

Supplementary table 1:
Isotopes analyzed using LA ICP
MS

| Element | Isotope analysed |
|---------|------------------|
| Na | 23 |
| Mg | 24 |
| Si | 28 |
| K | 39 |
| Ti | 47 |
| Mn | 55 |
| Fe | 56 |
| As | 75 |
| Sr | 88 |
| Y | 89 |
| Zr | 90 |
| Cd | 111 |
| Ba | 137 |
| La | 139 |
| Ce | 140 |
| Pr | 141 |
| Nd | 146 |
| Sm | 147 |
| Eu | 153 |
| Gd | 157 |
| Tb | 159 |
| Dy | 163 |
| Ho | 165 |
| Er | 166 |
| Tm | 169 |
| Yb | 172 |
| Lu | 175 |
| Pb | 208 |
| Th | 232 |
| U | 238 |

Figure S1 NIST SRM 612 check standard analyses.

Red lines represent published standard concentrations, upper and lower values represent uncertainties (95% CL)

Blue lines represent 10% upper and lower of the published standard value.

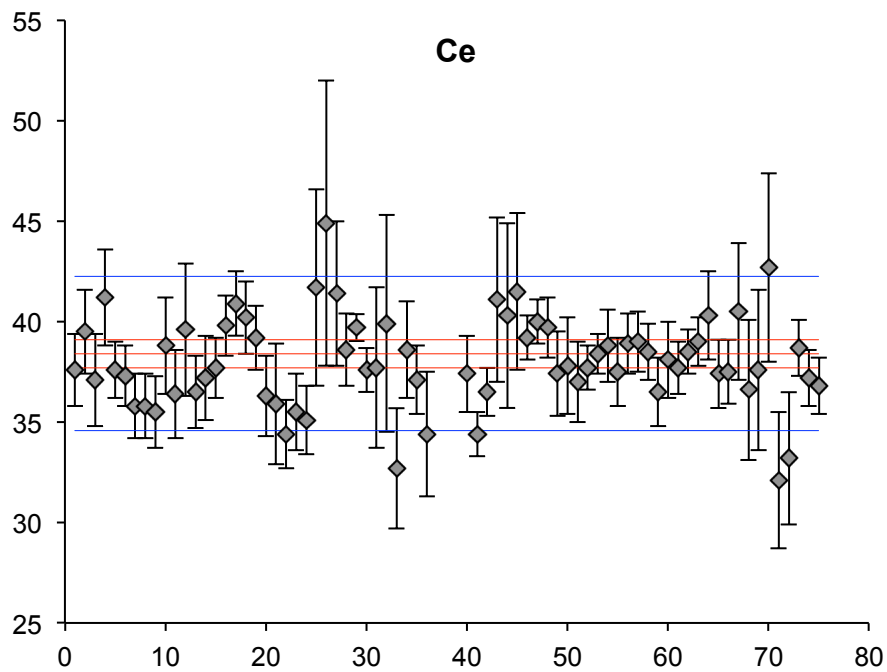
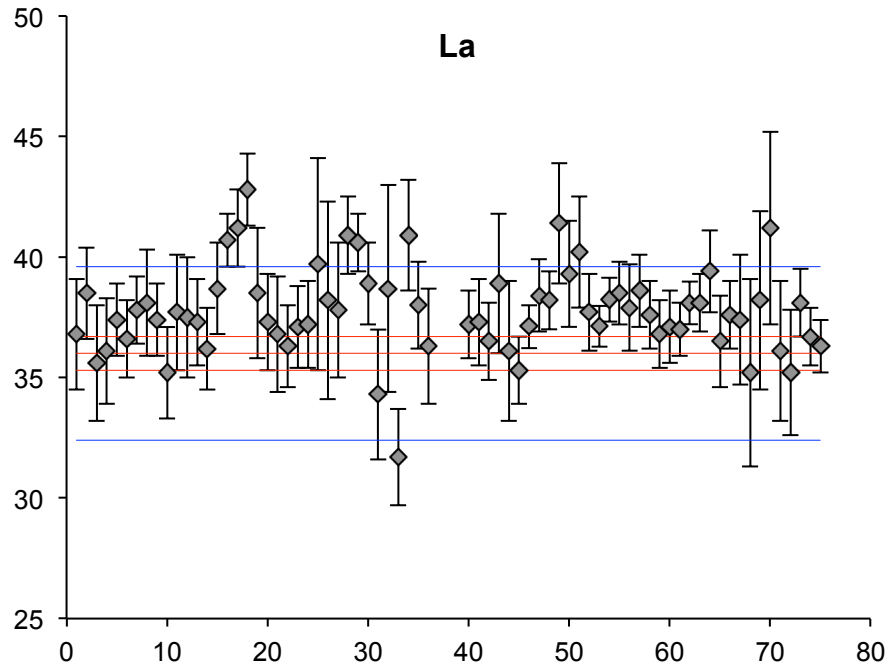
Grey points are analyse carried out during the start and finish of LA traces.

