Abstract
Spectroscopy provides a rapid and nondestructive means of extracting paleoenvironmental information from sedimentary sequences. Here we apply the technique to the Miocene red clay deposits of the Jianzha Basin in the Tibetan Plateau. The results show that decreases in spectral parameters such as D500, D900 (where D represents the depth of the absorption peaks), while increases in R500 and R900 (where R represents the reflectance) reflect decreases in pedogenesis under a dry and cold climate. Also, AS1400 (where AS represents the asymmetry of the absorption peaks), D1400/D1900 and D1900 are correlated with clay mineral indicators, with increases in D1900 indicating reduced weathering intensity, while increases in AS1400 and D1400/D1900 represent increased weathering. The temporal variations of the spectral parameters are consistent with independent paleoclimatic records from the Jiarang section and with the marine δ18O record, which demonstrates their utility as paleoclimate proxies in red clay deposits, and spectral parameters can respond well to the ~8.5 Ma Tibetan Plateau uplift event and the ~7.2 Ma global climate change event in the eolian red clay of the Jianzha Basin.

Materials and Methods
A total of 666 samples from the Jiarang section at 20-cm intervals. Reflectance data were obtained using a FieldSpec4 & HandHeld2 spectrometer (ASD, USA). The ViewSpecPro, ENVI 5.3, Origin, SPSS and Unscrambler X 10.4 softwares were used to further analyze the spectral parameters.

Results and Discussion
Figure 5: Age profiles of spectral parameters and reflectance corresponding to Fe-bearing minerals and clay minerals, compared with independent paleoclimatic indicators from the Jiarang section. Visible/near-infrared (VNIR) parameters such as D500, D900 reflect decreases in pedogenesis under a dry and cold climate, and they are more sensitive to temperature, which can reflect climate change on orbital time scales. Reflectance corresponding to Fe-bearing minerals, R500 and R900 can also reflect the Fe-bearing mineral content, while the difference is that they are negatively correlated. The short-wave infrared (SWIR) parameters, including AS1400, D1400/D1900 and D1900 are correlated with the clay mineralogy, with increases in D1900 indicating weaker weathering under a colder environment, while AS1400 and D1400/D1900 represent stronger weathering under a warmer climate, and the SWIR parameters are more sensitive to the weathering intensity. Reflectance corresponding to clay minerals, R1400 and R1900 are related to the water content, and R2340 can indicate the illite content. Comparison of our results with the marine δ18O record revealed a good correspondence. Overall, the spectral parameters in the VNIR band are more applicable than those in the SWIR band, and the former can be focused on in the future.

Figure 6: Comparison of spectral parameters corresponding to Fe-bearing minerals and clay minerals with independent paleoclimatic indicators from the Chaona section in the loess-paleosol sequences, in order to verify the applicability of the spectral parameters, we extracted the spectral parameters of the loess-paleosol sequences of Chaona section from the central Chinese Loess. We found that there is a strong correlation between D500, D900 and δ18O, which indicates the same results as the Jiarang section. The AS1400, D1400/D1900 and D1900 were also verified in the loess-paleosol sequences of Chaona section on the Chinese Loess Plateau, while the results show that the three spectral parameters are less indicative of weathering. R1400 and R1900 are related to the water content, while R2340 is not a good indicator for illite content in loess-paleosols, which may be influenced by other minerals.

Introduction
Reflectance spectroscopy is easily and rapidly implemented, requires minimal sample preparation, and is inexpensive and nondestructive. Here, in a study of red clay of the Jiarang section from Jianzha Basin in the northeastern margin of the Tibetan Plateau, we use linear correlation analysis to assess the relationship between spectral parameters in the VNIR and SWIR bands (350–2500 nm) with traditional paleoclimatic indicators, with the aim of providing a foundation for the further application of VNIR and SWIR spectroscopy in paleoclimatology.

Regional setting and study section
The study section (35°57′43.11″N, 101°58′24.1″E) is located in Jianzha Village, Jianzha County. The vertical height of the section is 361 m and the altitude of the base is 2200 m. The interval selected for this study is 44–185.8 m, with the age range of 8.95–6.55 Ma.

References