Dear reviewer,

We would like thank you for having read and commented our manuscript and we would like to apologize for the delay in our answers. We are grateful for your questions and suggestions. It's very useful and enlightening. We will take consideration in the revised version. Here, we provide some quick replies to your questions.

Major concerns:

1) The introduction part is not well written as there are many ambiguity and in accuracy (see detailed comments below). This section needs significant reworking.

2) The authors seem to preferentially pick 4.8 Ma as the boundary between the two climate intervals. However, most of the proxies exhibited in Fig. 3 seem has a distinct change at 4.6 Ma, but not 4.8 Ma, e.g., Al_2O_3, K_2O, as well as the three magnetic susceptibility plots. In addition, for the grain size and carbonate content plots, there is no apparent difference below and above 4.8 Ma.

3) This manuscript is generally good written in English, but additional efforts are required to polish the language.

Our response: Thank you for your suggestions. We would take consideration in the revised version. We would explain how we defined the boundary later.

Line-to-line comments:

L1-2: I found the title is kind of misleading. The authors emphasize the Tibetan Plateau as the location of their section. However, throughout the manuscript, the Xiaoshuizi section is compared with other sections on the Chinese Loess Plateau, and reflects nothing of the Tibetan Plateau evolution. So it would be more appropriate to emphasize the location as the "western Chinese Loess Plateau".

Our response: It's a very good question. The reason why we emphasize the NE Tibetan Plateau is that it significantly represents the location of the Xiaoshuizi planation surface. It locates the transition zone from the Tibetan Plateau to the Chinese Loess Plateau. The obvious difference between Xiaoshuizi deposit and the red clay in the Chinese Loess Plateau is the modern altitude, and this exactly results from the special geographical position of NE Tibetan Plateau. Compared with other sections on the Chinese Loess Plateau is the main method to address the evolution of palaeo-circulation over the Xiaoshuizi planation from late Miocene to early Pliocene. We would modify statement of lines 108-114 as "Clarification of the evolution and dynamics of the westerlies and the palaeo-ASM requires accurate paleoclimatic reconstructions in the East Asia especially in the NE Tibetan Plateau, which is at the junction of the westerlies and monsoonal influences.

Continuous red clay sequence was recently discovered on the uplifted Xiaoshuizi (XSZ) peneplain in the NE Tibetan Plateau and has been dated via high-resolution magnetostratigraphy analysis (Li et al., 2017)."

L49: one of the most intensively studied intervals of what? Climate I assume?
Our response: We would add "in climate research" at the end of the sentence.

L51: in line 41, the authors state closure of the Panamanian Seaway at 4.8 Ma, and it seems that the seaway closure has significant climate effects. Thus, it would be inappropriate to state here that the Zanclean is similar as present due to similar land-sea distribution.
Our response: We would remove the statement.

L52-53: references for "comparable temperatures in the tropical region" need to be added.
Our response: We would add the citations (Herbert et al., 2010, 2016).

L54: Zanclean is a period from cold to warm?
Our response: Zanclean (5.3-3.6 Ma) is a transition period from relative cold climate of Late Miocene to relative warm climate of late Pliocene (3.6-3 Ma).

L66-67: wired transition from the previous sentence. Not consistent.
Our response: We would modify it as "whether permanent El Nino–like conditions were sustained during the Pliocene is still controversial."

L68: This is at least not accurate, if not wrong. Numerous studies have demonstrated that surface uplift of the Tibetan Plateau is stepwise and spatially diachronous. See reviews of Tapponnier et al., 2001, Wang et al., 2014 and many others. The south-central parts of the Tibetan Plateau were uplifted much earlier than the Zanclean, e.g., Paleogene. In the northern Tibetan Plateau, although there might be tectonic deformation in the margins of the Plateau (Li et al., 2015), the major part of the northern Plateau is probably uplifted during the Miocene, as evidenced by numerous other evidence, see review of Yuan et al., 2012. While it's OK to stick on the authors' own preference, it's necessary to discuss/reflect other research progress.
Our response: Thank you for point it out. What we would like to express is the uplift of the Tibetan Plateau was underway. It may be inappropriate. We would modify the statement of lines 68-72 as "In addition, several major changes in global thermohaline and atmospheric circulation system occurred during the early Pliocene which are thought to be crucial preconditions for both the appearance of Northern Hemisphere ice sheets at ~2.6 Ma (Haug et al., 1998, 2005; Driscoll et al., 1998) and the development of the modern east-west hydrographic gradient in the equatorial Pacific (Lawrence et al., 2006; Chaisson et al., 2000)."

L72: 3 Ma or 2.6 Ma? Be accurate.

Our response: We would correct it.

L75: first appearance of ASM in the main text, need to define first. In addition, for summer monsoons in Asia, there is the East Asia Summer Monsoon and the South Asia (India) Summer Monsoon. Which one do you mean? I assume East Asia Summer Monsoon?

Our response: Actually, South Asia Summer Monsoon also put impact on the XSZ. However, the impact is not as significant as that put by East Asia summer Monsoon. We would consider modifying it.

L76-77: In the abstract, the authors consider the ASM as moisture carrying, but the Westerlies as moisture lacking. So it's not appropriate to list them together. In addition, moisture transport is short-time climate condition, how could it cause long-tern glaciation?

