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Early Telychian (Silurian) marine siliciclastic red beds in the Eastern Yangtze Platform, South China: distribution pattern and controlling factors

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1 Early Telychian (Silurian) marine siliciclastic red beds in the Eastern Yangtze

2 Platform, South China: distribution pattern and controlling factors

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1 **Abstract:** The distribution pattern of early Telychian (*turriculatus-crispus* graptolite
2 biozone) red beds in the Eastern Yangtze Platform of South China is reconstructed
3 based on regional geologic data. The red beds are developed in three areas, which are
4 separated by regions without red deposition. The distribution pattern indicates that the
5 Cathaysian Oldland was the provenance of sediment rich in ferric oxides, which are
6 essential for the formation of red beds. Silurian marine siliciclastic red beds, both in
7 China and worldwide, tended to develop during times of relatively low sea level.
8 Coeval hematitic oolites that formed far from the coast may record a change from
9 reducing to oxidizing conditions in the ocean. Furthermore, it is likely that a fall in
10 global sea level, a transition from reducing to oxidizing conditions in the ocean, and a
11 cooling climate, all of which were closely related to the early Telychian Valgu Event,
12 promoted the global development of marine red beds during this period.

13
14 **Keywords:** South China, Eastern Yangtze Platform, early Telychian, red beds,
15 sea level, climatic change, Valgu Event

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1 **Introduction**

2 Many studies have considered whether red bed deposition can be used as an
3 indicator of climatic and sedimentary conditions (Van Houten 1961; Walker 1967;
4 Dubiel 1994; Retallack 2001). However, most of them have concluded that red color
5 of sediment is not a reliable indicator of climatic conditions (e.g., Sheldon 2005).
6 Meanwhile, red beds are not exclusive in terrestrial environments, but also found in
7 nearshore (e.g., Douglas and Roger 1979), offshore settings (e.g., Ziegler and
8 McKerrow 1975), even deep marine environments (e.g., Wang and Hu 2005), some of
9 which are not in favor of the formation of red deposition, according to traditional
10 perceptions. These findings highlight the difficulty in identifying the controls on color
11 changes—a topic of particular interest in studies of red and black deposition.
12 Consequently, in recent years the nature of red marine strata has received considerable
13 attention (Wang and Hu 2005; Wang et al. 2011; Brett et al. 2012; Rong et al. 2012;
14 Zhang et al. 2014).

15 Marine red beds fall into three categories based primarily on the water depth of
16 deposition (Brett et al. 2012; Rong et al. 2012). Type I red beds are deep oceanic red
17 beds (DORBs) that are directly related to oceanic currents and the distribution of
18 organic carbon/oxygen pools (Wang and Hu 2005; Hu et al. 2006). Type II red beds
19 are deposited in offshore or deep oceanic basin environments (Ziegler and McKerrow
20 1975; Brett et al. 2012; McLaughlin et al. 2012). Type III red beds are deposited in
21 near-shore basins that are characterized by shallow-water sedimentary structures and
22 faunal assemblages (Rong et al. 2012; Zhang et al. 2014).

1 Marine red beds are widely distributed in Silurian sedimentary basins in Western
2 Europe, North America, southern and western China (Ziegler and McKerrow 1975;
3 Ettensohn 2008; Rong et al. 2003; Rong et al. 2012), and are characterized by type II
4 and III red beds. The exact ages of individual red beds vary from location to location.
5 However, in general they first appeared near the Aeronian–Telychian boundary and
6 formed widespread deposits in the early Telychian (primarily within the
7 *turriculatus-crispus* graptolite biozone), the mid Telychian (within the
8 *crenulata-spiralis* graptolite biozone), and near the Telychian–Wenlock boundary (Mu
9 1962; Ziegler and McKerrow 1975; Loydell 1998; McLaughlin et al. 2012; Rong et al.
10 2012) (Fig. 1).

