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Late Pleistocene loess-like deposits in the coastal area of south China

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ABSTRACT

A layer of yellow silt with thickness from tens of centimeters to a few meters is widely distributed on low hills and terraces in the coastal area of south China. The yellow silt has different sedimentological characteristics from other common types of Quaternary sediments and the bedrock weathering material in the area. Five representative sections were studied using scanning electron microscopy, grain size analysis, diffuse reflection spectroscopy, geochemical analysis and optically-stimulated luminescence (OSL) dating to reveal the sedimentary characteristics, deposition environment, origin and age of the yellow silt. Subrounded-subangular quartz grains showed typical aeolian impact pits, such as dish-like and crescent pits, and chemical precipitation and corrosion on grain surfaces. The grain size composition, grain size parameters and unimodal frequency distribution curves of the yellow silt were similar in all sections examined and consistent with those of north and central China loess. The iron mineral content of the yellow silt was dominated by hematite, indicating a similar sedimentary environment to that of typical Chinese loess. The major oxide composition of the yellow silt with respect to normalized upper continental crust (UCC) distribution patterns was close to that of the UCC and similar to north China loess and other aeolian deposits in China. However, the data suggested that the yellow silt in the coastal area of south China had suffered strong weathering after deposition. The OSL ages of the yellow silt indicated a deposition age of late Pleistocene. The results of the various analytical methods all showed an origin correlation and regular transition of loess deposits from northwest to southeast China. Hence, it was concluded that the yellow silt widely distributed in the coastal area of south China is a loess-like deposit formed during the late Pleistocene. It probably mostly originated from northwest inland China and constitutes the south extension of other loess in China.

1. Introduction

It is well known that Quaternary loess is an aeolian deposit in origin (Richthofen, 1882; Liu, 1985; Kukla and An, 1989; Porter and An, 1995; Vandenberghe, 2013). China has the widest distribution of loess in the world. The Chinese northwest inland region and the Loess Plateau in north China are considered the two main dust sources and distributional areas of loess (Liu, 1985; Lu and Sun, 2000) (Fig. 1A). However, recent research has shown that loess is not limited to these two areas but also occurs southward in a number of other places, e.g., buried in the coastal zones and continental shelves of the Bohai Sea, Yellow Sea and East China Sea (Liu and Zhao, 1995; Yu, 1997; Liu et al., 2002; Liu et al., 2007); in the middle and lower reaches of the Yangtze River in mid-east China, known as “Xiashu loess” (Shao, 1988; Li et al., 2001; Yang et al., 2001; Zheng et al., 2002; Yang et al., 2004; Zhang et al., 2009; Guan et al., 2016); in mid-subtropical zones in south China (mostly between 27°N–31°N), where it is mainly present as a Quaternary aeolian sequence with same origin and provenance relationship as north China loess, i.e., a typical section shows a transition of reticulate red earth - uniform red earth - yellow brown silt from bottom to top. The latter has also been referred to as “Xiashu loess” in some research (Li et al., 1983; Xiong et al., 1999; Liu and Gong, 2000; Zhu et al., 2006; Zhu et al., 2007; Li et al., 2006; Mao et al., 2008; Yang et al., 2008; Yi et al., 2009; Hu et al., 2010). For locations of the above loess, see Fig. 1. Thus, it seems possible that loess from north China has been transported across the Yangtze River and deposited in south China.

However, there are few reports of aeolian deposits in the coastal area of south China. Field investigations have shown that yellow silt, which becomes tan or brownish-red in colour after weathering, is widely distributed on low hills and terraces in the coastal area of south China (Fig. 1B). The silt is usually found on unweathered and weathered bedrock, and has been interpreted as a product of in-situ weathering (Xi, 1991; Huang et al., 1996; Zhu et al., 2004). However, the composition and texture of the homogeneous yellow silt are very different from the underlying bedrock and its weathered material, which

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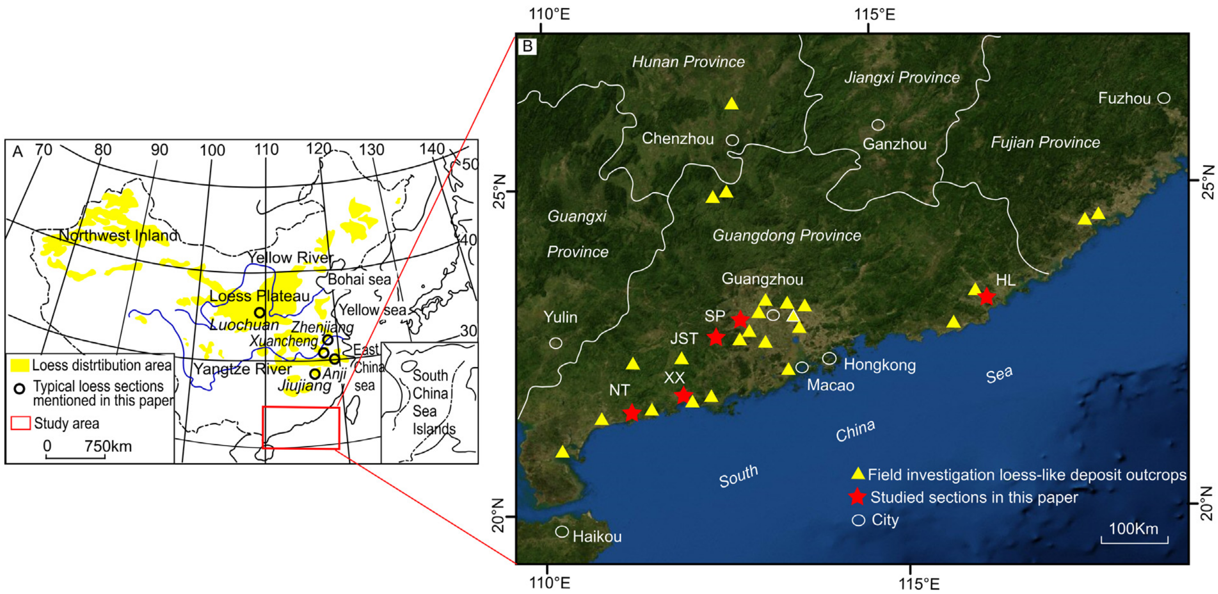