Our response: Thank you for point it out, we would modify it.

L82: "warm and wet" climate yield "wet" climate? Definitely!

Our response: We would modify it.

L84: a weakened summer monsoon of where? Globally or East Asia only?

Our response: It is East Asia Summer Monsoon. We would modify lines 75-88 as "The Asian summer monsoon (ASM) and the meridional (westerlies) circulation systems, as major components of the atmospheric circulation, delivered moisture to Eurasia. The onset and strength of the Asian monsoon during the early Pliocene was linked to the uplift of the Tibetan Plateau (TP), changes in latitudinal and longitudinal heat gradients, global temperature and ice volume (An et al., 2001; Ding et al., 2001; Li et al., 2008, 2010; Clift et al., 2008; Nie et al., 2014; Ao et al., 2016). Therefore, determining the range of climatic conditions across the East Asia during the Pliocene not only improves our understanding of the regional climate, but it can also provide insights into the palaeo-monsoon, and thus into changes in the global climate system at this time".

L89-91: onset of interior Asian aridification since the late Miocene? This is totally unjustified. Numerous studies indicate much earlier onset of Asian interior aridification, e.g., since 22 Ma (Guo et al., 2002), or much earlier at Eocene-Oligocene transition (Dupont-Nivet et al., 2007), or late Eocene (Bosboom et al., 2014).

Our response: We would modify the "onset" as the "enhancement".

L103-105: is this phenomenon also observed in other studies?

Our response: Yes, pollen assemblages at Chaona indicate a considerably warmer and more humid climate from 4.61-4.07 Ma which was not consistent with that the low magnetic susceptibility values (Ma et al., 2005).

L107-108: what inconsistent? Need to clarify. For the evidence listed above, it's necessary to point out which region is dominated by westerlies, which is dominated by ASM.

Our response: We would add “where climate is dominated by westerlies,” after “Tarim basin” in line 92 and “where climate is dominated by East Asia Monsoon,” after “In eastern and central CLP,” in line 94.

L110: why the western CLP is especially important? Need to give reasons here.

Our response: We would modify it as “Clarification of the evolution and dynamics of the westerlies and the palaeo-ASM requires accurate paleoclimatic reconstructions in the East Asia especially in the NE Tibetan Plateau, which is at the junction of the westerlies and monsoonal influences.”

L126-127: rejuvenated at what time?

Our response: The tectonic movement of the Pre-Sinian formed the inverse anticlinorium and several faults arranged as en echelon (or parallel) pattern, which lay the foundation for outline of Maxianshan (Li et al., 1990). The planation surface research indicates the tectonic movement since late Miocene made the area uplift with a great amplitude (Li et al., 2017, Ma et al., 2016).

L175-182: what are the criteria to divide the carbonate content plot into 6.7-4.8 Ma and 4.8-3.6 Ma. I do not see apparent difference between these two subdivisions. For the 6.7-4.8 Ma interval, the carbonate content is 3.8-39.2.The 6.0-5.5 interval, with much smaller amplitude of fluctuation, seems to be more different from the other time intervals.

Our response: Figure 3 may not show the distinct of two periods clearly enough due to variable deposition. Thus, we present figure of records versus stratigraphic depth (Fig 1s). Synthesized the values and variations of the carbonate content, elements content and magnetic susceptibility, a transition period is presented at 16.5-15 m (4.8-4.6 Ma). There is an obvious difference in the character of the fluctuations above and below the depth of 16.5-15 m. For example, above the 16.5 m, the carbonate content fluctuates at a lower level but with larger amplitude accompanied by the noted increase in nodule horizons underlaying leached zones in the field, and the magnetic susceptibility also fluctuates at greater amplitude. Meanwhile, a noticeable drop in deposition rate around 4.8 Ma occurred. Thus, we define the 4.8 Ma as the transition point.

The average value and coefficient of variation of the records during two periods (6.7-4.8 Ma and 4.8-3.6 Ma) have been given in Tables 1s. The coefficient of variation (CV) is defined as:

$$CV = 100 * \frac{\text{Standard deviation}}{\text{Mean}}$$

The higher the CV, the more changeable the record. It shows the average value and CV of the most records show the obvious difference between two periods and most of the records are more changeable during 4.8-3.6 Ma than 6.7-4.8 Ma.

We would explain it in revised version.

L185-187: looking at Fig. 3, it's pretty hard to determine whether two plots are of similar trend, or opposite trend. I would suggest to provide statistical evaluation to help readers understand the similarity between plots.

Our response: Would add table 2 in the revised version.

L188: provide the ranges of Al_2O_3 and K_2O for the two time intervals. L189: why choose 4.8 Ma as the boundary? The values between 4.8-4.6 seem be more similar as the 6.7-4.8 Ma interval.

Our response: Fig1s shows 16.5-15m (corresponding to 4.8-4.6 Ma) is a transition period. During this period, K_2O and Rb increased while CaO, Na_2O and Sr decreased. The transition period means climate translates from one condition to another. Meanwhile, a noticeable drop in deposition rate around 4.8 Ma occurred. Thus, we define the start of the transition period (4.8 Ma) as the transition point.

