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The Lanthanides and Yttrium in Minerals of the Apatite Group: A Review

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Abstract

More than 1000 analyses have been tabulated of the distribution of the lanthanides and yttrium in minerals of the apatite group, recalculated to atomic percentages. Average compositions have been calculated for apatites from 14 types of rocks. These show a progressive change of composition from apatites of granitic pegmatites, highest in the heavy lanthanides and yttrium, to those from alkalic pegmatites, highest in the light lanthanides and lowest in yttrium. This progression is clearly shown in plots of Σ (= at% La+Ce+Pr) vs the ratio La/Nd and of Σ vs the ratio 100Y/(Y+Ln), where Ln is the sum of the lanthanides.

Apatites of sedimentary phosphorites occupy a special position, being relatively depleted in Ce and relatively enriched in yttrium and the heavy lanthanides, consequences of deposition from sea water.

Apatites associated with iron ores are close in composition to apatites of carbonatites, alkalic ultramafic, and ultramafic rocks, being enriched in the light lanthanides and depleted in the heavy lanthanides. Their compositions do not support the hypothesis of Parak that the Kiruna-type ores are of sedimentary origin.

Table 9 and Figures 1-3 show the dependence of lanthanide distribution on the nature of the host rock. Although a given analysis of the lanthanides does not unequivocally permit certain identification of the host rock, it can indicate a choice of highly probable host rocks.

Introduction

In 1969, we pointed out (Fleischer and Altschuler, 1969) that the lanthanides in apatite vary widely in composition, with marked differences in the average compositions of apatites from granitic rocks, mafic rocks, and alkalic rocks and carbonatites. The conclusions then drawn were based on a total of 118 analyses.

During the intervening years, many new analyses have appeared (especially in the U.S.S.R.), and it seemed worthwhile to re-examine the available data, now sufficient to permit averages to be calculated for more types of rocks. The analyses, recalculated to atomic percent of lanthanides, are given in the accompanying tables: Table 1, apatite (939 analyses), Table 2, a selection of phosphorite analyses (98), Table 3, britholite and britholite-(Y)(83), and Table 4, miscellaneous members of the apatite group (5). In each of these tables, the analyses are listed in order of increasing Σ (= at.% La+Ce+Pr).

The apatite group consists of hexagonal or monoclinic phosphates, arsenates, and vanadates of general formula $A_5(XO_4)_3(F,Cl,OH)$, where A = Ba, Ca, Ce, K, Na, Pb, Sr, Y; X = As, C, P, S, Si, V. Table 1, analyses of apatite includes 939 analyses of fluorapatite, $Ca_5(PO_4)_3F$ (by far the most common), chlorapatite, $Ca_5(PO_4)_3Cl$, and hydroxylapatite, $Ca_5(PO_4)_3(OH)$. Table 2 gives 98 selected analyses of phosphorites, which are rocks composed mainly of carbonate-fluorapatite, $Ca_5(PO_4,CO_3)_3F$, and carbonate-hydroxylapatite, $Ca_5(PO_4,CO_3)(OH)$. Table 3 gives 83 analyses of the series britholite-britholite-(Y), $(Ce,Ca)_5(SiO_4,PO_4)_3(OH,F)$-$(Y,Ca)_5(SiO_4,PO_4)_3(OH,F)$. Table 4 gives the few available analyses of belovite, $(Sr,Ce,Na,Ca)_5(PO_4)_3(OH)$, pyromorphite, $Pb_5(PO_4)_3Cl$, and of tritomite-(Y) ("spencite"), $(Y,Ca,La,Fe^{+2})_5(Si,B,Al)_3O_{12}(OH,F)$.

It is extremely difficult to assess the precision and accuracy of the analyses and therefore of the averages derived. Few comparisons are available of analyses by the seven different methods used; X-ray fluorescence, optical emission spectrography, and paper chromatography were the methods used in most analyses. Furthermore, few authors give any details as to the methods used to separate and purify their minerals and still fewer give any information on the purity of the mineral separates analyzed. The presence of impurities is probably not a serious problem with minerals of high rare-earth content, such as britholite, but might cause serious errors in minerals of low rare-earth content, such as apatite from granitic rocks, if the impurities were minerals high in rare earths, such as monazite or xenotime.

1. The lanthanides and yttrium in apatite

Table 1 gives recalculated analyses of 939 samples. Table 5 gives average compositions for apatites from 14 types of host rocks, based on a total of 654 analyses; omitted from these averages are those of apatites from other types of rocks and about 60 analyses that were incomplete (omission of La, Ce, or Nd).

In addition, we rejected a few analyses that showed compositions extremely anomalous for the type of host rocks. Such singular distributions may provisionally be ascribed to analytical error in the absence of explanations in the source literature. Table 7 lists the entire range of composition for apatites from these 14 types of rocks.

The averages of Table 5 are plotted in Figures 1 and 2, except those in Column 14, Gneisses and Migmatites, for which the values are very close to those of Column 2, Granites. These plots have been shown empirically (Murata et al. 1953; Fleischer, 1965) to be useful in correlations of the variations of lanthanide composition with provenance. These two figures for apatites show continuous and reasonably smooth variation of the averages for eleven types of igneous rocks, with the ratio La/Nd increasing with increase of Σ, whereas the ratio 100Y/(Y+Ln) decreases with increase of Σ. In contrast, the average for apatites of sedimentary phosphorites falls well off both curves, as the consequence of their depletion in cerium and their enhancement in yttrium and heavy lanthanides, as discussed below.

It is evident from the wide range of compositions shown in Table 5 that attempting to give an average distribution of lanthanides and yttrium in apatite, without specifying the type of host rock, cannot give meaningful numbers, unless estimates are also given of the relative abundances of the various rock types.

Recent estimates for apatites from various rock types are assembled in Table 10. No. 7, by Mineev (1968), for "apatite" is intermediate between our averages for apatites of granite and alkalic rocks, nearer to the granitic; Mineev does not specify how the average was calculated. Of the averages by Lyakhovich and Balanova (1971), No. 3 of Table 10 (gneisses and migmatites) is not far from our Column 14 of Table 5; No. 5 of Table 10 ("basic rocks") is not far from our Column 5, "gabbro" of Table 5; No. 8 for "nepheline syenite" (Tikhonenkova, 1977) and Nos. 9 and 10 (Kravchenko et al., 1979) of Table 10, for "alkalic rocks" and "ijolite-urtite" are closer to our Column 13, Table 5, "alkalic pegmatites", than to Column 12, Table 5, "alkalic rocks". No. 4 of Table 10 (av. phosphatic bone) is reasonably close to the purified phosphorite, No. 3 of Table 5.

The averages in Table 5, plotted in Figs. 1 and 2, should be used with caution. As shown in Table 7, the range of composition within a single group may be very wide, with considerable overlaps from group to group, so that calculation of a single analysis does not always place it unequivocally in a single group. Fig. 3 shows plots for apatites of granitic pegmatites, granites, and granodiorites. The overlapping is extensive, and where it exists, a given analysis cannot be placed with certainty.

The overlapping may be due in part to analytical error, but is probably also due in part to uncertainties of terminology. For example, apatite from an alkalic granite (such as a riebeckite granite) is likely to have a higher value of Σ and a lower ratio of Y/(Y+Ln) than apatite from a muscovite granite, but both are averaged in Table 5 in Column 2, Granite.

As can readily be seen from Table 9, however, there is a high probability that an analysis can be assigned with a considerable degree of assurance from its value of Σ. Thus, the probability that an apatite with Σ 70.0 or greater does <u>not</u> come from granite pegmatite, granite, or gneiss is reasonably high. Similarly, an apatite with Σ 65.0 or less is almost certainly not from alkalic or ultramafic rocks.

Fig. 1. Σ vs ratio La/Nd for Apatite and Britholite
(Nos. of averages are from tables 5 and 7)

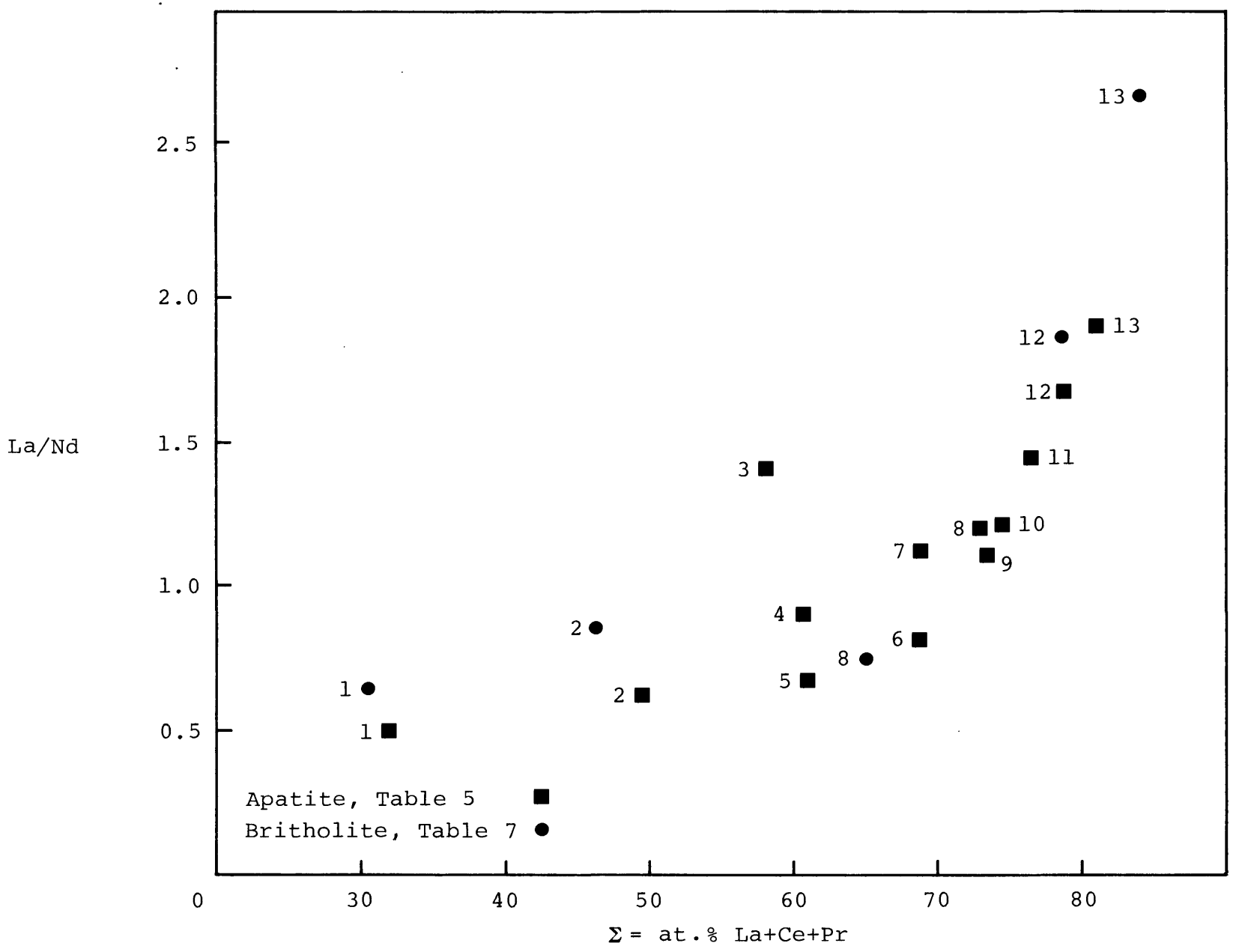
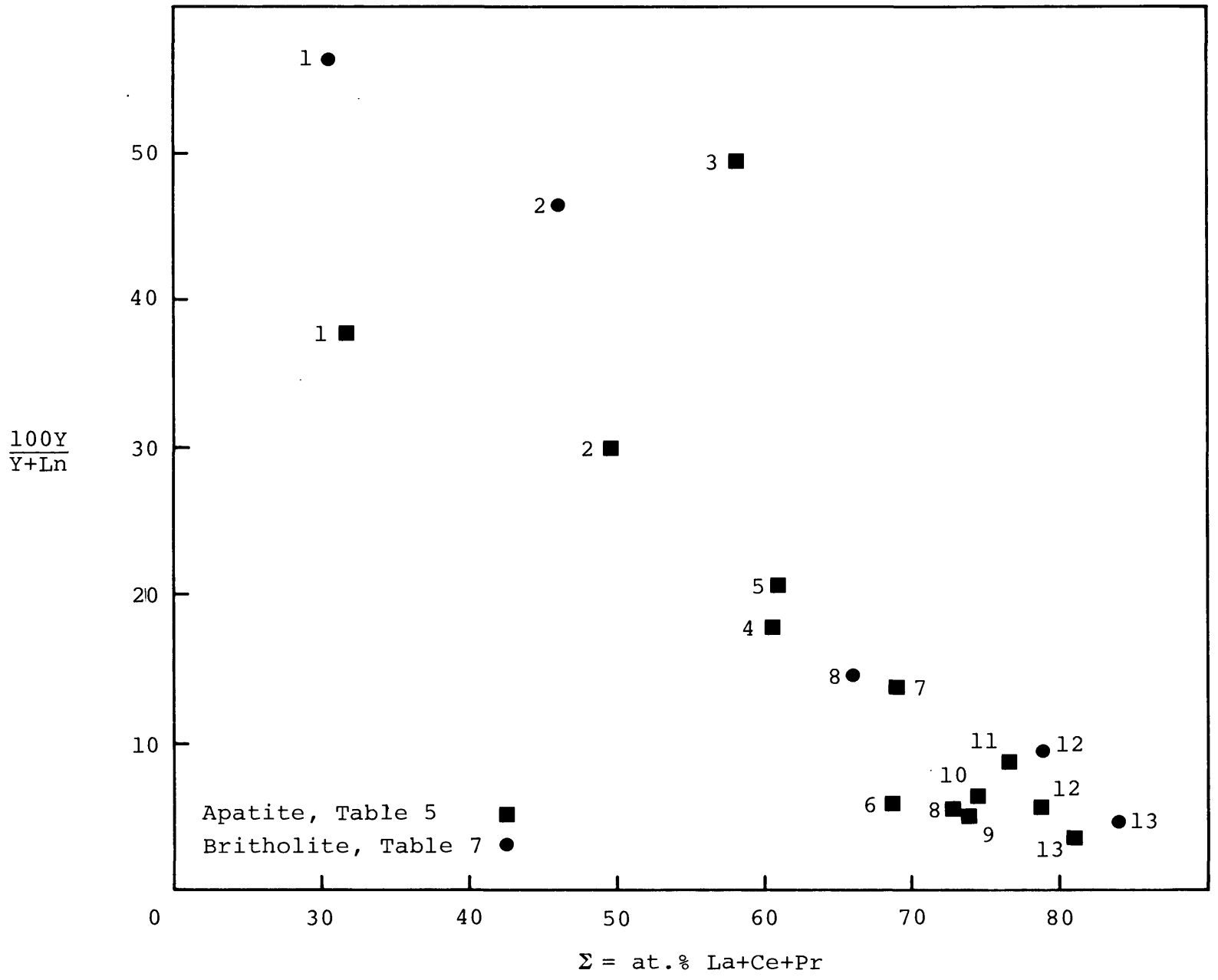


Fig. 2 Σ vs 100Y/(Y+Ln) for Apatite and Britholite
(Nos. of averages are from tables 5 and 7)



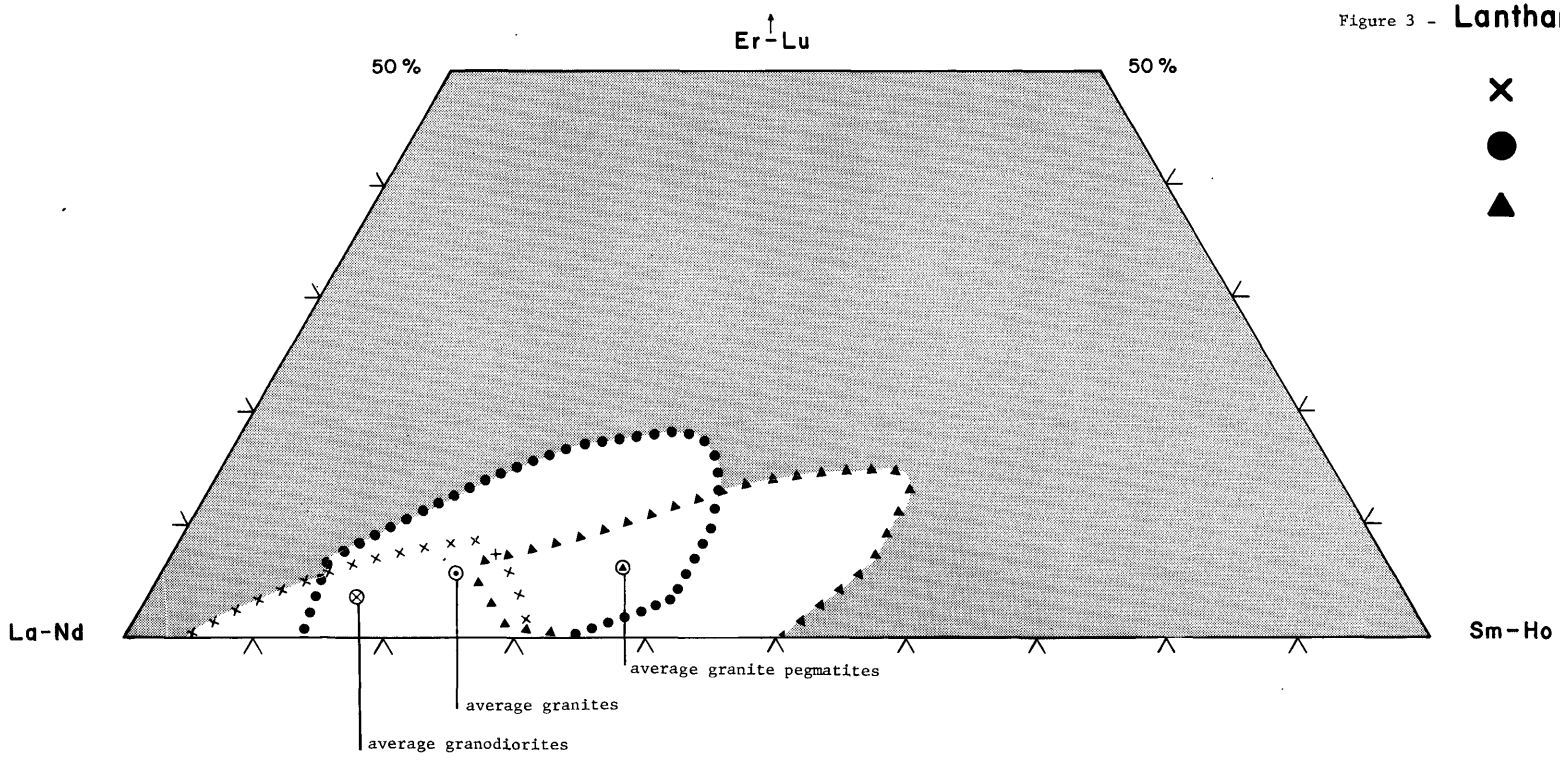


Figure 3 - **Lanthanides in Apatite**

× granodiorites

● granites

▲ granite pegmatites

2. Rare earths in phosphorites

The analyses in Table 2 differ markedly from those of Tables 1, 3, and 4 in that they are analyses of rocks, not of separated minerals. They have been selected as representative of the large number of analyses of phosphorite rocks and of detrital bony material; many more analyses will be found in the references given here, and additional ones are in Blokh (1961), Blokh and Kochenov (1964), Kabanova and Plotnikova (1973), Kochenov and Zinov'ev (1960), and Loginova et al. (1977).

Of the 99 analyses in Table 2, only 43 have P_2O_5 contents given and only 22 of these contained more than 18.5% P_2O_5, therefore consisting of more than 50% marine apatite. Thus, 77 of the analyses may be phosphatic rocks rather than phosphorites; they may be calcareous, dolomitic, cherty, arenaceous, or argillaceous. They may also be rich or poor in organic matter, pyrite, iron oxides, or glauconite. The apatite mineral of these rocks is richer in rare earths than shales, clays, dolomites, and limestones, and is certainly the principal carrier of the rare earths in these rocks, yet appreciable percentages of the lanthanides probably are not in the phosphate mineral.

We have, therefore, not attempted to average the analyses given in Table 2, but have used the average (Altschuler, 1980) of 13 purified marine apatites, separated from phosphorites. Comparison of this average (no. 3 in Table 5) with the averages there given for apatites from various types of igneous rocks shows that it differs from them in a marked deficiency in cerium. As can be seen in Tables 1 and 5, cerium exceeds lanthanum in nearly all apatites, excepting a few from alkalic pegmatites, and the ratio Ce/La in most igneous apatites is 2-3. In sea water from deep off-shore provenance, this relationship is reversed. Altschuler et al. (1967) suggested that the cerium deficiency of phosphorites is a signature of marine origin, and later analyses, both of sea water and of phosphorites, have confirmed their conclusion.

In addition, marine apatites and phosphorites differ from most igneous and metamorphic apatites by a higher proportion of yttrium, as shown by the ratios 100Y/(Y+Ln) of Table 5. The analyses of sea water by Høgdahl (1967) show marked enrichment in yttrium, indicating, just as the low cerium content of phosphorites does, their marine origin (Altschuler, 1980).

Although plots of phosphorite analyses are in accord with these conclusions, they show considerable scatter, presumably because of the contributions of admixed minerals present in the phosphorites. Although the cerium deficiency of marine apatite is clearly established, we need more analyses of beneficiated apatite to be certain that the relative enrichment of yttrium is also characteristic of marine apatite in general.

Rare Earths in Apatites from Iron Ore

The data summarized in Table 5 for rare earths in apatites of iron ores are of particular interest with respect to the controversy as to the origin of the so-called "Kiruna-type" of magnetite-apatite ores.

Parak (1973, 1975a, 1975b) states that these ores are not of intrusive-magmatic origin, but were formed in a volcanic-marine environment. His arguments have been challenged as to geological interpretations, most recently by Frietsch (1978), but Parak's geochemical arguments have been discussed only in part.

Parak (1973) analyzed 19 apatites from Kiruna and similar deposits for lanthanides. He concluded: "The rare earth metal content is between that of the Kola Peninsula (U.S.S.R.) apatites and the apatites in granite-pegmatites. The rare earth metal content in sedimentary and metamorphic rocks is commonly about the same as in the apatite-iron ore from Northern Sweden. The distribution of the rare earths suggests that the apatite-iron ores of Lappland are not of magmatic origin."

