Combined geochemistry and geochronology constrains coupled subduction of oceanic and continental crust in the Huwan shear zone, central China

HAO CHENG1,* AND JEFFREY D. VERVOORT2

1State Key Laboratory of Marine Geology, Tongji University, Shanghai 200092, China
2School of the Environment, Washington State University, Pullman, Washington 99164, U.S.A.

ABSTRACT

Subduction of rocks into the mantle results in high-pressure metamorphism and the formation of eclogites from basaltic precursor rocks. In general, many kilometers of oceanic lithosphere are ultimately consumed prior to the subsequent continental slab subduction and collision. The exposure of the eclogites derived from oceanic subduction and continental subduction at the surface of Earth today record different P-T-t records of the subduction process. The Huwan shear zone in the Hong’ an orogenic belt, marking a former ocean-continent transition zone, has been the focus of many studies on subduction-related high-pressure metamorphism. In this study, Lu-Hf garnet, U-Pb zircon, and Ar-Ar mica ages are combined with geochemical data to understand the origin of two coexisting eclogite bodies exposed along the Xuehe River in the Huwan Shear zone. In total, the results indicate that the two eclogite have different protoliths but experienced a similar metamorphic history. This observation requires new tectonic model for the coupled subduction of oceanic and continental crust in subduction zones. Combined geochemistry and zircon U-Pb geochronology suggest distinct oceanic and continental affinities for the eclogite protoliths. The Lu-Hf dates of 261.5 ± 2.4 Ma of the continental-type eclogite and 262.7 ± 1.7 Ma of the oceanic-type eclogite reflect garnet growth and are interpreted to closely approximate the age of eclogite-facies metamorphism. Therefore, both the geochemically oceanic- and continental-type eclogites underwent the same episode of Permian eclogite-facies metamorphism. The Permian Lu-Hf ages of ca. 262 Ma and the obtained Triassic Ar-Ar ages (~240 Ma) of the oceanic-type and continental-type eclogites imply coupled subduction and exhumation of oceanic and continental crustal materials in the Hong’an orogenic belt during the Permian and the Triassic. Though limited, the geochemical and geochronological results of this study, together with the discrepant Carboniferous dates for the nearby eclogites of previous studies, apparently suggest that the Huwan shear zone was not always a single coherent unit but instead comprises different tectonic slices that were metamorphosed at different times before final assembly. Some slices of the oceanic and continental crust underwent two subduction cycles during the Carboniferous and the Permian, whereas some eclogites registered only a single subduction-exhumation loop during the convergence between the South China Block and the North China Block in the Huwan shear zone. The consistent ages of the oceanic- and continental-type eclogites disfavor the traditional mélange model that high-pressure rocks are dismembered fragments that have been assembled and intercalated with rocks devoid of any high-pressure history at shallow crustal levels, forming a tectonic mélange.

Keywords: Lu-Hf; Huwan shear zone, eclogite, geochronology

INTRODUCTION

Subduction of oceanic and continental crust eventually leads to the closure of back-arc basins and arc-continent and continent-continent collisions (O’Brien 2001; Ernst 2005), forming various types of high-pressure and ultra-high-pressure (UHP) metamorphic rocks. Constraining the timing of the transition from subduction of oceanic to continental lithosphere is essential to understanding the details of this polyphase evolution. This can be done by dating the metamorphic rocks with both oceanic and continental affinities in the same collision zone. The collision between the South China Block and the North China Block formed one of the largest UHP metamorphic belts in the world (Fig. 1a). The initiation of continental subduction has been traced back to late Permain ages of ca. 256 Ma (cf. Liu et al. 2008a; Cheng et al. 2011) by dating the UHP/HP eclogites with continental affinity with various geochronological methods, such as Sm-Nd, Lu-Hf, Ar-Ar, and U-Pb. However, the time of the oceanic subduction prior to the onset of continental subduction remains controversial because geochronology of the oceanic-type metamorphic rocks within this belt yielded Carboniferous U-Pb zircon ages (Wu et al. 2009; Liu et al. 2010; Cheng et al. 2009) as well as Permian Lu-Hf and Sm-Nd ages (Cheng et al. 2009, 2013; Brouwer et al. 2011). Should the age discrepancies among high-pressure rocks of oceanic affinity suggest two distinct high-pressure metamorphism episodes or indicate a prolonged/