Geophysical Research Abstracts, Vol. 7, 00115, 2005
SRef-ID: 1607-7962/gra/EGU05-A-00115

Evolution of the archaean continental crust. Insights from the experimental study of archaean granitoids.

S. López (1), A. Castro (2) and C. Fernández (3)

(1) Institutt for geologi, Universitetet i Tromsø, 9037 Tromsø, Norway, (2) Departamento de Geología, Universidad de Huelva, 21071 Huelva, Spain, (3) Departamento de Geodinámica y Paleontología, Universidad de Huelva, 21071 Huelva, Spain (Susana.Aparicio@ig.uit.no / Phone: +47 77644673).

The Archaean–Proterozoic boundary is a limit of geological relevance. The Archaean continental crust is Na–rich, against a mainly K–rich post–Archaean continental crust. The igneous lithologies that predominate in the Archaean and Early Proterozoic terrains are tonalite-trondhjemite-granodiorite (TTG) complexes, sanukitoids and K–granites. TTG complexes appear from the Early Archaean. However, sanukitoids and K–granites crop out as sin– to post–kinematic intrusive complexes in Late Archaean terrains. Different tectonic regimes have been suggested for the Archaean and Early Proterozoic times (Smithies et al., 2003). Therefore, the understanding of the processes that originated the Archaean lithologies is a very important topic with regards to the study of the evolving continental crust.

The petrogenetic model suggested in this work is based on the results obtained in an experimental study of TTG, sanukitoids and K–granites, as a tool to constrain the hypotheses proposed by different authors. One of the assumptions has been that plate tectonics operated during the Archaean (de Wit, 1998). In addition, the model has considered a progressive decrease in geothermal gradients with time according to the studies of Martin (1999) and Martin and Moyen (2002). The progressive cooling of the Earth could have favoured a change in the angle of subducting zones, which tend to show steeper average dips with time (Smithies and Champion, 2000; Smithies et al., 2003). According to Condie (1989), a large number of small plates of basic composition (basalt–komatiite) characterized the Early Achaean. These plates were formed from a primitive magmatic ocean due to the progressive cooling of the Earth. This process favoured the formation of a global oceanic lithosphere. The thermal structure of the Archaean down-going plates was favourable for melting of the oceanic crust in subducting slabs (López and Castro, 2001). TTG magmas, which appear since the Early Archaean, were mainly formed by partial melting of subducting slabs. In the Early Archaean, the subduction zones probably were gently dipping (Smithies and Champion, 2000). Therefore, the TTG magmas did not interact with the mantle during its ascent. The progressive cooling of the Earth produced an increase in the dip of the subducting slab, and this geometrical change favoured the interaction of TTG magmas with the mantle wedge during its ascent. This process could explain the geochemical variation of TTG magmas with time, with a progressive increase in Cr, Ni, and #Mg (Martin and Moyen, 2002; Smithies et al., 2003).

The main contribution of the upper–plate mantle wedge to the Archaean igneous processes is in the generation of sanukitoids. These magmas were mainly originated late in the Archaean, and they have been ascribed to the realm of processes that led to cratonization and development of stable continental shields. Experimental results show that sanukitoid magmas could be generated by partial melting of the mantle wedge with participation of melt from subducted sediments and oceanic crust (Castro et al., submitted).

The model finishes considering the processes of crustal evolution at the Archaean–Proterozoic boundary, with the appearance of voluminous K–granite batholiths. These lithologies are associated with sanukitoids and older tonalites. The intrusion of sanukitoids into a tonalite crust and their crystallization favoured the migmatization of the tonalitic crust. Fluids released from the crystallizing hydrous sanukitic magma pervaded the continental crust and can modify its composition from tonalitic to granodioritic (López et al., 2004). Such a kind of metasomatic processes were probably more efficient during the initial stages of continental collision, within a thickened and heated tonalitic crust, producing granodioritic gneisses or modified tonalites similar to those observed in the Lewisian Complex (Castro, 2004). At a more advanced stage and in comparison with similar processes in Fanerozoic collisional orogens, voluminous K–granites batholiths were produced. This process could have been favoured by the activity of late orogenic extensional regimes. Under these conditions, partial melting of host rocks (tonalites and trondhjemites) allow mixing between the anatectic melt and the fluids released by the crystallizing sanukitoid magma, giving rise to granite and granodiorite magmas that may form batholiths.

Cooling of the Earth triggered the evolution towards the present–day subduction zone geometry. This conditioned a change toward the chemical compositions of typical magmas in modern convergent plate boundaries. Since the Archaean–Proterozoic boundary, plate tectonics shows modern characteristics. In addition, the whole composition of the continental crust is granodioritic, which has been a constant from the

Early Proterozoic up to our days. Therefore, the plate tectonic evolution conditioned the growth and chemical evolution of the continental crust.

References

Castro, A. (2004). The source of granites: inferences from the Lewisian Complex. Scottish Journal of Geology, 40, 49-65.

Castro, A., López, S. and Fernández, C. Experimental evidence for Mg-andesite magma generation by melting of subduction–accretion mélanges. (submitted to Lithos).

Condie, K.C. (1989). Plate tectonics and crustal evolution. Pergamon Press. 492 pp. 3ª Edition.

de Wit, M.J. (1998). On Archean granites, greenstone, cratons and tectonics: does the evidence demand a verdict? Precambrian Research, 91, 181–226.

López, S. and Castro, A. (2001). Determination of the fluid–absent solidus and super-solidus phase relationships of MORB–derived amphibolites in the range 4–14 kbar. American Mineralogist, 86, 1396–1403.

López, S., Castro, A. and García–Casco, A. (2004). Production of granodiorite melt by interaction between hydrous mafic magma and tonalitic crust. Experimental constraints and implications for the generation of Archaean TTG complexes. Lithos (in press).

Martin, H. (1999). Adakitic magmas: modern analogues of Archaean Granitoids. Lithos, 46, 411–429.

Martin, H. and Moyen, J.F. (2002). Secular changes in tonalite–trondhjemite–granodiorite composition as markers of the progressive cooling of Earth. Geology, 30, 319–322.

Smithies, R.H. and Champion, D.C. (2000). The Archaean high–Mg diorite suite: links to tonalite–trondhjemite–granodiorite magmatism and implications for Early Archaean crustal growth. Journal of Petrology, 41, 1653–1671.

Smithies, R.H., Champion, D.C., and Cassidy, K.F. (2003). Formation of Earth's early Archaean continental crust. Precambrian Research, 127, 89–101.