Eu – Europium

Introduction

See section on Rare Earth Elements (REEs). Table 27 compares the median concentrations of Eu in the FOREGS samples and in some reference datasets.

Table 27. Median concentrations of Eu in the FOREGS samples and in some reference data sets.

Europium (Eu)	*Origin – Source*	*Number of samples*	*Size fraction mm*	*Extraction*	*Median mg kg^{-1}*
Crust[1)]	Upper continental	n.a.	n.a.	Total	1.0
Subsoil	**FOREGS**	**790**	**<2.0**	**Total (ICP-MS)**	**0.84**
Topsoil	**FOREGS**	**843**	**<2.0**	**Total (ICP-MS)**	**0.77**
Soil[2)]	World	n.a.	n.a	Total	1
Water	**FOREGS**	**807**	**Filtered <0.45 µm**		**0.005 (µg l^{-1})**
Water[2)]	World	n.a.	n.a.		0.0015 (µg l^{-1})
Stream sediment	**FOREGS**	**848**	**<0.15**	**Total (XRF)**	**1.01**
Floodplain sediment	**FOREGS**	**743**	**<2.0**	**Total (XRF)**	**0.87**

[1)]Rudnick & Gao 2004, [2)]Ivanov 1996.

Eu in soil

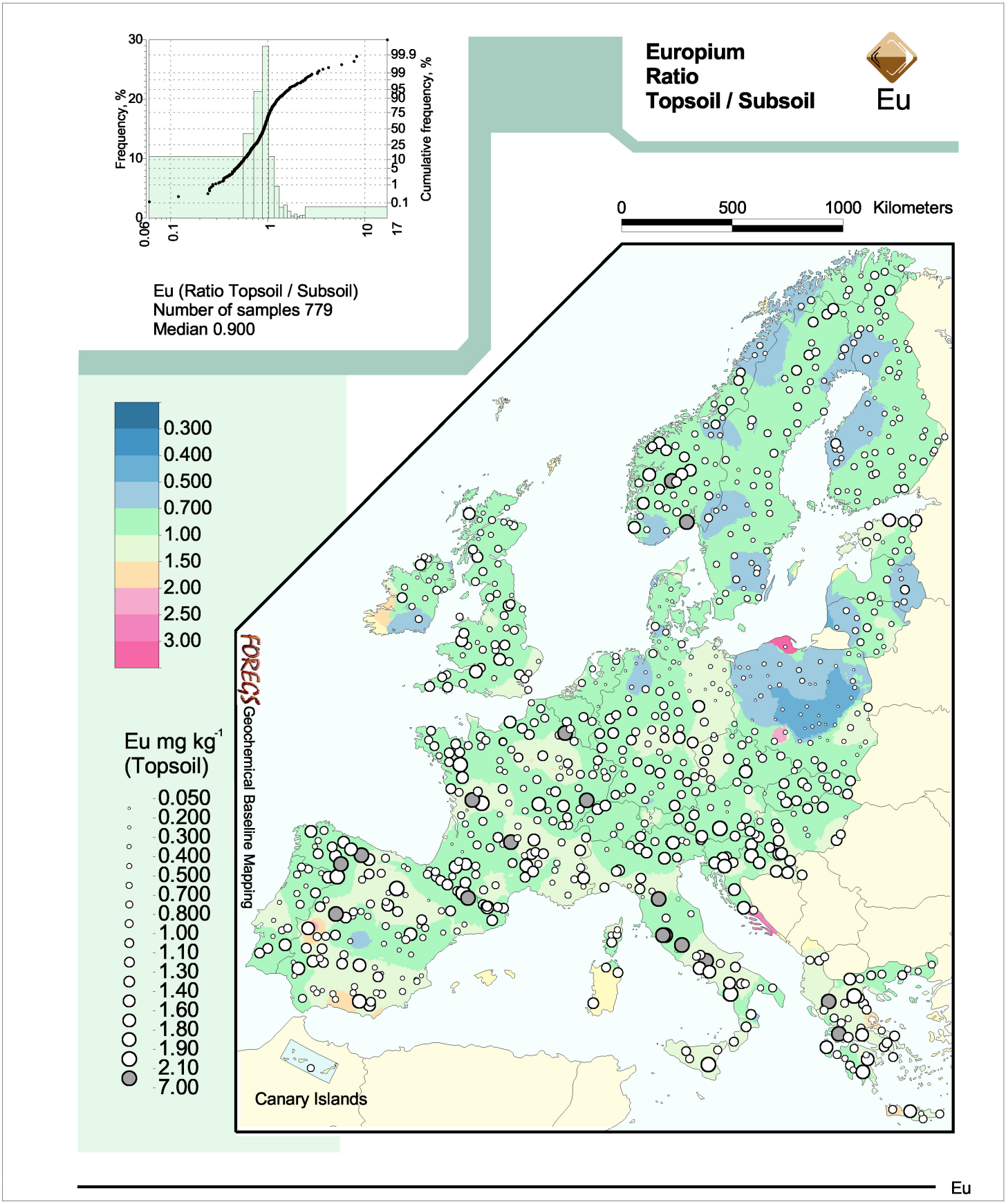
The median Eu content is 0.84 mg kg^{-1} in subsoil, and 0.77 mg kg^{-1} in topsoil, with a range from <0.05 to 4.66 mg kg^{-1} in subsoil, and 0.05 to 6.99 mg kg^{-1} in topsoil. The average ratio topsoil/subsoil is 0.884.

