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Quaternary evolution of the rivers of northeast Hainan Island, China: Tracking the history of avulsion from mineralogy and geochemistry of river and delta sands

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ABSTRACT

The mineralogy and geochemistry of sands were investigated in the Nandu and Wanquan rivers, Hainan Island, China, to determine the history of avulsion in the lower reaches of the Nandu River. The study also provided the opportunity to assess the utility of geochemical analysis of sands as a provenance tool. Much of the heavy mineral fraction in the rivers consists of subangular Fe-Ti oxide and Fe-(hydr)oxide minerals, and less stable minerals such as amphibole, epidote, and andalusite, whereas rounded resistant ilmenite, rutile, tourmaline and zircon predominate on the deltaic coast. Mineral assemblage and chemical composition of individual samples are related to specific source areas and river tributaries. The results demonstrate northwestwards flow of the Nandu River during the mid-Holocene and earlier avulsion of the river to the northeast coast, probably during a Late Pleistocene marine highstand. Minor basement tilting, producing little relief, was sufficient to divert the lower reaches of rivers, and this effect was enhanced where basalt flows dammed former river courses. Bulk sample REE geochemistry is largely controlled by the relative abundance of monazite, allanite, titanite, zircon and epidote, derived principally from granites. Detrital geochemistry alone shows too much variability to interpret provenance. However, a smaller number of heavy mineral analyses provide an understanding of the mineralogical origins of geochemical variation, thus enabling interpretations of provenance.

1. Introduction

Bulk geochemistry of sediments has been widely used in ancient rocks as an indicator of the tectonic setting of the sediment source (Bhatia, 1983; Ryan and Williams, 2007). It has the advantage of being a relatively inexpensive and rapid method of assessing provenance (von Eynatten et al., 2003). Its utility in discriminating precise sources from similar geological terranes is less clear (Pe-Piper et al., 2008). Provenance studies in such situations rely on more expensive and time consuming mineralogical and geochronological data.

In northern Hainan Island, southern China, neotectonic tilting and basaltic volcanism influenced the course of the largest river, the Nandu River, in the Holocene (Wang, 1998). The northeastern coast of Hainan has reworked prograded beach ridges, rich in heavy minerals, yet has insignificant Holocene river supply of sediment. Potential river supply in the past would have drained the mountainous interior of the island, comprising principally granites and metamorphic rocks (Fig. 1).

This study had two interlinked objectives. First, to investigate the history of avulsion of the Nandu River using bulk geochemical and mineralogical composition of river and deltaic sands. Second, to assess the success in using solely geochemical tracers of provenance in modern sediments to discriminate between drainage basins with rather similar geology. We hope to be able to apply the results of the second objective to our studies of Cretaceous sedimentary rocks in the Scotian Basin (Gould et al., 2010; Zhang et al., 2014), which had similar paleoclimate and source-area geology in the early Cretaceous to Hainan Island in the Quaternary.

2. Geological setting

2.1. Geomorphology

Hainan Island (Fig. 1) is a mountainous (reaching 1867 m asl), tropical island, with bedrock dominated by granite and orthogneiss (37% of the land area) in the centre and south, and widespread Quaternary basalts in the north. Active neotectonic faults follow E–W and NNW–SSE trends (Ma, 1989; Lei et al., 2009). The island receives over 1.6 m of rain annually and lies in one of the main cyclone tracks in the western

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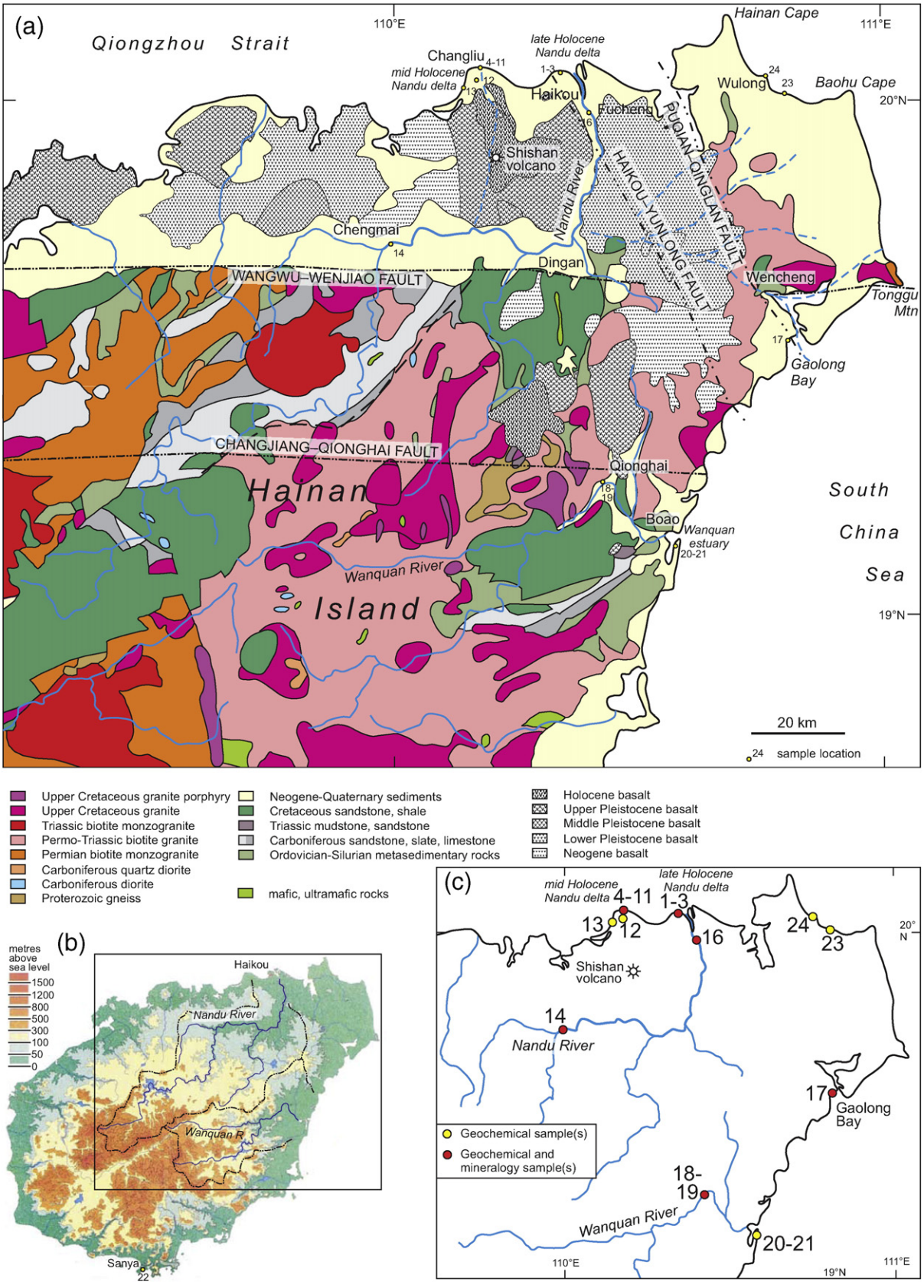

Fig. 1. (a) Geological map of northeastern Hainan Island. Geology from Guangdong BGMR (1988) with ages of volcanic rocks from Ho et al. (2000). Dashed lines show major dry valleys on the northeastern peninsula. (b) Topography of Hainan Island and the drainage basins of the Nandu and Wanquan rivers. (c) Map showing sample locations.