We would modify the statement of lines 184-191 as "The XSZ red clay consists mainly of SiO_2, Al_2O_3, CaO and Fe_2O_3 with low concentrations (<5%) of MgO, K_2O, Na_2O, Sr, Rb and Ba (Table 1). During *Interval* Ⅰ, K_2O ranges from 1.9-3.3% with an average content of 2.6%. Na_2O ranges from 0.14-1.52% with an average content of 1.2%. Rb ranges from 80-125 ppm with an average content of 103.9 ppm. Sr ranges from 150-252 ppm with an average content of 211.7 ppm. During *Interval* Ⅱ, K_2O ranges from 2-3.7% with an average content of 3%. Na_2O ranges from 0.94-1.54 % with an average content of 1.23%. Rb ranges from 74-134 ppm with an average content of 109.9 ppm. Sr ranges from 141-281 ppm with an average content of 214.6 ppm. The variations in CaO show the same trend as carbonate content. The variations of Rb and K_2O are synchronous and roughly opposite to that of CaO. The changes of Sr show some similarity with CaO. Accordingly, table 2 indicates CaO has positive correlation with $CaCO_3$ and Sr while negative correlation with other elements. The variations in CaO, K_2O, Sr and Rb content during 4.8-3.6 Ma are greater than those during 6.7-4.8 Ma, which is also indicated by the CV of these elements (Table 1) ."

L193: similar question, why group values between 6.7-4.8 together, but not include values between 4.8-4.6, which exhibit more similarities as the 6.7-4.8 Ma interval, which are of lower values and smaller amplitude of variation.

Our response: Fig1s shows magnetic susceptibility start to increase from 16.5m (4.8 Ma).

L204: there is no difference between these two intervals.

Our response: >40 um content is a proxy for winter monsoon strength. <2um content partly adheres to coarser silt and sand particles. Thus, we do not take two contents into consideration here.

L206: in Fig. 3, it shows >40 um.

Our response: It's >40 um. We would correct it.

L251: I have a question here, maybe very basic in your discipline. If one wants to use K_2O/Na_2O values to determine the intensity of chemical weathering, a pre-assumption is that before weathering, all the samples have similar K_2O/Na_2O values. Right? How about if the original K_2O/Na_2O values are different? This question might also exist for other chemical proxies used here.

Our response: It's really a good question. Previous studies have indicated the rare earth element distribution patterns of both the loess and red clay are identical to those of upper continental crust (Ding et al., 2001; Jahn et al., 2001). It suggested the initial geochemical composition of well mixed loess and red clay is similar. Thus, changes in K_2O/Na_2O and Rb/Sr ratios are mainly determined by post-depositional weathering.

L287-288: Could you please explain this in more detail? Which feature in Fig. 5d denotes orbital signal increase since 4.8 Ma? As far as I can infer from Fig. 5d, in the carbonate content plot, the orbital parameters increase since 4.9-5.0 Ma. While, in the Xpedo plot, it seems the increasing timings are diachronous for different orbital parameters.

Our response: Thank you for pointing it out. The explanation for plot Fig 5d may be not appropriate. We consider removing the wavelet plots and the statement "Furthermore, Morlet wavelet transform analysis of both carbonate content and χpedo show that the orbital signal increases since 4.8 Ma (Fig. 5 d)" in lines 286-288.

L292-295: Here the authors propose that the carbonate content and Xpedo signals reflect incomplete preservation of paleoclimate signals. Then the question is if the original paleoclimate signals are incomplete, how would you use these records to predict paleoclimate changes?

Our response: It involves scale problem. These records cannot document the millennial-scale climate change completely but can document paleoclimate changes in ten thousand scale. The reason why we said the signals are incomplete is that 20% of sample intervals are not satisfied with the requirement for detecting the precession signal (with the resolution 4 kyr or less).

L308-312: According to the authors' statement, the rapid change from 6.7-4.8 Ma low amplitude to 4.8-4.1 Ma large amplitude is observed in all the three orbital parameters. But for the benthic foraminiferal $d^{18}O$ record, similar change is only observed in the 41-kyr component. Why? This does not read like strong evidence to infer that the wet-dry oscillations were driven by changes in ice volume or global temperature. An associated question would be if the authors do not consider solar radiation intensity is the cause of the wet-dry cycles, but ice volume or global temperature, then what's the cause of ice volume and global temperature changes? Isn't solar radiation intensity a driving factor?

Our response: "This may mean that the increased contrast in wet-dry oscillations at the XSZ site was not driven directly by changes in solar radiation intensity but rather was linked with changes in ice volume or global temperature."(lines 310-312). Sorry, the sentence is an ambiguous or misleading expression. It's the enhancement for wet-dry contrast not wet-dry oscillation, which was linked with changes in ice volume or global temperature. We would correct it. Changes of Earth orbital parameters (linked to solar radiation intensity) would dynamically lead to the variation of the climate including changes in global temperature, ice volume and also wet-dry cycles of Xiaoshuizi. However, the change of Earth orbital parameters is just one of forcing factors and some internal process or feedback could magnify or cover the orbital forcing, which means the climate changes probably show non-linear response to orbital forcing (solar radiation intensity). In this specific case, it might be the expansion of the palaeo-ASM that enhanced the orbital periodic signals of XSZ red clay between 4.8 and 4.1 Ma.

