Yb – Ytterbium

Introduction

See section on Rare Earth Elements (REEs).

Table 75 compares the median concentrations of Yb in the FOREGS samples and in some reference datasets.

Table 75. Median concentrations of Yb in the FOREGS samples and in some reference data sets.

Ytterbium (Yb)	*Origin – Source*	*Number of samples*	*Size fraction mm*	*Extraction*	*Median mg kg^{-1}*
Crust[1)]	Upper continental	n.a.	n.a.	Total	1.96
Subsoil	**FOREGS**	**790**	**<2.0**	**Total (ICP-MS)**	**2.13**
Topsoil	**FOREGS**	**843**	**<2.0**	**Total (ICP-MS)**	**1.99**
Soil[2)]	World	n.a.	n.a.	Total	3.3
Water	**FOREGS**	**807**	**Filtered <0.45 µm**		**0.006 (µg l^{-1})**
Water[3)]	World	n.a.	n.a.		0.0036 (µg l^{-1})
Stream sediment	**FOREGS**	**848**	**<0.15**	**Total (XRF)**	**2.58**
Floodplain sediment	**FOREGS**	**743**	**<2.0**	**Total (XRF)**	**1.80**

[1)]Rudnick & Gao 2004, [2)]Koljonen 1992, [3)]Ivanov 1996.

Yb in soil

The median Yb content is 2.13 mg kg^{-1} in subsoil and 1.99 mg kg^{-1} in topsoil; the range varies from <0.05 to 7.37 mg kg^{-1} in subsoil and from 0.09 to 25 mg kg^{-1} in topsoil. The average ratio topsoil/subsoil is 0.944, which is similar to other HREEs (heavy rare earth elements.

The geochemical behaviour of Yb is most similar to that of the other heavy REEs (Gd, Tb, Dy, Ho, Er, Tm and Lu).

Ytterbium in subsoil shows low values (<1.43 mg kg^{-1}) throughout central Finland, the glacial drift area from Poland to the Netherlands, the Paris Basin in France, the western Alps and Rhône valley, central Hungary, central Portugal and southern Spain.

High Yb values in subsoil (>2.83 mg kg^{-1}) are located mainly in the crystalline basement of the Iberian Massif in northern Portugal and north-west Spain, in the Italian alkaline magmatic province, in the Massif Central, in residual 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 Yb anomalies in subsoil appear in western Greece, associated with *terra rossa* soil and phosphorite mineralisation, and in northern Ireland near the Mourne granite.

In topsoil, Yb is lower in Norway and Sweden, but elsewhere the pattern is similar to that of the subsoil.

Ytterbium in subsoil has a strong to very strong correlation with the other REEs. For more information, see the section on REEs.

Yb in stream water

Ytterbium values in stream water range over two and a half orders of magnitude from <0.002 µg l^{-1} to 0.41 µg l^{-1} (excluding an outlier of 1.79 µg l^{-1}), with a median value of 0.006 µg l^{-1}. About 20% of the data is below the analytical quantification limit. Ytterbium data correlate

most closely with the rare earths elements in general, but in particular with erbium and yttrium. See section on REEs for a general discussion.

Lowest Yb values in stream water (<0.002 μg l^{-1}) are predominantly found in eastern Spain, in south-eastern and north-eastern France, in southern Italy (including Sicily) and most of northern Italy, in western Slovenia, Hungary and western Austria, in north-eastern Germany, and throughout Albania and Greece. Most of the areas of lowest Yb values in stream water occur on Variscan and Alpine Orogen terrains (southern Europe), whereas other areas (mainly northern Germany) are related to the glacial drift.

Highest Yb concentrations in stream water (>0.09 μg l^{-1}) are predominantly found in northern Denmark, southernmost Norway and in southern Sweden and Finland. The areas of highest Yb values are on Precambrian terrains (mostly intrusive and metamorphic rocks). Enhanced values in stream water (>0.03 μg l^{-1}) also occur throughout central and southern Norway, in central and northern Sweden and Finland, eastern and northern Ireland, eastern Scotland, characterised by Fennoscandian and Irish-Scottish Caledonides, and in France (Brittany and Massif Central) by Variscan terrains (intrusive and volcanic rocks). In Northern Ireland, the anomalously high Yb values in stream water are associated with the Mourne granite. Highly anomalous Yb values in northern Germany are associated with high DOC values. The isolated stream water Y anomaly in southern Italy is related to Neapolitan alkaline volcanism.

Yb in stream sediment

The median Yb content in stream sediment is 2.48 mg kg^{-1}, and the range varies from 0.10 to 42.8 mg kg^{-1}.

The Yb stream sediment distribution map shows low values (< 1.78 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 north-east France, in the western Alps and the northern Apennines, in north-easternmost Italy, coastal Croatia, western and southern Greece.

The two areas with the highest anomalous Yb 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 Yb values in stream sediment (>3.57 mg kg^{-1}) also occur in most of Norway, north, south and east Sweden, a point anomaly in northern Estonia (phosphate deposits), eastern Scotland, the Bohemian Massif, with a point anomaly near the U deposit of Dolny Rozinka in the central Czech Republic, Albania, south-eastern Austria, and near the Mourne granite in northern Ireland.

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

Yb in floodplain sediment

Total Yb values in floodplain sediment, determined by ICP-MS, vary from 0.11 to 13.0 mg kg^{-1}, with a median of 1.80 mg kg^{-1}.

Low Yb values in floodplain sediment (<1.2 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, and northern Ireland on crystalline and clastic rocks; the Ebro River 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 Yb values in floodplain sediment (>2.58 mg kg^{-1}) occur over the felsic igneous and metamorphic rocks and mineralised areas of the Precambrian Shield of northern Sweden, northernmost and south-west Finland, and almost the whole of Norway (even on the amphibolite); on glacial outwash cover in Estonia, where there

may be a relation with the phosphorite mineralisation. High Yb values in floodplain sediment occur in France over the Massif Central on felsic crystalline rocks, and north part of the Paris Basin on mostly carbonate rocks; in central Portugal and Sierra Morena in southern Spain they are associated with felsic rocks; in central Swiss-Italian Alps with felsic intrusives and mineralisation, the Roman Alkaline Province and Corsica over granite and schist; in Germany from the Harz Mountains to the Erzgebirge and Bohemian Massif they are associated with felsic rocks and mineralisation; in the Czech Republic a small area south of Brno (Li deposits); eastern and southern Austria on Tertiary and Quaternary sediments; Slovenia and Croatia, except Dalmatia, explained by possible concentration in karstic soil; in eastern Hungary the Yb anomalous values are probably due to mineralisation in the Apuseni Mts in neighbouring Romania.

The highest Yb anomalous sites in floodplain sediment are in the mineralised areas of northern Sweden (13 mg kg^{-1}), and northern Norway (7.92 mg kg^{-1}), and in Finnmark (6.57 mg kg^{-1}) on gneiss of the Fennoscandian Shield.

Linear correlation coefficients between Yb and the other REEs are strong to very strong in floodplain sediment; in addition there is a strong positive correlation with Hf, Ta, Y, and a good correlation with Al_2O_3, Ga, K_2O, Rb, Ti, Fe, V, Nb, Th and Tl.

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