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Editorial: (Paleo-) Pacific plate subduction tectonics and related magmatism and mineralization

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Editorial on the Research Topic
(Paleo-) Pacific plate subduction tectonics and related magmatism and mineralization

1 Introduction

The Pacific oceanic plate started forming in the Early Jurassic and is currently the largest oceanic plate on the Earth since Mesozoic (Boschman and Van Hinsbergen, 2016). The Pacific plate initially formed as the cores of the Izanagi, Farallon, and Phoenix plates as a result of the expansion of triangular three-ridge system (Li et al., 2019). During the Early Jurassic, the subduction of the Paleo-Pacific Plate along the eastern margin of Eurasia and related circum-Pacific terranes resulted in the formation of magmatic rocks, rejuvenation of pre-existing structures, and polymetallic mineralization (Yang et al., 2020a; Ma and Xu, 2021; Zeng et al., 2023). In the Cenozoic, the subducting Pacific Plate transitioned to steep subduction, which facilitated deformation and uplift of the overriding plate (Miller et al., 2006; Yang et al., 2020b; Ju et al., 2021). The complex subduction processes are correlated with widespread mineralization and weakening of stable terranes (e.g., North China Craton), propogating seismicity and volcanism into previously stable areas (Mao et al., 2018; Zhu and Xu, 2019; Zhao, 2021). As a result, the prolonged history of Mesozoic to Cenozoic subduction defines many geological and environmental conditions observed today. Thus, we propose the Research Topic of "(Paleo-) Pacific Plate Subduction Tectonics and Related Magmatism and Mineralization" in *Frontiers in Earth Science*. This Research Topic includes twenty-three papers (Figure 1) that have a link with the (Paleo-) Pacific plate subduction tectonics. In this special edition, nine papers focus on petrogenesis and tectonic implications of magmatic rocks, ten papers are concentrated on polymetallic mineralization, and four papers are related to the geodynamic implications of plate subduction. Below we sumarize a brief introduction to these papers in this Research Topic.

2 Summary of papers

2.1 Magmatism

Dong et al. this Research Topic conducted whole-rock major and trace element and zircon U-Pb and Lu-Hf isotope analyses on the granitic intrusions from the Dazeshan region, Jiaodong Peninsula, North China Craton. Zircon U-Pb dating constrain the emplacement ages of these granitic intrusions at ca. 120 Ma. Geochemical and isotopic data show that these magmatic rocks underwent variable crustal melting and differentiation processes. This study suggests that these intrusions were produced by the underplating of water-rich mafic magma. The mafic magma provided fluid and heat that sourced from the dehydration of the subducting Paleo-Pacific plate.

Gao et al. this Research Topic performed zircon U-Pb dating, and whole-rock major and trace element and Sr-Nd-Hf isotope analyses on the syenite from Inexpressible Island in the Antarctica's Ross Orogenic Belt within the framework of the convergence of Paleo-Pacific oceanic plate and Gondwana continental margin. Zircon U-Pb dating document the emplacement ages of these syenites at ca. 477–471 Ma. Zircon Lu-Hf and whole-rock Sr-Nd isotopes suggest partial melting of lithospheric mantle enriched with subduction slab fluids and subcontinental lithosphere for the formation of these syenites. Whole-rock geochemical data show that these syenties have island arc geochemical affinities. This study finally suggests that the Inexpressible Island magmatism was related to localized melting zone of an older previously enriched layer of subcontinental lithospheric mantle, which was metasomatized by a more recent subduction components.

Hu et al. this Research Topic present zircon U-Pb and Lu-Hf isotopes and whole-rock major and trace element analyses for the Baihesi aluminous A-type granite in the eastern Jiangnan Massif, South China. Zircon U-Pb dating document the onset of the Cretaceous extension in the eastern Jiangnan Massif at ca. 145–140 Ma. Zircon Lu-Hf isotopes suggest that the Baihesi granite was derived from partial melting of reworked juvenile crust associated with Neoproterozoic arc-related magmatism. This work also suggests that the formation of Baihesi granite was associated with the Paleo-Pacific plate subduction along the South