Before discussing these conclusions by Parak, it is worthwhile to examine averages of analyses by various investigators, including Parak, of the distribution of lanthanides in apatites from iron ores of various kinds. These have been assembled in Table 8. It is evident that the averages in Table 8 are remarkably consistent and do not vary much from the general average given in Column 10 of Table 5 and Column 10 of Table 8.

The first sentence of the quotation from Parak is correct, but since it states only that the composition of the rare earths of Kiruna ore apatites lies between those of Column 1 and Columns 12-13 of Table 5, i.e. of the extremes of the known range, it is not very informative. Much more to the point is that the average composition of the lanthanides in apatite from iron ores is far over towards enrichment in light lanthanides (high Σ), close to the averages for apatites from kimberlites, carbonatites, and alkalic ultramafic rocks.

The second sentence quoted above from Parak compares the rare earths of apatite from iron ores with the rare earths of sedimentary and metamorphic rocks. The comparison is meaningless - distribution in a mineral vs. distribution in rocks. Comparison of Column 10, Table 5 (apatite, iron ores) with Column 3, Table 5 (apatite of sedimentary phosphorites) shows that they differ markedly in contents of light lanthanides and yttrium.

Parak's own analyses appear to indicate a close resemblance of apatites from Kiruna-type ores to apatites associated with ultramafic and alkalic ultramafic rocks and carbonatites, the main difference being the higher yttrium content in the Kiruna-type ores. It will be noted from the data in Table 8 that the distribution of lanthanides in magnetite-apatite deposits does not vary as widely as one might expect. The Lebyazhin and Evstyunin deposits (columns 6 and 7) are at the contact of syenites with trachybasalts. The apatite and magnetite of the Aboyan deposit, Armenian S.S.R. (column 8) are stated to fill fissures in and to replace andesite-dacites. It is somewhat surprising that apatite from these silica-rich environments should show high contents of light lanthanides, contrary to the trend shown in Table 5 for granitic rocks and pegmatites.

It may be noted that britholite-apatite (SiO_2 12.9, P_2O_5 17.3%) has been reported from a magnetite deposit of the Adirondacks (Lindberg and Ingram, 1963).

Rare Earths in the series Britholite-Britholite-(Y)

Recalculated analyses of the series Britholite-Britholite-(Y) are given in Table 3 and averages for five types of rocks are given in Table 10 and are shown in Figures 1 and 2. In general, the trends of composition resemble those of apatite, but the data on other types of rocks are too sparse to permit calculation of averages for them.

Explanation of Tables

The compositions of the rare earths in the tables are given in atomic percentages of the lanthanides, excluding yttrium. This is done because of the many different ways analyses are stated (for example, Ce, Ce_2O_3, CeO_2) and because yttrium was not determined in many analyses.

The entry $\frac{Y}{(Y+Ln)} \times 100$ is the ratio of the atomic percentage of yttrium to that of Y + those of the lanthanides (Ln). It is therefore not directly comparable to the atomic percentages given for the lanthanides and so is given in parentheses. Σ is the sum of the atomic percentages of La+Ce+Pr.

Abbreviations used for methods of analysis: AA, atomic absorption; CH, paper chromatography; EP, electron microprobe; MS, mass spectrometry; NA, neutron activation; OS, optical emission spectrography; XF, X-ray fluorescence.

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Table 1. Rare Earths in Apatite, atomic percent

No.	1	2	3	4	5	6	7	8	9	10
La	1.4	1.5	1.7	2.3	2.6	2.6	3.3	4.0	3.6	4.8
Ce	4.5	5.0	5.5	7.2	9.0	8.7	9.9	11.4	11.1	11.6
Pr	1.3	2.9	3.2	2.6	2.5	2.9	2.0	–	1.4	3.0
Nd	4.4	22.0	24.6	17.0	18.0	6.5	7.8	18.6	14.3	22.1
Sm	5.0	8.5	6.1	5.6	8.0	3.8	3.9	–	16.2	13.0
Eu	0.8	a	a	a	a	0.5	–	–	–	a
Gd	14.1	15.6[a]	9.1[a]	13.8[a]	14.2[a]	7.0	8.8	14.4	28.6	19.7[a]
Tb	2.4	b	b	0.8	1.6	1.3	2.9	–	4.6	0.9
Dy	21.6	19.1	21.4	5.2	10.3	15.2	19.2	13.5	13.1	5.6
Ho	6.2	6.3	7.1	2.4	4.7	3.5	4.9	26.5	2.2	2.9
Er	19.1	9.2	10.2	7.4	14.3	14.8	19.3	6.2	2.9	8.7
Tm	2.9	–	–	2.8	5.4	2.5	–	1.2	0.6	0.8
Yb	14.1	9.9	11.1	5.0	9.4	24.3	16.0	4.2	1.0	6.9
Lu	2.2	–	–	–	–	6.4	2.0	–	0.4	–
Y/(Y+Ln)x100	(61.8)	(28.0)[b]	(30.3)[b]	(51.4)	(65.2)	(62.4)	(56.5)	(45.9)	(47.0)	(57.6)
Method	XF	CH	CH	CH	CH	XF	–	XF	CH	CH
Σ = La+Ce+Pr	7.2	9.4	10.4	12.1	14.1	14.2	15.2	15.4	16.1	19.4
La-Nd	11.6	31.4	35.0	29.1	32.1	20.7	23.0	37.0	30.4	41.5
Sm-Ho	50.1	49.5	43.7	45.6	38.8	31.3	39.7	54.4	64.7	42.1
Er-Lu	38.3	19.1	21.3	25.3	29.1	48.0	37.3	11.6	4.9	16.4
RE_2O_3, %	0.22	0.03	0.12	0.72	0.23	0.78	0.65	0.53	0.81	0.21
La/Nd	0.31	0.07	0.07	0.14	0.14	0.40	0.42	0.21	0.25	0.22

(a) Eu+Gd calcd. as Gd
(b) Y+Tb calcd. as Y

(1) Semenov (1963), granite pegmatite, central Urals; (2) Bel'kov and Batieva (1971), granodiorite, Umba River, Kola peninsula, U.S.S.R.; (3) Bel'kov (1979), granodiorite, Umba River; (4-5) Orsa et al. (1967), Middle Dnepr region, U.S.S.R.; (4) biotite-plagioclase gneiss; (5) granite; (6) Semenov (1963), granite pegmatite, Kaita Tundra, Karelia; (7) Tugarinov et al. (1969), metamorphosed Precambrian rock, Krivoi Rog, U.S.S.R.; (8) Yurgina et al. (1975), plagioclase pegmatite, Sludyanya, Kola-Karelia region; (9) Leonova and Elina (1969), muscovite pegmatite, White Sea area, U.S.S.R.; (10) Orsa et al. (1967), biotite-plagioclase gneiss, Middle Dnepr Region.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No —	11	12	13	14	15	16	17	18	19	20
La	2.3	3.1	3.6	3.7	9.2	5.2	7.2	5.6	5.3	5.5
Ce	14.4	14.0	13.4	16.5	10.2	13.8	12.1	11.7	15.0	12.2
Pr	2.9	2.7	2.8	-	1.1	1.9	2.4	4.6	1.9	4.7
Nd	10.8	13.2	16.0	19.3	15.1	14.5	10.0	7.2	8.6	7.1
Sm	7.1	7.5	9.5	15.5	15.8	12.2	4.8	24.5	2.5	24.3
Eu	0.5	0.7	0.9	-	-	-	-	0.7	-	0.7
Gd	11.0	13.8	13.9	14.0	15.3	15.6	9.3	26.2	7.9	26.0
Tb	1.6	1.3	5.7	-	3.4	3.9	3.1	3.9	-	3.9
Dy	16.2	11.9	13.0	12.8	12.9	13.5	22.2	9.3	14.5	9.2
Ho	3.1	1.1	3.4	2.6	4.9	4.1	4.9	1.8	3.9	1.7
Er	12.9	9.9	9.2	8.8	6.0	5.3	12.2	1.9	17.1	2.0
Tm	2.4	2.0	1.5	1.3	1.6	1.5	-	0.8	-	0.9
Yb	12.0	16.0	6.0	5.5	4.5	5.3	11.8	1.2	17.2	1.2
Lu	2.8	2.8	1.1	-	—	3.2	-	0.6	6.1	0.6
Y/(Y+Ln)x100	-	-	(58.7)	(56.4)	(33.0)	(42.0)	(71.6)	-	(60.6)	(34.4)
Method	XF	XF	-	XF	CH	CH	-	XF	-	XF
Σ = La+Ce+Pr	19.6	19.8	19.8	20.2	20.5	20.9	21.7	21.9	22.2	22.4
La-Nd	30.4	33.0	35.8	39.5	35.6	35.4	31.7	29.1	30.8	29.5
Sm-Ho	39.5	36.3	46.4	44.9	52.3	49.3	44.3	66.4	28.8	65.8
Er-Lu	30.1	30.7	17.8	15.6	12.1	15.3	24.0	4.5	40.4	4.7
RE_2O_3	0.80	0.73	0.63	0.60	0.28	0.61	0.81	-	0.17	1.83
La/Nd	0.22	0.24	0.23	0.19	0.61	0.36	0.72	0.78	0.62	0.77

(11-12) Ganzeev et al. (1966), biotite-gneiss, Vishnevye Mts., U.S.S.R.; (12) biotite migmatite, Vishnevye Mts.; (13) Batieva (1976), alkalic granite, Kola Peninsula; (14) Yurgina et al. (1975), quartz-muscovite rock, Sludyanya, Kola-Karelia region; (15-16) Leonova and Elina (1969), muscovite pegmatite, Chernaya Salma, White Sea region, U.S.S.R.; (17) Sinkova and Turanskaya (1968), metamorphosed Precambrian rocks, Krivoi Rog, U.S.S.R.; (18) Semenov and Barinskii (1958), granite pegmatite, Elovka, Transbaikal; (19) Tugarinov et al. (1969), metamorphosed Precambrian rocks, Krivoi Rog; (20) Kornetova and Vasil'eva (1961), albitized granite pegmatite, same as (18)(?)

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.	21	22	23	24	25	26	27	28	29	30
La	3.3	3.9	4.5	5.3	5.9	5.4	7.7	10.6	3.2	3.7
Ce	15.9	14.8	15.4	14.8	11.8	14.6	14.1	11.7	21.8	20.5
Pr	3.2	3.8	3.2	3.2	5.6	3.4	2.2	2.6	–	1.0
Nd	28.8	20.4	18.1	13.2	7.9	12.9	9.2	13.5	21.9	22.5
Sm	10.3	10.4	10.0	6.1	25.6	7.3	4.5	15.7	8.8	11.5
Eu	–	3.0	4.1	–	a	–	–	–	–	a
Gd	28.2	9.0	10.6	11.3	19.6[a]	11.2	10.9	17.5	22.7	17.1[a]
Tb	b	2.9	3.5	2.9	c	3.0	3.7	2.2	–	1.1
Dy	7.2	14.5	15.3	19.7	c	20.5	21.9	13.6	13.0	7.4
Ho	0.8	3.6	4.6	3.0	5.9	3.6	4.0	3.6	1.9	1.9
Er	2.3	5.7	4.8	9.6	5.9	10.0	15.7	4.9	4.1	5.7
Tm	–	1.3	1.2	–	–	–	–	–	0.8	0.1
Yb	–	5.0	3.1	9.2	11.8[d]	8.1	6.1	4.1	1.8	7.5
Lu	–	1.7	1.6	1.7	d	–	–	–	–	–
Y/(Y+Ln)x100	(56.0)[b]	(52.6)	(50.3)	(58.3)	(45.8)[c]	(59.4)	(54.9)	(30.0)	(57.5)	(60.4)
Method	CH	XF	XF	–	CH	–	–	CH	XF	CH
Σ = La+Ce+Pr	22.4	22.5	23.1	23.3	23.3	23.4	24.0	24.9	25.0	25.2
La-Nd	51.2	42.9	41.2	36.5	31.2	36.3	33.2	38.4	46.9	47.7
Sm-Ho	46.5	43.4	48.1	43.0	51.1	45.6	45.0	52.6	46.4	39.0
Er-Lu	2.3	13.7	10.7	20.5	17.7	18.1	21.8	9.0	6.7	13.3
RE_2O_3	0.20	0.39	0.24	0.72	0.24	0.76	0.66	0.77	0.62	0.28
La/Nd	0.12	0.19	0.25	0.40	0.75	0.42	0.85	0.78	0.15	0.17

(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y
(d) Yb+Lu calcd. as Yb

(21) Afanas'ev et al. (1976), garnet rock, Mahropidzh River, Caucasus; (22-23) Lee et al. (1973); (22) biotite schist, Gilpin Co., Colo; (23) metamorphic rock, White Pine Co., Nev.; (24) Tugarinov et al. (1969), metamorphosed Precambrian rock, Krivoi Rog, U.S.S.R.; (25) Ploshko and Knyazeva (1965), plagiogranite gneiss, Caucasus; (26-27) same as (24); (28) Leonova and Elina (1969), muscovite pegmatite, White Sea region, U.S.S.R.; (29) Yurgina et al. (1975), plagioclase pegmatite, Sludyanya, Kola-Karelia region; (30) Orsa et al. (1967), plagiogranite, Middle Dnepr region, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.	31	32	33	34	35	36	37	38	39	40
La	6.8	5.3	7.6	2.8	5.4	4.8	6.6	5.2	3.6	4.7
Ce	16.0	16.8	16.2	20.9	21.0	21.8	18.3	18.4	20.3	20.1
Pr	2.7	3.7	2.0	2.2	–	–	2.0	3.9	3.8	3.1
Nd	6.3	19.9	18.7	19.9	19.9	19.4	31.0	20.6	18.2	17.6
Sm	10.2	11.2	11.7	7.8	13.6	12.5	7.7	10.6	9.6	11.1
Eu	–	–	a	a	–	–	a	2.3	a	–
Gd	17.3	20.2	12.5[a]	9.6[a]	14.9	16.3	11.8[a]	9.3	9.5[a]	10.3
Tb	3.2	2.9	b	b	–	–	b	2.6	b	3.6
Dy	17.7	5.2	11.1	13.3	11.4	16.7	13.6	11.4	13.7	11.8
Ho	5.5	1.7	4.5	2.1	2.5	1.8	2.4	3.8	1.2	3.1
Er	10.3	4.9	6.3	7.6	5.6	4.1	5.6	4.9	8.3	6.5
Tm	–	3.8	2.0	2.8	0.8	0.7	–	1.3	1.2	3.0
Yb	4.0	4.4	7.4	6.9	4.9	1.9	1.0	4.0	9.4	3.6
Lu	–	–	–	4.1	–	–	–	1.7	1.2	1.5
Y/(Y+Ln)x100	(44.0)	(30.0)	(41.5)[b]	(59.7)[b]	(51.3)	(48.2)	(36.4)[b]	(54.4)	(60.8)[b]	(44.0)
Method	CH	CH	CH	CH	XF	XF	CH	XF	CH	CH
Σ = La+Ce+Pr	25.5	25.8	25.8	25.9	26.4	26.6	26.9	27.5	27.7	27.9
La-Nd	31.8	45.7	44.5	45.8	46.3	46.0	57.9	48.1	45.9	45.5
Sm-Ho	53.9	41.2	39.8	32.8	42.4	47.3	35.5	40.0	34.0	39.9
Er-Lu	14.3	13.1	15.7	21.4	11.3	6.7	6.6	11.9	20.1	14.6
RE_2O_3	0.06	0.21	0.32	0.67*	0.94	0.72	0.08	0.88	0.53*	0.47
La/Nd	1.07	0.27	0.41	0.14	0.27	0.25	0.21	0.25	0.20	0.27

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(31-32) Leonova and Elina (1969), muscovite pegmatites, White Sea region; (33) Belkov and Batieva (1971), granodiorite, Voron'ya River, Kola Peninsula; (34) Chashchukhina (1975), two-mica granite, Aduisk massif, Murzinsk, U.S.S.R.; (35-36) Yurgina et al. (1975), Sludyana, Kola-Karelia region; (35) contact of plagioclase-microcline pegmatite; (36) plagioclase pegmatite; (37) Belkov and Batieva (1971), two-mica granite, Aduisk massif; (38) Lee et al. (1973), xenolith, White Pine Co., Nev.; (39) same as (34); (40) Leonova and Elina (1969), muscovite pegmatite, White Sea region.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	41	42	43	44	45	46	47	48	49	50
La	6.0	7.8	7.6	9.0	10.0	5.0	4.7	2.1	5.3	5.7
Ce	19.5	17.1	18.0	19.4	16.5	22.9	22.4	21.2	21.0	20.0
Pr	2.5	3.2	2.7	–	2.0	0.9	2.1	6.2	3.3	4.0
Nd	16.8	15.1	21.5	19.7	21.7	20.1	14.5	19.2	18.9	16.7
Sm	4.7	7.2	9.1	14.4	13.9	7.5	7.0	9.2	8.3	7.2
Eu	a	–	–	–	–	a	–	a	a	0.7
Gd	14.1[a]	11.7	13.2	15.3	16.7	11.4[a]	6.7	10.0[a]	14.4[a]	11.2
Tb	b	–	1.7	–	3.0	b	–	b	b	1.3
Dy	15.3	16.1	13.4	11.5	5.1	14.8	20.5	18.1	12.4	11.4
Ho	1.2	4.6	1.9	1.3	1.3	0.8	16.1	2.0	1.0	1.9
Er	9.4	10.4	4.5	5.4	6.6	9.1	–	3.9	7.2	8.4
Tm	1.2	–	1.2	3.1	0.5	1.6	–	–	1.0	1.6
Yb	9.3	6.8	3.9	0.9	2.1	5.9	4.2	8.1	7.2	7.8
Lu	–	–	1.3	–	0.6	–	0.4	–	–	2.1
Y/(Y+Ln)x100	(64.9[b])	(59.1)	(30.0)	(47.5)	(30.0)	(67.6)[b]	(50.8)	(21.5)[b]	(62.2)[b]	–
Method	CH	–	CH	OS	CH	CH	XF	CH	CH	XF
Σ = La+Ce+Pr	28.0	28.1	28.3	28.4	28.5	28.8	29.2	29.5	29.6	29.7
La-Nd	44.8	43.2	49.8	48.1	50.2	48.9	43.7	48.7	48.5	46.4
Sm-Ho	35.3	39.6	39.3	42.5	40.0	34.5	51.7	39.3	36.1	33.7
Er-Lu	19.9	17.2	10.9	9.4	9.8	16.6	4.6	12.0	15.4	19.9
RE_2O_3	0.34*	0.41	0.67	0.96	0.13	0.40	0.37*	0.02	0.43*	0.42
La/Nd	0.36	0.52	0.36	0.46	0.46	0.25	0.32	0.11	0.28	0.34

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(41) Chashchukhina (1975), two-mica granite, Aduisk massif, Murzhinsk, U.S.S.R.; (42) Tugarinov et al. (1969), metamorphosed Precambrian rock. Krivoi Rog, U.S.S.R.; (43) Leonova and Elina (1969), muscovite pegmatite, White Sea region; (44) Yurgina et al. (1975), plagioclase pegmatite, Karelia; (45) same as (43); (46) Chashchukina (1975), granite pegmatite, Aduisk massif, Murzhinsk; (47) Aleksiev (1965), pegmatite, northern Nikolskii granite, Bulgaria; (48) Belkov and Batieva (1971), granodiorite, Ponoi River, Kola Peninsula; (49) same as (46); (50) Ganzeev et al. (1966), kyanite gneiss, Vishnevye Mts., Urals, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	51	52	53	54	55	56	57	58	59	60
La	4.7	6.7	1.5	6.1	6.7	6.6	5.5	3.9	13.0	5.2
Ce	25.0	19.2	16.3	20.3	19.6	20.1	20.1	22.0	10.7	24.7
Pr	—	3.9	12.1	3.8	4.0	3.7	5.2	5.1	7.3	1.3
Nd	22.6	27.9	19.3	19.8	22.2	15.8	26.3	24.4	28.4	21.5
Sm	8.4	12.6	24.4	10.3	8.9	14.0	12.9	12.2	10.3	8.4
Eu	—	0.5	—	2.1	2.0	—	a	—	—	a
Gd	14.7	12.1	19.3	9.3	13.4	16.9	13.6[a]	17.4	14.0	12.1[a]
Tb	—	—	—	2.9	—	1.7	0.6	—	—	b
Dy	11.1	8.4	5.4	11.6	8.5	12.6	7.0	12.0	6.0	11.5
Ho	3.5	1.6	1.1	3.8	2.4	2.1	1.8	0.8	1.5	0.6
Er	6.0	2.5	0.1	4.8	5.5	3.1	3.8	1.5	4.3	7.7
Tm	3.2	0.5	—	1.0	0.8	0.5	0.1	—	0.5	0.6
Yb	0.8	3.2	0.5	2.8	5.1	2.9	2.9	0.7	3.5	6.4
Lu	—	0.9	—	1.4	0.9	—	0.1	—	0.5	—
Y/(Y+Ln)x100	(64.7)	(43.1)	(40.7)	(50.8)	(34.7)	(30.0)	(32.6)	(48.1)	(32.1)	(66.8)[b]
Method	OS	OS	—	XF	OS	CH	CH	CH	OS	CH
Σ = La+Ce+Pr	29.7	29.8	29.9	30.2	30.3	30.4	30.8	31.0	31.0	31.2
La-Nd	52.3	57.7	49.2	50.0	52.5	46.2	57.2	55.4	59.4	52.7
Sm-Ho	37.7	35.2	50.2	40.0	35.2	47.3	35.9	42.4	31.8	32.6
Er-Lu	10.0	7.1	0.6	10.0	12.3	6.5	6.9	2.2	8.8	14.7
RE_2O_3	1.26	0.80*	2.40	0.41	0.14	0.16	0.88	—	1.39	0.58
La/Nd	0.21	0.24	0.08	0.31	0.30	0.42	0.21	0.16	0.46	0.24

