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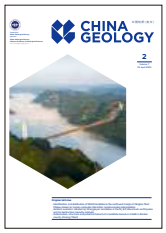

Short Communications (Research Advances)

Zircon U-Pb ages in the Nuratau ophiolitic mélange in the southern Tianshan, Uzbekistan: Implication for the closure of Paleo-Asian Ocean

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1. Objective

The Central Asian Orogenic Belt (CAOB), which is located between the European craton, Siberian craton, and Tarim-North China craton (Fig. 1a), is the largest phanerozoic accretionary orogen in the world. It resulted from the long-term subduction and accretion of the Paleo-Asian Ocean (PAO). The PAO has been in existence since at least the late Mesoproterozoic (about 1020 Ma). However, there has been debate about the closing time of the PAO. While some scholars believe that the PAO finally closed during the Devonian to Early Carboniferous, others argue that the PAO closed during the Late Permian to Early Triassic. The presence of ophiolitic mélange in the orogenic belt is a significant indicator of the ancient ocean basin. The Central Asian Tianshan, being a substantial component of the CAOB, not only possesses vast mineral resources, but also encompasses several ophiolitic mélange belts (Figs. 1b, c). The Nuratau ophiolitic mélange in the southern Tianshan of Uzbekistan is intermittently distributed along the northern border (NW-trending) of the Nuratau Mountain. This constitutes the suture zone of the Turkestan Ocean (a branch of the PAO), which lies between the Kazakh-Kyrgyz continent and Alai microcontinent (Nurtaev B et al., 2013). The Nuratau ophiolitic mélange comprises the rock blocks (ophiolites and marine sedimentary rocks) and the matrix, forming a grid structure. The ophiolite blocks are mainly serpentinite, gabbro, cumulate gabbro, pillowed basalt, metamorphic mafic rock, and altered diabase, etc (Fig. 2). The marine sedimentary rocks are chiefly chert, limestone, meta-flysch (quartz schist), etc (Fig. 2). The matrix is majorly schist that has undergone strong deformation and deterioration. Additionally, mylonitization has been observed in the western outcrop (Fig. 2). To further understand the tectonic evolution of the Turkestan Ocean and restrict the final closing time of the PAO, we present zircon U-Pb age data for different lithologic types of rock block samples from the Nuratau ophiolitic mélange .

2. Methods

The samples included two gabbros, one metamorphic mafic rock, two pillow basalts, and one quartz schist. These samples were collected from the ophiolitic mélange located on the northern slope of Nuratau Mountain (Fig. 1c). *In-situ* zircon U-Pb analyses were analyzed at Key Laboratory for the Study of Focused Magmatism and Giant Ore Deposits, Xi'an Center of China Geological Survey, MNR. The analyses were performed using an Agilent 7700x ICP-MS instrument equipped with a GeoLas Pro 193 nm ArF excimer laser ablation system. Laser spot size is 24 μm. Zircon 91500 was used as the standard for correcting the measured isotopic ratios. The details of the instrumental conditions and data acquisition procedures were similar to those described by Li YG et al. (2015). The offline data were computed by GLITTER software 4.4, and age data were plotted by Isoplot/Ex_ver 3.

3. Results

The dating results of zircon U-Pb isotope analysis for rock block samples (two gabbros, one metamorphic mafic rock, two pillow basalts, one quartz schist) are shown in Supplementary Table 1.