11 Figure 1

12 Silurian marine red beds developed very well in both the Upper and Lower
13 Yangtze Region, and extend laterally for hundreds of kilometers. They are commonly
14 used for regional stratigraphic correlation given their striking color (Rong et al. 1984).
15 Comprehensive biostratigraphic studies using graptolites (Chen 1984), conodonts
16 (Wang 1998, 2011), and chitinozoans (Geng et al. 1997) have documented red beds
17 occurrence at three distinct horizons: ‘lower red beds’ (LRBs) of early Telychian age,
18 ‘upper red beds’ (URBs) of mid Telychian age, and red beds of Ludlow-Pridoli age
19 (Wang et al. 2010, 2011; Rong et al. 2012). The geological ages of red beds at each
20 horizon fall into short time intervals and each show a clear synchronicity in different
21 locations in South China (Rong et al. 2003; Rong et al. 2012), based on evidences of
22 biostratigraphy, for example, the graptolite zones.

1 These studies of Telychian marine red beds resulted in the publication of several
2 geological maps (Chen and Rong 1996; Rong et al. 2003; Rong et al. 2012) that have
3 subsequently been used to reconstruct the Kwangsian Orogeny in South China (Chen
4 et al. 2014). However, the depositional setting of the South China red beds and the
5 relationships between the red beds and Silurian paleoceanography, paleoclimatology,
6 and tectonics remain poorly known (Rong et al. 2012).

7 In recent years, there has been a remarkable transition towards viewing the
8 Silurian as a highly dynamic period (e.g., Munnecke 2010). Six large positive carbon
9 isotope excursions associated with major extinctions and sea level fluctuations have
10 been recognized (Calner 2008; Munnecke et al. 2010; Cramer et al. 2011); however,
11 our understanding of the nature of these events and their inner correlations remains
12 incomplete. Some relative studies concerning two transitions in sediment color (green
13 to red and gray to black) have aroused much attention in these years (Kiipli 2004;
14 Brett et al. 2012; McLaughlin et al. 2012) and may shed light on these puzzles. The
15 role played by red beds as possible time-specific facies (e.g., Brett et al. 2012)
16 requires more detailed studies before they can be used as an indicator of geological
17 events.

18 **Geological setting**

19 The distribution pattern and probable controlling factors of early Telychian red
20 beds in the Upper Yangtze Region were talked in detail by Rong et al. (2012). This
21 study focuses on the red beds of early Telychian age (primarily within the
22 *turriculatus-crispus* graptolite biozone) from the Eastern Yangtze Platform of South

1 China (Fig. 2RA). The study area covers the Lower Yangtze region (Anhui, Jiangsu
2 and Jiangxi provinces) and parts of other adjacent regions (Hubei and Zhejiang
3 provinces). It belongs to the South China Block (SCB). The SCB consists of the
4 Yangtze and Cathaysian blocks and were under constant influence of NW-SE
5 compressional stress of the Kwangsian Orogeny (approximately equivalent in age to
6 the Caledonian Orogeny) (Rong et al. 2010; Chen et al. 2014). From the Late
7 Ordovician to the Early Silurian, the Cathaysian Oldland expanded rapidly to the
8 northwest (Rong et al. 2010; Chen et al. 2014). The Nanhua Foreland Basin (NFB)
9 formed and evolved during this time, deposited thousands of meters of sediment (Li
10 1998) before terminated by a final stage with association of the uplift of the Nanhua
11 Orogenic Belt (NOB). Today, only a remnant basin is recognized due to later geologic
12 modification. The evolutionary history and provenance of the NFB are still under
13 discussions (Yao et al. 2015). However, it appears to have undergone a similar
14 tectonic evolution to other foreland basins of the same age, such as the Appalachian
15 Foreland Basin (AFB) (Su et al. 2009).

16 In the earliest Silurian (Rhuddanian stage), the Yangtze Ocean, a vast epeiric sea,
17 was characterized by the widespread deposition of black shale and flysch. During the
18 subsequent Aeronian stage, sea level was lower than earlier stage but remained
19 relatively stable (Rong et al. 1984). At this time, carbonate rocks were deposited along
20 the platform margin while clastic rocks were deposited near the oldland. Following
21 the Aeronian stage, marine red beds were widely distributed during the Telychian
22 stage (Rong et al. 2003). The lower Silurian upward-coarsening sequence is

1 interrupted by a major uplift event (Rong et al. 2012) that resulted in a depositional
2 hiatus in most Yangtze Region until the Devonian (Wang et al. 2010, 2011).