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(51) Yurgina et al. (1975), plagioclase pegmatite, Malinovka Varaka, Karelia; (52) Lee et al. (1973), hybrid granitoid, Snake Range, Nev.; (53) Portnov and Gorobets (1969), granite pegmatite, E. Transbaikal; (54) Lee et al. (1973), muscovite-rich granite, White Pine Co., Nev.; (55) Kholodnov et al. (1975a), biotite gneiss, Aleksandr-Akhten complex, Urals; (56) Leonova and Elina (1969), beryl pegmatite, White Sea region, U.S.S.R.; (57) Kuts (1971), biotite granite, Novo-Alekseev, W. Azov region, U.S.S.R.; (58) Shmakin and Shiryaeva (1968), muscovite pegmatite, E. Siberia; (59) Kholodnov et al. (1975b), granite, Murzinsk, Urals, U.S.S.R.; (60) Chashchukhina (1975), two-mica granite, Alduisk massif, Murzhinsk, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	61	62	63	64	65	66	67	68	69	70
La	8.1	7.2	6.6	4.7	6.7	7.6	7.1	4.2	7.7	4.9
Ce	19.5	19.9	22.4	24.1	20.4	21.7	22.3	16.2	21.3	23.9
Pr	3.7	4.2	2.4	3.0	5.6	3.4	3.4	12.8	4.4	4.8
Nd	23.1	25.4	20.3	13.5	18.9	49.8	19.9	38.0	25.6	18.7
Sm	9.5	9.3	12.6	4.9	9.7	8.8	7.0	16.2	10.3	13.0
Eu	–	0.9	–	–	0.4	–	a	–	–	0.4
Gd	17.2	10.0	18.9	6.0	13.7	8.7	11.5[a]	8.5	11.6	15.4
Tb	6.2	1.7	–	–	1.7	–	b	b	3.8	1.3
Dy	5.9	6.9	13.3	17.6	10.1	–	8.8	3.5	7.4	9.8
Ho	1.2	2.7	0.8	0.1	3.4	–	2.8	–	0.8	1.0
Er	3.0	4.9	1.5	–	4.9	–	7.4	0.6	3.1	3.4
Tm	0.3	2.0	0.1	–	0.5	–	2.8	–	1.2	0.5
Yb	1.9	3.4	1.1	9.7	3.6	–	6.5	–	2.8	2.5
Lu	0.4	1.5	–	0.4	0.4	–	0.5	–	–	0.4
Y/(Y+Ln)x100	(29.0)	(31.7)	(54.7)	(59.3)	–	(22.0)	(55.7)[b]	(21.2)[b]	(24.0)	–
Method	CH	CH	CH	XF	XF	–	CH	CH	CH	XF
Σ = La+Ce+Pr	31.3	31.3	31.4	31.8	32.7	32.7	32.8	33.2	33.4	33.6
La-Nd	54.4	56.7	51.7	45.3	51.6	82.5	52.7	71.2	59.0	52.3
Sm-Ho	40.0	31.5	45.6	44.6	39.0	17.5	30.1	28.2	33.9	40.9
Er-Lu	5.6	11.8	2.7	10.1	9.4	–	17.2	0.6	7.1	6.8
RE_2O_3	0.41	1.19	–	0.44*	0.80	–	0.72	–	0.56	0.36
La/Nd	0.35	0.28	0.32	0.35	0.35	0.15	0.36	0.11	0.30	0.26

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(61) Leonova and Elina (1969), muscovite pegmatite, White Sea region, U.S.S.R.; (62) Batieva (1976), alkalic granite, Kola Peninsula, U.S.S.R.; (63) Shmakin and Shiryaeva (1968), muscovite pegmatite, E. Siberia; (64) Aleksiev (1965) endogenic zone, northern Nikolskii granite, Bulgaria; (65) Lyakhovich (1968), granodiorite, E. Sayan; (66) Ivantishin et al. (1964), Precambrian granite, Ukraine; (67) Chaschukhina (1975), biotite granite, Aduisk massif, Murzinsk, Urals; (68) Afanas'ev et al. (1976), amphibole-diopside rock, Bolshaya Laba River, Caucasus, U.S.S.R.; (69) same as (61); (70) Ganzeev et al. (1966), kyanite gneiss, Vishnevye Mts., Urals, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.—	71	72	73	74	75	76	77	78	79	80
La	7.2	5.5	5.8	4.6	9.0	7.3	6.8	7.5	6.6	7.4
Ce	22.1	20.8	28.0	26.5	16.9	23.0	23.1	22.4	22.1	22.4
Pr	4.4	7.4	–	2.7	7.9	3.0	4.2	4.3	5.6	5.1
Nd	21.0	37.1	9.6	17.0	28.2	15.8	29.5	23.5	21.4	20.9
Sm	7.4	10.5	8.3	24.6	6.6	12.1	10.7	10.8	9.8	8.0
Eu	1.0	1.0	–	0.6	0.5	a	a	–	–	1.1
Gd	14.0	6.0	17.7	11.2	14.4	10.7[a]	13.0[a]	12.0	11.6	13.8
Tb	–	–	–	–	7.1	b	1.1	2.4	–	–
Dy	10.3	7.8	13.7	7.6	6.1	8.3	3.5	8.3	14.4	10.4
Ho	1.5	0.6	1.5	1.6	–	1.2	2.0	1.6	2.0	2.2
Er	5.5	1.7	3.6	2.3	–	8.3	3.7	3.5	4.8	5.3
Tm	0.8	0.5	8.0	0.3	–	1.2	–	0.5	0.8	0.6
Yb	4.2	0.8	3.8	1.0	3.3	8.3	2.8	2.9	0.9	2.4
Lu	0.6	0.3	–	–	–	–	–	0.3	–	0.4
Y/(Y+Ln)x100	(39.3)	–	(47.0)	(29.4)	(42.1)	(66.1)[b]	(38.7)	(26.0)	(47.0)	(33.2)
Method	OS	OS	OS	OS	XF	CH	CH	CH	CH	OS
Σ = La+Ce+Pr	33.7	33.7	33.8	33.8	33.8	34.1	34.1	34.2	34.3	34.9
La-Nd	54.7	70.8	43.4	50.8	62.0	49.9	63.6	57.7	55.7	55.8
Sm-Ho	34.2	25.9	41.2	45.6	34.7	32.3	29.9	35.1	37.8	35.5
Er-Lu	11.1	3.3	15.4	3.6	3.3	17.8	6.5	7.2	6.5	8.7
RE_2O_3	0.46	0.26	0.94	0.77*	0.19	0.43	0.44	0.46	–	0.29
La/Nd	0.34	0.15	0.61	0.28	0.32	0.46	0.23	0.32	0.31	0.35

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(71) Kholodnov et al. (1975a), two-mica granite gneiss, Varlanov, Urals, U.S.S.R.; (72) Zayats and Kuts (1964), gneiss, Ukraine; (73) Yurgina et al. (1975), cleavelandite pegmatite, Kolovai, Karelia, U.S.S.R.; (74) Lee et al. (1973), hybrid granitoid, Snake Range, Nev.; (75) Lyakhovich and Barinskii (1961), granite, E. Transbaikal; (76) Chashchukhina (1975), two-mica granite, Aduisk massif, Murzhinsk, Urals, U.S.S.R.; (77) Orsa et al. (1967), aplitic-pegmatite granite, Middle Dnepr region, U.S.S.R.; (78) Leonova and Elina (1969), muscovite pegmatite, White Sea region, U.S.S.R.; (79) Shmakin and Shiryaeva (1968), muscovite pegmatite, Mamsk region, E. Siberia; (80) Kholodnov et al. (1975a), biotite gneiss, Marinovskii, Urals.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	81	82	83	84	85	86	87	88	89	90
La	8.4	7.5	5.1	12.0	4.7	6.5	4.6	14.9	8.5	7.5
Ce	26.5	27.5	24.2	19.6	18 9	22.1	24.5	20.3	17.4	23.3
Pr	–	–	5.7	3.5	11.5	6.5	6.1	–	9.4	4.5
Nd	22.6	23.8	26.5	13.7	29.5	21.5	20.4	52.9	25.9	34.1
Sm	12.5	10.0	10.8	6.6	17.2	8.5	12.2	8.6	8.5	10.8
Eu	–	–	–	–	–	1.0	–	0.5	2.4	1.1
Gd	14.3	11.9	14.7	12.5	17.2	6.6	19.1	–	13.5	10.4
Tb	–	–	–	2.7	c	–	–	0.9	–	–
Dy	7.3	8.2	9.0	13.3	c	10.0	10.6	–	5.4	6.3
Ho	2.0	3.0	1.5	–	0.4	2 6	0.8	–	1.3	1 0
Er	3.7	4.8	1.7	8.8	0.6	6.3	1.4	–	3 5	–
Tm	0.4	0.8	–	–	–	0.8	–	–	0.6	–
Yb	2.2	2.5	0.8	4.0	–	6.8	0.3	1.7	2.8	1.0
Lu	0.1	–	–	3 3	–	0.8	–	0.2	0.8	–
Y/(Y+Ln)x100	(41.5)	(48.3)	(40.7)	(52.3)	(36.8)[c]	(33.1)	(49.7)	–	(33.2)	(42.5)
Method	OS	OS	CH	–	CH	OS	CH	NA	OS	OS
Σ = La+Ce+Pr	34.9	35.0	35.0	35.1	35.1	35.1	35.2	35.2	35.3	35.3
La-Nd	57.5	58.8	61.5	48.8	64.6	56.6	55.6	88.1	61.2	69.4
Sm-Ho	36 1	33.1	36.0	35.1	34.8	28.7	42.7	10.0	31.1	29.6
Er-Lu	6.4	8.1	2.5	16.1	0.6	14.7	1 7	1.9	7.7	1.0
RE_2O_3	0.93	0.54	–	–	–	0.36	–	0.37*	0.09	0 65*
La/Nd	0.37	0.32	0.19	0.88	0.16	0.30	0.23	0.28	0.33	0.22

* = % R.E.
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(81) Yurgina et al. (1975), quartz-muscovite metasomatite, Lapatova-guba, Karelia, U.S.S.R.; (82) Yurgina et al. (1975), plagioclase pegmatite, Khetolambino, Karelia; (83) Shmakin and Shiryaeva (1968), muscovite pegmatite, Mamsk region, E. Siberia; (84) Tugarinov et al. (1967), metamorphosed Precambrian rock, Krivoi Rog, U.S.S.R.; (85) Afanas'ev et al. (1976), amphibole-omphacite rock, Markopidze River, Caucasus, U.S.S.R. (86) Kholodnov et al. (1975a), biotite granite, Syrostanskii, Urals, U.S.S.R.; (87) same as (83); (88) Puchelt and Emmermann (1976), monzonite, Black Forest, Germany; (89) Kholodnov et al. (1975a), granodiorite, Verkhisetskii, Urals; (90) Lee et al. (1973), aplite, Snake Range, Nev.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	91	92	93	94	95	96	97	98	99	100
La	6.7	8.6	9.4	12.9	6.2	8.4	9.6	7.4	6.8	8.5
Ce	25.3	20.3	17.7	22.7	25.1	22.8	26.4	23.6	24.3	23.7
Pr	3.4	6.5	8.3	—	4.3	4.5	—	5.2	5.3	4.5
Nd	21.4	22.4	29.4	17.1	23.1	21.5	23.7	18.9	18.1	21.9
Sm	9.2	10.9	6.9	9.4	9.1	7.7	12.9	14.4	13.8	8.6
Eu	0.6	a	0.5	0.5	1.5	1.1	—	1.2	1.4	—
Gd	11.9	15.8[a]	15.1	12.9	10.8	12.0	11.5	16.3	12.5	11.3
Tb	1.8	1.6	2.8	—	—	—	—	1.9	2.6	1.8
Dy	9.6	5.6	6.4	8.8	7.4	8.6	7.9	6.8	9.5	10.5
Ho	1.6	2.1	—	3.5	1.9	1.5	1.6	1.1	1.1	1.5
Er	4.5	2.3	—	6.4	5.3	6.4	2.7	1.8	2.7	3.0
Tm	0.9	0.5	—	0.6	0.7	0.9	0.7	0.3	0.3	2.0
Yb	2.7	3.0	3.5	—	4.6	3.8	3.0	1.0	1.5	2.7
Lu	0.4	0.4	—	0.6	—	0.8	—	0.1	0.1	—
Y/(Y+Ln)x100	—	(43.2)	—	(49.7)	(35.4)	(37.3)	(45.8)	(27.5)	(22.9)	(32.0)
Method	—	CH	XF	—	MS	OS	OS	XF	OS	CH
Σ = La+Ce+Pr	35.4	35.4	35.4	35.6	35.6	35.7	36.0	36.2	36.4	36.7
La-Nd	56.8	57.8	64.8	52.7	58.7	57.2	59.7	55.1	54.5	58.6
Sm-Ho	34.7	36.0	31.7	35.1	30.7	30.9	33.9	41.7	40.9	33.7
Er-Lu	8.5	6.2	3.5	12.2	10.6	11.9	6.4	3.2	4.6	7.7
RE_2O_3	0.34	0.12	0.19	0.70	0.10*	0.40	0.30	0.22	0.80	0.61
La/Nd	0.31	0.38	0.32	0.75	0.27	0.39	0.40	0.39	0.37	0.39

* = % R.E.
(a) Eu+Gd calcd. as Gd

(91) Lyakhovich and Kasaeva (1968), Precambrian granite, Bansan River canyon, Kabaridan-Balkar A.S.S.R.; (92) Vinogradov and Elina (1968), granite, N.W. Kola Peninsula, U.S.S.R.; (93) Lyakhovich (1968), biotite granite, E. Transbaikal; (94) Starkov et al. (1973), granite, eastern Mugodzhar; (95) Mason (1975), gneiss, Godfhab region, W. Greenland; (96) Kholodnov et al. (1975a), biotite gneiss, Varlanov complex, Urals, U.S.S.R.; (97) Yurgina et al. (1975), plagioclase pegmatite, Leveira, Karelia, U.S.S.R.; (98) Lyakhovich (1962), granite, Konev massif, Urals; (99) Kholodnov et al. (1975a), biotite gneiss, Il'men Mts., Urals; (100) Leonova and Elina (1969), muscovite pegmatite, White Sea region, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	101	102	103	104	105	106	107	108	109	110
La	6.6	6.1	6.7	8.3	5.5	12.0	12.0	8.3	7.4	6.3
Ce	30.1	22.6	25.3	22.5	25.7	21.0	25.3	29.1	24.8	27.1
Pr	—	8.1	5.0	6.4	6.0	4.2	—	—	5.2	4.0
Nd	22.1	32.2	36.8	23.0	23.4	24.0	15.7	25.5	26.1	26.2
Sm	7.7	11.9	7.1	7.1	9.7	13.9	5.0	10.5	10.0	8.8
Eu	—	—	—	a	2.6	1.1	—	—	0.8	0.6
Gd	6.3	15.0	—	10.1[a]	10.1	12.8	15.0	7.8	12.0	8.6
Tb	—	b	—	1.5	1.2	1.6	—	—	—	—
Dy	6.0	3.0	11.0	6.6	6.7	5.9	7.7	7.5	6.8	8.1
Ho	15.5	—	1.3	1.3	0.9	0.8	4.4	2.7	1.1	1.7
Er	3.3	0.7	3.3	3.3	3.3	2.1	7.3	4.5	3.8	5.7
Tm	0.5	—	—	2.5	1.3	0.4	5.8	0.9	0.4	—
Yb	1.9	0.4	3.5	7.4	2.7	—	1.8	3.2	1.4	2.3
Lu	—	—	—	—	0.9	0.2	—	—	0.2	0.6
Y/(Y+Ln)x100	(40.2)	(23.0)[b]	(47.9)	(30.6)	—	(2.6)	(55.3)	(50.9)	(29.5)	(29.9)
Method	OS	CH	OS	CH	XF	XF	OS	OS	OS	OS
Σ = La+Ce+Pr	36.7	36.8	37.0	37.2	37.2	37.2	37.3	37.4	37.4	37.4
La-Nd	58.8	69.0	73.8	60.2	60.6	61.2	53.0	62.9	63.5	63.6
Sm-Ho	35.5	30.6	19.4	26.6	31.2	36.1	32.1	28.5	30.7	27.8
Er-Lu	5.7	0.4	6.8	13.2	8.2	2.7	14.9	8.6	5.8	8.6
RE_2O_3	0.63	—	0.65*	0.15	0.82	3.40	0.83	0.47	0.32	0.98*
La/Nd	0.30	0.19	0.18	0.36	0.24	0.50	0.77	0.32	0.28	0.24

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(101) Yurgina et al. (1975), contact of microcline- and plagioclase-pegmatites, Kura-vaara, Karelia, U.S.S.R.; (102) Afanas'ev et al. (1976), amphibole-pyroxene rock, Bolshaya Laba River, Caucasus, U.S.S.R.; (103) Lee et al. (1973), hybrid granitoid, Snake Range, Nev.; (104) Vinogradov and Elina (1968), granite, N.W. Kola Peninsula, U.S.S.R.,; (105) Ganzeev et al. (1966), biotite gneiss, Vishnevye Mts., Urals; (106) Turovskii et al. (1968), hydrothermal vein in granite, locality not given; (107-108) Yurgina et al. (1975), plagioclase pegmatites, Karelia; (107) Malinovaya Varaka; (108) Khetolambino; (109) Kholodnov et al. (1975a), gneiss, Taratashi complex, Ukraine; (110) same as (103).

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	111	112	113	114	115	116	117	118	119	120
La	7.8	7.2	6.2	17.3	6.8	8.0	7.1	8.7	12.3	7.8
Ce	22.8	25.2	23.2	20.3	28.0	21.3	30.7	25.7	25.6	25.2
Pr	6.9	5.2	8.2	—	2.9	8.4	—	3.4	—	5.0
Nd	22.9	25.9	42.4	47.6	27.4	35.0	13.4	24.9	15.0	17.3
Sm	8.4	8.6	16.9	10.2	8.7	13.3	11.9	8.0	10.7	16.5
Eu	1.3	—	1.2	0.2	0.8	—	—	0.7	—	0.7
Gd	10.7	10.6	6.9	—	8.4	11.8	21.2	10.7	17.0	11.4
Tb	—	2.6	—	1.4	—	b	—	—	—	—
Dy	7.9	9.2	—	—	8.1	2.2	7.3	7.4	10.0	10.9
Ho	1.7	2.2	—	—	1.6	—	8.1	0.9	2.0	1.0
Er	4.5	3.3	—	—	4.7	—	—	4.3	3.6	2.2
Tm	0.5	—	—	—	—	—	—	—	0.5	0.3
Yb	4.1	—	—	2.7	2.6	—	0.3	3.1	3.1	1.7
Lu	0.5	—	—	0.3	—	—	—	2.2	0.2	—
Y/(Y+Ln)x100	(24.2)	(35.5)	(23.4)	—	(38.2)	(19.8) b	(31.3)	(44.7)	(65.5)	(30.5)
Method	OS	—	—	NA	OS	CH	OS	OS	OS	OS
Σ = La+Ce+Pr	37.5	37.6	37.6	37.6	37.7	37.7	37.8	37.8	37.9	38.0
La-Nd	60.4	63.5	80.0	85.2	65.1	72.7	51.2	62.7	52.9	55.3
Sm-Ho	30.0	33.2	20.0	11.8	27.6	27.3	48.5	27.7	39.7	40.5
Er-Lu	9.6	3.3	—	3.0	7.3	—	0.3	9.6	7.4	4.2
RE_2O_3	0.45	0.5	—	0.60*	0.77*	—	0.38	0.92*	0.59	0.53*
La/Nd	0.34	0.28	0.15	0.36	0.25	0.24	0.53	0.35	0.82	0.45

* = % R.E.
(b) Tb+Y calcd. as Y

(111) Kholodnov et al. (1975a), granodiorite, Chelyabinsk, Urals, U.S.S.R.; (112) Gavrilova and Turanskaya (1957), quoted by Semenov (1963), granite, Kirovgrad region, Ukraine; (113) Ivantishin et al. (1964), Precambrian gneiss, Ukraine; (114) Puchelt and Emmermann (1976), granite, Black Forest, Germany; (115) Lee et al. (1973), hybrid granitoid, Snake Range, Nev.; (116) Afanas'ev et al. (1976), apatite-carbonate rock, Markopidzh River, Caucasus, U.S.S.R.; (117) Yurgina et al. (1975), plagioclase pegmatite, Sludyana, Karelia, U.S.S.R.; (118) same as (115); (119) Yurgina et al. (1975), plagioclase-microcline pegmatite, Kilpyavr, Karelia; (120) same as (115).

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	121	122	123	124	125	126	127	128	129	130
La	10.8	8.5	14.5	9.9	4.4	16.5	8.7	6.4	8.2	6.3
Ce	22.7	24.7	23.9	22.7	24.5	22.0	29.8	26.5	25.7	27.1
Pr	4.5	5.0	–	5.8	9.5	–	–	5.7	4.7	5.3
Nd	27.9	27.6	19.8	22.8	37.8	5.9	14.6	23.0	26.0	26.4
Sm	10.4	8.4	11.5	12.0	11.6	–	7.4	10.4	9.6	12.0
Eu	–	–	0.8	–	–	–	–	–	–	0.8
Gd	10.1	10.6	11.1	14.2	11.8	18.1	16.4	14.2	9.9	16.2
Tb	–	b	–	–	c	–	–	–	1.7	–
Dy	6.1	6.5	8.2	10.6	c	21.5	10.3	11.9	6.4	4.9
Ho	1.3	0.6	1.6	0.6	0.1	4.4	2.9	0.8	1.2	0.8
Er	3.4	4.5	4.6	1.3	0.3	7.1	4.9	1.0	3.4	–
Tm	0.3	0.1	0.5	–	–	3.4	3.9	–	0.6	–
Yb	2.1	3.4	3.5	0.1	–	1.1	1.1	0.1	2.5	0.2
Lu	0.4	0.1	–	–	–	–	–	–	0.1	–
Y/(Y+Ln)x100	(27.9)	(47.3)[b]	(39.9)	(41.3)	(21.8)[c]	(59.8)	(57.5)	(48.0)	(20.0)	(22.3)
Method	OS	CH	–	CH	CH	OS	OS	CH	CH	OS
Σ = La+Ce+Pr	38.0	38.2	38.4	38.4	38.4	38.5	38.5	38.6	38.6	38.7
La-Nd	65.9	65.8	58.2	61.2	76.2	44.4	53.1	61.6	64.6	65.1
Sm-Ho	27.9	26.1	33.2	37.4	23.5	44.0	37.0	37.3	28.8	34.7
Er-Lu	6.2	8.1	8.6	1.4	0.3	11.6	9.9	1.1	6.6	0.2
RE_2O_3	0.54	0.39	0.505	–	–	0.86	0.84	–	0.57	0.68*
La/Nd	0.39	0.31	0.73	0.44	0.12	2.77	0.59	0.28	0.32	0.24

* = % R.E.
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(121) Kholodnov et al. (1975a), migmatite, Il'men Mts., Urals, U.S.S.R.; (122) Afanas'ev et al. (1976), granite, Mushte River, Caucasus, U.S.S.R.; (123) Starkov et al. (1973), gneiss, eastern Mugodzhar; (124) Shmakin and Shiryaeva (1968), muscovite pegmatite, E. Siberia; (125) Afanas'ev et al. (1976), amphibole-carbonate rock, Caucasus; (126-127) Yurgina et al. (1975), plagioclase pegmatite, Malinova varaka, Karelia, U.S.S.R.; (128) same as (124); (129) Leonova and Elina (1969), muscovite pegmatite, White Sea region, U.S.S.R.; (130) Lee et al. (1973), aplite, Snake Range, Nev.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	131	132	133	134	135	136	137	138	139	140
La	7.1	10.4	6.3	11.1	7.4	10.6	9.4	12.9	9.7	7.4
Ce	25.5	21.7	24.5	28.0	26.7	24.6	24.4	26.5	24.5	25.0
Pr	6.2	6.9	8.2	–	5.2	4.1	5.5	–	5.7	7.5
Nd	15.6	10.1	32.4	38.5	23.4	27.0	33.8	17.7	39.8	20.3
Sm	11.0	12.1	6.1	6.9	8.8	8.9	5.0	5.8	8.4	13.4
Eu	1.0	–	0.8	1.5	–	–	1.5	–	3.0	0.6
Gd	9.1	12.9	5.7	5.8	10.9	11.1	9.2	16.2	8.9	10.9
Tb	1.3	1.8	–	0.8	2.7	–	–	–	–	0.7
Dy	10.3	10.2	9.3	4.1	9.4	6.4	5.8	11.5	–	4.6
Ho	2.4	1.6	0.8	0.8	2.2	1.3	3.0	2.9	–	0.7
Er	5.0	2.5	3.0	1.5	3.3	3.4	–	5.2	–	2.1
Tm	0.8	–	0.9	–	–	0.3	–	0.3	–	0.5
Yb	4.0	9.8	1.7	0.9	–	2.0	2.4	1.0	–	6.1
Lu	0.7	–	0.3	0.1	–	0.3	–	–	–	0.2
Y/(Y+Ln)x100	(43.7)	(31.0)	–	–	(35.1)	(25.5)	(46.8)	(62.4)	(17.2)	(60.2)
Method	XF	CH	OS	NA	–	OS	OS	OS	–	XF
Σ = La+Ce+Pr	38.8	39.0	39.0	39.1	39.3	39.3	39.3	39.4	39.9	39.9
La-Nd	54.4	49.1	71.4	77.6	62.7	66.3	73.1	57.1	79.7	60.2
Sm-Ho	35.1	38.6	22.7	19.9	34.0	27.7	24.5	36.4	20.3	30.9
Er-Lu	10.5	12.3	5.9	2.5	3.3	6.0	2.4	6.5	–	8.9
RE_2O_3	0.70	0.06	0.71	–	2.15	1.35	0.46*	0.79	–	2.39
La/Nd	0.46	1.03	0.19	0.29	0.32	0.39	0.28	0.73	0.24	0.36

* = % R.E.

