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Research Advances

New Petrological and Sedimentary Evidences on the Late Cretaceous Uplift of the Tibetan Plateau

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Objective

The India-Asia collision and uplift of the Tibetan plateau are the most important geological events in Earth's history; it profoundly affects our understanding of global climate change during the Cenozoic. Despite a research history over half a century, the uplifting history remains hotly controversial. The early uplifting model suggested that the Lhasa terrane attained an elevation of 3–4 km at ~99 Ma due to the Lhasa-Qiangtang collision. However, the evidences are mainly from deformation of the Lhasa terrane and inconsistency with the palaeontological data. In order to gain a better understanding on the uplift history of the central Tibet during the Late Cretaceous, we carried out researches on the Late Cretaceous magmatism and sedimentation in the Qiangtang terrane, and attempt to reconstruct the relationship between the geological evolution and the uplifting history of central Tibet.

Methods

Our study is mainly focused on the Late Cretaceous magmatic genesis and depositional environment of the Qiangtang terrane. Four suits of volcanic rocks and eleven stratigraphic sections were measured for analysis. We first carried out zircon U-Pb dating, whole rock geochemistry, Sr-Nd isotopes and zircon Hf isotopic analysis with the aim of gaining petrogenesis of the Late Cretaceous magmas. We then conducted detailed study of outcrop stratigraphic sections and sedimentary facies analysis of the surface stratigraphic data. Finally, we discussed the Late Cretaceous magmatic-sedimentary records and its relationship with the Lhasa-Qiangtang collision and early uplift of the Tibetan plateau.

Results

Our new researches show that the Late Cretaceous volcanic rocks are widely distributed in the Qiangtang terrane (Fig. 1). These volcanic rocks are interbedded with coarse lithic conglomerates and pebbly sandstones of the Late Cretaceous alluvial-lacustrine facies sediments. The volcanic rocks are composed of andesites, dacites and rhyolites. Zircon U-Pb dating constrains the time of emplacement as the Late Cretaceous (78.7±1.9–72.9±1.4 Ma) (Fig. 1), which is lags behind the Lhasa-Qiangtang collision. Geochemistry shows that these volcanic rocks belong to high-K calc-alkaline series, which are enriched in large ion lithophile elements (e.g. Rb, Th and U) and light rare earth elements (LREE), and depleted in high field strength elements (Nb, Ta and Ti) and heavy rare earth elements (HREE). Furthermore, the volcanic rocks have negative $\varepsilon_{Nd}(t)$ (−5.6–−1.7), relatively constant $^{87}Sr/^{86}Sr$ ratios (0.70614–0.70885) and negative $\varepsilon_{Hf}(t)$ values (−5.8–−2.1). The isotope signatures suggest that the volcanic rocks were generated in a post-collisional setting and the magmas were most likely derived from the anatexis of mafic lower crust because of intrusion or underplating of mantle-derived basaltic magma. Geological investigations indicate that the Late Cretaceous sediments unconformably overlie the Late Jurassic-Early Cretaceous marine strata. The strata and sedimentary facies analysis indicates that the Late Cretaceous is predominated by continental facies, and is composed mainly of alluvial-diluvial facies and fluvial-lacustrine facies association. The thickness of the deposit varies greatly in space, and the deposit shows a wedge shape. Sediment composition and paleocurrent direction analyses show that the source of the sediments was derived from the central uplift belt of the Qiangtang terrane and few from the Bangong-Nujiang suture. Provenance analysis and sedimentary thickness distribution of the sediments reveal that the Late Cretaceous basin has characteristics of the typical extensional (rift) basin.

Conclusion

Taking the magmatism and sedimentation into consideration, the following conclusions can be reached.

