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Research Advances

Late Ordovician to Early Silurian Tectonic Events in the Himalayan Terrain

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Objective

The Himalaya terrain together with the ribbon terrains (e.g., Lhasa, Qiangtang, and Sibumasu blocks) of the Gondwana supercontinent has experienced episodic tectonic events since the Neoproterozoic. However, almost not any documentation with regard to the tectonic processes links the peri-Gondwana subduction between 510–480 Ma with the Carboniferous–Permian (~360–260 Ma) continental rifting event. This possible link is important for testing and formulating the tectonic model for the evolution of the present-day Himalayan orogenic belt, if we consider this belt has also experienced typical Wilson cycle plate tectonics. Recently, we have found several lines of evidence which imply that the Himalayan terrain and possibly other ribbon terrains of the eastern Gondwana have experienced unrecognized tectonic processes during the Late Ordovician to Early Silurian.

Methods

Zircons were separated from representative samples. The internal growth structure of zircon grains was revealed by cathodoluminescence and back-scattered electronic imaging techniques. Selected zircon grains were analyzed for U, Th, and Pb analysis using LAMC-ICP-MS at the Key Laboratory of Metallogeny and Mineral Assessment, Institute of Mineral Resources, CAGS. Bulk rock major, trace, and rare earth element concentrations were obtained by X-ray fluorescence and inductively coupled plasma mass spectrometry (ICP-MS) at the National Research Center for Geoanalysis, CAGS, Beijing. Zircon Hf isotope analysis was carried out in-situ using a Newwave UP213 laser-ablation microprobe, attached to a Neptune multi-collector ICP-MS at Institute of Mineral Resources, CAGS, Beijing.

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Results

In the Xiaru Dome, two leucogranites record ages of 455.1±1.7 Ma and 446.9±1.1 Ma. In the Nielamu area within the High Himalaya, we recently found granitic gneisses with a protolith age of ~443 Ma. Furthermore, the detrital zircon grains from the Tethyan sedimentary rocks as well as inherited zircon grains in the Himalayan Cenozoic granitic rocks frequently show concordant U/Pb ages spanning from 460 to 410 Ma. These findings suggest that the Himalayan Terrain has experienced a major episode of tectonic and thermal processes during the Late Ordovician to Early Silurian. This phase of tectonic events is younger by 30–60 m. y. than those previously reported Andean-type orogeny along the northern margin of the Gondwana continent. These leucogranites are characterized by (1) relatively high SiO_2 (71.2wt%–76.3wt%), Al_2O_3 (13.1wt%–13.9wt%), K_2O (4.3wt%–7.4wt%) with K_2O/Na_2O > 1.0 and A/CNK > 1.0; (2) enrichment in LREE and LILE, but depletion in HFSE; (3) relatively higher $\varepsilon_{Hf}(t)$ ranging from −7.3 up to 0.0 than those in the >470 Ma and <430 magmatic rocks. All these geochemical characteristics indicate that they are peraluminous S-type granite with relatively high K/Na ratios and derived from partial melting dominantly of crustal sources with subordinate contribution of mantle material.

Conclusions

Most of the granitic rocks during the Late Ordovician to Early Silurian show geochemistry consistent with those syn-collisonal granites, in great contrast with those 500–470 Ma arc-like granites. If those >470 Ma granitic rocks were the product of magmatism during the subduction of fringed Proto-Tethyan oceanic basin beneath the northern Gondwana margin, it is possible that the ~465–445 Ma

leucogranites formed during terrain collision between the ribbon terrains of the Gondwana supercontinent. According to the tectonic reconstruction, magmatism and metamorphism in Himalaya, Lhasa and South Qiangtang terrains, the missing story between >470 Ma and ~375 Ma might be the terrain collision between South Qiangtang and Himalaya (Fig. 1), and results in the formation of 465–445 Ma leucogranites and metamorphism at 465–438 Ma and ~410 Ma in the Himalaya Terrain, as well as granulite facies metamorphism at 427–422 Ma in the Qiangtang terrain.

