Precambrian Tectonics and the Physiochemical Evolution of the Continental Crust. Part I: The Gabbro-Eclogite Transition

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Abstract

We report the first occurrence of retrograde eclogite shear zones cutting Proterozoic granulites from Australia. The Musgrave Range granulites were metamorphosed at about 12 kbar pressure and 850–900°C. The granulites then cooled isobarically and developed a variety of lower-temperature mineral reaction coronas typical of garnet granulites. These rocks are cut by a major shear zone, the Davenport Shear, in which lower-temperature, fine-grained eclogite developed. This demonstrates that mafic rocks in the deep crust can cool down into the thermodynamic stability field of eclogite without undergoing transformation to eclogite. We agree with Harte et al. (1981) that rocks lacking a fluid phase in stable tectonic regions are unlikely to maintain local equilibrium at ambient geotherm conditions until depths well within the upper mantle are reached.

It is proposed that many isobaric, high-pressure granulites could have cooled down into the eclogite field before their later excavation to the surface, and did not transform to an eclogite mineralogy. The inability of the lower crust to transform into eclogite by retrograde reaction has important implications for the seismic, petrologic and geochemical character of the lower crust. The continental Moho cannot be caused by the gabbro-eclogite transition. Preservation of relatively low density, high-temperature granulite and gabbroic mineral assemblages in the lower continental crust prohibits major recycling of lower crust back into the mantle once it is removed from active plate boundaries. However, in island arcs with magmatically thickened crust, mafic rocks at a depth of 60 to 70 km will be in the eclogite stability field at high enough temperatures (800–900°C) for eclogite to rapidly form and sink back into the mantle. This could result in a net accreted crust of broadly andesitic composition. In contrast, later growth of continental crust by basalt underplating in stabilised shield regions will not result in subsequent eclogite formation, and lower crustal recycling back into the mantle will not occur. Thus, estimates of the average composition of the continental crust which are based on a mass balance of plate margin basaltic input from the mantle will not be adequate.