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Editorial: Plate subduction and mineralization in East and Central Asia

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Editorial on the Research Topic
Plate subduction and mineralization in East and Central Asia

Introduction

Plate subduction has played a pivotal role in shaping the tectonics in East and Central Asia. Since the Paleozoic, the closure of the Paleo-Asian and Tethyan oceans have brought together various continental blocks (e.g., Siberia, Sino-Korea, South China, Indochina and Sibumasu), and many ophiolites and accreted island arc terranes in between to form the present-day tectonic configuration. This generated the Central Asian Orogenic Belt, the world's largest Phanerozoic accretionary orogen, and the Tethyan tectonic domain that extends across much of the southern Central Asia and mainland SE Asia. During this prolonged multiphase subduction process, a number of world-class subduction-related ore deposits within related regional tectonic belts were formed. In the following, we have briefly summarized the key findings of the papers in this Research Topic (Figure 1):

Many ore deposits in East and Central Asia are characterized by multistage metallogeny. By integrating fluid inclusion microthermometry and H-O-S-Pb isotopes on the Haerdaban Pb-Zn deposit (Chinese Western Tianshan Orogen), Xia et al. suggested that the stratiform ores there were sedimentary exhalative (SEDEX)-type formed in the Proterozoic Haerdaban Group meta-carbonate/clastic sequences. Meanwhile, the crosscutting vein-type ores were likely formed by a Late Ordovician-Silurian magmatic-hydrothermal event genetically linked to North Tianshan Ocean subduction. Led by Paleo-Asian Ocean subduction, the Devonian-Carboniferous is a key metallogenic epoch in Central Asia, generating many world-class porphyry Cu deposits in the Balkhash (e.g., Kounrad and Borly; Kazakhstan), Gurvansayhan (e.g., Oyu Tolgoi; Mongolia) and

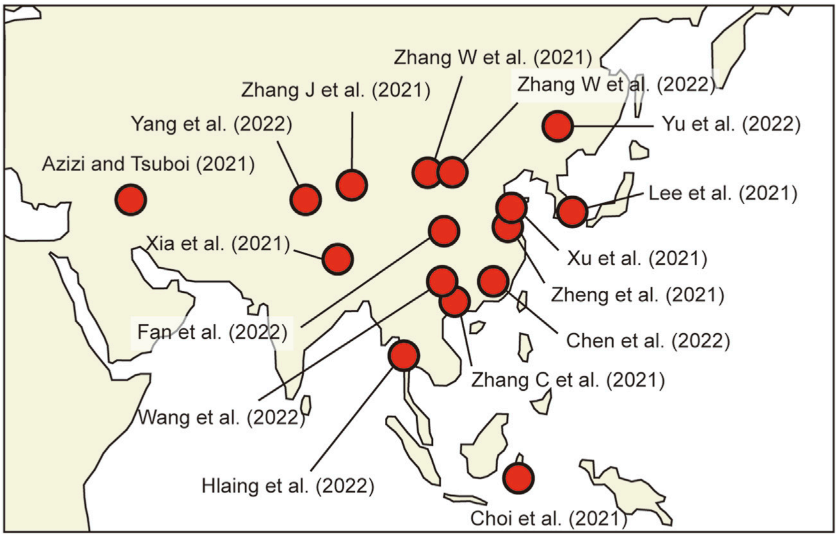

FIGURE 1
Geographic map of East and Central Asia, showing the study area of the 16 papers in this Research Topic.

Chinese Tianshan (Tuwu-Yandong, Xinjiang) regions (e.g., Wainwright et al., 2011; Shen et al., 2017; Mao et al., 2022). Yang et al. reported on the newly discovered Qia'erdunbasixi Fe-Cu skarn deposit in the Zarma-Sawur Cu-Au belt (Kazakhstan-NW China). The ores are hosted along the diorite exocontact by arc-type calc-alkaline andesite and minor basalt and tuff. SHRIMP zircon U-Pb dating of the post-ore syenite (345 ± 2. 2 Ma) provided a minimum age for the mineralization.

Despite that fact the Paleo-Asian Ocean was largely closed by the Permian, the influence of subduction may have lasted long after. Zhang et al. presented a new Early Cretaceous age (129. 7 Ma) on the dolerite dykes from the Bailingshan Fe deposit (Eastern Tianshan Orogen, NW China). The dolerite has low initial $^{87}Sr/^{86}Sr$ and positive εNd(t) values, indicative of an asthenospheric mantle source. The authors suggested that the mafic magmatism may have occurred in an intraplate extension setting, related to the delamination and sinking of dense, Late Paleozoic subduction-modified lithospheric mantle.

