Precambrian Research 259 (2015) 130–142

Contents lists available at ScienceDirect

Precambrian Research

journal homepage: www.elsevier.com/locate/precamres

New paleomagnetic results from the Ediacaran Doushantuo Formation in South China and their paleogeographic implications

Shihong Zhang[a,*], Haiyan Li[a], Ganqing Jiang[b], David A.D. Evans[c], Jin Dong[a,d], Huaichun Wu[a], Tianshui Yang[a], Pengju Liu[d], Qisheng Xiao[a]

[a] State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China
[b] Department of Geoscience, University of Nevada, Las Vegas, NV 89154-4010, USA
[c] Department of Geology and Geophysics, Yale University, New Haven, CT 06520-8109, USA
[d] Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China

ARTICLE INFO

Article history:
Received 28 May 2014
Received in revised form
15 September 2014
Accepted 19 September 2014
Available online 28 September 2014

Keywords:
Paleomagnetism
Doushantuo Formation
South China
Ediacaran
Supercontinent reconstruction

ABSTRACT

A new paleomagnetic pole is obtained from the top of Member 3 of the Doushantuo Formation in the Jiulongwan section of the Yangtze Gorges area in South China. A total of 191 samples from 23 sites were collected and subjected to stepwise alternating field (AF) and thermal demagnetization. After the removal of a soft component (SC) of viscous magnetic remanence acquired in present geomagnetic field, a high temperature component (HC), likely carried by magnetite, was isolated. The HC includes vectors from 147 samples using principal component analysis and arc constraints from 44 samples using remagnetization great-circle analysis. Both the vectors only and the combined vectors and arc constraints of the HC passed a reversal test. This is the first Ediacaran paleomagnetic remanence from the South China Block (SCB) that passes a reversal test, and it is interpreted as a primary remanence. The HC vectors were thus used to calculate the paleomagnetic pole, and in combination with arc constraints, were used for polarity interpretation. The vectors give a mean direction of ($D = 75.2^\circ$, $I = 41.0^\circ$, $\alpha_{95} = 2.5^\circ$, $N = 147$) after bedding correction, and a corresponding paleomagnetic pole at 23.9° N, 187.0° E (dm/dp = 3.0/1.8). This pole differs significantly from previously published results of the Doushantuo Formation, which may have been subjected to Paleozoic remagnetization. Our results provide a $23.5 \pm 1.8^\circ$ N paleolatitude for the Yangtze Gorges area of the SCB and suggest several alternative paleogeographic options for the Ediacaran–Cambrian amalgamation of East Gondwana, depending on chronostratigraphic correlations.

1. Introduction

The South China Block (SCB) is one of the most intensively investigated Neoproterozoic tectonic units for its well-preserved records encompassing some of the major geological, biological and geochemical events including the breakup of supercontinent Rodinia and assembly of Gondwana, the initiation and meltdown of the most severe glaciations in Earth history, the rise of early animal life and possible ocean oxygenation events. A reliable paleogeographic reconstruction for the SCB is crucial for understanding the potential causal links between these geological, biological and geochemical events. Existing paleogeographic reconstructions pose uncertainties or controversies on whether, when and how the SCB was connected to Australia and India, and the position of the SCB during the 'snowball' Earth times (e.g., Jiang et al., 2003; Macouin et al., 2004; Hoffman and Li, 2009; Li et al., 2013, 2014; Zhang et al., 2013; Yao et al., 2014).

In some paleogeographic reconstructions, the SCB was placed close to the paleo-equator through the Ediacaran Period (ca. 635–541 Ma). Evidence supporting this low-latitude position was from an eastward, shallow remanent magnetization observed from the Doushantuo Formation (ca. 635–551 Ma) in the Yangjiaping Section, northern Hunan Province (Macouin et al., 2004; Fig. 1a). However, the primary origin of this paleomagnetic direction has been questioned (Zhang et al., 2013) because, (1) it does not contain the pattern of numerous Ediacaran geomagnetic field reversals observed in Australia (e.g., Sohl et al., 1999; Raub, 2008; Schmidt et al., 2009; Schmidt and Williams, 2010); (2) the calculated paleomagnetic pole is similar to Early Cambrian and Silurian poles of the SCB; and (3) the positive fold test only constrains the magnetization to pre-Jurassic in age. Therefore, a more rigorous examination is required.

