FURTHER PALEOMAGNETIC RESULTS FROM THE PERMIAN EMEISHAN BASALT IN SW CHINA

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In recent years scientists at home and abroad have been conducting paleomagnetic investigations on the Permian Emeishan Basalt in SW China. The results reported, however, vary from one locality to another[1-3]. We report here some new paleomagnetic results for the Emeishan Basalt from three localities in W. Sichuan and Yunnan provinces and compare them with the relevant data published hitherto.

I. SAMPLING AND LABORABORY TECHNIQUES

The samples were collected at three localities: the Daqiao section, Huidong County, W. Sichuan (26.7° N, 102.9°E); the Dapingzi section, Dongchuan City, NE. Yunnan (26.1°N, 103.1°E); and the Lijiao section, Bingchuan County, W. Yunnan (25.9° N, 100.6°E). All samples are hand samples and were oriented in the field by using a pocket magnetic compass. The measurements were made on a Schonstedt DSM-2 spinner magnetometer in the Paleomagnetic Lab of Department of Geology, University of Florida. The pilot specimens were subjected to both stepwise AF demagnetization up to 900 Oe and thermal demagnetization to temperatures up to 685°C in a few cases. It rapidly became apparent that thermal demagnetization was more efficient as was previously recognized by other workers[1,4]. Therefore the remaining samples were demagnetized using the thermal method. Analysis of the demagnetization data was made by using orthogonal vector diagrams[5], and individual components were calculated using principal component technique[6]. Statistics follows that given in [7].

II. PALEOMAGNETIC RESULTS

Orthogonal vector analysis reveals different types of behaviors. For most of the samples (from 16 sites out of 26), a characteristic component whose direction is different from the present geomagnetic field direction was isolated above 450°C (Fig. 2(a) and (b), base portions). However, some samples (from 8 sites) possess a large soft component below 200°C, while at higher temperatures the data points tend to cluster

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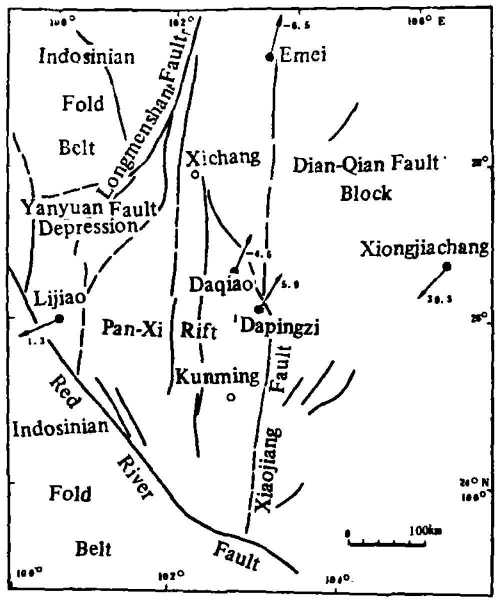

Fig. 1. Sketch map showing tectonic units and formation means of Emeishan Basalt determined from different localities.

near the origin. When blocking up the higher temperature segment of the vector trajectory, it became clear that the characteristic component was not well defined (Fig. 2 (c)). For the samples from the remaining two sites, the characteristic components were not resolved until exceeding 660°C (Fig. 2(d)).

Four types of blocking temperature distribution spectra were recognized. Samples from 5 sites displayed an evident blocking temperature in the range of 520°—550°C (Fig. 2(a), upper portion). The behavior of the samples from other 11 sites is a little different in that after being thermally demagnetized to 500°—520°C, the intensity was decreased by about 40% and thereafter dropped much more drastically, thus forming a kink on the demagnetization curve (Fig. 2(b)). Both behaviors described above indicate that magnetites or titanomagnetites are the magnetic carriers of the characteristic components isolated. Samples from 8 sites showed a third type of behavior (Fig. 2 (c)), their intensity was dropped by 70—80% when heated to 200°C only and then decreased gradually with no kink on the demagnetization curve, seemingly suggesting that a low blocking temperature or fine-grained mineral, probably secondary in origin (pyrrhotite?), might be the magnetic carrier. Thin section inspection of some of these samples reveals a severe alteration. According to Irving and Opdyke[8], the first type of thermal demagnetization behavior is termed thermally discrete, while the third one clearly shows a thermally distributed component and the second one a mixture of both. The samples from the remaining two sites displayed the fourth type of behavior which is characterized by blocking temperatures as high as 660°—670°C (Fig. 2(d)), indicating that the remenance is carried by hematites.

