital exhibitions and multimedia materials, visitors can explore the history of mining operations, the development of production and processing technologies, major stages in the growth of EMC, and important achievements and innovations of the corporation. The museum also highlights the people who contributed to the development of Erdenet and the company's role in the social and economic development of the region and Mongolia as a whole. Historical photographs, documents, publications, audiovisual materials, and other exhibits provide an opportunity to understand the evolution of the corporation and its industrial heritage (Fig. 13).

As a digital museum, the exhibition combines historical collections with modern digital presentation methods, making the corporation's heritage accessible in an engaging and informative format. It serves not only as a repository of EMC's history but also as an educational resource for visitors, researchers, employees, and the wider public interested in Mongolia's mining history and industrial development.



Figure 13. EMC Digital Museum

Stop 3. Tsagaan Chuluut lithocap

The Erdenet porphyry Cu–Mo system is overprinted by advanced argillic alteration exposed approximately 2 km northeast of the open pit. This alteration forms an extensive lithocap (~10 × 2.5 km) characterized by quartz, andalusite, Na–Ca and K-alunite, diaspore, pyrophyllite, zunyite, topaz, dickite, and kaolinite (Kavalieris et al., 2017)

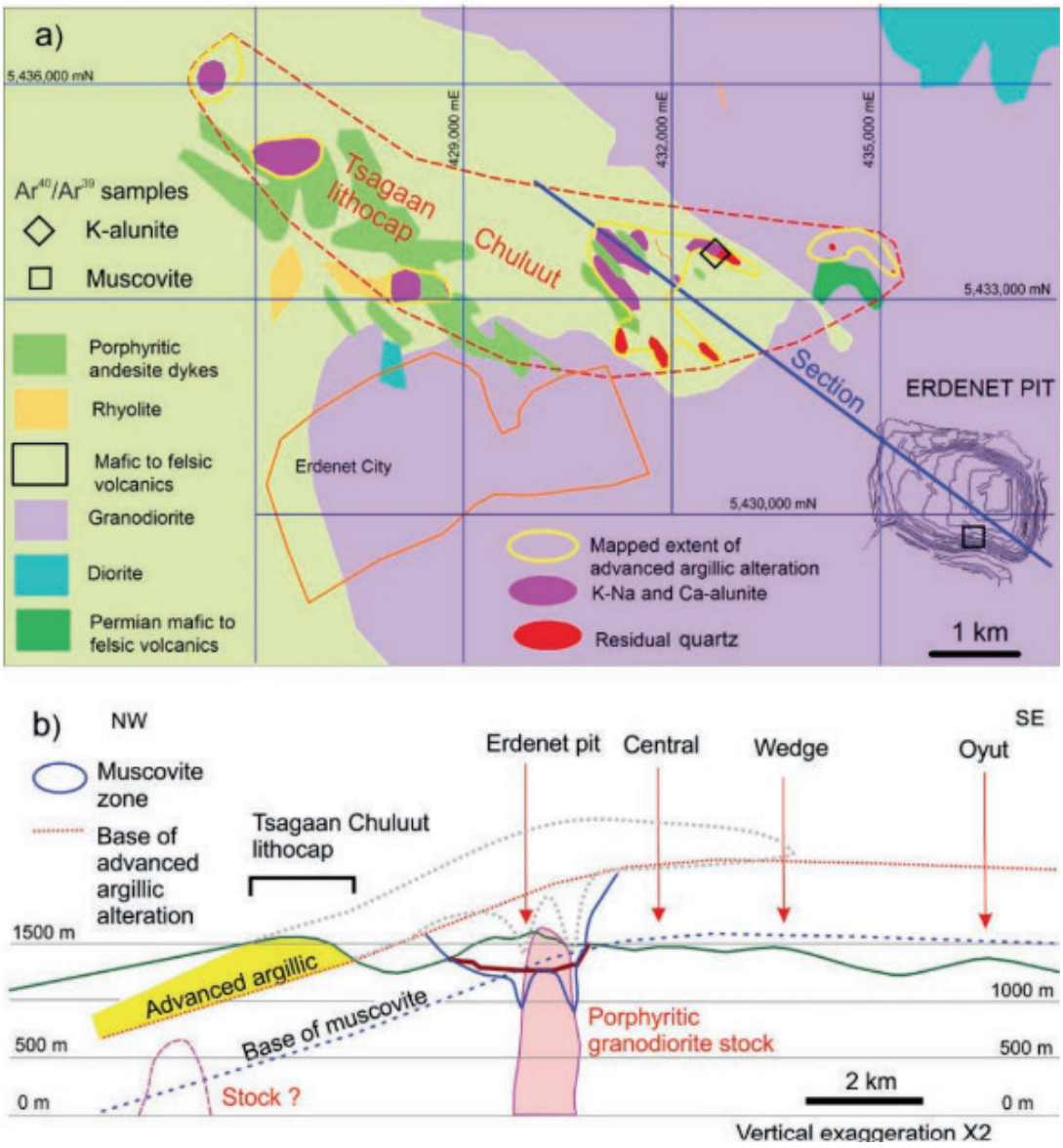


Figure 14. a). Simplified geology of the Tsagaan Chuluut lithocap. b). northwest-southeast cross section showing possible relationship between the lithocap and the Erdenet Cu-Mo porphyry system; Central, Wedge, and Oyut are porphyry Cu-Mo prospects, that extend to about 6 km southeast of Erdenet open pit (Kavalieris et al., 2017)

The Erdenet porphyry Cu–Mo system is overlain and regionally overprinted by an extensive advanced argillic lithocap exposed approximately 2 km northeast of the open pit at Tsagaan Chuluut (Fig. 14). The lithocap covers approximately 10× 2.5 km and is characterized by quartz, andalusite, Na–Ca and K-alunite, diaspore, pyrophyllite, zunyite, topaz, dickite, and kaolinite (Kavalieris et al., 2017).

The lithocap occurs within volcanic rocks of possible Late Triassic–Jurassic age and is spatially associated with a composite stock of crystal-rich granodiorite porphyry intruding the Selenge granodiorite and the overlying volcanic sequence. The relationship between the Selenge granodiorite and the volcanic rocks remains uncertain, as the contact may be either intrusive or erosional (Japanese International Cooperation Agency, 1992).

The Erdenet porphyry Cu–Mo mineralization is Middle Triassic in age, whereas 40Ar/39Ar dating of K-alunite indicates that the Tsagaan Chuluut lithocap formed approximately 16 m.y. later (Kavalieris et al., 2019). Its younger age, advanced argillic mineralogy, and distinct tabular geometry indicate that the high-sulfidation system represents a separate, later magmatic–hydrothermal event that overprinted the earlier porphyry system.

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