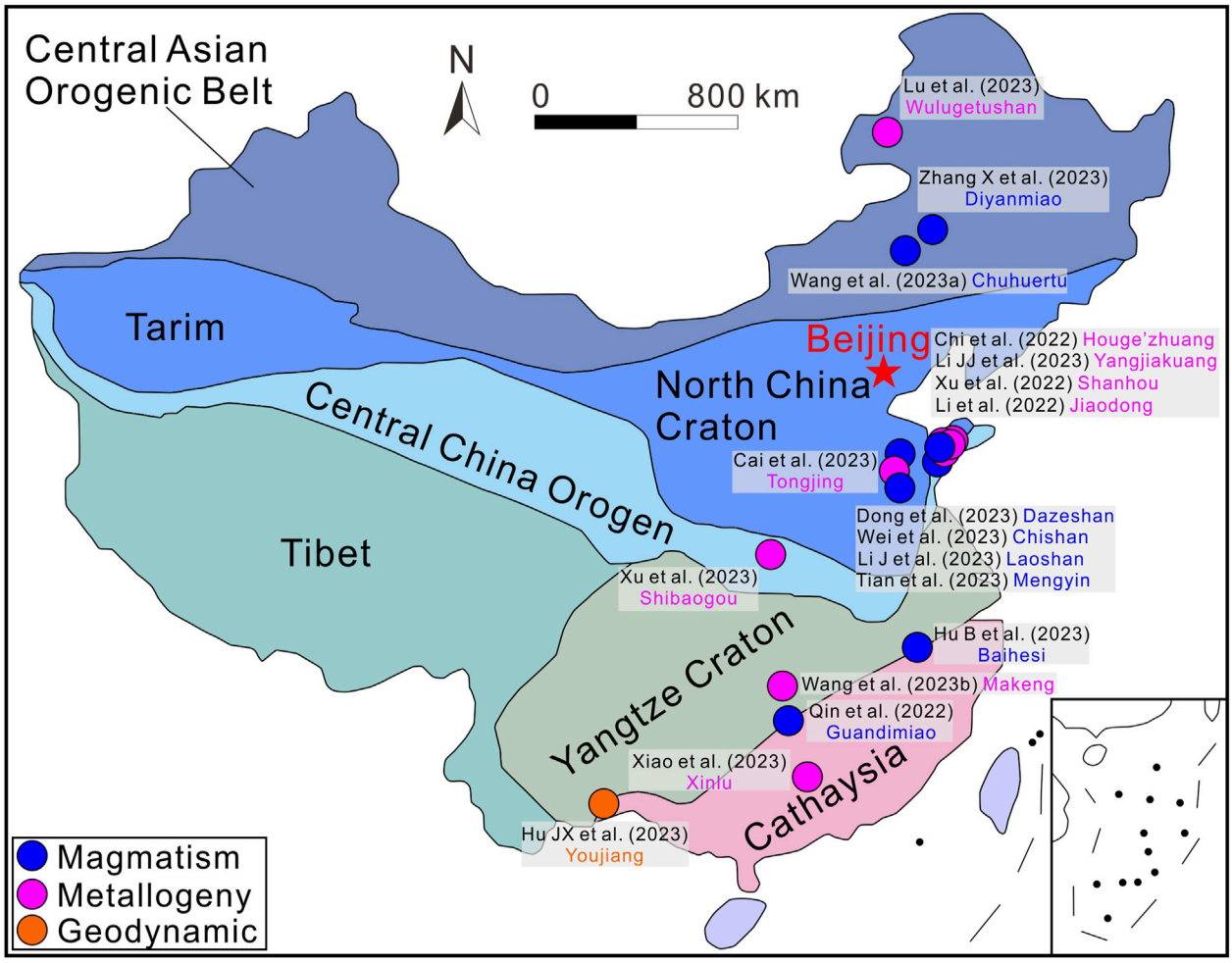

FIGURE 1
Simplified geological map of China (modified after Yang et al., 2022) showing the distribution of study areas of most papers in this Research Topic, but not including Liu et al. (Northwest Pacific Wadati-Benioff zone), Parcutela et al. (Western Pacific oceanic island arcs), Zhang et al. (nephrite jade deposits in China), and Zhang et al. (Japan Islands).

China active continental margin in the Late Jurassic to Early Cretaceous.

