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Research Advances

Discovery of Kilometer-Scale Uplift and Exhumation Related to the Late Indosinian Movement in the Northern Ordos Basin, North China

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Objective

The tectonic response of the Ordos Basin to Indosinian movement mainly occurred in the southwestern part of the basin due to the Late Triassic collisional Qinling orogeny to the south. The orogeny resulted in intense uplift and exhumation of the southwestern section of the Ordos Basin, where the upper and middle parts of the Upper Triassic Yanchang Formation were exhumated and the magnitude of exhumation progressively decreased to the northeast (Liu Chiyang et al., 2008). However, little attention has been paid to the influence of Indosinian movement to the northern Ordos Basin. In this study, stratigraphic observations and new apatite fission track (AFT) data are integrated to characterize the effect of Indosinian movement in the northern Ordos Basin.

Methods

Samples from the wells SH-1, SH-2, E-1 and outcrops were collected for AFT analysis in the northern Ordos Basin. Apatite grains were separated using standard heavy liquid and magnetic techniques and then mounted in epoxy resin on glass slides. Mounts were ground and polished to an optical finish to expose internal grain surfaces. Apatite fission track analysis was performed at the University of Melbourne (Australia) with an integrated analytical system based on automated track counting and ^{238}U determination by LA-ICP-MS. Polished mounts were etched in 5N HNO_3 for 20 seconds at 20°C to reveal the fission tracks. Automated counting of spontaneous fission tracks was carried out using the coincidence mapping procedure and then manually corrected as necessary. The confined track lengths were determined in 3D using captured digital images. Etch pit diameters (Dpar) of all analyzed grains were measured and used as kinetic parameters during thermal modeling. Radial plots were constructed using the RadialPlotter software. Time-temperature modeling from AFT data was carried out using the HeFTy software, Version 1.8.0.

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Results

A northwest-trending angular unconformity is identified between the Middle Jurassic Yanan Formation and Late Triassic Yanchang Formation (Fig. 1a). The Triassic strata mainly dip westward and southwestward beneath the Early Jurassic unconformity. The Upper Triassic Yanchang Formation thickens to the southwest, reaching more than 500 m in Fugu County and up to approximately 1100 m in the gas fields to the west. To the northeast across the angular unconformity, we observed the Jurassic unconformably overlies on the lower parts of the Middle Triassic Zhifang Formation (Fig. 1b), indicating that the Yanchang Formation and the upper part of the Zhifang Formation were completely removed during this uplift event. The Upper Triassic unit is mainly composed of fine-grained deltic and lacustrine sediments in the northern Ordos Basin, where no coarse marginal facies are observed. Therefore, it can be concluded that the thinning of the Upper Triassic is the result of uplift and erosion. The northeastern margin of the Late Triassic Ordos Basin northeastward extended far relative to the present-day margin of the Yanchang Formation. The lack of Triassic strata likely indicates that at least 1000 m of the strata were exhumated before the deposition of Jurassic sediments.

All the AFT samples passed the Chi-square test ($P(\chi^2)$ >5%), as indicative of a homogeneous population, and the pooled ages are used. Most samples' AFT ages are younger than the age of their host rock, indicating post-depositional AFT annealing. Gaussian peak-fitting reveal three groups of AFT ages: 224–170.1 Ma, 163.3–140.1 Ma, and 113.1–22.1 Ma. Regarding the northwest-trending angular unconformity as a boundary in the study area, the samples in the southwest were totally annealed at the latest Early Cretaceous (ca. 110 Ma) and only record the last cooling event beginning at the Late Cretaceous (Fig. 1c). In contrast, the samples in the northeast were not totally reset during the Early Cretaceous and contain a large group of AFT ages that range from the latest Triassic to Early Jurassic (Fig. 1d), including the crystalline basement samples. Thermal history modeling shows that

