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.

I think the manuscript needs to present the geochemistry data versus stratigraphic depth, in addition to just age. There also needs to be more discussion on the relationship between sedimentation rate and pedogenesis. For example, it would be helpful if Figure 3 was plotted vs. depth and there was also a column that plots sedimentation rate, and the presence of nodule horizons. This is important because the interval between 4.5 and 4.3 Ma, for example, shows a strong increase in magnetic evidence for pedogenesis and also coincides with a noticeable drop in deposition rate. Therefore, it needs to be discussed if this increase in pedogenesis was driven solely by wetter conditions, or was there also more time for soil formation and leaching of Ca. I do think more stratigraphic context will help some of the arguments presented in the text. For example, upon my initial reading of the text and figure, the division into the 2 primary intervals placed at 4.8 Ma seemed somewhat arbitrary looking at figure 3 (i.e. why not 4.6 or 5.1). But it makes much more sense in terms of the large decline in sedimentation rate around 4.8, which accompanied by the deposition of a carbonate nodule layer, and then the noted increase up-section in nodule horizons underlaying leached zones. Also with deposition of loess being connected to regional wind patterns, is it significant that there was a notable _200 kyr drop in sedimentation rates before a shift to generally wetter/more seasonal conditions?

Our response: Many thanks for your useful suggestions. We would use Fig 1s to replace the Fig 3 and we would add a brief statement "Profiles of the various proxies are illustrated in Fig 3 and there is an obvious difference in the character of the fluctuations above and below the depth of 16.5 m (~4.8 Ma). Above 16.5 m, the carbonate content fluctuates at a lower level but with greater amplitude, and the magnetic susceptibility also fluctuates at a greater amplitude. In addition, the CV of most of the records is greater above the boundary than below (Table 1). This suggests that the climate became more humid and variable after 4.8 Ma. Meanwhile, a noticeable drop in deposition rate around 4.8 Ma occurred (Li et al., 2017). Thus, the red clay sequence was divided into two intervals: *Interval Ⅰ* (6.7-4.8 Ma) and *Interval Ⅱ (*4.8-3.6 Ma). The characteristics of the individual proxy records are describe in detail below" in front of line 174. We will also add "We use the coefficient of variation (CV) to measure the variability of the records. The higher the CV, the more variable the record. The CV is defined as:

$\mathrm{CV} = 100 * \frac{\text{Standard deviation}}{\text{Mean}}$,," at the end of chapter 3(line 172).

I am somewhat confused by the explanation of K/Al ratios as a weathering proxy (lines 238-245). With time, Al can mobilize and become depleted at the top of a paleosol and enriched down profile. And in certain situations, you might expect K to be enriched at the soil surface, due to its biological importance. So, within the same well developed soil, you might expect a higher K/Al ratio at the top, and a lower ratio deeper in the profile. This is never plotted, so it might be worth eliminating this text?
The various magnetic susceptibility terms are well described in the discussion, but I think it would help readers if at least some of this information was moved up to either the results or methods. This would help provide context to all of the values presented in the results.
Our response: We would consider removing the K_2O/Al_2O_3 ratio and modify the statement "In addition, previous…" in lines 238-252 as "In addition, the K_2O/Na_2O ratio is used to evaluate the clay content in loess and is also a measure of plagioclase weathering, avoiding biases due to uncertainties in separating carbonate Ca from silicate Ca (Liu et al., 1993; Buggle et al., 2011). Na_2O is mainly produced by plagioclase weathering and is easily lost during leaching as precipitation increases. By contrast, K_2O (mainly produced by the weathering of potash feldspar) is easily leached from primary minerals and is then absorbed by secondary clay minerals with ongoing weathering (Yang et al., 2006; Liang et al., 2013). In the arid and semi-arid regions of Asia, K_2O is enriched in palaeosols compared to loess horizons (Yang et al., 2006). Thus, high K_2O/Na_2O ratios are indicative of intense chemical weathering. " We would also remove "The K_2O/Al_2O_3 ratio also increased rapidly at about 4.8-4.7 Ma and maintained relatively high values after 4.7 Ma. This may indicate that the overall weathering intensity was sufficient to produce secondary clays, resulting in a spike in K2O concentration" in lines 409-312.

Minor suggestions:
Line 57: suggest "occurring" or "underway" instead of "ongoing"
Our response: We would modify "ongoing" as "underway".