Li et al. this Research Topic present whole-rock geochemistry, zircon U-Pb isotope, and zircon and apatite trace element analyses for the Laoshan A-type granite in the Shandong Peninsula, eastern North China Craton. Zircon U-Pb dating constrain the emplacement ages of these granites at ca. 120–117 Ma, and associated geochemical data suggest that the Laoshan grainte is an A_1-type and crystallized under moderate and low oxygen fugacity conditions. This study suggests that the flat subduction of the spreading ridge between the Pacific and Izanagi plates was responsible for the formation of Laoshan A-type granite and the decratonization of North China Craton.

Qin et al. this Research Topic present zircon U-Pb isotopes, whole-rock major and trace element and Sr-Nd-Pb isotope analyses on the Guandimiao batholith in the South China Block. Four stages of magmatism at ~239 Ma, ~230–203 Ma, ~211–190 Ma and ~121 Ma were identified in the Guandimiao batholith. This study proposes that the Guandimiao batholith recorded the closure of the Paleo-Tethys Ocean in the Triassic, the regional extension during post-collision, the transition of tectonic and dynamic regimes in the Jurassic to Cretaceous (Yanshanian), and the rollback and steep subduction of Paleo-Pacific Ocean in the Jurassic to Cretaceous.

Tian et al. this Research Topic report carbonate U-Pb dating and fluid inclusions for the Mengyin kimberlite matrix and xenolithic marble in the Luxi terrane, Shandong Peninsula, North China Craton. Carbonate U-Pb dating yield the eruption age of kimberlite at ca. 383 Ma and the timing of marbleization at ca. 359 Ma. Fluid inclusions in xenolithic marble suggest formation temperature of 243°C–370°C, salinity of 2.57%–14.77% (NaCl), and pressure of 3.22–20.70 MPa. This study estimates that the overall denudation depth of the west Shandong area in the west Pacific domain is at about 900–1000 m and the overall crustal rise rate is at ca. 3 m/Ma since the Late Devonian.

Wang et al. this Research Topic preform zircon U-Pb isotopes and whole-rock major and trace element analysis on the Chuhuertu granite from the central Inner Mongolia, North China. Zircon U-Pb dating constrain the emplacement ages of the granite in the Late Jurassic (ca. 156 Ma). Whole-rock geochemical data suggest that the Chuhuertu granite is highly differentiated A-type granite which formed via partial melting of intermediate-mafic crust and differentiation crystallization. The study also suggests that the Chuhuertu granite was the product of extension of the closure of the Mongo-Okhotsk Ocean in the Late Jurassic, which was also superimposed the coeval tectonic effects of the Paleo-Pacific plate rollback.

Wei et al. this Research Topic present zircon U-Pb and Lu-Hf isotopes, and whole-rock Sr-Nd-Pb and major and trace element analyses from the quartz syenite from Chishan and Longbaoshan alkaline complex, North China Craton. Zircon U-Pb dating document that the quartz syenite was emplaced at ca. 126–123 Ma. Whole-rock geochemical data show arc- and extension-related geochemical affinities in response to the rollback and retreat of the subducting Paleo-Pacific plate. The Sr-Nd-Pb-Hf isotopic data indicate an EM-2 type lithospheric mantle source. This study also highlights homologous source characterisitics for quartz syenite and REE mineralization related to magmatic hydrothermal evolution.

Zhang et al. this Research Topic present zircon U-Pb isotopes and whole-rock major and trace element and Sr-Nd isotope analysis on a newly discovered gabbro in the Diyanmiao ophiolite zone, Inner Mongolia, North China. Zircon U-Pb dating yield an emplacement age of 294 Ma for gabbro. The whole-rock geochemical and Sr-Nd isotopes suggest N-MORB and subduction-related geochemical affinities. The gabbro formed at the initial stage of intra-oceanic subduction of the Paleo-Asian Ocean. The study also emphasizes the tectonic transition from the Paleo-Asian Ocean to Paleo-Pacific subduction during the Triassic to Jurassic in North China.

2.2 Metallogeny

Cai et al. this Research Topic perform systematic scanning electron microscope-backscattered electron imaging, electron probe microanalysis, and *in-situ* trace element, sulfur and lead isotope analyses on the Yi'nan Tongjing Au-Cu deposit, Luxi terrane, North China Craton. This study identifies five hydrothermal stages of early skarn, late skarn, oxide, sulfide and late quartz-calcite, with gold mostly as silver-bearing native grains. The trace element data of sulfides and oxides suggest that the ore-forming fluid is of medium-high temperature magmatic-hydrothermal origin. The S-Pb isotopes reveal that the ore-forming materials are derived mainly from the Early Cretaceous diorite porphyry and partly from the host rocks (carbonate rocks). These findings suggest that the Tongjing Au-Cu deposit occurs as an important metallogenic response to the decratonization of North China Craton induced by the Paleo-Pacific Plate rollback during the Early Cretaceous.