In addition, glacial–interglacial climate cycles show different response to three orbital periodic changes in different time periods. For example, the LR04 benthic stack exhibits significant coherency with insolation in the obliquity band throughout the entire 5.3 Ma (Lisiecki, 2005) and glacial–interglacial cycles was dominated by 100-kyr eccentricity band approximately 0.8 Ma ago (Lisiecki et al., 2010). Thus, the change is only observed in the 41-kyr component of benthic foraminiferal $\delta^{18}O$ record is reasonable. Furthermore, in our records, the most significant change is also observed in 41kyr filtered components. The remarkably increased amplitude of the 41kyr filtered components from XSZ and the deep sea $\delta^{18}O$ record at about 4.8 Ma indicating common changes may have synchronously amplified the response of $\delta^{18}O$ record and XSZ wet-dry oscillations to obliquity forcing. The variation of deep sea $\delta^{18}O$ related to the changes in global temperature and ice volume (Zachos et al., 2001). The increased wet-dry oscillation of XSZ related to the expansion of palaeo-ASM. Thus, the expansion of palaeo-ASM may be related to changes in global temperature and ice volume. It is not the evidence but just one possibility.

L317-318: I find this conclusion hard to believe. For the carbonate content signal, the authors state that they record incomplete paleoclimate signal (see comments for L292-295). For the K2O/Na2O and Rb/Sr record, a more apparent change seems to be at 4.6 Ma. If higher carbonate content represents dry climate, and lower carbonate content representshumid climate, compared with 6.7-4.8 Ma, the 4.8-3.6 Ma would have more humid period, but also much drier period, because the 4.8-3.6 Ma has larger variability. While, I did not see a clear wetting trend.

Our response: Firstly, as mentioned above, paleoclimate signal is incomplete in millennial scale. In ten thousand scale, it is complete. Secondly, carbonate content averaged with 13.8% during the interval of 4.8-3.6 Ma and 17.4% during the interval of 6.7-4.8 Ma, which indicate climate became wetter after 4.8 Ma. In detail, during the interval of 4.8-3.6 Ma, the carbonate content fluctuates with greater amplitude but at a lower level and leached horizons is thicker than the interval of 6.7-4.8 Ma, which means leaching process enhanced after 4.8 Ma. Thirdly, the similar phenomenon was also observed in Xijin loess-paleosol series that in loess layers carbonate has a high average content with small fluctuation amplitude while in paleosol layers carbonate has a low average content with large fluctuation amplitude (Ye, 2017).

L363-364: This is a false statement. Even at present, the Tibetan Plateau cannot block the

Westerlies completely. The Westerlies can travel to the northeastern Tibet through valleys in the Tianshan.

Our response: Thank you for pointing it out. We would consider removing it.

L368: which plots are pedogenesis proxies? Cite the specific plots here. "roughly"? how rough? Better to give a quantitative value.

Our response: We would add "χ_{pedo} shows a significant positive relationship with $\delta^{18}O$ at 80 % confidence (Fig. 4f)" after "pedogenesis proxies roughly parallel to the stacked deep- sea benthic foraminiferal oxygen isotope curve" of lines 368-369. We would also add the fig 4f

L391-392: is there evidence to suggest reduced amount of atmospheric water vapor? Weakening of the paleo-ASM and dominance of Westerlies can explain the aridity. This does not necessarily need reduced amount of atmospheric water vapor.

Our response: We would modify the statement of lines 391-393 as "However, moisture sources for the westerly flow are distant from the CLP (Nie et al., 2014), and only a relatively small amount of moisture was carried to the CLP, resulting in a dry and stable climate in the XSZ region."

L469: "extremely wet"? wetter than any other period?

Our response: The expression is inappropriate. We would modify "As mentioned above, the extremely wet climate across the CLP was synchronous with the gradual closure of the Panama Seaway, which led to a larger reorganization of the global thermohaline circulation pattern" as "The occurrence of humid climate across the CLP was synchronous with the gradual closure of the Panama Seaway (Jackson and O'Dea, 2013; O'Dea et al., 2016)."

L528-530: I probably missed it, but how could your records reflect seasonality of precipitation? Which proxy records seasonal signals?

Our response: Research on migration process of carbonate indicated seasonally wet/dry climate is a key factor in driving carbonate dissolution and reprecipitation, and strong seasonally biased precipitation enhances the leaching process and produces thick leached horizons (Rossinsky and Swart, 1993; Zhao, 1995, 1998). The emergence of high-frequency cycles of carbonate eluviation-redeposition and thicker leached horizons indicates that seasonal precipitation increased during the interval of 4.8-3.6 Ma.

L532: why the strongest summer monsoon is between 4.6-4.25 Ma? What are the possible reasons for the decreasing strength after 4.25 Ma?

Our response: From 4.60-4.25 Ma, pedogenesis and weathering intensity of XSZ reached a maximum, as did precipitation intensity, which is manifested by the enhanced eluviation and carbonate accumulation. These evidences indicate the strength of summer monsoon is strongest from 4.60-4.25 Ma. Meanwhile, the temperatures of both high northern latitude and subtropic Pacific were relatively high, which may be responsible for enhancement of the paleo-ASM system. On the other hand, input of ice raft debris into subarctic northwest Pacific increased from 4.25 to 4.1 Ma which indicates temperature of the high northern latitudes decreased. Temperature at subtropic Pacific also decreased after 4.0 Ma. The decreased temperature of high northern latitude and subtropic Pacific may be the reason for the decreasing strength of palaeo-ASM after 4.25 Ma (Fig. 6).

