Study of the natural iron fertilization off Crozet and Kerguelen Islands (Southern Ocean) using radium isotopes as tracers

PIETER VAN BEEK[1,*], VIRGINIE SANIAL[1], BRUNO LANSARD[1], MARC SOUHAUT[1], ELODIE KESTENARE[1], FRANCESCO D'OVIDIO[2], MENG ZHOU[3] AND STÉPHANE BLAIN[4]

[1]LEGOS (CNRS/UPS/CNES/IRD), Toulouse, France
[2]LOCEAN-IPSL (CNRS/UPMC/MNHN/IRD), Paris, Fr
[3]University of Massachusetts, Boston, USA
[4]LOMIC (CNRS/UPMC), Banyuls-sur-Mer, France

The Southern Ocean is known as the largest High-Nutrient, Low-Chlorophyll (HNLC) region of the global ocean. Phytoplankton blooms, however, take place annually off islands and associated plateaus that constitute physical barriers for the Antarctic Circumpolar Current. These phytoplankton blooms were shown to be sustained by natural iron fertilization associated with these topographic features. In the framework of the KEOPS-2 project, we used radium isotopes (Ra) as tracers of iron sources that fuel the phytoplankton blooms around Crozet and Kerguelen Islands, following previous works by [*Charette et al.* , 2007] and [*van Beek et al.* , 2008], respectively. In this work, we report one of the few studies that analyzed all four radium isotopes (^{224}Ra, ^{223}Ra, ^{228}Ra, ^{226}Ra) in Southern Ocean waters. Ra isotopes were used i) to trace the input of iron - and other micronutrients - released by the sediments deposited onto the margins and that sustain phytoplankton blooms, ii) to investigate the pathways of the waters that fuel the phytoplankton bloom north of Crozet Islands and east of Kerguelen Island, and iii) to estimate "apparent ages" for offshore waters. When combined to physical observations and modeling, information provided by our geochemical tracers allows us to assess the rates and timescales of the exchange between the islands and offshore waters and to give information on the origin and mechanism of iron fertilization in these areas.

Ocean ridge magma generation rates at slow-spreading ridges favour Hess-type oceanic crust

PETER VAN CALSTEREN[1]* BRAMLEY MURTON[2] AND ROGER SEARLE[3]

[1] Earth Sciences, The Open University, Milton Keynes MK7 6AA, UK, p.v.calsteren@open.ac.uk
[2] National Oceanography Centre, Southampton SO14 3ZH, UK, bramley.murton@noc.soton.ac.uk
[3] Department of Earth Sciences, Durham University, Durham DH1 3LE, UK, r.c.searle@durham.ac.uk

The widely accepted model for the structure and composition of oceanic crust is based on the 'Steinmann Trinity' or Penrose ophiolite stratigraphy. This has an oceanic crust of mafic rocks: basalt pillow lavas with their feeder dykes (sheeted dyke complex) and gabbro plutons, underlain by the ultramafic, peridotite mantle. However, recent work on slow-spreading ridge systems has revealed significant deviations from this simple layered structure[1,2,3].

The thickness of the oceanic crust is derived from geophysical data interpretations assuming that the crust is wholly mafic but a melange of partly serpentinised mantle peridotite and mafic rocks can equally fit the data. If it is accepted that the crust is not completely mafic, then constraints on the amount of generated mafic magma have to be derived elsewhere. The amount of generated magma is determined by the melt generation rate and time, and by the volume of the melt zone.

We have derived melt generation rates for peridotite melting in the garnet stability zone between depths of the solidus at130Km and 95Km by modelling our U-series data for basaltic glass samples collected by ROV from the Mid Atlantic Ridge slow-spreading centre at 45ºN. Our results can be expanded with published results from thermodynamic modelling to estimate total decompression melt generation. We assume that the volume of the melt zone is given by the width of the active volcanicity in the median valley and the depth to the solidus, with 1Km along strike as the distance over which volcanic and tectonic characteristics can be considered as representative. We argue that in an area of tectonic extension, magma ascends vertically and is not focussed.

The our derived magma flux at 'normal' slow-spreading ridge segments, contributes <50% of the volume of crust, the remainder probably is serpentinised mantle peridotite. These inferences are agreement with the 'Hess' model for oceanic crust.

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DOI:10.1180/minmag.2013.077.5.22