Comment on ‘Permo-Triassic magnetostratigraphy in China: the type section near Taiyuan, Shanxi Province, North China’ by B. J. J. Embleton, M. W. McElhinny, X. Ma, Z. Zhang and Z. X. Li

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Embleton et al. (1996; hereafter referred to as EMMZL) detected the Late Permian Illawarra Reversal (IR: top of the Carboniferous–Permian reversed megazone, Kiaman, 265 Ma) in the lower Upper Shihezi (Shihhotse) Formation of North China.

In their stratigraphic scheme (Table 1 and Fig. 5, redrawn in our Fig. 1) the lower boundaries of the Upper Shihezi Formation, Ufimian and Late Permian coincide. Consequently, EMMZL conclude that the Permo-Carboniferous reversed (Kiaman) superchron ends in mid-Ufimian time. This interpretation does not agree with the position of the IR in the lower part of the type Tatarian on the East European Platform (Khramov 1963), which has been accepted for the last 30 years and has been confirmed most recently by Gialanella et al. (1997). EMMZL do not mention this significant discrepancy (Fig. 1). We are certain that the difference can be explained better using a revised stratigraphic scheme than by suggesting methodological insufficiencies or remagnetization.

EMMZL use reliable paleomagnetic equipment and methodologies. Their magnetostratigraphic results are significant according to the sequences investigated, although no fold test or conglomerate test is possible and mainly the red horizons of a grey/red Permian/Triassic succession yield stable remanent magnetizations. Plenty of facts support their magnetic zones. The Zijderfeld plots reflect continuous thermal demagnetization and stable remanence (EMMZL, Fig. 2). Inclination and declination of the remanence are at the expected values; normal and reversed samples are grouped and bipolar (EMMZL, Fig. 3). A minimum of 13 polarity zones have been detected between the IR and the Permian/Triassic boundary. This number is in good agreement with data from the Salt Range (Haag & Heller 1991), Central Europe (Menning 1995) and Australia (Håvenæs et al. 1994).

The different position of the IR within the Tatarian (Khramov 1963) and within the Ufimian (EMMZL) results from the stratigraphic schemes used by EMMZL (Table 1, Fig. 5). They refer their data to the ‘official Chinese stratigraphic scheme’ (EMMZL, no details given) and the Harland et al. (1990) timescale (cf. Fig. 1). On the other hand, the magnetostratigraphic results of EMMZL and Khramov (1963) are consistent when referred to the correlation chart of Permian deposits in China (Sheng et al. 1982; Sheng & Jin 1994) (Fig. 2).

EMMZL’s incorrect dating of the Illawarra Reversal resulted from a false correlation between the Upper Permian of Chinese chronostratigraphic schemes and that of Harland et al. (1990). The Upper Permian used in China is equivalent to the Lopingian Series (Zhan, Zhaang & Li 1988; Sheng et al. 1982), while the Lower Permian is equivalent to the Chisian and the Maokouan (Fig. 2). However, Harland et al.’s (1990) Upper Permian spans the Ufimian to the Changhsingian, and therefore closely corresponds to the entire Permian succession that EMMZL identified in the Shanxi section. In the EMMZL scheme (Fig. 1) the Lower Shihezi Formation corresponds to the entire Lower Permian, whereas in the Sheng & Jin (1994) scheme it is assigned to the upper Chisian and the lower Maokouan and, combined with the Jin et al. (1994) scheme, corresponds to the middle part of the Permian (upper Kungurian plus Roadian plus Wordian; Fig. 2).

EMMZL (p. 382) stated ‘The Shanxi Formation is rich in brachiopods, corals and fusulinids that date it as Late Carboniferous’. This statement is untrue. In reality, the underlying Taiyuan Formation comprises normal marine sediments and contains fusulinids, corals and brachiopods, but the Shanxi (Shansi) Formation does not as it is of lacustrine origin (BGRM Shanxi 1989). The Shanxi (Shansi) Formation has never been assigned to the Late Carboniferous in the last decade. It is late Artinskian to post-Artinskian in age, because the upper part of the underlying Taiyuan Formation contains Artinskian conodonts such as Streptognathodus whitei (Wang et al. 1987) (Fig. 2).

The plant fossils from the Upper Shihezi (Shihhotse) Formation and the Shiqianfeng (Shichenfeng) Formation are referred to as the late stage of the Cathaysian flora (Li 1963). Indeed, the plant assemblage of the Shichienfeng (Shiqianfeng) Formation contains some characteristic Zechstein species (Wang et al. 1989; also see Sheng & Jin 1994, p. 65). Consequently, the Upper Shihezi Formation (position of the IR of EMMZL) may correspond with part of the Upper Rotliegend (conformable below the Zechstein), where the IR is detected (Menning et al. 1988).

In the Sheng & Jin (1994) scheme the lower part of the Upper Shihhotse (Shihezi) Formation (position of the IR of EMMZL) corresponds with the Upper Maokouan (Fig. 2). The IR has been expected within the Maokouan (Menning,
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Figure 1. The Illawarra Reversal (IR) in the Permian section near Taiyuan, Shanxi Province, North China (Embleton et al. 1996) referred to the "official Chinese stratigraphic scheme" and the Harland et al. (1990) timescale.