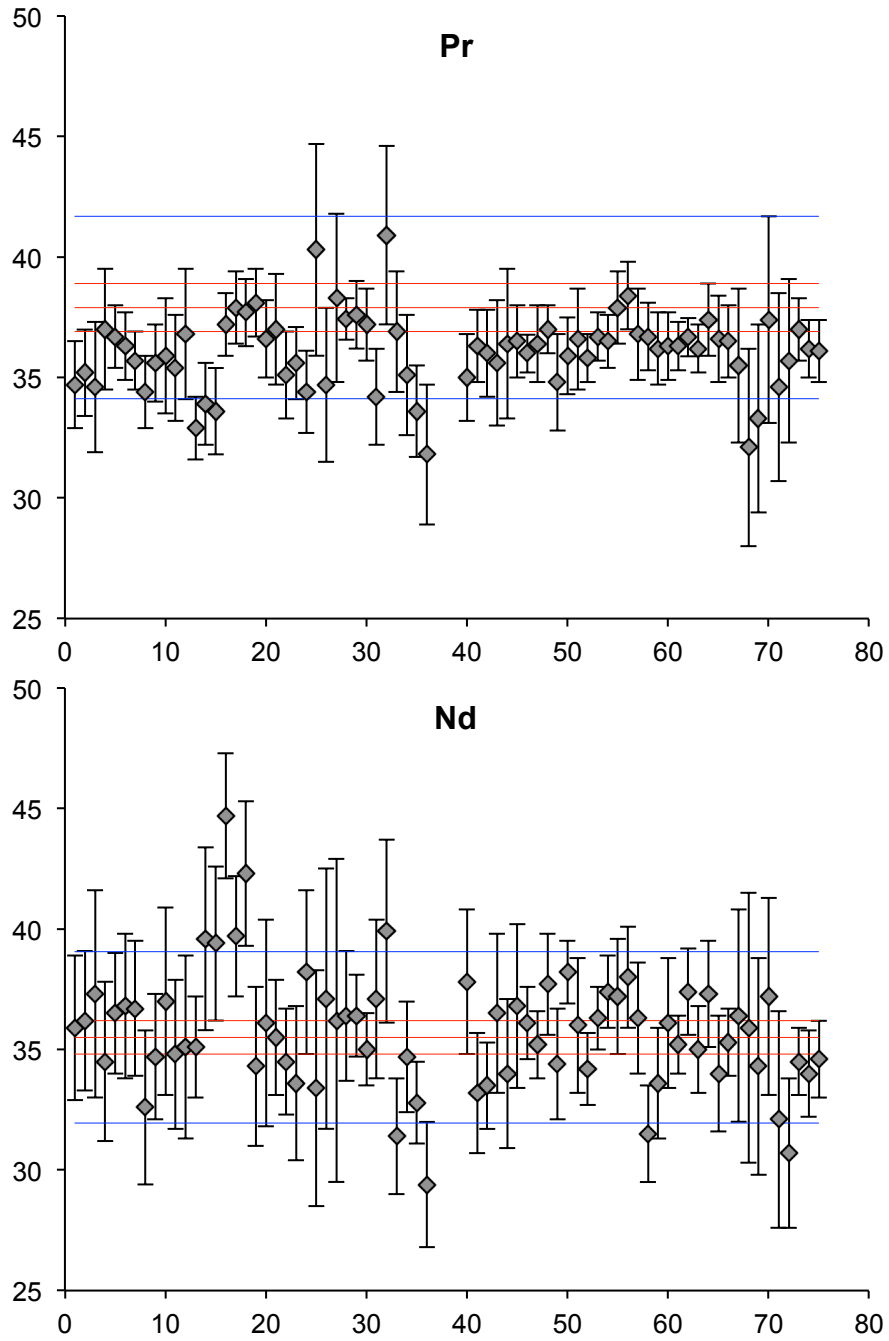
Y axes: concentration (ppm)