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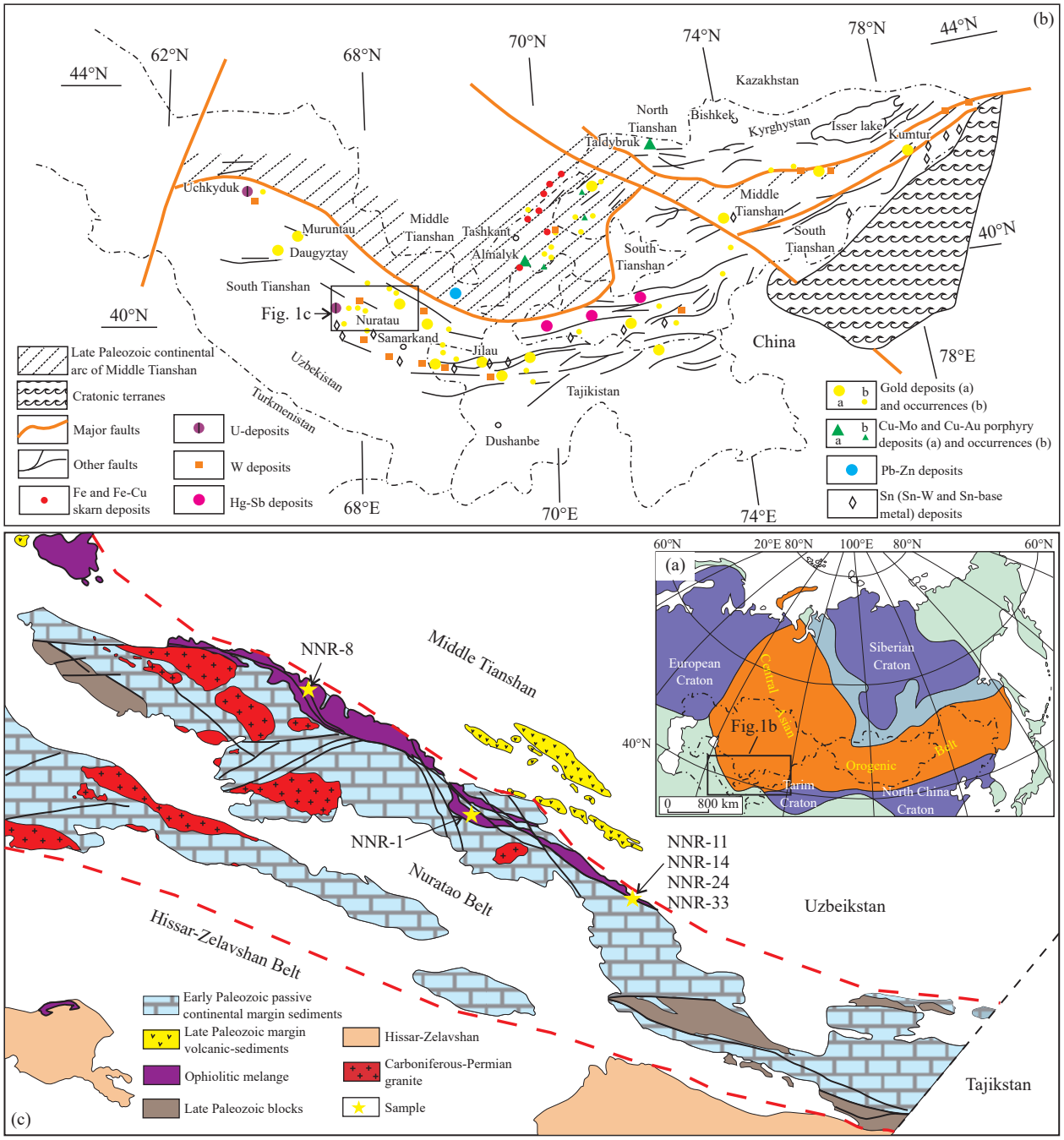

Fig. 1. a–Simplified tectonic divisions of the Central Asian Orogenic Belt; b–regional tectonic setting and the major deposits of the Central Asian TianShan; c–simplified geological map of the Nuratau region.

The zircon grains of gabbro sample NNR-08 exhibit concentric oscillatory and stripped zoning, suggesting a magmatic origin. Twenty-three analysis spots yield concordant $^{206}Pb/^{238}U$ ages ranging from 385 Ma to 417 Ma, with a weighted mean $^{206}Pb/^{238}U$ age of 399±4 Ma (Fig. 3a). Zircon grains of gabbro sample NNR-11 show well-preserved concentric oscillatory zoning in CL images. Eleven concentrated analyses give $^{206}Pb/^{238}U$ ages ranging from 380 Ma to 418 Ma, with a weighted mean $^{206}Pb/^{238}U$ age of 396±7 Ma (Fig. 3b). Zircon grains of metamorphic mafic rock develop a typical core-mantle structure. Seventeen analysis spots give two groups of $^{206}Pb/^{238}U$ ages: One ranging from 387 Ma to 407 Ma, with a mean age of 395±4 Ma and another ranging from 218 Ma to 236 Ma, with a mean age of 226±10 Ma (Fig. 3c). These age data indicate that Nuratau ophiolite was formed during the Early Devonian (395–399 Ma) and subsequently experienced the Late Triassic (226 Ma) regional tectonic thermal event.

Ten zircon grains of pillow basalt sample NNR-1 give $^{206}Pb/^{238}U$ ages ranging from 290 Ma to 462 Ma. Among these, the four youngest ages are relatively concentrated, with a weighted mean $^{206}Pb/^{238}U$ age of 295±5 Ma (Fig. 3d). Twenty zircon grains of pillow basalt sample NNR-33 yield widely $^{206}Pb/^{238}U$ ages ranging from 296 Ma to 1611 Ma. Among these, the nine youngest ages are relatively concentrated, with a weighted mean $^{206}Pb/^{238}U$ age of 301±5