3 **Methods**

4 As part of this study, eighty-seven sections, with and without red beds, were
5 catalogued. All of these sections are gathered by the authors through regional geology
6 instructions and maps, and were checked at first place to make sure their geological
7 age is early Telychian based on evidences of biostratigraphy (trilobites, brachiopods
8 and graptolites). Calculations of red bed thickness are based on regional geologic data,
9 and include the total thickness of red strata and green interlayers. The distribution
10 pattern of red beds is reconstructed to interpret the influence of sedimentary
11 environment, sea level change, oceanic chemistry, and climatic change on their
12 deposition.

13 **Results**

14 Early Telychian red beds in the Eastern Yangtze Platform occur in three discrete
15 areas (Fig. 2RB). Area A is located at the intersection of southwest Jiangsu, southeast
16 Anhui, and northwest Zhejiang provinces, and extends to the northeast border of
17 Jiangxi Province. Area B is a narrow region in the mid-southern part of Anhui
18 Province. Area C lies along the border between Jiangxi and Hubei provinces.

19 **Area A**

20 Area A has the largest areal extent of early Telychian red beds in the Eastern
21 Yangtze Platform. The red beds deposit around Anji County (Fig. 2RB, sections
22 13–15) are characterized by massive fine-grained sediments with a total thicknesses

1 of >1000 m (Geology and Minerals Bureau of Zhejiang Province 1989). The thickest
2 sequence recorded in this study (2022 m) is located in the Kangshan section (Fig.
3 2RB, section 15). A horn-shaped region extending south of Anji into western Zhejiang
4 is known as the Zhe-Gan Ocean (Rong et al. 2010), and red beds in this area are ~100
5 m thick (e.g., Wangjia section, Fig. 2RB, section 25). Red beds from the Zhe-Gan
6 Ocean occur as far south as Yushan County, Jiangxi Province, in the yellowish-green
7 clastic rocks of the Shisaidi section (Fig. 2RB, section 29) (Li and Jiang 1997).

8 Red beds extend westward from Anji County into Anhui Province, crossing
9 Chaoxian, Hexian, and Hanshan counties (Fig. 2RB, sections 30–35), where they
10 occur as interbeds in grayish-green siltstone and mudstone (Geology and Minerals
11 Bureau of Anhui Province 1987; Li and Jiang 1997). Farther west, in Taiping,
12 Jiangxian, Ningguo, Langxi and De'an counties, red beds are present in the thick
13 lower Silurian succession (Fig. 2RB, sections 39–42) (Li and Jiang 1997).

14 North of Anji County, in southern Jiangsu Province, early Telychian red beds
15 (Fig. 2RB, sections 1–11) generally do not attain great thickness (~100m) (Geology
16 and Minerals Bureau of Jiangsu Province 1984). In the Maoshan Mountain Range, red
17 beds are up to 100 m thick (99.3 m in the Fangshan section; Fig. 2RB, section 9), but
18 farther north, near Nanjing, red beds are only several meters thick (0.7–3.77 m in the
19 Houjiatang section; Fig. 2RB, section 1).

20 **Area B**

21 In a narrow region crossing Susong, Tongcheng, and Lujiang counties (Fig. 2RB,
22 sections 43–51), red beds are present in grayish-green siltstone, mudstone, and fine

1 quartz sandstone (Li and Jiang 1997). In the Zuoshan section of Susong County (Fig.
2 2RB, section 51), hematitic oolites occur at the same stratigraphic level as the red
3 beds.

4 **Area C**

5 In Jiangxi Province, early Telychian strata consist of grayish-green and
6 purple-red siltstone and mudstone, and red beds are thickest (569–1137 m) in the
7 region between Wuning and Xiushui (Fig. 2RB, sections 66–73). For example, in the
8 Qiaotou section (Fig. 2RB, section 68) the red beds are 943 m thick. In the area
9 around De'an and Maanshan (Fig. 2RB, 74–79), red beds thickness decreases from
10 890 to 418 m from west to east (Geology and Minerals Bureau of Jiangxi Province
11 1984; Liu 1997). Red beds are also present in the early Telychian yellowish-green and
12 grayish-green fine clastic rocks in Huibei Province (Fig. 2RB, sections 80–83). In the
13 area north of Huangshi and Tongshan, Silurian strata are poorly exposed due to a
14 cover of extremely thick Quaternary deposits (Fig. 2RB, sections 84, 85, 87);
15 consequently, the record of red beds in this area is sparse.

