

## The energy balance at the core-mantle boundary

J. W. HERNLUND<sup>1</sup>, S. LABROSSE<sup>2</sup> AND N. COLTICE<sup>3</sup>

<sup>1</sup>Department of Earth and Ocean Sciences, University of British Columbia, Canada (hernlund@gmail.com)

<sup>2</sup>Laboratoire des Sciences de la Terre, Ecole Normale Supérieure de Lyon, CNRS, Université Lyon 1, France (stephane.labrosse@ens-lyon.fr)

<sup>3</sup>Laboratoire des Sciences de la Terre, Ecole Normale Supérieure de Lyon, CNRS, Université Lyon 1, France (coltice@univ-lyon1.fr)

Cooling of Earth's core occurs because relatively cool rocks sink to the core-mantle boundary (CMB) and absorb heat by conduction in a continuous cycle of sluggish mantle convection. A thermal boundary layer (TBL) is formed where heat is conducted from the core into the mantle and is characterized by an increased geothermal gradient in the D'' region. The recent discovery of post-perovskite (pPv) and increasing seismic evidence for a double-crossing of the pPv phase boundary by the TBL geotherm provides auspicious new constraints on the heat flow in D'', yielding lower bounds in the range 5-15 TW. However, if a several km thick layer of partially molten material just above the CMB was much thicker in the past when Earth's deep interior was hotter, then it is possible that the layer fractionally crystallized over time to achieve its present state and could therefore retain a significant budget of incompatible radioactive species. The power released by radioactivity (on the order of several TW) in this ultralow-velocity zone (ULVZ) layer would contribute to overall D'' heat flow and have potentially important consequences for the structure and dynamics of the mantle and core. Numerical models of mantle convection including a thin dense radioactive layer show that significant lateral variations in the thickness of the ULVZ arise which enhance variations in heat flux at the top of the core, with the thickest and hence most internally heated patches swept up beneath upwelling plumes. On the other hand, inclusion of larger modestly dense chemical piles (or "crypto-continent") moderates the excess heat that would otherwise be transferred into upwelling plumes.

## An integrated NMR and FTICR mass spectroscopic study to characterize a new and major refractory component of (marine) natural organic matter (NOM) at the molecular level, CRAM: Carboxyl-rich alicyclic molecules

N. HERTKORN<sup>1</sup>, R. BENNER<sup>2</sup>, M. WITT<sup>3</sup>,  
M. FROMMBERGER<sup>1</sup>, PH. SCHMITT-KOPPLIN<sup>1</sup>,  
K. KAISER<sup>2</sup>, A. KETTRUP<sup>1</sup> AND I. J. HEDGES<sup>4</sup>

<sup>1</sup>GSF Research Center for Environment and Health, Institute of Ecological Chemistry, Ingolstaedter Landstrasse 1, D-85764 Neuherberg, Germany (hertkorn@gsf.de);

<sup>2</sup>Department of Biological Sciences and Marine Science Program, University of South Carolina, Columbia, SC 29208, USA (benner@biol.sc.edu);

<sup>3</sup>Bruker Daltonics, Fahrenheitstrasse 4, D-28359 Bremen, Germany (matthias.witt@bdal.de);

<sup>4</sup>School of Oceanography, Box 355351, University of Washington, Seattle, WA 98195-5351, USA (deceased).

Advances in organic structural spectroscopy have enabled a direct molecular level analysis of very complex natural mixtures such as the very abundant natural organic matter (NOM), a key contributor to the global carbon cycle and other element cycles (N, P, S,...). NOM often defines the chemical environment and the bioavailability of toxic and nutrient metal ions in the biosphere. Little is known about the chemical composition of NOM and the reason for its refractory nature.

Recently we have identified a new and major constituent of NOM, namely carboxyl-rich alicyclic molecules (CRAM), using nuclear magnetic resonance spectroscopy and ultrahigh resolution mass spectrometry [Fourier transform ion cyclotron mass spectrometry (FTICR-MS)]. CRAM are compositionally and structurally more heterogeneous than other NOM constituents (like peptides and carbohydrates), and are comprised of a complex mixture of carboxylated and fused alicyclic aliphatics with a carboxyl-C:aliphatic-C ratio of 1:2 to 1:7. The structural diversity found within CRAM and their substantial content of alicyclic rings and branching contribute to their resistance to biodegradation and refractory nature.

CRAM are expected to constitute a strong ligand for metal binding, and multiple coordination across cations could promote aggregation and marine gel formation thereby affecting CRAM reactivity and the bioavailability of nutrients and trace metals. It appears CRAM are ultimately derived from biomolecules with structural similarities to sterols and hopanoids. The occurrence of CRAM in freshwater and terrestrial environments seems likely, considering the global distribution of biomolecules and the similarities of biogeochemical processes among environments.