(131) Lyakhovich and Barinskii (1961), granite, Talitsk massif, Gornyi Altai; (132) Leonova and Elina (1969), Na-Li pegmatite, White Sea region, U.S.S.R.; (133) Zayats and Kuts (1964), biotite gneiss, Ukraine; (134) Roelandts and Duchesne (1979), Fe-Ti ore, Rogaland, Norway; (135) Gavrilova and Turanskaya (1958), granite, Kirovgrad, U.S.S.R.; (136) Kholodnov et al. (1975a), granite, Murzinsk, Urals, U.S.S.R.; (137) Lee et al. (1973) hybrid granitoid, Snake Range, Nev.; (138) Yurgina et al. (1975), plagioclase pegmatite, Malinova varaka, Karelia, U.S.S.R.; (139) Ivantishin et al. (1964), Precambrian gneiss, Ukraine; (140) Semenov et al. (1967), quartz-fluorite pegmatite, Tarbagatau, Kazakhstan.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.	141	142	143	144	145	146	147	148	149	150
La	6.5	10.7	10.7	4.0	6.9	8.4	11.2	3.8	5.9	5.4
Ce	29.0	29.5	22.6	28.7	23.7	23.5	29.7	22.7	29.3	31.0
Pr	4.5	–	6.9	7.8	10.1	8.9	–	4.4	5.8	4.8
Nd	23.6	6.0	36.5	11.7	30.3	32.0	26.3	29.9	29.0	17.9
Sm	12.5	26.8	5.6	17.1	9.9	15.7	11.4	10.9	9.1	14.1
Eu	–	–	0.8	–	–	–	–	–	–	–
Gd	14.7	16.0	8.0	7.8	10.3	11.5	8.9	15.3	9.4	12.8
Tb	–	–	–	–	–	c	–	b	–	–
Dy	6.7	7.6	4.6	21.1	6.7	c	6.8	1.7	9.0	10.5
Ho	0.7	1.0	0.6	1.4	0.4	–	1.6	0.3	0.8	1.5
Er	1.1	1.9	1.6	0.1	1.3	–	2.3	0.6	1.5	1.7
Tm	0.1	–	1.0	–	–	–	–	–	–	–
Yb	0.6	0.5	0.7	0.3	0.4	–	1.8	0.4	0.2	0.3
Lu	–	–	0.4	–	–	–	–	–	–	–
Y/(Y+Ln)x100	(36.7)	(36.9)	–	(44.1)	(33.6)	(19.5)[c]	(44.0)	(20.6)[b]	(38.1)	(43.0)
Method	CH	OS	OS	–	CH	CH	OS	CH	CH	CH
Σ = La+Ce+Pr	40.0	40.2	40.2	40.5	40.7	40.8	40.9	40.9	41.0	41.2
La-Nd	63.6	46.2	76.7	52.2	71.0	72.8	67.2	70.8	70.0	59.1
Sm-Ho	34.6	51.4	19.6	47.4	27.3	27.2	28.7	28.2	28.3	38.9
Er-Lu	1.8	2.4	3.7	0.4	1.7	–	4.1	1.0	1.7	2.0
RE_2O_3	–	0.74	0.18	100	–	–	0.47	–	–	–
La/Nd	0.28	1.80	0.29	0.34	0.23	0.26	0.43	0.46	0.20	0.30

(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(141) Shmakin and Shiryaeva (1968), muscovite pegmatite, E. Siberia; (142) Yurgina et al. (1975), plagioclase pegmatite, Strel'na, Karelia, U.S.S.R.; (143) Zayats and Kuts (1964), biotite gneiss, Ukraine; (144) Portnov and Gorobets (1969), granite pegmatite, Chupa, Karelia; (145) Semenov et al (1967), quartz-fluorite pegmatite, Tarbagatau, Kazakhstan; (146) Afanas'ev et al. (1976), apatite-carbonate rock, Markopidzh River, Caucasus, U.S.S.R.; (147) same as (142); (148) Afanas'ev et al. (1976), carbonatized amphibole-omphacite rock, Caucasus; (149-150) same as (141).

Table 1 - Rare Earths in Apatite, atomic percent - continued

No	151	152	153	154	155	156	157	158	159	160
La	11.4	10.7	7.1	7.6	12.2	8.2	6 5	10.3	9.4	7.6
Ce	20.6	22.8	29.4	29.9	25.1	28.7	34.5	32.0	32.9	30.0
Pr	9.2	7.8	4.9	4.1	4.7	5.3	1.3	-	-	4.7
Nd	33.6	24.9	14.1	19.9	25.7	32.0	25.9	26.7	26.8	35.0
Sm	6.7	9.2	9.6	7.1	11.2	7.4	18.7	9.3	7.5	7.4
Eu	1.2	-	0.7	0.4	-	a	0.6	-	0.6	a
Gd	8.0	10.1	15.9	9.1	12.5	9.4[a]	5.4	7.4	8.2	8.4[a]
Tb	-	4.5	1 2	2 8	-	0.4	-	-	1.4	0.5
Dy	3.8	3.5	7.4	9.0	6.7	2 3	5.3	7.1	6 9	1.8
Ho	1 0	3.6	1.6	1.6	0.6	1.5	0.9	1.2	1.1	0.6
Er	2.0	2.9	4.5	4.8	1.1	2 5	0.1	4.0	3 2	1.8
Tm	1.1	-	0.6	0.5	-	0.1	-	1.0	-	-
Yb	1.0	-	2 4	2.5	0.2	2.2	0.8	1.0	1 8	2.2
Lu	0.4	-	0.6	0.7	-	-	-	-	0.2	-
Y/(Y+Ln)x100	-	-	-	(39.8)	(34.4)	(32.9)	(19.8)	(45.8)	-	(34.4)
Method	OS	CH	XF	CH	CH	CH	-	OS	NA	CH
Σ = La+Ce+Pr	41.2	41.3	41.4	41 6	42.0	42.2	42.3	42.3	42.3	42.3
La-Nd	74.8	66.2	55.5	61.5	67.7	74.2	68.2	69.0	69.1	77.3
Sm-Ho	20.7	30.9	36.4	30.0	31.0	21.0	30.9	25.0	25.7	18.7
Er-Lu	4 5	2 9	8.1	8.5	1.3	4.8	0.9	6.0	5.2	4.0
RE_2O_3	0.12	-	0.59	0.82	-	0.21	1.90	0.56	0.71*	0.29
La/Nd	0.34	0.43	0.51	0.38	0.47	0.26	0 25	0.38	0.35	0.22

* = % R.E.
(a) Eu+Gd calcd. as Gd

(151) Zayats and Kuts (1964), amphibole-biotite gneiss, Ukraine; (152) Afanas'ev et al. (1976), apatite-carbonate rock, Tref'ya Rota, Caucasus, U.S.S.R.; (153) Lyakhovich (1967), biotite granite, E. Transbaikal; (154) Kuts (1971), hornblende-biotite granite, Svobodna, W. Azov region; (155) Shmakin and Shiryaeva (1968), muscovite pegmatite, E. Siberia; (156) Orsa et al. (1967), migmatite, Middle Dnepr region, U.S.S.R.; (157) Portnov and Gorobets (1969), granite pegmatite, Kazakhstan; (158) Yurgina et al. (1975), albite-muscovite pegmatite, Kolovan, Karelia, U.S.S.R.; (159) Brunfelt and Roelandts (1974), chlorapatite, gabbro, Odegarden, Norway; (160) same as (156).

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.	161	162	163	164	165	166	167	168	169	170
La	9.6	11.0	7.8	6.1	10.0	8.9	6.9	11.8	11.4	8.5
Ce	26.6	22.1	31.6	28.9	24.0	25.5	31.7	31.5	31.9	25.5
Pr	6.2	9.4	3.1	7.6	8.9	8.7	4.6	-	-	5.1
Nd	24.1	21.2	35.0	28.5	16.5	22.0	38.7	15.2	36.3	18.6
Sm	7.8	6.7	9.3	10.4	8.0	7.6	6.7	10.2	6.7	6.0
Eu	1.5	2.9	a	-	-	0.9	a	-	1.4	-
Gd	8.9	12.8	10.8[a]	10.0	14.4	9.0	7.2[a]	12.0	5.6	11.5
Tb	-	-	0.4	-	-	0.3	0.5	-	0.8	2.8
Dy	6.5	5.3	1.7	6.8	13.3	6.1	2.4	10.3	3.3	11.2
Ho	1.5	1.2	0.1	0.6	1.5	1.1	-	2.3	0.6	1.6
Er	4.3	3.2	0.1	1.0	2.1	4.2	0.7	3.3	1.2	3.3
Tm	0.4	0.6	-	-	0.2	0.7	-	0.7	-	-
Yb	2.2	2.8	0.1	0.1	1.1	3.5	0.6	2.7	0.7	1.6
Lu	0.4	0.8	-	-	-	0.5	-	-	0.1	-
Y/(Y+Ln)x100	(28.5)	(33.2)	(31.4)	(25.9)	(55.3)	(34.3)	(36.2)	(54.1)	-	(48.2)
Method	OS	OS	CH	CH	CH	XF	CH	OS	NA	XF
Σ = La+Ce+Pr	42.4	42.5	42.5	42.6	42.9	43.1	43.2	43.3	43.3	43.4
La-Nd	66.5	63.7	77.5	71.1	59.4	65.1	81.9	58.5	79.6	62.0
Sm-Ho	26.2	28.9	22.3	27.8	37.2	26.0	16.8	34.8	18.4	33.1
Er-Lu	7.3	7.4	0.2	1.1	3.4	8.9	1.3	6.7	2.0	4.9
RE_2O_3	0.58	0.12	0.82	-	-	1.16	0.32	0.62	-	2.57
La/Nd	0.40	0.52	0.22	0.22	0.61	0.40	0.18	0.77	0.31	0.69

(a) Eu+Gd calcd. as Gd

(161-162) Kholodnov et al. (1975a), Urals, U.S.S.R.; (161) granodiorite, Nizhne Samarskii; (162) biotite-amphibole granite, Verkhisetskii; (163) Orsa et al. (1967), aplitic pegmatitic granite, Middle Dnepr region, U.S.S.R.; (164-165) Shmakin and Shiryaeva (1968), muscovite pegmatites, E. Siberia; (166) Khvostova (1962), diopside-scapolite vein, Federov, S. Yakutia; (167) Orsa et al. (1967), biotite-plagioclase gneiss, Middle Dnepr region; (168) Yurgina et al. (1975), quartz-muscovite metasomatite, Strel'na, Karelia, U.S.S.R.; (169) Roelandts and Duchesne (1979), av. of 3, Fe-Ti ore, Rogaland, Norway; (170) Semenov and Barinskii (1958), granite, Talitsk massif, Gornyi Altai.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.	171	172	173	174	175	176	177	178	179	180
La	12.8	10.6	10.3	8.0	30.7	12.3	7.0	10.6	7.0	11.5
Ce	25.5	26.6	28.7	31.7	–	28.7	29.1	28.3	31.9	24.7
Pr	5.1	6.2	4.8	4.2	13.3	3.1	8.3	5.6	5.8	8.5
Nd	18.6	23.5	19.2	30.8	40.3	15.4	26.0	25.5	25.7	39.6
Sm	6.0	6.7	7.4	9.7	6.9	5.3	8.9	6.8	8.3	6.4
Eu	–	–	–	0.6	1.2	0.8	0.6	–	0.9	0.8
Gd	11.5	8.1	11.2	9.5	–	8.9	7.8	7.5	7.9	8.5
Tb	2.8	–	1.3	–	0.9	1.4	1.1	–	–	–
Dy	11.2	6.3	3.3	2.7	4.5	10.1	6.2	4.5	4.4	–
Ho	1.6	2.0	1.8	1.1	0.9	2.0	6.9	1.8	1.3	–
Er	3.3	5.1	6.3	–	–	7.5	2.1	3.5	3.6	–
Tm	–	0.6	2.1	–	–	1.1	0.4	3.3	0.4	–
Yb	1.6	3.7	3.1	1.7	1.3	2.7	1.4	2.3	2.5	–
Lu	–	0.6	0.5	–	–	0.7	0.2	0.3	0.3	–
Y/(Y+Ln)x100	(48.2)	(35.5)	(17.0)	(30.2)	(28.6)	(29.0)	–	(26.3)	(26.3)	(17.2)
Method	XF	OS	CH	OS	–	OS	XF	OS	OS	–
Σ = La+Ce+Pr	43.4	43.4	43.8	43.9	44.0	44.1	44.4	44.5	44.7	44.7
La-Nd	62.0	66.9	63.0	74.7	84.3	59.5	70.4	70.0	70.4	84.3
Sm-Ho	33.1	23.1	25.0	23.6	14.4	28.5	25.5	20.6	22.8	15.7
Er-Lu	4.9	10.0	12.0	17	1.3	12.0	4.1	9.4	6.8	–
RE_2O_3	2.57	0.95	0.07	0.62*	0.29*	0.42	1.07	0.18	0.46	–
La/Nd	0.69	0.45	0.54	0.26	0.76	0.80	0.27	0.41	0.27	0.29

* = % R.E.

(171) Sahama and Vahatalo (1941), granite pegmatite, Uinerla, Finland; (172) Kholodnov et al. (1975b), granite, Il'men Mts., Urals, U.S.S.R.; (173) Leonova and Elina (1969), muscovite pegmatite, White Sea region, U.S.S.R.; (174) Lee et al. (1973), xenolith from hybrid granitoid, Snake Range, Nev.; (175) Nadareishvili (1973), gabbro, S. Calif. batholith; (176) Kholodnov et al. (1975a), biotite gneiss, Taratshchii complex, Urals, U.S.S.R.; (177) Lyakhovich (1968), granodiorite, Far Eastern U.S.S.R.; (178-179) Kholodnov et al. (1975a), Urals, (178) quartz diorite, Marinovskii; (179) biotite granite; (180) Ivantishin et al. (1964), Precambrian migmatite, Ukraine.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.	181	182	183	184	185	186	187	188	189	190
La	15.0	9.1	9.8	13.1	11.9	9.6	11.9	11.2	21.4	22.2
Ce	27.4	30.7	30.2	26.1	30.5	31.0	33.6	34.3	24.1	23.3
Pr	2.4	5.0	5.1	6.1	2.9	4.8	-	-	-	-
Nd	25.2	27.2	16.4	18.0	41.0	30.1	6.3	29.4	42.2	44.0
Sm	10.5	6.4	5.8	6.1	7.6	14.4	4.4	9.0	8.1	6.6
Eu	-	0.6	a	0.6	-	0.9	-	2.0	1.2	0.9
Gd	12.6	8.5	11.4[a]	7.9	6.1	5.7	12.2	9.9	-	-
Tb	-	-	b	-	c	-	-	1.5	0.8	0.9
Dy	5.2	5.2	6.6	9.8	c	0.9	9.4	-	-	-
Ho	0.5	1.2	1.4	2.3	-	0.9	5.1	1.3	-	-
Er	0.9	3.0	8.2	4.8	-	-	14.5	-	-	-
Tm	-	0.3	1 2	0.8	-	0.4	1.8	-	-	-
Yb	0.3	2 5	3.7	3.9	-	1.3	0.8	1.4	1.9	1.9
Lu	-	0.3	0.2	0.5	-	-	-	-	0.3	0.2
Y/(Y+Ln)x100	(32.8)	(27.5)	(47.5)[b]	(30.6)	(9.2)[c]	(22.9)	(54.1)	-	-	-
Method	CH	OS	CH	OS	CH	OS	OS	NA	NA	NA
Σ = La+Ce+Pr	44.8	44.8	45.1	45.3	45.3	45.4	45.5	45.5	45.5	45.5
La-Nd	70.0	72 0	61.5	63.3	86 3	75.5	51.8	74.9	87.7	89.5
Sm-Ho	28.8	21.9	25.2	26.7	13.7	22.8	31.1	23 7	10 1	8.4
Er-Lu	1.2	6.1	13 3	10.0	-	1.7	17.1	1.4	2 2	2.1
RE_2O_3	-	0.51	0.20	0.53	-	0.39*	0.81	0 30*	0.12*	0.23*
La/Nd	0.60	0.34	0.59	0.73	0.29	0.32	1.88	0.38	0.51	0.50

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(181) Shmakin and Shiryaeva (1968), muscovite pegmatite, E. Siberia; (182) Kholodnov et al. (1975a), biotite granite, Dzhabik-Karagusik, Urals, U.S.S.R.; (183) Bel'kov (1979), biotite granite, Purnach River, Kola Peninsula, U.S.S.R.; (184) Kholodnov et al. (1975a), biotite granite, Chelyabinsk, Urals; (185) Afanas'ev et al. (1976), apatite-carbonate rock, Zagedan Mt., Caucasus, U.S.S.R.; (186) Lee et al., (1973), hybrid granitoid, Snake Range, Nev.; (187) Yurgina et al. (1975), plagioclase pegmatite, Karelia, U.S.S.R.; (188) Paster et al. (1974), upper zone, Skaergaard intrusive, Greenland; (189-190) Puchelt and Emmerman (1976), gneisses, Black Forest, Germany; (189) Berna; (190) Mambach.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.	191	192	193	194	195	196	197	198	199	200
La	11.3	9.4	9.7	9.0	7.6	9.8	8.9	7.0	10.4	8.7
Ce	28.1	31.6	29.9	33.2	33.0	22.7	29.2	39.2	29.9	37.7
Pr	6.2	4.6	6.0	3.6	5.3	13.5	8.0	–	6.0	–
Nd	17.7	20.6	29.1	33.6	35.9	18.5	29.6	22.6	16.2	6.6
Sm	8.6	9.2	13.9	7.9	7.3	9.2	6.8	15.1	6.6	8.6
Eu	0.6	–	0.8	a	a	1.5	0.8	–	0.2	–
Gd	8.4	13.1	5.6	9.5[a]	7.2[a]	8.2	4.9	10.3	9.3	17.1
Tb	1.2	–	–	0.6	0.4	–	–	–	1.1	–
Dy	8.9	7.4	1.6	1.1	1.7	14.3	8.6	6.3	7.9	11.1
Ho	1.7	1.5	0.8	–	–	–	0.5	1.1	3.2	0.9
Er	4.3	2.5	–	1.3	1.1	2.2	1.4	0.3	4.3	5.1
Tm	0.3	–	0.4	–	–	–	0.5	0.3	0.5	3.2
Yb	2.2	0.1	2.2	0.1	0.5	0.1	0.6	1.8	3.9	1.0
Lu	0.5	–	–	0.1	–	–	0.2	–	0.5	–
Y/(Y+Ln)x100	(38.6)	(40.0)	(26.1)	(30.3)	(28.2)	(31.0)	–	(34.1)	–	(59.2)
Method	CH	CH	OS	CH	CH	–	OS	OS	XF	OS
Σ = La+Ce+Pr	45.6	45.6	45.6	45.8	45.9	46.0	46.1	46.2	46.3	46.4
La-Nd	63.3	66.2	74.7	79.4	81.8	64.5	75.7	68.8	62.5	53.0
Sm-Ho	29.4	31.2	22.7	19.1	16.6	33.2	21.6	28.8	28.3	37.7
Er-Lu	7.3	2.6	2.6	1.5	1.6	2.3	2.7	2.4	9.2	9.3
RE_2O_3	0.60	–	0.42*	0.36	0.26	0.80	0.21	0.78	0.41	0.76
La/Nd	0.64	0.46	0.33	0.27	0.21	0.53	0.30	0.31	0.64	1.32

