Thermal history energy balance compared with convection modeling

SCOTT D. KING*

Department of Geosciences, Virginia Tech, Blacksburg, VA 24061, USA (*correspondence: sdk@vt.edu)

Thermal history calculations are based on balancing the flux of heat into and out of the mantle with the heat generated internally due to the decay of radiogenic elements [1]. In order to reduce this balance to a tractable equation, a relationship between the surface heat flow and temperature is necessary. Often this is a relationship between the Nusselt number and Rayleigh number and variants of this relationship have been proposed based on both theory and numerical experimentation [1, 2, 3]. The power of thermal history calculations is that they can explore a large parameter space with minimal computational resources; however they provide only an average mantle temperature as a function of time.

3D spherical-shell convection calculations are becoming increasingly prevalent. These solve the conservation of mass, momentum and energy in a 3D spherical geometry; however two important aspects of thermal history modeling are infrequently employed in 3D convection calculations: a cooling core boundary condition and decreasing radiogenic heating with time. In many recent investigations the time-span of interest is such that these do not vary significantly.

This raises an interesting question: *Just how comparable are thermal history calculations and 3D spherical-shell convection calculations?* In this presentation I will compare 3D convection and thermal history calculations with the same properties. These will include temperature and pressure dependent rheology and a 'mobile lid' using the methodology outlined by *van Heck and Tackley* [4], decaying radiogenic heat sources, and a cooling core boundary condition. Even with advances in computing power, it is unlikely that solving the set of conservation equations will replace thermal history models any time soon. The goal is to assess whether given the same parameters these two formulations will produce a similar temperature history. While there are a myriad of parameters and assumptions, many of which are unknown and perhaps even unknowable (e.g., the average mantle temperature at formation), both 3D and thermal history calculations face these challenges. While the observations relevant to Earth's thermal evolution are being assessed, so to should the computational tools used to model it.

[1] Schubert, Turcotte & Olsen (2001) *Mantle Convection in the Earth and Planets*, Ch 13. [2] Gurnis (1989) *GRL* **16**, 179-182. [3] Solomatov (1995) *Phys. Fluids* **7**, 266-274. [4] van Heck & Tackley (2008) *GRL* **35**, L19312.

Distribution and migration of americium-241 in the East Pacific

NORIKAZU KINOSHITA[1]*, MIKA NAGAOKA[2], TAKAHIRO SUMI[3], KIYOTAKA TAKIMOTO[3], AKIHIKO YOKOYAMA[3] AND TAKASHI NAKANISHI[3]

[1]Shimizu Corporation, Tokyo 135-8530, Japan.
[2]Japan Atomic Energy Agency, Ibaraki 319-1194, Japan.
[3]Kanazawa University, Ishikawa 920-1192, Japan.
(*norikazu.kinoshita@shimz.co.jp)

Anthropogenic radionuclides of plutonium-239, 240 and americium-241, that is, a decay product of ^{241}Pu, are present on the earth as a result of atmospheric nuclear tests carried out during the 1950s and 1960s. It is known that most of the nuclides deposited in ocean and deposition in North Pacific is higher than South Pacific due to location of the test site. Few data on ^{241}Am in marine environment have been reported, so far. Depth profile, residence time, applicability as a tracer of migration of the nuclide have not been well investigated yet. We have investigated on its distribution at the East Pacific by assaying large volume seawater collected in 2003.

The Am atoms were collected as hydroxides together with iron from 250 L of sea water spiked with ^{243}Am yield tracer. The Am atoms were isolated through a solvent extraction and anion exchange procedure, followed by an assay in α-spectroemtry. The concentration of ^{241}Am was found low in surface water and the depths below 2000 m as well, and enhanced at the depths around 800 m. The depth profile shows a pattern similar to that of $^{239+240}$Pu [1]. Although concentration and depth of the subsurface maximum were different depends on the location, the subsurface maximum was observed in a isopycnic surface; the distribution is affected by water mass structure.

Comparing the present data on ^{241}Am with previous data on $^{239+240}$Pu [1], ^{241}Am/$^{239+240}$Pu activity ratio showed constant value. Substantial differences between different locations and depths have not been observed in the profiles of ^{241}Am/$^{239+240}$Pu ratio. The Am atoms appear to have the same residence time as those of Pu in the East Pacific.

Besides, The ^{241}Am inflow from North Pacific to South Pacific across the equator is observed in a depth of 500 – 1500 m along longitude of 95° W. Similar flows were observed for the Pu isotopes and the nutrients in the same area as well [1]. Our result supports a model simulation of migration in the East Pacific reported by Nakano *et al*. [2].

[1] Kinoshita *et al*. (2011) *Sci. Tot. Environ*. **409**, 1889-1899. [2] Nakano *et al*. (2010) *J. Geophys. Res*. **15**, C06015.

DOI:10.1180/minmag.2013.077.5.11