Radiogenic and stable isotopic study of metamorphic rocks: Case studies from Qinglongshan UHP rocks (Sulu terrain, China) and the Isorssua complex (southern West Greenland)

GIORGIS David; December 21, 2001

Supervisor: Dr. Michaël Cosca, Institut de Minéralogie et Géochimie

The UHP eclogite, meta-granite and meta-sedimentary rocks from Qinglongshan (Eastern China) were formed during the early Mesozoic collision of the North China and Yangtze Blocks. These rocks are unusual because of their “excess” argon and their extremely low dD and d18O signatures (-15‰ to -1‰), which is interpreted as the result of Proterozoic meteoric water-rock interaction in a cold climate prior to Triassic (220-240 Ma) continental collision. In order to understand the origin of excess argon, these rocks were investigated by different analytical techniques (in situ UV-laser analysis, furnace step heating analysis, EMPA, oxygen isotopes analysis).

In situ UV-laser analyses (chapter 2) of an eclogitic sample indicate that large intragranular variation in 40Ar/39Ar dates (from 300-1100 Ma) in compositionally zoned phengite grains are positively correlated with celadonite content. This is consistent with retrograde chemical exchange and argon isotopic repartitioning in response to decreasing partial pressures of argon during decompression. These data support an interpretation that the extraneous Ar was incorporated early in the crystallization history of the eclogite, and not from a late infiltrating fluid and it is suggested that, like the oxygen isotopic system, the argon isotopic system was closed during the UHP metamorphism and that extraneous argon has been inherited from the protolith of the eclogite.

White mica, biotite and K-feldspar furnace step heating analyses (chapter 3) from several lithologies indicate that excess argon is exclusively located in phengitic white micas illustrated by a range of 40Ar/39Ar total gas ages between 260 Ma and 950 Ma. Comparison of phengite d18O values with their 40Ar/39Ar total gas ages yields a correlation between the lowest (-9.7‰) and the highest (-1.2‰) d18O values and the oldest (950 Ma) and the youngest (260 Ma) 40Ar/39Ar total gas ages, respectively. This correlation is interpreted as the result of pre-metamorphic isotopic heterogeneities in the different protoliths of these samples and may reflect partial isotopic exchange between the protoliths and oceanic meteoric or metamorphic water in a downgoing accretionary prism during the Permian (preceding the HP-UHP metamorphic event). These data confirm that the excess argon was internally recycled during the metamorphism and inherited from the protolith. Furthermore, muscovitic white micas, biotite and K-feldspar are free of excess argon and present ages corresponding to metamorphic cooling, providing constraints on the cooling and exhumation history of these rocks.

Oxygen isotope analyses of zircons from the UHP meta-granite of Qinglongshan (chapter 4), indicate very negative d18O values (ranging from –0.2 to –7.3‰) for pre-metamorphic cores (isolated by air-abrasion) and for UHP metamorphic rims of zircons. In addition, zircon cores have unusual morphologies (illustrated by CL and BSE images) and are characterized by abundant inclusions, suggesting crystallization within a fluid-rich environment. Consequently, the pre-UHP

metamorphic zircon cores probably acquired their negative d18O values during their sub-solidus crystallization in an unusual hydrothermal context, where rocks (or magma) interacted with cold meteoric water. These results are in agreement with the idea that the meta-granite was the pre-metamorphic geothermal heat source that drove convective circulation of ground (meteoric) water.

The last part of this thesis (chapter 5) is a geochronological study of rocks coming from the Isorssua complex of southern West Greenland. These rocks (migmatized gneiss, grt-crd-sil micaschist and amphibolite all metamorphosed at upper amphibolite conditions; 700-750°C; 4-6kb) were investigated in order to constrain the timing of the metamorphism using a diverse set of geochronological data. The reported U/Pb, U/Th/Total Pb (EMPA), Sm/Nd, Rb/Sr and 40Ar/39Ar ages emphasize a new 2,55 Ga metamorphic event. These geochronological data provide important constraints for correlation of Archean terranes between Greenland and Canada, where similar ages are also reported.