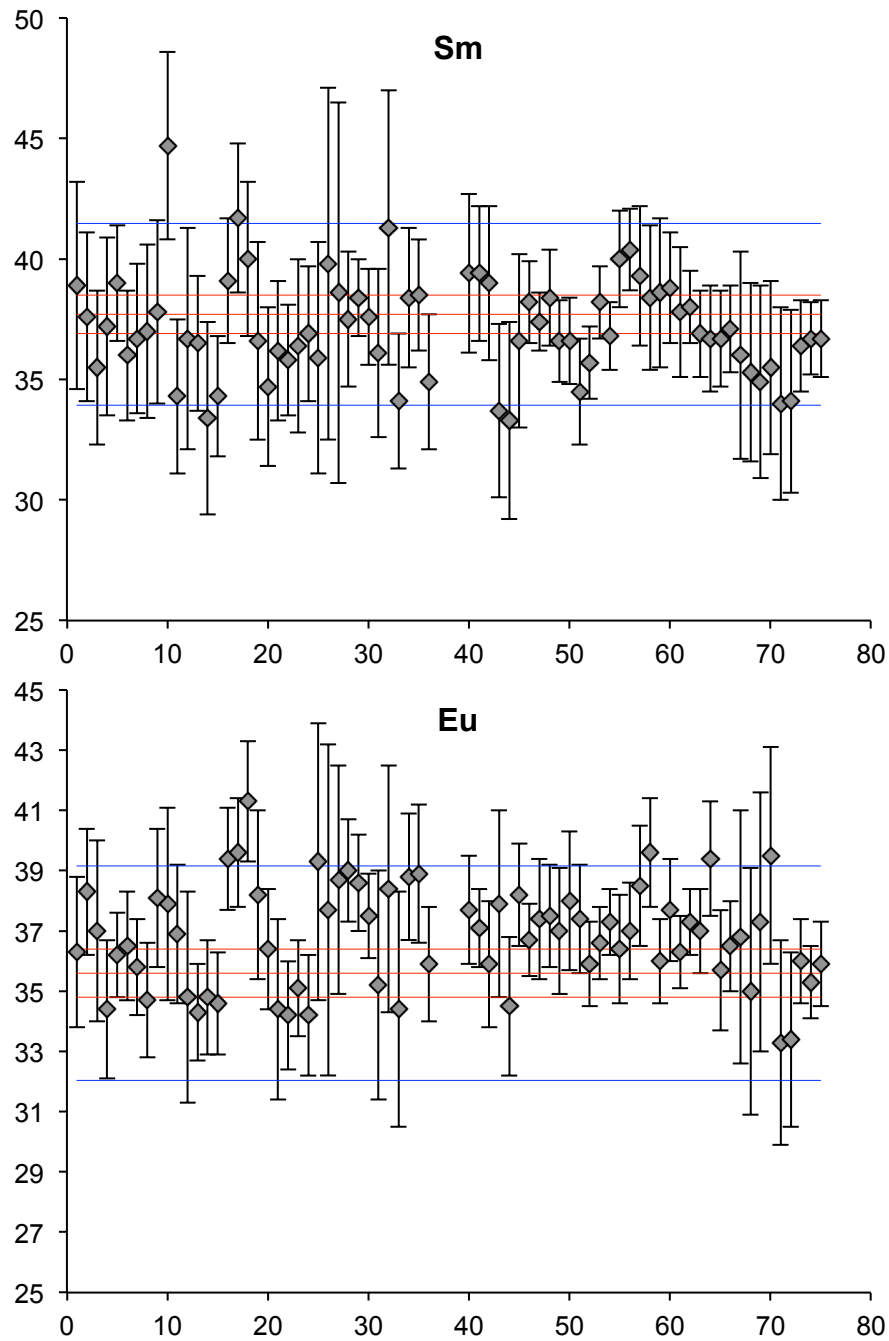
X axes: analyses number

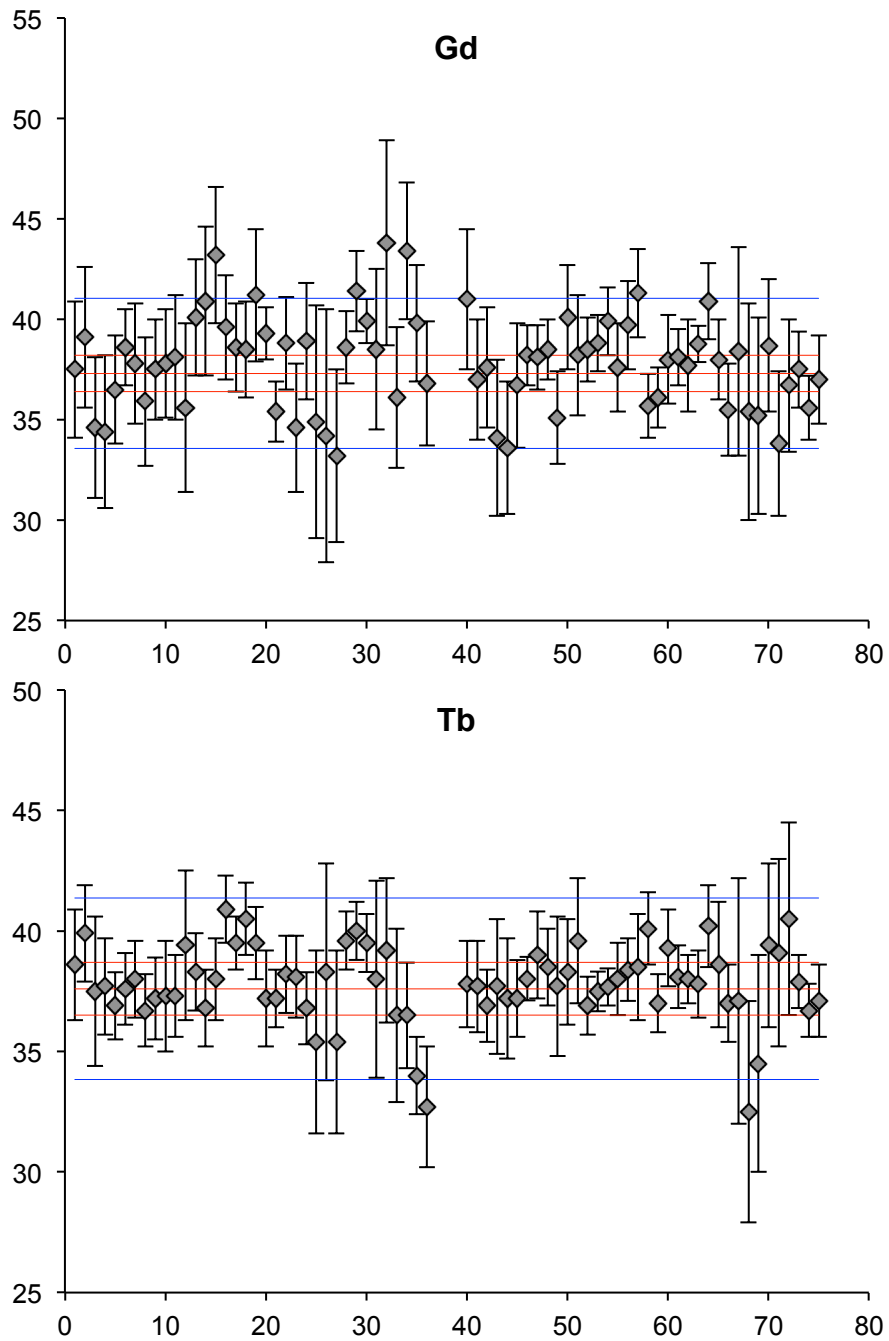
References:

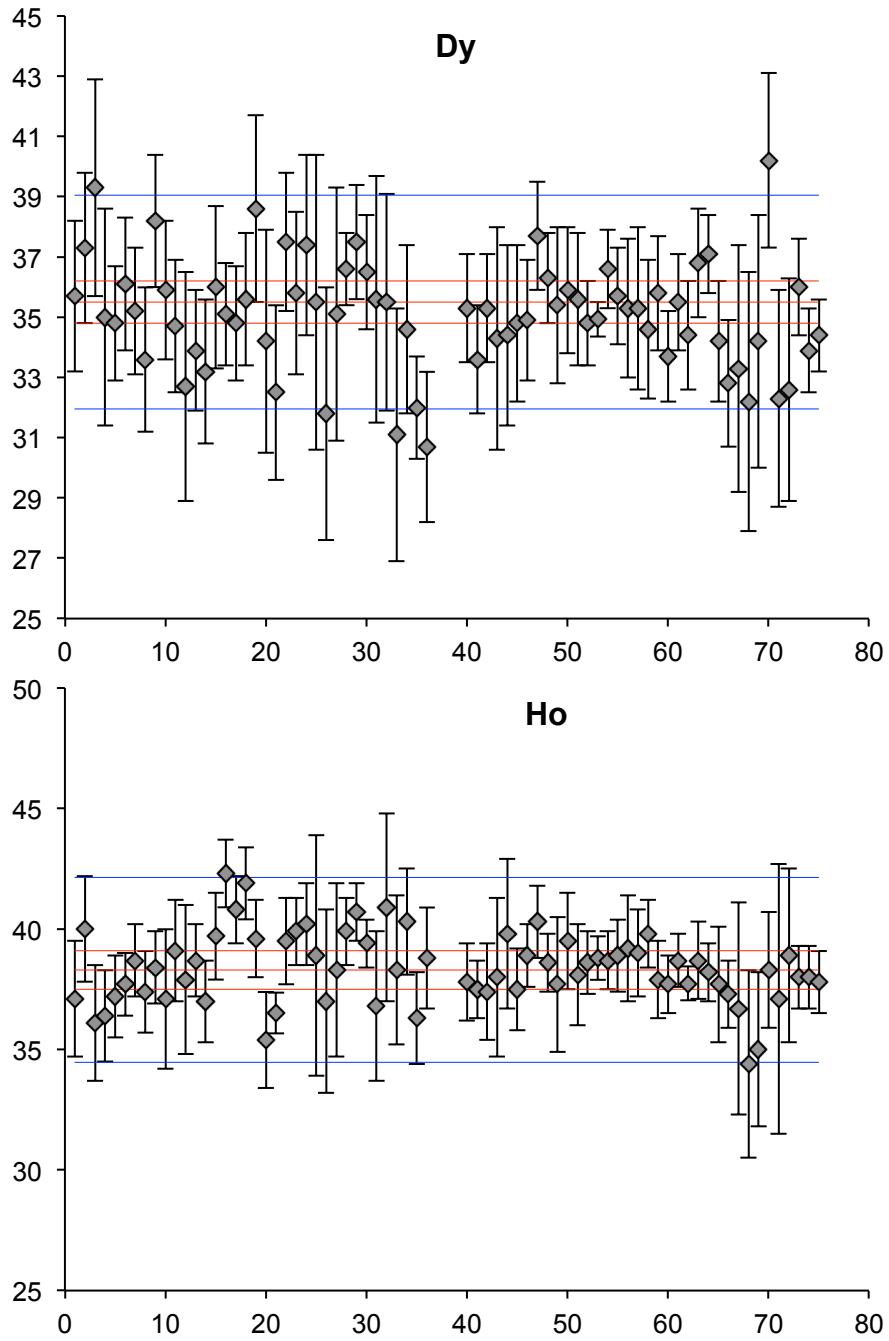
K.P. Jochum, U. Weis, B. Stoll, D. Kuzmin, Q. Yang, I. Raczek, D.E. Jacob, A. Stracke, A. Birbaum, D.A. Frick, D. Günther, J. Enzweiler. Determination of Reference Values for NIST SRM 610–617 Glasses Following ISO Guidelines. *Geostand. Geoanal. Res.*, 35 (2011), pp. 397–429

