29 april 2003: Præsentation af Danmarks Geologipris 2002

Prisen overrækkes til:

Hans Christian Larsen - Dansk Lithosfærecenter

Geologisk Museum, Øster Voldgade 5–7, kl. 16-18

I anledning overrækkelsen af Danmarks Geologipris 2002 til Hans Christian Larsen, leder af Dansk Lithosfærecenter, afholdes en temaeftermiddag hvor Lithosfærecenteret præsenterer nogle af deres mest aktuelle arbejdsområder og forskningsresultater. Programmet ser ud som følger:

kl. 16:00 Martin Ghisler (GEUS): Velkomst og overrækkelse af Danmarks Geologipris 2002

kl. 16:15 Hans Christian Larsen: Introduktion

kl. 16:20 Hans Christian Larsen: Characteristic features of volcanic rifted margins: what can we learn about rifting and deep mantle processes?

kl. 16:50 John R. Hopper: Characteristic features of non-volcanic rifted margins: what can we learn about rifting and shallow mantle processes

kl. 17:10 Joel Baker: New frontiers in isotope geochemistry

kl. 17:30 Martin Bizzarro: Early History of Earth's crust-mantle system inferred from Hafnium isotopes in chondrite

kl. 17: 50 Hans Christian Larsen: Afslutning med efterfølgende **reception**

Characteristic features of volcanic rifted margins: what can we learn about rifting and deep mantle processes?

Hans Christian Larsen (Danish Lithosphere Centre)

A new class of rifted margins, volcanic rifted margins, were first discovered in the North Atlantic during the 1980s. Through a number of later studies including ocean drilling, large scale geological sampling and deep crustal seismic studies, the East Greenland margin is now a global type locality for this margin structure. The igneous (oceanic) crust that accreted along this margin during breakup was 3-5 times thicker than normal oceanic (igneous) crust, and it formed above or at sea-level for several million years. Given the globally very uniform thickness of oceanic crust (ca. 6 km) and an average depth of oceanic rifts (spreading ridges) of ca. 2.7 km, these anomalies in crustal thickness and rift elevation are remarkably distinct and requires, in a plate tectonic context, unusual conditions of formation. A possible link to the Iceland hot-spot was already made early on, but requires this to have been an order of magnitude larger during breakup than at the present day. Furthermore, similar margin structures have now also been identified along large sections of the central and south Atlantic margins, off Antarctica and north-west Australia, and possibly within the Red Sea region. Can we from this infer that such giant hot-spots exist and are needed in order to initiate the plate-tectonic cycle through continental breakup? Alternatively, can rifting itself drive special, transient mantle convection leading to excessive magmatism? In other words, is it a bottom-up or top-down driven process?

The North Atlantic is the only region so far where critical data encompassing chronology, crustal thickness variations, rates of melting, and melt compositional variations in time and space exists in sufficient amounts to address this fundamental question. In addition, the still active Iceland hot-spot uniquely allows comparative study of the ancient margins with active processes in Iceland. As usual in science, things are not that black and white. So the answer is: It is a bottom-up and top-down process. And in that order, both in terms of geological time and importance. If you want the details, attend the talk!

In the broader perspective, the massive and sudden mantle upwellings, referred to as mantle plumes, that can be inferred from volcanic rifted margins represent deep mantle convection working in parallel with the more steady state plate tectonic mantle convection and perhaps have more in common with the rare, but extreme events of mantle convection inferred for Venus. Likewise, the steady state plate tectonic mantle convection is now seen more and more as a very much top-down driven process preferentially being controlled by the cool lithospheric plates. Thus, while the plate-tectonic paradigm probably is as healthy as ever, our understanding of the driving forces are changing.

Characteristic features of non-volcanic rifted margins: what can we learn about rifting and shallow mantle processes

John R. Hopper, Thomas Funck and **Hans Christian Larsen**

Danish Lithosphere Centre

It is recognized now that rifted margins form a spectrum of types, primarily categorized by how much magmatism is associated with final breakup and the initiation of seafloor spreading. One end member shows almost no melting and volcanism. Extension proceeds through progressive thinning of the continental crust until there is effectively nothing left, exposing the underlying mantle to the surface. While at first glance, this seems like a simple and straightforward idea, the mechanics of how this occurs have proven difficult to understand. In the last decade, a key component of rifted margin research has been the collection of new data to characterize thinned continental crust and lithosphere to test ideas about their formation. Complicated structural patterns imaged on the Galicia Bank and Iberia margins suggest that detachment surfaces may exist at the base of the lower crust, despite the high shear stresses required to form them. Large scale asymmetries have been hypothesized that make predictions about the pattern of strain that should be seen in the other half of the rift, in this case off the coast of Newfoundland. Studies on Galicia Bank and Iberia have also shown that mantle can be brought to the surface without undergoing decompression melting. Instead, it is mechanically unroofed where it interacts with seawater to form a thin layer of serpentinized crust that is neither continental, nor igneous oceanic crust. How important these processes are on other rifted margins or in other tectonic environments remains largely unknown. In collaboration with Institutes in the US and Canada, we collected new seismic reflection and refraction data off Newfoundland to examine the nature of rifted continental crust conjugate to the well studied areas off Iberia. This new data, which will be briefly summarized in this talk, shows remarkable new images of thin crust off a continental margin and has important implications for understanding the final stages of breakup and the onset of seafloor spreading in the North Atlantic.

