
### The Tongbai HP Metamorphic Terrane in Central China: Constraints on the Onset and Diachroneity of Continental Subduction

LIU Xiaochun*, JAHN Bor-ming, CHENG Hao, LI Sanzhong and QU Wei

1 Institute of Geomechanics, Chinese Academy of Geological Sciences, Beijing 100081, China
2 Department of Geosciences, National Taiwan University, Taipei 10699, Taiwan
3 State Key Laboratory of Marine Geology, Tongji University, Shanghai 200092, China
4 College of Marine Geosciences, Ocean University of China, Qingdao 266100, China

The Tongbai orogen is located in a key tectonic position linking the Qinling orogen to the west and the Dabie-Sulu orogen to the east. This orogen comprises a Paleozoic accretionary orogenic system in the north and a Permo-Triassic collisional orogenic system in the south; hence it may hold a key to understanding the geological relationships and tectonic evolution of different units in the Qinling-Tongbai-Dabie-Sulu orogenic belt. The Tongbai high-pressure (HP) metamorphic terrane consists of two HP slices (I and II) and a tectonic mélange zone in the north and a blueschist-greenschist zone in the south. We recently undertook petrological and geochronological studies on the two HP slices (Liu et al., 2008, 2010; Cheng et al., 2011). In conjunction with the available data, we ascertained the framework of the collisional orogenic system in the Tongbai orogen and advocated a diachronous subduction-exhumation model for interpreting the formation and uplifting of the HP/UHP rocks in the orogen.

The HP slice I is represented by the northern and southern eclogite zones occurring on the two sides of the Tongbaishan antiform. It comprises mylonitized granites, quartzofeldspathic gneisses, mica schists, quartzites and marbles with numerous eclogite and garnet amphibolite lenses. Using conventional geothermometers and geobarometers, the peak metamorphic conditions were estimated to be 530-610°C and 1.7-2.0 GPa for the northern zone and 460-560°C and 1.3-1.9 GPa for the retrograde amphibolite facies. The conventional thermobarometries yielded P-T conditions of 660-700°C and 0.80-1.03 GPa for the retrograde amphibolite facies metamorphic stage, whereas the peak metamorphic conditions were inferred to be within the eclogite facies field at <700°C and >1.2 GPa (Liu et al., 2010). Zircon U-Pb ages of 255 ± 6 Ma and 257 ± 16 Ma, two garnet-whole rock Lu-Hf isochron ages of 252.3 ± 3.4 Ma and 256.4 ± 2.6 Ma, and one mineral-whole rock Rb-Sr isochron ages of 253 ± 11 Ma were obtained in eclogites from the HP slice I (Liu et al., 2008; Cheng et al., 2011). Since inclusions of garnet, omphacite, amphibole, paragonite, epidote, quartz and rutile were discovered in metamorphic zircon domains, and omphacite occur as inclusions in garnet, the age of ~255 Ma was regarded as the timing of eclogite facies metamorphism. On the other hand, muscovite 40Ar/39Ar dating for 3 quartzofeldspathic gneisses and 1 quartzite yielded ages of 238 ± 2 Ma, 238 ± 2 Ma, 234 ± 2 Ma and 217 ± 1 Ma, respectively, whereas the time of muscovite cooling through its closure temperature of ~350°C.

The HP slice II is represented by the metamorphic enclaves in coarse-grained gneissic granites in the Tongbai Complex. The Tongbai Complex constitutes the core of the Tongbaishan antiform. The metamorphic enclaves, which make up ~20% of the complex, consist of fine-grained dioritic-trondjhemitic gneisses and subordinate amphibolites, paragneisses, calc-silicates and marbles with a few retrograded eclogite lenses. The conventional thermobarometries yielded P-T conditions of 660-700°C and 0.80-1.03 GPa for the retrograde amphibolite facies metamorphic stage, whereas the peak metamorphic conditions were inferred to be within the eclogite facies field at <700°C and >1.2 GPa (Liu et al., 2010). Zircon U-Pb geochronology for retrograded eclogites, garnet amphibolites and dioritic-trondjhemitic gneisses reveals a long-term magmatism from 933 to 742 Ma, and metamorphic ages ranging from 232 ± 6 Ma to 220 ± 3 Ma (Liu et al., 2010). The coarse-grained gneissic granites dominating the Tongbai Complex were dated at ~140 Ma. By contrast, 40Ar/39Ar thermochronology on hornblende, muscovite from diverse gneisses and amphibolites yielded two age groups at ~135-120 Ma and ~100-90 Ma (Webb