16 Red bed deposition occurs in the three discrete regions discussed above; no red
17 beds are present in sections located within the intervening (Fig. 2RB, sections 52–65,
18 86) or other areas within the Eastern Yangtze Platform.

19 **Figure 2**

20 An isopach map of red bed thickness (Fig. 2RB) shows that the reds bed
21 depositional centers were typically located proximal to the Telychian paleoshoreline.
22 Red beds become thinner farther from the paleoshoreline and are supplanted by

1 yellowish-green strata eventually. For example, in area A, which contains the largest
2 distribution of red beds in this region, the red beds in the Kangshan section (Fig. 2RB,
3 section 15) are the thickest (>2000 m), while in peripheral areas, such as near
4 Erjieling and Kangshan (Fig. 2RB, sections 13–14), the red beds thin to ~ 1000 m. At
5 sites even farther from the depositional center, the thickness decreases dramatically to
6 ~ 200 m (Fig. 2RB, sections 16–22). In southern Jiangsu Province and southeast Anhui
7 Province, red beds are ~ 100 m thick (Fig. 2RB, sections 9–11, 35), and those farthest
8 from the paleoshoreline are <100 m thick (Fig. 2RB, sections 1–8, 36–38), before
9 disappearing completely. The same pattern of decreasing red bed thickness with
10 increasing distance from the paleoshoreline can also be observed in area C.

11 The trend in red bed thickness is shown in cross-sectional view in Fig. 3. Red
12 beds nearest to the paleoshoreline (section 15) have a greater total thickness and
13 contain a higher proportion of red bed layers relative to those deposited farther from
14 the paleoshoreline (section 51). In a word, red beds developed better near the
15 oldland, which is the same to that observed in the early Telychian red beds in the
16 Upper Yangtze Region (Rong et al. 2012). It is reasonable to infer that the Cathaysian
17 Oldland provided the sedimentary material in the red bed deposits and that this
18 material was an essential requirement for the formation of shallow-marine siliciclastic
19 red beds in the Eastern Yangtze Platform.

20 **Discussions**

21 As described above, marine siliciclastic red beds are a product of debris rich in
22 ferric iron that is derived from terrestrial environments and redeposited in a marine

1 setting. Oxidic or low-primary-production conditions, such as those in near-shore
2 environments, are conducive to red bed formation (Loydell 1998; McLaughlin et al.
3 2012; Rong et al. 2012). Farther from the source area, the ferric oxide component of
4 terrestrially sourced sediment decreases gradually, due to the loss of ferric oxides for
5 longer residence time in the reducing environment. Consequently, sediments
6 deposited distal to source areas are usually characterized by drab colors such as
7 grayish-green or yellowish-green. However, the existence of area B, isolated from all
8 the other distribution areas, seems unusual, and the controlling factors of this
9 distribution pattern are talked below.

10 **Sedimentary environment**

11 No systematic sedimentary studies have yet been carried out concerning the early
12 Telychian red strata of the Eastern Yangtze Platform. Nevertheless, in some regions,
13 especially the border between Jiangsu and Zhejiang provinces, the early Telychian red
14 beds are of great thickness and represent the substantial accumulation of detritus in a
15 rapidly subsiding basin. These deposits are interpreted as representing a deltaic setting
16 (Geology and Minerals Bureau of Zhejiang Province 1989). Few fossils are found in
17 the red strata; however, shelly fossils in the overlying and underlying yellowish-green
18 strata primarily represent benthic assemblages 1 and 2 according to Rong et al. (1984,
19 2012). The interpretation of a near-shore setting is consistent with the abundant
20 shallow-water sedimentary structures observed in the lithologic record. For example,
21 along the white dotted cross-section line in Fig. 2RB, cross-bedding, tidal bedding,
22 tidal scours, ripple marks, and mud cracks are common (Geology and Minerals