Line 76: suggest "supplied" instead of "prepared"
Our response: We would modify "prepared" as "supplied".

Lines 75-88: I'm guessing the sentence beginning with "Make clear: : :" on line 78 was accidentally left in as a comment, which I still think needs to be addressed. I think I understand what the authors are going for within the paragraph, but I think the logic can be expressed more clearly. The strength/onset of the Asian monsoon is linked to these globally significant events (Tibetan uplift, northern hemisphere ice, etc). Therefore, by constraining paleoclimate across the Chinese Loess Plateau not only does this improve our understanding of regional climate, but it can also provide insight about the paleomonsoon, and therefore changes in the global climate system during the Pliocene.

Our response: Many thanks for your suggestions. We would modify the statement of 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 Chinese Loess Plateau (CLP) during the Pliocene not only improves our understanding of the regional climate, but it can also provide insights into the paleomonsoon, and thus into changes in the global climate system at this time."

Line 96: suggest removing "condition" and changing "aridification process" to "regional aridification"

Our response: We would removing "condition" and modify "aridification process" as "regional aridification"

Line 104: change "to be" to "that", and I think it would be helpful for the future readers not just to say "gleying", but instead state briefly what that means (waterlogging, and iron reduction) and why it matters for the magnetic susceptibility record.

Our response: We would take consideration in the revised version.

Line 105-106: This sentence does not make sense. Are you trying to say that climate in this region is influenced by the strength of both the westerlies and the monsoon, and that those two factors may not be directly related?

Our response: We would remove it and add "where climate is dominated by westerlies," after "Tarim basin" in line 92.

Lines 114-115: What makes the XSZ red clay different geomorphologically?

Our response: The Xiaoshuizi peneplain of the Maxian mountain occupies a critical transition position between the high-altitude TP and the low North China Craton (Li et al., 2017). 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.

Line 118: suggest "are" instead of "have been"

Our response: We would modify "have been" as "are"

Line 121: This sentence is slightly off.

Our response: We would modify it as "Finally, we consider the nature of the regional climate and its possible mechanisms"

Line 133: suggest "reconstruct and discuss" instead of "discuss "
Our response: We would modify "discuss"as "reconstruct and discuss"

Line 133-134: not sure exactly what is meant here. Is the XSZ core characterized by more continuous deposition and records a longer time interval than the Shangyantan core?
Our response: Yes, SYT core is only covered the age from 6.4 Ma to 4.2 Ma.

Line 136: capitalize China
Our response: We would modify it.

Lines 137-138: Not sure what is mean by the sentence beginning with "The East Asian Monsoon." Are you trying to explain how these two factors together control climate at the study site. This could be elaborated.
Our response: We will remove it.

Line 144: Where in the section is the increase in gravel? From the strat column it looks like it is at the base. Say this in-text.
Our response: We would add "at the base" after "…gravel content" in line 144.

Lines 145-147: Clarify if most carbonate horizon are overlain by a brownish red-layer, or if the carbonate zone in its entirety underlies a larger brownish-red layer. Lines 148-150: It's not clear as written if carbonized root channels have more abundant Fe-Mn staining.
Our response: We would modify statement of lines 145-147 as "The upper 20 m contains numerous horizontal carbonate nodule horizons and most of these horizons underline the brownish red layer" and modify "horizons containing" in line149 as "the".

Line 168: Is all of the remaining Ca in silicate minerals? Won't a lot of it be loosely bound to clay minerals in the soils? Also, the correction for Phosphorous also needs to be explained. I'm guessing you are assuming some component of Ca-bearing phosphate minerals, but what is the basis for this assumption.
Our response: Thanks for your questions and suggestions. No, not all of remaining Ca in silicate minerals and the Ca bound to clay minerals is also included. Silicate-bound CaO* is obtained, in theory, by the simple equation (Fedo et al., 1995): $CaO^*(mol) = CaO(mol) - CO_2(calcite\ mol) - 0.5\ CO_2(dolomite\ mol) - 10/3\ mol\ P_2O_5(apatite)$. It generally calculated based the assumption that all P_2O_5 is associated with apatite and all inorganic carbon is associated with carbonates. It may neglect the Ca bound to clay minerals and overestimate the component of Ca-bearing phosphate minerals (Garzanti and Resentini., 2016). The reason we use the equation to calculate the values is that we try to expel the