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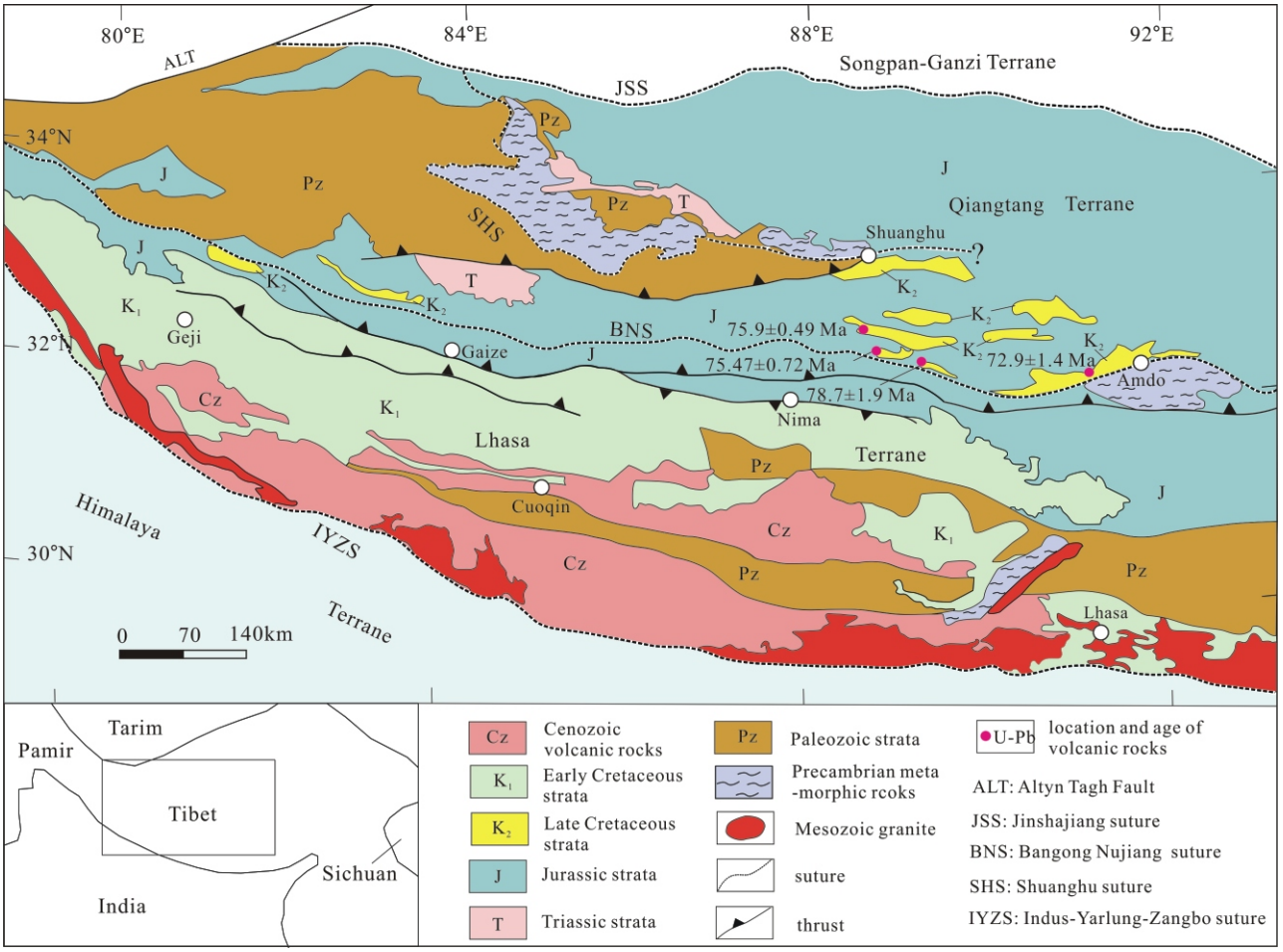

Fig. 1. Distribution characteristics of Late Cretaceous volcanic rocks and sediments in the Qiangtang terrane.

Owing to the Lhasa-Qiangtang collision during the Early Cretaceous, the Qiangtang terrane underwent significant crustal shortening and delamination of the lower crust, which invoked the Late Cretaceous magmatism. Under the control of the above process, the upper crust underwent extension and induced the development of extensional (rift) basin. Our model indicates that the Lhasa-Qiangtang collision and subsequent delamination played an important role in the Early Cretaceous uplift of the Tibetan plateau.

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