1 Bureau of Anhui Province 1987; Geology and Minerals Bureau of Zhejiang Province
2 1989).

3 We propose that early Telychian red beds in the Eastern Yangtze Platform were
4 deposited in a tide-dominated delta system (consulting Dalrymple et al. 1992) (Fig.
5 3A). Area B could be interpreted as a distal bar system that was oriented parallel to
6 the coastline and was influenced by tidal activities. Travelling from the coastline to
7 the basin center, submarine topography changed during sedimentary facies transition.
8 Relative water depth increased at first, then decreased because of the uplifting near
9 the distal bar. The relatively deep water between the shoreline and Area B precluded
10 the deposition of near-shore red beds. It is clear that red beds tend to develop in the
11 settings of shallower water compared to the green strata, as the study of early
12 Telychian red beds from the Upper Yangtze Region has already shown (Zhang et al.
13 2014).

14 Figure 3

15 **Global sea-level fluctuations**

16 Silurian marine red beds were especially developed during periods of relatively
17 low sea level. For example, red beds within the *turriculatus-crispus* graptolite biozone,
18 whether type II or III (see the Introduction), were deposited during periods of
19 regression period (McLaughlin et al. 2012; Rong et al. 2012). Silurian marine red
20 beds within the *spiralis* graptolite biozone were also deposited during a minor
21 regression within a major transgressive phase (Loydell 1998). These interpretations
22 differ from the prior view that Silurian marine red beds were related to transgression

1 (Ziegler and McKerrow 1975). We believe that early Telychian red beds in South
2 China were overall formed during regression times. Sea level reconstructions from
3 brachiopods (Rong et al. 1984; Johnson et al. 1985) indicates such a trend, which also
4 coincides with the sequence stratigraphic studies from the Yangtze Region (Chen et al.
5 1998). Silurian marine siliciclastic red beds were associated with low sea levels at
6 both global and regional scales.

7 This study also provides some crucial evidences concerning Silurian sea level
8 change. Ironstone and hematitic oolites developed widely in the geologic record
9 (Young 1989, 1992), yet their geological meanings are controversial. Some scholars
10 think that they represent deposition during the latest stage of a highstand systems tract
11 (HST) (Young 1992). However, more evidences, such as the regional disconformity or
12 a discontinuity surfaces which usually present above the ironstones and hematitic
13 oolites are signals of sediment starvation, suggesting that these sediments were
14 associated with initial transgressions following regressions (Brett et al. 1998;
15 McLaughlin et al. 2008). The hematitic oolites found in area B may represent
16 intervals of transgression or early highstand during regressive periods when red beds
17 were deposited. Two regressive and transgressive cycles took place during the
18 *turriculatus-crispus* biozone (Johnson 2010), the hematitic oolites may be formed
19 either during the early transgression stage of the first cycle or the second cycle. These
20 characters show a high synchronization in sea level changes between South China and
21 the global trend during the early Telychian stage.

22 **Oceanic chemistry and climatic change**

1 So what was unusual in these early Telychian sedimentary basins with red bed
2 deposition? The answers have already been suggested for the early Telychian
3 deposition in the offshore or deep basin environments. In western Europe (Kiipli 2004)
4 and North America (McLaughlin et al. 2012), red beds have been interpreted to
5 indicate geochemical events, in which reducing or anoxic environments were replaced
6 by oxic conditions. The occurrence of ironstone and hematitic oolites indicates such a
7 change. Generally speaking, ferric iron is of low solubility; however, ferric oxide
8 concentrations in ironstones and hematitic oolites are many times higher than in their
9 siliciclastic red bed equivalents. In the latter, a low concentration of ferric oxide is
10 sufficient to produce a bright red color (Bensing et al. 2005). This contradiction is
11 resolved by arguing that ironstone and hematitic oolites are actually redeposited
12 ferrous iron derived from reducing environments (Young 1989), and indicate a
13 transition between reducing and oxidizing conditions. The hematitic oolites found in
14 early Telychian deposits of the Eastern Yangtze Platform likely indicate the same
15 transition. The change from an oxidizing to a reducing environment not only provided
16 conditions conducive to the development of siliciclastic red beds in near-shore
17 environments, but also the coeval siliciclastic red beds and hematitic oolites deposited
18 farther from the coastline.