possibility the variation of Sr is determined by the bound of secondary carbonate, but not by weathering intensity. For Sr can substitute Ca in secondary carbonates (Reeder et al., 2006; Buggle et al., 2011). We will modify statement "The molar content of silicate Ca (CaO*) was calculated using the following equation:" as "Silicate-bound CaO (CaO*) can be estimated, in principle, by the equation: CaO*(mol) = CaO(mol) – CO_2(calcite mol) − 0.5 CO_2(dolomite mol) − 10/3 mol P_2O_5(apatite) (Fedo et al., 1995). It is generally calculated based on the assumption that all the P_2O_5 is associated with apatite and all the inorganic carbon is associated with carbonates Thus, the CaO* of the XSZ red clay was calculated using the following equivalent equation" .

Line 199: What do you mean by durations? Are you saying there are some thicker intervals of high magnetic susceptibility?
Our response: Yes, it means the interval of strong pedogenesis sustained longer.

Line 256: space between "susceptibility" and "of"
Our response: We would correct it.

Line 257: suggest removing "two"
Our response: We would remove it.

Line 314: Spelling of "Multiproxy"
Our response: We would modify it.

Line 317-318: suggest "a significant change is recorded by most of the proxies that occurred"
Our response: We would take consideration in the revised version.

Line 318: K/Al is not plotted, but K/Na is plotted. Based on the comment above, I think this is probably a better choice.
Our response: We would modify "K_2O/Al_2O_3" as "K_2O/Na_2O".

Line 327: suggest "relatively" instead of "relative" and "and" instead of "which"
Our response: We would modify "relative" as "relatively" and modify "which" as "and".

Line 328: Not sure what this sentence is trying to say.
Our response: This sentence may be redundancy. We would remove it.

Line 329: I suggest clarifying the beginning of this sentence to say something along the lines of "Carbonate content becomes more variable after 5.5 Ma, which is…"
Our response: We would modify the sentence "It is evident that the carbonate content decreases with

increased variation amplitude after 5.5 Ma" as "Carbonate content becomes more variable after 5.5 Ma, which is…"

Line 333: spelling of "indices"

Our response: We would correct it.

Line 345: suggest "central and eastern" instead of "hinterland of the"

Our response: We would modify "hinterland of the" as "central and eastern".

Line 377: suggest rewording the sentence beginning with: "Look around the globe,.."

Our response: We would remove the sentence.

Line 415: I'm not sure what "humid toward arid direction" means

Our response: It means climate tended to be dryer.

Line 521: suggest "provides the opportunity constrain and discuss.."

Our response: We would take consideration in the revised version.

Line 526: again suggest "central and eastern" instead of "hinterland of the"

Our response: We would take consideration in the revised version.

Line 531: suggest removing "obviously"

Our response: We would remove it.

Figure 1: I think it would help if you put a larger non-circle shape on panel A corresponding to the study site. Then you can remove the Xiashuizi label, which slightly obscures the vector. Then, match this symbol on panel C You are missing the white reversals between C3n.1n, C3n.2n, and C3n.3n on the Polarity plot for the XSZ section. These were included in the age model presented in Li et al. (2017). What do the black bars on the lithology column represent.

Our response: Thank you for suggestions and pointing faults out. We have not noticed it in Fig. 1b. There is something wrong with this figure when we convert it into PDF format. Some thin white rectangles are missed. The black bars on the lithology column were the thin white rectangles representing the carbonate nodule layer. We would give the new figure (Fig 1).

Figure 2: I think it would help if the line thicknesses were slightly thinner.

Our response: You mean figure 3? We would modify it.

Reference

Buggle B, Glaser B, Hambach U, et al. (2011). An evaluation of geochemical weathering indices in loess–paleosol studies[J]. Quaternary International, 240(1–2):12-21

Fedo, C. M., Nesbitt, H. W., & Young, G. M. (1995). Unraveling the effects of potassium metasomatism in sedimentary rocks and paleosols, with implications for paleoweathering conditions and provenance. Geology, 23(10), 921-924.

Garzanti, E., & Resentini, A. (2016). Provenance control on chemical indices of weathering (taiwan river sands). Sedimentary Geology, 336, 81-95.