Figures:

Fig. 1: a, the present outline is too large, the wind vectors are too small to see. It's better to show a smaller region with more details; e.g., regions between 10N-50N, 70E-130E. c. highlights the Xiaoshuizi section. Hard to find now.

Our response: Thank you for suggestions. We would modify it. (Fig 1)

Fig. 2: These photos exhibit very few useful information.

Our response: These photos visually exhibit information about Xiaoshuizi planation surface and red clay.

Fig. 3: Between 4.8-4.6 Ma, most plots show a weird shape. Is this because there are limited samples compared with other time intervals?

Our response: Yes, it is. We would use figure1s to replace the figure 3

Fig. 5: apparently the authors need to provide more information in the caption about their plots. For example, Fig. 5d, what does the color mean? What does the black curve represent? Also, the horizontal age scale is better to use Ma, but not ka, as Ma is used throughout the manuscript. In Fig. 5a-b, there are other strong periodicities denoted. How about these periodicities in Fig. 6d?

Our response: We would modify it. (Fig. 5)

Fig. 6. It will be better to arrange all the proxies with the same logic, e.g., left-wet, right-dry.

Our response: The reason why we put the benthic foraminiferal $\delta^{18}O$ record with different logic from other records is that we would like to show the similarity of benthic foraminiferal $\delta^{18}O$ record and χ_{pedo} curve during 6.7 to 4.8 Ma.

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Figures and tables

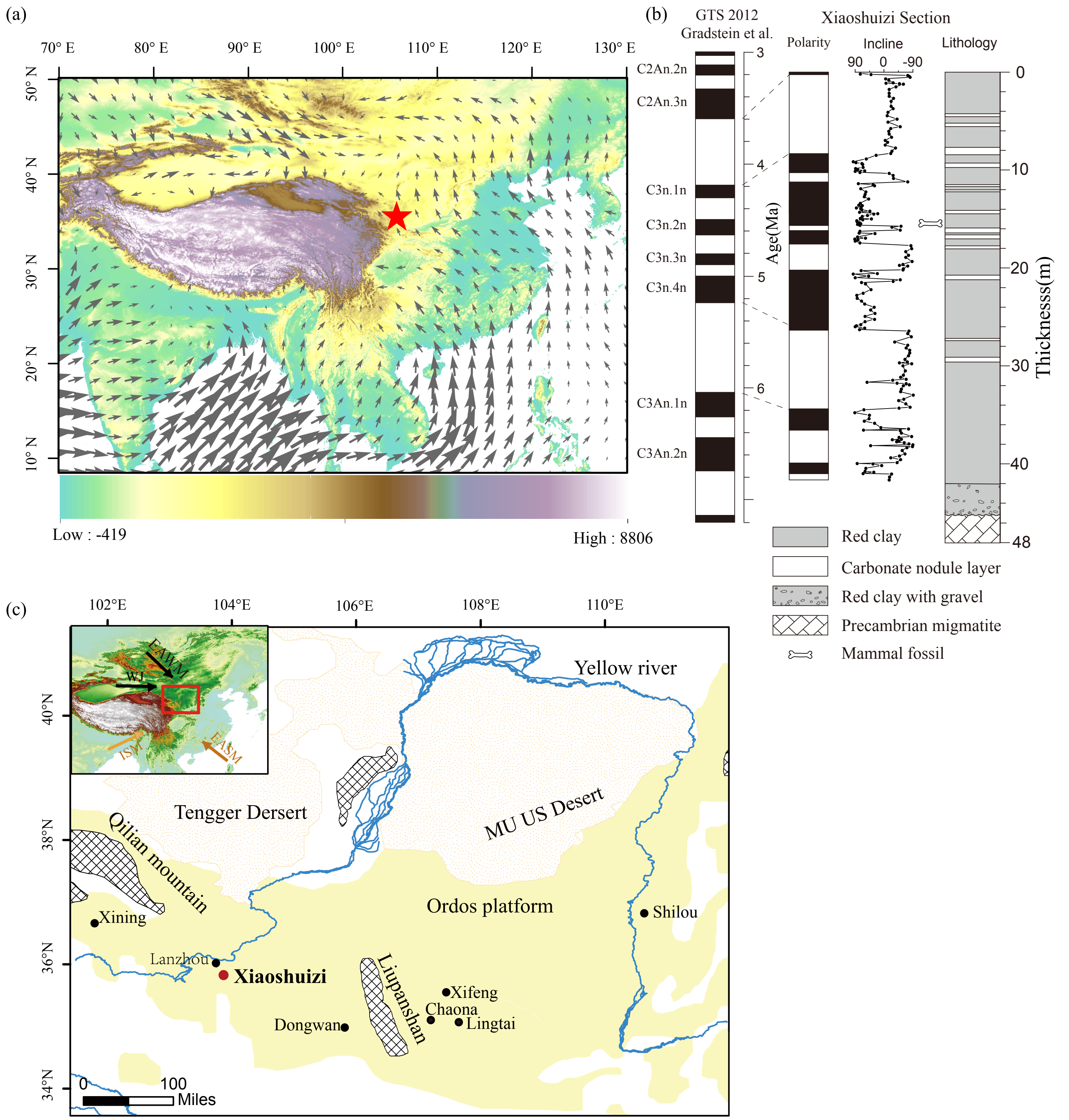

Fig. 1. The location of the study area and atmospheric circulation patterns. (a) 850 mb vector wind averaged from June to August for 1982-2012 based on NOAA Earth System Research Laboratory reanalysis data (Compo et al., 2013). (b) Lithology and magnetostratigraphy of the XSZ drill core. (c) The Chinese Loess Plateau with locations of the studied Xiaoshuizi site and other sections mentioned in the text.