* = % R.E.
(a) Eu+Gd calcd. as Gd

(191) Kuts (1971), granite, Beletserkov, W. Azov region, U.S.S.R.; (192) Shmakin and Shiryaeva (1968), muscovite pegmatite, E. Siberia; (193) Lee et al. (1973), hybrid granitoid, Snake Range, Nev.; (194-195) Orsa et al. (1967), Middle Dnepr region, U.S.S.R.; (194) amphibole migmatite; (195) plagiogranite; (196) Portnov and Gorobets (1969), granite pegmatite, Mama, E. Siberia; (197) Zayats and Kuts (1964), biotite gneiss, Ukraine; (198) Yurgina et al. (1975), plagioclase pegmatite, Bolshoi Olenii, Karelia, U.S.S.R.; (199) Lyakhovich (1968), greisenized granite, N.E. U.S.S.R.; (200) Yurgina et al. (1975), quartz-muscovite metasomatite, Khetolambino, Karelia.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	201	202	203	204	205	206	207	208	209	210
La	12.5	7.4	9.6	17.9	10.5	9.0	8.6	1.7	23.4	13.0
Ce	34.2	29.5	32.1	29.3	30.6	32.9	32.5	39.2	24.3	35.0
Pr	—	9.8	3.1	—	6.1	5.5	6.4	6.7	—	—
Nd	31.9	39.0	32.7	21.8	26.2	20.1	31.0	17.4	39.6	28.5
Sm	6.7	7.4	7.4	8.7	6.4	7.7	5.5	12.3	7.4	7.0
Eu	1.3	—	a	—	1.0	a	a	0.4	0.3	1.3
Gd	6.5	6.9	8.9[a]	7.6	7.7	8.1[a]	5.2[a]	9.7	—	7.2
Tb	0.8	—	0.6	—	—	b	0.7	1.3	0.8	1.0
Dy	3.2	—	2.3	6.3	4.0	7.0	1.5	5.9	—	3.8
Ho	0.6	—	—	1.4	1.0	1.7	0.6	1.0	—	0.7
Er	1.4	—	3.2	3.0	2.9	3.4	1.5	2.6	—	1.4
Tm	—	—	—	0.5	0.4	1.2	0.4	0.4	—	—
Yb	0.8	—	0.1	3.5	2.6	3.4	5.2	1.4	3.7	1.0
Lu	0.1	—	—	—	0.6	—	0.9	0.2	0.5	0.1
Y/(Y+Ln)x100	—	(24.8)	(33.4)	(46.0)	(25.2)	(54.9)[b]	(15.3)	—	—	—
Method	NA	—	CH	OS	OS	CH	CH	XF	NA	NA
Σ = La+Ce+Pr	46.7	46.7	46.8	47.2	47.2	47.4	47.5	47.6	47.7	48.0
La-Nd	78.6	85.7	77.5	69.0	73.4	67.5	78.5	65.0	87.3	76.5
Sm-Ho	19.1	14.3	19.2	24.0	20.1	24.5	13.5	30.4	8.5	21.0
Er-Lu	2.3	—	3.3	7.0	6.5	8.0	8.0	4.6	4.2	2.5
RE_2O_3	—	—	0.23	0.78	0.31	0.49	0.22	0.12	0.49*	—
La/Nd	0.39	0.19	0.29	0.82	0.40	0.45	0.28	0.10	0.59	0.46

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(201) Roelandts and Duchesne (1979), Fe-Ti ore, Rogaland, Norway; (202) Ivantishin et al. (1964), Precambrian gneiss, Ukraine; (203) Orsa et al. (1967), migmatite, Middle Dnepr region, U.S.S.R.; (204) Yurgina et al. (1975), plagioclase pegmatite, Strel'na, Karelia, U.S.S.R.; (205) Kholodnov et al. (1975a), granodiorite, Nizhne Sanarskii, Urals, U.S.S.R.; (206) Chaschukhina (1975), pegmatite, Aduisk massif, Murzhinsk, U.S.S.R.; (207) Vinogradov and Elina (1968), granite, N.W. Kola Peninsula, U.S.S.R.; (208) Sobolev (1968), gabbro-norite, Sobskii, Urals; (209) Puchelt and Emmermann (1976), granite, Tegernau, Black Forest, Germany; (210) Roelandts and Duchesne (1979), Fe-Ti ore, Rogaland, Norway.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.—	211	212	213	214	215	216	217	218	219	220
La	13.1	10.9	7.9	9.7	23.3	9.7	9.0	10.5	10.8	12.9
Ce	35.3	32.3	36.9	31.5	14.6	31.6	33.3	38.8	33.3	31.5
Pr	—	5.4	3.8	7.6	10.9	7.6	6.8	—	5.2	5.1
Nd	27.6	23.3	35.8	26.7	32.2	26.7	32.4	30.1	32.4	26.5
Sm	7.0	7.2	3.4	8.8	6.1	8.7	8.4	6.4	4.7	5.7
Eu	1.3	2.9	0.6	1.0	1.2	1.0	a	0.6	—	—
Gd	7.1	4.5	6.5	5.7	5.1	5.7	8.0[a]	5.5	4.6	7.7
Tb	1.0	1.4	—	0.5	—	0.5	c	0.9	—	b
Dy	3.9	4.5	3.1	4.3	2.7	4.3	c	3.8	4.2	3.5
Ho	1.0	1.6	0.6	0.7	0.6	0.7	0.8	0.6	1.5	2.9
Er	1.7	2.3	—	1.9	1.8	1.9	0.5	1.7	—	3.6
Tm	—	0.7	—	—	0.2	—	—	—	—	—
Yb	0.9	2.2	1.4	1.4	1.1	1.4	0.8[d]	1.0	3.3	0.6
Lu	0.1	0.8	—	0.2	0.2	0.2	d	0.1	—	—
Y/(Y+Ln)x100	—	(33.8)	(21.4)	—	(29.4)	—	(15.6)[c]	—	(38.8)	(17.9)[b]
Method	NA	XF	OS	XF	OS	OS	CH	NA	OS	CH
Σ = La+Ce+Pr	48.4	48.6	48.6	48.8	48.8	48.9	49.1	49.3	49.3	49.5
La-Nd	76.0	71.9	84.4	75.5	81.0	75.6	81.5	79.4	81.7	76.0
Sm-Ho	21.3	22.1	14.2	21.0	15.7	20.9	17.2	17.8	15.0	19.8
Er-Lu	2.7	6.0	1.4	3.5	3.3	3.5	1.3	2.8	3.3	4.2
RE_2O_3	—	0.45*	0.49*	0.06	0.32	0.06	0.34	0.71*	0.43*	0.25
La/Nd	0.47	0.47	0.22	0.36	0.72	0.36	0.28	0.35	0.33	0.49

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y
(d) Yb+Lu calcd. as Yb

(211) Roelandts and Duchesne (1979), Fe-Ti ore, Rogaland, Norway; (212-213) Lee et al. (1973), Snake Range, Nev., (212) xenolith, (213) hybrid granitoid; (214) Sobolev (1968), diorite, Sobskii, Urals, U.S.S.R.; (215) Kholodnov et al. (1975a), migmatite, Il'men Mts., Urals; (216) Kholodnov et al. (1975b), gabbro, western slope, Urals; (217) Ploshko and Knyazeva (1965), quartz-phlogopite-carbonate rock, Caucasus, U.S.S.R.; (218) Brunfelt and Roelandts (1974), fluroapatite, nelsonite, Hesnas, Norway; (219) same as (213); (220) Bogatikov (1968), Kizirsk gabbro-syenite pluton, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. –	221	222	223	224	225	226	227	228	229	230
La	12.6	8.8	16.7	12.6	14.0	13.6	25.5	15.4	17.1	1.8
Ce	31.2	32.2	27.8	32.3	27.5	37.4	11.7	30.4	28.3	42.6
Pr	6.0	8.9	5.5	5.2	9.2	–	14.0	5.6	6.1	7.1
Nd	23.8	27.0	27.1	22.6	18.9	29.0	36.5	22.8	20.8	24.3
Sm	7.3	5.0	7.9	5.7	6.1	6.1	7.3	7.2	5.0	6.7
Eu	–	0.9	–	a	–	0.6	a	–	0.7	–
Gd	8.4	7.5	6.3	6.1 [a]	8.2	5.3	2.9 [a]	6.3	6.1	12.8
Tb	–	0.8	1.3	b	–	0.8	2.1	1.5	–	–
Dy	4.2	4.9	1.2	5.4	5.8	3.7	–	5.5	6.4	4.7
Ho	1.0	0.8	0.9	2.1	1.3	0.7	–	1.2	1.5	–
Er	2.9	2.6	3.0	3.8	4.0	1.7	–	2.8	4.6	–
Tm	0.3	0.2	–	1.2	0.3	–	–	–	0.5	–
Yb	2.0	0.2	2.3	2.3	2.6	1.0	–	1.3	2.4	–
Lu	0.3	0.2	–	0.7	2.1	0.1	–	–	0.5	–
Y/(Y+Ln)x100	(23.8)	–	(37.8)	(33.5) [b]	(31.5)	–	(2.0)	(37.1)	(32.3)	(41.1)
Method	OS	XF	XF	CH	OS	NA	CH	XF	OS	EP
Σ = La+Ce+Pr	49.8	49.9	50.0	50.1	50.7	51.0	51.2	51.4	51.5	51.5
La-Nd	73.6	76.9	77.1	72.7	69.6	80.0	87.7	74.2	72.3	75.8
Sm-Ho	20.9	19.9	17.6	19.3	21.4	17.2	12.3	21.7	19.7	24.2
Er-Lu	5.5	3.2	5.3	8.0	9.0	2.8	–	4.1	8.0	–
RE_2O_3	0.74	0.07	0.3	5.79	0.29	–	0.79	0.9*	0.53	0.85
La/Nd	0.53	0.32	0.61	0.56	0.74	0.47	0.70	0.68	0.82	0.074

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(221) Kholodnov et al. (1975a), migmatite, Marzinsk complex, Urals, U.S.S.R.; (222) Sobolev (1968), silicified diorite, Sobskii, Urals; (223) Nadezhdina, quoted by Semenov (1963), granophyre, Krasnoyarsk region, U.S.S.R.; (224) Bel'kov (1979), alkali granite, Kuliok River, Kola peninsula, U.S.S.R.; (225) Kholodnov et al. (1975a), plagiogranite, Uruzhaevskii, Urals; (226) Roelandts and Duchesne (1979), Fe-Ti ore, Hesnes, Rogaland, Norway; (227) Ploshko and Knyazeva (1965), granitoid, Urushtun complex, N. Caucasus, U.S.S.R.; (228) Nadezhdina (1968), diorite pegmatite, Tungus River, Siberia; (229) Kholodnov (1975b), granite, Il'men Mts., Urals; (230) Griffin et al. (1972), chlorapatite, gabbro, Odegarden, Norway.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.—	231	232	233	234	235	236	237	238	239	240
La	14.1	14.2	14.0	12.6	9.6	10.4	3.4	12.3	10.9	7.6
Ce	37.5	37.5	33.8	33.8	33.4	35.1	41.6	36.8	34.9	44.8
Pr	–	–	4.1	5.5	8.9	6.5	7.1	3.1	6.5	–
Nd	26.0	27.3	20.8	22.7	34.2	24.7	24.7	26.9	30.6	8.7
Sm	6.7	6.7	13.0	5.6	7.5	7.2	3.5	7.2	3.3	6.7
Eu	0.7	1.2	–	0.5	0.9	0.8	–	1.4	–	–
Gd	6.1	5.9	6.8	6.0	5.5	6.9	2.9	8.3	7.7	11.7
Tb	1.0	0.9	b	1.3	–	–	–	–	b	–
Dy	4.0	3.4	3.6	4.1	–	3.5	9.3	2.7	4.3	7.3
Ho	0.9	0.6	0.5	0.7	–	0.7	6.9	–	0.5	4.4
Er	1.9	1.4	1.9	4.1	–	2.1	–	1.3	0.7	3.1
Tm	–	–	0.1	0.5	–	0.2	–	–	–	3.0
Yb	1.0	0.8	1.4	1.9	–	0.8	0.3	–	0.6	1.7
Lu	0.1	0.1	–	0.7	–	1.1	0.3	–	–	1.0
Y/(Y+Ln)x100	–	–	(29.0)[b]	(23.8)	(15.5)	(19.4)	(28.6)	–	(40.2)[b]	(53.4)
Method	NA	NA	CH	CH	–	OS	X-F	OS	CH	OS
Σ = La+Ce+Pr	51.6	51.7	51.9	51.9	51.9	52.0	52.1	52.2	52.3	52.4
La-Nd	77.6	79.0	72.7	74.6	86.1	76.7	76.8	79.1	82.9	61.1
Sm-Ho	19.4	18.7	23.9	18.2	13.9	19.1	22.6	19.6	15.8	30.1
Er-Lu	3.0	2.3	3.4	7.2	–	4.2	0.6	1.3	1.3	8.8
RE_2O_3	–	–	0.05	1.52	–	0.68	0.38*	0.98	0.42	0.50
La/Nd	0.54	0.52	0.67	0.56	0.28	0.42	0.14	0.46	0.36	0.87

* = % R.E.
(b) Tb+Y calcd. as Y

(231-232) Roelandts and Duchesne (1979), Fe-Ti ores, Rogaland, Norway; (233) Afanas'ev et al. (1976), granite, Moshchevaya, Caucasus, U.S.S.R.; (234) Kuts (1971), biotite granite, Kuznetsov-Mikhailov, W. Azov region, U.S.S.R.; (235) Ivantishin et al. (1964), Precambrian gneiss, Ukraine; (236) Kholodnov et al. (1975a), granodiorite, Shigirskii, Urals, U.S.S.R.; (237) Aleksiev (1965), granite, Nikolskii, Bulgaria; (238) Kholodnov et al. (1975b), gabbro, western slopes, Urals; (239) Afanas'ev et al. (1976), granodiorite, Belaya River, Caucasus; (240) Yurgina et al. (1975), contact of plagioclase pegmatite and muscovite with quartz, Karelia, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	241	242	243	244	245	246	247	248	249	250
La	17.0	16.0	11.4	18.1	10.2	22.0	12.9	12.8	2.1	11.2
Ce	27.4	31.4	34.8	29.5	34.6	31.2	34.1	34.0	42.2	37.3
Pr	-	5.2	6.5	5.2	8.2	-	6.6	6.8	-	5.3
Nd	32.1	25.7	30.0	29.3	32.2	16.2	22.8	23.1	36.7	22.4
Sm	-	7.6	6.3	7.6	3.2	7.2	7.3	6.8	10.0	4.8
Eu	-	-	0.7	-	0.7	-	1.3	a	5.0	1.7
Gd	3.9	5.9	4.9	4.7	4.0	11.3	7.4	5.8[a]	-	6.9
Tb	3.7	1.2	-	-	-	-	-	b	-	-
Dy	8.8	1.1	2.6	5.6	4.0	5.5	3.5	2.7	1.0	4.2
Ho	1.1	0.9	0.5	-	0.4	1.3	0.7	0.8	1.9	0.9
Er	1.9	2.8	1.5	-	1.0	2.7	2.1	4.8	0.5	2.7
Tm	1.4	-	0.1	-	0.5	0.4	0.2	-	0.2	0.3
Yb	2.7	2.2	0.6	-	0.7	2.0	0.8	2.4	0.4	2.3
Lu	-	-	0.1	-	0.3	0.2	0.3	-	-	-
Y/(Y+Ln)x100	(7.1)	(38.7)	(15.5)	(32.4)	-	(36.5)	(20.8)	(25.6)[b]	(6.3)	(36.5)
Method	-	XF	OS	EP	OS	OS	OS	CH	-	MS
Σ = La+Ce+Pr	52.6	52.7	52.7	52.8	53.0	53.2	53.6	53.6	53.6	53.8
La-Nd	76.5	78.3	82.7	82.1	85.2	69.4	76.4	76.7	81.0	76.2
Sm-Ho	17.5	16.7	15.0	17.9	12.3	25.3	20.2	16.1	17.9	18.5
Er-Lu	6.0	5.0	2.3	-	2.5	5.3	3.4	7.2	1.1	5.3
RE_2O_3	4.50	-	0.82	2.34	0.20	1.38	0.17	1.03	0.55	0.16*
La/Nd	0.53	0.62	0.38	0.62	0.32	1.36	0.57	0.55	0.06	0.50

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(241) Komov and Gorobets (1978), hydrothermally altered quartzite, Pamir; (242) Nadezhdina (1968), granophyre, Tungus River, Siberia; (243) Kholodnov et al. (1975a), granosyenite, Taratashkii, Urals, U.S.S.R.; (244) Griffin et al. (1972), lunar basalt no. 14310; (245) Zayats and Kuts (1964), pyroxene-hornblende gneiss, Ukraine; (246) Yurgina et al. (1975), microcline pegmatite, Bolshoi Olenii, Karelia, U.S.S.R.; (247) Kholodnov et al. (1975a), migmatite, Aleksandr-Akhten complex, Urals; (248) Kovalenko et al. (1971), biotite granite, Ongan-Khairkan, Mongolia; (249) Komov and Gorobets (1978), amphibolite, Pamirs; (250) Mason (1975), gneiss, Godthab region, Greenland.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. -	251	252	253	254	255	256	257	258	259	260
La	11.1	11.4	13.6	21.0	13.1	13.9	12.7	12.2	14.6	11.3
Ce	39.5	36.8	34.3	26.4	34.9	34.3	34.8	34.5	33.9	37.9
Pr	3.3	5.8	6.2	6.7	6.2	6.1	6.8	7.6	5.9	5.2
Nd	17.5	35.8	17.2	20.3	22.0	19.4	25.7	30.3	15.8	27.4
Sm	6.4	3.6	7.8	13.0	5.9	5.9	4.1	7.4	10.5	4.0
Eu	a	1.1	0.4	-	-	1.1	0.4	-	0.4	a
Gd	9.5[a]	3.0	6.4	12.6	7.3	6.7	4.1	7.3	8.4	5.5[a]
Tb	b	-	1.0	c	-	-	2.4	c	1.1	b
Dy	6.4	1.5	6.6	c	4.0	5.8	3.4	c	4.8	3.3
Ho	0.3	0.5	1.3	-	1.1	1.5	0.7	-	0.9	1.1
Er	2.5	-	2.0	-	2.7	3.7	2.2	0.7	2.1	2.2
Tm	0.3	-	0.4	-	0.3	0.5	0.2	-	0.3	0.5
Yb	3.2	0.5	2.4	-	2.2	0.3	2.1	-	1.2	1.6
Lu	-	-	0.4	-	0.3	0.8	0.4	-	0.1	-
Y/(Y+Ln)x100	(46.0)[b]	(15.0)	-	(33.5)[c]	(24.5)	(30.4)	(26.8)	(28.3)[c]	(39.1)	(21.3)[b]
Method	CH	OS	XF	CH	OS	OS	CH	CH	XF	CH
Σ = La+Ce+Pr	53.9	54.0	54.1	54.1	54.2	54.3	54.3	54.3	54.4	54.4
La-Nd	71.4	89.8	71.3	74.4	76.2	73.7	80.0	84.6	70.2	81.8
Sm-Ho	22.6	9.7	23.5	25.6	18.3	21.0	15.1	14.7	26.1	13.9
Er-Lu	6.0	0.5	5.2	-	5.5	5.3	4.9	0.7	3.7	4.3
RE_2O_3	0.60	0.31*	0.31	0.01	0.69	0.63	1.54	0.28	-	0.07
La/Nd	0.63	0.32	0.79	1.03	0.59	0.71	0.49	0.40	0.92	0.41

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(251) Chashchukhina (1975), pegmatitic granite, Aduisk massif, Urals, U.S.S.R.; (252) Lee et al. (1973), hybrid granitoid, Snake Range, Nev.; (253) Borodin (1960), granite pegmatite, Gornyi Altai; (254) Afanas'ev et al. (1976), meta-amphibolite, Buruny River, Caucasus, U.S.S.R.; (255-256) Kholodnov et al. (1975a), Urals; (255) biotite granite, Chelyabinsk; (256) biotite migmatite, Il'men Mts.; (257) Kuts (1971), hornblende-biotite granite, W. Azov region, U.S.S.R.; (258) Afanas'ev et al. (1976), plagiogranite, Bolshoi Zelenchak River, Caucasus; (259) Sobolev, quoted by Semenov (1963), gabbro-norite, Polar Urals; (260) Chashchukina (1975), biotite granite, Shemeisk massif, Urals.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.—	261	262	263	264	265	266	267	268	269	270
La	15.2	14.8	14.3	15.5	15.7	18.1	12.3	12.6	18.5	13.0
Ce	32.4	39.2	31.7	33.9	21.9	31.2	37.1	35.0	31.0	37.0
Pr	6.9	0.6	8.7	5.4	17.2	5.6	5.5	7.3	5.6	5.1
Nd	21.5	16.4	19.9	24.0	25.0	21.8	22.2	27.2	9.6	29.3
Sm	6.8	7.3	5.6	6.2	11.2	7.5	6.6	6.7	–	6.1
Eu	3.5	a	–	–	a	–	–	1.0	–	6.2
Gd	6.7	7.7[a]	6.6	6.4	8.2[a]	5.8	8.0	5.4	–	4.2
Tb	0.5	b	2.8	0.6	–	1.0	–	0.4	–	–
Dy	3.6	5.0	7.4	3.7	0.8	4.8	4.1	2.5	2.5	0.2
Ho	0.4	0.6	0.6	1.5	–	0.9	0.8	0.4	–	3.0
Er	1.7	3.3	–	1.5	–	2.2	2.2	0.9	–	0.1
Tm	0.3	1.1	–	–	–	–	0.2	–	–	1.7
Yb	0.4	4.0	1.5	1.0	–	1.1	0.9	0.4	32.8	0.1
Lu	0.1	–	0.9	0.3	–	–	0.1	0.2	–	0.1
Y/(Y+Ln)x100	(16.0)	(46.6)[b]	(12.1)	(21.0)	(14.8)	(33.0)	(32.8)	–	(14.1)	(13.8)
Method	OS	CH	CH	CH	CH	XF	OS	OS	XF	CH
Σ = La+Ce+Pr	54.5	54.6	54.7	54.8	54.8	54.9	54.9	54.9	55.1	55.1
La-Nd	76.0	71.0	74.6	78.8	79.8	76.7	77.1	82.1	64.7	84.4
Sm-Ho	21.5	20.6	23.0	18.2	20.2	20.0	19.5	16.4	25	13.6
Er-Lu	2.5	8.4	2.4	2.0	–	3.3	3.4	1.5	32.8	2.0
RE_2O_3	0.89	0.39	0.59*	0.87	–	–	0.36	0.16	–	1.58
La/Nd	0.71	0.90	0.72	0.65	0.63	0.83	0.56	0.46	1.92	0.44

