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Research Advances

The Early Breakup of Rodinia Supercontinent in the Northeastern Margin of the Yangtze Plate: New Evidence from SIMS Zircon Ages of the Granitic Gneiss from the Chaolian Island, Shandong Peninsula

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Objective

The amalgamation and breakup mechanisms of the Rodinia supercontinent during the Meso- and Neoproterozoic have been the focus of much research. However, few studies have examined the response of Neoproterozoic tectonics and magmatism along the northeastern margin of the Yangtze Plate to synchronous global events. The Qianliyan Uplift is located on the eastern margin of the Sulu orogenic belt in the ocean, but the tectonic affinity of the uplift and its relationship to the Sulu orogenic belt remains unclear. In this study, we investigated the formation age, geochemical characteristics, genesis type, and affinity of the granitic gneiss on Chaolian Island of the Qianliyan uplift and its tectonic significance.

Methods

Rock samples were collected from the Chaolian Island (Fig. 1). Zircon cathode luminescence (CL) imaging was conducted on a JEOL JSM6510 scanning electron microscope under a voltage of 10 kV and current of 70 μA. Laser Raman microscopy was done on a DXR microscope. We used an inductively coupled plasma mass spectrometer to analyze trace elements (Ba, Li, Mo, Nb, Ni, Pb, Ta, U, and V), with Re used as an internal reference to calibrate the instrument's signal drift.

The concentrations of U, Th, and Pb of all samples were measured using a CAMECA IMS-1280 secondary ion mass spectrometer (SIMS) at the Institute of Geology and Geophysics, CAS. The zircon standards and zircon samples were analyzed alternately at a ratio of 1:3. The isotope ratios were calibrated using standard zircon Plésovice (337 Ma). The U concentration was calibrated using standard zircon 91500. We used the standard Qinghu sample (159.5 Ma) as an unknown one to monitor data accuracy, and used the measured ^{204}Pb values for common Pb correction. We used ISOPLOT software to process the data.

Results

The Chaolian Island granitic gneiss is rich in Si and Fe, depleted in Mg and peralkaline, unsaturated in Al, rich in large-ion lithophile elements of K, Rb, Ba, and U, and depleted in high field strength elements of Nb, Ta, and Zr, enriched in LREEs, depleted in HREEs, and shows moderate to strong Eu depletion. The zircon age is approximately ~782.6 Ma to ~802.3 Ma, suggesting that the pluton is a Neoproterozoic magmatic product. The pluton protolith is an A2 subtype of A-type granite, characterized by Nb and Ta depletion, with geochemical footprints of early "arc" magmatic products.

We believe that the Chaolian Island structure-magma evolution is as follows: the Rodinia supercontinent was created after a series of collisions and amalgamation worldwide approximately 1300–900 Ma, the northeastern margin of the Yangtze Plate was situated in a stable active continental margin subducted by oceanic crust; influenced by the mantle superplume, the supercontinent began to break up ~825 Ma, and magmatic activity became increasingly frequent, particularly pre-rift magmatic activity during 840–790 Ma and syn-rift magmatic activity during 780–740 Ma. Therefore, the Middle Neoproterozoic is an important period of crustal evolution of the northeastern margin of the Yangtze Plate. Under the above mechanism, the Yangtze Plate gradually drifted from the supercontinent nucleus, and ocean-continent subduction became more violent. Approximately ~782.6