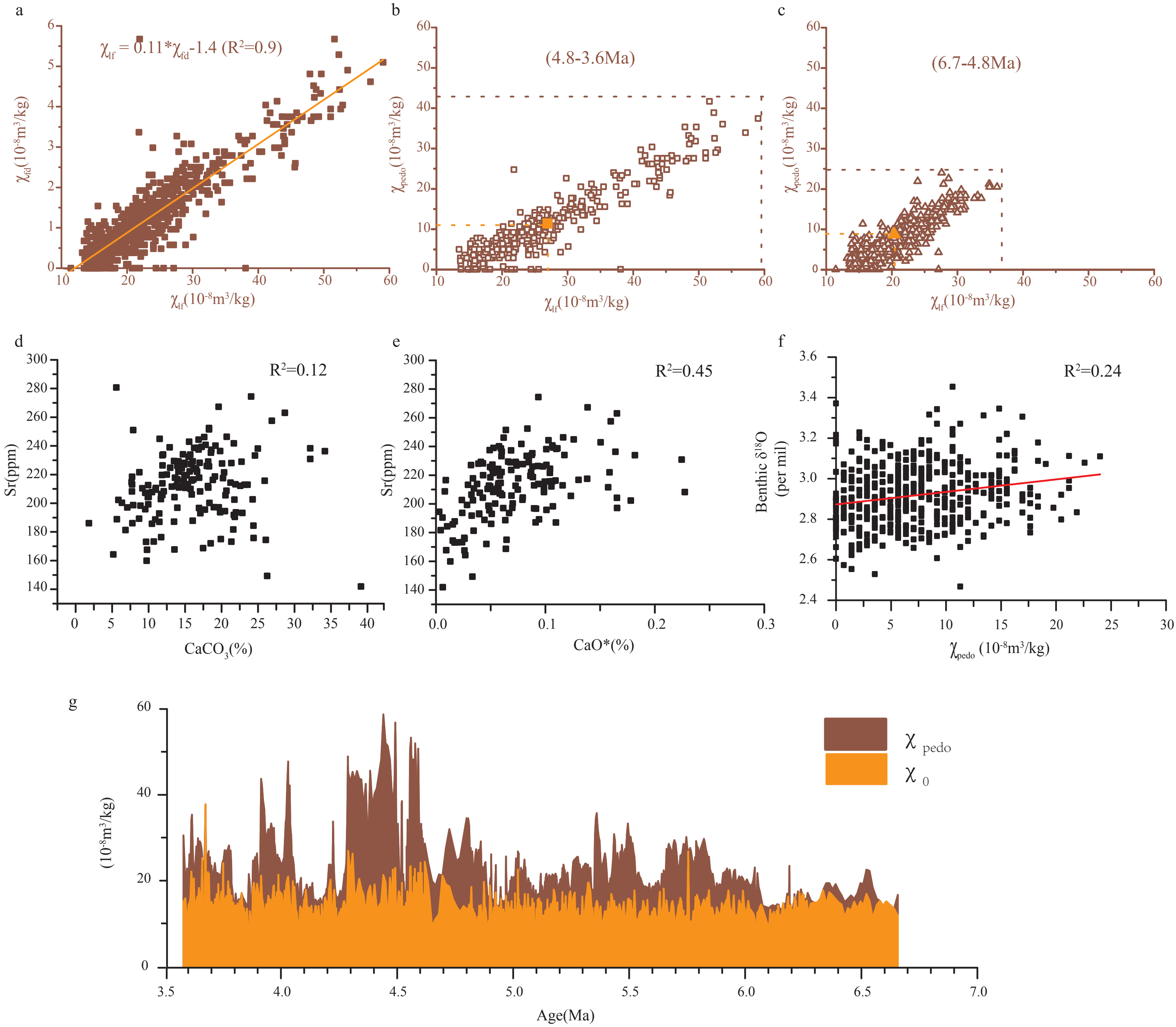

Fig. 4. (a) Scatter plot of χ_{lf} versus χ_{fd}. (b) Scatter plot of χ_{lf} versus χ_{pedo} during 4.8-3.6 Ma. (c) Scatter plot of χ_{lf} versus χ_{pedo} during 6.7-4.8 Ma. (d) Scatter plot of Sr versus $CaCO_3$. (e) Scatter plot of Sr versus CaO*. (f) Scatter plot of benthic $\delta^{18}O$ versus χ_{pedo} during 6.7-4.8 Ma. (g) Separation of χ_{pedo} and χ_0.Solid squares and triangles are the average values during 4.8-3.6 Ma and 6.7-4.8 Ma, respectively. χ_{pedo} is the magnetic susceptibility of pedogenic origin and χ_0 is the magnetic susceptibility of the detrital material.

