

Sedimentology and sequence stratigraphy

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The Early Cambrian sedimentary sequences of the mid Yangtze Block consists of a wide variety of sedimentary rocks from carbonate to siliciclastics. These sedimentary strata include the Niutitang, Jiumenchong and Bianmachong formations in ascending order.

Niutitang Formation

The black shale of Niutitang Formation (and lateral equivalents) is extensively deposited on the Yangtze Block and covers approximately 1×10^6 km² (Li, 1986). The formation overlies the Ediacaran-Cambrian transitional deposits of Dengying Formation on carbonate platform or Liuchapo Formation in the slope-basin areas (Chen et al., 2009; Wang et al., 2012a). In some part of the Yangtze Block, this lower contact is unconformable, mainly in the shallow previous carbonate platform regions which represent regional subaerial exposure (Pi et al., 2013). But its upper boundary with Jiumenchong Formation is gradual.

In the study areas, continuous deposition of the Niutitang Formation have been observed and the formation is about ~17 to 46 m thick (Figs. 3, 4). The deposition was started with several thin (~2 -20 cm thick) nodular phosphate-rich beds (e. g., Mao et al., 2002; Jiang et al., 2006; Kříbek et al., 2007; Lehmann et al., 2007; Xu et al., 2012). In some part of the Yangtze Platform, especially over 1600 km along the NE striking paleocoastline, extreme metal enrichments had been occurred sporadically just above this phosphate-rich horizon (Kříbek et al., 2007; Jiang et al., 2007) and formed a regionally distributed polymetallic Ni–Mo–PGE–Au sulfide layer (Fan et al., 1973; Murowchick et al., 1994; Lott et al., 1999; Wu et al., 2001; Luo et al., 2003; Yi et al., 2004). Although this metal enrich layer is absent in Longbizui

and Bahuang areas, several layers of barium-ore deposits are interbedded within black shale layers of lower Niutitang at Longbizui. The overlying black shale layers in the study areas are relatively thick (~10 – 15 m).

The upper Niutitang Formation is lithologically variable from one section to another (Figs. 3, 4). In Daotuo, it consists of several 1 – 6 cm thick limestone and siltstone bands within black shale sequence. But the carbonate layers are decreased from mid-upper Niutitang Formation, and the siltstone bands become more frequent in upper part (Fig. 3). On the other hand, in Longbizui and Bahuang sections the upper Niutitang Formation is composed mostly of thick mudstone sequence with a ~1 – 5m thick black shale sequence at top; in addition, a 1.2 m thick dolomite layer at mid Niutitang Formation has been observed in Longbizui.

The Niutitang Formation in the study areas is almost fossil deprived and only some layers are fossiliferous, for example, the phosphate layer in Daotuo and mudstone layers in Longbizui and Bahuang contains sponge spicules fossils (Figs. 3, 5B, E). Thus, the fossil based age determination is difficult for Niutitang Formation. In recent years, extensive radiometric dating at the base of Niutitang Formation yielded the ages from the late Nemakit-Daldynian to early Tommotian times (Xu et al., 2011; Wang et al., 2012b). Although the sponges and sponge spicules present in the base and upper part of Niutitang Formation, their constraint on chronostratigraphic correlation is generally weak in view of their facies-dependent behavior. Nevertheless, some researchers suggested their occurrence in the lower part of Niutitang Formation may be correlated to the Atdabanian Stage.

Jiumenchong Formation

The Jiumenchong Formation is thick in Daotuo section (28.5 m), but became relatively thin in Longbizui and Bahuang locations (Figs. 3, 4). In contrast to its gradational lower boundary, the upper boundary with Bianmachong Formation is sharp due to abrupt lithological changes. The formation is characterized by alternations of thin-bedded limestones with shales (Figs. 3, 4). In Daotuo, the lower part of the formation is shale dominated, but the carbonate content increases in upper part (Fig. 3). The biostratigraphic studies suggested that the Jiumenchong Formation, which contains the trilobite *Hupeidiscus-Sinodiscus* assemblage co-occurring with archaeocyaths, corresponds to the upper part of Qiongzhusi Stage in South China (Yin et al., 1987; 1996) or the upper part of Atdabanian Stage in Siberia (Peng et al., 2012). Although only minor archaeocyaths are found in the Jiumenchong Formation at Daotuo (Fig. 3), their co-occurrence with trilobites in other places reconciles its placement within the Qiongzhusi or Atdabanian Stage.

Bianmachong Formation

Only lower part of the Bianmachong Formation is observed in Daotuo and Longbizui sections, consists mainly of thick black shale sequence; although several siltstone bands are found in mid-lower, middle and uppermost part of this formation at Daotuo borehole section (Figs. 3, 4). Some of these bands are fossil-rich, comprise hyolitha and brachiopod shell remains (Fig. 3), but black shale parts in this borehole lack any type of fossil or bioturbation. On the other hand, in Longbizui outcrop section, fossil sponges and sponge spicules are abundant within black shale layer (Fig. 4). However, the basal

part of formation in the eastern Guizhou, South China generally bears trilobites *Protelenella* and *Chengkouia* which have been suggested to correlated to the base of Canglangpu Stage (Yin, 1987, 1996) or the base of Botoman in Siberia.