



Palaeo-debris flow activities around Qiaotou archaeological site, upstream of Qiantang River, eastern China

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The Qiantang River drains mountainous terrain in Zhejiang Province, lower Yangze River region, southeast coast of China. Shangshan Culture (11000 - 9000 yr BP) and Kuahuqiao Culture (8000 - 7000 yr BP), mainly distributed on floodplain terraces and earth mounds in the headwaters of Qiantang River, are the earliest Neolithic cultures in this area. Most of the cultural occupation sites were abandoned after Kuahuqiao phases. The relationship between settlements and environmental factors over the Holocene is poorly known. Natural hazards such as debris flow and river flooding could be important factors affecting environmental stability during occupation.

The Qiaotou archaeological site, located at Yiwu city, central Zhejiang Province, is one of the Shangshan Culture sites sharing characteristics of middle and late Shangshan phases. We investigated the surrounding area using sedimentology of infill sediments, geophysical methods (GPR) and terrain analysis to evaluate the impact of palaeo-natural hazards. Excavated outcrops indicate at least two major periods of debris flow activity around Qiaotou site. A lower unit of poorly sorted, loose and clast-dominated sand and gravel, is interpreted as a water-dominated debris flow event occurring just after 31000 cal yr BP. An overlying unit of cohesive, matrix-supported, silts to gravels is interpreted as mud-dominated debris flow events occurring around 6200 cal yr BP. A GPR survey of the piedmont alluvial fan where Qiaotou is situated, distinguishes areas dominated by debris flow activity as distinct from events dominated by more fluvial processes.

The Qiaotou site is situated in a region mainly affected by debris flow events discharged from fan-building mountain watersheds. The results of morphometric analysis of these tributary basins, mainly underlain by sedimentary bedrock, suggest that most of the watersheds with higher Melton ratios and relief ratios are prone to produce muddy debris flows. Furthermore, past climatic and geological records indicate a weakening period of the East Asian summer monsoon (EASM) around 6 ky BP. Weakening of the EASM causes the northernmost frontal zone to retreat, resulting in persistent summer monsoons in the Yangze River valley leading to increased bedrock weathering and more frequent muddy debris flows. The investigations around the Qiaotou archaeological site provide a better understanding of Holocene palaeo-environments where there were increased debris flow hazards perhaps affecting occupation after 6 ky BP.