

The missing link: Cenozoic evolution of the Middle Yangtze River

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Durham University, Dept of Geography
In partnership with **University of St Andrews, Glasgow University**

Supervisory Team

- Prof Alexander Densmore, Durham University
- Dr Ruth Robinson, University of St Andrews
- Dr Fin Stuart, Glasgow University
- Dr Cristina Persano, Glasgow University

Key Words

Large rivers, Asia, drainage capture, incision, provenance

Overview

The major rivers that drain the India-Asia collision have undergone rapid and dramatic shifts in their flow directions over the last 55 Ma (Clift et al. 2008).

These shifts are important because they determine the pattern and rate at which river loads are delivered to the ocean and to marginal basins around south and east Asia. Because the major rivers of the India-Asia collision – notably the Huang He, Yangtze, Brahmaputra, and Ganga – carry some of the largest sediment loads on Earth, unravelling their past courses is critical for understanding erosion, landscape evolution and sediment transfer in the collision zone. Onshore evidence for these changes in river course is complicated by poor preservation of sedimentary evidence; offshore records of sediment transfer can record the timing of major shifts, but their utility can be limited by onshore storage or incomplete data.

Of the rivers draining the collision, the Yangtze has received perhaps the most attention, and yet we still lack a clear picture of the river's evolution since 55 Ma. It has long been hypothesized that much of the current Yangtze River basin originally flowed toward the southwest, and drained into the ocean via the Red River. Clark et al. (2004) outlined a model by which the Yangtze River was assembled through the progressive capture and amalgamation of several smaller sub-catchments, termed the lower, middle, and upper Yangtze rivers. While simplified, this model has provided a useful framework for studying those

individual capture events. At the downstream end of the basin, Richardson et al. (2010) argued that capture of the middle Yangtze by the lower Yangtze probably began by about 40 Ma, and was accomplished by incision into the modern Three Gorges area.

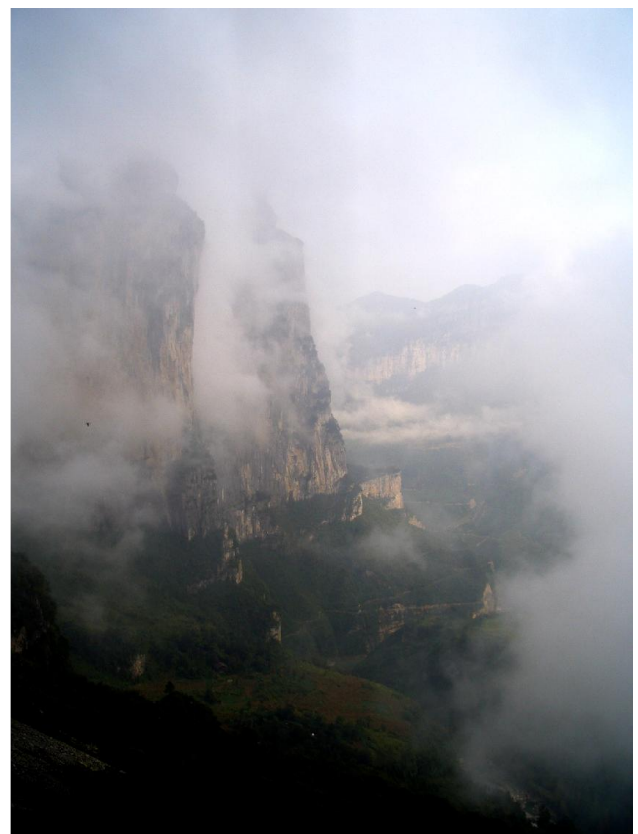


Fig. 1. Cliffs along the modern Yangtze River in southern Sichuan Province, China

This event triggered a wave of erosion that propagated upstream into the Sichuan Basin, and must have caused incision of the middle Yangtze as well. Zheng et al. (2013) summarized a number of different pieces of evidence to argue that this capture event must have occurred before 23 Ma, and probably after about 36 Ma, based on sedimentological evidence in the lower Yangtze basin and offshore.

In the upper part of the basin, there is only limited evidence for capture of the upper Yangtze by the middle Yangtze, away from the Red River. Sediments in the Red River delta suggest that this capture event took place between the Eocene and Miocene (Clift et al. 2008; Hoang et al. 2009), but it is difficult to be more precise. Kong et al. (2009, 2012) argued instead that capture of the upper Yangtze, and formation of the 'First Bend' at Shigu, occurred much later, around 1.4-1.7 Ma, based on ages of lacustrine deposits supposedly laid down during the capture event. Their estimates, however, require that the lake deposits must have formed during the capture event. Kong et al. (2009, 2012) carried out some preliminary provenance analyses on the deposits, but their results are limited and equivocal.

No work to date has focused on geological evidence for incision and sediment transfer through the middle Yangtze – the ~1400 km between the 'First Bend' and the Three Gorges. Similarly, there have been no careful studies of the provenance of sediment along the middle Yangtze River. Thus, it is not yet possible to establish (1) when the middle Yangtze began to route sediment from the upper Yangtze basin, and (2) when the middle Yangtze began to incise in response to downstream capture and amalgamation events. This PhD studentship sets out to address both of these outstanding issues, and to provide a link between upstream-focused and downstream-focused studies of Yangtze basin evolution. The proposed research sits equally under the Geodynamics and Earth Resources (crustal processes) and Hazards, Risk, and Resilience (fluvial processes and flooding) research themes.

Methodology

The student will

1. Map and log sedimentary deposits of the middle Yangtze River, including sections near Panzhihua studied by Kong et al. (2009, 2012) as well as deposits downstream;

2. Date these sediments using OSL techniques, and establish their provenance using linked U/Pb and Lu-Hf on detrital zircons (Robinson et al. 2013) and Ar/Ar on detrital mica;

3. Use low-temperature thermochronological analysis to establish the timing of rapid cooling, and thus middle Yangtze River incision, into Proterozoic granitic rocks near Panzhihua;

4. If feasible, use detrital low-temperature thermochronological analysis to establish the cooling and erosional history of sedimentary rocks where the middle Yangtze River enters the Sichuan Basin;

4. Integrate the results of (1)-(4) with existing knowledge of river evolution around and upstream of the 'First Bend' in order to propose a comprehensive model for evolution of the Yangtze River system.

Timeline

Year 1:

Literature review and compilation of existing constraints on river basin evolution

Topographic analysis of river basin

Identification of target sedimentary sections using high-resolution satellite imagery

Field work: logging of sections and collection of samples for OSL and low-temperature thermochronology near Panzhihua

Year 2:

Sedimentological and provenance analysis

OSL and low-temperature thermochronological analysis

Thermal modelling

Identification of target sedimentary sections

Field work: logging of sections and collection of samples between Panzhihua and Yibin

Year 3:

Sedimentological and provenance analysis

OSL and low-temperature thermochronological analysis

Thermal modelling

Conference and manuscript preparation

Year 4:

Integration of results with existing knowledge and preparation of comprehensive model for Yangtze River evolution

Manuscript and thesis preparation

Training & Skills

The student will undergo specialist training in the specific techniques and approaches to be used in the project. This will include quantitative topographic analysis and mapping, sedimentology and provenance analysis, low-temperature thermochronology (apatite fission-track and (U-Th)/He dating), and U/Pb and Lu-

Hf isotopic analyses. Depending on the student's background, experience, and interests, some of the analytical work may be done on a contract basis by the relevant facilities involved.

References & Further Reading

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Further Information

Prof. Alexander Densmore, a.l.densmore@dur.ac.uk