Gd – Gadolinium

Introduction

See section on Rare Earth Elements (REEs).

Table 31 compares the median concentrations of Gd in the FOREGS samples and in some reference datasets.

Table 31. Median concentrations of Gd in the FOREGS samples and in some reference data sets.

Gadolinium (Gd)	*Origin – Source*	*Number of samples*	*Size fraction mm*	*Extraction*	*Median mg kg^{-1}*
Crust[1)]	Upper continental	n.a.	n.a.	Total	4.0
Subsoil	**FOREGS**	**790**	**<2.0**	**Total (ICP-MS)**	**4.24**
Topsoil	**FOREGS**	**843**	**<2.0**	**Total (ICP-MS)**	**3.85**
Soil[2)]	World	n.a.	n.a	Total	4
Water	**FOREGS**	**807**	**Filtered <0.45 µm**		**0.01 (µg l^{-1})**
Water[2)]	World	n.a.	n.a.		0.0085 (µg l^{-1})
Stream sediment	**FOREGS**	**848**	**<0.15**	**Total (XRF)**	**5.06**
Floodplain sediment	**FOREGS**	**743**	**<2.0**	**Total (XRF)**	**3.92**

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

Gd in soil

The median Gd content is 4.24 mg kg^{-1} in subsoil and 3.85 mg kg^{-1} in topsoil; the range varies from <0.1 to 16 mg kg^{-1} in subsoil and from 0.20 to 36 mg kg^{-1} in topsoil. The average ratio topsoil/subsoil is 0.897.

Gadolinium in subsoil shows low values (<2.86 mg kg^{-1}) throughout central and northern Finland, the glacial drift area from Poland to the Netherlands, the Paris basin in France, central Hungary, southern Spain, and part of east Spain.

High Gd values in subsoil (>6.0 mg kg^{-1}) are located mainly in the crystalline basement of the Iberian Massif in northern Portugal and north-west Spain, in the central and eastern Pyrenees, the Massif Central in France, in the Italian and northern Greece alkaline magmatic provinces (Plant *et al*. 2005), in soil on karst of Slovenia and Croatia, in southern Hungary and Austria, the loess/palaeoplacer area of northern France to Germany, south-western Norway, and northern Sweden (Salpeteur *et al*. 2005). Point anomalies appear in western Greece, associated with terra rossa soil and phosphorite mineralisation.

In topsoil, the Gd pattern is very similar to that of subsoil. Values are generally lower in Scandinavia. There is a point anomaly in Gran Canaria in alkali basalt.

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

Gd in stream water

Gadolinium values in stream water range over two and a half orders of magnitude, from <0.002 µg l^{-1} to 0.97 µg l^{-1} (excluding an outlier of 4.32 µg l^{-1}), with a median value of 0.01 µg l^{-1}. Gadolinium data correlate most closely with the other lanthanides. See section on REE for a general discussion.

Lowest Gd values in stream water (<0.002

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

Highest Gd concentrations in stream water (>0.19 μg l^{-1}) are predominantly found in northern Denmark and southern Norway, Sweden and Finland. The areas of highest values are characterised by Precambrian Shield terrains (mostly intrusive and metamorphic rocks). Enhanced values (between 0.07 and 0.19 μg l^{-1}) also occur in northern Fennoscandia, eastern and northern Ireland, northern Scotland, in Caledonides, and in France (Brittany and Massif Central), characterised by Variscan terrains (intrusive and volcanic rocks). Highly anomalous Gd values in northern Germany are associated with high DOC values.

Gd in stream sediment

The median Gd content in stream sediment is 4.88 mg kg^{-1}, and the range varies from 0.20 to 90.5 mg kg^{-1}.

The Gd distribution map shows low stream sediment values (<3.46 mg kg^{-1}) in east and north Finland, in the northern European plain on glacial drift, in western Ireland, in parts of south, east and north Spain, in the western Alps and the northern Apennines, in north-easternmost Italy, coastal Croatia, western and southern Greece.

The two areas with the highest Gd values in stream sediment are the Variscan part of the Iberian Peninsula, *i.e.,* north Portugal, Galicia and the Sierra de Gredos in Old Castilia (Spain), and the Massif Central in France (Variscan granite), extending into the Poitou region to the north-west. High Gd (>7.12 mg kg^{-1}) also occurs in south-west Norway, north Sweden and adjacent Norway, parts of south and east Sweden, a point anomaly in northern Estonia (phosphate deposits), eastern Scotland, the Bohemian Massif, Albania, and south-eastern Austria.

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

Gd in floodplain sediment

Total Gd values in floodplain sediment, determined by ICP-MS, vary from 0.21 to 22.6 mg kg^{-1}, with a median of 3.92 mg kg^{-1}.

Low Gd values in floodplain sediment (<2.64 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, Lithuania and Latvia; northern Ireland on schist, gneiss, basalt and clastic rocks; the Ebro River basin, Cantabria, Pyrenees, and La Mancha 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 Gd values in floodplain sediment (>5.33 mg kg^{-1}) occur over the metamorphic and felsic igneous rocks and mineralised areas of the Precambrian Shield in northern, central and southernmost Sweden, south-west Finland, and almost the whole of Norway; on glacial outwash cover in Estonia, where there may be an association with phosphorite mineralisation. High Gd values in floodplain sediment occur in France over the Massif Central on felsic crystalline rocks; over northern Portugal and adjacent parts of Galicia, and Sierra Morena in southern Spain, where they are associated with felsic rocks and mineralisation; in central Swiss-Italian Alps with felsic intrusives and mineralisation, the Roman Alkaline Province; an extensive area with felsic rocks and mineralisation begins from the Harz Mountains, Erzgebirge, Bohemian Massif to Brno (Li deposits) in the Czech Republic and ends in north-eastern Austria on Tertiary and Quaternary sediments; southern Austria with felsic intrusives;

high Gd values in floodplain sediment of Slovenia and Croatia, except Dalmatia, are explained by possible concentration in karstic soil; in eastern Hungary the Gd anomalous values are probably due to mineralisation in the Apuseni Mountains in neighbouring Romania. The Gd point anomaly in the floodplain sediment of the Navia River in north-west Spain is related to felsic intrusives and mineralisation.

In conclusion, granite, granodiorite, shale, sandstone and schist lithologies show the highest Gd concentrations in floodplain sediment, and the glacial drift covered terrain (north-east Germany and Poland) the lowest; low Gd 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 Gd 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 Gd is similar to that of other HREEs (Dy, Er, Ho, Lu, Tb, Tm, Yb).