ABSTRACT

The North Qaidam orogenic belt is located in the northwestern part of the Tibetan Plateau and has been recognized as an early Palaeozoic high/ultra-high pressure (HP/UHP) metamorphic belt with the identification of coesite-bearing eclogite and gneiss and diamond-bearing garnet-peridotite lenses in different terranes over the past ten years. Previous geochronological studies mainly focused on the timing of peak metamorphism for the North Qaidam UHP metamorphic rocks. Systematic geochronological studies addressing the exact timing of amphibolite facies retrogression and the cooling/exhumation history of these HP/UHP metamorphic rocks are limited. In order to better understand the metamorphic conditions, and to clarify the exhumation and tectonothermal evolution of these HP/UHP metamorphic rocks, petrologic study and $^{40}Ar/^{39}Ar$ dating analyses were performed on various metamorphic rock types from two key localities, namely the Yuka terrane and the Xitieshan terrane. The main conclusions of this thesis are:

(1) Petrographic data and reaction textures in the eclogite samples indicate that the Yuka terrane recorded four successive phases of metamorphism connected to subduction and subsequent exhumation. Pressure- temperature *(P-T)* conditions of the pre-eclogite stage are P = 7.1 – 9.1 kbar and T = 464 – 545°C, followed by peak eclogite stage metamorphism at P = 26.2 – 31.2 kbar and T = 671 – 711°C. During their ascent from maximum depth, the rocks recorded upper amphibolite-facies metamorphism at P = 13.3 – 17.2 kbar and T = 633 – 687°C, and amphibolite facies metamorphism at P = 5.6 – 8.8 kbar and T = 490 – 587°C, respectively. In contrast, eclogites from the Xitieshan terrane lack prograde mineral inclusions due to pervasive HP granulite facies overprinting. Amphibolized eclogites record peak eclogite facies conditions of $P \geq 27$ kbar, and T = 651 – 733°C, high-pressure granulite facies conditions of P = 11.5 – 13.2 kbar and T = 760 – 810°C, upper amphibolite facies conditions of P = 8.1 – 9.1 kbar, and T = 630 – 670°C and lower amphibolite facies conditions of P = 5.0 – 7.2 kbar, T = 530 – 630°C. The different *P-T* paths between these two localities show that their subduction and exhumation histories are not connected.

(2) Amphiboles from the Yuka and Xitieshan mafic HP/UHP metamorphic rocks analyzed by $^{40}Ar/^{39}Ar$ laser stepwise heating yielded complex age spectra and anomalously old apparent ages, indicating the presence of extraneous ^{40}Ar. Meanwhile, isotope correlation diagrams ($^{36}Ar/^{40}Ar$ vs. $^{39}Ar/^{40}Ar$) not only confirmed the presence of extraneous ^{40}Ar, but also provided reasonable age information. The intercept age results indicate that amphibolite facies overprinting of the Yuka and Xitieshan eclogite started no later than *ca.* 472 and *ca.* 425 Ma, respectively. *In vacuo* crushing and residual powder stepwise heating analyses conducted on the duplicate amphibole separates reveal that the extraneous ^{40}Ar was mainly trapped in fluid inclusions rather than hosted in mineral crystal lattice.

(3) $^{40}Ar/^{39}Ar$ laser stepwise heating studies on metamorphic phengite have demonstrated a close link between lithology and argon isotope age results. Phengite

separates from Yuka eclogite and amphibolite yielded complex release patterns and anomalously old apparent ages (475 – 797 Ma) and total gas ages (555 – 708 Ma), reflecting the presence of extraneous ^{40}Ar. However, phengite from schist and gneiss samples show flat age plateaux and reasonable plateau ages (418 Ma and 455 Ma). The extraneous ^{40}Ar in phengite is strongly correlated with its mineral chemical composition and is most likely a locally derived component from the Neoproterozoic protolith that has been trapped in the process of metamorphic recrystallization at depth.

(4) Preliminary petrographic observations and micro-thermometric measurements show that three types of fluid inclusions can be distinguished in Yuka quartz veins, including hypersaline primary aqueous inclusions, intermediate to high-salinity primary and pseudo-secondary fluid inclusions, and low-salinity secondary aqueous inclusions. *In vacuo* crushing $^{40}Ar/^{39}Ar$ dating results show that the secondary fluid inclusions contain a significant amount of excess argon. Primary and pseudo-secondary fluid inclusions are virtually uncontaminated by excess argon and have plateau ages from 429 to 420 Ma. These ages are our best estimate for the time of quartz vein formation and records aqueous fluid flow during the later uplift stages of the UHP rocks.

(5) New $^{40}Ar/^{39}Ar$ dating results combined with petrological analyses and published zircon U-Pb ages indicate that subduction and exhumation of the Yuka and Xitieshan HP/UHP metamorphic rocks are characterized by a multistage evolution. The Yuka HP/UHP rocks were exhumed rapidly (3 ± 0.4 km/Myr) in the early stage from upper mantle levels of about 95 km beneath the earth surface at *ca.* 495 Ma to the lower crust at about 26 km about 472 Ma ago. The Xitieshan HP/UHP metamorphic rocks were exhumed at a somewhat faster rate of 4 ± 0.1 km/Myr from upper mantle depths at *ca.* 441 Ma to the lower crust at *ca.* 425 Ma. The rapid initial exhumation process may have been driven by buoyancy forces affecting the HP/UHP rocks after slab breakoff. Moreover, the newly obtained $^{40}Ar/^{39}Ar$ dating results indicate that the timing of corresponding cooling as well as subsequent uplift rates of the Yuka and Xitieshan HP/UHP rocks through the lower crust to the upper crust are also distinct from each other.

Key words: North Qaidam, Yuka terrane, Xitieshan terrane, Eclogite, Ultra-high pressure metamorphism, *P-T-t* path, $^{40}Ar/^{39}Ar$ dating