In subsoil, low Eu values (<0.59 mg kg^{-1}) are located mainly in central Finland, central Sweden, in the glacial drift area of northern mainland Europe (Netherlands to Poland), central Hungary, the Paris Basin in France, and parts of south and east Spain.

Europium in subsoil has high values (>1.18 mg kg^{-1}) in the igneous and metamorphic Variscan basement of northern Portugal, Galicia and Extremadura in Spain, the central Pyrenees (granitic rocks), in the Italian alkaline province (which contains the strongest anomalies), in Brittany (France), in Slovenia and Croatia, the loess/palaeoplacer area of northern France to Germany, eastern Slovakia and adjacent Hungary, south-western Norway and in northern Sweden (Salpeteur *et al*. 2005). In central Macedonia and Thrace in Greece high Eu values are related to felsic rocks and mineralisation, and in western Greece the point anomalies are associated with *terra rossa* soil and phoshorite mineralisation.

In topsoil, Eu is lower in Scandinavia, and higher in the eastern Pyrenees, western Variscan Spain, southern Spain (metamorphic rocks of Nevado Filábride near Almería), in Gran Canaria (alkaline mafic volcanics), and northern Italy, but elsewhere the pattern is similar to that of the subsoil. The average ratio topsoil/subsoil is 0.88 for Eu, the lowest figure of all the REE, but with a correlation of 0.83 between topsoils and subsoils, and the highest figure of all the REEs except La. This expresses an apparent Eu depletion in topsoils, which is stronger but more uniform than for other REE (Map 6).

A discussion on the relation of Eu to other REEs will be found in the section on REEs.



Map 6. Ratio of Eu in topsoil vs subsoil.

Eu in stream water

Europium values in European stream water range over two orders of magnitude, from <0.002 μg l^{-1} to about 0.2 μg l^{-1}, with a median value of 0.005 μg l^{-1}. Europium data correlate relatively well with the other lanthanides, especially ytterbium, for the low values, but not to the same extent for the distribution of highest values. See section on Rare Earth Elements (REEs) for a general discussion.

Lowest Eu values in stream water (<0.002 μg l^{-1}) are predominantly found in most of central Spain, in southern and northern Portugal, in north-eastern France and in Corsica, in Belgium and north-western Germany, in western Ireland and in south-eastern England, in central Sweden, in western Norway, in northern Finland, in southern (including Sicily) and north-eastern Italy, in most of Austria, in eastern Hungary, in western Slovenia, in Albania and Greece. Most of the areas of lowest values are on Alpine Orogen terrains (southern Europe) and Variscan terrains (Spain and eastern France), whereas other areas (north-western Germany and southern England) are characterised by Eastern Avalonian terrains (English – North German Caledonides), Irish-Scottish and Fennoscandian Caledonides (Ireland, Scotland and Norway) terrains, and Precambrian central Finnish Lapland.