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(261) Kapustin (1977), redeposited apatite, Novopoltavsk carbonatite, Ukraine; (262) Chaschukhina (1975), pegmatite, Aduisk massif, Urals, U.S.S.R.; (263) Nadezhdina (1968), ferrogabbro, Bol'shaya Botuobiya River; (264) Kuts (1971), aplitic granite, Petrovskii-Gnutov, W. Azov region, U.S.S.R.; (265) Kukharenko et al. (1969), gabbro, Karelia, U.S.S.R.; (266) Nadezhdina (1968), diorite pegmatite, Tungus River, Siberia; (267-268) Kholodnov et al. (1975), Urals; (267) granite, Murzinsk; (268) gabbro; (269) Bel'kov and Batieva (1969), syenite, Sakhariok massif; (270) Kuts (1971), granite, Tokmok, W. Azov region, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. -	271	272	273	274	275	276	277	278	279	280
La	10.5	13.6	18.8	15.6	10.9	1 4	11.7	12 8	11 8	10.2
Ce	39.4	34.9	31.0	33.7	38.7	48.7	39.5	38.6	39 3	40.3
Pr	5.2	6.7	5.5	4.2	6 0	5.6	4.7	4.6	5.2	5.9
Nd	31.2	23.6	21.2	24.4	23.0	10.3	25.2	23.0	25.3	25.3
Sm	5.2	5.2	7.5	5.5	5.6	6 1	5.6	5.9	4.8	6.3
Eu	a	0.8	-	-	1.2	-	0.2	0.3	1.1	0.5
Gd	4.6[a]	6.5	5.7	6.6	5.9	21.6	6.5	6 0	7.0	6.9
Tb	0.3	-	1.0	0.5	-	c	-	0.9	-	-
Dy	1.0	3.2	4.9	5.1	3 3	c	3.2	4.2	3.3	2.3
Ho	-	0.8	0.9	0.5	0.7	1.5	0.5	0.5	1.1	0.3
Er	1.0	2.3	2.3	1.1	2.1	2.0	1 8	1.7	-	1.4
Tm	-	0.3	-	0.1	0.3	0.7	0.2	0.3	-	0.1
Yb	1.6	1.8	1.2	0.5	2.0	2.1	0.8	1 1	1.1	0 4
Lu	-	0.3	-	0.2	0.3	-	0.1	0.1	-	0.1
Y/(Y+Ln)x100	(20.4)	(25.3)	(31.1)	(23.7)	(24.7)	(33.6)[c]	(19.0)	-	(27 1)	(11.0)
Method	CH	OS	XF	CH	OS	CH	OS	-	OS	OS
Σ = La+Ce+Pr	55.1	55.2	55.3	55 5	55.6	55.7	55.9	56.0	56 3	56.4
La-Nd	86 3	78.8	76.5	79.9	78.6	66.0	81 1	79.0	81.6	81.7
Sm-Ho	11.1	16.5	20.0	18.2	17.7	29.2	16 0	17.8	17.3	16.3
Er-Lu	2.6	4.7	3 5	1.9	4.7	4 8	2.9	3.2	1.1	2.0
RE_2O_3	0.24	0.22	0.8	0.52	0.50	0.18	0.99	-	0.49*	0 60
La/Nd	0.34	0.58	0.89	0.64	0 47	0.14	0.47	0.56	0 47	0.40

* = % R.E.
(a) Eu+Gd calcd. as Gd
(c) Tb+Dy+Y calcd. as Y

(271) Kuts (1971), granodiorite, W. Azov region, U.S.S.R.; (272) Kholodnov et al. (1975a), quartz diorite, Minovskii, Urals, U.S.S.R.; (273) Nadezhdina, quoted by Semenov (1963), diorite pegmatite, Krasnoyarsk region, U.S.S.R.; (274) Azimov and Likhoidov (1966), hornblende gabbro, Shaidavaz, W. Uzbekistan; (275) Kholodnov et al. (1975a), granite gneiss, Il'men Mts., Urals; (276) Afanas'ev et al. (1976), plagioclase gneiss, Caucasus, U.S.S.R.; (277) Kholodnov et al. (1975a), migmatite, Murzinsk, Urals; (278) Lyakhovich and Kasaeva (1968), granite, Baksan River Canyon, Kabaridin-Balkanks A.S.R.; (279) Lee et al. (1973), xenolith in hybrid granitoid, Snake Range, Nev.; (280) Kholodnov et al (1975b), alaskite, Murzinsk, Urals.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. -	281	282	283	284	285	286	287	288	289	290
La	10.3	13.3	10.9	13.3	12.0	8.1	12 4	14.7	8.4	10.9
Ce	38.8	36.8	37.2	36.4	36.8	39 1	40.6	36.9	42.5	41.4
Pr	7.3	6.6	8.8	7.3	8.2	9.9	4.2	5.6	6.6	5.3
Nd	26.9	22.9	34.7	25.1	26.2	23 1	21.2	23.2	41.3	18.9
Sm	6.4	6.2	3.4	5.1	5.2	7.1	7.2	5.1	-	3.0
Eu	0.8	-	0.7	-	-	1.4	0.8	0.6	-	1.0
Gd	3 7	5.0	4.3	5.1	4.6	4.1	6 9	6.9	-	2.9
Tb	0.5	-	-	-	3.5	0.2	-	0.4	-	0.5
Dy	2.4	2.4	-	4.7	1 6	3.1	3 7	3 4	0.6	2.6
Ho	0.4	4.5	-	1.5	0.6	0.9	0.7	0.6	-	0.9
Er	1.1	1.5	-	-	1 3	1.7	1.5	1.5	-	8.9
Tm	-	0.1	-	-	-	0 4	-	0.2	-	0.1
Yb	1 2	0.7	-	1.5	-	0.9	0.9	0.9	0.6	1.8
Lu	0.2	-	-	-	-	-	-	-	-	1.8
Y/(Y+Ln)x100	-	(16.1)	(14.0)	(27.2)	-	-	-	(24.3)	(18.6)	(23.7)
Method	XF	OS	-	OS	CH	XF	OS	XF	OS	XF
Σ = La+Ce+Pr	56.4	56 7	56.9	57 0	57 0	57.1	57.2	57 2	57.5	57.6
La-Nd	83 3	79.6	91.6	82 1	83.2	80.2	78 3	80.4	98 8	76.5
Sm-Ho	14.2	18.1	8 4	16.4	15.5	16.8	19.3	17.0	0.6	10.9
Er-Lu	2 5.	2.3	-	1.5	1.3	3.0.	2.4	2.6	0.6	12.6
RE_2O_3	0.8	0.62	-	0.35*	-	0.5	0.52	0.39	0.27*	0.41
La/Nd	0.38	0.58	0 31	0.53	0.46	0.35	0.58	0.63	0.20	0.57

* = % R.E. (281) Khomyakov (1964), hydrothermal calcite vein, southern Siberia; (282) Kholodnov et al. (1975a), biotite granite gneiss, Murzinsk, Urals, U.S.S.R.; (283) Ivantishin et al. (1964), Precambrian gneiss, Ukraine; (284) Lee et al. (1973), hybrid granitoid, Snake Range, Nev.; (285) Afanas'ev et al. (1976), apatite-carbonate rock, Buruny River, Caucasus, U.S.S.R.; (286) Khomyakov (1964), hydrothermal granosyenite, southern Siberia; (287) Kholodnov et al. (1975b), gabbro, western slopes, Urals; (288) Parak (1973), Henry iron ore, Lappland; (289) Kholodnov et al. (1975a), biotite granite gneiss, Murzinsk, Urals; (290) same as (288).

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. –	291	292	293	294	295	296	297	298	299	300
La	12.8	2.3	11.4	12.5	17.7	12.1	16.5	12.3	10.5	7.7
Ce	39.8	49.1	39.4	39.9	35.3	38.5	36.9	40.6	41.2	43.7
Pr	5.2	6.6	7.2	5.6	5.2	7.7	4.9	5.6	7.0	7.4
Nd	28.9	12.6	24.7	25.0	21.8	20.2	21.2	20.6	23.6	22.4
Sm	4.4	5.8	7.4	3.2	7.0	6.5	4.2	5.7	6.8	9.6
Eu	a	–	0.5	a	–	0.3	0.6	0.6	0.6	–
Gd	5.2[a]	14.8	4.5	5.3[a]	5.7	6.8	7.1	2.4	4.8	9.2
Tb	0.2	–	.0.4	b	–	0.7	0.6	0.7	0.4	c
Dy	1.0	6.8	2.4	3.2	3.4	3.3	4.5	6.4	2.6	c
Ho	–	0.4	–	1.1	0.5	0.8	0.6	1.1	0.3	–
Er	1.0	–	1.2	2.1	2.1	1.8	1.6	1.7	1.1	–
Tm	–	–	0.3	0.5	0.1	0.3	0.2	0.2	0.1	–
Yb	1.5	1.4	0.5	1.6	1.2	0.9	1.1	1.6	0.9	–
Lu	–	0.2	0.1	–	–	0.1	–	0.5	0.1	–
Y/(Y+Ln)x100	(16.0)	(8.1)	–	(18.5)[b]	(20.1)	–	(28.8)	(17.0)	–	(25.0)[c]
Method	CH	XF	XF	CH	OS	XF	XF	CH	XF	CH
Σ = La+Ce+Pr	57.8	58.0	58.0	58.0	58.2	58.3	58.3	58.5	58.7	58.8
La-Nd	86.7	70.6	82.7	83.0	80.0	79.5	79.5	79.1	82.3	82.8
Sm-Ho	10.8	27.8	15.2	12.8	16.6	17.6	17.6	16.9	15.5	16.0
Er-Lu	2.5	1.6	2.1	4.2	3.4	2.9	2.9	4.0	2.2	1.2
RE_2O_3	0.22	0.35*	0.31	0.07	0.77	0.45	0.45	2.04	0.44	0.29
La/Nd	0.44	0.18	0.46	0.50	0.81	0.78	0.78	0.60	0.44	0.49

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(291) Orsa et al. (1967), amphibolite, Middle Dnepr region, U.S.S.R.; (292) Aleksiev and Chernokolev (1967), leuco-monzonite, Rossen pluton, Bulgaria; (293) Ganzeev et al. (1966), amphibole-biotite migmatite, Vishnevye Mts., Urals, U.S.S.R.; (294) Chashchukhina (1975), biotite granite, Kameninskii massif, Urals; (295) Kholodnov et al. (1975a), quartz diorite, Milisaiskaya, Urals; (296) Lyakhovich (1968), granodiorite, E. Trans-baikal; (297) Parak (1973), Rektorn iron ore deposit, Lappland; (298) Kuts (1971), hornblende-biotite granite, W. Azov region, U.S.S.R.; (299) same as (293); (300) Berzina et al. (1979), Archean carbonate rocks.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	301	302	303	304	305	306	307	308	309	310
La	11.7	25.6	18.2	17.6	14.5	13.7	16.0	17.9	14.8	14.3
Ce	40.2	29.4	37.5	36.1	39.7	39 7	31 9	37.4	36.8	40.1
Pr	6.9	4.0	3.6	5.8	5.3	6.2	11.7	4.4	8.3	5.6
Nd	24.0	25.4	21.2	19.3	21.7	23.3	25.9	20.3	23.9	25.0
Sm	7.4	8.7	4.0	5.7	5.2	4.8	2.0	5.5	6.9	6.3
Eu	0.4	–	0.6	3.0	0.3	0.2	0.5	–	0.6	a
Gd	4.8	6.9	5.5	6.6	5.3	6.2	4.8	5.8	4.4	6.2[a]
Tb	0.4	c	0 6	0.4	–	0.8	0.7	–	0.2	b
Dy	2.6	c	3.7	3 3	3.2	3.0	3.7	3.3	2.2	1.0
Ho	0.4	–	0.5	0.4	0.7	0.6	0.2	0.9	0.2	0.5
Er	0.9	–	2.1	1.2	2.1	0.9	1.8	2.4	0.4	1.0
Tm	–	–	–	0.2	0 3	0.1	–	0.4	0.2	–
Yb	0.3	–	1.5	0.3	1.4	0.5	0.7	1.7	0.9	–
Lu	–	–	1.0	0.1	0.3	–	0.1	–	0.2	–
Y/(Y+Ln)x100	–	(6.8)[c]	–	(16.8)	(23 3)	(18.3)	(5.8)	(24.2)	–	(22.0)[b]
Method	XF	CH	XF	OS	OS	XF	XF	OS	XF	CH
Σ = La+Ce+Pr	58.8	59.0	59.3	59.5	59.5	59.6	59.6	59.7	59.9	60.0
La-Nd	82.8	84 4	80.5	78.8	81.2	82.9	85.5	80.0	83.8	85.0
Sm-Ho	16.0	15.6	14.9	19.4	14.7	15.6	11.9	15.5	14.5	14.0
Er-Lu	1.2	–	4.6	1.8	4.1	1.5	2.6	4.5	1.7	1.0
RE_2O_3	0.29	0.54	0.03	0.65	0.49	0.49	~1	1.26	0.15	0.24
La/Nd	0.49	1.01	0.86	0.91	0.67	0.59	0.62	0.88	0.62	0.57

(a) Eu+Gd calcd. as Gd
(c) Tb+Dy+Y calcd. as Y

(301) Ganzeev et al. (1966), biotite gneiss, Vishnevye Mts., Urals, U.S.S.R.; (302) Vasil'eva (1976), kimberlite pipe, Yakutia; (303) Bliskovskii et al. (1969), metamorphic rock, Sladyanka, U.S.S.R.; (304) Kapustin (1977), redeposited apatite, carbonatite, Novopoltavskii, Ukraine; (305) Kholodnov et al. (1975a), granodiorite, Auebekhov, Urals; (306) Lyakhovich and Barinskii (1961) gabbro, Edygei massif, W. Tuva; (307) Sahama and Vahatalo (1941), gabbro, Volkov, Urals; (308) Kholodnov et al. (1975a), adamellite, E. Kairatinsk, Urals; (309) Lyakhovich (1968), diorite associated with gabbro, Urals; (310) Chashchukhina (1975), biotite granite, Shomeisk massif, Urals.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	311	312	313	314	315	316	317	318	319	320
La	18.1	16.1	16.0	18.5	18.2	25.9	12.7	16.7	14.1	10.9
Ce	39.9	39.5	39.2	32.6	36.1	28.4	40.8	33.4	41.3	45.0
Pr	2.1	4.5	4.9	9 2	6.0	6.1	7.0	10.4	5.1	4.7
Nd	14.8	22.2	25.3	23.5	23.5	23.5	21.8	24.6	27.8	29.0
Sm	3.6	3.7	4.4	3.5	5.6	5.5	3.6	8.1	4.5	4.1
Eu	—	1.1	1 1	0.4	—	a	1.1	a	a	0.9
Gd	4.4	3.7	4 6	5.2	5.4	4.3[a]	3.5	6.8[a]	3.6[a]	2.5
Tb	—	0.8	0.6	0.6	—	b	0.3	c	0.2	—
Dy	4.6	3 8	2.3	2.7	5.2	2.9	3.0	c	1.0	1.6
Ho	—	0.5	—	0.5	—	1.6	1.0	-	—	0.4
Er	5.6	2.4	0.9	1.4	—	0.6	3.0	—	1.2	—
Tm	—	0.2	—	0.2	—	0.2	0.3	—	—	—
Yb	6 9	1 4	0.7	1.5	—	0.6	1.6	—	1 2	0.9
Lu	-	0.1	—	0.2	—	0.4	0.3	—	—	—
Y/(Y+Ln)x100	(35.5)	(25.4)	(13 9)	-	(13.2)	(15.2)[b]	(22.9)	(15.5)[c]	(18 4)	(20.6)
Method	CH	XF	XF	XF	XF	CH	XF	CH	CH	OS
Σ = La+Ce+Pr	60.1	60.1	60.1	60.3	60.3	60.4	60.5	60.5	60.5	60.6
La-Nd	74.9	82.3	85.4	83 8	83 8	83.9	82.3	85.1	88.3	89.6
Sm-Ho	12.6	13.6	13.0	12.9	16 2	14 3	12.5	14.9	9.3	9.5
Er-Lu	12 5	4.1	1.6	3.3	—	1.8	5.2	-	2 4	0.9
RE_2O_3	0.43	0.58	—	0.12	1.86	11.20	1.55	0.10	0.20	0.40*
La/Nd	1.23	0.72	0.63	0.79	0.78	1.10	0.58	0.68	0.51	0.38

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(311) Koptyaev (1969), also Khvostova (1969), metamorphosed Precambrian conglomerate, Urals, U.S.S.R.; (312) Parak (1973), iron ore, Malmberget, Lappland; (313) Ilupin et al. (1971), dike, mainly carbonate, in kimberlite, Middle Oleneksii region, Yakutia; (314) Sobolev (1968), Sobskii, Urals; (315) Azimov and Likhoidov (1966), granite-aplite, W. Uzbekistan; (316) Bel'kov (1979), alkali granite, Purnach massif, Kola Peninsula, U.S.S.R.; (317) Parak (1973), iron ore, Leveaniemi, Lappland; (318) Ploshko and Knyazeva (1965), granitoid, Urushten complex, N. Caucasus, U.S.S.R.; (319) Orsa et al. (1967), amphibole migmatite, Middle Dnepr region, U.S.S.R.; (320) Lee et al. (1973), xenolith in hybrid granitoid, Snake Range, Nev.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	321	322	323	324	325	326	327	328	329	330
La	18.3	1.8	15.6	18 2	19.9	9.6	18.3	15.8	13.6	14.7
Ce	42.3	52 0	49.2	39.3	35.1	46.5	39.4	37.8	42.1	41.8
Pr	-	6 9	5.9	3.3	5.8	4 8	3 3	7.5	5.4	4.7
Nd	29.5	19.2	21.4	20.7	21.4	29.9	19.2	20.5	22.8	17.5
Sm	5.6	8.3	3.6	5 6	5.2	-	5.2	7.4	5.2	4.1
Eu	6.8	-	0.8	-	1.7	0.9	-	0.8	0.4	1.4
Gd	1 6	6.1	2.0	5.6	6.0	5.7	6.0	4.1	4.9	4.9
Tb	-	-	0.3	-	0.5	-	-	0.5	0.4	1.7
Dy	1.6	4.1	0.7	2.7	2 6	1.3	2.9	2.6	2.7	4.5
Ho	0.2	1.6	0.1	0.8	0.4	0.4	0.8	0.5	0.4	0.9
Er	-	-	0.2	2.2	0 9	-	2.7	1.6	1.1	2.2
Tm	-	-	-	0.2	0.1	-	0.3	—	0.3	0.2
Yb	0.1	-	0.2	1 4	0 3	0.9	1.9	0.9	0.7	1.2
Lu	-	-	-	-	0 1	-	-	—	-	0 2
Y/(Y+Ln)x100	(6.3)	(24.7)	-	(23.6)	(8.8)	(22.8)	(21.7)	—	-	(26.5)
Method	OS	XF	OS	-	OS	OS	OS	XF	OS	CH
Σ = La+Ce+Pr	60.6	60.7	60.7	60.8	60.8	60.9	61.0	61.1	611	61.2
La-Nd	90.1	79.9	92.1	81.7	82.2	90.8	80.2	81.6	83 9	78.7
Sm-Ho	9.8	20.1	7.5	14.5	16.4	8 3	14.9	15.9	14.0	17 5
Er-Lu	0.1	-	0.4	3.8	1.4	0.9	4 9	2.5	2.1	3.8
RE_2O_3	1.75*	0.43*	0.37	1.16	0 05	0.39*	1.61	0.09	1 92	0.30
La/Nd	0.62	0.10	0.73	0.88	0.93	0 32	0.95	0.77	0.60	0 84

* = % R.E. (321) Parker and Sharp (1970), carbonatite, Gem Park complex, Colo.; (322) Aleksiev and Chernokolev (1967), aplite, Rossen pluton, Bulgaria; (323) Zhirova and Lyagushkin (1979), carbonatite, Meimech-Kotui province, U.S.S.R.; (324) Starkov et al. (1973), av. of 6; granite, eastern Mugodzhar, U.S.S.R.; (325) Zhirova and Lyagushkin (1979), apatite-magnetite ore, Essei, Meimech-Kotui province; (326) Lee et al. (1973), hybrid granitoid, Snake Range, Nev.; (327) Kholodnov et al. (1975a), granite, Milisaiskaya, Urals, U.S.S.R.; (328) Sobolev et al. (1968), hornblendite vein, Sobskii, Urals; (329) Kholodnov et al. (1975b), gabbro, western slopes, Urals; (330) Kuts (1971), hornblende-biotite pegmatite, Vitosha pluton, Bulgaria.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	331	332	333	334	335	336	337	338	339	340
La	13.4	19.0	16.5	17.9	11.2	10.0	15.2	18 9	13.7	15.1
Ce	40.3	37.7	39.6	36.2	44.5	48.0	37.6	36.3	40.6	39.2
Pr	7.5	4.6	5.2	7.2	5.7	3 5	8.7	6.4	7.3	7.4
Nd	26.7	16.7	22.1	24.3	21.5	22.9	24.5	20.2	22.8	22.7
Sm	4.7	2.6	4.9	5.3	3.3	5.4	4.3	4.6	5.0	8.6
Eu	0.3	—	—	—	1.0	—	0.8	—	0 4	—
Gd	3 4	2.3	4.2	4.7	3.1	6.5	36	5.0	4 3	5.3
Tb	0.3	—	—	—	0.5	—	1.0	—	0.5	b
Dy	1.6	2.9	33	1.5	32	2.5	2.2	3 0	3.1	1.1
Ho	0.3	3 8	0.8	0.8	1.0	—	0.6	0.8	0.5	0.2
Er	0.7	-	1.9	1.3	3 1	1.2	0.5	2.2	1.1	0.4
Tm	—	-	0.2	0.1	0.1	-	0.3	0.3	0.2	-
Yb	0.6	2.0	1.0	0.7	1.4	-	0.7	2.0	0.5	-
Lu	0,2	8.4	0.3	-	0 4	-	-	0.3	-	-
Y/(Y+Ln)x100	—	(20.9)	(22.5)	(15.2)	(27.7)	-	(25.3)	(20.7)	(18.3)	(15.6)[b]
Method	0S	XF	0S	0S	XF	0S	0S	0S	XF	CH
Σ = La+Ce+Pr	61.2	61.3	61 3	61.3	61 4	61.5	61.5	61.6	61.6	61.7
La-Nd	87.9	78.0	83.4	85.6	82.9	84.4	86 0	81.8	84.4	844
Sm-Ho	10.6	11.6	13.2	12.3	12 1	14.4	12.5	13.4	13.8	15.2
Er-Lu	1.5	10.4	3 4	2.1	5.0	1.2	1.5	4 8	1 8	0 4
RE_2O_3	0.11	0.58*	0.72	0.25	0.37	0.56	0.19	0.57	0.82	0.006
La/Nd	0 50	1.14	0.75	0.74	0 52	0.44	0.62	0.94	0.60	0.67

* = % R.E.