Jin & Shen 1996), because Heller et al. (1995, Figs 7 and 8) detected normal polarity in the uppermost Maokouan of the Wulong section and because of intercontinental magnetostratigraphic correlations (Menning 1986, p. 397). The precise position of the IR within the Maokouan is under investigation (Menning et al. 1996). The expected position of the IR in the Maokouan of South China is in good agreement with the IR in the lower Upper Shihhotse (Shihezi) Formation of North China (EMMZL) when using the Sheng & Jin (1994) scheme.

The Upper Maokouan corresponds to the Capitanian (Jin et al. 1994, p. 9). The IR is expected within the Capitanian (Menning 1986, p. 397) because in SW North America exclusively reversed magnetized rocks are detected from the Seven Rivers Formation (lower Capitanian) downwards (Peterson & Nairn 1971). The correlation of the main part of the Capitanian with the Lower Tatarian by means of the IR is suggested by Menning, Katzung & Lützner (1988, Fig. 7) (Fig. 2). There is no significant biostratigraphic evidence against this correlation.

As a consequence, the position of the IR within the Upper Shihezi (Shihhotse) Formation (EMMZL) agrees with the position of the IR in the lower part of the Tatarian (Khramov 1963) and the expected positions of the IR within the Maokouan and the Capitanian. In particular, the results of

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Figure 2. The Illawarra Reversal (IR) in the Permian section near Taiyuan, Shanxi Province, North China (Embleton et al. 1996) referred to the Permian correlation chart of China (Sheng & Jin 1994) and the modified Permian timescale of Menning (1995). The IR has been detected in the lower Tatarian of East Europe and in the lower Upper Shihhotse (Shihezi) Formation of North China. It is expected within the Maokouan and the Capitanian.

EMMZL confirm the pioneering work of Khramov (1963): the IR is in the lower part of the Tatarian; it is not in the Ufimian (Fig. 2). Apparently inconsistent magnetostratigraphic results from the Sydney Basin, where the IR has been interpreted as being of Ufimian age (Théveniaut et al. 1994), can be explained by the poor correlation between Russia and eastern Australia. In eastern Australia, the IR should be located below the Watermark Formation of Gunnedah Basin, and near or below the base of the Wittingham Coal Measure in the Hunter Coal Field (Théveniaut et al. 1994). A probable Ufimian age was assigned to the mixed polarized lower part of the Wittingham Coal Measures, because the palynozone APP5 is interpreted

as being of Kazanian age (Théveniaut et al. 1994). This palynological dating should be questioned. Except for the foraminifers of the *Pseudonodosaria borealis* zone from the Ingelara Formation of Bowen Basin, 'almost all the other Permian biota in eastern Australia are Gondwanan: they... cannot be used to correlate with type Russian Permian' (Roberts, Claué-Long & Foster 1996, p. 401). On the other hand, a U/Pb zircon age of 264.1 ± 2.2 Ma for the Mulbring Siltstone Formation of the northern Sydney Basin (Roberts et al. 1996) is in full agreement with the predicated age of 265 Ma for the IR (Menning 1995) (Fig. 2). The Mulbring Siltstone of the Muswellbrook Anticline underlies the Wittingham Coal Measures (Roberts et al. 1996, Fig. 6). Thus,
the IR should be close to the base of the Wittingham Coal Measures (Théveniault et al. 1994, Fig. 6) or below it (that is, in the Mulbring Siltstone). Such a position of the IR in the northern Sydney Basin does not conflict with the position of the IR in the Lower Tatarian.

The lithostratigraphic units of the Taiyuan section, Shanxi, are inhomogeneously distributed within the Permian when referred to the ‘official Chinese stratigraphic scheme’ (EMMZL) and the Harland et al. (1990) timescale (Fig. 1). In the latter, the Lower Permian is about three times longer than the Upper Permian; the Tatarian is significantly underestimated (Menning 1995). A timespan of 34 Myr is available for the Lower Shihezi Formation (Fig. 1).

The distribution of the stratigraphic units in the Permian is homogeneous when referred to the correlation scheme of Sheng & Jin (1994) and the timescale of Menning (1995), which is calibrated using the few most reliable radiometric ages and geological time indicators (Fig. 2). According to that timescale the Lower Permian series (Cisuralian: Asselian, Sakmarian, Artinskian, Kungurian) and the Middle/Upper Permian series (Guadalupian: Roadian, Wordian, Capitanian; Lopingian: Wuchiapingian, Changxingian) have comparable durations; the Taiyuan Formation and the Shanxi (Shansi) Formation move from the Carboniferous (Fig. 1) into the Permian (Sheng & Jin 1994) (Fig. 2). In Fig. 2 the stratigraphic units are not compressed or stretched as in Fig. 1.

To sum up, referred to the updated stratigraphic scheme of Sheng & Jin (1994) and the modified Permian timescale of Menning (1995), the magnetostratigraphic results of EMMZL agree with the fundamental magnetostratigraphic work on the East European Platform (Khramov 1963).

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