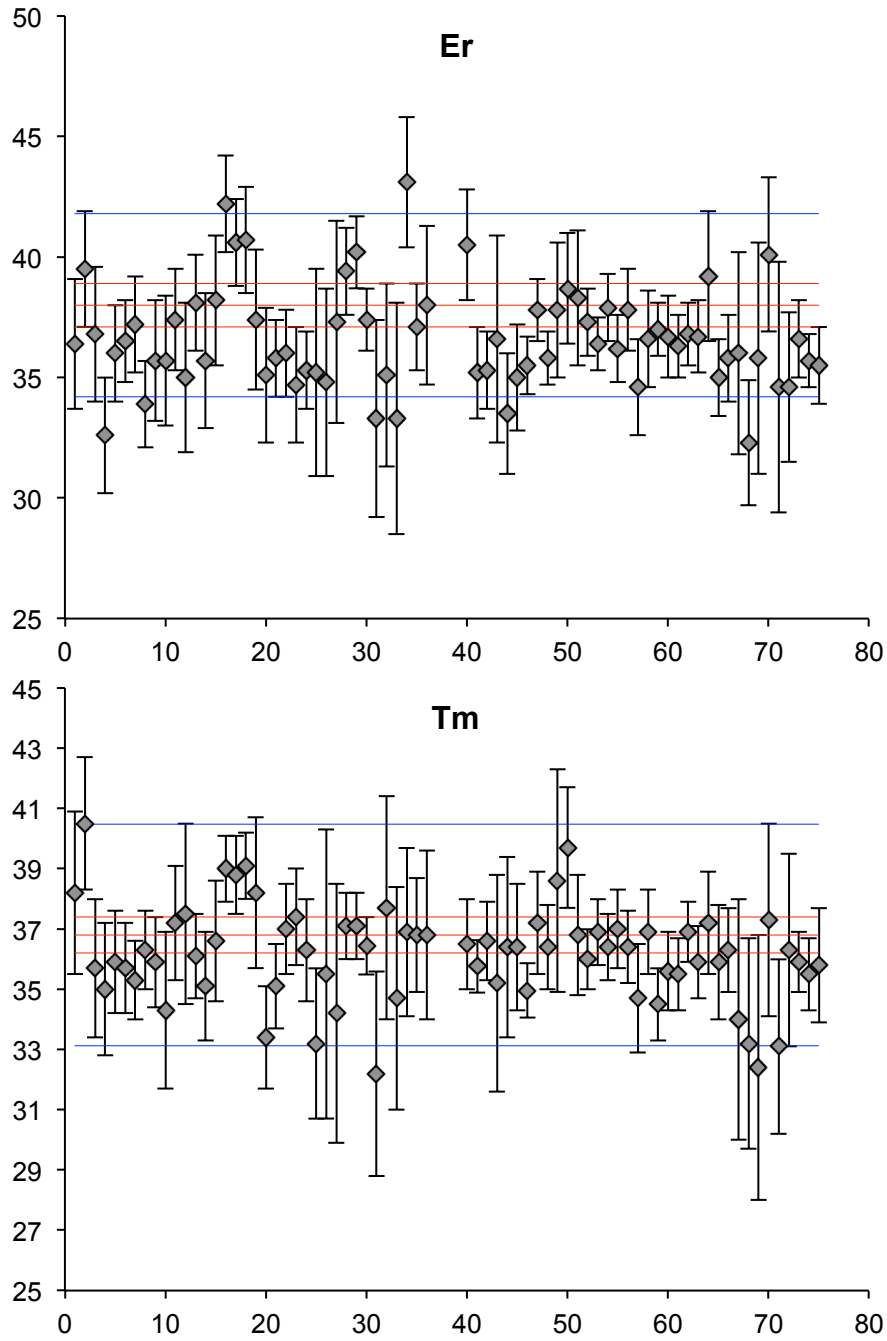


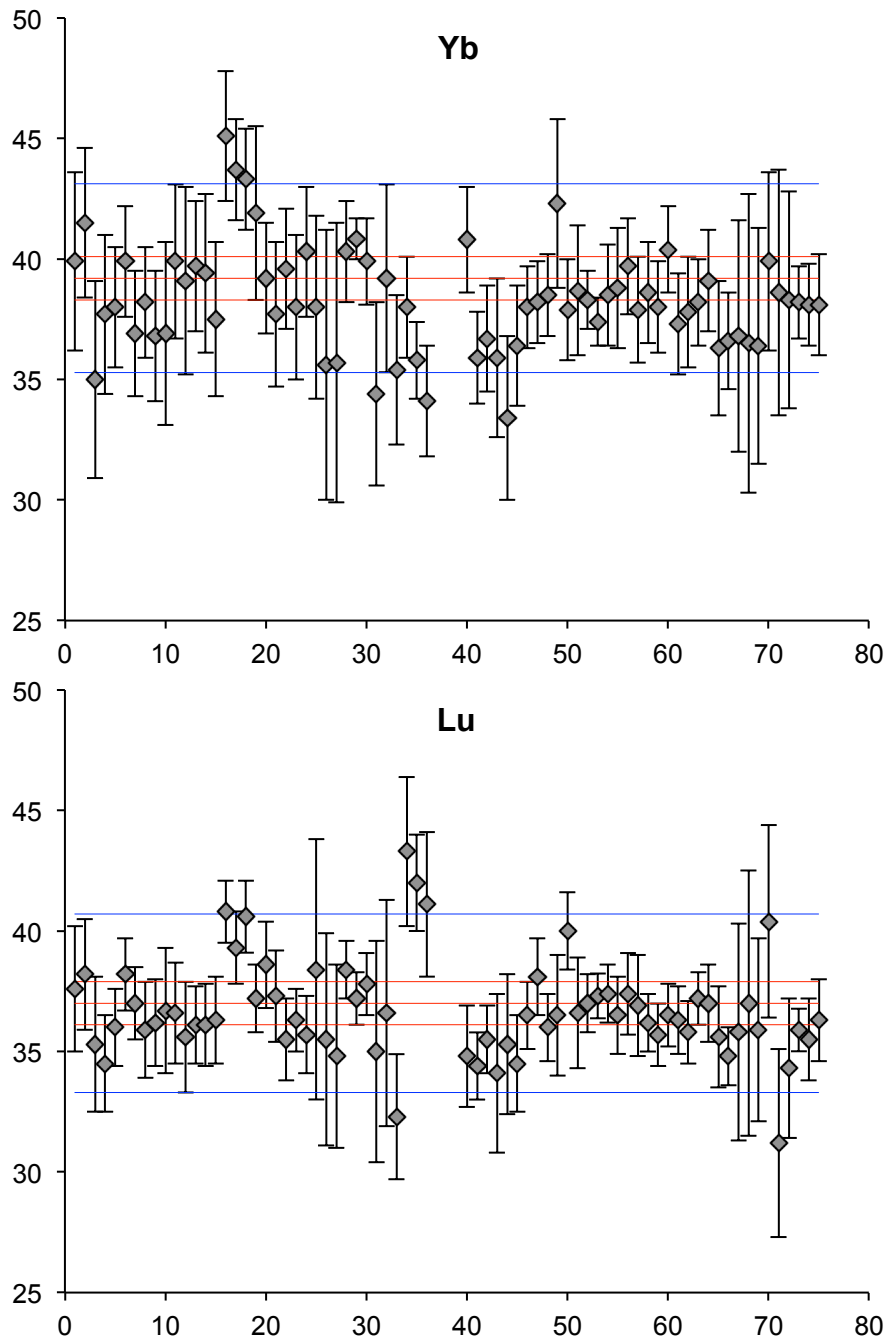












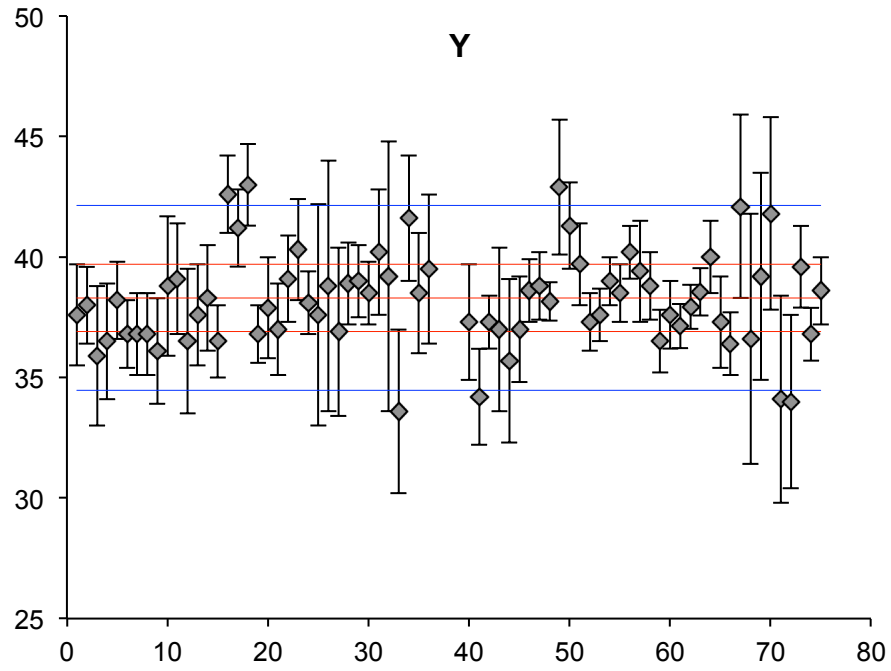


