ABSTRACT

The most extensive evidence for the evolution of the primitive crust is preserved at the base of the continental roots (140 to 200 km depth). However, this is completely inaccessible and hard to evaluate, except through the study of mantle xenoliths brought to the surface by kimberlite magmas. Most mantle xenoliths undergo kimberlitic/carbonaceous metasomatism prior to their entrapment, altering their primary composition. Despite a very complex history and a very low abundance (<1 % mantle xenoliths), cratonic eclogites are the oldest relics of the ancient crust and unique in allowing us to decipher the composition and evolution of the early continents.

This study is based on the most complete existing collection of cratonic eclogites (>180 nodules), sampled in four main localities from the Siberian (Obn Zhennaya, Udachnaya) and South African (Jagersfontein, Roberts Victor) cratons. Major and trace element compositions have been analysed in representative bimineralic (garnet (gt)-omphacite (cpx)), coesite-, kyanite- and corundum-bearing eclogites. Metasomatized eclogites (Type I) have a higher alkali-(Na₂O in garnet and K₂O in omphacite) and LREE, LILE-content. Non-metasomatized (Type II) eclogites include two main compositional groups, derived from different protoliths. The first group (Type IIA) is typically more magnesian, enriched in LREE and has δ¹⁸O values from 3.73 to 7.50 ‰, with positive Sr anomalies and corresponding to a low pressure-temperature layer. The whole-rock composition is consistent with a basaltic protolith. The second group (Type IIB) is more sodic and aluminous, depleted in LREE and has δ¹⁸O values of 2.35 to 3.59 ‰, corresponding to equilibrium at high pressure and temperature. The whole-rock trace element composition is consistent with a pyroxenitic protolith. Eclogites that contain coesite, kyanite and corundum (coe-ky-cor) are typically characterized by jadeite-rich clinopyroxenes with positive Eu and Sr anomalies and grossular-rich garnets with corresponding positive Eu and negative Sr anomalies. Additionally, corundum-bearing samples are overall LREE-depleted. Pressure-
temperature estimates indicate coe-ky-cor-bearing eclogites equilibrated in the lowermost part of the cratonic keel, and the reconstructed whole-rock trace element composition corresponds to a very depleted gabbroic protolith.

Corundum-bearing eclogites often show topotactic exsolution textures hosted in omphacite, consisting of a more calcic garnet ± kyanite/zoisite. Based on Si, Al and Mg diffusion profiles it can be inferred that exsolution was controlled by chemical exchange in an isochemical system. Similarly, an interpretation can be made for the variable HREE fractionation of intermediate composition between the exsolutions and the host omphacite, as evidence for intermineral partitioning. The formation of zoisite (1.7 % H₂O) from a precursor clinopyroxene requires a significant amount of hydrogen (as H⁺, OH⁻ or H₂O) incorporated in omphacite at mantle conditions. Calculated water content of omphacite, based on Fourier transform infrared spectrometry (FTIR) analyses, varies from ~930—1410 to ~1100—1680 ppm by weight H₂O, according to different absorption coefficients. Primary garnets are typically anhydrous (<7 ppm H₂O), whereas coarse exsolutions contain between 165—1950 ppm H₂O. Reconstructed estimates for whole-rock water content (~310—890 ppm H₂O) for the Obnazhennaya eclogites are significantly higher than those of the surrounding peridotites.

The variability of δ¹⁸O in garnet among 41 xenoliths, shows a bi-modal distribution with median values at 3.57 ‰ and 5.68 ‰ and strong correlation (r = 0.96) between garnet and omphacite. The δ¹⁸O values and the reconstructed whole-rock trace element compositions indicate an oceanic crustal protolith for mantle eclogite xenoliths. This is consistent with the subduction of a hydrothermally altered, basaltic to websteritic sequence of an incompatible-element-depleted oceanic crust.

Furthermore, although eclogites represent a small fraction of the upper mantle, they may be an important water reservoir at the base of the cratonic root. High water content in the lithospheric mantle would have major consequences for the longevity of the cratonic keel, for
physical and chemical properties in minerals, partial melting, mantle rheology and electrical conductivity and the global water cycle.