(b) Tb+Y calcd. as Y

(331) Kholodnov et al. (1975b), gabbro, western slopes, Urals, U.S.S.R.; (332) Aleksiev (1965), pegmatite, Vitosha pluton, Bulgaria; (333-334) Kholodnov et al. (1975a), Urals; (333) migmatite, Il'men Mts.; (334) plagio-migmatite, Murzinsk; (335) Parak (1973), iron ore, Nukutusvaara, Lappland; (336) Kholodnov et al. (1975b), gabbro, western slopes, Urals; (337) Kapustin (1977), carbonatite, Novopoltavskii, Ukraine; (338) Kholodnov et al. (1975a), granitized gneiss, Murzinsk, Urals; (339) Lyakhovich and Barinskii (1961), Edygei massif, W. Tuva; (340) Rass (1972), phlogopite-melitite rock, Kovdor massif, Karelia, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. -	341	342	343	344	345	346	347	348	349	350
La	18.8	18.4	19.5	11.5	10.3	22.9	21.5	14.5	17.8	16.8
Ce	39.4	37.5	48.3	43.5	47.1	36.3	35.5	40.4	36.2	40.4
Pr	3.6	5.9	4.0	6.9	4.5	3.0	5.3	7.4	8.3	5.2
Nd	18.1	19.4	22.1	23.0	30.0	26.5	21.0	22.5	28.3	23.2
Sm	5.3	4.4	2.7	6.3	3.9	6.8	4.8	5.5	3.9	4.7
Eu	–	0.4	–	0.6	–	–	0.8	0.3	–	1.2
Gd	5.8	5.9	2.5	4.2	3.9	3.7	4.0	5.4	0.9	3.2
Tb	–	–	b	0.4	b	–	0.6	0.6	–	0.4
Dy	3.3	2.9	0.7	2.0	0.3	–	3.2	2.2	4.6	2.5
Ho	0.9	0.7	0.1	0.4	–	–	0.5	–	–	0.4
Er	2.6	2.2	0.1	0.9	–	0.7	1.6	1.2	–	1.3
Tm	0.3	0.3	–	–	–	–	–	–	–	0.2
Yb	1.9	1.7	–	0.3	–	0.1	1.2	–	–	0.4
Lu	–	0.3	–	–	–	–	–	–	–	0.1
Y/(Y+Ln)x100	(24.4)	(25.1)	(7.5)[b]	–	(2.3)[b]	(1.6)	(27.3)	–	–	–
Method	OS	OS	CH	XF	CH	CH	XF	XF	XF	OS
Σ = La+Ce+Pr	61.8	61.8	61.8	61.9	61.9	62.2	62.3	62.3	62.3	62.4
La-Nd	79.9	81.2	83.9	84.9	91.9	88.7	83.3	84.8	90.6	85.6
Sm-Ho	15.3	14.3	6.0	13.9	8.1	10.5	13.9	14.0	9.4	12.4
Er-Lu	4.8	4.5	0.1	1.2	–	0.8	2.8	1.2	–	2.0
RE_2O_3	1.20	0.20	0.32	0.31	0.40	0.11	0.42*	0.74	0.34	0.20
La/Nd	1.04	0.95	0.89	0.50	0.35	0.86	1.03	0.64	0.63	0.725

* = % R.E.
(b) Tb+Y calcd. as Y

(341-342) Kholodnov et al. (1975a), Urals, U.S.S.R.; (341) granite, Milisaiskaya, (342) plagiogranite gneiss, Murzinsk; (343) Rass (1970), pyroxene-fluorite-apatite rock, Bolshesayan massif, E. Siberia; (344) Ganzeev et al. (1966), biotite gneiss, Vishnevye Mts., Urals; (345) Vasil'eva (1976), carbonatite, Yakutia; (346) Kirillov and Ryzhova (1968), carbonatite, Kovdor, Karelia, U.S.S.R.; (347) Nadareishvili (1973), biotite gabbro, Adzheri-Triolat intrusive, Georgian S.S.R.; (348-349) Lyakhovich (1968), Urals; (348) diorite associated with gabbro; (349) granodiorite; (350) Knubovets et al. (1979), ijolite, Meimech-Kotui province, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No -	351	352	353	354	355	356	357	358	359	360
La	53.4	19.3	18.8	17.9	15.7	19.5	18 6	21.9	17.9	16.4
Ce	9.1	38.4	36.2	37.8	39.0	35.9	39.1	38.4	39.5	40.9
Pr	-	4.8	7.6	7.0	8.2	7.6	5.4	2.9	5.8	5.9
Nd	9.8	20.5	19.4	21.9	26.8	18.3	21.3	22.3	22.9	22.9
Sm	6.0	5.0	7.1	4.2	5.8	7.9	5.0	5.2	4.1	4.2
Eu	-	0.7	1.4	0.9	-	1.6	-	-	0.5	0.4
Gd	9.9	5.0	4.7	4.7	4.1	5.0	6.6	4.6	4.4	4.7
Tb	-	0.7	0.2	1.3	-	-	0.5	-	0.2	0.3
Dy	5.6	2.9	2.6	2.7	-	2.5	2.6	1.8	2.3	2.3
Ho	1.4	-	0.3	0.5	-	0.3	0.2	0.7	0 4	0.3
Er	2.8	1.8	1.0	0.5	-	0.9	0.4	1.4	1.1	1.0
Tm	0.2	-	0.3	-	-	0.2	0.1	0.1	0.1	0.1
Yb	1.6	0.9	0.4	0.6	0.4	0.3	0.1	0.7	0.8	0.6
Lu	0.2	-	-	-	-	-	0.1	-	-	-
Y/(Y+Ln)x100	(35.8)	(25.0)	(11)	(20.0)	(12.3)	(1.4)	(22.6)	(18.1)	(20.4)	(18.0)
Method	OS	XF	OS	OS	XF	OS	CH	-	XF	XF
Σ = La+Ce+Pr	62.5	62.5	62.6	62.7	62.9	63.0	63.1	63.2	63.2	63 2
La-Nd	72.3	83.0	82.0	84.6	89.7	81.3	844	85.5	86.1	86.1
Sm-Ho	22.9	14.3	16.3	14.3	9.9	17.3	14.9	12.3	11.9	12 2
Er-Lu	4.8	2 7	1.7	1.1	0 4	1 4	0.7	2.2	2 0	1.7
RE_2O_3	1.55	0.13	0.29	0.17	0.44*	0.34	1 18	0.96	0.49	0.37
La/Nd	5.44	0.94	0.96	0.82	0.58	1.06	0.88	0.98	0.78	0.71

* = % R.E.

(351) Yurgina et al. (1975), plagioclase pegmatite, Lopatova gube, Karelia, U.S.S.R.; (352) Nadareishvili (1973), essexite, Adzhari-Triolet intrusive, Georgian S.S.R.; (353-354) Kapustin (1977), carbonatites; (353) Magnet Cove, Ark.; (354) Novopoltarskii, Ukraine; (355) Plaksenko (1979), leucocratic gabbro-norite, Shiryeesk intrusive, U.S.S.R.; (356) Kapustin (1977), calcite carbonatite, Magnet Cove, Ark.; (357) Azimov and Likhoidov (1966), quartz-hornblende gabbro, Bel Tau, W. Uzbekistan; (358) Starkov et al. (1973), av. of 2 vulcanites, Mugodzhar, Urals, U.S.S.R.; (359-360) Parak (1973), iron ores, Lappland; (359) Kirunavaara; (360) Nukutusvaara.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	361	362	363	364	365	366	367	368	369	370
La	18.0	16.1	15.1	23.9	20.3	13.0	24.2	21.5	10.1	17.8
Ce	36.8	40.3	42.0	34.5	40.3	46.0	36.6	39.5	49.9	39.7
Pr	8.4	7.0	6.3	5.2	3.0	4.7	3.0	2.9	4.0	6.5
Nd	23.7	16.2	22.9	20.4	23.7	17.4	28.1	21.9	19.5	21.6
Sm	2.0	9.8	4.9	4.7	5.3	4.0	4.2	5.1	4.5	4.8
Eu	0.9	1.9	0.3	0.8	1.5	1.2	–	–	–	0.6
Gd	3.8	4.2	4.1	3.7	5.1	3.5	3.9	4.5	7.1	4.0
Tb	0.6	0.5	0.4	0.5	–	0.7	–	–	–	–
Dy	2.8	2.2	2.3	3.1	0.7	3.3	–	1.8	3.5	2.1
Ho	0.3	0.4	0.3	0.4	–	0.5	–	0.6	–	0.5
Er	1.8	0.8	1.0	1.6	–	2.2	–	1.4	0.8	1.3
Tm	–	0.3	–	–	–	0.3	–	0.1	–	0.1
Yb	0.8	0.3	0.4	1.2	0.1	2.9	–	0.7	0.6	0.8
Lu	0.1	–	–	–	–	0.3	–	–	–	0.2
Y/(Y+Ln)x100	(4.4)	(9.5)	–	(26.4)	(1.1)	(30.6)	(1.7)	(17.8)	(20.1)	(16.9)
Method	XF	OS	XF	XF	CH	XF	CH	–	OS	OS
Σ = La+Ce+Pr	63.2	63.4	63.4	63.6	63.6	63.7	63.8	63.9	64.0	64.0
La-Nd	86.9	79.6	86.3	84.0	87.3	81.1	91.9	85.8	83.5	85.6
Sm-Ho	10.4	19.0	12.3	13.2	12.6	13.2	8.1	12.0	15.1	12.0
Er-Lu	2.7	1.4	1.4	2.8	0.1	5.7	–	2.2	1.4	2.4
RE_2O_3	~1	0.82	0.67	0.42*	0.12	0.56	0.60	1.10	–	0.44
La/Nd	0.76	0.99	0.66	1.17	0.84	0.74	0.86	0.98	0.52	0.82

* = % R.E. (361) Sahama and Vahatalo (1941), gabbro, Vakis-Djvari, Georgian S.S.R.; (362) Kapustin (1977), calcite carbonatite, Novopoltavskii, Ukraine; (363) Sobolev et al. (1968), gabbro pegmatite, Kopanskii, Urals; U.S.S.R.; (364) Balashov et al. (1970), biotite gabbro, Kviran intrusive, Georgian S.S.R.; (365) Kirillov and Ryzhova (1968), dolomite carbonatite, Kovdor, Karelia, U.S.S.R.; (366) Parak (1973), iron ore, Malmberg, Lappland; (367) Rass (1973), carbonatite, Kovdor massif, Karelia; (368) Starkov et al. (1973), vulcanite, E. Mugodzhar, Urals; (369) Dagenhart and Maddox (1977), magnetite-ilmenite-apatite ore, North Garden, Va.; (370) Kholodnov et al. (1975a), migmatite, Il'men Mts., Urals.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	371	372	373	374	375	376	377	378	379	380
La	16.7	14.4	16.7	15.4	28.0	17.5	18.8	18.4	17.9	2.4
Ce	38.5	42.1	41.4	43.0	33.3	42.3	39.4	42.8	38.1	56.4
Pr	9.0	7.7	6.1	6.0	3.1	4.8	6.5	3.5	8.7	6.1
Nd	24.1	24.9.	25.2	22.1	24.4	25.2	16.0	17.1	17.3	17.8
Sm	6.1	4.7	4.1	4.2	3.9	3.7	8.3	3.8	5.1	6.5
Eu	—	a	—	1.1	1.5	0.9	2.0	0.5	0.3	—
Gd	3.1	4.3[a]	3.9	3.3	3.8	2.4	5.0	5.8	5.0	5.0
Tb	—	0.5	0.2	—	—	0.5	0.3	0.7	0.8	—
Dy	—	0.3	1.6	2.3	0.9	1.7	2.9	3.0	3.4	4.0
Ho	0.6	0.1	—	—	—	—	0.3	0.7	1.1	1.4
Er	1.4	0.2	0.8	1.6	1.0	0.6	—	2.2	1.3	—
Tm	—	0.3	—	—	—	—	0.2	0.5	—	—
Yb	0.5	0.5	—	1.0	0.1	0.4	0.3	0.8	0.8	—
Lu	—	—	—	—	—	—	—	0.2	0.2	—
Y/(Y+Ln)x100	(14.1)	(17.8)	—	(18.4)	(5.8)	(10.3)	(10.5)	(12.9)	(18.8)	(0.4
Method	XF	CH	XF	XF	CH	XF	OS	OS	CH	XF
Σ = La+Ce+Pr	64.2	64.2	64.2	64.4	64.4	64.6	64.7	64.7	64.7	64.7
La-Nd	88.3	84.1	89.4	86.5	88.8	89.8	80.7	81.8	82.0	82.5
Sm-Ho	9.8	9.9	9.8	10.9	10.1	9.2	18.8	14.5	15.7	17.5
Er-Lu	1.9	1.0	0.8	2.6	1.1	1.0	0.5	3.7	2.3	—
RE_2O_3	0.445*	0.95	0.62	—	0.37	0.43*	0.80	0.60	1.32	0.38
La/Nd	0.69	0.58	0.66	0.70	1.15	0.70	1.17	1.07	1.03	0.12

* = % R.E.
(a) Eu+Gd calcd. as Gd

(371) Plaksenko (1979), amphibolitized gabbro, Podkolovnar intrusive, U.S.S.R.; (372) Vinogradov and Elina (1968), granite, N.W. Kola Peninsula, U.S.S.R.; (373) Lyakhovich (1968), alaskite, Gornyi Altai; (374) Ilupin et al. (1971), kimberlite, Daddyne-Alakitskii region, Yakutia; (375) Kirillov and Ryzhova (1968), calcite carbonatite, Vuorijarvi, Karelia, U.S.S.R.; (376) Balashov and Pozharitskaya (1968), carbonatite, 3rd stage, W. Siberia; (377) Kapustin (1977), placer from Novopoltavskii carbonatite, Ukraine; (378) Kholodnov et al. (1975a), diorite, Krasuinsk, Urals, U.S.S.R.; (379) Kuts et al. (1971), granite, Tokmok Mogila, W. Azov region, U.S.S.R.; (380) Aleksiev and Chernokolev (1967), monzonite, Rossen pluton, Bulgaria.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.—	381	382	383	384	385	386	387	388	389	390
La	11.5	20.5	18.3	20.1	15.7	19.9	19.2	15.3	25.1	17.2
Ce	45.6	33.6	39.7	37.7	41.6	38.5	41.4	42.1	33.3	41.4
Pr	7.7	10.7	6.8	7.0	7.6	6.6	4.4	7.6	6.6	6.5
Nd	15.4	20.4	21.0	25.9	26.0	20.4	20.6	25.1	28.6	22.6
Sm	10.3	5.0	3.3	4.3	4.4	4.1	4.3	1.6	3.2	4.4
Eu	–	–	0.7	0.4	1.0	2.0	–	0.5	–	0.6
Gd	3.7	7.3	3.9	2.7	2.4	5.0	4.7	3.2	2.7	3.8
Tb	–	c	1.3	0.3	0.2	0.2	–	–	b	0.3
Dy	5.8	c	2.9	1.1	0.7	2.4	1.9	2.1	0.5	1.8
Ho	–	–	0.4	0.2	0.1	0.3	0.7	–	–	0.1
Er	–	1.5	0.5	0.3	0.2	–	1.6	1.5	–	0.7
Tm	–	–	0.4	–	–	0.2	0.1	–	–	0.1
Yb	–	1.0	0.8	–	0.1	0.3	1.1	1.0	–	0.4
Lu	–	–	–	–	–	0.1	–	–	–	0.1
Y/(Y+Ln)x100	(11.2)	(31.0)[c]	(14.1)	–	(4.4)	(12.0)	(17.9)	(18.1)	(2.5)[b]	–
Method	XF	CH	OS	XF	AA	OS	OS	–	CH	XF
Σ = La+Ce+Pr	64.8	64.8	64.8	64.8	64.9	65.0	65.0	65.0	65.0	65.1
La-Nd	80.2	85.2	85.8	90.7	90.9	85.4	85.6	90.1	93.6	87.7
Sm-Ho	19.8	12.3	12.5	9.0	8.8	14.0	11.6	7.4	6.4	11.0
Er-Lu	–	2.5	1.7	0.3	0.3	0.6	2.8	2.5	–	1.3
RE_2O_3	0.17*	0.05	0.21	0.24	6.16	0.11	1.14	0.70	0.36	0.44
La/Nd	0.75	1.01	0.87	0.78	0.60	0.98	0.91	0.61	0.88	0.76

* = % R.E.
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(381) Aleksiev et al. (1969), gabbro, Plana pluton, Bulgaria; (382) Afanas'ev et al. (1976), meta-amphibolite, Malaya Laba River, Caucasus, U.S.S.R.; (383) Kapustin (1977), gneiss, Afrikanda, Kola Peninsula, U.S.S.R.; (384) Lyakhovich (1962) granite, Konev, Urals, U.S.S.R.; (385) Papunen and Lindsjö (1972), skarn, lead deposit, Korsnäs, Finland; (386) Kapustin (1977), supergene, Novopoltavskii, Ukraine; (387) Kholodnov et al. (1975a), leucocratic granite, Borlinskii, Urals; (388) Portnov and Gorobets (1969), granite pegmatite, emerald field, Urals; (389) Vasil'eva (1976), carbonatite, Yakutia; (390) Sobolev (1968), gabbro, Kopanskii, Urals.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	391	392	393	394	395	396	397	398	399	400
La	16.6	18.0	19.4	21.2	17.1	18.6	18.5	14.0	21.2	24.2
Ce	40.8	40.6	39.9	37.8	41.5	41.2	40.2	44.3	37.9	36.3
Pr	9.7	6.6	5.9	6.2	6.6	5.4	6.6	7.0	6.2	4.9
Nd	23.8	17.0	19.1	20.0	22.6	24.1	17.0	18.0	20.0	18.1
Sm	3.9	6.7	4.9	5.9	4.3	4.0	7.7	4.5	5.9	4.6
Eu	0.2	1.4	0.7	1.8	0.5	0.7	1.2	0.2	1.8	4.6
Gd	2.9	4.2	5.3	4.4	3.8	2.5	3.7	4.4	4.4	2.7
Tb	0.5	0.5	–	–	0.4	–	0.5	1.1	–	1.5
Dy	1.7	2.7	2.1	1.5	1.8	1.8	2.6	3.6	1.5	1.3
Ho	0.4	0.3	0.5	0.2	0.1	0.4	0.3	0.5	0.2	0.4
Er	0.9	1.3	1.3	0.7	0.7	0.8	1.1	1.3	0.7	0.4
Tm	0.2	0.3	0.1	0.1	0.1	–	0.3	0.2	–	0.3
Yb	0.4	0.4	0.7	0.2	0.4	0.5	0.3	0.8	0.2	0.5
Lu	–	–	0.1	–	0.1	–	–	0.1	–	0.2
Y/(Y+Ln)x100	(10.1)	(0.9)	(15.2)	(7.5)	–	(13.5)	–	(20.1)	(7.4)	(9.5)
Method	XF	OS	OS	OS	OS	XF	XF	CH	OS	CH
Σ = La+Ce+Pr	65.1	65.2	65.2	65.2	65.2	65.2	65.3	65.3	65.3	65.4
La-Nd	89.4	82.2	84.3	85.2	87.8	89.3	82.3	83.3	85.3	83.5
Sm-Ho	9.4	15.8	13.5	13.8	10.9	9.4	16.0	14.3	13.8	15.1
Er-Lu	1.2	2.0	2.2	1.0	1.3	1.3	1.7	2.4	0.9	1.4
RE_2O_3	1.23	0.38	0.95	0.10	0.44	0.90*	0.35	1.19	0.10	0.40
La/Nd	0.74	1.06	1.01	1.06	0.76	0.77	1.09	0.78	1.06	1.34

* = % R.E. (391) Khvostova (1962), diopside-scapolite rock, Yakutia; (392) Kapustin (1977), calcite carbonatite, Alnö, Sweden; (393) Kholodnov et al. (1975a), leucocratic syenite, Tagilsk, Urals, U.S.S.R.; (394) Zhirova and Lyagushkin (1979), apatite-magnetite ores, Byras, Meimich-Kotui province, U.S.S.R.; (395) Kholodnov et al. (1975b), gabbro, western slopes, Urals; (396) Bergstol (1972), jacupirangite, Vestfold, Norway; (397) same as (392); (398) Kuts (1971), granite, Tokmok-Mogile, W. Azov region, U.S.S.R.; (399) Knubovets et al. (1979), apatite-magnetite ore, Meimech-Kotui province, U.S.S.R. (same as 394 (?); (400) Kuts (1971), biotite granite, Salovi, W. Azov region, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	401	402	403	404	405	406	407	408	409	410
La	21.8	20.2	38.8	17.5	39.5	17.9	19.1	17.4	19.4	17.1
Ce	38.9	40.0	26.7	40.2	26.1	42.3	41.9	43.6	38.6	42.2
Pr	4.7	5.3	–	7.9	–	5.5	4.9	5.0	8.0	6.8
Nd	30.8	22.3	30.1	22.3	31.0	21.6	22.7	22.3	24.2	15.5
Sm	2.0	4.6	3.1	3.7	2.4	5.8	3.7	4.1	3.8	8.5
Eu	–	0.9	0.8	0.5	0.6	–	1.0	0.9	0.5	1.6
Gd	1.5	4.0	–	3.3	–	4.2	3.1	2.9	2.9	4.9
Tb	c	–	0.3	0.5	0.2	–	–	0.5	0.6	0.3
Dy	c	1.7	–	2.1	–	2.7	1.9	1.6	1.3	2.2
Ho	–	0.3	–	0.4	–	–	–	–	0.2	0.3
Er	0.2	0.5	–	0.8	–	–	1.1	0.9	0.2	0.1
Tm	–	0.2	–	0.2	–	–	–	–	0.1	0.2
Yb	0.1	–	0.2	0.5	0.2	–	0.6	0.8	0.2	0.3
Lu	–	–	–	0.1	–	–	–	–	–	–
Y/(Y+Ln)x100	(11.2)[c]	(7.2)	–	(8.7)	–	–	(13.8)	(17.8)	(10.5)	(14.9)
Method	CH	OS	NA	–	NA	–	XF	XF	OS	OS
Σ = La+Ce+Pr	65.4	65.5	65.5	65.6	65.6	65.7	65.9	66.0	66.0	66.1
La-Nd	96.2	87.8	95.6	87.9	96.6	87.3	88.6	88.3	90.2	88.3
Sm-Ho	3.5	11.5	4.2	10.5	3.2	12.7	9.7	10.0	9.3	11.4
Er-Lu	0.3	0.7	0.2	1.6	0.2	–	1.7	1.7	0.5	0.3
RE_2O_3	0.39	0.43	–	0.50	0.74*	0.09	0.41*	0.54*	0.84	9.50
La/Nd	0.71	0.90	1.23	0.79	1.27	0.83	0.84	0.78	0.80	0.63

