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Research Advances

The Middle–Late Triassic Closure of the East Paleotethys Ocean: Paleomagnetic Evidence from the Baoshan Terrane, China

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Objective

It is still controversial about when, where and how the East Paleotethys Ocean closed due to the lack of reliable paleomagnetic data from the blocks or terranes located in both sides of the suture, which prohibits our better understanding of a series of key scientific issues such as how major blocks of East Asia collided together, and the relationship between the major blocks of East Asia and the Pangea supercontinent before its breakup. This study reports paleomagnetic results from the Middle Triassic Hewanjie Formation limestones in the Baoshan Terrane, northernmost extension of the Sibumasu Block (Fig. 1). We aim to accurately reconstruct paleogeographic position of the Baoshan Terrane during this interval and to further discuss the timing and position of the Sibumasu-Indochina Collision.

Methods

Based on field investigation, two sections around the Minglang area of Yongde County were selected for sampling, and nine sites embracing 108 samples were drilled with a portable gasoline-powered drill and oriented using magnetic compass. The samples were cut into standard cylindrical specimens of ~2.0 cm in height. All the specimens were subject to hybrid demagnetization comprising progressive thermal demagnetization with temperature interval of 50℃ up to 250–300℃ followed by alternating field demagnetization with a field interval of 5 mT below 30 mT and 10 mT up to 90 mT. All the remanence measurements were performed on a 2G-755 cryogenic magnetometer. Both demagnetizer and magnetometer are installed in a magnetically shielded space with the field inside minimized to 300 nT in the Paleomagnetism and Geochronology Laboratory of the Institute of Geology and Geophysics, Chinese Academy of Sciences.

Results

In general, the demagnetization behaviour of the specimens shows a character of two components. After the removal of a low temperature component below 300℃ which is related to the overprint of present geomagnetic field (PGF), a stable high field characteristic component can be isolated during alternating field between 10–30 mT and 90 mT. This suggests that this characteristic remanence is mainly carried by magnetite. The high field characteristic components are of unique normal polarity and are concentrated inside section, while the sub-mean directions of the two sections have similar inclinations of ~25° with a declination difference of ~32° which is compatible to strike azimuth difference of the strata, thus we think this is most likely resulted from a local rotation due to the fault activity (Fig. 2). If we rotate the sub-mean direction of the Section 2 to that of the Section 1, we can get a tilt-corrected mean direction of all sites with Ds=95.7°, Is=25.8°, α_{95}=3.0°. Further fold test yields an inconclusive result probably due to approximate strata dips of the two sections. Taking all things into consideration, we suggest that the high field component is probably of primary origin while further study is still needed.

Conclusions

The mean direction of the high field characteristic remanence defines a paleolatitude of ~14°N for the Baoshan Terrane during the formation of the Hewanjie deposits. Taking together our previous paleomagnetic study of the Late Triassic Niuhetang lava flows from the Baoshan Terrane, we propose that the Baoshan Terrame was located at a low latitude around 15°N during the Middle–Late Triassic. In particular, noting that Huang et al. (2016) reported that the Simao Terrane, northern extension of the Indochina was also located at ~16°N during the Late Triassic. We thus believe that the East Paleotethys Ocean, separating the northern Qiangtang-Indochina and southern Qiangtang-Sibumasu blocks during the Late Paleozoic and earliest Mesozoic times, should have closed during the Middle–Late Triassic. Further paleomagnetic, geological, geochemical and

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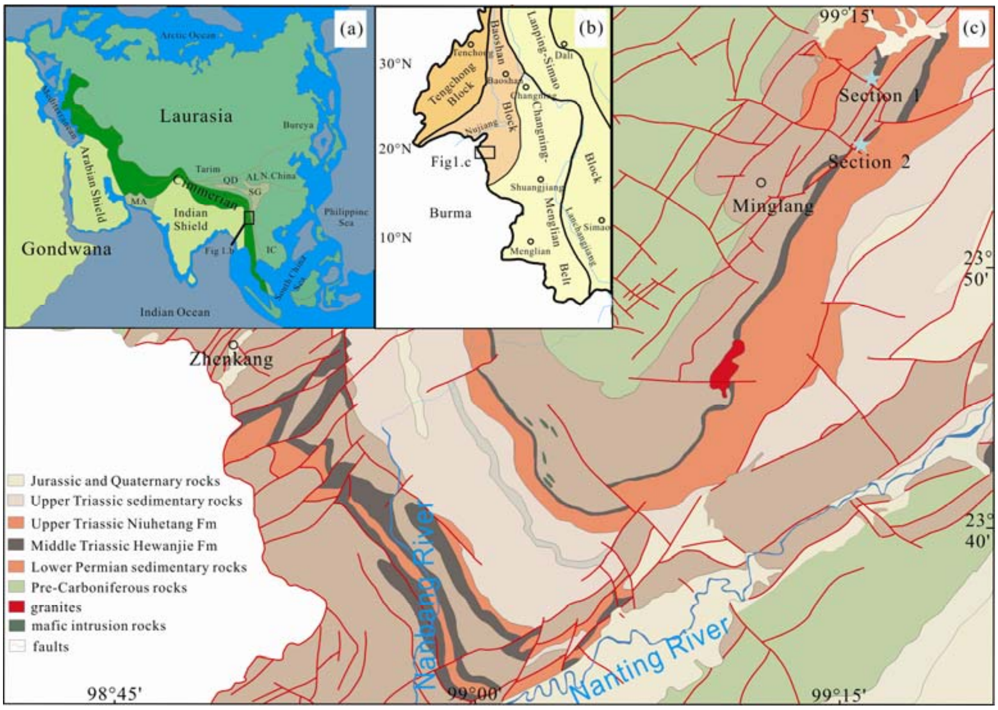

