

Elemental quantification was performed with a triple quadrupole inductively coupled plasma mass spectrometer (ICP-MS, Agilent 8900, Santa Clara, California). An external calibration curve was prepared from 1000 mg/L single element standards (Inorganic Ventures, Christiansburg, VA) covering a concentration of REEs up to ~10 ng/mL. Samples, calibration solutions, and blanks were added 10 ng/mL In as internal standard and run in the ICP-MS using a dual-pass quartz spray chamber, PTFE nebulizer, dual-syringe introduction system (Teledyne, AVX 71000), platinum cones and sapphire injector in a platinum-shielded quartz torch. Masses 45, 89, 139, 140, 141, 146, 147, 153, 157, 159, 163, 165, 166, 169, 172, and 175 were used to monitor Sc, Y, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu intensities, respectively. The limits of determination (LoD) were calculated as three times the standard deviation of the blanks, multiplied by the total dilution factor used for samples. The instrument was located in a filtered air positive pressure lab, and sample handling and dilutions were performed in laminar flow benches using calibrated pipettors (Eppendorf Reference, Hamburg, Germany). The hot plate was located in a laminar flow bench exhausted into a fume hood and dilution done by weight was corrected by the estimated density of concentrated HCl. The total dilution factor was typically in the range of 5000-10,000. Standard reference material SRM SBC-1 (Brush Creek, PA shale), certified by the United States Geological Survey, was used to test the recovery obtained by the methodology used, and the results are shown in the following table.

REE element	Certified concentration (ppm)	Recovery %
La	52.5	97%
Ce	108.2	106%
Pr	12.6	96%
Nd	49.2	97%
Sm	9.62	101%
Eu	1.98	101%
Gd	8.54	94%
Tb	1.23	95%
Dy	7.1	99%
Ho	1.36	99%
Er	3.79	99%
Yb	3.64	100%
Lu	0.54	97%