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# Editorial: Paleo-Asian and Tethyan domains: magmatism, tectonics, mineralization, and geodynamics

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Editorial on the Research Topic
Paleo-Asian and Tethyan domains: magmatism, tectonics, mineralization, and geodynamics

## 1 Introduction

The Paleo-Asian and Tethyan oceans are two extinct ancient oceans. The Paleo-Asian Ocean was formed during the breakup of the Rodinia Supercontinent in the Mesoproterozoic to Neoproterozoic (Wan et al., 2018; Xiao et al., 2019; Liu et al., 2021). Tethys can be further subdivided into the Proto-, Paleo-, and Neo-Tethys Oceans (Metcalfe, 2013; Wu et al., 2020). Tethys was formed during the Cambrian to Cretaceous, corresponding to the separation and northward migration of the various continental terranes from Gondwana (Liu et al., 2023). The Central Asian Orogenic Belt and Tethyan Tectonic domains are the two largest, complex tectonic domains associated with the evolution and closure of the Paleo-Asian and Tethys oceans, respectively (Liu et al., 2015; Xiao et al., 2019). In this regard, the Central Asian Orogenic Belt and Tethyan Tectonic domains are ideal natural laboratories for scrutinizing the processes associated with paleo-ocean evolution and the related plate tectonic geodynamics.

Phanerozoic tectono-magmatic and metallogenic events are recorded in the Paleo-Asian and Tethyan domains. In-depth studies of geology, structure geology, petrology, geochronology, geochemistry, magmatism, mineralization, accretion and continent collision tectonics, as well as geodynamics will facilitate a better understanding of the tectonic evolution and geodynamic processes of the Paleo-Asian and Tethyan domains. This Research Topic aims to gather state-of-the-art studies on tectonic-magmatism evolution of the Paleo-Asian and Tethyan domains, subduction, petrogenic and magmatic processes

of the Paleo-Asian and Tethyan Ocean subduction zone, accretion, collision, continental growth, metallogenesis and Geodynamics of the Paleo-Asian and Tethyan domains.

This Research Topic is dedicated to assembling cutting-edge studies focused on the tectonic and magmatic evolution of the Paleo-Asian and Tethyan domains. It seeks to delve into the complexities of subduction, petrogenic and magmatic processes within the Paleo-Asian and Tethyan Ocean subduction zones, and to unravel the narratives of accretion, collision, continental growth, metallogenesis, and the overarching geodynamics that define these ancient tectonic landscapes. Through this scholarly endeavor, we aim to enhance our understanding of the grand tectonic narratives that have played a pivotal role in shaping the Earth's geological history.

Hou et al. presents an analysis of the 3-D S-wave velocity structure within the crust and upper mantle of Inner Mongolia's Abaga volcanic region, achieved through surface-wave tomography, leveraging data from seismic stations operational from 2012 to 2018. The study unveils pronounced high-velocity anomalies at depths between 80 and 140 km, overlaying significant low-velocity anomalies, suggestive of lithospheric delamination phenomena. These anomalies imply a deep-seated connection between the Abaga volcanic group and the South Gobi area of the Mongolian Plateau, possibly indicating asthenospheric upwelling. The research also hints at lithospheric delamination in the Songliao basin, evidenced by a distinct low-velocity anomaly east of the Honggeertu volcano, pointing to the ascent of local mantle materials.

Cai et al. presents geochronological and geochemical investigations of granodiorites, monzogranites, and two-mica granites from the Yamansu area in Eastern Tianshan, NW China, aimed to elucidate the Triassic tectonic setting of the region. Zircon U-Pb dating yielded crystallization ages between 250 and 241 Ma. The granodiorites, dated at approximately 250 Ma, exhibited medium-K calc-alkaline I-type features, with geochemical signatures indicating derivation from partial crustal melting under pressures below 12 kbar. Monzogranites, around 247 Ma, displayed adakitic traits, suggesting origins from thickened mafic lower crust melting at 12–15 kbar. The two-mica granites, dating to approximately 244 and 241 Ma, were high-K calc-alkaline, highly fractionated I-type granites formed from medium-to-high-K crustal rocks at pressures below 5 kbar. Zircon εHf(t) values suggested juvenile crustal sources. The study suggests that Triassic granitic magmatism in Eastern Tianshan was significant, likely influenced by the far-field effects of the Paleo-Tethys system within an intracontinental setting, characterized by concurrent compression and extension at varying lithospheric depths.

