

Introduction

See section on Rare Earth Elements (REEs).
Table 65 compares the median concentrations

of Tb in the FOREGS samples and in some reference datasets.

Table 65. Median concentrations of Tb in the FOREGS samples and in some reference data sets.

Terbium (Tb)	Origin – Source	Number of samples	Size fraction mm	Extraction	Median mg kg⁻¹
Crust ¹⁾	Upper continental	n.a.	n.a.	Total	0.7
Subsoil	FOREGS	790	<2.0	Total (ICP-MS)	0.641
Topsoil	FOREGS	843	<2.0	Total (ICP-MS)	0.600
Soil ²⁾	World	n.a.	n.a.	Total	0.7
Water	FOREGS	807	Filtered <0.45 µm		0.002 (µg l⁻¹)
Water ²⁾	World	n.a.	n.a.		0.001 (µg l ⁻¹)
Stream sediment	FOREGS	848	<0.15	Total (XRF)	0.790
Floodplain sediment	FOREGS	743	<2.0	Total (XRF)	0.600

¹⁾Rudnick & Gao 2004, ²⁾Ivanov 1996.

Tb in soil

The median Tb content is 0.64 mg kg⁻¹ in subsoil and 0.60 mg kg⁻¹ in topsoil; the range varies from <0.02 to 2.36 mg kg⁻¹ in subsoil and from 0.03 to 7.01 mg kg⁻¹ in topsoil. The average ratio topsoil/subsoil is 0.910.

Terbium in subsoil shows low values (<0.45 mg kg⁻¹) throughout central and northern Finland, the glacial drift area from Poland to the Netherlands, the Paris Basin in France, central Hungary, central Portugal, southern Spain, and part of east Spain.

High Tb values in subsoil (>0.90 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, the alkaline magmatic province of Italy and central Macedonia

in Greece (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 Tb patterns are very similar to those of subsoil. Terbium values are generally lower in Scandinavia. There is a point anomaly in Gran Canaria in alkali basalt.

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

Tb in stream water

Terbium values in stream water range over almost two orders of magnitude, from <0.002 µg l⁻¹ to 0.13 µg l⁻¹ (excluding an outlier of 0.59 µg l⁻¹), with a median value of 0.002 µg l⁻¹.

Almost 50% of the data are less than the analytical limit of quantification, which precludes a good interpretation of the distribution. Terbium data correlate with the rare earth elements in

general for the highest values in Fennoscandia, but not for the distribution of the lowest values in the rest of Europe.

Lowest Tb values in stream water ($<0.002 \mu\text{g l}^{-1}$) are uniformly found in all of southern and central Europe, in western Ireland, north-western and south-eastern England, south-western Norway, in central Sweden, northern Finland and the Baltic states. Highest Tb ($>0.03 \mu\text{g l}^{-1}$) are found in southern Norway and mostly in southern Sweden and southern Finland, characterised by

Precambrian terrains (mostly intrusive and metamorphic rocks).

Enhanced values in stream water ($>0.01 \mu\text{g l}^{-1}$) also occur in central and northern Sweden and in southern Finland over Precambrian and Caledonide terrains, in southern Ireland and in northern Scotland characterised by Caledonides, and in France (Brittany) by Variscan terrains. Highly anomalous Tb values in northern Germany are associated with high DOC values.

Tb in stream sediment

The median Tb content in stream sediment is 0.77 mg kg^{-1} , and the range varies from 0.02 to 14.5 mg kg^{-1} .

The Tb stream sediment distribution map shows low values ($<0.55 \text{ mg kg}^{-1}$) in central and east 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 north-west and central Greece.

High Tb values in stream sediment (>1.09

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, and Albania.

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

Tb in floodplain sediment

Total Tb values in floodplain sediment, determined by ICP-MS, vary from 0.02 to 3.26 mg kg^{-1} , with a median of 0.6 mg kg^{-1} .

Low Tb values in floodplain sediment ($<0.4 \text{ mg kg}^{-1}$) 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 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 Tb values in floodplain sediment ($>0.82 \text{ mg kg}^{-1}$) 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 also be an association with phosphorite mineralisation. In Wales, the high Tb levels are ascribed to felsic intrusives and mineralisation. High Tb 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 northern Portugal and adjacent Spain are ascribed to felsic rocks and mineralisation; 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 Harz Mountains to the Erzgebirge, Bohemian Massif to Brno (Li deposits) in the Czech Republic and north-eastern Austria on Tertiary and Quaternary sediments. There is an extensive areas with high Tb contents in

floodplain sediment beginning from the Austrian-Italian border and into Slovenia, Croatia (except Dalmatia) and most of Hungary over mainly Tertiary and Quaternary sediments; the high Tb levels in southern Austria are associated with felsic intrusives and mineralisation, and in Slovenia and Croatia, except Dalmatia, they are explained by possible concentration in karstic soil; whereas in eastern Hungary the Tb anomalous values are probably due to sediment derived from the mineralisation in the Apuseni Mountains in neighbouring Romania.

There are three Tb point anomalies in floodplain sediment; in northern Norway ($1.6 \text{ mg kg}^{-1} \text{ Tb}$) it is associated with granulite and metamorphic basement rocks, and in Poland, the one in the north-east ($1.5 \text{ mg kg}^{-1} \text{ Tb}$) is ascribed to sediments derived possibly from phosphorite mineralisation in the Soviet Union, and the second

in northern Poland ($1.07 - 1.6 \text{ mg kg}^{-1} \text{ Tb}$) is in area with halite deposits.

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