Li, J., Ma, Z., Li, X., Peng, T., Guo, B., & Zhang, J., et al. (2017). Late miocene-pliocene geomorphological evolution of the xiaoshuizi peneplain in the maxian mountains and its tectonic significance for the northeastern tibetan plateau. Geomorphology, 295.

Reeder, S., Taylor, H., Shaw, R.A., Demetriades, A., (2006). Introduction to the chemistry and geochemistry of the elements. In: Tarvainen, T., de Vos, M. (Eds.), Geochemical Atlas of Europe. Part 2. Interpretation of Geochemical Maps, Additional Tables, Figures, Maps, and Related Publications. Geological Survey of Finland, Espoo, pp. 48-429

Figures and tables

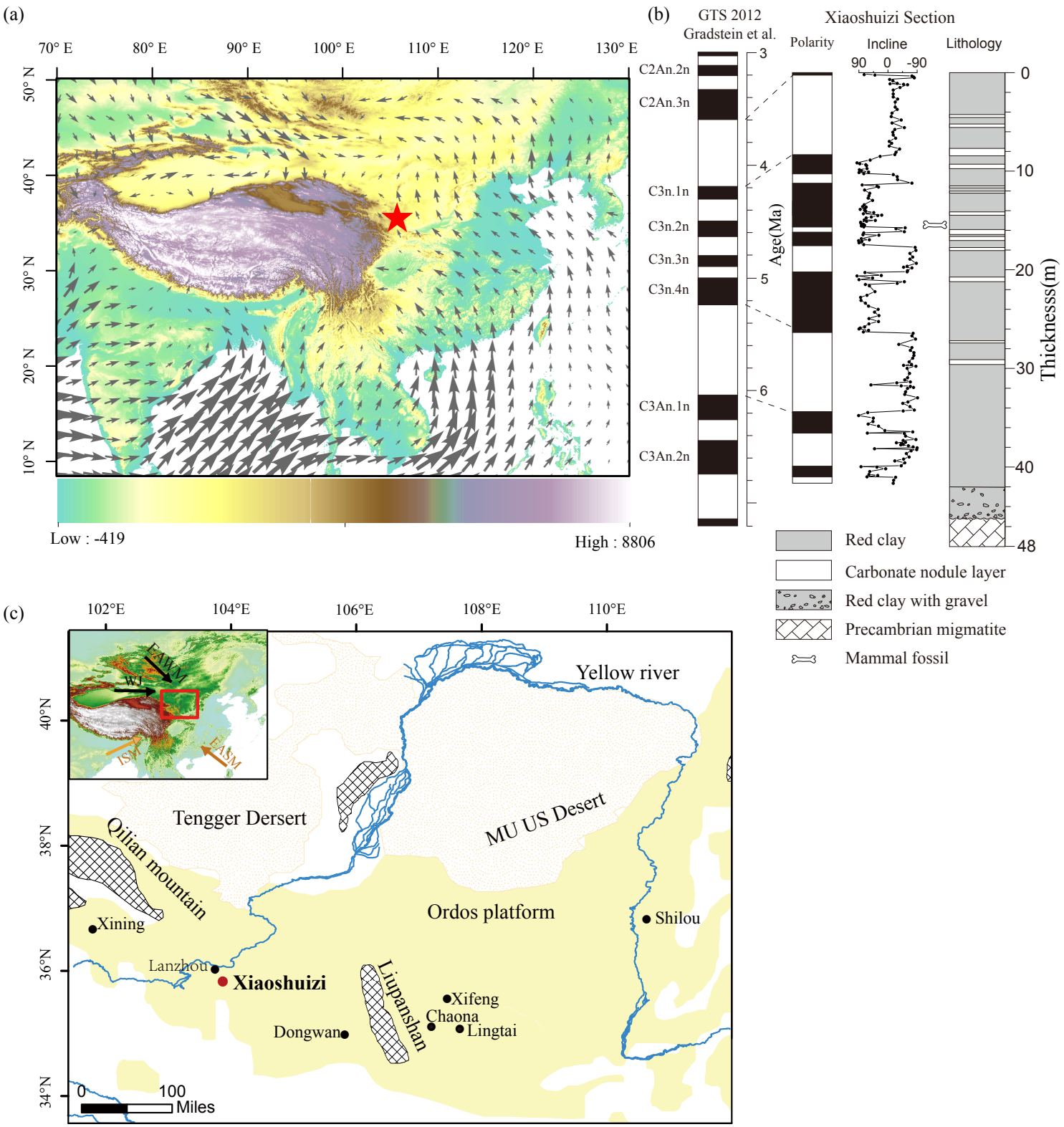

Fig. 1. The location of the study area and atmospheric circulation patterns. (a) 850 mb vector wind averaged from June to August for 1982-2012 based on NOAA Earth System Research Laboratory reanalysis data (Compo et al., 2013). (b) Lithology and magnetostratigraphy of the XSZ drill core. (c) The Chinese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