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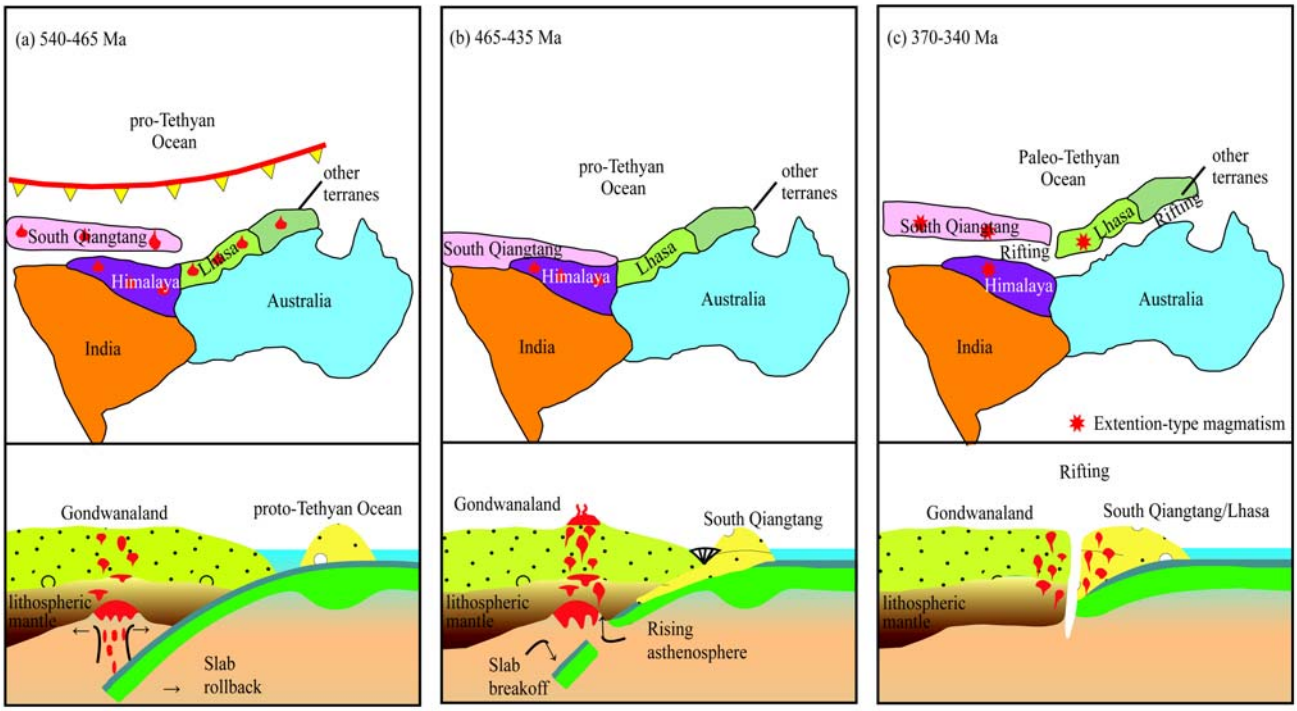

Fig. 1. Diagrams showing the sequence of tectonic processes that possibly occurred along the northern margin of the east Gondwana.
(a), Reconstruction of the northern margin of the eastern Gondwana land showing the location of the proposed early Paleozoic Andean-type magmatic arc that had affected the South Qiangtang, Himalaya, Lhasa, and other possible microcontinental blocks (e.g., Gongshan, Baoshan, Tengchong and Sibumasu) of the northern Gondwana; (b), The terrane collision postdated the peri-Gondwana subduction event between the South Qiangtang and the Himalaya during late Ordovician to early Silurian; (c), Continental rifting represented by the formation of ~360 Ma alkaline granites along the southern margin of the Lhasa terrain, the South Qiangtang terrain and the Himalaya terrain.