Fig. 1. A. Regional distribution of Chinese loess (modified from Wang et al., 2015); B. Our investigated well-exposed yellow silt sites (triangles) in the coastal area of south China and the main locations considered in this paper (stars) (map based on Arcgis data).

typically consists of angular rock fragments and mineral grain detritus with often a clearly delineated boundary between them, implying that the silt is not a weathering residual. Moreover, none of the common Quaternary sediments in the coastal area of south China (marine, fluvial, lacustrine, alluvial) can be linked with the formation of the yellow silt. Field observations indicate that the grain size and composition of the yellow silt are homogeneous. The silt is characterized by vertical cracks, is unbedded, hardens on drying and is easily powdered and lifted by wind when rubbed. These features are all typical of north China loess.

Therefore, it is highly likely that the investigated yellow silt with aeolian-like features in the coastal area of south China (Fig. 1) represents extension of loess from north China - central China (mainly the middle and lower reaches of the Yangtze River) - the mid-subtropical region of south China. As the climate of the south China area is subtropical to tropical, most sections of the yellow silt are not well preserved and of small thickness because of strong post-depositional weathering and denudation. Therefore, high resolution research of the sedimentology, paleoclimatology, chronology and monsoon activity cannot be undertaken as for north China loess-paleosol sequences. Also, Mesozoic granite and red beds or other bedrocks in south China are deeply weathered, compounding the difficulty of unambiguously identifying the yellow silt. In this paper, we document field relationships, quartz grain texture and grain size, material composition and age of the yellow silt in the coastal area of south China in order to determine its sedimentary features, deposition environment and time of deposition. From comparison with the commonest Quaternary sedimentary types in the area, i.e., fluvial and marine sediments, and other aeolian deposits in China, inferences are made regarding the origin, sedimentary environment, chronological significance and possible source of the yellow silt in the coastal area of south China. These results are important for re-evaluating the late Quaternary paleoclimate and paleoenvironment of the south China coastal region.

2. Distribution and field relationships of the yellow silt

Yellow silt, with thickness varying from tens of centimeters to a few meters, sometimes with a paleosol, is widely developed on low hills and terraces in the coastal area of south China and is mainly embodied in the bedrock forms as follows.

In western Guangdong Province, yellow silt on low hills or terraces overlies both weathered and fresh bedrock of Mesozoic red beds of the Enkai Basin. Fig. 2A shows an example of red bed weathered crust that has been weathered to mud with depths of 2–4 m and contains high concentrations of limonite (0.2–1 cm diameter) (Fig. 2a), overlain by 1.5 m of yellow silt. The yellow silt consists of silt and clay with a homogeneous composition and the contact with the weathered red bed gravel is sharply defined (Fig. 2A (a)).

Fig. 2B shows an example of yellow silt overlying weathered Mesosoic granite at Hualin village in Puning city, eastern Guangdong Province. The granite weathering crust here typically features pedogenic clay with a mixture of colors of yellow, red and white as a result of weathering of different feldspar types (Fig. 2b), and it also contains a large number of quartz grains with unequal size and irregular shape. Although the granite has been intensively weathered, there is still an obvious boundary with the overlying yellow silt (Fig. 2B). The difference in composition between the yellow silt and weathered granite residuals indicates that the yellow silt is not a weathering product of the granite.

Yellow silt is also found on late Paleozoic carbonate platform rocks in the coastal area of south China and has previously been considered as the weathering product of limestone (Sun et al., 2002; Feng et al., 2003). However, as shown in Fig. 2C, the corroded surface of the limestone is clearly unweathered and the compositional difference between the limestone and overlying yellow silt is obvious. As this outcrop lies within an extensive area of limestone, the yellow silt must have derived from a distal source.

Fig. 2D shows an example of yellow silt overlying weathered mica schist at Hechen town in Jiangmen city, central Guangdong Province. Here, the yellow silt is fissured and contains vertical joints at the top. The underlying bedrock has been weathered into a muddy material with sticky feel, but it still retains the original schistosity structure with a large amount of mica and the boundary with the overlying layer is obvious (Fig. 2D (d)). The yellow silt is also found overlying weathered migmatite, which presents as a mixed colour clay matrix containing large coarse quartz and rock fragments (0.2–1 cm) with sharp edges and corners.

In general, the colour, number and type of particles, grain size, material composition and structure of the weathered basement material, as described above, are nonhomogeneous in the vertical direction of each section and among different sections owing to the different original rocks, locations, environmental conditions and