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Geochemistry of eclogites from the Dabie–Sulu terrane, eastern China: New insights into protoliths and trace element behaviour during UHP metamorphism

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Abstract

The major and trace element compositions of nine eclogites from the Dabie–Sulu ultrahigh pressure (UHP) metamorphic terrane in eastern China were determined for both whole rock and the main constituent minerals, garnet and clinopyroxene. The results indicate that the eclogite protoliths originated from a basaltic magma, which formed in a continental setting as shown by isotopic and immobile element data. Based on the garnet REE characteristics, the eclogites can be roughly divided into two groups. Group 1 has LREE enrichment with no Eu anomaly for whole rock, and smooth LREE depletion but HREE enrichment pattern for garnet, whereas group 2 shows a depletion of LREE with a pronounced positive Eu anomaly and flat HREE pattern for both whole rock and garnet. From these features, we suggest that the protoliths for group 2 are Fe–Ti–gabbros with relatively high cumulus plagioclase and Fe–Ti oxide, whereas the group 1 eclogites are probably from basalts. Therefore, the unusual garnet REE pattern observed in group 2 can be considered as an important signature for identifying gabbro protoliths for eclogites. The identification of gabbro protoliths from the eclogites in the Dabie–Sulu terrane provides evidence for Neoproterozoic rift magmatism in the northern margin of the Yangtze craton. During ultrahigh pressure metamorphism in the Dabie–Sulu terrane, LILEs (including Ba, Rb, Th, U, K) had high mobility, but REEs and HFSEs were immobile, and trace element distribution equilibrium was approached between garnet and clinopyroxene. An estimate of mass balance indicates that garnet and clinopyroxene host the majority of HREEs and Y, and clinopyroxene is a significant host for Sr, but minor and accessory minerals predominantly account for LREEs, Th, U, and Zr.

Keywords: Trace elements; UHP metamorphism; Protolith; Eclogite; Dabie–Sulu terrane

1. Introduction

Eclogites are bimineralic rocks with a mineral assemblage of garnet and clinopyroxene. They are generally formed under high or ultrahigh pressure (UHP) conditions created by a specific geological process. A large number of experimental and field-based investigations have shown that subduction and subsequent collision between blocks is the most important among these processes (Wyllie, 1982; Liou et al., 1996; Becker et al., 2000; Hermann, 2002; Spandler et al., 2004). Thus, eclogites have particular geodynamic significance for exploring circulation and interaction of materials between tectonic blocks. In order to show the

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origin and process of UHP metamorphism, we need to firstly determine the nature of the eclogite protolith. Numerous studies have demonstrated that trace element, in particular rare earth element (REE), investigation is a crucial approach for this issue. At an earlier stage, trace element data were mainly obtained by dissolution for whole rocks and mineral separates. With the development of analytical techniques, in situ trace element procedures are now proving to be a more effective method to explore the protolith nature of eclogites, especially for those with alteration produced by retrograde metamorphism, metasomatism, partial melting. Recent studies on some xenolithic eclogites (e.g. Barth et al., 2001, 2002; Jacob et al., 2003) have provided useful results. Another issue closely related to eclogites is trace element behaviour during high or ultrahigh pressure metamorphism such as mobility, distribution and redistribution among phases (Shatsky et al., 1990 and references therein; O'Reilly and Griffin, 1995; Tribuzio et al., 1996; Harte and Kirkley, 1997; Becker et al., 2000; Sassi et al., 2000).

The Dabie–Sulu terrane in eastern China is known to contain the largest distribution of UHP metamorphic rocks in the world (Chavagnac et al., 2001). It has become an important region for studying UHP metamorphism since the discovery of coesite and microdiamond inclusions in eclogites occurring there (Okay et al., 1989; Wang et al., 1989; Xu et al., 1992). Over the last fifteen years, a number of studies have been carried out on the geology, petrology, mineralogy, and geochemistry of the eclogites and their associated rocks. The results have allowed great progress to be made in understanding the geodynamic and geochemical processes of subduction and the resultant collision between Sino-Korean and Yangtze cratons. Several genetic models have been developed (e.g. Liou et al., 1996; Zheng et al., 2003). However, the trace element compositions of the eclogites and their constituent minerals are not well documented, and thus their protoliths remain controversial. It is now widely accepted that the eclogites occurring in the Dabie–Sulu terrane can be divided into three types based on their occurrence and host rocks, i.e., Type I eclogites occurring as enclaves or layers in granitic orthogneisses, Type II as enclaves in or interlayered with marbles, and Type III as enclaves and interlayers with ultramafic rocks. With only whole rock trace element data, Zhai

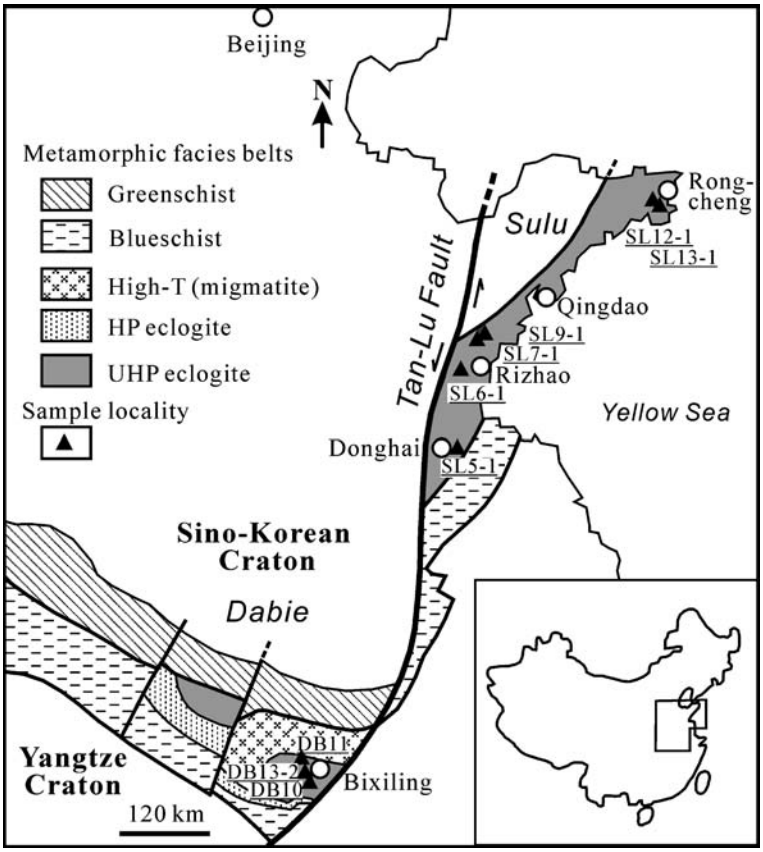

Fig. 1. Geological sketch map of the Dabie–Sulu UHP metamorphic terrane (simplified after Liou et al., 1996) with sample localities.