Sr isotope Studies and Melting of the Sulu UHP Gneiss

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The Sulu ultrahigh-pressure (UHP) metamorphic belt consists mainly of acidic gneiss and eclogite blocks. Sm-Nd age dating gives the age of UHP metamorphism as c. 230 Ma. U-Pb dating shows that the protolith age is 700 to 750 Ma. The Sulu terrane is intruded by Cretaceous granitic plutons.

The processes by which UHP rocks rise back to the Earths surface are still disputed. The Chemenda model has received particularly wide support. This model appeals to buoyancy as the driving force and requires the upper and lower boundaries of the UHP domain to be weak slip zones. The UHP rocks rise as a largely undeformed rigid slab. However, the Sulu UHP terrane is penetratively deformed in disagreement with this prediction. In the northern part of the Sulu terrane there is also field evidence of partial melting. If partial melting takes place during metamorphism this will cause a drastic drop in the strength, which would make it difficult for the metamorphic domain to behave as a rigid slab. In order to determine the exhumation mechanism it is, therefore, important to determine the relationship between the melt and metamorphism.

Under the peak metamorphic conditions of the Sulu terrane (30 kbar and 700 to 800C) granitic gneiss will melt in the presence of water. The isothermal decompression P-T paths proposed for this region make increase the likelihood of partial melting. The field evidence that suggests partial melting is: the presence of mixed metamorphic and igneous textures and the presence of strongly deformed peraluminous granitic dykes. It is possible, however, that these igneous features were formed during the Cretaceous igneous event and are unrelated to UHP metamorphism. To distinguish these possibilities it is necessary to determine the age of the dykes. U-Pb dating of idiomorphic zircon separated from dyke samples shows the zircons have 200 to 220 Ma rims overgrowing Precambrian cores: the dykes were formed during the UHP event and are not Cretaceous.

Sr isotope studies can help assess the origin of melt. Partial melting will produce a melt that has a higher initial 87Sr/86Sr ratio (SrI) than the SrI of the host rock. If the dykes were formed by partial melting of the Sulu gneiss, they should have a higher SrI. To estimate the SrI in both the dykes and gneiss, we used the known formation ages and whole-rock Sr isotopic ratios. We measured a total of 5 whole rock samples of gneiss and combined these data with previously published results. The combined data define a clear straight line in an Rb-Sr diagram. The slope of this line implies an age of 731 Ma in very good agreement with the U-Pb ages suggesting an SrI for the gneiss of less than 0.7070. A similar study for three samples of the dykes gives SrI values greater than 0.7139, 0.7100, 0.7088: all significantly higher than the Sulu gneiss.

From the above results we can conclude that around the time of UHP metamorphism there was melt present in the Sulu gneiss and that this melt was either formed by partial melting of the Sulu gneiss or at least represents considerable chemical interaction between the melt and gneiss. In either case, around the time of UHP there were significant quantities of melt in the Sulu terrane. Melt causes an increase in reaction speed and this could help explain why key UHP minerals are very rarely preserved in felsic gneisses. Also, melting of the gneiss is most likely during exhumation and incompatible elements such as zirconium will be concentrated in these melts. This could help explain why growth of zircon tends to be after the peak of metamorphism. Finally, the presence of even relatively small quantities of melt will cause a drastic reduction in the strength of the gneiss suggesting that exhumation models that treat the Sulu gneiss as a rigid slab should be reconsidered.