Highest Eu concentrations in stream water (>0.03 μg l^{-1}) are predominantly found in southern Norway, in southern and central Sweden and in southern Finland. The areas of highest Eu values are over Precambrian Sveconorwegian and Svecofennian terrains (mostly intrusive rocks). Enhanced Eu values (between 0.01 and 0.03 μg l^{-1}) occur as well, mostly, in southern Fennoscandia, in eastern Ireland, in north-eastern Scotland, characterised by Fennoscandian and Irish-Scottish Caledonides, in France (Brittany and southern area), characterised by Variscan terrains (intrusive and volcanic rocks), in southern Germany and in central Czech Republic, characterised by Variscan terrains, in southern Spain (gneissic rocks of Betic cordillera), characterised by Alpine Orogen terrains and in Italy (Sardinia), characterised by Variscan Gondwana terrains. Highly anomalous Eu values in northern Germany are associated with high DOC values.

Eu in stream sediment

The median Eu content in stream sediment is 0.99 mg kg^{-1}, with a range from 0.05 to 7.06 mg kg^{-1}.

Europium in stream sediment shows a distribution roughly similar to Ce and Y, with high values (>1.18 mg kg^{-1}) mostly associated with igneous and metamorphic rocks, in southern Norway and the Massif Central and south Brittany in France, in northern Scandinavia, Bavaria and the Bohemian Massif, an anomaly in the Italian alkaline province and in Pannonian Croatia. Notable differences with Ce and Y are higher Eu values in the southern Variscan zone of Iberia (Lower Palaeozoic schist of the Sierra Morena with monazite nodules) and in the Canary Islands, no Eu anomaly in Old Castilia in Spain (except for one point anomaly), high values in the Baetic Cordillera of Spain, a stronger Eu anomaly in most of Norway, and a moderate anomaly in northern England and Scotland. There is no Eu anomaly in northern Ireland, and a weak point anomaly in northern Estonia.

Europium in stream sediment has strong correlation (between 0.6 and 0.72) with Y and the other REEs, in contrast to the very strong correlation (0.8 to 0.99) that the other REEs show among themselves. It also shows a good correlation (>0.4) with Al, Ga, Fe, V, Nb, Ta, Ba and Th.

Eu in floodplain sediment

Total Eu distribution in floodplain sediment, determined by ICP-MS, vary from 0.07 to 4.11 mg kg^{-1}, with a median of 0.87 mg kg^{-1}.

Low Eu values in floodplain sediment (<0.6 mg kg^{-1}) occur over the glacial drift covered plain from north Germany and Poland to Latvia; the calcareous and Lower Palaeozoic rocks of Ireland; the calcareous regions of lower Garonne river in France, the Cantabrian Mountains, Ebro Basin, central Iberian Meseta in Spain, the molasse basin in Austria and the calcareous Dalmatian coast in Croatia; the ophiolite and calcareous rocks of Albania and Greece.

High Eu values in floodplain sediment (>1.18 mg kg^{-1}) are found in all types of crystalline and clastic rocks over the whole of Norway and some adjacent parts of Sweden, south-eastern Sweden, and northern Finland; in crystalline and sedimentary rocks of Wales and in sediments of East Anglia in England; in a belt running across central France from Poitou to the northern Massif Central over felsic intrusives; southern Portugal, and its north-east border crossing over into Spain (small Variscan granitic intrusions of Boal and Carlés, with Au-As-Sb mineralisation), and Sierra Morena in southern Spain; central Swiss-Italian Alps; the Roman Alkaline Province; a belt from the Harz Mountains, Erzgebirge and the Bohemian Massif with felsic intrusives, to clastic rocks of northern Bavaria; another belt from the Austrian-Czech-Slovakian-Hungarian border region to eastern Hungary, and the Austrian-Slovenian border area and Croatia with variable lithology.

The highest Eu point anomalies in floodplain sediment occur in Northumberland in England (4.11 mg kg^{-1}), possibly related to phosphorite in the Carboniferous, in northern Sweden (3.88 mg kg^{-1}), and Wales (3.35 mg kg^{-1}), probably related to Ordovician volcanics. An isolated Eu anomaly (2.51 mg kg^{-1}) occurs in the Navia river in Asturias, Spain (Lower Palaeozoic schist), and in Gran Canaria (2.78 mg kg^{-1}) where it is associated with alkaline basalt.

