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Elemental compositions and monazite age patterns of core sediments in the Changjiang Delta: Implications for sediment provenance and development history of the Changjiang River

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Abstract

Core from a continuous borehole in the Changjiang Delta to a depth of 318.7 m dated back to the Pliocene (>3.58 Ma) and was selected for geochemical measurements and determinations of Th–U–Pb ages of monazite, in order to investigate the changing sediment provenance and development history of the Changjiang River. Geochemical proxies including fractionation parameters of rare earth elements (cerium and europium anomalies) and elemental ratios Cr/Th, Nb/Co and Th/Co suggest that the Pliocene and Quaternary sediments have remarkably different provenances. Six peak ages of monazite grains dated at <25, 50–200, 200–400, 400–550, 800–1000, and 1800–2000 Ma are consistent with the main tectonic and magmatic events in the Yangtze Craton. The data imply that the Pliocene sediments were mostly derived from proximal and more silicic sources whereas the Quaternary sediments were sourced from distal and more basic provenances, including the Emeishan basalt province in the upper Changjiang valley. We propose that during the Pliocene the "paleo-Changjiang" or its eastern equivalent was a locally small river draining today's lower Changjiang valley, whereas during the early Pleistocene not later than 1.18 Ma it changed its drainage pattern and developed into a large river that originated from the eastern Tibetan Plateau. This time matches well with many previous studies based upon geomorphologic, geographic and tectonic observations in the Jinshajiang valley and the Three Gorges.

Keywords: Changjiang; geochemistry; monazite; Tibetan Plateau; Quaternary

1. Introduction

The major rivers draining the southeastern Tibetan Plateau have been investigated in recent years because they directly transport a large quantity of terrestrial materials eroded from the Himalayan–Tibetan Plateau into the marginal seas surrounding Asia and have exerted significant influence on chemical flux budget of the global ocean [1–8]. Furthermore, the basin morphology and regional fluvial patterns of these rivers are closely linked to plateau uplift and thus can reflect the Cenozoic uplift history of the Tibetan Plateau following the continental collision between India and Eurasia [6,9–13].

The Changjiang is the third longest river in the world and the fourth largest in terms of its water discharge

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[14]. The river originates from the northeastern Tibetan Plateau at elevations above 5000 m and drains more than one-fifth of the continental area of China before finally entering the East China Sea. In past the development of the Changjiang has been the focus of increasing researches [15–31]. Pioneer work on the river evolution can be traced back almost 100 yrs ago, to the work of Willis and Blackwelder in 1907 [15]. Studies of the evolution of the Changjiang and its main tributary in the upper reaches, the Jinshajiang, first flourished during the 1920–1930s [16–19]. These studies and some later attempts proposed that the Changjiang can be dated back to the Cretaceous or the Early Tertiary periods [15–21]. Since the end of 20th century the evolution of the Changjiang has been highlighted again [22–30]. Research results primarily based on geomorphologic and geographic observations suggested that the Changjiang formed in the early Quaternary (2.5–0.7 Ma) [23–27,29,30] or late Pleistocene (0.15–0.20 Ma) [10,28,31]. Therefore, the formation age and the development history of the Changjiang remain to be resolved and more substantial evidence with reliable age constraints are required.

Most previous studies highlighted two regions in the Changjiang valley, i.e. the first bend located in the Jinshajiang and the Three Gorges in the upper-middle Changjiang valley (Fig. 1). In contrast, the Changjiang Delta forming one of the Quaternary depocenters of Changjiang sediment [32] has rarely been studied. It is evident that the Changjiang must record its evolution history in the delta area through the gradual accumulation of river sediments since its formation.

In this study one continuous borehole (Core PD) with penetration to 318.7 m subsurface was taken from the Changjiang Delta. Sediments were selected for geochemical analysis and monazite dating. The main purpose of this paper is: 1) to examine downcore variations of geochemical compositions and monazite age spectra in sediments; 2) to identify the provenances of the upper Pliocene and Quaternary sediments; 3) to reconstruct the Changjiang development history during the Pliocene and Quaternary.

2. River setting and study area

2.1. Geomorphologic, geographical and geological backgrounds of the Changjiang drainage basin

The Changjiang drainage basin is located between 24°27′–35°44′N and 90°33′–122°19′E and has an area of 1.8×10^6 km^2 (Fig. 1). The drainage basin spans the regional structure of China with three-grade relief terraces, the highest source area with the average elevation of 3500–5000 m, the highlands in the upper-

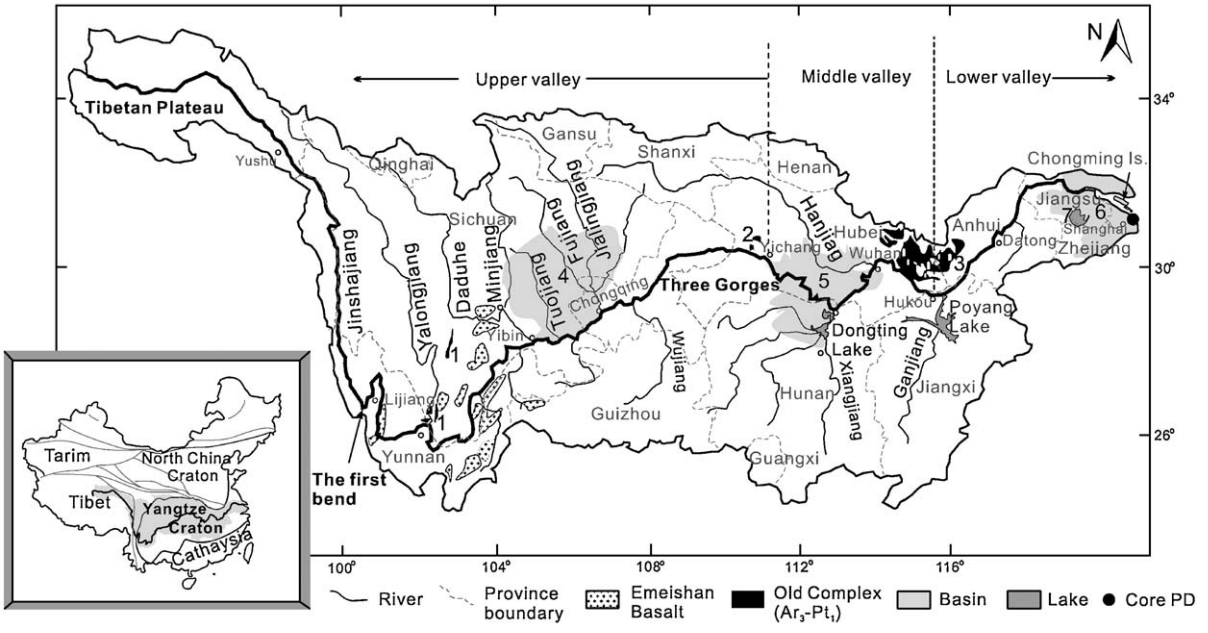

Fig. 1. A sketch map showing the drainage basin, main distributaries, and provincial boundaries of the Changjiang. The locations of the Yangtze Craton, first bend in the Jinshajiang, the Three Gorges in the upper-middle Changjiang, and the drilling core PD in the delta area are also shown. The distributions of the Emeishan Basalt and the old (late Archean to early Proterozoic, Ar_3–Pt_1) metamorphic complexes are outlined. 1: Kangding Complex; 2: Kongling Complex; 3: Dabie Complex; 4: Sichuan Basin; 5: Jianghan Basin; 6: Changjiang Delta; 7: Taihu Lake.