First record and timing of UHP metamorphism from zircon in the Xitieshan terrane:
Implications for the evolution of the entire North Qaidam metamorphic belt

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ABSTRACT

The Xitieshan terrane is one of four metamorphic terranes in the North Qaidam metamorphic belt, which is an early Paleozoic high-pressure to ultrahigh-pressure (HP-UHP) metamorphic belt in NW China. However, conclusive evidence and precise timing of UHP metamorphism in the Xitieshan terrane have not been well documented. In this study, we report an integrated study of zircon grains from an amphibolite in the Xitieshan terrane in terms of mineral inclusions, trace elements, and U-Pb age systematics. The first record of coesite is reported as an inclusion in a metamorphic zircon, which provides unambiguous evidence for the UHP metamorphism of the Xitieshan terrane. The metamorphic zircon domains have weak or no zoning, very low Th/U ratios, insignificant Eu anomalies, and flat HREE patterns. Zircon grains contain inclusions of garnet, omphacite and rutile, in addition to the coesite inclusion. These inclusions indicate that the metamorphic zircon grains formed under UHP metamorphic conditions. The metamorphic zircon grains were dated by the SIMS and LA-ICPMS methods and yield weighted mean ages of 432 ± 14 and 441 ± 9 Ma, respectively. Combined with previous results, the HP-UHP metamorphism of the Xitieshan terrane may have lasted 460–440 Ma with the peak UHP metamorphism at 441 ± 9 Ma. A compilation of the reported geochronological data reveals that all four terranes of the North Qaidam metamorphic belt might have experienced coeval UHP metamorphism during the early Paleozoic (420–450 Ma), and thus may have suffered a coherent subduction, UHP metamorphism, and exhumation cycle.

Keywords: The Xitieshan terrane, coesite, zircon U-Pb age, UHP metamorphism, the North Qaidam metamorphic belt

INTRODUCTION

Progress in understanding continental dynamics has been enhanced by the discovery of coesite and micro-diamond inclusions in metamorphic minerals from supracrustal rocks (e.g., Chopin 1984; Smith 1984; Sobolev and Shatsky 1990). These inclusions provide unequivocal evidence that the least dense part of the lithosphere can be buried to 100–150 km depth or more and return to surface (Chopin 2003; Zheng 2008; Liou et al. 2009). However, indicator minerals are rarely preserved in UHP metamorphic rocks due to extensive retrogression during exhumation (Chopin 1984; Sobolev and Shatsky 1990; Liu et al. 2008; Liou et al. 2009). Zircon is considered to be the best container of UHP inclusions because of its resistance to physical and chemical changes (Rubatto and Hermann 2007). Zircon can protect mineral inclusions formed at UHP conditions from subsequent retrogression, whereas other mineralogical and geochemical tracers of UHP metamorphism may be nearly obliterated (Katayama et al. 2001; Liu and Liou 2011). Moreover, in situ U-Pb dating of zircon is a powerful technique for the timing of different stages of subduction metamorphism (Mattinson et al. 2006; Rubatto and Hermann 2007; Wu et al. 2008; Zhang, J.X. et al. 2008b) because zircon can form in different metamorphic conditions and has very low rate of Pb diffusion (Cherniak and Watson 2003). Therefore, identification of HP-UHP indicator minerals as inclusions in zircon is crucial, not only for the diagnosis of UHP metamorphism, but also to relate U-Pb ages to metamorphic P-T conditions of the zircon’s host rock (Chopin and Sobolev 1995; Katayama et al. 2001; Rubatto and Hermann 2007; Zhang, J.X. et al. 2010; Liu and Liou 2011). However, such work has not been done for the Xitieshan terrane in the North Qaidam HP-UHP metamorphic belt.

The North Qaidam HP-UHP metamorphic belt, located in western China, forms a major early Paleozoic continental subduction zone. The belt contains four sub-metamorphic terranes, from east to west: the Dulan terrane, the Xitieshan terrane, the Lüliangshan terrane, and the Yuka terrane (Fig. 1a). Over the past 20 years, considerable progress has been made in the study of the HP-UHP metamorphism in this belt (e.g., Chen et al. 2007; Yang and Deng 1994; Yang et al. 1998, 2001; Mattinson et al. 2006, 2009; Song et al. 2003a, 2005a, 2006; Zhang, J.X. et al.