Based on the foregoing analysis, we tentatively interpret the characteristic components isolated from the samples with the first two types and the fourth type of demagnetization behavior as primary. The samples with the third type of demagnetization

Before tilt correction, the directions for different sites tend to be distributed along a great circle which passes through the direction of the present dipole field, with those sites of the third type demagnetization behavior close to it. After tilt correction, all site means also tend to be distributed along great circles, one of whose intersections is in the southwest quadrant but on the upper hemisphere, with those sites of the third type behavior away from it. The implication is that these sites were more severely overprinted by the present Earth's magnetic field. Therefore, only those sites with isolated primary components (Types 1, 2 and 4) were used in computation of the formation means (Table 1).

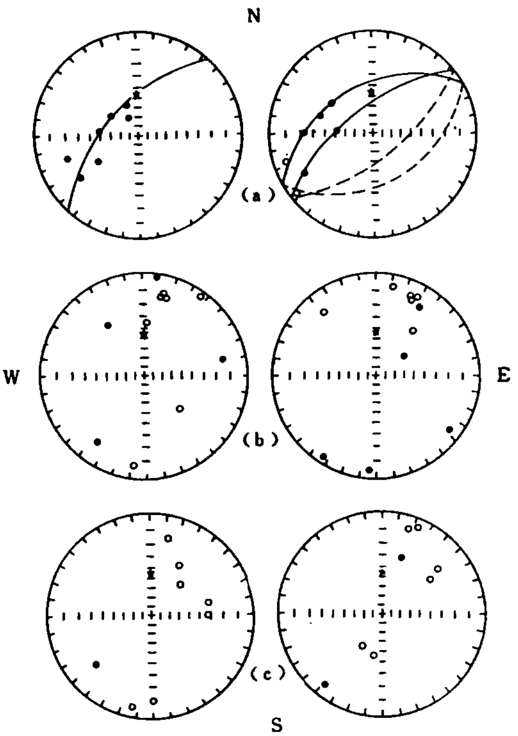

Fig. 3. Site means, before (left) and after (right) bedding correction, from the Lijiao (a), the Daqiao (b) and the Dapingzi (c) sections. Directions plotted on equal angle net with solid circles on lower hemisphere and open circles on upper hemisphere. The star is the direction of the present axial dipole field.

III. Discussion

Among the paleomagnetic results of the Emeishan Basalt reported to date (see Table 2), those given by McElhinny et al.[1] are by far the most internally consistent within the sampling locality, have been confirmed by later workers[2], and also yield a positive fold test. Lin's results[3], however, vary from site to site. An evident NW overprinting is present in most of his samples. Only one site of the ten studied was accepted by him, whose statistical accuracy needs be attested with further work. Our results are of the nature of preliminary survey only. The inclinations determined from the Dapingzi section are scattered, but the declinations are in the NE-SW direction. The Daqiao section yields internally consistent results which are approximately in agree-

Table 1

Site and Formation Means

Sa(Si)	Sp	α_{95}	K	Geographic		Stratigraphic	
				D	I	D_c	I_c
Daqiao section, Huidong County, W. Sichuan (26.7°N, 102.9°E)							
1	4	3.8	578.5	37.0	−2.2	32.1	13.1
2[a]	5	2.0	1436.5	326.1	28.6	321.7	−12.8
3	2	14.6	293.1	205.9	14.0	213.8	3.0
4[a]	5	4.6	277.3	132.9	−39.8	127.0	7.1
5[a]	5	13.7	32.1	78.6	13.6	55.2	53.2
6	5	4.1	357.4	13.7	13.3	25.6	−11.7
7	5	2.6	850.6	14.5	−10.8	24.1	−9.6
8	5	2.6	841.0	8.4	0.3	11.5	−7.1
9[a]	5	2.9	688.6	4.6	−35.2	39.8	−31.0
10	5	2.0	1531.2	17.4	−13.5	28.0	−9.1
11	4	6.7	189.1	187.2	−6.8	185.9	3.7
F.M.	7	10.0	37.1	17.7	−6.8	23.0	−4.5
Dapingzi section, Dongchuan City, E. Yunnan (26.1°N,103.1°E)							
12	4	9.0	105.5	43.5	−44.5	22.5	−6.2
13	4	1.7	2973.5	193.1	−5.7	210.6	−48.3
14	5	2.1	1279.9	78.7	−31.4	50.8	−22.1
15	4	8.1	130.0	89.7	−32.7	54.6	−30.8
16	4	4.6	399.0	13.9	−15.1	17.8	29.9
17	5	2.5	935.1	228.0	19.2	218.6	7.2
18	5	3.2	571.3	179.5	−11.1	192.3	−44.1
19	5	3.2	567.6	29.8	−32.7	17.3	−8.2
F.M.	8	24.9	5.9	37.1	−22.6	30.1	5.9
Lijiao section, Bingchuan County, W. Yunnan (25.9°N,100.6°E)							
20[a]	5	12.8	36.8	307.6	53.6	289.5	33.6
21	5	3.4	497.2	252.4	19.3	252.5	−7.7
22[a]	5	4.4	301.0	277.7	48.9	271.0	23.3
23	5	5.1	228.1	236.2	41.6	240.5	15.7
24	5	10.1	58.9	233.9	21.2	233.0	−4.1
25[a]	5	6.9	123.7	339.2	55.6	307.2	37.1
26[a]	4	15.4	36.7	333.3	68.9	275.4	51.7
F.M.	3	24.8	25.9	241.2	27.6	242.0	1.3