Chi et al. this Research Topic present fluid inclusions and *in-situ* trace element and sulfur isotope analyses for the Houge'zhuang gold deposit, Jiaodong Peninsula, North China Craton. Three different type pyrites and fluid inclusions document the role of arsenic and sulfur isotopes in gold precipitation and the association of gold with specific pyrite types. The study also proposes that the As-bearing pyrites have close spatiotemporal links with gold, and these pyrites play an important role in the formation and exploration of high-grade gold deposits in Jiaodong reigon of the west Pacific subduction zone.

Li et al. this Research Topic conducted calcite Sm-Nd and zircon U-Pb dating and S-Pb-He-Ar isotope analyses on the Yangjiakuang gold deposit from the Jiaodong Peninsula, North China Craton. Calcite Sm-Nd and zircon U-Pb dating document the Yangjiakuang deposit that formed in the Early Cretaceous (ca. 123 Ma). Pyrite S-Pb-He-Ar isotopes suggest that the ore-forming materials and fluids contain a mixture of crustal and mantle components. The formation of the Yangjiakuang deposit is correlated with crustal extension caused by the rollback of the subducting Izanagi Plate during the early Cretaceous.

Li et al. this Research Topic present results of gold nanoparticles in ore and build the fundamental linkage to geochemical anomaly distribution maps of gold in drainage sediments, wall rocks, and ore within Jiaodong gold province, North China Craton. This study suggests that the gold particles in Jiaodong Peninsula have a close relationship with the evolution of Mesozoic structural-controlled gold mineralization related to the Paleo-Pacific plate subduction and

could be used to interpret diverse geochemical anomalies for exploration. In addition, a migration pathway of gold nanoparticles was built to illustrate the processes of massive gold accumulation and prospecting in Jiaodong Peninsula.

Lu et al. this Research Topic present geochemical analysis of melt inclusions in porphyry intrusions and fluid inclusions in quartz veins from the Wunugetushan large porphyry Cu-Mo deposit in NE China (west Pacific domain). Melt inclusion data yield rhyolitic compositions of 71.7–85.3 wt% SiO_2, 1.9–31.3 ppm Cu and 1.7–2. 6 ppm Mo. Fluid inclusions suggest that the hydrothermal fluids evolved through three main stages of the early Mo mineralization, late Mo mineralization and Cu mineralization. This study also highlights that the separation of Cu and Mo was promoted by multiple factors, including the increased Cu/Mo ratios in residual melt and the changing redox state and acidity of ore-forming fluids.

Wang et al. this Research Topic carried out garnet U-Pb isotopes and rare Earth element analysis on the Makeng-style iron polymetallic deposits from SE China within the Paleo-Pacific tectonic domain. Garnet U-Pb dating suggest that these deposits formed at ca. 137–130 Ma. Garnet rare Earth element data have geochemical affinities of skarn deposits, and these Makeng-style deposits underwent distinct ore-forming processes and mineralizing fluids. This study provides valuable insight into mineralization age and genesis, in addition to the novel application of U-Pb dating in skarn-type deposits.

Xiao et al. this Research Topic report results of rock slab and thin section reflection mapping, element mapping by Micro-XRF (μ-XRF), and *in-situ* LA-ICP-MS cassiterite U-Pb dating for the Xinlu Sn-Zn deposit, Nanling Sn-W belt, South China. The μ-XRF analytical results reveal four mineralization episodes of prograde skarn, retrograde skarn-sulfide, quartz sulfide vein and barren calcite stages in the Baimianshan segment of Xinlu deposit. Cassiterite U-Pb dating determine the timing of retrograde skarn-sulfide mineralization at ca. 169 Ma, which indicate a Sn mineralization associated with the ca. 160–169 Ma magmatism in the Guposhan-Huashan district. The study suggests that there are links between the subduction of the Paleo-Pacific plate and the formation of the Xinlu Sn-Zn mineralization and the Middle-Late Jurassic Sn-W mineralization in the Nanling belt, South China.