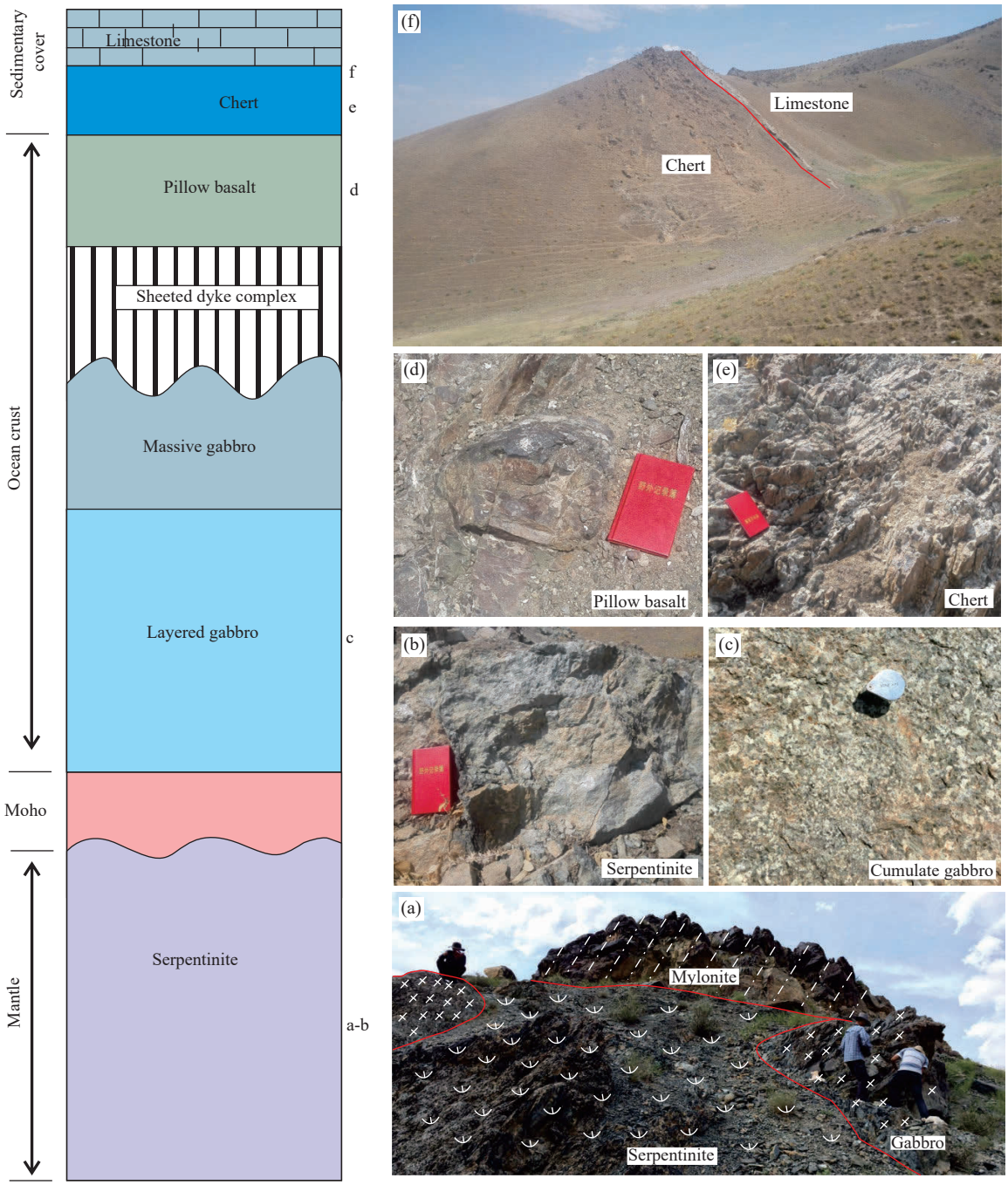

Fig. 2. Photographs showing the representative rock types and typical structures of the Nuratau ophiolitic mélange.

Ma (Fig. 3e). The young zircon ages are interpreted as the crystallization age of the pillow basalt, while the presence of numerous old zircons is interpreted as captured zircons.

One quartz schist sample NNR-24 yields 58 usable detrital zircon ages showing a widely variation from 411 Ma to 2503 Ma, with peaks at 450–460 Ma (Fig. 3f). The youngest age represents the era when the oceanic sedimentary strata formed after, and the peak ages implies that the sedimentary material predominantly originates from the Late Ordovician.

4. Conclusion

Three groups of meaningful zircon U-Pb ages of 411–396 Ma (Early Devonian), 301–295 Ma (Early Permian) and 226 Ma (Late Triassic) were obtained from magmatic and sedimentary rock blocks in the Nuratau ophiolitic mélange. These ages record the evolution of Turkestan ocean in the Nuratau region of Uzbekistan, which lasted from 411 Ma ago until after 295 Ma and serve to restrict the closure timeframe of the PAO to after 295 Ma. Additionally, the 226 Ma age of metamorphic zircon records a Late Triassic regional tectonic thermal event occurring in the ophiolitic mélange after the ocean basin closed.

