Sm – Samarium

Introduction

See section on Rare Earth Elements (REEs).

Table 61 compares the median concentrations of Sm in the FOREGS samples and in some reference datasets.

Table 61. Median concentrations of Sm in the FOREGS samples and in some reference data sets.

Samarium (Sm)	*Origin – Source*	*Number of samples*	*Size fraction mm*	*Extraction*	*Median mg kg^{-1}*
Crust[1)]	Upper continental	n.a.	n.a.	Total	4.7
Subsoil	**FOREGS**	**790**	**<2.0**	**Total (ICP-MS)**	**4.38**
Topsoil	**FOREGS**	**843**	**<2.0**	**Total (ICP-MS)**	**3.96**
Soil[2)]	World	n.a.	n.a.	Total	4.5
Water	**FOREGS**	**807**	**Filtered <0.45 µm**		**0.009 (µg l^{-1})**
Water[2)]	World	n.a.	n.a.		0.0045 (µg l^{-1})
Stream sediment	**FOREGS**	**848**	**<0.15**	**Total (XRF)**	**5.40**
Floodplain sediment	**FOREGS**	**743**	**<2.0**	**Total (XRF)**	**4.25**

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

Sm in soil

The median Sm content is 4.38 mg kg^{-1} in subsoil and 3.96 mg kg^{-1} in topsoil, and the range is from <0.1 to 18.2 mg kg^{-1} in subsoil and from 0.23 to 30.0 mg kg^{-1} in topsoil. The average ratio topsoil/subsoil is 0.888.

In subsoil, low Sm values (<2.87 mg kg^{-1}) are located mainly throughout Finland, in the glacial drift covered area of northern mainland Europe (Netherlands to Poland), central Hungary, the Paris Basin in France, and parts of south and east Spain.

Samarium in subsoil has high values (>6.61 mg kg^{-1}) over Variscan granitic and metamorphic rocks in northern Portugal and north-western Spain, the Massif Central in France; in the Italian Alkaline Province (which contains the strongest anomalies); in Slovenia, Croatia and adjacent Austria; in parts of the loess/palaeoplacer area of northern France to Germany; south-western Norway and northern Sweden (Salpeteur *et al.* 2005).

In topsoil, Sm is much lower in Scandinavia, and somewhat higher in Slovakia. A much larger area in the Iberian Massif of western Spain shows high Sm values; also near Almeria (south-east Spain), in the Central and Eastern Pyrenees; and on Gran Canaria island related to alkaline mafic volcanism. There is a point Sm anomaly near the Mourne granite in northern Ireland. Elsewhere in Europe the Sm pattern is similar to that of subsoil.

Samarium shows strong to very strong correlations with most other REEs, both in subsoil and topsoil. Correlations are strongest with the light REEs (La, Ce, Pr, Nd), which are more similar in atomic weight and ionic radius. For additional information, refer to the section on Rare Earth Elements.

Sm in stream water

Samarium values in stream water range over almost three orders of magnitude from <0.002 µg l^{-1} to 1.07 µg l^{-1} (excluding an outlier of 3.53 µg l^{-1}), with a median value of 0.009 µg l^{-1}.

Samarium data correlate most closely with the lanthanides. See section on REEs for a general discussion.

Lowest Sm values in stream water (<0.002 μg l^{-1}) are predominantly found in most of Spain, eastern and southern France, northern, central and southern Italy, western Slovenia, central Austria and western Hungary, Albania and Greece, north-eastern Germany and south-eastern Poland. Most of the areas of lowest values are characterised by Alpine Orogen terrains (southern Europe), whereas other areas (especially northern Germany and Poland) are over Variscan and Precambrian terrains.

Highest Sm concentrations in stream water (>0.20 μg l^{-1}) are predominantly found in southern Norway, Sweden and Finland, and Denmark. These areas of highest values are on Precambrian terrains (mostly intrusive and metamorphic rocks) or on glacial till derived from them. Enhanced values (>0.07 μg l^{-1}) also occur in northern Fennoscandia, northern Ireland and Scotland, characterised by Caledonides, and in France (Brittany and Massif Central) by Variscan terrains. Highly anomalous Sm values in northern Germany are associated with high DOC values.