Subduction of the Eastern Paleo-Tethys has been attributed by some authors to contribute to the end-Permian Emeishan Large Igneous Province (LIP) (Xu et al., 2019). The Emeishan LIP has hosted many magmatic Fe-Ti-V oxide and Ni-Cu-PGE sulfide deposits, yet its spatial continuation to the SE (e.g., in Guangxi and NW Vietnam) is still inadequately constrained (Halpin et al., 2016). By studying the Longlin basalt in western Guangxi, Zhang et al. revealed that these basalts (256. 7–259.5 Ma) were largely coeval with the Emeishan LIP volcanism and have similar whole-rock geochemical and Sr-Nd isotope features to the Emeishan high-Ti flood basalt sequence. The authors argued that the Emeishan LIP activity had extended to western Guangxi.

In the Kunlun Orogen (Qinghai Province, NW China), Zhang et al. presented new ages on the magmatic Cu–Ni sulfide ore-bearing olivine-pyroxenite (250.8 Ma) and weakly mineralized gabbro (257.3 Ma) from the Xiwanggou complex. These Late Permian ages are much younger than most deposits (Late Silurian–Early Devonian) in this region. Whole-rock Sr–Nd and zircon Hf isotopes suggest that the magma was mainly derived from the metasomatized subcontinental lithospheric mantle (SCLM), and formation of the Xiwanggou complex was likely related to subduction of the Paleo-Tethyan Anemaqen Ocean. The dextral shear of the crustal-scale Wenquan and South Kunlun faults may have served as a major conduit for the magma ascent. Paleo-Tethyan subduction in the Kunlun Orogen was likely completed in the Middle Triassic. Zhang et al. reported new ages and geochemical data on the ore-causative granodiorite porphyry (217.3 Ma) and granite porphyry (217.0 Ma) at the large Harizha Cu polymetallic deposit. The Late Triassic ages of these porphyries fall into the post-collisional magmatic age range of the East Kunlun Orogen, whilst their peraluminous and high-K nature is consistent with a post-collisional petrogenetic setting.

Further west, Neo-Tethyan subduction and post-collisional extension between the Arabian and Eurasian plates has caused the assembly of microcontinents (incl. Taurides–Anatolides and Biston–Avoramanm, Bilitis) along various suture zones, notably the Oshnavieh–Salmas–Khoy ophiolite belt. Through extensive geochemical data compilation and analysis, Azizi and Tsuboi, the newly defined the Van microplate in eastern Turkey-NW Iran was recognized, which drifted from the Arabian plate in the Jurassic and accreted onto the southern Eurasian plate after the closure of northern Neo-Tethyan branch. The process had generated prolonged multiphase magmatism in the Cretaceous, Eocene, Oligocene-Miocene, and late Miocene-Quaternary.

In the Jurassic-Cretaceous, the Eastern Asian tectono-metallogeny was mainly driven by the Paleo-Pacific subduction, forming the Great Yanshanian Metallogenic Event (Goldfarb, 2021). The event extended from the Russia Far East-NE China-Korea, through the regional Tanlu Fault to South China. In NE and Central China, the metallogeny has formed many world-class porphyry Mo deposits (e.g., Chalukou), as well as numerous intrusion-related, epithermal Cu (-Au-Ag) and skarn Fe (-Cu) deposits. By dating various lamprophyre units from the western Songliao Basin (NE China), Yu et al. found that they were mainly emplaced in the Late Jurassic and Early Cretaceous. Geochemical features suggest that the Early Cretaceous suite was formed at a shallower depth than the Late Jurassic suite. This indicates a probable crustal thickening during 156–132 Ma, prior to the widely reported Early Cretaceous crustal thinning caused by subduction rollback.

In the SE Korean Peninsula, the Paleo-Pacific subduction had formed a series of Cretaceous hydrothermal vein-type Cu deposits in the Gyeongsang basin. Lee et al. analyzed the mineralogy and fluid inclusion geothermometry of the Haman, Gunbuk, and Daejang deposits (Gyeongnam metallogenic belt). The results indicate that Haman was formed at the central-upper part of crystallizing stock under higher P-T conditions than those of typical porphyry Cu deposits, whilst the Gunbuk-Daejang deposits were formed at a shallower peripheral location with partially overlapping P-T conditions with porphyry-style mineralization.