Tang et al. explores the Early Paleozoic tectonic evolution of the South China Block (SCB), focusing on granodiorites from the Yuechengling pluton and volcanic breccias from the Damingshan pluton within the Jiangnan Orogen. Using LA-ICP-MS zircon U-Pb dating, ages were determined to be 438–436 Ma for Yuechengling granitoids and post-451 Ma for Damingshan volcaniclastic rocks. Geochemical analyses revealed that Yuechengling granitoids were derived from Paleoproterozoic basement materials, showing signs of fractional crystallization. Damingshan rocks, indicating a mix of Neoarchean-Neoproterozoic crustal materials and mantle contributions, were deposited after a Late Ordovician eruption. These findings advocate for an intracontinental orogenic model over oceanic subduction for the SCB's Early Paleozoic evolution.

Weng et al. examines granite porphyries in the Keziergayin region of the Kelan Basin within the Chinese Altai, using zircon U-Pb-O isotopes, whole-rock elements, and Nd-Hf-Pb isotopes. The porphyries, dated at 394 ± 3 Ma, exhibit subalkaline, metaluminous to peraluminous characteristics, akin to I-type granite. Geochemical data reveal negative εNd(t), positive εHf(t) values, and Nd-Hf decoupling, suggesting origins from lower crust igneous rocks influenced by metasomatized lithospheric mantle due to subducted melt. High SiO2, Rb/Sr, and low CaO, K/Rb ratios, alongside specific elemental anomalies, indicate highly evolved magmas and island arc formation processes. This supports the presence of an Early Devonian arc-basin system in the Chinese Altai, part of the Siberian continental margin, shaped by subducting slab rollback.

Chen et al. utilizes WorldView-3 (WV-3) high-spatial resolution multispectral images to study the Huitongshan skarn-type deposits, focusing on hydrothermally altered minerals between K-feldspar granite and marble in Beishan. Techniques like radiometric calibration, atmospheric correction, and image fusion pre-processed the spectral data. Directed principal component analysis (PCA) and a novel mineral index were crafted to harness WV-3's spectral bands effectively. The study successfully distinguished between hydroxy-bearing alterations, particularly Fe-OH and Mg-OH alterations, aiding in identifying potential skarn-type copper deposit targets. The findings validate the use of WV-3 imagery for mineral exploration, demonstrating its capability in extracting alteration information and guiding prospecting efforts, thereby underscoring the significance of multispectral remote sensing in geological studies.

Wang et al. presents the study on the Upper Carboniferous Liushugou Formation in eastern Bogda reveals key insights into the Late Carboniferous volcanic magmatic evolution in the Bogda Orogenic Belt, crucial for understanding the Eastern Tianshan's history in the Central Asian Belt. Analyzing volcanics and sediments, it presents new paleontological, zircon U-Pb ages, and geochemical data, indicating a range from basic to acidic volcanic compositions. Rhyolites date to 311.2 ± 1.7 Ma, supported by fossils, suggesting Late Carboniferous formation. Geochemical and isotopic data suggest basalts from metasomatized mantle and andesites/rhyolites from differentiation and mixing, marking a transition to post-collisional orogeny by the Late Carboniferous.

Zhen et al. unveils a significant thrust nappe across the southwestern Santanghu Basin margin, aiding in understanding the Mesozoic-Cenozoic tectonics of Moqinwula Mountain. Utilizing electromagnetic and seismic data, it is shown that the nappe's hanging wall comprises Carboniferous to Middle Jurassic pre-growth and Cretaceous to Quaternary syntectonic strata. The nappe, influenced by Baiyishan thrust's branch faults, forms fault-propagation and fault-bend folds, with a monocline near the mountain base. The area's fold-thrust belt, recording five thrusting episodes from the Late Triassic to Quaternary, has shortened by over 55 km, illustrating the Yanshanian to Himalayan tectonic transition in Eastern Tianshan.

Xue et al. investigates foamy oil flow's impact on enhanced oil recovery in Venezuelan super-heavy oil reservoirs M and H during depressurized cold production (DCP). Despite similar properties, their foamy oil flow stages yield different production outcomes. Through novel microscopic experiments, the research delineates three DCP stages, observing single-phase flow at Stage I and two-phase at Stage III in both reservoirs. However, Stage II presents strong foamy oil flow in M but weak in H, significantly affecting production rates and cumulative outputs. M's superiors performance is attributed to its higher dissolved gas-oil ratio (GOR) and asphaltene content, alongside more conducive pressure and temperature conditions for foamy oil flow, highlighting the critical role of reservoir characteristics in EOR strategies.

