

the Dead Sea Transform (DST). Knowledge of the thermal state of the lithosphere is essential for understanding the complicated geodynamic setting that gave rise to the DST. Steady-state geotherms for the area east of the DST, calculated using surface heat flows of 50 and 60 mW/m² and the P-T-dependent thermal conductivity values for a three-layered lithosphere, result in Moho temperatures of resp. 600 °C and 840 °C, and mantle heat flows of 22 and 32 mW/m². In contrast, a published geotherm for the area west of the DST, based on surface heat flow of 40 mW/m², implies a considerably colder lithosphere, with a Moho temperature as low as 390 °C. This geotherm cannot explain the absence of earthquakes generated in the uppermost mantle and underestimates the xenolith-derived mantle temperatures for Israel by about 500 °C. Underestimation of mantle temperatures (850-1050 °C; 1.2-1.8 GPa) is evident also for the Jordan geotherms of higher heat flow. This discrepancy argues for transient thermal conditions in close proximity to the DST and east of it owing to lithosphere thinning and asthenosphere upwelling.

T12A CC: 516 D Monday 1030h

Deep Structure of the Continental Lithosphere: Combining Seismic, Heat Flow, and Other Geophysical Data II (joint with G, GP, S, V, NS, MR)

Presiding: M Ritzwoller, University of Colorado at Boulder; S Sobolev, GeoForschungsZentrum Potsdam

T12A-01 1030h INVITED

Three Dimensional Deep Electrical Structure of the Slave Craton, Canada

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The lithospheric-scale structure of the Archean Slave craton, northern Canada, has been studied using magnetotelluric surveys over the past decade. Novel MT acquisition techniques were required given the lack of all-weather road access, and included measurements on frozen lakes in winter and deployment of ocean-bottom instrumentation in lakes from float airplanes. Measurements were made at a total of 138 sites over different frequency ranges. Areal MT coverage of the craton is excellent in the south and center, but limited to the north and west. A subset of these data are being modeled using a new 3-D code which inverts the geomagnetic vertical field transfer functions jointly with all four elements of the MT impedance tensor. The inversion is challenging given the regional nature of the problem, the differing site density and the differing acquisition frequencies. Preliminary models exhibit conductivity features broadly consistent with prior 2-D results and 3-D trial-and-error forward modelling, but with superior resolution of detail. A crustal structure on the eastern boundary of the craton can be associated with Paleoproterozoic orogenesis as the Slave craton indented into the Churchill Province. The known Central Slave Mantle Conductor (CSMC) is shown to commence at depths of 70-80 km initially as two separate bodies coalescing at approximately 100 km. Contrary to the forward modelling, these preliminary inversions suggest that the CSMC does not extend appreciably to the west, but this result requires further verification particularly as site density is poor in this region.

T12A-02 1050h INVITED

Petrological Constraints on Seismic Properties of the Slave Mantle and its Deep Structure.

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Mantle xenoliths is one of few major sources of petrological information on the cratonic mantle. This

study uses mantle-derived xenoliths of the Slave craton (NWT, Canada) to constrain the thermal state, composition, chemical zoning and seismic properties of the mantle. The Slave peridotites are equilibrated on a cold geotherm characteristic of Archean craton; the SE Slave peridotite is cooler than the mantle beneath other cratons and other Slave terranes. All terranes of the Slave mantle show broadly similar compositions and are markedly distinct from low-T peridotites from the Kaapvaal and Siberian cratons. Olivine-poor, orthopyroxene-rich, low-T peridotite is absent on the Slave craton, and compositions of its olivine extend to less magnesian values. A pronounced contrast in chemical compositions between the shallow and deeper lithosphere characterizes all Slave mantle terranes. Everywhere the shallow mantle shows greater chemical depletion than its deeper portion. The minimum lithospheric thickness of the Slave craton varies greatly between terranes, from 250 km in the SE Slave to 190 km in the N Slave. Various depleted peridotites of the Slave craton provide an excellent natural laboratory that allows us to investigate effects of depletion on the chemical and physical characteristics of rocks. We computed seismic velocities for the variously depleted peridotites of the N and SE Slave based on single-crystal elastic moduli and volume fractions of constituent minerals. The depleted peridotites enriched in MgO have lower V_p and higher V_s, where lower Poisson's ratios are due to orthopyroxene enrichment. The correlation observed on the Slave craton contradicts the established view that peridotite depleted in basaltic magmaphile elements has higher seismic wave velocities. However, evidence amassed in the past 15 years suggests that cratonic mantle peridotite is chemically distinct from off-cratonic peridotite and depletion in the cratonic mantle may have a distinct seismic signature compared to the off-cratonic mantle. Our data suggest that chemical depletion of peridotite could also be mapped by a magnetotelluric survey. Ultra-depleted shallow harzburgitic layer of the Central Slave craton has low electromagnetic conductivity. The latter can be explained by a higher abundance of graphite, which should be the prevalent carbon-bearing mineral in the reduced shallow mantle. Our Mossbauer spectroscopy data confirm the low fO₂ of the Slave spinel peridotite.

