Observation of geoneutrinos in Borexino

A. IANNI[1,]* AND Y. SUVOROV[2]

[1] *correspondance: aldo.ianni@lngs.infn.it
[2] yury.suvorov@lngs.infn.it

Geoneutrinos are electron anti-neutrinos produced by long-lived radioactive isotopes in the earth's crust and mantle. Geoneutrinos can be deteted in kton scale organic liquid scintillator detectors located in underground laboratories. The detection reaction being the inverse-beta decay which has a prompt and delayed signal. These signals are correlated in space and time. The anti-neutrino interacts with a proton from an hydrogen atom and will make a positron plus a neutron. The positron will promptly annihilate; the neutron will thermalize and be captured on hydrogen in some 250 μs. In spite of the strong signature geoneutrino can only be detected in massive low background set-ups designed for low energy (1 MeV) neutrinos. Borexino at the Gran Sasso underground laboratory in Italy has been in operation since 2007 to search for sub-MeV solar neutrinos. The sun is a huge source of electron neutrinos. Observation of solar neutrinos provides a unique tool to study the interior of the sun. At present experimental studies of geoneutrinos are carried out with KamLAND at the Kamioka mine in Japan and with Borexino at Gran Sasso. The first attempt of a geoneutrino measurement was done in KamLAND in 2005. Only in 2010 and 2011 both Borexino and KamLAND observed at more the 4σ C.L. a signal from geoneutrinos. The search of geoneutrinos likewise the one of solar neutrinos for the sun provides a unique tool to probe the interior of the earth. Uranium and thorium from the crust and the mantle make the geoneutrino flux on surface. The energy spectrum of the detected geoneutrinos depends on the abundance of uranium and thorium and on the different beta decays in the two radioactive chains. A spectroscopy determination of the geoneutrino signal can be done. This has been recently shown by Borexino. By means of this analysis the ultimate goal of the geoneutrino search will be the determination of the uranium and thorium content in the mantle. For this purpose a combined analysis of more than one experiment results will be necessary. In this talk we will review the present status of geoneutrino research. We elaborate on the recent results from Borexino and KamLAND. The experimental difficulties and background sources will be discussed.

Influence of osteopontin on apatite formation

C. J. S. IBSEN[1], J. OLSEN[1], D. GEBAUER[2], H. BIRKEDAL[1]

[1] iNANO & Department of Chemistry, Aarhus University, Aarhus 8000, Denmark (*correspondence: hbirkedal@chem.au.dk)
[2] Department of Chemistry, University of Konstanz, Konstanz 78457, Germany

The classical crystallization theories have been shown to be incomplete, particularly in the field biomineralization where non-classical crystallization pathways are widespread [1], including prenucleation clusters in solution as known in $CaCO_3$ and calcium phosphates [2-4]. The picture is even more complicated when additives are also considered. For calcium phosphate biomineralization in vertebrates, phosphate-rich proteins are known to be important. Herein we show how one of these, the calcium binding phosphoprotein osteopontin, drastically modifies the prenucleation behavior during calcium phosphate formation.

The formation of calcium phosphate was investigated by constant pH (8.0) titration of dilute calcium chloride into a sodium phosphate solution [2]. The calcium activity was measured *in situ* using a calcium sensitive electrode.

In the osteopontin-free case, the calcium activity is lower than the added amount reflecting the formation of a bound prenucleation state [2-4]. As the supersaturation increases, an amorphous intermediate is formed which transforms into crystalline apatite upon continued titration. When introducing osteopontin an additional intermediate is observed that remains in dispersion. Both intermediates were stabilized by osteopontin in a dose dependent manner. However, osteopontin did not significantly affect the prenucleation behaviour prior to the formation of the first intermediate.

The initial amorphous phase was HPO_4^{2-}-rich. As more calcium was added, the stoichiometry gradually changed towards stoichiometric amorphous calcium phosphate (ACP), with a distinct increase in the PO_4^{3-}/HPO_4^{2-} ratio at the transition from intermediate 1 to 2. The final apatitic phase was also found to be calcium deficient.

For carbonates, multiple amorphous forms are known, which might influence what polymorph is formed [2]. The observed additive-stabilization of ACP could help unravel the role of additives in biomineral formation, including polymorph selection.

[1] Gower (2008) *Chem. Rev.* **108**, 4551-4627. [2] Gebauer *et al.*. (2008) *Science* **322**, 1819-1822. [3] Dey *et al.*. (2010) *Nat. Mater.* **9**, 1010-1014. [4] Habraken *et al.*. (2013) *Nat Commun.* **4**, 1507

DOI:10.1180/minmag.2013.077.5.9