* Corresponding author. Tel.: +86 10 82322257; fax: +86 10 82321983.
E-mail address: shzhang@cugb.edu.cn (S. Zhang).

http://dx.doi.org/10.1016/j.precamres.2014.09.018
0301-9268/

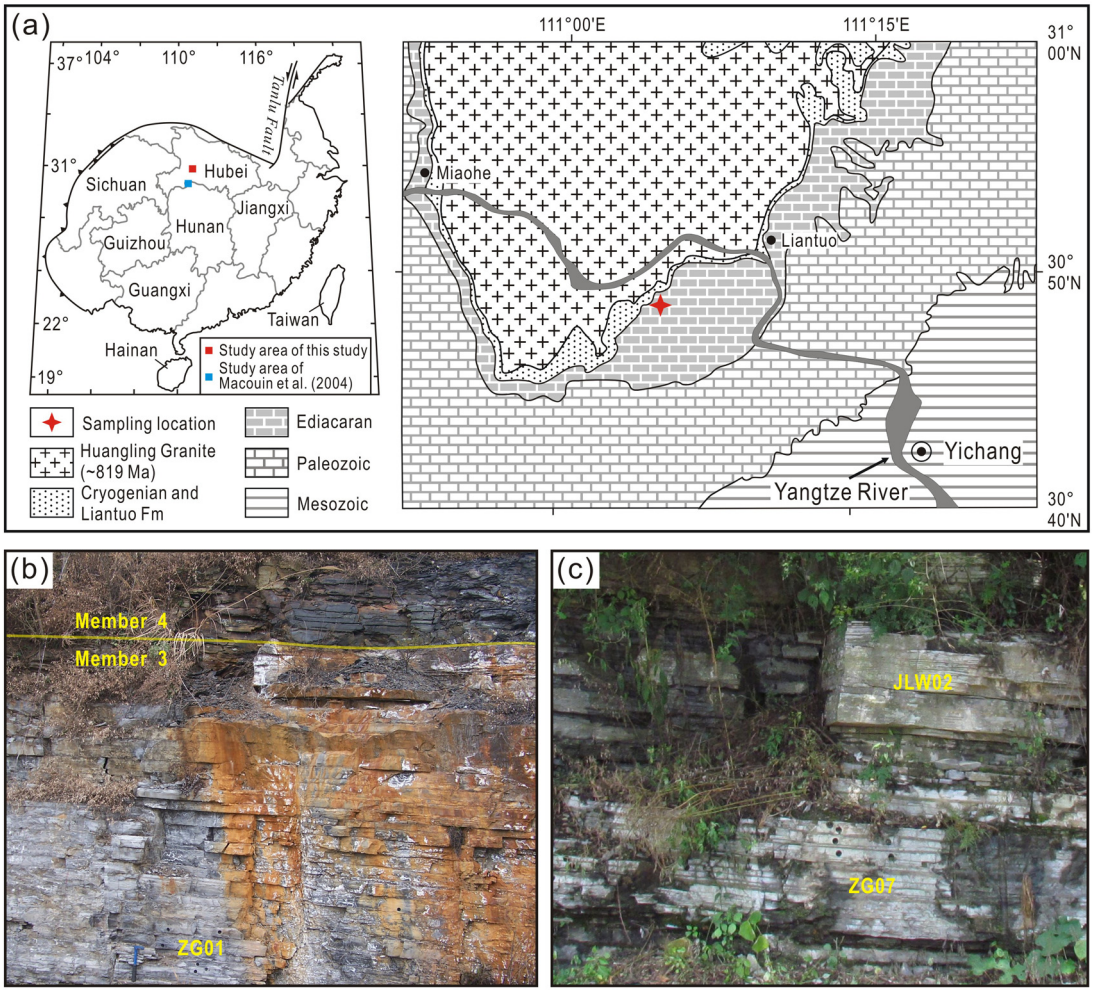

Fig. 1. (a) Simplified Geological map of the Yangtze Gorge region showing the sampling location. (b) and (c) Typical outcrop photos of the dolomite/limestone ribbon rocks of the upper Member 3 of the Doushantuo Formation, with paleomagnetic sites labeled. The diameter of paleomagnetic drilling holes is ~2.5 cm.

In this paper, we report new paleomagnetic results that pass a reversal test from the upper Doushantuo Formation in the Yangtze Gorges area of the SCB. The new data are significantly steeper than those previously determined (e.g., Macouin et al., 2004), fill the gap of the paleomagnetic database of the SCB between ca. 635 Ma and Early Cambrian, and provide important constraints for the Ediacaran paleogeographic position of the SCB.

2. Geological background and sampling

The SCB contains the Yangtze Block (YB) in the northwest and the Cathaysia Block in the southeast. Almost all the available Precambrian paleomagnetic data for the SCB are from the YB, because the Precambrian strata in the Cathaysia Block are poorly dated and strongly deformed. Although no paleomagnetic data are available from the Cathaysia Block, paleogeographic reconstructions commonly place the Cathaysia and Yangtze Blocks as one coherent continental unit since ca. 900 Ma (e.g., Li et al., 2008).

Neoproterozoic strata in the YB are well dated and consist of three major parts (Fig. 2): (1) the pre-Cryogenian siliciclastic units in the lower part, represented by the Liantuo Formation/Banxi Group, with ages ranging from ~820 Ma to ~720 Ma (Zhang et al., 2008a,b); (2) the Cryogenian glacial and interglacial deposits in