Figure S2

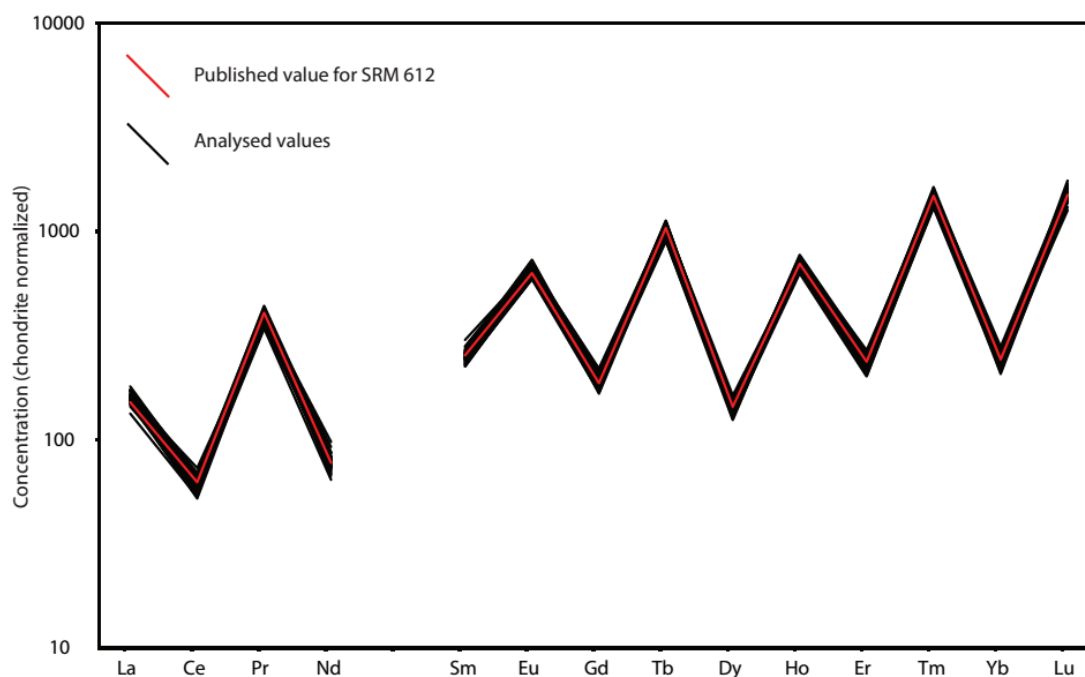


Figure S2: Comparison of repeat analyses of standard SRM-612 with published values. Note chondrite-normalized distribution. Published standard values from Jochum et al, 2011.