CRediT authorship contribution statement

Kai Weng, Ji-fei Cao, and Divayev Farid Karibovich conceived the presented idea. Kai Weng and Bo Chen carried

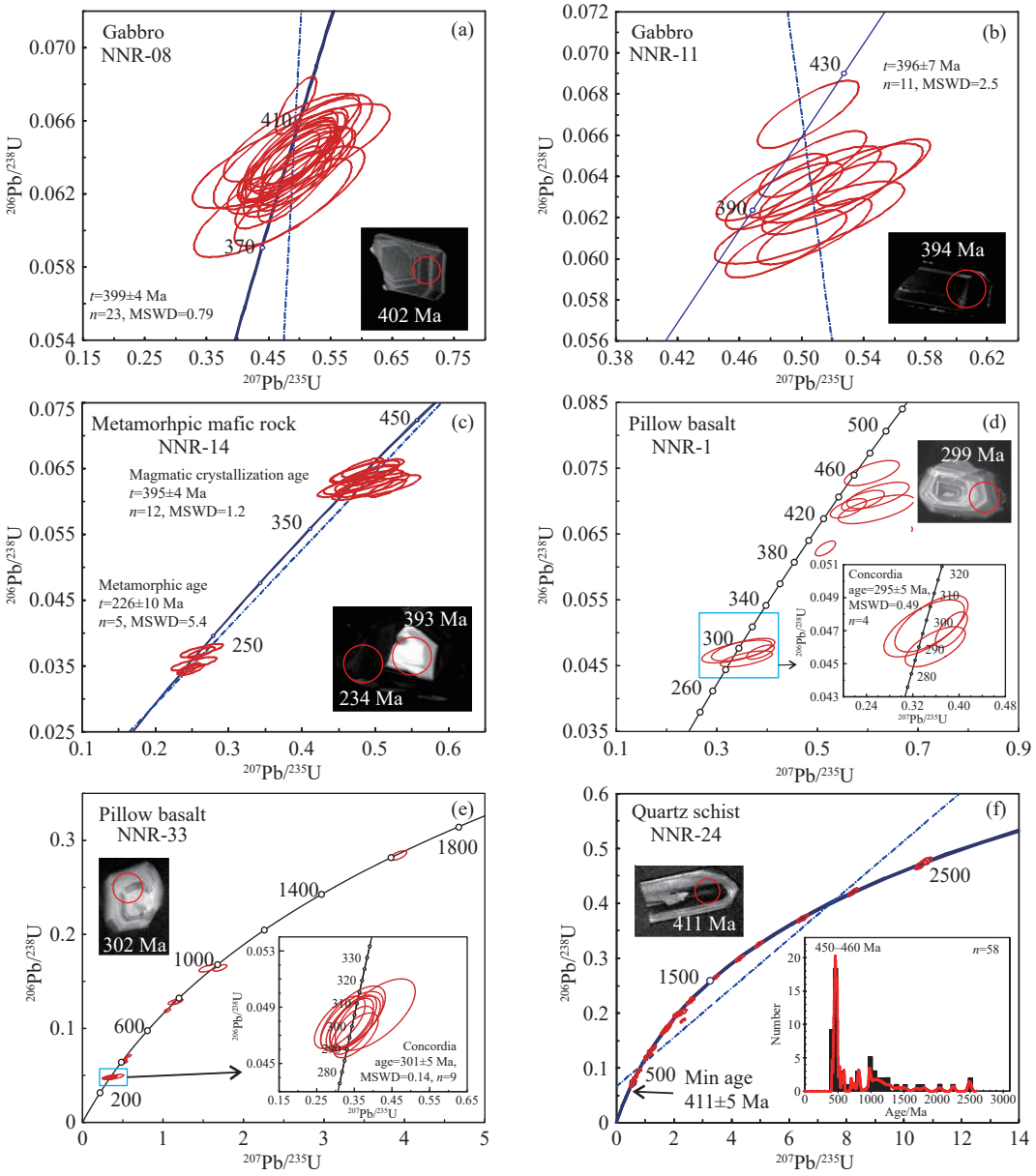

Fig. 3. Zircon U-Pb concordia diagrams of rock block samples from the Nuratau ophiolitic mélange.

out the experimental analysis. Kai Weng wrote the manuscript with supported from Ji-fei Cao, Bo Chen, Zhong-ping Ma. All authors conducted the filed work, collected the samples, discussed the results and contributed to the final manuscript.

Declaration of competing interest

The authors declare no conflicts of interest.

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Data availability

Supplementary data (Supplementary Table 1) to this article can be found online at http://chinageology.cgs.cn/ or available on request from the authors.

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