the middle, including two glacial diamictite intervals (the Chang'an/Dongshanfeng formations and the Nantuo Formation) separated by interglacial manganese-bearing shale/siltstone of the Datangpo/Xiangmeng formations dated between ~663 and ~654 Ma (Zhou et al., 2004; Zhang et al., 2008a,c); and (3) the Ediacaran mixed carbonate-siliciclastic units assigned to the Doushantuo and Dengying/Liuchapo formations at the top.

The Doushantuo Formation was deposited along a passive margin, facing southeast in present-day coordinates (Jiang et al., 2011). In the Yangtze Gorges area, the Doushantuo Formation conformably overlies the Nantuo glacial diamictite and is divided into four members (Fig. 2). Member 1 refers to the ca. 5-m-thick cap carbonate at the base of the Doushantuo Formation. Member 2 consists of ~100-m-thick alternating organic-rich shale and carbonates with abundant pea-sized chert nodules. Member 3 consists of 60–80-m-thick limestone and dolostone with thin shaly interbeds. Member 4 refers to the ca. 10-m-thick black, organic-rich shale interval at the top of the Doushantuo Formation, containing abundant carbonate concretions (Dong et al., 2013). The cap carbonate of Member 1 and the organic-rich black shale of Member 4 are the stratigraphic marker beds for regional correlations of the Doushantuo Formation (Jiang et al., 2011). A prominent negative $\delta^{13}C$ excursion from Members 3 and 4 was intensively studied in many exposed sections of the YB, and has been correlated with the Shuram $\delta^{13}C$ excursion in Oman and Wonoka $\delta^{13}C$ anomaly in Australia (e.g., Jiang et al., 2007; Zhou and Xiao, 2007; Zhu et al., 2007, 2013b; Sawaki et al., 2010; Tahata et al., 2013).

The age of the Doushantuo Formation in the Yangtze Gorges area is constrained by a few zircon U–Pb ages (Condon et al., 2005;