* Corresponding author. E-mail: liuxchqw@yahoo.com.cn
et al., 1999; Cui et al., 2012), implying that the Cretaceous extension of the Tongbai Complex may have involved two episodes of deformation (cooling) and exhumation.

The age of ~255 Ma obtained for the HP slice I marks the oldest date of HP metamorphism in the Tongbai-Dabie-Sulu HP/UHP metamorphic belt. This signifies that the onset of continental subduction and subsequent continent-continent collision were not later than Late Permian. The conclusion is supported by the following two facts. One is that the garnet-whole rock Lu-Hf and Sm-Nd isochron ages of the oceanic-type eclogites from Xiongdian and adjacent area are concentrated to 271-252 Ma (Cheng et al., 2009, 2010a, 2013), which are later than the zircon U-Pb ages of ~315 Ma obtained for the same eclogites (Sun et al., 2002; Cheng et al., 2009; Wu et al., 2009; Liu et al., 2011a). This suggests that these oceanic-type eclogites may have been reworked by continental subduction during the Late Permian. The second is that the muscovite 40Ar/39Ar ages obtained for the Nanwan flysch of the Tongbai orogen and the Foziling Group of the Dabie orogen are also clustered at 271-261 Ma (Niu et al., 1994; Faure et al., 2003; Ratschbacher et al., 2006). As generally accepted, these two Devonian flysch sequences represent the hangingwall accretionary complex of the subduction zone (Liu et al., 2013). Considering that the metamorphic ages of 340-310 Ma for the Guishan complex (Liu et al., 2011b) are comparable with those of the Xiongdian eclogites, the oceanic subduction prior to the final collision between the Sino-Korean and Yangtze cratons is inferred to have lasted for ~60 Ma (Fig. 1).

On the other hand, the cooling age (~238 Ma) of the HP slice I is older than the metamorphic age (232-220 Ma) of the HP slice II. This suggests that, when the HP slice II was subducted to deep levels and underwent HP metamorphism, the HP slice I overlain it might have been exhumed to mid- to upper-crustal levels. A muscovite 40Ar/39Ar age of 256 ± 1 Ma was obtained for the tectonic mélange zone north of the HP slice I (Huang et al., 2006), suggesting that this epidote-amphibolite facies basement complex of the Yangtze craton represents another medium P/T slice formerly taken its place at a shallow level. This testifies a diachronous (differential) subduction/exhumation model of different HP and UHP slices proposed for the western Dabie (Liu et al., 2004a,b), eastern Dabie (Liu et al., 2007) and Sulu terranes (Liu et al., 2009). Therefore, diachronous subduction and exhumation, or multi-slice or differential subduction and exhumation called respectively by Liu et al. (2007) and Liu et al. (2009), might be a major mechanism for the formation and uplifting of the HP/UHP rocks in the Tongbai-Dabie-Sulu orogen. Furthermore, the HP metamorphism of the Huwan and Hong’an eclogite belts in the western Dabie orogen, which correspond to the HP slice I of the Tongbai orogen, was dated at ~240 Ma (Cheng et al., 2010b; Liu et al., 2012), later than the latter by ~15 Ma. This implies that the HP slice is also

![Fig. 1. Tectonic evolution of the Tongbai orogen from oceanic subduction/accretion to continental collision (after Liu et al., 2013)](image-url)
diachronous along the orogen, mostly as a consequence of the oblique subduction of the Yangtze continental crust.

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**References**