## 2 Concluding remarks

The collective research presented in this Research Topic delves into the intricate geological histories of the Paleo-Asian and Tethyan domains, offering profound insights into the ancient oceans that once pervaded these regions. Through a series of detailed studies, the research explores various aspects of geological evolution, from the magmatic activities and tectonic shifts in the Central Asian Orogenic Belt and Tethyan Tectonic domains to the specific characteristics of individual formations across different geographical locales.

Hou et al.'s investigation into the Abaga volcanic region's sub-surface structures highlights the dynamic interplay between lithospheric delamination and asthenospheric upwelling, shedding light on the complex geodynamic processes at play. Cai et al.'s study on the granitoids of Eastern Tianshan reveals the significant role of Triassic granitic magmatism and its connection to the broader Paleo-Tethys system, emphasizing the intricate relationship between magmatic processes and tectonic settings. Tang et al.'s work on the South China Block elucidates the Early Paleozoic tectonic evolution, advocating for an intracontinental orogenic model that challenges previous notions of oceanic subduction-collision. Weng et al.'s examination of granite porphyries in the Chinese Altai presents evidence of an Early Devonian arc-basin system, contributing to the understanding of subduction and magmatic evolution in this region. Chen et al.'s utilization of WorldView-3 multispectral imagery in the Huitongshan skarn-type deposits demonstrates the power of remote sensing in geological exploration, particularly in identifying mineral alterations indicative of significant copper deposits. Wang et al.'s analysis of the Liushugou Formation in the Bogda Orogenic Belt uncovers the magmatic evolution during the Late Carboniferous, providing clues to the post-collisional orogenic processes. Zhen et al.'s discovery of a large-scale thrust nappe in the Santanghu Basin offers valuable data on the Mesozoic-Cenozoic tectonic activities in the Moqinwula Mountain area, highlighting the dramatic tectonic transitions from the Yanshanian to the Himalayan phases. Lastly, Xue et al.'s study on foamy oil flow in Venezuelan super-heavy oil reservoirs underlines the significance of reservoir characteristics in enhanced oil recovery, demonstrating the varied outcomes due to differing geological features.

In conclusion, these studies collectively enhance our understanding of the geodynamic processes, tectonic evolution, and magmatic activities that have shaped the Earth's crust in these regions. They underscore the importance of integrating various geological disciplines to unravel the complex history of Paleo-Asian and Tethyan domains, offering valuable perspectives for future research in geology and related fields.

## Author contributions

XL: Writing–original draft. WX: Writing–review and editing. SA: Writing–review and editing. QM: Writing–review and editing. BW: Writing–review and editing.

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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

# References

Liu, X. J., Xu, J. F., Castillo, P. R., Xiao, W. J., Shi, Y., Zhang, Z., et al. (2021). Long-lived low Th/U Pacific-type isotopic mantle domain: constraints from Nd and Pb isotopes of the Paleo-Asian Ocean mantle. *Earth Planet. Sci. Lett.* 567, 117006. doi:10.1016/j.epsl.2021.117006

Liu, X. J., Xu, J. F., Xiao, W. J., Castillo, P. R., Shi, Y., Wang, S. Q., et al. (2015). The boundary between the Central Asian Orogenic belt and Tethyan tectonic domain deduced from Pb isotopic data. *J. Asian Earth Sci.* 113, Part 1, 7–15. doi:10.1016/j.jseaes.2015.04.039

Liu, X. J., Xu, J. F., Xiao, W. J., and Liu, P. D. (2023). Origin of the DUPAL anomaly in the Tethyan mantle domain and its geodynamic significance. *Sci. China Earth Sci.* 66, 2712–2727. doi:10.1007/s11430-023-1193-6

Metcalfe, I. (2013). Gondwana dispersion and Asian accretion: tectonic and palaeogeographic evolution of eastern Tethys. *J. Asian Earth Sci.* 66, 1–33. doi:10.1016/j.jseaes.2012.12.020

Wan, B., Li, S., Xiao, W., and Windley, B. F. (2018). Where and when did the Paleo-Asian ocean form? *Precambrian Res.* 317, 241–252. doi:10.1016/j.precamres.2018.09.003

Wu, F. Y., Wan, B., Zhao, L., Xiao, W. J., and Zhu, R. X. (2020). Tethyan geodynamics. *Acta Petrol Sin.* 36, 1627–1674. (in Chinese with English abstract). doi:10.18654/1000-0569/2020.06.01

Xiao, W. J., Zheng, Y. F., Hou, Z. Q., Windley, B. F., Zhao, G. C., Sun, M., et al. (2019). Tectonic framework and Phanerozoic geologic evolution of China. *Soc. Econ. Geol.* 22, 21–102. doi:10.5382/SP.22.03