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Editorial: Evolution of subcontinental and oceanic lithospheric mantle

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Editorial on the Research Topic
Evolution of subcontinental and oceanic lithospheric mantle

1 Scope

Lithospheric mantle serves as crucial connections between the underlying asthenosphere and the overlying crust. Understanding the evolution history of lithospheric mantle beneath continents and ocean floors sheds insights into the plate tectonics of our dynamic planet Earth (e.g., Griffin et al., 2008). The compositions and attributes of mantle rocks, encompassing peridotites, pyroxenites, and eclogites, along with their constituent minerals, are extensively employed to delineate the evolutionary trajectories of the lithospheric mantle. Notably, it is intriguing to note instances where ancient subcontinental mantle has been identified within active oceanic mantle, highlighting the potential recycling of crustal materials into the upper mantle through processes such as subduction and delamination (e.g., Müntener et al., 2005; Liu et al., 2022).

Petrology and geochemistry are widely used to investigate the evolution of subcontinental and oceanic lithospheric mantle. Peridotites, prevalent lithologies in both oceanic and continental mantle, offer evidence of phenomena such as melt depletion, refertilization, and metasomatic events (Arai, 1994; Hellebrand et al., 2001; Bizimis et al., 2007; Warren, 2016). Pyroxenites provide invaluable insights into lithospheric geodynamics and the geochemical evolution of the convecting mantle (Bizimis et al., 2005; Borghini et al., 2020). Samples from ophiolites, which are regarded as ancient oceanic lithospheric relicts, and those from active settings (e.g., IODP drilling), serve as probes of recycled crustal and mantle materials during the formation and evolution of oceanic lithosphere, as well as during orogenic and rifting processes (Bodinier and Godard, 2014; Dick et al., 2002; Nicolas et al., 1981). Kimberlite and carbonatite, considered low-volume, volatile-rich, mantle-derived magmas, are also ideal specimens for studying the lithospheric mantle (Giuliani et al., 2020; Tappe et al., 2020).

Additionally, geophysics is another important method to explore the structure of lithosphere. Geophysical methods serve as crucial means to delve into the internal structure of the Earth. Among these, seismic waves stand out as vital tools for deciphering the Earth's internal configuration (Rawlinson et al., 2010). As seismic waves propagate through the Earth, their velocity and paths are influenced by physical properties of materials such as density and elasticity (Shearer, 2019). By observing and analyzing the propagation velocity and paths of seismic waves, we can infer the structure of the Earth's lithosphere, revealing the thickness, density distribution, and variations in properties of both continental and oceanic lithospheres (Dziewonski and Woodhouse, 1987). These variations manifest in changes in seismic wave velocities, thus unveiling interfaces and boundaries between different geological layers. Through the study of these interfaces and boundaries, we can gain deeper insights into the Earth's structural evolution, including processes such as plate tectonics, crustal formation, and deformation. The application of geophysical methods provides us with a window into exploring the Earth's deep interior, offering crucial support and foundations for the advancement of Earth science and understanding of internal processes.

This Research Topic comprises a compilation of six papers aimed at delineating the scale and distribution of heterogeneities within the lithospheric mantle. The primary focus lies in comprehending its formation, evolution, and its interrelation with processes involving crustal formation and the recycling of crustal materials, employing a combination of geochemical and geophysical methodologies. Among these, three papers use geochemical methods to analyze carbonatite and kimberlite, pyroxenite, and ophiolitic peridotites, shedding light on their composition and evolution. The remaining three papers use seismic wave analysis to investigate the internal structure and dynamics of the lithospheric mantle, providing valuable insights into its seismic properties and internal processes.

2 Contributions

Gornova et al. (2023-this Research Topic) studied mantle peridotites from the Mesoproterozoic forearc-type ophiolites in the Eastern Sayan range (Eastern Siberia). The major and trace elements studies suggest that most peridotites suffered high degrees of partial melting in the garnet facies with Paleo- to Mesoproterozoic Re-Os model ages. Therefore, the authors suggest that the Khara-Nur mantle rocks most likely represent a block of SCLM which underwent melt interaction in a supra-subduction tectonic setting that yielded boninitic and tholeiitic melts comprising now the crustal part of Eastern Sayan ophiolites. Similarly, Pattnaik et al. (2023-this Research Topic) used pyroxenites from the Pakkanadu Alkaline Ultramafic Complex from the southern India to understand their origin and the characteristics of lithospheric mantle underneath Southern India.

Sun et al. (2023-this Research Topic) reported the ages of carbonatite and kimberlite from Northeastern Oman by U-Pb apatite method. The age results (140 Ma) suggest that the carbonatite, kimberlite and spessartite of Oman was contemporaneous with the time of Gondwana breakup during the opening of the Indian Ocean. Additionally, 140–130 Ma is one of the strongest global kimberlite abundance peaks.

Wang and Gao (2023-this Research Topic) conducts an in-depth analysis of seismic anisotropy around the Longmenshan Faults by using a dataset with 7710 earthquake catalogs. The authors used S wave splitting and receiver function methods to examine Pms and XKS waveforms collected from 12 fixed broadband stations across Gansu and Sichuan provinces. Their analysis posits the existence of layered anisotropy around the Longmenshan Fault Zone and new very important constrains to understand the structure and evolution of lithosphere.

Xia et al. (2023-this Research Topic) and Wu et al. (2023-this Research Topic) studied seismic anisotropy in the Tibetan plateau, which effectively reflect the rheological characteristics of the crust and upper mantle of the plateau. In the northeastern Tibet, the upper mantle anisotropy obtained from XKS splitting based on permanent broadband seismic stations shows that fast directions are oriented towards WNW or NW, parallel with surface tectonics, implying crust-mantle coupling deformation. Local variations in anisotropy indicate that the escape of lithospheric material is obstructed by surrounding rigid blocks. In the southeastern Tibet, using the data recorded by a dense seismic array across the Ailaoshan belt, the detailed lateral variations of crustal anisotropy are investigated on the basis of Pms phase of receiver functions. The crustal anisotropy is strong along the Ailaoshan-Red River shear zone, with fast directions parallel to the fault strike. This, combined with high Vp/Vs ratios, indicates that shear zone slip motion has led to partial melting and strong anisotropy. However, the inconsistency between crust and mantle anisotropy suggests crust-mantle decoupling deformation, supporting a predominant crustal-scale block extrusion mode.

Author contributions

JS: Writing–original draft, Writing–review and editing. CZ: Writing–original draft, Writing–review and editing.

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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