19 Are falling sea level and oxic oceans alone sufficient to produce coeval red bed
20 deposits in many basins in the world? The color transition from yellowish-green to
21 red in the early Telychian deposits of the AFB was controlled by changing redox
22 potential (anoxic or reduced to oxic) and climatic change (warm to cool), which were

1 far-field responses to the Valgu Event (McLaughlin et al. 2012). No isotope data
2 relevant to the Valgu Event in the Yangtze Region of South China have been reported
3 to date; however, Geng et al. (1999) described glacial advance as a trigger for Silurian
4 marine red bed formation. The patterns of sea level fluctuation in this period seem to
5 be similar to that of North America (Johnson et al. 1985), and sediment color
6 transitions indicate a similar changing pattern of redox potential (Fig. 1). Thus, the
7 early Telychian red beds of the Eastern Yangtze Platform probably also developed
8 during a cooling climate.

9 Geological history may repeat itself. The globally distributed Cretaceous
10 Oceanic Red Beds (CORBs, type I red beds) were triggered by oxic events (Wang et
11 al. 2011) and were deposited during cooler periods than were the underlying black
12 and green sedimentary deposits (Wang and Hu 2005; Hu et al. 2006). Oceanic anoxic
13 and oxic events may not have been as intense as the Cretaceous during the Silurian;
14 however, the mechanisms that caused these depositional patterns were probably
15 similar during these two periods. Behind the red beds is a delicate feedback system.
16 Falling sea level and a cooling climate in the early Telychian not only promoted the
17 formation of ferric oxides in terrestrial environments, but also led to lower levels of
18 primary production. Consequently, the ocean became more oxic, which in turn
19 enhanced red bed formation in lower-latitude regions worldwide.

20 **Conclusions**

21 Early Telychian red beds in the Eastern Yangtze Platform may have been
22 deposited in a tide-dominated deltaic system. These deposits occur in three

1 sub-regions of varying areal extent that are separated by a region without red bed
2 deposition. The distribution pattern indicates that the Cathaysian Oldland served as
3 the provenance of the red beds and created the geological conditions necessary for red
4 bed formation. Regional and global factors also influenced red bed deposition; i.e.,
5 relative water depth and the Valgu Event, respectively. Lower sea level, changes in
6 redox potential from reducing to oxic, and a cooling climate may have created the
7 geological conditions that resulted in deposition of marine siliciclastic red beds near
8 the *turriculatus-crispus* graptolite biozone in locations worldwide.

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1 Fig.1 Global carbon, oxygen isotope curves, sea level changes and sediment
 2 colors transition patterns from typical locations during early to middle Telychian.
 3 Graptolites standard from Rong et al. 2012

4 Fig.2 Distribution patterns of early Telychian red beds in the Eastern Yangtze
 5 Platform. Numbers represent sections. Jiangsu Province: 1 Houjiatang; 2 Taishan; 3
 6 Fentou; 4 Tangquan; 5 Heluoshan; 6 Dinggong; 7 Fangshan; 8 Yajishan; 9 Fangshan;
 7 10 Shengshan; 11 Shiluoshan. Zhejiang Province: 12 Shuikou; 13 Erjieling; 14
 8 Xiaoshu; 15 Kangshan; 16 Wukang; 17 Gaotingshan; 18 Wuchaoshan; 19 Laojiaoshan;
 9 20 Tangjiawu; 21 Yuqian; 22 Sanxikou; 23 Zhaixi; 24 Gewuling; 25 Wangjia; 26
 10 Wenchang; 27 Xiwu; 28 Huafu. Anhui Province: 30 Dazhucun; 31 Xiyu; 32 Fancun;
 11 33 Tianzimen; 34 Houjiadian; 35 Caijialing; 36 Northeast Chaohu; 37 Jiashanguan;
 12 38 Gushan; 39 Longmen; 40 Jukeng; 41 Tongluotan; 42 Sanxizhen; 43 Shihuiyao; 44
 13 Yangqiao; 45 Dongguanshan; 46 Dapaishan; 47 Baizishan; 48 Tuolongshan; 49
 14 Gutang; 50 Hengshan; 51 Zuoshan; 52 Xiage; 53 Zhonghan; 54 Shengqiao; 55
 15 Xinhezhuang; 56 Litouqiao; 57 Shanbei; 58 Lutang; 59 Jiulianshan; 60 Wufengshan;
 16 61 Jingtingshan; 62 Xiejiagan; 63 Waima; 64 Yangjie; 65 Meijie. Jiangxi Province: 29
 17 Shisaidi; 66 Jiulongshan; 67 Hejiaqiao; 68 Qiaotou; 69 Dianbei; 70 Chaqi; 71
 18 Putianqiao; 72 Lukou; 73 Xiajiaqiao; 74 Xiongjiazui; 75 Maanshan; 76 Huanglaomen;
 19 77 Zhujia; 78 Daqiao; 79 Jieshou. Hubei Province: 80 Xiangshan; 81 Mingdengshan;
 20 82 Gushi; 83 Guantangyi; 84 Renjiawan; 85 Yanwo; 86 Emeiling; 87 Sujiashan