New frontiers in isotope geochemistry

Joel Baker [1], **Martin Bizzarro** [1,2], **Ingrid Ukstins** [1] and **Tod Waight** [1]

[1] *Danish Lithosphere centre,* [2] *Geological Museum*

Plasma-source mass spectrometers differ from older generation mass spectrometers in that samples are ionised in an argon plasma at temperatures equivalent to those on the surface of the sun. This allows: (1) Elements that were difficult to ionise by conventional mass spectrometry (e.g., W, Hf, Zr, Fe) to be readily analysed and utilised in earth, environmental and space sciences (2) A laser to be directly coupled to the mass spectrometer for in situ analysis of rocks or minerals. (3) precise analysis of new stable isotopic systems like Mg, Fe, Cu or Zn, and much improved precision for radiogenic isotope systems like Pb. Recent tungsten isotope studies, based on the decay of the now extinct ^{182}Hf ($t_{1/2}$ = 9 Myr), shows that Earth's core formed within 30 Myr of the accretion of the planet and that core formation in smaller planets progressively decreases with planet size. Precise Lu-Hf isotopic data for meteorites produced at the DLC demonstrate that crustal differentiation on Earth took place very early, perhaps starting within 200-400 Myr of accretion from the solar nebula. Laser ablation Pb isotope work at the DLC has shown that is possible to date minerals like apatite, sphene, monazite and rutile in situ with relative precisions $<<$ 1%, which were previously only obtainable after time-consuming chemical separation of Pb. Moreover, in situ Pb isotopic analysis can be used as a tracer for oceanographic and volcanological processes. The potential of new "heavy" stable isotopic systems to complement and extend the cosmochemical and paleoenvironmental information routinely extracted from oxygen and carbon isotopes is illustrated by recent magnesium isotopic studies. Magnesium isotopes in chondrites, basaltic rocks from the angrite and eucrite parent bodies, Mars and Earth, and low-temperature terrestrial samples display a range in Mg isotope ratios of 6 per mil. Unlike the different oxygen isotopic arrays defined by meteorite samples, all our data recently acquired for these samples lie on a single mass fractionation line in Mg isotopic space. Intriguingly, basaltic rocks are systematically lighter than the chondritic reservoir commonly assumed to represent the starting material for building planets. Despite the long residence time of Mg in the oceans, Fe-Mn nodules display larger Mg isotopic variations (3 per mil) than any other stable isotopic systems in these materials. With more than 50 new isotopic systems now analysable in our laboratory there remains much to understand in these rapidly developing fields of isotope geochemistry!

Early history of Earth's crust-mantle system inferred from hafnium isotopes in chondrites

Martin Bizzarro[1,2], **Joel Baker** [1], **Henning Haack** [2], **David Ulfbeck** [1] and **Minik Rosing** [2,1]

[1] Danish Lithosphere Centre, [2] Geological Museum

The DLC mass spectrometry laboratory has placed itself in the international forefront by developing a new technique for precise determination of the Lu-Hf system in ultra low concentration samples like chondrite meteorites (Nature, 27/02/03). With a half-life of about 37,000 million years, the decay series from 176-lutetium (Lu) to 176-hafnium (Hf) is both a precise geochronometer and a powerful tool for studying early planetary differentiation processes. The interpretation, however, of Lu–Hf isotope data requires accurate knowledge of the radioactive decay constant of ^{176}Lu, as well as bulk-Earth reference parameters. Chondrite meteorites are among the most primitive objects derived from the solar nebula, and are considered to represent our best estimate of the average composition of the Solar System. Therefore it is commonly accepted that the average evolution of the chondritic Lu–Hf system also represents its evolution in the terrestrial planets as a whole. Deviation from the chondritic evolution is thus a measure of planetary differentiation processes such as mantle melting and solidification of these melts into crustal or mantle reservoirs. In order to precisely re-define the decay constant of ^{176}Lu and bulk-Earth reference parameters, we have measured Lu–Hf concentrations and Hf isotope ratios on a number of chondrite meterorites. Our results provide a new and clear picture of the early Earth, indicating that the differentiation of our planet into a first persistent crust and residual mantle occurred very early in its history, approximately 320 million years after accretion. This is as much as ca. 400 million years before the oldest, large crustal fragments (e.g., Isua in West Greenland) known on Earth. A rapid timescale for differentiation of Earth suggests that it may have had an early history similar to other planetary bodies such as the Moon, Mercury and Mars.