Studying Earth's Interior Using Chemical & Analytical Tools

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Presented in 1st Interdisciplinary Scientific Seminar (ISS), March 18, 2006, Tokyo
Organized by
Science and Technology Expatriates of Pakistan (STEP), Japan
www.uderc.com/step

First Part: My present research

Our mother planet has been divided into three main portions such as core, mantle and crust on the basis of their respective chemical and physical nature. The formation of the innermost portion i.e., core is one of the highly significant events in Earth's development history. The core-formation event is important for constraining i) thermal state of the early Earth ii) compositions of the core and mantle and, iii) nature of the accretion processes. The modeling of core-formation would explain composition of the mantle regarding the excess siderophile-element problem and the mechanism by which metal separates from its silicate matrix. The extinct nuclide ^{182}Hf decays to ^{182}W with a half life of 9 Ma. Both Hf and W are refractory in nature but the former stays in the mantle while later goes to the core during core segregation (Quitte et al., 2000; Lee & Halliday, 1995, 1996, 2000a, 2000b; Lee et al., 1997; Jacobsen & Harper, 1998; Horan et al., 1998; Halliday et al., 1996, 2000). This different geochemical behavior of Hf and W during metal/silicate differentiation makes the short-lived ^{182}Hf-^{182}W isotope system an ideal chronometer to constrain the core-formation age. The core will develop a deficit in ^{182}W, while the silicate Earth will attain ^{182}W excess during the early stages of accretion. The core-formation defines the most major differentiation of the Earth, during which 1/3 of the mass of the Earth composed of siderophile elements went to the core and the remaining 2/3 of the mass representing lithophile elements retained in the mantle (Ringwood, 1960; Oversby & Ringwood, 1971; Jones & Drake, 1986; Lee & Agee, 1996; Walker, 2000). Because of this fractionation, Hf/W ratio is about 1.11 in CI chondrites and hence the whole Earth (McDonough & Sun, 1995), and 17.7 (Newsom et al., 1996) in bulk silicate earth (BSE, including the mantle, crust, oceans and atmosphere). With technical advancement in the MC-ICP-MS spectrometry and separation techniques for Hf and W, it became possible to handle and measure precisely small amounts of the elements. Many workers (Horan et al., 1998; Quitte et al., 2000; Yin et al., 2002; Schoenberg et al., 2002) have recently discussed Hf-W systematic in meteorites, terrestrial rocks and lunar rocks. Iron meteorites and the metal portion of ordinary chondrites have smaller ^{182}W/^{184}W ratio than the bulk chondrites or the stone portion of ordinary chondrites, terrestrial and lunar samples. In addition, it is also observed (Lee & Halliday, 1995, 1996, 2000a, 2000b) that all terrestrial rocks studied (MORB, OIB etc.) have an identical $^{182}W/^{184}W$ ratio, that is the same as the ratio in carbonaceous chondrites within uncertainty. This similarity in $^{182}W/^{184}W$ ratio between terrestrial rocks and carbonaceous chondrites and among different samples implies that core formation occurred after ^{182}Hf in the Earth decayed to a negligible level. Hence the absence of ^{182}W anomaly in terrestrial rocks only provides a limit on core-formation age. The small difference in $^{182}W/^{183}W$ (^{184}W has isobaric effects due to ^{184}Os while mass ^{183}W is free of any such effects) ratio between terrestrial sample and CI chondrites can be resolved using MC-ICPMS technique. The Hf-W system would be able to provide a much more stringent constraint on core-formation time and consequently the compositions of the core and mantle. Still there is no W isotope data available for mantle rocks like carbonatites. Fresh lava samples from Oldoinyo Lengai (OL), Tanzania were selected for this study because they contain high contents of W unlike other deep-seated rocks such as komatiites and kimberlites. Oxygen isotope studies (Keller & Hoefs, 1995; Ali et al., 2005) of OL lavas have shown that they are originated from deep mantle. Purified W fraction using column chromatographic technique (Yuvin et al., 2006) was analyzed for $^{182}W/^{183}W$ ratios on MC-ICPMS. There is no anomaly in the εW i.e., $\mathbf{[[(^{182}W/^{183}W)_{unknown}/ (^{182}W/^{183}W)_{std}-1]*10^4]}$ which can be interpreted as the lavas might have not experienced core contribution or if they did then it might be masked due to high content of W in OL lavas. Further research to see anomalous behavior of W isotopes in carbonatites from Pakistan, Canadian komatiites and kimberlites from Greenland is underway.

Second Part: Scientific research in Pakistan: Problems and Challenges

Geo-scientific research in Pakistan has been hampered due to proper availability of analytical instrumentation. Most of the universities and research institutes have old instruments which are kept under used due to the unavailability of proper maintenance and technical staff. This problem can be solved if user-facility labs are established having latest state-of–art equipments and efficient trained technical staff where scientists, researchers and even students can come and analyze their samples. Furthermore scarce of technicians in Pakistan should be overcome. Another important aspect, which requires immediate attention for the smooth execution of research in Pakistan, is the local production of ordinary stuff used in a scientific research laboratory. The prices of the imported stuff are always high compared to local products and also there are many items which put the scientists on long waits due to tedious and slow system of import formalities to the developing country like Pakistan.