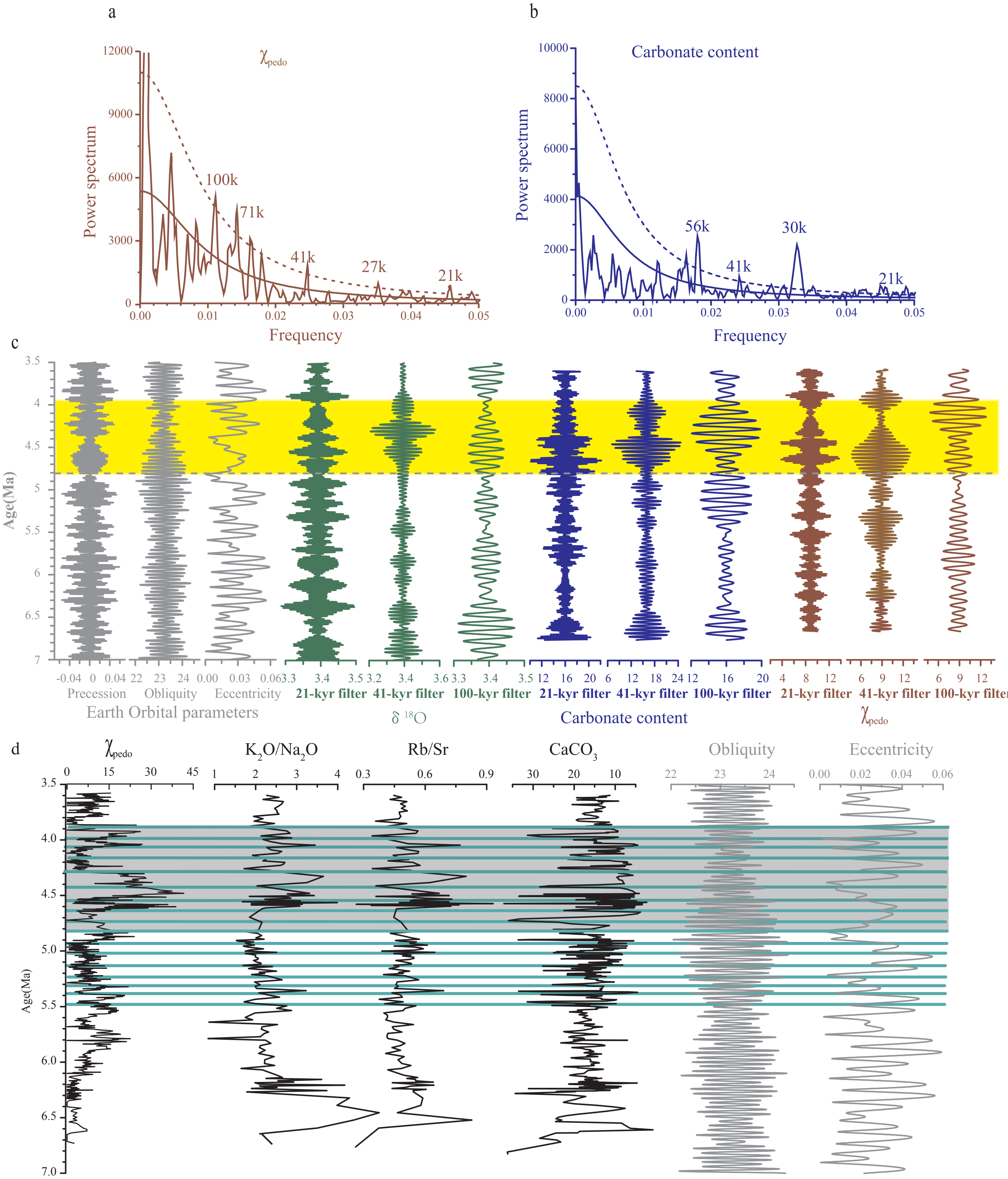

Fig. 5. Spectrum analysis of the red clay. (a) χ_{pedo} and (b) carbonate content(blue) . (c) Comparison of orbital parameters (i.e., eccentricity, obliquity and precession,Laskar et al., 2004) with filtered components of the carbonate content, χ_{pedo} and $\delta^{18}O$ records (Zachos et al.,2001) at the 18-24 kyr, 36-46kyr, and 90-110 kyr bands. Yellow shading denote the largest amplitude of filtered components of carbonate and χ_{pedo} at the three orbital bands. Dashed lines indicate a large shift in the East Asian monsoon circulation occurred around 4.8 Ma. (d) Carbonate, weathering and pedogenesis intensity fluctuations linked to eccentricity and obliquity orbital variations at 4.8–3.9 Ma.

