The Vermiculated Red Soil in southern China and the strength extreme of East Asian monsoon

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Introduction

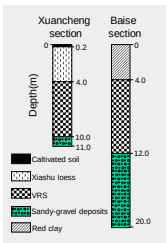
The palaeosol, widely distributed in the areas south of the Yangtze River and characterized by red and white veins, is called Vermiculated Red Soil (VRS). It formed in mid-Pleistocene based on chronological studies [1,2] , corresponding to the marine $\delta^{18}O$ stages 11-15 in times.

However, there are still some disputes about soil-forming processes and environmental significances of the VRS, which are very important to understand the palaeoenvironment of southern China in mid-Pleistocene. Moreover, many sections of the VRS are important Paleolithic sites [2,3], so the environmental study of the VRS will provide important background for archaeology.

The VRS from the Xuancheng section in Anhui province and the Baise section in Guangxi province are studied. These two sections both have reliable chronological data and are very important for the studies of palaeoenvironment and archaeology [2,3].

Based on soil micromorphology, clay mineralogy and chemistry, the following problems are discussed :(1) Morphological, chemical and mineralogical characteristics of the VRS and their implications for soil-geological processes; (2) Climate and environment when the VRS formed, and their potential relations with regional and global environment.

Materials and Methods

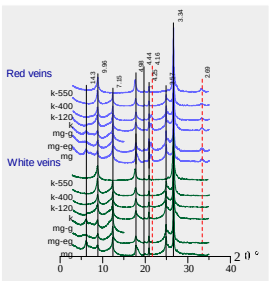


Stratigraphy of the Xuancheng and Baise section

Field pictures of the VRS from Baise

Soil Micromorphology is of special importance in reconstructing the original properties of the palaeosols. Micromorphological thin sections were studied using an optical microscope. The chemical analyses of the Clay fractions(<2 μ m) of the red and white veins were conducted on a XRF-1500 spectrum instrument. The oriented specimens of these clay fractions were treated with X-ray diffraction analyses on a DMAX 2400 X-ray diffraction instrument.

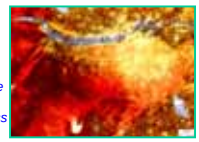
Results and discussion



X-ray diffractograms of the clay fractions from the red and white veins of the Xuancheng section

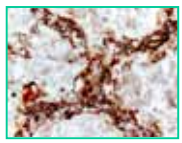
X-ray diffraction analyses indicate that the clay mineral assemblages are typical ones in tropical-subtropical regions, mostly kaolinite, secondly vermiculite and just a very little illite. The red veins have much more geothite than the white veins, and has much hametite that the white veins have not.

The gradual transition between the red and white veins(Baise, XPL);

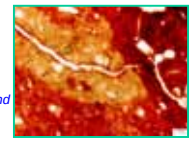


The clay coating at the transition. The part in the white veins shows lark color because of iron loss (Baise,XPL)

The gradual transition between the red and white veins indicates that they were disparted from the same and homogeneous soil matrixes.



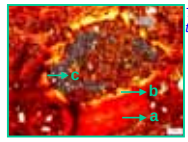
The planes in the white veins (Xuancheng, PPL)



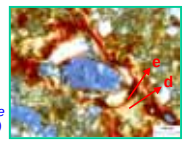
The planes in the White veins end at the boundary of the red veins (Baise, PPL) .

The voids in the VRS are mainly planes. The bulky planes develope very strongly in the white veins , and are very little in the red veins. The white veins around planes are usually symmetrical, indicating that the planes formed earlier than the white veins.

Clay coatings are very abundant in the VRS, and can be classified as the following five types .



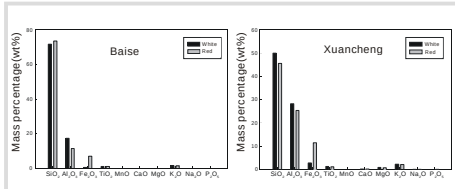
The clay coatings of type a, b, and c in the red veins (Baise, XPL)



The alternation of clay coatings of type d and e in the white veins(Baise, XPL)

The clay coatings of type b and c on the walls of the planes in the white veins (Baise, XPL)

The different kinds of clay coatings in the VRS indicate that it is complex palaeosol and developed under multistage and different climates .



Chemical analysis of the clay fractions of the red and white veins

The chemical components of the red and white veins are almost the same except for Fe_2O_3 and Al_2O_3 . The content of Fe_2O_3 in the red veins is far more than that in the white veins.

Micromorphology, chemical compositions and clay mineral assemblages of the red and white veins indicate that they were disparted from the same and homogeneous soil matrixes, and the former contain far more iron oxides than the latter, indicating that the white veins were formed due to the leaching and moving of local iron from the original red soil matrixes.

Based on their relative situations to each other, the homogeneous red soil matrixes containing coatings of type **a** and planes were formed firstly, the white veins were formed around the planes subsequently and the coatings of type **b**, **c**, **d**, and **e** were formed in turn lastly. According to this , the development of the VRS can be divided into the following three stages.

Stage 1 Formation of homogeneous red soil matrixes

clay mineral assemblages
clay coatings of type **a**
→ The homogeneous red soil is typical Red Earth in Chinese soil genetic classification , equivalent to Ultisols in Soil Taxonomy
→ hot, moist climates and indeciduous, latifoliate vegetation in the vast areas south of the Yangtze River during the soil forming period

Stage 2 Formation of the white veins

absence of Fe/Mn pedofeatures
great loss of iron
→ no conspicuous dry season, great rainfall even in winter

The studied areas are under the control of typical East Asian monsoon, so the vast areas of southern China were strongly controlled by East Asian summer monsoon circulations even though in winter, representing an unusually period with extremely strong East Asian summer monsoon when the white veins formed.

Stage 3 Climate fluctuations between cold and warm indicated by the alternating yellow clay coatings (type **b**, **d**) and red clay coatings (type **c**, **e**).

Conclusion

The VRS had mainly undergone three development periods. The first is the formation period of red soil matrixes which have the characteristics of Red Earth in Chinese soil genetic classification, the second is the white veins forming period characterized by large rainfall all the year and great iron loss, and the last is the period with the alternating temperate-subtropical soil-forming processes. The formation of the white veins is the key for the vermiculated characteristics.

The white veins represented the extreme strength of East Asian summer monsoon circulations. The vast areas south of the Yangtze River were under the control of summer monsoon circulations all the year in mid-Pleistocene, and there was no visible dry season. Some studies that showed unusually strong African and Indian Ocean monsoon in mid-Pleistocene [4,5] shows that the extreme strength of the East Asian monsoon is of global significance.

Main references related to the contents

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