21 Fig.3 Sedimentary environment (A), lithofacies changes and red beds
 22 development (B) from the coastline to basin center (cross-sectional view)

Fig.1 Global carbon, oxygen isotope curves, sea level changes and deposition colors transition patterns from typical locations during early to middle Telychian. Graptolites standard from Rong et al. 2012
84x46mm (600 x 600 DPI)

Fig.2 Distribution patterns of early Telychian red beds in the Eastern Yangtze Platform. Numbers represent sections. Jiangsu Province: 1 Houjiatang; 2 Taishan; 3 Fentou; 4 Tangquan; 5 Heluoshan; 6 Dinggong; 7 Fangshan; 8 Yajishan; 9 Fangshan; 10 Shengshan; 11 Shiluoshan. Zhejiang Province: 12 Shuikou; 13 Erjieling; 14 Xiaoshu; 15 Kangshan; 16 Wukang; 17 Gaotingshan; 18 Wuchaoshan; 19 Laojiaoshan; 20 Tangjiawu; 21 Yuqian; 22 Sanxikou; 23 Zhaixi; 24 Gewuling; 25 Wangjia; 26 Wenchang; 27 Xiwu; 28 Huaifu. Anhui Province: 30 Dazhucun; 31 Xiyu; 32 Fancun; 33 Tianzimen; 34 Houjiadian; 35 Caijialing; 36 Northeast Chaohu; 37 Jiashangguan; 38 Gushan; 39 Longmen; 40 Jukeng; 41 Tongluotan; 42 Sanxizhen; 43 Shihuiyao; 44 Yangqiao; 45 Dongguanshan; 46 Dapaishan; 47 Baizishan; 48 Tuolongsan; 49 Gutang; 50 Hengshan; 51 Zuoshan; 52 Xiage; 53 Zhonghan; 54 Shengqiao; 55 Xinhezhuang; 56 Litouqiao; 57 Shanbei; 58 Lutang; 59 Jiulianshan; 60 Wufengshan; 61 Jingtingshan; 62 Xiejiagan; 63 Waima; 64 Yangjie; 65 Meijie. Jiangxi Province: 29 Shisaidi; 66 Jiulongshan; 67 Hejiaqiao; 68 Qiaotou; 69 Dianbei; 70 Chaqi; 71 Putianqiao; 72 Lukou; 73 Xiajiaqiao; 74 Xiongjazui; 75 Maanshan; 76 Huanglaomen; 77 Zhujia; 78 Daqiao; 79 Jieshou. Hubei Province: 80 Xiangshan; 81 Mingdengshan; 82 Gushi; 83 Guantangyi; 84 Renjiawan; 85 Yanwo; 86 Emeiling; 87 Sujiashan

173x125mm (600 x 600 DPI)

Fig.3 Sedimentary environment (A), lithofacies changes and red beds development (B) from the coastline to basin center (cross-sectional view)
200x336mm (600 x 600 DPI)