MAPPING THE SIBERIAN LITHOSPHERE WITH GARNETS AND SPINELS

Griffin, W.L.[1], Kaminsky, F.[2], O'Reilly, S.Y.[3], Ryan, C.G.[1], Sobolev, N.V.[4]

1. CSIRO Division of Exploration and Mining, Box 136, North Ryde, NSW 2113, Australia
2. Inst. of Diamonds, Moscow, Russia
3. Macquarie Univ., Sydney 2109, Australia
4. Russian Acad. of Sciences, Novosibirsk, Russia

Trace- and major-element analyses of garnets and chromites from kimberlites and other volcanic rocks can be used to study the thermal and compositional structure of lithospheric mantle in space and time (Griffin and Ryan, 1995). Because concentrates have a very high information content, and are easier to obtain and faster and cheaper to study than appropriate xenolith suites, this type of lithospheric mapping can be done on a large scale, making it especially suitable for integration with regional geophysical data.

We have carried out an extensive study of concentrates from Paleozoic (340-390 Ma) kimberlites in the Daldyn field of the Siberian platform. Major elements have been determined by EMP, and trace elements by proton microprobe, for >800 garnets and ca 100 chromites. These data have been used to determine the thermal state and the compositional structure of the lithosphere beneath this important diamond province.

The Garnet Geotherm (Ryan et al., 1995; this conference) lies near a 35 mW/m^2 conductive model up to $T \geq 1100°C$, in agreement with some xenolith data (Pokhilenko et al., 1991; Griffin et al. 1995). The geotherm apparently is kinked or stepped near 1200°C (Boyd, 1984), and this T coincides with the disappearance of depleted garnets and the appearance of a pronounced "asthenospheric" signature typical of high-T sheared peridotite xenoliths. This chemical and thermal discontinuity lies near 210 km depth, and coincides with the seismically determined Lehman Discontinuity in this area; this depth therefore is interpreted as the base of the lithosphere. The coincidence of the Paleozoic lithosphere-asthenosphere boundary with the present-day seismic boundary suggests that the lower lithosphere has changed little between the Paleozoic and the present.

The Nickel Temperature (T_{Ni}) of each garnet and the Zinc Temperature (T_{Zn}) of each chromite can be referred to the Garnet Geotherm to place the grains into a stratigraphic context (Ryan et al., 1995; this volume). Their parent rock types can be determined by comparison of their chemistry with that of the corresponding minerals in xenoliths. Similarly, the action of different types of metasomatic fluids on the original rocks can be recognised by specific trace-element "fingerprints", and these processes also may be assigned to specific depth ranges.

Beneath the Daldyn field, harzburgites (including the "megacrystalline dunites") are concentrated in the depth range 140-190 km, making up 30-60% of the peridotitic rock types (assuming all lithologies contribute similar amounts of garnet). This harzburgite-rich zone is underlain by depleted lherzolites, and then by lherzolites with "asthenospheric" chemical signatures (reduced Cr and Mg, elevated Ti, Zr, Y and Ga).

Similar data from the main pipes of the Alakit field and from the Malo-Botuobiya field indicate geotherms of ≤35 mW/m^2. Both the lithosphere and the harzburgite zone may be somewhat thinner in these areas (lithosphere-asthenosphere boundary at ca 200 km and 180 km, respectively). In the Malo-Botuobiya region, available evidence suggests that the lherzolitic portion of the lithospheric mantle is unusually depleted; despite this, harzburgites are less abundant, and less strongly stratified.

Data from several Devonian kimberlite fields along a north-south traverse from Mirny to the lower Olenek River indicate that both the geotherm and the base of the lithosphere rise northward from the Daldyn area, with the lithosphere thinning to ca 120 km in the lower Olenek region. The base of the harzburgite-rich layer also rises, while the top stays near 140 km, and this layer apparently pinches out in the region of the upper Olenek River. Depleted lherzolites also are much less common in the northern part of the Platform. The lithosphere beneath the northern areas is more typical of Proterozoic areas (Protons) than of Archean cratonic mantle, although this area is shown as an Archon on some compilations. The northward thinning and compositional variation of the lithosphere is defined by kimberlites with ages in the 350-450 Ma age range, extending into the Middle Olenek region, and appears to rpresent a synchronous lateral variation. However, the northernmost kimberlites sampled in this study (in the Kuoika field) are Jurassic-Cretaceous in age, and the still higher geotherm and much thinner lithosphere in this area may reflect post-Paleozoic processes, perhaps related to the opening of the Arctic Ocean. If this is the case, then older kimberlites in this area may reflect a thicker lithosphere.

References

Boyd, F.R. (1984) A Siberian geotherm based on lherzolite zenoliths from the Udachnaya kimberlite, U.S.S.R... Geology, 12: 528-530.

Griffin, W.L. and Ryan, C.G. (1995) Trace elements in indicator minerals: Area selection and target evaluation in diamond exploration. *In* W.L. Griffin, Ed., Diamond Exploration: Into the 21st Century. Jour. Geochem. Explor. 52 (in press).

Griffin, W.L., Ryan, C.G., Gurney, J.J., Sobolev, N.V. and Win, T.T. (1994) Chromite macrocrysts in kimberlites and lamproites: geochemistry and origin. *In* H.O.A. Meyer and O.H. Leonardos (eds). Kimberlites, Related Rocks and Mantle Xenoliths. CPRM Spec. Publ. 1A/93, pp. 366-377.

Griffin, W.L., Kaminsky, F.V., Ryan, C.G., O'Reilly, S.Y., Win, T.T. and Ilupin, I.P. (1995) Thermal state and composition of the lithospheric mantle beneath the Daldyn kimberlite field, Yakutia. Tectonophysics (in press).

Pokhilenko, N.P., Pearson, G., Boyd, F.R. and Sobolev, N.V. (1991) Megacrystalline dunites and peridotites: Hosts for Siberian diamonds. Ann. Rept. Geophys. Lab., Carnegie Institutions, Washington D.C., 11-18.

Ryan, C.G., Griffin, W.L. and Pearson, N., 1995. Garnet Geotherms: a technique for derivation of P-T data from Cr-pyrope garnets. Jour. Geophys. Res. (submitted).