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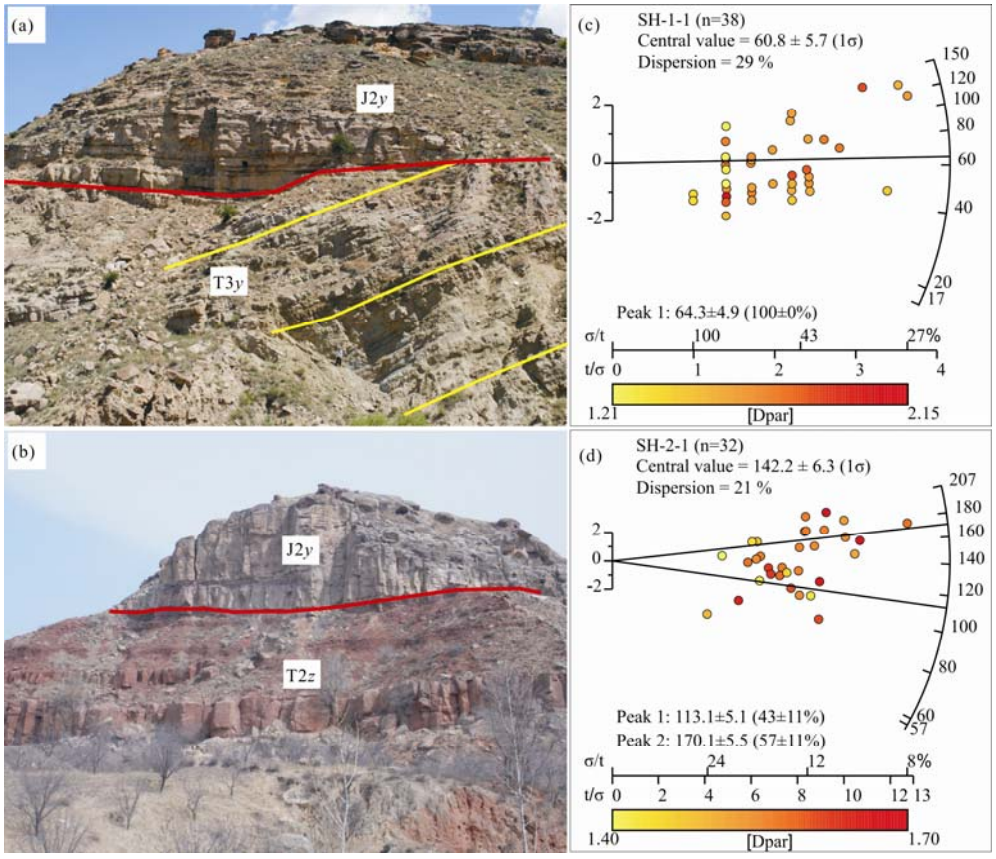

Fig. 1. (a), Angular unconformity between the Middle Jurassic Yanan Formation (J_2y) and Upper Triassic Yanchang Formation (T_3y); (b), Parallel unconformity between the Middle Jurassic Yanan Formation (J_2y) and Middle Triassic Zhifang Formation (T_2z); Radial plots of fission track ages for the basement samples (Archean gneissic granite) in wells SH-1(c) and SH-2 (d).

the samples in the northeast reached their maximum paleotemperature at the Late Triassic and experienced a temperature decrease of 40–70°C during the latest Triassic to the Early Jurassic due to exhumation, as indicative of kilometer-scale uplift and exhumation.

Conclusions

This study discovered kilometer-scale uplift and exhumation related to the late Indosinian movement in the northern Ordos Basin based on field observation and AFT analysis. This intense uplift and exhumation likely induced the low maturity of the Upper Paleozoic source rocks in this region, where the R_o% of source rocks ranges from 0.5% to 0.7%. Far-field compression induced by the orogenesis of the Qinling and Songpan–Ganzi terrane to the southwest may be the driving mechanism of the uplift and exhumation during the late Indosinian period. In light of the high rigidity and stability of the Ordos Basin, intense tectonic effects tended to develop around the margins of the basin.

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Reference

Liu Chiyang, Zhao Hongge, Zhao Junfeng, Wang Jianqiang, Zhang Dongdong and Yang Minghui, 2008. Temporo-spatial coordinates of evolution of the Ordos Basin and its mineralization responses. *Acta Geologica Sinica* (English Edition), 82(6): 1229–1243.