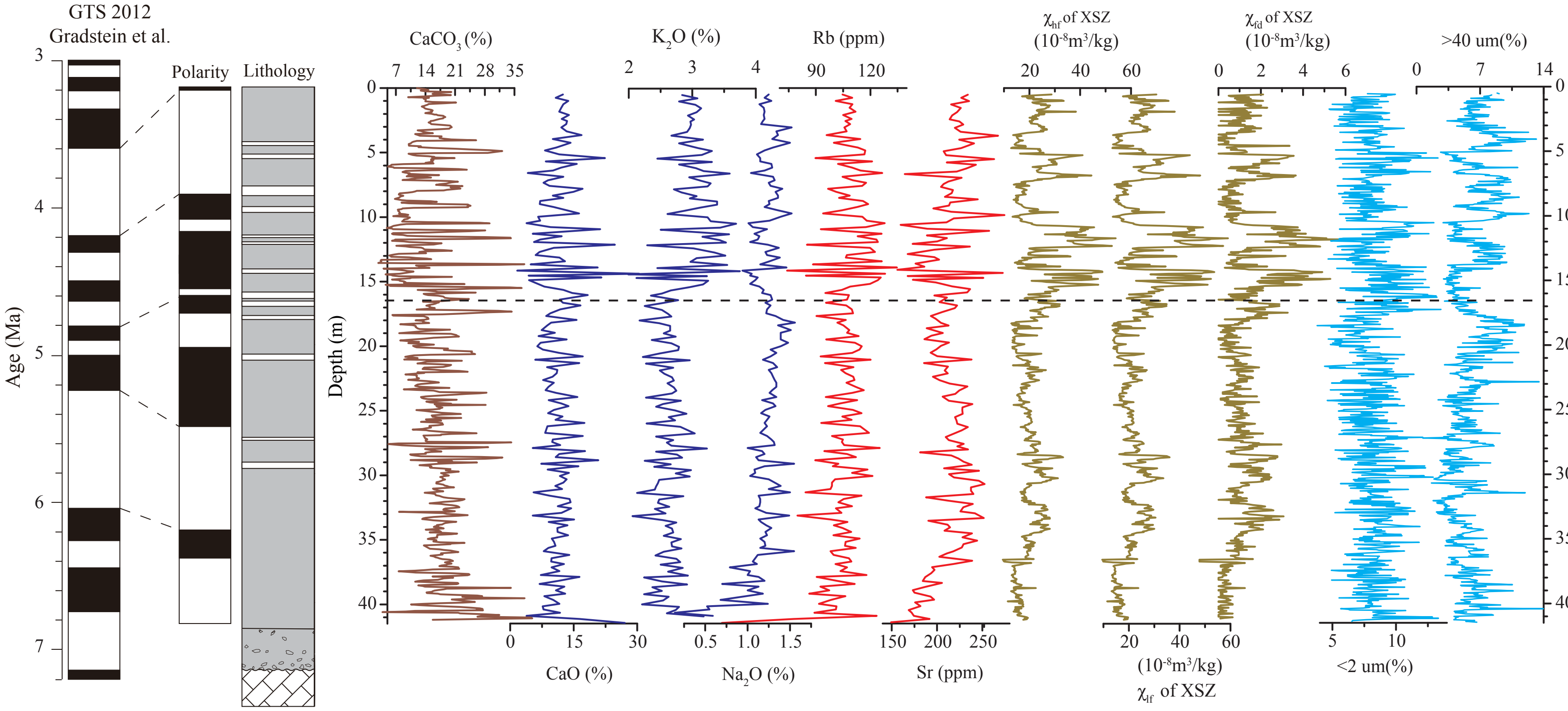

Fig. 1 s. Variations in carbonate content, major element concentration, minor element concentration, magnetic susceptibility and grain size from the XSZ red clay section, spanning 6.7-3.6 Ma

Table. 1. The average value and coefficident of variation of the records during two periods of 6.7-4.8 Ma and 4.8-3.6 Ma.

		SiO_2(%)	Al_2O_3(%)	CaO(%)	Fe_2O_3(%)	K_2O(%)
4.8-3.6 Ma	Average	48.9	13.2	11.6	5.69	3
	CV	14.6	9.58	45.57	9.3	12.3
6.7-4.8 Ma	Average	49.5	12.2	11.2	5.2	2.6
	CV	11.6	9.09	32.18	9.6	10.3
		Na_2O(%)	MgO(%)	Sr(ppm)	Rb(ppm)	Ba(ppm)
4.8-3.6 Ma	Average	1.23	2.3	214.6	109.9	558
	CV	24.4	9	12.5	10.9	11.5
6.7-4.8 Ma	Average	1.2	3.1	211.7	103.9	494
	CV	10.2	61	10.04	10.8	13.2
		$CaCO_3$(%)	χ_{hf}	χlf	χfd	
4.8-3.6 Ma	Average	13.8	25.4	26.9	1.2	
	CV	45.6	38.3	36.2	78.2	
6.7-4.8 Ma	Average	17.4	19.4	20.3	1	
	CV	29.3	23.8	21.2	72.8	

Table. 2. The correlation coefficient between elements and CaO, $CaCO_3$ and K_2O

	CaO	$CaCO_3$	K_2O
Fe_2O_3	-0.63	-0.18	-0.29
SiO_2	-0.95	-0.39	0.72
Al_2O_3	-0.77	-0.61	0.95
CaO	1	0.51	-0.67
MgO	-0.04	0.13	-0.11
Na_2O	-0.06	-0.10	-0.38
K2O	-0.67	-0.47	1
Rb	-0.20	-0.36	0.12
Sr	0.24	0.34	-0.29
Ba	-0.25	-0.33	0.63
$CaCO_3$	0.51	1	-0.47