

## Research Advances

# Provenance of Detrital Magnetites from Quaternary Sediments in the Yichang Area and its Significance to the Birth of the Three Gorges, Yangtze River

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## Objective

In recent years, the birth time and evolution of the Three Gorges, Yangtze River has become a focused topic. Different from previous studies, this study used provenance analysis of Quaternary sediments to discuss this question. Among those minerals in Quaternary sediments, magnetite was rarely studied. This paper presents element geochemistry and backscatter images of detrital magnetites from the Quaternary sediments in the Yichang area of Hubei Province. By discussing the provenance changes of detrital magnetites, we suggested the birth time of the Three Gorges of the Yangtze River.

## Samples and Methods

The detrital magnetites came from the samples 015, 017, 021, 022, 024, 025, YC02, 00B and 060 in the Yichang area. By field investigation and ESR dating, the samples of 015, 021, 017, 022 and 024 were deduced to be the alluvial fan and fan-delta sediments of the Yunchi Formation and Shanxiyao Formation older than 0.73 Ma. The sample 025 was the modern riverbed sediment and the samples 00B and YC02 were taken from the fourth and fifth fluvial terraces with post-0.73 Ma in age. The sample 060 was taken from granites in the Huangling Dome. Magnetites were obtained by magnetic separation from samples with grain size of 0.063–0.125 mm, and were picked out according to different degrees of rounding, grain type and size by binocular eyepiece. In this study, 220 magnetites from 9 samples were analyzed by electron microprobe to acquire content of 15 oxides: FeO, SiO<sub>2</sub>, MnO, MgO, CaO, TiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Cr<sub>2</sub>O<sub>3</sub>, V<sub>2</sub>O<sub>3</sub>, SO<sub>3</sub>, ZnO, NiO, P<sub>2</sub>O<sub>5</sub>, Nb<sub>2</sub>O<sub>5</sub> and Ta<sub>2</sub>O<sub>5</sub>, and backscatter images of magnetites were acquired. The data of oxide content were processed by cluster analysis using SPSS software.

## Results

In the TiO<sub>2</sub>-Al<sub>2</sub>O<sub>3</sub>-MgO diagram, detrital magnetites are classified into different rock types (Fig. 1), showing a complicated provenance for these magnetites, including granite, basalt, gabbro, hydrothermal type, calcium skarn, and some transitional rock type of these rocks.

Cluster analysis based on the oxide composition of the detrital magnetites shows that most magnetites from samples 015, 017, 021, 022, 024 and 060 were classified into the same category. This indicates detrital magnetites from these samples most probably came from the same parent rocks. The granites in the Huangling Dome would be the sources for those detrital magnetites. The second categories of magnetites in the samples 015, 017, 021, 022 and 024 indicate additional provenance from diabases and andesites located in the Huangling dome and

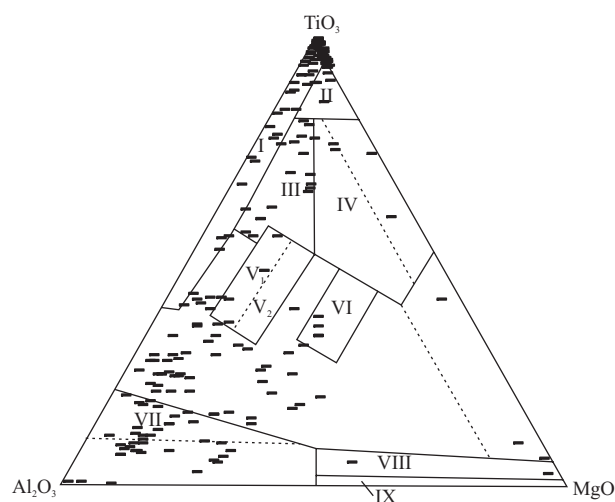


Fig. 1. The TiO<sub>2</sub>-Al<sub>2</sub>O<sub>3</sub>-MgO diagram of magnetites (base-map was taken from Wang, 1984).

I, Granite zone; II, Basalt zone; III, Gabbro zone; IV, Peridotite zone; V<sub>1</sub>, Amphibolite zone; V<sub>2</sub>, Diorite zone; VI, Kimberlite zone; VII, Hydrothermal type and Calcium skarn zone; VIII, Hydrothermal type and Magnesium skarn zone; IX, Sedimentary metamorphism and hydrothermal superimposition zone; X, Carbonatite zone; XI, Transition zone.

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Shenlongjia area.

Some of detrital magnetites from the samples 025, 00B and YC02 were classified into the same category as the samples 015, 017, 021, 022, 024 and 060, indicating the parent rocks were mainly the granites in the Huangling Dome. In addition, there are three categories not including in samples 015, 017, 021, 22 and 024, indicating the provenance of the samples 025, 00B and YC02 was quite different with the samples from the Yunchi Formation and Shanxiyao Formation. Compared with the element geochemistry of Emeishan large igneous province basalts and Panzhihua vanadic titanomagnetite ore, detrital magnetites from samples 025, 00B and YC02 had similar chemical characteristics. In addition, backscatter images of detrital magnetites from the samples 025, 00B and YC02 indicate a homogeneous structure as well as exsolution intergrowth structure mainly found in titanomagnetite, titanium-iron spar and ilmenite. The latter was formed by dissolving in specific high temperature in felsic volcanic rocks and was common in Panzhihua vanadic titanomagnetite. Furthermore, the complex categories of detrital magnetites from the samples 025, 00B and YC02 suggest their complicated provenances. This is consistent

with the fact that the samples 025, 00B and YC02 were taken from modern sediments of the Yangtze River.

## Conclusion

Based on the discussion, we conclude that the magnetite compositions and backscatter images from alluvial fan and fan-delta sediments of the Yunchi and Shanxiyao Formations before 0.73 Ma were different from those from the fluvial terraces and the modern riverbed forming after 0.73 Ma. Our data indicate there was a major provenance change of detrital magnetites, resulting from the cutting-through of the Yangtze Three Gorges at the time about 0.73 Ma.

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