Lu – Lutetium

Introduction

See section on Rare Earth Elements (REEs). Table 42 compares the median concentrations of Lu in the FOREGS samples and in some reference datasets.

Table 42. Median concentrations of Lu in the FOREGS samples and in some reference data sets.

Lutetium (Lu)	*Origin – Source*	*Number of samples*	*Size fraction mm*	*Extraction*	*Median mg kg^{-1}*
Crust[1)]	Upper continental	n.a.	n.a.	Total	0.31
Subsoil	**FOREGS**	**790**	**<2.0**	**Total (ICP-MS)**	**0.31**
Topsoil	**FOREGS**	**843**	**<2.0**	**Total (ICP-MS)**	**0.30**
Soil[2)]	World	n.a.	n.a.	Total	0.4
Water	**FOREGS**	**807**	**Filtered <0.45 µm**		**<0.002 (µg l^{-1})**
Water[2)]	World	n.a.	n.a.		0.0064 (µg l^{-1})
Stream sediment	**FOREGS**	**848**	**<0.15**	**Total (XRF)**	**0.39**
Floodplain sediment	**FOREGS**	**743**	**<2.0**	**Total (XRF)**	**0.27**

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

Lu in soil

The median Lu content is 0.31 mg kg^{-1} in subsoil and 0.30 mg kg^{-1} in topsoil; the range varies from <0.02 to 1.06 mg kg^{-1} in subsoils and from <0.02 to 3.21 mg kg^{-1} in topsoil. The average ratio topsoil/subsoil is 0.947.

Lutetium in subsoil shows low values (<0.22 mg kg^{-1}) in central and north Finland, the glacial drift area from Poland to the Netherlands, the Paris Basin in France, the western Alps and Rhône River valley, central Hungary, central Portugal and southern Spain.

High Lu values in subsoil (>0.42 mg kg^{-1}) are located mainly in the crystalline basement of the Iberian Massif in northern Portugal and north-west Spain, in the Italian and Greek central Macedonian alkaline magmatic provinces (Plant *et al*. 2005), in soil on karst of Slovenia and Croatia, in southern Hungary and Austria, south-eastern Germany, Brittany and the loess/palaeoplacer area of northern France to Germany, south-western Norway, and northern Sweden (Salpeteur *et al*. 2005). Point Lu anomalies appear in western Greece are associated with *terra rossa* soil and phosphorite mineralisation, and in northern Ireland with the Mourne granite.

In topsoil, Lu is lower in Norway and Sweden, but elsewhere patterns are similar to those in subsoil.

Lutetium in subsoil has a strong to very strong correlation with the other REEs. The geochemical behaviour of Lu is most similar to that of the other heavy REEs (Gd, Tb, Dy, Ho, Er, Tm and Yb). For more information, see the section on REEs.

Lu in stream water

Lutetium values in stream water range over one and a half orders of magnitude, from <0.002 µg l^{-1} to 0.07 µg l^{-1} (excluding an outlier of 0.3 µg l^{-1}), with a median of <0.002 µg l^{-1}. Over 60% of the data are less than the analytical limit of quantification (0.002 µg l^{-1}). The inappropriate analytical method precludes a sensible interpretation. Lutetium data correlate very well with holmium and terbium. See section on REE for a general discussion.

Lowest Lu values in stream water (<0.002 µg l^{-1}) are uniformly found in all of southern and

central Europe, in western Ireland, most of Britain, in south-western Norway, central Norway and Sweden and in northern Norway, Sweden and Finland.

Highest Lu concentrations in stream water (>0.015 μg l^{-1}) are found in southern and central Sweden, characterised by Precambrian terrains (mostly intrusive and metamorphic rocks), and in north-eastern Scotland Caledonides terrain.

Enhanced values in stream water (>0.005 μg l^{-1}) also occur in southern Norway and Sweden, in northern Sweden and in southern Finlandover Precambrian and Caledonides terrains (mostly intrusive and metamorphic rocks), in Denmark in glacial drift, and in western France with Variscan terrains. Isolated high values occur in northern Germany and in southern Italy. The latter are certainly controlled by recent alkaline volcanism of the Neapolitan geochemical province. In Northern Ireland, the isolated Lu anomalously is associated with the Mourne granite. Highly anomalous Lu values in northern Germany are associated with high DOC values.

Lu in stream sediment

The median Lu content in stream sediment is 0.38 mg kg^{-1}, and the range varies from <0.02 to 6.04 mg kg^{-1}.

The Lu stream sediment distribution map shows low values (<0.27 mg kg^{-1}) in east and north Finland, in the North European plain from Poland to the Netherlands on glacial drift, in western Ireland, in parts of south, east and north Spain on mostly calcareous sediments, in the French-Swiss Jura Mountains, in the western Alps and the northern Apennines, part of the south Apennines, in north-easternmost Italy, coastal Croatia, and west and central Greece.

High Lu values in stream sediment (>0.55 mg kg^{-1}) occur in the Variscan part of the Iberian Peninsula on felsic rocks in north Portugal, Galicia and the Sierra de Gredos in Old Castilia (Spain); in the Massif Central in France (Variscan granite) extending into the Poitou region to the north-west; in most of Norway, north Sweden, parts of south and east Sweden, a point anomaly in northern Estonia (phosphate deposits), eastern Scotland, the Bohemian Massif, the eastern Alps, Albania, and a point anomaly in northern Ireland near the Mourne granite.

Lutetium in stream sediment has a strong to very strong correlation with Th, U and the REEs. For more information, see the section on REEs.