Fig. 1. (a) Schematic tectonic map of Eurasia showing the Cimmerian continent; (b) Schematic structural map around the Baoshan area and (c) simplified geological map of southern Baoshan Terrane in West Yunnan.

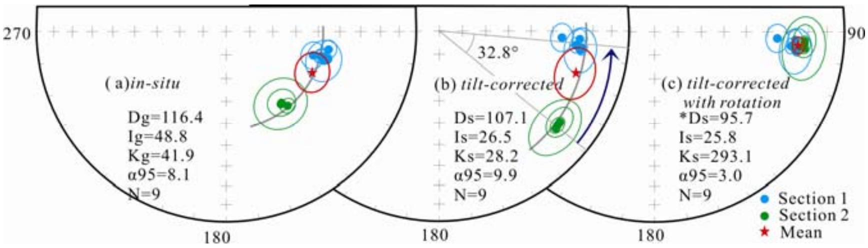

Fig. 2. Equal area projection of the site-mean high field component (a, b and c) directions of the limestones from Middle Triassic Hewanjie Formation in the Baoshan Terrane with corresponding 95% of confidence circle before tilt correction, after the tilt correction and after tilt correction with rotation.

geochronological constraints on the closure of the East Paleotethys Ocean were discussed by Huang et al. (2018) and Wang et al. (2018).

Acknowledgments

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Appendix 1 Summary of high field characteristic remanent magnetizations from Middle Triassic Hewanjie Formation in the Yongde area of the Baoshan Terrane

Site ID	λs(°N)	φs(°E)	Strike/dip	n/n_0	Dg(°)	Ig(°)	Ds(°)	*Ds(°)	Is(°)	κ	α_{95}(°)	φ_p(°E)	λ_p(°N)
Section 1													
YY29	23.96	99.24	330/20	11/13	105.3	50.9	93.1	-	35.5	72.4	5.4	170.0	5.2
YY30	23.96	99.24	340/20	11/12	100	44.5	93.3	-	26.7	153.2	3.7	175.0	2.8
YY31	23.96	99.24	341/22	10/10	104.8	47.6	96.0	-	28.5	278.3	2.9	173.0	0.8
YY32	23.96	99.24	346/24	8/12	104.5	47.1	96.8	-	25.3	421.6	2.7	174.3	-0.7
YY33	23.96	99.24	341/23	8/10	106.7	45.4	97.8	-	25.8	46.6	8.2	173.7	-1.4
YY34	23.96	99.24	339/21	15/16	105.2	44.0	97.0	-	26.3	366.1	2.0	173.7	-0.6
Submean					104.1	46.6				718.7	2.5		
							95.7		28.0	367.2	3.5		
Section 2													
YY39	23.92	99.26	13/31	8/11	140.3	48.1	128.5	95.7	21.5	300.4	3.2	176.4	-1.3
YY40	23.92	99.26	16/34	9/12	143.0	50.6	129.8	97.0	21.2	22.1	11.2	176.1	-2.6
YY41	23.92	99.26	11/35	8/12	142.1	50.9	127.1	94.3	21.5	89.1	5.9	177.0	-0.1
Submean					141.8	49.9				2084.0	2.7		
							128.5	95.7	21.4	4207.0	1.9		
Mean				9/9	116.1	49.0				41.1	8.1	174.4	0.2
							108.5		26.4	27.9	8.8	K=636.8	A_{95}=2.0
								95.7	25.8	293.1	3.0		

Abbreviations are: Site ID, site identification; φ_s, λs, Latitude and longitude of the sampling site; Strike/dip, Strike azimuth and dip of bed; n/n_0, Number of specimens used in the calculation/demagnetized; Dg, Ig (Ds, Is), Declination and inclination of direction in-situ (after tilt correction), *Ds represent the declination of direction after tilt correction with rotation; φ_p, λ_p, Latitude and longitude of corresponding virtue geomagnetic pole (VGP) in stratigraphic coordinates with the rotation; κ and α_{95} (K and A_{95}), Precision parameter and the radius of the cone of 95% confidence for the mean direction (VGP).