Lithos 120 (2010) vii–viii

Contents lists available at ScienceDirect

Lithos

journal homepage: www.elsevier.com/locate/lithos

Preface

This volume is based on the very lively Session EIL-03 titled "The lithosphere/asthenosphere boundary: Nature, formation and evolution from Hadean to now" held at the International Geological Congress in Oslo, Norway, in 2007. Many of the papers in this volume were presented there, but some represent contributions from other key researchers in the field to round out the subject area covered.

The basis for the Session was that the nature of the Lithosphere–Asthenosphere boundary (LAB) is critical to our understanding of the geodynamic and geochemical evolution of Earth, yet its detection, physical state, and controlling mechanisms are still controversial. Advances in seismic tomography and potential-field analysis (especially magnetotelluric data) are providing imagery of the present-day subcontinental lithosphere to depths of several hundred kilometers and beyond. Studies of seismic discontinuities increasingly address the sharpness, velocity jump, depth and nature of the LAB. Geochemical analysis of xenolithic material and orogenic terranes from the upper mantle and lower crust is providing increasingly sophisticated data on the compositional and thermal structure of this lithosphere, as sampled by volcanic eruptions through time. The geochemistry of primitive magmas tells about the changing composition, temperature and thus rheological behaviour of the convecting mantle. Numerical modelling of dynamic processes in the Earth can investigate how the lithosphere and underlying mantle have behaved through time in response to changing thermal and tectonic regimes.

This Session brought together experts in all these disciplines, in an attempt to integrate the different types of data, and to discuss the constraints that help us elucidate the character and location of the LAB in the present-day and older Earth. This provided a basis for exploring the current state of knowledge in this context and communicating the latest relevant research as represented in this volume.

Some key problems identified and discussed include:

- is the LAB a fundamental boundary where mantle rheology changes (e.g. Mainprice et al., 2005; Gung et al., 2003) and/or a surface where the mantle solidus exceeded for some compositions, so that melts form and segregate (e.g. Wyllie, 1988; Gudfinnsson and Presnall, 1996)?
- do magnetotelluric data record the presence of melts at the LAB (e.g. Gaillard et al., 2008), and does the conductivity boundary coincide with the seismic LAB?
- what type of seismic data and tomographic models best identify the location and nature of the LAB?
- does the seismic LAB coincide with the geochemical or magnetotelluric lithosphere/asthenosphere boundary?
- can mantle xenoliths and exposed orogenic peridotite bodies clarify the petrologic, geochemical and petrophysical characteristics of the LAB?
- does mantle metasomatism change the depth and character of the lithosphere/asthenosphere boundary with time?
- what is the significance of persistent Archean mantle volumes recognized within the Atlantic Ocean Basin, and where is the LAB in such domains?
- what does the LAB represent if old cratonic lithospheric roots or a tectosphere extend to depths over 300 km?

Unsurprisingly, these questions were not comprehensively answered and a sequel session is planned for the International Geological Congress in Brisbane, Australia in 2014. However, the editors consider that this volume contains thought-provoking papers that are stimulating and significantly advance our knowledge of this first-order Earth boundary.

The papers in this volume have been organized in five themes. The first three papers present reviews and original research on different aspects of the lithosphere/asthenosphere boundary: O'Reilly and Griffin use information from mantle xenoliths to address the petrologic and geochemical nature, and the changes in depth of the lithosphere/asthenosphere boundary through Earth's evolution; Jones et al. review and compare seismological and electromagnetic studies of the lithosphere/asthenosphere boundary in Europe; Qin reviews the effects of water in olivine and resultant rheological properties of the mantle relevant to the defining the extent of the lithosphere. The next two papers (by O'Neill and Houseman) deal with different aspects of geodynamic modeling relevant to understanding the mechanical behaviour of the lithosphere through time. The following five papers (Fishwick, Fullea et al., Chen, Feng et al., Plomerova and Babuska, and Darbyshire and Eaton) present new models/methods based on different geophysical datasets that constrain the physical state and evolution of the LAB from localities ranging from South Africa, the Atlantic–Mediterranean area, North China Craton, China, Europe and Hudson Bay, Canada. The next two papers (Dalton and Faul and Rychert et al.) present new ways to use seismic data to address the nature of the LAB. The final three papers (Scambelluri et al., Alard et al., and Coltorti et al.) use petrologic and geochemical data to explore the nature of deep lithospheric mantle boundaries and fluid processes relevant to geological ground-truthing of geophysical approaches. The last paper, in addition, addresses the significance of the occurrence of oceanic lithosphere showing evidence of original formation in the Archean, interpreted as relict buoyant domains stranded during the rifting event.

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26 September 2010