Europium in floodplain sediment shows a very strong positive correlation (>0.8) with most of the REEs, a strong correlation (>0.6) with Al_2O_3, Ga, Fe_2O_3, Ti_2O, Nb, Y and V, and a good correlation with K, Co, Hf, Ta, Tl, Rb, and Th.

In conclusion, the variability of Eu in floodplain sediment, like the other REEs, is related mainly to the geological substratum and mineralised areas, and no distinguishable influences from anthropogenic activities are recognised.

Eu comparison between sample media

In general there are broad similarities between all solid sample media. Topsoil is relatively low in Eu compared to subsoil in parts of Norway, Sweden and Lithuania, but patterns between topsoil and subsoil are otherwise virtually identical. Coastal Croatia and Slovenia and western parts of Austria are low in Eu in stream sediments compared to other solid sample media, which is possibly explained by the removal of fine-grained material from the residual soils and karst. In stream and floodplain sediments, higher Eu concentrations are observed throughout Norway compared to soil. Central and northern Britain show high Eu in stream sediment only. In Wales, Hungary, south-eastern Germany and parts of Sweden, floodplain sediment is enriched in Eu compared to other solid sample media. In the alkaline volcanic province of Italy and parts of western Greece, Eu is low in sediments compared to soil. Stream sediment is relatively enriched in Eu compared to soil in the Central Massif of France.

A boxplot comparing Eu variation in subsoil, topsoil, stream sediment and floodplain sediment is presented in Figure 17.

The distribution of Eu in stream water is complex, but generally forms opposite patterns to those observed in the solid sample media, except in the Baltic states, part of northern Finland and Sweden, central and southern France and parts of central mainland Europe. Europium solubility is strongly controlled by acid pH and the presence of DOC, and highest concentrations are observed throughout southern Fennoscandia.

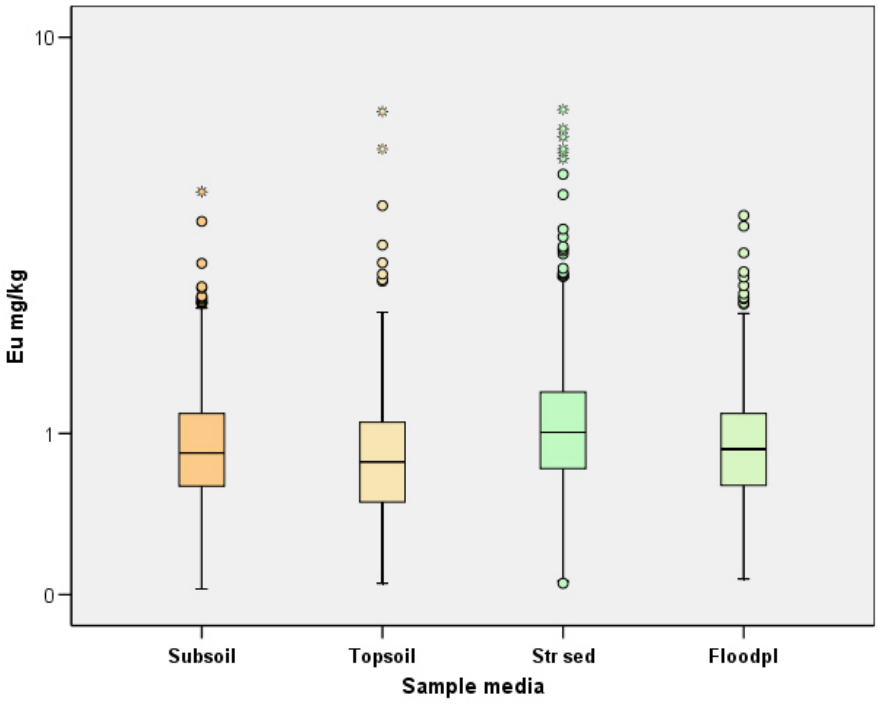


Figure 17. Boxplot comparison of Eu variation in subsoil, topsoil, stream sediment and floodplain sediment.