Lu in floodplain sediment

Total Lu values in floodplain sediment, determined by ICP-MS, vary from 0.02 to 2.21 mg kg^{-1}, with a median of 0.27 mg kg^{-1}.

Low Lu values in floodplain sediment (<0.18 mg kg^{-1}) occur in northern and eastern Finland on gneiss and greenstone of the Fennoscandian Shield, the glacial drift covered plain from north Germany to Poland; the Ebro basin, Cantabria, Pyrenees, Galicia, La Mancha and Valencia in Spain on chiefly clastic and partly calcareous rocks; the alluvial sediments of the lower Garonne river in France; north-central Austria mostly on molasse deposits; in central Greece on calcareous and clastic rocks.

High Lu values in floodplain sediment (>0.39 mg kg^{-1}) occur over the metamorphic and felsic igneous rocks and mineralised areas of the Precambrian Shield in northern and central Sweden, south-west Finland, and almost the whole of Norway; on glacial outwash cover in Estonia, where there may also be an association with phosphorites. In Wales, the high Lu levels are ascribed to felsic intrusives and mineralisation. High Lu values in floodplain sediment occur in France over the Massif Central on crystalline rocks, and north part of the Paris Basin on mostly carbonate rocks; in central Swiss-Italian Alps with felsic intrusives and mineralisation, the Roman Alkaline Province, and Corsica over granite and schist; an extensive area with felsic rocks and mineralisation begins from the Erzgebirge, Bohemian Massif to Brno (Li deposits) in the Czech Republic and continues into eastern Austria on Tertiary and Quaternary sediments, and southern Austria with felsic intrusives; high Lu values in floodplain sediment of Slovenia and Croatia, except Dalmatia, are explained by possible concentration in karstic soil; in eastern Hungary the Lu anomalous values are probably due to the mineralisation in the Apuseni

Mountains in neighbouring Romania. The point Lu anomaly in southern Sweden is associated with granitic intrusions.

In conclusion, granite, granodiorite, shale, sandstone and schist lithologies show the highest Lu concentrations in floodplain sediment, and the glacial drift covered terrain (north-east Germany and Poland) the lowest; low Lu contents are also generally found in calcareous areas (*e.g.,* eastern Spain, Greece and Dalmatian coast), except where there is intense development of residual soil in karst terrain (*e.g.,* Slovenia and Croatia). The distribution map of total Lu in floodplain sediment shows, therefore, the geochemical differences of the geological substratum and mineralised areas quite well, and no distinguishable influences from anthropogenic activities are recognised. It is noted that the spatial distribution of Lu is similar to that of the other HREEs (Dy, Er, Gd, Ho, Tb, Tm, Yb).

Lu comparison between sample media

In general, there are broad similarities between all solid sample media. Topsoil is relatively low in Lu compared to subsoil in parts of Norway and Sweden and richer in the alkaline province of Italy and central and south-western Spain, but patterns between topsoil and subsoil are otherwise virtually identical. Coastal Croatia and Slovenia and central parts of Austria are low in Lu in stream sediment compared to other solid sample media (removal of fine-grained material from residual soil and karst). In stream and floodplain sediments, higher Lu concentrations are observed throughout Norway, most of Sweden and Estonia compared to soil. In stream sediment, northern Estonia shows two point anomalies of Lu, possibly related to the phosphorite lower-Palaeozoic sediments, and the whole of Estonia is anomalous in floodplain sediment. Scotland shows high Lu in stream sediments only, Wales is enhanced in floodplain sediment. In stream sediment, the Central Massif of France and central Spain are enhanced in Lu compared to all other solid sample media. In the alkaline volcanic province of Italy and parts of western Greece, Lu is low in sediments compared to soil.

A boxplot comparing Lu variation in subsoil, topsoil, stream sediment and floodplain sediment is presented in Figure 26.

The distribution of Lu in stream water generally forms opposite patterns to those observed in solid sample media, although many data are below the limit of detection so comparison is difficult. Lutetium solubility is strongly controlled by acid pH and the presence of DOC, and highest concentrations are observed throughout southern Fennoscandia.

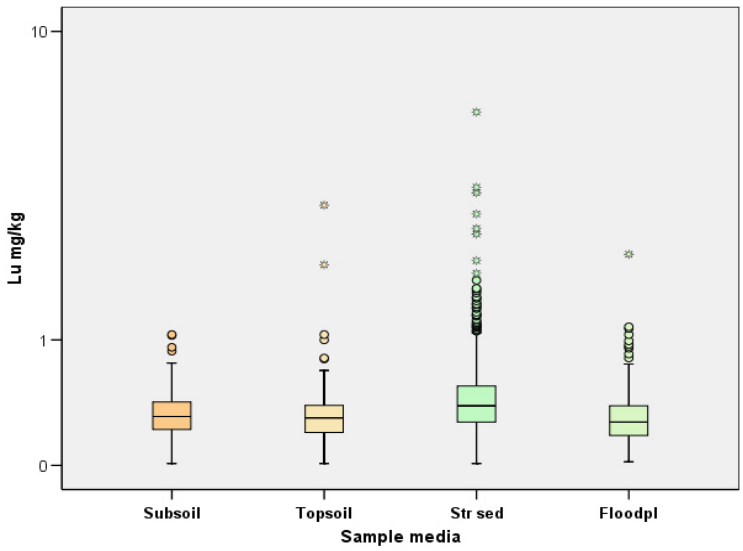

Figure 26. Boxplot comparison of Lu variation in subsoil, topsoil, stream sediment and floodplain sediment.