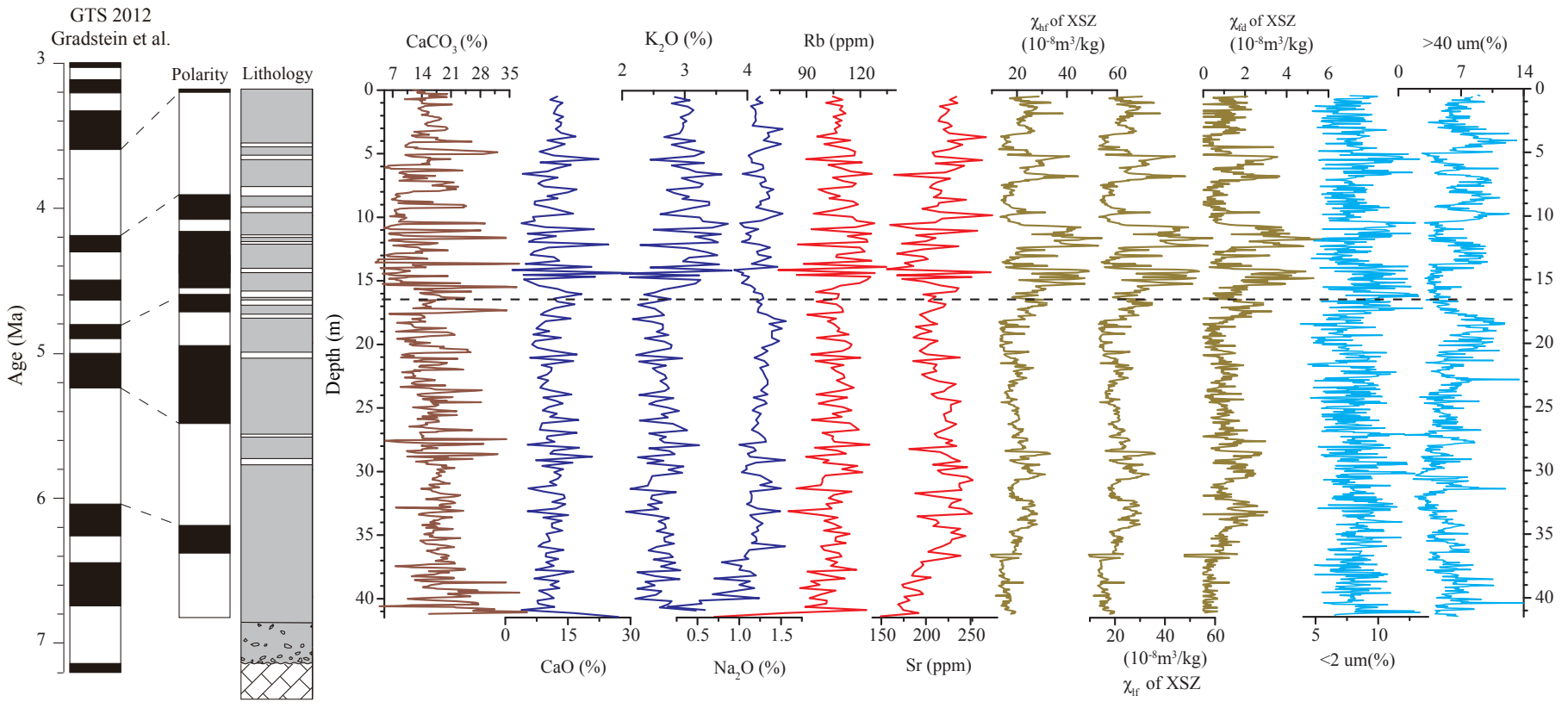

Fig. 1 s. Variations in carbonate content, major element concentration, minor element concentration, magnetic susceptibility and grain size from the XSZ red clay section, spanning 6.7-3.6 Ma