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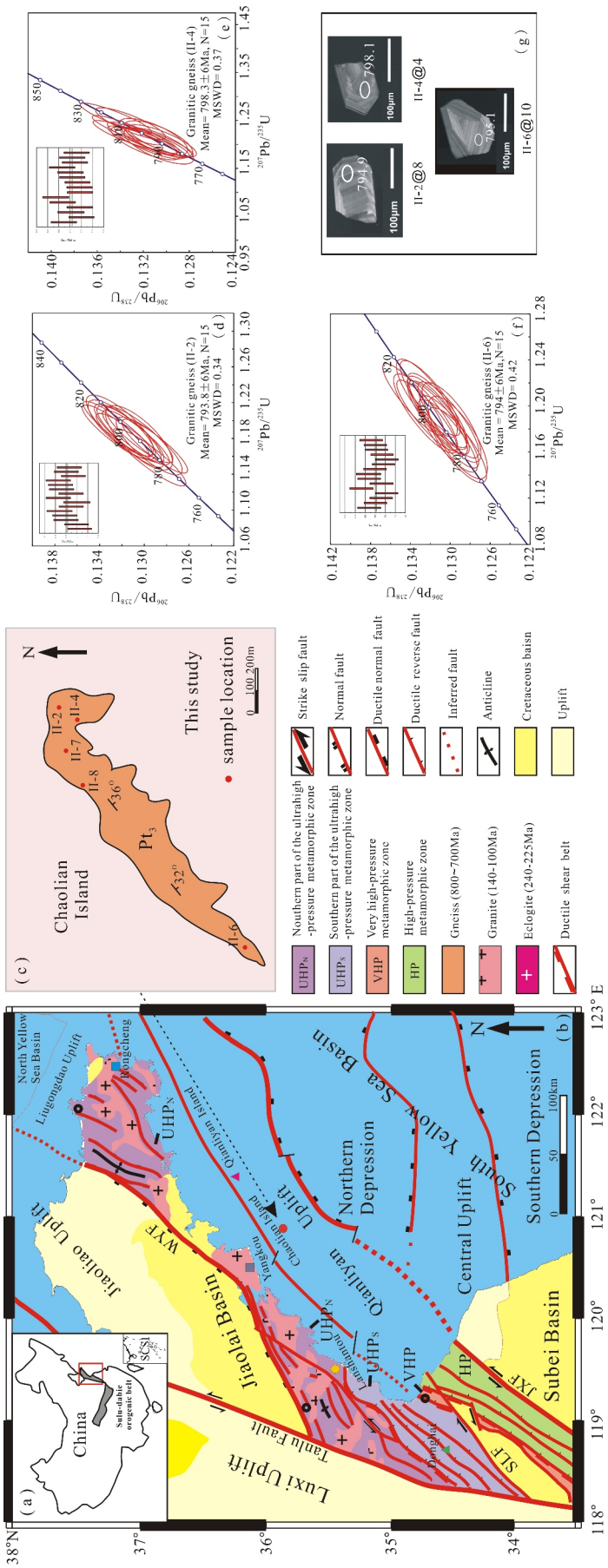

Fig. 1. (a), Sketch map of the Sulu orogen; (b), Geological map of Shandong Peninsula showing major lithotectonic units; (c), Geological map of the Chaolian Island; (d, e, f, g), U-Pb concordia diagrams and CL images of zircons from the granitic gneisses of the Chaolian Island; (d), Sample II-2; (e), Sample II-4; (f), Sample II-6; (g), CL images of representative zircons.

Ma to ~802.3 Ma, the development of A2-type alkaline granite on the Chaolian Island signified the formation of a back-arc tension setting, and subsequently, with increasing tensional extent, rifting tendency was gradually reinforced and magmatic activity became more frequent in response to the supercontinent breakup. This granite underwent subduction metamorphism and exhumation during the late Triassic as the Yangtze Plate subducted towards the North China Plate. Of note, we found no iconic UHP metamorphic minerals or distinct nucleus-mantle structures in the zircon CL images for the Chaolian Island granitic gneiss.

Conclusions

We suggest that the northeastern margin of the Yangtze Plate was an active continental margin during the Middle Neoproterozoic. Furthermore, the granitic gneiss protolith at the Chaolian Island represents the early breakup of the Rodinia supercontinent, and is a product of the combined action of this breakup and back-arc extension. We believe that the Qianliyan Uplift has an affinity with the Yangtze Plate, and is the eastern margin of the Sulu orogenic belt.

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