Nonetheless, despite having similarly favorable tectonic triggers (Paleo-Pacific subduction and the Tanlu crustal-scale fault movement) and adakitic-like geochemical signature, some intrusives are Cu-Au ore-forming but others are not. To understand this disparity, Zheng et al. compared the age and geochemistry between the ore-barren adakitic rocks (130–129 Ma, 115.8, and 105.8 Ma) from the Huaibei-Linhuan coalfield with other fertile/barren adakites across Eastern China. They found that the parental magma of the Huaibei-Linhuan adakites may have been considerably more reduced than typical porphyry Cu-Au ore-forming magmas, possibly led by the late assimilation of Carboniferous-Permian coal seams.

In the world-class Jiaodong gold province (east of Tanlu fault, Eastern China), Xu et al. presented a new age on the cataclastic granite ore host (142 Ma) for the Zhaoxian gold deposit, which helps to constrain the maximum mineralization age and is coeval with the regional Yanshanian magmatism. Auriferous pyrite geochemistry and S-He-Ar isotopes suggest that the ore fluids were derived from a crustal-mantle mixed source, with metamorphic and magmatic fluids dominating the early and main ore stages, respectively.

In the Mangling orefield of North Qinling Terrane (west of Tanlu fault, Central China), Fan et al. suggested that the Yaozhuang Mo polymetallic deposits are closely related to the ore-bearing porphyry stocks, which were zircon U-Pb dated to be 157–153 Ma, coeval with the regional magmatic peak. The Yaozhuang stocks were likely formed by the lower crustal delamination in North Qinling.

In South China, the Paleo-Tethys closure (Indosinian orogeny) and Paleo-Pacific subduction has led to major regional tectonic reconfiguration and development of crustal-scale faults, e.g., the Ziyun-Luodian Fault (Wang et al.), as well as the Great Yanshanian Metallogenic Event (Goldfarb et al., 2021), which is well-known to have formed the world-class W-Sn and many rare-metal deposits in the Nanling Range. By studying the ore-forming Jianfengling biotite monzogranite in the Xianghualing orefield (Nanling Range), Ze-Yi et al. suggest that the Jianfengling granite was emplaced in the Late Jurassic (161.3–158.7 Ma), probably sourced from the Mesoproterozoic Cathaysian basement in a lithospheric extensional setting. The Nb-Ta contents increase with fluorine from the porphyritic to equigranular lithofacies of the granite, indicating that the Nb-Ta enrichment may have been caused by the gradual F increase during granitic magma fractionation.

Coincident with the Paleo-Pacific subduction, Neo-Tethys subduction in western SE Asia and the subsequent India-Asia collision had generated many porphyry to epithermal-type Au (-Cu) and Pb-Zn (-Ag) and orogenic gold deposits (Zaw et al., 2014). The latter is well-developed along the 1,300 km long Mogok-Mandalay-Mergui Belt in Central Myanmar. Hlaing et al. presented and compared the geology and genesis of two major gold districts (Modi Taung-Nankwe and Kyaikhto) in the belt. Both gold districts have similar shear zone-hosted ore vein textures and orientation, together with similar ore host of the Carboniferous Mergui Group meta-sediments. They have also similar wallrock alteration styles, ore mineral assemblage and low to medium salinity ore fluids, comparable to typical mesozonal orogenic gold systems.

Further southeast in the Indonesia archipelago, the East Sulawesi Ophiolite, an interpreted Cretaceous-Paleogene oceanic plateau fragment obducted onto the Sundaland margin by the Pacific plate subduction (Kadarusman et al., 2004). The ophiolite at Morowali consists mainly of serpentinized harzburgite and lherzolite, and the extensive weathering formed substantial laterite-type Ni resources. Based on garnierite (main ore mineral) color and XRD/EPMA and whole-rock geochemical analyses, Choi et al. suggested that the garnierite consists of serpentine-like and talc-like phases. The former has high Ni-Fe contents and likely originated from the bedrock, whereas the latter has lower Fe content and a secondary origin, formed by weathering during repeated annual dry and wet cycles.

This Research Topic of 16 articles in the Research Topic does not provide all the new research progress on the tectonic evolution and associated metal mineralization in the region, although tries to cover the wider significant developments in this field. The East and Central Asia region is highly endowed with a diversity of metallic ore deposits, including porphyry, skarn, epithermal, VHMS, sediment-hosted/orogenic gold, vein-type W-Sn deposits, and critical metal deposits. We envisaged that further work on petrogenetic/metallogenetic studies of these mineral systems, e.g., on the rare-metal enrichments in fractionating magmas, are strategically important for future mineral resource and green energy industry of the region.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

Author C-KL was employed by the company Fortescue Metals Group Ltd.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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