Sm in stream sediment

The median Sm content in stream sediment is 5.2 mg kg^{-1} with a range from 0.20 to 106 mg kg^{-1}.

The Sm stream sediment distribution map shows low values (<3.7 mg kg^{-1}) in most of eastern Finland, the northern European plain including Denmark, western Ireland, southern and eastern Spain, the western Pyrenees, the western Alps and northern Appenines, north-easternmost Italy, the Jura Mountains, Slovenia, coastal Croatia, and western and southern Greece.

High Sm contents in stream sediment (>7.59 mg kg^{-1}) are well represented in Variscan Spain and Portugal, where they outline the granitic basement of the Iberian Massif; moderate values fit with metamorphic areas of the Iberian Massif in a similar way as they do in the French Massif Central. In the southern part of the Massif Central, the highest Sm values are associated with Ce, U, Sn and Ta, indicating hydrothermal alteration related to the late Variscan granitic phases.

High Sm in stream sediment also occurs in southern Norway, northern Norway and Sweden, parts of central and south-eastern Sweden, north-east and south-western Finland, a point anomaly in northern Estonia (phosphate deposits), Scotland, the Bohemian Massif (including a point anomaly in Variscan granite near the border of Austria, Czech Republic and northern Bavaria), the Roman Alkaline Province, and point anomalies in south-eastern Austria, westernmost Austria (probably Variscan granite), and the Canary Islands.

Samarium in stream sediment has a strong to very strong correlation with Y, with the other REEs, and with Th and U.

For a comparison with the other rare earth elements, see the section on REEs.

Sm in floodplain sediment

Total Sm values in floodplain sediment, determined by ICP-MS, vary from 0.4 to 23.6 mg kg^{-1}, with a median of 4.25 mg kg^{-1}.

Low Sm values in floodplain sediment (<2.9 mg kg^{-1}) occur over the glacial drift covered plain extending from north Germany to Poland, Lithuania and Latvia; the greenstone, schist, paragneiss, metagreywacke and granulite areas of northern and eastern Finland; north-eastern Ireland with mostly basaltic rocks; the alluvial parts of the lower Garonne and Rhône rivers in France, the Ebro River basin, La Mancha in Spain with calcareous and clastic rocks, the molasse basin in central Austria and the calcareous Dalmatian coast in Croatia; the ophiolite, flysch and calcareous rocks of Albania and Greece.

High Sm values in floodplain sediment (>5.74 mg kg^{-1}) occur overall in areas with felsic intrusives and mineralisation as in south-west Finland; southernmost, south-eastern, central and northern Sweden; southern, central and northern Norway, Wales, and Massif Central extending,

with a slightly weaker anomaly, to the Pyrenees in France; almost the whole of Portugal and adjacent parts of north-western Spain, south-central Spain (Sierra Morena); central Swiss-Italian Alps; the Roman Alkaline Province in Italy; an extensive zone from the Ardennes to the Harz Mountains, Erzgebirge, Bohemian Massif, northern Bavaria, the Austrian-Czech border area, southern Austrian, eastern Slovenia and central Croatia, and eastern Hungary (sediments derived from the volcanic rocks and mineralisation of the Apuseni Mountains in Romania). The high Pr values in Estonia are on glacial outwash cover, and there may also be an association with phosphorite mineralisation.

There are three Sm point anomalies in floodplain sediment; the first and highest (23.6 mg kg^{-1}), is in the Skellefte mineralised region of northern Sweden; the second (12.9 mg kg^{-1}) in the floodplain sediment of the Navia River in north-west Spain is related to felsic intrusives and mineralisation, and the third on Gran Canaria in the Canary Islands (10 mg kg^{-1} Sm) is unusual since it is associated with intermediate to mafic igneous rocks.

In conclusion, granite, granodiorite, shale, sandstone and schist lithologies show the highest Sm concentrations in floodplain sediment, and the glacial drift covered terrain (north-east Germany and Poland) the lowest; low Sm 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 Sm 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 Sm is similar to that of other light rare earth elements (Ce, Nd, Pr).