K.P. Jochum, U. Weis, B. Stoll, D. Kuzmin, Q. Yang, I. Raczek, D.E. Jacob, A. Stracke, A. Birbaum, D.A. Frick, D. Günther, J. Enzweiler. Determination of Reference Values for NIST SRM 610–617 Glasses Following ISO Guidelines. *Geostand. Geoanal. Res.*, 35 (2011), pp. 397–429

Figure S3

Summary of infra-red spectra data from Styles (1988):

Styles, M.T., (1988). A preliminary report on the mineralogy of the Tundulu and Songwe carbonatite complexes, Malawi. Nottingham, UK, British Geological Survey, 10pp. (WG/88/006) (Unpublished) available at <http://nora.nerc.ac.uk/511266>

Method:

A small (3 mg) sample of clear apatite from samples T-159 and T-160, hand-picked under a binocular microscope, was analyzed using a Perkin-Elmer 577 infra-red spectrometer (Styles, 1988). This sample was treated in 10% acetic acid, prior to analysis, to remove any calcite contaminant.

Result:

The infra-red spectrum of a sample of non-turbid apatite fraction shows adsorptions at 3500, 1450, 1050, 850, 800, 600, and 450 cm^{-1} . These are attributed to the presence of H_2O , CO_3 , PO_4 , and SiO_2 (Figure S1). The H_2O is from atmospheric water, and, as no OH adsorption is present, there is no hydroxyl group in the apatite structure, commensurate with the high F content. Similarly, SiO_2 adsorption is interpreted as due to the inclusion of small quartz grains and not from SiO_2 substitution. The sample was treated with 10% acetic acid prior to analysis, and the CO_3 group is considered to be structural carbonate in the apatite rims.

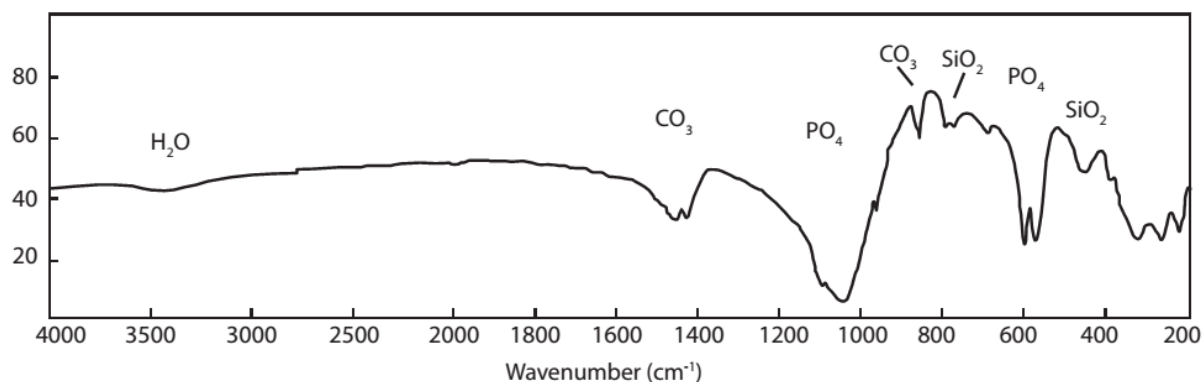


Figure S3 Infra-red spectrum of an acid-treated sample of hand-picked, predominantly clear, apatite. H_2O and SiO_2 adsorptions result from atmospheric and quartz contamination. From Styles (1988).

Figure S4

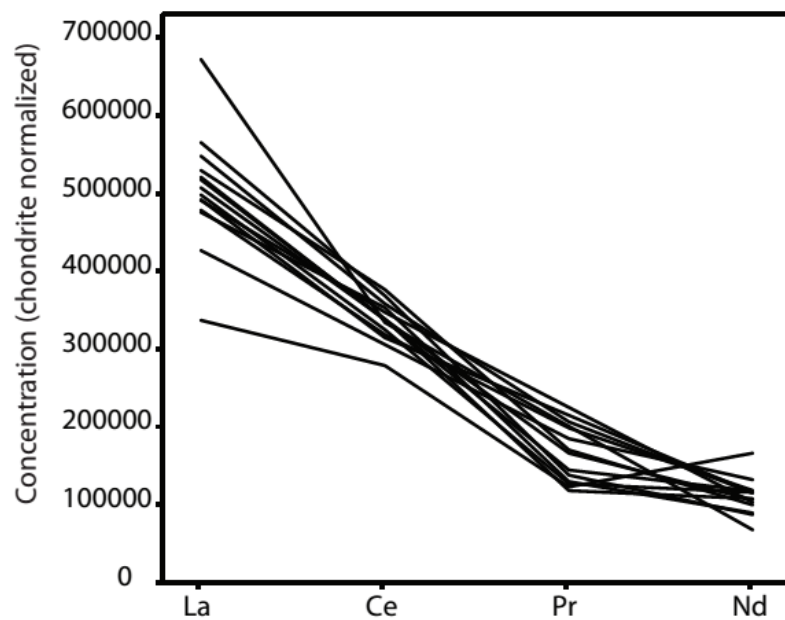


Figure S4: Chondrite-normalized distributions of the REE in synchysite-(Ce) from Tundulu showing strong LREE enrichment. Chondrite values from McDonough and Sun (1995).