Note: Sa (Si): Sample/site number. At the Lijiao section three blocks were collected from each site, while at other sections only one block was collected.

Sp: Number of specimens for the calculation of site means or number of sites for the calculation of formation means.

α_{95}: 95% confidence radius after bedding correction.

K: Precision parameter after bedding correction. $D(D_c)$, $I(I_c)$: Declination east of north, inclination positive down.

F.M.: Formation mean.

a) Not included in the calculation of the formation means.

Table 2

Formation Means of Emeishan Basalt and Attendant Pole Positions

Worker (s)	Locality		Means			Pole			
	Lat.	Long.	N	D_c	I_c	Lat.	Long.	α_{95}	K
McElhinny, et al. (1981)	29.6	103.4	22	18.4	−6.5	53.7S	72.1E	6.2	26.4
Chan et al. (1984)	29.6	103.4	7	22.9	2.2	54	116 E	15.9	
Lin (1984)	26.4	105.7	1	224.5	30.3	29.3	235.3	12.0	41
This study	26.7	102.9	7	23.0	−4.5	53.5	241.8	10.0	37.1
	26.1	103.1	8	30.8	5.9	52.4	225.9	24.9	5.9
	25.9	100.6	3	242.0	1.3	−24.7	24.3	24.8	25.9

Note: N is the number of the sites or samples involved in the calculation of the formation means. Other symbols are the same as in Table 1.

ment with those of McElhinny et al., although the locality is 300 km south of the Emei section where they sampled. It is also interesting to note that the results from the Lijiao section are similar to that from W. Guizhou, studied and accepted by Lin.

It appears that the inclinations of the remenant magnetization of the Emeishan Basalt determined from different localities are very shallow but that the declinations obtained from the Pan-Xi Rift area are almost opposite to those from its adjacent tectonic units on both sides (see Fig. 1).

One possibility is that some terranes in the Pan-Xi Rift area were rotated clockwise by about 140°—150° relative to the Yanyuan Fault Depression and Dian-Qian Fault Block after the Late Permian. This seems to gain support from the regional geology, for the Pan-Xi Rift is more fragmental with a number of multi-episodally activated deep fracture zones compared with the adjacent units, and the terranes within it are easy to rotate under tectonic force. However, such consistent and large-scale rotation needs to be confirmed with more geological evidence.

Another possibility is remagnetization imposed after the Late Permian. It is true that overprinting is common for the Emeishan Basalt[1,3]. The directions, before and after tilt correction of the low blocking temperature (100°—300°C) components for the pilot specimens from the Daqiao section were calculated as: D=0.7°, I=35.7°, D_c=340.2° and I_c=11° with N=7, α_{95}=10.1° and K=36.8 in both cases. This shows the influence of the present geomagnetic field. The presence of an undetected Mesozoic remagnetization seems unlikely since the formation means so far reported for the Emeishan Basalt from different localities in the Pan-Xi Rift area are different from those of the Jurassic through the Tertiary determined for the South China Block by Lin[3].

Suppose that the basalt started eruption in the Pan-Xi Rift area later than in the Yanyuan Fault Depression and the Dian-Qian Fault Block and that it largely postdated the Kiaman Magnetic Interval[10]. As a result, the mean declinations from the central sections might become NNE (normal polarity) while those from the western and eastern sections become SSW (reversed polarity). Regional geological mapping has discovered some lenses or interbeds of limestone in the Yanyuan Depression and the western Guizhou Province, which contain the Early Permian fusulina fossils. In addition two polarities do exist at our Daqiao and Dapingzi sections (Fig. 3(b) and (c)). But still, it is not known for sure whether or not the age difference in the basalt could be so great.

In conclusion, it is over-optimistic at the present time to think that the problems mentioned above have been solved. In order to accurately determine the Late Permian paleopole position of the Yangtze Block and the real cause of regional difference in declination in the Emeishan Basalt, it is essential to undertake a more detailed study of paleomagnetism and magnetostratigraphy at some selected sections with sufficient thickness exposed in different tectonic units.

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