Upgrades to CHARISMA: approaching the atom-counting limit

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Microbeam resonant ionization mass spectrometry of single presolar SiC grains with the CHARISMA instrument has been highly successful in improving our understanding of heavy element nucleosynthesis in stars (e.g., Nicolussi et al., 1997; Davis et al., 2001). In this technique, a laser focused to ~1 µm is used to ablate atoms from a sample. Atoms of only one element are then ionized using lasers tuned to resonances of that element. These photoions are then accelerated and counted in a time-of-flight mass spectrometer (Savina et al., 2002). The useful yield (atoms detected per atom removed) is currently ~4% and tunable dye lasers operating at ~60 Hz were used for most of our published results. We describe here several improvements that substantially improve performance.

New desorption and photoionization laser systems have been installed within the last year. The desorption laser, an intracavity frequency-tripled diode-pumped Nd:YAG, delivers >600 µJ of 355 nm light at 1 kHz. The laser has excellent pulse-to-pulse stability to give steady, controllable desorbed neutral yields. The tunable laser system has two separate Ti:sapphire cavities, both of which are longitudinally pumped by a single Nd:YLF laser, operating at 1 kHz. Each cavity is tunable over the range 700–1000 nm and 2nd, 3rd and 4th harmonics of this range can be obtained with nonlinear optical crystals.

A completely redesigned front end, with new ion extraction optics and a new Schwarzchild microscope (Veryovkin et al., 2001), coupled with a new, more sensitive microchannel plate detector, will be installed shortly and will increase the useful yield to 30–40%, improve optical imaging and lower the laser ablation spot size to less than 0.5 µm. Future modifications include improved detectors to allow counting of many ions per pulse and use of a tunable free electron laser in the VUV to allow photoionization of elements with high ionization potentials.

References

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Chemical composition and thermal state of the continental mantle in central Fennoscandia

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Kimberlites and olivine lamproites

Kimberlites that intruded the Karelian continental margin in eastern Finland ~600 Ma have yielded a suite of mantle samples (xenoliths and xenocrysts) from the SCLM of the central Fennoscandian Shield. Sr-Nd isotopic compositions imply that most of these kimberlites have been derived from well-mixed mantle and as such do not provide information about the SCLM. Some pipes from eastern Finland and Archangel, however, record enriched isotopic signatures indicative of a contribution from veins of mica + amphibole + trace minerals within the SCLM that over time have developed extreme isotopic compositions.

Mantle xenoliths

Three distinct suites of mantle xenoliths have been recovered. Coarse *garnet facies peridotites* derived from the depth interval of 170–230 km dominate. They are harzburgites, lherzolites and wherlites with near-Bulk Earth Nd and Sr isotopic compositions and no signs of mantle metasomatism. *Mantle eclogites* originated from the same depth interval as the garnet facies peridotites. Their chemical and isotopic compositions suggest that they represent (Proterozoic?) mantle melts or cumulates rather than subducted oceanic lithosphere. These eclogites can be extremely diamondiferous rendering it possible that a substantial proportion of the diamonds occur as very high-grade pods or thin seams in the Fennoscandian SCLM. The *garnet-spinel facies peridotites* are distinct from the garnet facies peridotites representing highly depleted, fine grained, granuloblastic harzburgites that originated from a depth interval of 100–150 km. They show chemical and isotopic garnet-clinopyroxene disequilibrium together with cryptic and modal metasomatism.

Geotherms

Geobarometry of the mantle xenoliths is consistent with a conductive geotherm that corresponds to a surface heat flow density value of 36 mWm^{-2}. Ni thermometry on Finnish kimberlite pyrope garnet concentrates clearly defines the compositional break in the SCLM at about 1075°C, or about 175 km depth deduced from the geotherm. This break is manifested as a change in pyrope composition with Ti < 250 ppm below the 1075°C isotherm and ranging from 100 to 4500 ppm Ti above the isotherm.

Thus, the SCLM in central Fennoscandia is compositionally stratified into a shallow highly depleted layer interpreted as Archean SCLM and a deep more fertile base thought to represent Proterozoic additions at the base of the lithosphere that appears to be intact to at least 230 km.