Introduction

See section on Rare Earth Elements (REEs).

Table 49 compares the median concentrations of Nd in the FOREGS samples and in some reference datasets.

Table 49. Median concentrations of Nd in the FOREGS samples and in some reference data sets.

Neodymium (Nd)	*Origin – Source*	*Number of samples*	*Size fraction mm*	*Extraction*	*Median mg kg^{-1}*
Crust[1)]	Upper continental	n.a.	n.a.	Total	27
Subsoil	**FOREGS**	**790**	**<2.0**	**Total (ICP-MS)**	**22.4**
Topsoil	**FOREGS**	**843**	**<2.0**	**Total (ICP-MS)**	**20.8**
Soil[2)]	World	n.a.	n.a.	Total	28
Water	**FOREGS**	**807**	**Filtered <0.45 µm**		**0.04 (µg l^{-1})**
Water[2)]	World	n.a.	n.a.		0.38 (µg l^{-1})
Stream sediment	**FOREGS**	**848**	**<0.15**	**Total (XRF)**	**28.2**
Floodplain sediment	**FOREGS**	**743**	**<2.0**	**Total (XRF)**	**21.3**

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

Nd in soil

The median Nd content is 22.4 mg kg^{-1} in subsoil and 20.8 mg kg^{-1} in topsoil, and the range is from 0.46 to 111 mg kg^{-1} in subsoil and from 1.14 to 132 mg kg^{-1} in topsoil. The average ratio topsoil/subsoil is 0.896.

In subsoil, low Nd values (<15 mg kg^{-1}) are located mainly throughout Finland, in the glacial drift covered area of northern mainland Europe (Netherlands to Poland), the Paris Basin in France, central Hungary, and parts of south and east Spain.

Neodymium in subsoil has high values (>32 mg kg^{-1}) over Variscan granitic and metamorphic rocks in northern Portugal and north-western Spain, the Massif Central and Brittany in France; in the Italian alkaline province (which contains the strongest anomalies); in karst of Slovenia, Croatia and adjacent Austria; the loess/palaeoplacer area of northern France to Germany; south-western Norway and northern Sweden (Salpeteur *et al*. 2005).

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

Neodymium shows strong (>0.6) to very strong (>0.8) correlations with most other REEs, both in subsoil and topsoil. Correlations are strongest with the light REEs (La, Ce, Pr, Sm), which are more similar in atomic weight and ionic radius. For additional information, refer to the section on Rare Earth Elements.

Nd in stream water

Neodymium values in stream water range over three and a half orders of magnitude, from <0.002 μg l^{-1} to 5.76 μg l^{-1} (excluding an outlier of 19.8 μg l^{-1}), with a median of 0.04 μg l^{-1}. Neodymium data correlate most closely with the lanthanides. See section on REE for a general discussion.

Lowest Nd values in stream water (<0.005 μg l^{-1}) are predominantly found in most of southern and eastern Spain, south-eastern and north-eastern France, most of Italy (including Sicily), western Slovenia, Croatia and Hungary, most of Austria, southern and north-eastern Germany, south-east Poland, all of Albania and Greece. Most of the areas of lowest values are characterised by Alpine Orogen terrains (southern Europe), whereas other areas (mainly northern Germany and Poland) are over Variscan terrains and glacial drift.

Highest Nd concentrations in stream water (>1 μg l^{-1}) are predominantly found in Denmark, in southern and central Norway, in southern and north-eastern Sweden and southern Finland. The areas of highest values are on Precambrian terrains (mostly intrusive and metamorphic rocks). Enhanced values (>0.14 μg l^{-1}) also occur in northern Fennoscandia, northern Ireland and Scotland, characterised by Caledonides, in France (Brittany and Massif Central), over Variscan terrains (intrusive and volcanic rocks) and in northern Germanyon glacial drift. Highly anomalous Nd values in northern Germany are associated with high DOC values.

Nd in stream sediment

The median Nd content in stream sediment is 27.6 mg kg^{-1}, with a range from 1.1 to 524 mg kg^{-1}.

The Nd stream sediment distribution map shows low values (<19 mg kg^{-1}) in most of eastern Finland, the North European plain including Denmark, western Ireland, southern and eastern Spain, the western Alps and northern Appenines, north-easternmost Italy, the Jura Mountains, Slovenia, coastal Croatia, and western and southern Greece.

High Ce contents in stream sediment (>39.2 mg kg^{-1}) are well represented in Variscan Spain and Portugal, where they outline the granitic basement of the Iberian Massif; the highest Nd anomalies are found over the granitic-metamorphic rocks of the eastern Cordillera Central; intermediate values occur over the metamorphic areas of the Iberian Massif in a similar way as they do in the French Massif Central. Here the area with high values extends into the Poitou region and southern Brittany. In the southern part of the Massif Central, the highest Nd values are associated with Ce, U, Sn and Ta, indicating hydrothermal alteration related to the late Variscan granitic phases.

High Nd in stream sediment also occurs in southern Norway (including the Sovi deposit), northern coastal Norway and adjacent Sweden, parts of central and south-eastern Sweden, north-east and south-west Finland, a point anomaly in northern Estonia (phosphate deposits), Scotland and north-east England, 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 (Gran Canaria).

Neodymium in stream sediment has strong to very strong correlations with Y, with the other REEs and with Th and U; and a good correlation with Nb, Ta, Ti, Zr, Hf and Rb. In part, this points to the association of the heavy minerals columbo-tantalite, monazite, zircon and rutile, which are often enriched together in sediments.

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

Nd in floodplain sediment

Total Nd values in floodplain sediment, determined by ICP-MS, vary from 1.5 to 117

mg kg^{-1}, with a median of 21.3 mg kg^{-1}.

Low Nd values in floodplain sediment (<15 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; most of western Ireland with calcareous, clastic, basaltic and metamorphic rocks; the alluvial parts of the lower Garonne and Rhône rivers in France, the Ebro River basin, La Mancha and Murcia areas 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 Nd values in floodplain sediment (>29.3 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 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 Nd values in Estonia are on glacial outwash cover, and there may also be an association with phosphorites.

There are three Nd point anomalies in floodplain sediment; the first and highest (117 mg kg^{-1}), is in the Skellefte mineralised region of northern Sweden; the second (70.5 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 is on Gran Canaria in the Canary Islands (61.3 mg kg^{-1} Nd) is unusual since it is associated with intermediate to mafic igneous rocks.

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