Ce anomalies in the 2.6–2.4 Ga Kalkkloof paleosol in South Africa: Evidence for the early development of an oxygenated atmosphere

Y. WATANABE[1], T. NAGASE[2], AND H. OHMOTO[1]

[1] Astrobiology Research Center and Dept. of Geosciences, The Pennsylvania State Univeristy, University Park, PA, USA (yumiko@geosc.psu.edu)
[2] The Tohoku University Museum, Tohoku University, Sendai, Japan.

The behaviors of rare earth elements (REEs) during soil formation are influenced by Eh, pH, and the concentrations of carbonate and organic ligands in soil water. Compared to other REEs, Ce behaves differently in oxic conditions. This sometimes results in the presence of a positive-Ce anomaly in the upper part and a negative-Ce anomaly in the lower part of a modern soil profile. Therefore, the REE distribution of a paleosol can be used as an excellent indicator for the redox state of soil water and the paleoatmosphere.

The ~15 m thick paleosol at Kalkkloof developed on >2.7-Ga ultramafic rock (dunite) and is overlain by 2.35 Ga sedimentary rock. This stratigraphic relationship suggests the paleosol formed between ~2.6 Ga and ~2.4 Ga. Whereas the Al_2O_3/TiO_2 ratio of the paleosol remains essentially the same as that of the parent rock (i.e., ~22), the REE/TiO_2 ratio is strongly enriched by 1-2 orders of magnitude compared to that of the parent rock. It is significant that all paleosol samples show a negative Ce anomaly that varies from 0.1-0.8 (c.f., 1.27 for the parent rock). Furthermore, there is a positive correlation in their magnitudes. The samples from the lower part of the profile are more enriched in REEs and show a stronger negative Ce anomaly. SEM observation indicates REEs of the lower samples are hosted by phosphates (e.g., rhabdophane) with a Ce negative anomaly, whereas no rhabdophane was recognized in either the parent rock or the upper samples. Phosphates are present in cracks of chromite, which is a charactristic primary mineral of the parent rock.

These data suggest that the oxygenated rainwater leached REEs from the upper soil zone and reprecipitated them as phosphate minerals in the lower soil zone 2.6-2.4 Ga ago.

References

Nesbitt, H. W. (1979) *Nature* **279** 206-210.
Braun, J. J. et al. (1990) *Geochim. Cosmochim. Acta* **54**, 781-795.
Murakami, T. et al., (2001) *Earth Planet. Sci. Let.* **184**, 523-528.

Silicate dust in circumstellar and interstellar environments

L.B.F.M. WATERS

Astronomical Institute, University of Amsterdam, Kruislaan 403, NL-1098 SJ Amsterdam, the Netherlands
Instituut voor Sterrenkunde, Katholieke Universiteit Leuven, Celestijnenlaan 200B B-3001 Heverlee, Belgium
Rensw@science.uva.nl

Recent advances in infrared spectroscopy have made it possible to investigate the nature and composition of silicate dust in space, both in circumstellar and interstellar environments. These new observations have revealed a remarkably rich mineralogy of the silicate dust in circumstellar dust shells. In particular, the dust which condenses in the cool, molecular winds of old, evolved red giants and supergiants contains a wide variety of minerals, such as olivines, pyroxenes, diopside, spinel, corundum, and possibly calcite and dolomite. The composition of the dust which condenses probably reflects the physical and chemical conditions near the star. There is strong evidence that the dust composition is a strong function of density. A rich mineralogy can also be identified in the vicinity of young stars that are surrounded by proto-planetary disks. The mineral composition of these disks may trace planet formation.

The dust which is produced by red giants and supergiants is believed to be the dominant source of dust which enters into the interstellar medium. Remarkably, evidence for minerals in interstellar space is so far lacking. This may indicate that the dust produced by red giants is rapidly modified or destroyed in the harsh environment which persists in the interstellar medium, and loses its rich mineralogy in the process.