Hf-in-zircon perspective on crustal growth and recycling in the Arabian-Nubian Shield

NAVOT MORAG[1]*, DOV AVIGAD[1], KEREN KOLODNER[1], ELENA BELOUSOVA[2], TREVOR IRELAND[3] AND YEHUDIT HARLAVAN[4]

[1]Institute of Earth Sciences, The Hebrew University of Jerusalem, Jerusalem 91904, Israel *(navotm@pob.huji.ac.il)

[2]GEMOC, Department of Earth and Planetary Sciences, Macquarie University, NSW 2109, Australia

[3]Planetary Science Institute, The Australian National University, ACT 2611, Australia

[4]The Geological Survey of Israel, Jerusalem 95501, Israel

The Arabian-Nubian Shield (ANS) is a collage of Neoproterozoic (850-750 Ma) island arcs that were accreted together and then squeezed again towards 640 Ma in relation to Gondwana assembly. Arcs accretion was followed by a widespread, late-post kinematic, calc-alkaline igneous activity that culminated at ~ 630-600 Ma, and by subordinate alkaline magmatism. Isotopic evidence, mostly Sr and Nd, indicate that the ANS was formed as juvenile crust during the Neoproterozoic. The northern tip of the ANS is exposed in southern Israel (Elat area) where it displays ca. 200 m.y of crustal evolution via igneous activity and dynamo-thermal metamorphism. We analyzed zircon U-Pb and Lu-Hf isotope data from 5 representative rock units of the Elat association whose age spans the entire crustal history in the region. All calculated Epsilon Hf values are positive, and define a linear array when plotted versus age. Intersect of this line with the DM evolution line suggests crustal extraction at ca. 1000 Ma. This demonstrates that although the ANS as a whole is rightly considered juvenile, most of its Neoproterozoic evolution is characterized by crustal recycling and or differentiation processes. Detrital zircons from the Elat schist representing the oldest island arc material show a considerable spread over more than 8 Epsilon units, from the DM evolution line down towards CHUR values. This spread highlights the possible contribution from an additional source, beside the DM, to the island arc magmas. This additional source could either be an enriched mantle or a slightly older, ca. 1100-1200 Ma, juvenile crust.

Terrestrial plantes formation: Our Solar System and extra-solar Worlds

ALESSANDRO MORBIDELLI

Observatoire de la Côte d'Azur, B.P. 4229, 06304 Nice Cedex 4, France. (morby@obs-nice.fr)

According to our current understanding, terrestrial planets form in two steps. First, a disk of planetesimals gives origin to the rapid formation of a system of numerous planetary embryos, of masses comparable to that of the Moon or of Mars. Then, the embryos start to collide with each other, as their orbital eccentricities are excited by mutual perturbations and by the giant planets. According to N-body simulations for our Solar System, this leads to the formation of a few (3-4) terrestrial planets in the 0.5-2 AU region, and a substantially depleted asteroid belt. The problems with these simulations is that the resulting planets are typically on orbits that are too eccentric and inclined with respect to the real orbits, and the formation time exceeds 100 My.

A possible solution of the problem consists in accounting for the interaction between the growing planets and the disk of planetesimals. By a process called dynamical friction, the planetesimals damp the eccentricities and inclinations of the terrestrial planets. The most modern simulations accounting for this process have allowed to achieve, for the first time, terrestrial planets on orbits consistent with the real ones and formation timescales of order of 30-40 My, consistent with Hf/W chronology. However, these spectacular results have been achieved assuming that the giant planets at the time were already on their current orbits. Unfortunately, there is a growing consensus that Jupiter and Saturn had to have quasi-circular, less separated orbits. With this set-up, the terrestrial planets still appear to form a bit too slowly and on orbits slightly too excited. It is possible that the future generation of simulations, accounting for a larger number of planetesimals and for their regeneration during collisions among the embryos, will allow to obtain `good' terrestrial planets even in the framework of circular giant planets.

All current simulations show that the accretion of terrestrial planets is heterogeneous: material is incorporated in a stochastic way from a large variety of heliocentric distances, including from the asteroid belt. Thus, water could have been accreted during the formation process from the regions where hydrated meteorites come from.

The process of terrestrial planets formation has also been explored in the context of different giant planets systems, inspired by extra-solar planets discoveries. In general, more eccentric or massive giant planets lead to the formation of a smaller number of more massive terrestrial planets. Eccentric planets also inhibit the delivery of water from the asteroid belt equivalent. More recently, it has been shown that the radial migration of a giant planet toward the central star does not abort terrestrial planets formation.