Xu et al. this Research Topic present molybdenite Re-Os dating, fluid inclusions and H-O-S-Pb isotopes on the Shibaogou skarn-type Mo (Pb-Zn) deposit, East Qinling, China. This study documents that the Shibaogou deposit formed in the Late Jurassic (ca. 147 Ma). The ore-forming fluids are suggested to be from magmatic and atmospheric water, whereas the ore-forming material is derived from Shibaogou intrusion. The formation of the Shibaogou deposit is correlated with the subduction of Paleo-Pacific plate during the Late Mesozoic.

Xu et al. this Research Topic present results of high-precision geophysical surveys including gravity and controlled source audio frequency magnetotellurics for the Shanhou gold deposit in Jiaodong gold provice, eastern North China Craton. The spatial distribution of stratum, structure and magmatite of the Shanhou gold deposit were identified. The study revealed a gold orebody at depths greater than 1,015 m, which supports the presence of gold mineralization in the brittle deformation of the Zhaoping fracture zone, correlated with the subduction of Paleo-Pacific plate.

Zhang et al. this Research Topic review the nephrite jade deposits from different tectonic units in China, through integrating published geochronology, major and trace elements and H-O isotopes. This study divides the nephrite jade deposits in China into green jade-type (GJ-type) and white jade-type (WJ-type). The GJ-type nephrite deposits mainly formed through the late auto-metamorphic metasomatism of serpentine or the spontaneous crystallization/precipitation along suture/shear zones. The WJ-type nephrite jade, the main nephrite jade type in China, is generated via metamorphism-metasomatism during post continent-continent collisions. This study also suggests that the formation of the nephrite jade deposits is associated with multiple tectonic episodes (e.g., Pacific plate subduction) and the interaction between hydrothermal fluids and metamorphism under subduction accretion- and collision orogenesis-related settings. Further, this study provides insights into the genetic discrimination, mineral exploration, and quality assessment of nephrite jade deposits in China.

2.3 Geodynamic

Hu et al. this Research Topic present structural analysis at the middle of the Youjiang fold-and-thrust belt and discuss the Mesozoic tectonic transition of the South China Block. This study reveals four phases of deformation, including the Permian-Middle Triassic NE-SW shortening deformation, the Late Triassic nearly N-S extension, the Jurassic NW-SE shortening, and the Cretaceous nearly E-W extension. These structural episodes are correlated with the collision and post-collision during the Indosinian orogeny as well as the Paleo-Pacific plate subduction and subsequent slab-rollback during the Jurassic to Cretaceous. This findings also highlights the tectonic transition of South China Block in response to the subduction of Paleo-Pacific plate that likely occurred in the Early Jurassic.

Liu et al. this Research Topic document the present-day stress field along the Northwest Pacific Wadati-Benioff Zone (WBZ) through using earthquake focal mechanism. This study reveals pure compression in shallow WBZ segment and is correlated with negative buoyancy of plate and convergence between plates. A stress regime of pure compression was identified in the deep segment of northern Izu-Bonin trench WBZ, which is possibly triggered by the resistance offered by mantle to penetration of slab. The stress states at intermediate depths along the junction of the trench WBZ were inferred to have been influenced by lateral deformation due to increasing slab's dip.

Parcutela et al. this Research Topic carried out a comparison of gravity-derived magmatic growth rates of Western Pacific oceanic island arcs, using statistical correlation between the Bouguer anomalies and the seismic-derived crustal thicknesses to estimate the magmatic growth rates of the western Pacific island arcs and the Philippine island arc system. The results show that the magmatic growth rate of the Western Pacific island arcs is significantly higher (28–60 km^3/km/m.y), which is correlated with the Pacific Plate subduction. The growth rate of the Pacific island arcs is higher than other oceanic island arcs (12–25 km^3/km/m.y) and are derived from the subduction of other oceanic lithospheres (e.g., Philippine Plate).

Zhang et al. this Research Topic applied double-difference tomography to determine 3-D velocity structure of P- and S-waves from Japan Trench to back arc under Japan Islands. The results reveal the morphological and high-velocity characteristics of the subduction of Pacific plate and low-V anomalies in the surrounding mantle. The fluids released by the dehydration of the subducting plate and transported upward by mantle upwelling are indicated to have played crucial roles in the formation of arc magmatism and plate melting in the mantle wedge behind the Japan Trench.

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

The 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.

Publisher's note

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