T12A-03 1110h

Peridotites, Garnets, Trace Elements, and the Structure of Mantle Lithosphere Beneath the Archean Superior Province

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A recent large data compilation of trace element analyses on over 1700 mantle peridotite whole rocks and 80 peridotitic garnets from the literature leads to simple correlations between garnets and whole rock data that can be applied to empirically estimate the degree of depletion, mineralogy and potentially seismic velocity and density in the peridotite sections represented by kimberlite-borne garnet xenocrysts. More than 70 percent of the Yb in whole rock analyses of garnet peridotites is contained in garnet. Studies of garnets and coexisting whole rocks indicate that Yb in garnet Gt(Yb) can serve as a simple proxy of Yb in a whole rock garnet peridotite WR(Yb). The correlations of Gt(Yb) with WR(Yb) can then be used to estimate the whole rock Al content of a peridotite WR(Al) from which a garnet xenocryst was derived. Al is a useful depletion index in peridotites, and furthermore correlates very well with modal garnet in well-characterized peridotite samples, and with bulk Mg/(Mg+Fe) (Mg#) in world peridotite datasets from ophiolites, ocean basins, off- and on-craton volcanic-hosted xenoliths. The above correlations are applied to internally consistent trace element datasets (n=800+) we have determined by LAICPMS on garnet suites from 17 kimberlites in North America. Using Ni thermometry in the garnets projected to xenolith-derived geotherms, we construct lithospheric sections of WR(Al), WR(Mg#), and modal garnet with depth in the subcontinental lithosphere beneath cratonic regions. In almost all regions sampled in the Superior Province, depleted peridotite the shallowest sections (<120 km depth) of the lithospheric mantle, supporting the compositional buoyancy inferred to support the cratonic root against convective removal. A different trend with depth is observed for garnet suites from 1.1 Ga kimberlites and alkaline rocks, perhaps due to a different mantle structure at this time. Differences in the chemical signatures between garnet suites in kimberlites within only kilometers of one another across major fault grabens in the Lake Timiskaming region imply chemically modified mantle lithosphere along extremely narrow zones that are still observed there today by seismic tomography. From correlations of WR(Al) with WR(Mg#) we can potentially invert the garnet geochemical profiles to obtain information on density and seismic velocities with depth in the craton, using

correlations of these parameters in garnet-facies mantle peridotite as elucidated by C.T. Lee (2003, J.Geophys. Res., 108).

T12A-04 1125h

Mechanical anisotropy of the lithosphere in the Canadian Shield

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We investigated the anisotropy in the flexural response of the elastic lithosphere. We have used three different methods to determine the azimuthal variations of the coherence between Bouguer gravity and topography. The Fourier spectra were calculated with the standard windowed Fourier transform, and averaging was performed with a moving window in wavevector space. We have also estimated the coherence over overlapping azimuthal sectors and averaged on annuli in wavevector space. With the multitaper method, direct estimates of the coherence for each wavevector are obtained by stacking the spectra of orthogonal representation of the data. Synthetic data were generated following the method of Swain and Kirby [2004]¹. Using these synthetics, we verified that the three methods recover the anisotropy of the data, but the multitaper method offers a greater variance reduction and is the only unbiased 2-D coherence estimator. We hence applied these methods to the Canadian Shield data set. The isotropic effective elastic thickness in the Canadian Shield has been estimated by different methods. These studies show that T_e varies from 30 to > 120 km. Regions of high and low T_e are found throughout the Shield. The mean T_e is the same for all provinces (90 ± 40 km) except for the Grenville, where T_e is lower (70 ± 27 km). The study of anisotropy shows a marked contrast between the eastern Shield, where the weak axis is trending N-S, approximately perpendicular to the Grenville Front, and the western Shield, where the weak axis is trending WNW, roughly perpendicular to the structure of the Trans-Hudson Orogen. ¹Geophys.

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T12A-05 1140h

Subduction Zone Backarcs, Continental Mobile Belts, and Orogenic Heat

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Two important problems of continental tectonics are resolved by recognizing that all subduction zone backarcs are hot and have thin weak lithospheres over considerable widths: (1) the origin of long-lived active "mobile belts" contrasted to the stability of cratons and platforms, (2) the origin of the heat of continental collision orogeny. At many continental margin plate boundaries there are broad mobile belts with a long history of distributed deformation. They are mobile because they are sufficiently weak to be deformed by the forces developed at plate boundaries. We conclude that mobile belts are weak because they are hot, and they are hot because they are in present or recent backarcs. Most continental backarcs are very hot, not just those with extensional and rift zones. Moho temperatures are 800-900C and lithosphere thicknesses are 50-60 km, compared to 400-500C and 200-300 km for cratons. Due to the temperature differences, backarc lithospheres are more than a factor of 10 weaker than cratons. Backarcs may be hot because shallow asthenosphere convection results from viscosity reduction by water released from the underlying subducting plate. Hot weak former backarcs are the locus of most deformation during continent or terrane collision orogeny, i.e., the vice or inherited weakness model. We conclude that the orogenic heat indicated by plutonism, high grade metamorphism, and ductile deformation, comes from the pre-existing hot backarc lithosphere, not from the orogenic deformation process itself.