Geochemistry of sandstones from the Neoproterozoic Jinshanzhai Formation in northern Anhui Province, China: Provenance, weathering and tectonic setting

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Abstract Sandstones from the Neoproterozoic Jinshanzhai Formation in northern Anhui Province, China, were analyzed for major oxides and trace elements to infer their provenance, the intensity of paleo-weathering of their source rocks and the depositional tectonic setting. Diagrams of (SiO$_2$/20)–(Na$_2$O+K$_2$O)–(MgO+TiO$_2$+FeO*), TiO$_2$–Ni, Th–Hf–Co, Hf–La/Th and some ratios of elements indicate that felsic rocks constitute the source rocks in the provenance. The values of Chemical Index of Alteration (CIA) are low, which are considered to be affected by K-metasomatism. Whereas the high CIW (Chemical Index of Weathering) values indicate intensive weathering of the source material. Plots of sandstones on bivariate and triangle discriminant diagrams, as well as ICV (Index of Compositional Variation) values revealed that they were deposited on a passive continental margin or in an intra-plate basin. Our recent study, in combination with previous studies and the research progress of the Rodinia super continent, demonstrated that the convergence and extension of the Rodinia super continent were preserved by twice extension as expressed by petrological variation of the southeastern margin of the North China Craton (NCC) during the Neoproterozoic.

Key words sandstone; geochemistry; provenance; tectonic setting; neoproterozoic; Anhui

1 Introduction

Studies on the provenance of siliclastic sedimentary rocks aim at revealing the composition and geological evolution of the sediment source areas and at constraining the tectonic setting of the depositional basin. Previous research revealed that the chemical composition of clastic sediments is a function of a complex interplay of several variables, including the source rock composition, the extent of weathering and diagenesis (Bhatia, 1983, 1985). However, the tectonic setting of the sedimentary basin may play a predominant role over other factors.

Chemical and petrographic analyses are two complementary methods in provenance study. However, because there are some indefinite influencing factors (e.g. the artificial effects during counting of minerals), provenance study of siliclastic sediments based on petrographical study is gradually replaced by geochemical method due to the relatively immobile nature of the selected trace elements (Yan Quanren et al., 2002; Li Zhiming et al., 2003; Armstrong-Altrin et al., 2004; Rashid, 2005; Odigi and Amajor, 2009), such as the high field strength elements (Th, Sc and Zr and rare-earth elements). Additionally, some trace element ratios (e.g. La/Sc, La/Th, Co/Th, Th/Sc, Cr/Th, Cr/Zr) are widely used to discriminate the provenance and tectonic setting of siliclastic sediments (Taylor and McLennan, 1985; Bhatia and Crook, 1986; McLennan and Taylor, 1991).

The Neoproterozoic tectonic evolution of China is a “hot” object of study at the moment and a series of progresses have been brought to light during the last ten years, especially the research work related to the tectonic evolution of the Rodinia super continent, as well as the Grenville orogeny (e.g. Wang Xiaolei et al., 2008; Lu Songnian et al., 2008). However, similar research work related to the Neoproterozoic evolution...
of the southeastern margin of the North China Craton (NCC) has not been well documented recently, and two major issues are still far less to be understood: (1) when the sedimentation took place, and (2) what about the tectonic setting during sedimentation? The ideas about the Neoproterozoic tectonic setting of the southeastern margin include intra-plate rift (Pan Guoqiang et al., 2000), passive continental margin (Kuang Hongwei et al., 2004) and back-arc basin (Li Shuangying et al., 2003; Liu Yongqing et al., 2006; Sun Linhua et al., 2010, 2011).

A main reason leading to the above controversy is the lack of magmatism during the period, as well as the research related to them. Therefore, we reported the geochemical composition of sandstones from the Jinshanzhai Formation (a scarce formation composed of siliciclastic sediments among the Neoproterozoic strata in northern Anhui Province, China), with an attempt to constrain their provenance, paleo-weathering and tectonic background, which will provide additional information for reconstructing the tectonic evolution of the southeastern margin of NCC during the Neoproterozoic.

2 Geological background and analytical methods

The study area is located in the Lingbi uplift of the Huaibei depression on the southeastern margin of NCC, about 120 km west to the Tancheng-Lujiang fault (AHBGMR, 1993; Fig. 1a). The Neoproterozoic strata in the region include the Jiayuan, Zhaowei, Niuyuan, Jiudingshan, Zhangqu, Weiji, Shijia, Wangshan, Jinshanzhai and Gouhou formations from the bottom to the top. Clastic sediments can only be found in three formations (the Jiayuan, Shijia and Jinshanzhai formations), and the ages of these sedimentary rocks are considered to have a large span (0.6–0.8 Ga, Pan Guoqiang et al., 2000; 0.7–0.9 Ga, Kuang Hongwei et al., 2004; 0.9–1.0 Ga, Liu Yongqing et al., 2006). Previous studies revealed that the elastic components of the Jiayuan Formation were derived from an active continental margin source related to the convergence of the Rodinia super continent (Sun Linhua et al., 2010, 2011), whereas the tectonic background of the Shijia Formation was controversial with a back-arc basin (Li Shuangying et al., 2003) and a passive continental margin or intraplate environment (Sun Linhua and Gui Herong, 2011).

The Jinshanzhai Formation is composed of two parts, including sandy shale and quartzite in the lower part and thick limestone in the upper part, respectively. A 0.7 m-thick conglomerite or 0.15 m-thick weathering crust was found at the bottom of the formation, indicating that the area had uplifted before the deposition of the Jinshanzhai Formation. Samples were collected from outcrops in Heifengling, a small hill located in eastern Suzhou City, northern Anhui Province (Fig. 1b).