* = % R.E.
(c) Tb+Dy+Y calcd. as Y

(401) Rass (1970), nepheline-pyroxene rock, Bolshesayan massif, E. Siberia; (402) Kapustin (1977), calcite carbonatite, Lower Sayan; (403) Puchelt and Emmermann (1976), shonkinite porphyry, Horberg, Germany; (404) Vlasov and Kutukova, quoted by Semenov (1963), pneumatolytic-hydrothermal vein, Urals, U.S.S.R.; (405) Puchelt and Emmermann (1976), phonolite dike, Bötzingen, Germany; (406) Tugarinov et al. (1969), metamorphosed Precambrian rocks, Krivoi Rog, U.S.S.R.; (407) Ilupin et al. (1971), picrite porphyry, Kuonapskii region, Yakutia; (408) Balashov and Pozharitskaya (1968), carbonatite, 1st stage, W. Siberia; (409) Kapustin (1977), fenite, Vuojarvi, Karelia, U.S.S.R.; (410) Kapustin (1977), placer of carbonatite, Novopoltavskii, Ukraine

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.	411	412	413	414	415	416	417	418	419	420
La	13.9	28.2	23.7	18.4	22.5	21.6	3.5	16.4	21.0	22.1
Ce	45.3	35.0	36.7	41.9	37.7	41.1	56.4	44.8	40.7	39.9
Pr	6.9	3.0	5.9	6.0	6.2	3.8	6.7	5.4	5.0	4.9
Nd	22.2	22.8	20.1	24.1	21.2	28.9	11.7	23.9	27.5	23.2
Sm	6.9	4.4	4.2	3.6	3.9	2.5	4.0	3.7	3.0	4.0
Eu	0.4	1.3	0.4	0.7	0.5	0.2	–	0.9	–	–
Gd	1.3	3.2	3.2	2.4	3.9	1.9	3.4	2.2	2.8	4.5
Tb	–	–	0.5	0.6	–	–	–	0.4	c	–
Dy	2.6	1.4	2.8	1.3	1.7	–	2.4	1.3	c	–
Ho	0.2	–	–	–	0.4	–	11.8	0.2	–	0.1
Er	0.1	0.6	1.5	0.7	1.2	–	–	0.5	–	1.0
Tm	–	–	–	–	0.1	–	–	0.1	–	–
Yb	0.2	0.1	1.0	0.3	0.6	–	–	0.2	–	0.3
Lu	–	–	–	–	0.1	–	–	–	–	–
Y/(Y+Ln)x100	(4.8)	(4.0)	(23.7)	(9.0)	(17.7)	–	(11.4)	–	(1.5)[c]	(16.6)
Method	–	CH	XF	XF	OS	OS	XF	OS	CH	CH
Σ = La+Ce+Pr	66.1	66.2	66.3	66.3	66.4	66.5	66.6	66.6	66.7	66.9
La-Nd	88.3	89.0	86.4	90.4	87.6	95.4	78.3	90.5	94.2	90.1
Sm-Ho	11.4	10.3	11.1	8.6	10.4	4.6	21.6	8.7	5.8	9.6
Er-Lu	0.3	0.7	2.5	1.0	2.0	–	0.1	0.8	–	0.3
RE_2O_3	9.50	0.43	0.13	–	0.76	3.41	0.50*	0.20	0.45	0.22
La/Nd	0.63	1.24	1.18	0.76	1.06	0.74	0.30	0.69	0.76	0.95

* = % R.E.
(c) Tb+Dy+Y calcd. as Y

(411) Portnov and Gorobets (1969), alkalic pegmatite, Il'men Mts., Urals, U.S.S.R.; (412) Kirillov and Ryzhova (1968), calcite carbonatite, Vuorijarvi, Karelia, U.S.S.R.; (413) Nadareishvili (1973), diorite porphyry, Adzhari-Trialet intrusive, Georgian S.S.R.; (414) Ilupin et al. (1971), kimberlite, Lower Olenekskii region, Yakutia; (415) Kholodnov et al. (1975a), quartz diorite, Pardinsk, Urals; (416) Marchenko et al. (1980), dolomite carbonatite, Ukrainian Shield; (417) Aleksiev and Chernokolev (1967), granosyenite, Rossen pluton, Bulgaria; (418) Knubovets et al. (1979), carbonatite, Meimech-Kotui province, U.S.S.R. (419) Glagolev (1968), pyroxene-mica rock, Arbarastakh massif, S.E. Siberian platform; (420) Rass (1964), amphibolitized pyroxenite, Koksharov complex, Maritime Prov., U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No —	421	422	423	424	425	426	427	428	429	430
La	43.1	20.7	1.8	15.3	20.2	21.4	21.1	18.4	18.2	19.7
Ce	23.9	39.4	56.7	45.5	41.3	41.5	43.2	41.8	43.3	42.0
Pr	–	7.0	8.7	6.4	5.7	4.4	3.0	7.1	5.8	5.7
Nd	28.2	19.7	14.4	19.5	23.1	17.2	18.7	20.0	26.0	22.0
Sm	2.6	4.7	3.2	6.3	4.0	4.8	3.3	5.5	3.2	3.9
Eu	0.6	–	–	a	0.9	–	0.5	1.2	–	0.7
Gd	–	4.4	13.2	6.0[a]	2.6	4.2	4.1	1.8	3.3	2.6
Tb	0.3	–	–	–	–	–	0.6	0.4	–	–
Dy	–	1.8	0.8	0.9	1.2	2.3	2.6	2.0	0.2	1.7
Ho	–	0.3	0.4	–	–	1.0	0.5	0.3	–	–
Er	–	1.2	–	0.1	0.7	1.8	1.1	1.0	–	1.0
Tm	–	0.1	–	–	–	0.1	0.3	0.2	–	–
Yb	1.1	0.6	0.8	–	0.3	1.3	0.8	0.3	–	0.7
Lu	0.2	0.1	–	–	–	–	0.2	–	–	–
Y/(Y+Ln)x100	–	(12.3)	(10.5)	(9.0)	(10.1)	(21.4)	(18.0)	–	(6.3)	(13.8)
Method	NA	OS	XF	CH	XF	OS	OS	XF	CH	XF
Σ = La+Ce+Pr	67.0	67.1	67.2	67.2	67.2	67.3	67.3	67.3	67.3	67.4
La-Nd	95.2	86.8	81.6	86.7	90.3	84.5	86.0	87.3	93.3	89.4
Sm-Ho	3.5	11.2	17.6	13.2	8.7	12.3	11.6	11.2	6.7	8.9
Er-Lu	1.3	2.0	0.8	0.1	1.0	3.2	2.4	1.5	–	1.7
RE_2O_3	0.12*	0.82	0.13	0.11	–	1.42	1.22	0.29	0.46	–
La/Nd	1.64	1.05	0.12	0.79	0.87	1.25	1.13	0.92	0.70	0.90

* = % R.E.
(a) Eu+Gd calcd. as Gd

(421) Puchelt and Emmermann (1976), anatectic gneiss, Membach, Black Forest, Germany; (422) Kholodnov et al. (1975a), quartz diorite, Knyaspinsk, Urals, U.S.S.R.; (423) Aleksiev et al. (1969), monzodiorite, Plana pluton, Bulgaria; (424) Rimskaya-Korsakova et al. (1979), apatite-magnetite vein, Kovdor massif, Kola Peninsula, U.S.S.R.; (425) Ilupin et al. (1971), kimberlite, Prilenskii region, Yakutia; (426-427) Kholodnov et al (1975a), Urals; (426) granite, Magnitogorsk; (427) granodiorite, Bradimirse; (428) Kapustin (1977), dolomitic carbonatite, Alnö, Sweden; (429) Rass (1973), carbonatite, southern Guli massif, Karelia, U.S.S.R.; (430) same as (425).

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	431	432	433	434	435	436	437	438	439	440
La	32.1	19.3	25.9	40.4	20.1	20.7	14.6	18.4	19.8	10.3
Ce	32.8	43.5	38.6	26.6	42.7	43.4	46.3	43.5	42.3	52.0
Pr	2.5	4.7	3.0	—	4.8	3.8	7.0	6.0	5.9	5.7
Nd	30.2	20.6	21.9	28.6	23.2	20.8	22.6	22.7	22.1	24.3
Sm	1.0	4.6	6.0	2.8	3.5	5.0	4.8	4 8	4.6	5.0
Eu	0.2	—	1.2	0.7	0.9	—	0.5	0.9	0.9	0.4
Gd	0.6	3.5	1.7	—	2.3	5.0	3.6	2.7	2.7	1.9
Tb	—	—	—	0.2	—	6	—	0.4	0.3	—
Dy	0.6	1 3	—	—	1.1	0.7	0.6	0.2	0.7	—
Ho	—	0.4	—	—	—	0.1	—	0.1	0.1	0.2
Er	—	1.2	1.6	—	0.8	0.4	—	0.2	0.4	0.2
Tm	—	0.1	—	—	—	—	—	—	—	—
Yb	—	0.8	0.1	0.2	0.5	0.1	—	0.1	0.2	—
Lu	—	—	—	—	—	—	—	—	—	—
Y/(Y+Ln)x100	—	(13.1)	(23)	—	(11.5)	(19.7)[b]	(6.9)	—	—	(9.5)
Method	XF	OS	CH	NA	XF	CH	XF	XF	XF	—
Σ = La+Ce+Pr	67.4	67.5	67.5	67.5	67.7	67.9	67.9	67.9	68.0	68.0
La-Nd	97 6	88.1	89.4	96.1	90.9	88.7	90.5	90.6	90.1	92 3
Sm-Ho	2.4	9 8	8.9	3.7	7.8	10.8	9.5	9 1	9.3	7.5
Er-Lu	—	2 1	1.7	0.2	1.3	0.5	—	0 3	0.6	0.2
RE_2O_3	2 72	1.09	0.16	0.78*	—	0.19	0.15	0.09	0.29	13.0
La/Nd	1 06	0.93	0.65	1 43	0.87	0.99	0.65	0 81	0.90	0.43

* = % R.E.
(b) Tb+Y calcd. as Y

(431) Mikhailov and Mineev (1970), metasomatic diopside rock, Aldan massif; (432) Kholodnov et al. (1975a), quartz diorite, Upper Tagilsk, Urals, U.S.S.R.; (433) Kirillov and Ryzhova (1968), carbonatite, Kovdor Karelia, U.S.S.R.; (434) Puchelt and Emmermann (1976), carbonatite, Schelingen, Kaiserstuhl, Germany; (435) Ilupin et al. (1971), explosive carbonatite breccia, Kuonapskii region, Yakutia; (436) Afanas'ev et al. (1976), granite, Caucasus, U.S.S.R.; (437) Lyakhovich (1962), granite, Murzinsk, Urals; (438) Kapustin (1966), ankeritic carbonatite, Kovdor, Karelia; (439) Kapustin (1977), ankerite carbonatite, Namo-Vara, Karelia; (440) Portnov et al. (1967), pegmatitic alkali syenite, Burpapa massif, N. Baikal.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.—	441	442	443	444	445	446	447	448	449	450
La	13.6	19.3	18.9	15.9	24.2	17.7	14.0	22.0	24.7	18.1
Ce	44.7	43.7	43.8	45.1	42 1	45.1	45.8	41.6	38.1	43 9
Pr	9.8	5.2	5.5	7.2	2.0	5.6	8.6	4.8	5.7	6 7
Nd	17.8	22.1	22.5	23.3	19.5	21.1	25.0	25.4	20.8	13.3
Sm	9 6	3.7	4.2	3.5	4.7	4.0	3.1	2.7	4.5	8.5
Eu	1.6	—	a	0.7	—	0 8	0.4	0.3	—	1.5
Gd	0.9	2.8	4.1[a]	2.3	3.6	3.1	2.2	2.0	5.4	4.0
Tb	—	—	—	0.1	—	—	0.3	0.3	—	0 3
Dy	—	1 6	—	1.1	1.6	1.5	0.5	0.7	—	1 9
Ho	—	—	0.3	0.1	0.5	—	—	0.1	—	0.4
Er	0.9	0.9	0.4	0.4	1.1	0.7	0.1	—	0.5	0.9
Tm	0.2	—	—	—	0 1	—	—	—	—	0.2
Yb	0.9	0.7	0.3	0.3	0.6	0.4	—	0.1	0.3	0.3
Lu	—	—	—	—	—	—	—	—	—	—
Y/(Y+Ln)x100	(3.5)	(15.3)	(10.9)	—	(14.2)	(9.1)	—	—	(12.5)	(13.3)
Method	—	XF	CH	XF	OS	XF	XF	XF	CH	OS
Σ = La+Ce+Pr	68.1	68.2	68 2	68.2	68.3	68.4	68.4	68.4	68.5	68.7
La-Nd	85.9	90.3	90.7	91.5	87 8	89.5	93 4	93 8	89.3	82 0
Sm-Ho	12 1	8.1	8.6	7.8	10.4	49.4	6.5	6.1	10.4	16.6
Er-Lu	2 0	1.6	0 7	0.7	1.8	1.1	0 1	0.1	0.3	1.4
RE_2O_3	0.60	0.62*	0 14	0.15	1.15	0.61*	0.21	1.05	0 18	0 78
La/Nd	0.77	0.87	0.84	0.68	1.24	0.84	0.56	0.87	1.19	1.37

* = % R.E.
(a) Eu+Gd calcd. as Gd

(441) Portnov and Gorobets (1969), carbonatite, Guli, Karelia, U.S.S.R.; (442) Balashov and Pozharitskaya (1968), carbonatite, 1st stage, W. Siberia; (443) Rimskaya-Korsakova et al. (1979), apatite-forsterite-magnetite ore, Kovdor massif, Kola Peninsula, U.S.S.R.; (444) Sobolev (1968), tonalite, Sobskii, Urals, U.S.S.R.; (445) Kholodnov et al. (1975a). liparitic porphyry, Teldyks, Urals; (446) same as (442), 2nd stage; (447-448) Lyakhovich (1962); (447), granite, Konev massif, Urals; (448) monzonite, Megrin massif, Armenian S.S.R.; (449) Rass (1964), nepheline syenite, Koksharov complex, Maritime Province, U.S.S.R.; (450) Kapustin (1977), calcite carbonatite, Novopoltavskii, Ukraine.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. -	451	452	453	454	455	456	457	458	459	460
La	22.7	21.6	16.6	22.3	23.9	17.4	22.5	19.4	18.7	23.7
Ce	43.0	41.5	46.9	42.2	41.6	45.6	41.4	42.5	45.0	39.5
Pr	3.0	5.7	5.3	4.4	3.4	5.9	5.0	7.1	5.3	5.8
Nd	17.8	17.4	20.2	21.1	23.5	24.0	24.9	20.7	21.4	22.9
Sm	3.9	5.3	2.6	4.9	4.0	2.4	2.7	4.8	3.8	3.2
Eu	0.1	1.1	0.8	1.0	1.2	0.2	0.3	1.9	0.7	0.4
Gd	4.1	3.0	2.2	2.8	2.2	1.7	2.0	2.7	2.3	2.7
Tb	-	0.3	0.3	-	-	0.1	0.3	-	-	0.4
Dy	1.9	2.1	1.8	0.3	-	1.1	0.7	0.9	1.3	0.8
Ho	0.5	0.2	0.6	0.3	0.1	0.1	0.1	-	-	0.2
Er	1.5	1.4	1.6	0.3	-	0.5	-	-	0.9	0.4
Tm	0.2	0.2	0.1	-	-	0.1	-	-	-	-
Yb	1.3	0.2	0.9	0.4	0.1	0.8	0.1	-	0.6	-
Lu	-	-	0.1	-	-	0.1	-	-	-	-
Y/(Y+Ln)x100	(23.2)	(12.0)	(19.8)	(1.5)	(0.7)	-	(7.2)	-	(14.2)	(7.2)
Method	-	OS	XF	OS	OS	XF	XF	XF	XF	XF
Σ = La+Ce+Pr	68.7	68.8	68.8	68.9	68.9	68.9	68.9	69.0	69.0	69.0
La-Nd	86.5	86.2	89.0	90.0	92.4	92.9	93.8	89.7	90.4	91.9
Sm-Ho	10.5	12.0	8.3	9.3	7.5	5.6	6.1	10.3	8.1	7.7
Er-Lu	3.0	1.8	2.7	0.7	0.1	1.5	0.1	-	1.5	0.4
RE_2O_3	0.97	0.35	0.53	1.20	1.14	0.36	0.51	0.33	0.60*	1.90
La/Nd	1.29	1.24	0.82	1.06	1.02	1.02	0.90	0.93	0.87	1.03

* = % R.E.

(451) Starkov et al. (1973), average of 5 adamellites, Mugodzhar, Urals, U.S.S.R.; (452) Kapustin (1977), calcite carbonatite, Oka, Quebec; (453) Parak (1973), iron ore, Kiruna-vaara, Lappland; (454-455) Marchenko et al. (1980), carbonatites, Ukrainian Shield; (455) weathered, (456) Mineev (1968), pegmatite with rock crystal, Akzhailyan, Kazakhstan; (457) Meliksetyan quoted by Semenov (1963), alkalic granite, Armenian S.S.R.; (458) Kapustin (1977), placer, Lower Sayan; (459) Balashov and Pozharitskaya (1968), carbonatite, 2nd stage, W. Siberia; (460) Zolotarev quoted by Semenov (1963), carbonatite, Kola Peninsula, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. -	461	462	463	464	465	466	467	468	469	470
La	20.4	16.3	17.0	19.6	19.1	22.4	17.3	18.4	19.3	14.4
Ce	43.4	45.6	47.1	42.9	45.3	41.6	46.5	42.1	44.7	46.9
Pr	5.3	7.2	5.0	6.7	4.8	5.2	5.4	8.7	5.2	8.0
Nd	18.2	20.5	20.5	13.0	17.4	19.8	21.1	22.0	23.0	22.1
Sm	3.7	5.7	3.5	8.2	2.7	4.3	3.9	6.3	3.1	4.3
Eu	0.2	-	0.8	1.5	a	-	0.6	-	0.9	0.3
Gd	3.5	4.1	2.6	4.0	2.4[a]	4.8	2.4	2.2	1.8	1.6
Tb	-	c	-	0.3	b	-	-	-	0.3	-
Dy	2.0	c	2.1	2.0	2.8	0.9	1.5	-	1.0	1.3
Ho	0.4	-	-	0.4	0.7	0.2	-	-	0.2	0.1
Er	1.5	0.4	0.8	0.9	1.9	0.5	0.7	-	0.3	0.7
Tm	0.2	-	-	0.2	0.5	-	-	-	-	-
Yb	1.0	0.2	0.6	0.3	2.4	0.3	0.6	0.3	0.2	0.3
Lu	0.2	-	-	-	-	-	-	-	-	-
Y/(Y+Ln)x100	(11.9)	(24.2)[c]	(13.2)	(7.7)	(16.1)[b]	(13.3)	(12.0)	(7.6)	-	-
Method	OS	CH	XF	OS	CH	CH	XF	XF	OS	XF
Σ = La+Ce+Pr	69.1	69.1	69.1	69.2	69.2	69.2	69.2	69.2	69.2	69.3
La-Nd	87.3	89.6	89.6	82.2	86.6	89.0	90.3	91.2	92.2	91.4
Sm-Ho	9.8	9.8	9.0	16.4	8.6	10.2	8.4	8.5	7.3	7.6
Er-Lu	2.9	0.6	1.4	1.4	4.8	0.8	1.3	0.3	0.5	1.0
RE_2O_3	0.93	0.68	0.46*	0.81	8.12	0.08	0.50*	0.42*	0.54	0.31
La/Nd	1.12	0.80	0.83	1.51	1.09	1.13	0.82	0.84	0.84	0.65

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(461) Kholodnov et al. (1975a), quartz diorite, Auebakhovsk, Urals, U.S.S.R.; (462) Afanas'ev et al. (1976), ignimbrite, Kozlinka River, Caucasus, U.S.S.R.; (463) Balashov and Pozharitskaya (1968), carbonatite, 3rd stage, W. Siberia; (464) Kapustin (1977), calcite carbonatite, Novopoltavskii, Ukraine; (465) Bel'kov (1979), nepheline syenite, Sakhariok massif, Kola Peninsula, U.S.S.R.; (466) Rass (1973), altered ankaratrite, Guli massif, Karelia, U.S.S.R.; (467) same as (463), 2nd stage; (468) Plaksenko (1979), orthopyroxenite, Elenskaya intrusive, U.S.S.R.; (469) Knubovets et al. (1979), carbonatite, Meimech-Kotui province, Siberia; (470) Sobolev (1968), quartz diorite, Sobskii, Urals, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	471	472	473	474	475	476	477	478	479	480
La	22.6	17.5	24.8	20.7	15.0	14.5	24.4	22.3	28.4	20.3
Ce	43.3	46.0	39.2	42.2	47.3	46.9	38.6	44.3	35.4	43.2
Pr	3.4	5.8	5.4	6.5	7.1	8.0	6.4	2.9	5.7	6.0
Nd	22.3	22.6	20.2	21.1	21.6	22.1	24.5	17.5	18.3	20.4
Sm	2.8	3.9	4.4	2.2	4.9	4.3	1.5	3.9	5.2	4.7
Eu	–	1.0	1.3	0.5	–	0.3	–	0.1	–	0.9
Gd	3.9	0.3	3.0	2.6	4.1	1.5	3.5	4.0	4.3	2.7
Tb	b	0.5	–	0.9	c	–	b	–	–	0.4
Dy	1.4	1.6	0.9	2.0	c	1.2	0.5	1.8	2.7	0.7
Ho	0.1	–	0.2	0.3	–	0.1	–	0.4	–	0.1
Er	0.2	0.5	0.5	0.4	–	0.8	0.3	1.4	–	0.4
Tm	–	–	–	0.2	–	–	–	0.2	–	–
Yb	–	0.3	0.1	0.4	–	0.3	0.3	1.2	–	0.2
Lu	–	–	–	–	–	–	–	–	–	–
Y/(Y+Ln)x100	(9.9)[b]	(11.9)	(4.7)	(9.0)	(5.6)[c]	–	(2.2)[b]	(18.9)	(0.2)	–
Method	CH	XF	OS	OS	CH	OS	CH	–	CH	XF
Σ = La+Ce+Pr	69.3	69.3	69.4	69.4	69.4	69.4	69.4	69.5	69.5	69.5
La-Nd	91.6	91.9	89.6	90.5	91.0	91.5	93.9	87.0	87.8	89.9
Sm-Ho	8.2	7.3	9.8	8.5	9.0	7.4	5.5	10.2	12.2	9.5
Er-Lu	0.2	0.8	0.6	1.0	–	1.1	0.6	2.8	–	0.6
RE_2O_3	0.36	0.48*	0.10	0.61	0.40	0.31	0.29	1.12	0.99	0.29
La/Nd	1.02	0.77	1.23	0.98	0.70	0.65	0.99	1.28	1.55	1.00

* = % R.E.
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(471) Rass (1970), mica-rich rock, Bolshesayan alkalic massif, E. Siberia; (472) Kaminskii et al. (1978), av. of 13, from kimberlites; (473) Knubovets et al. (1979), fenite, Meimech-Kotui province, Siberia; (474) Kapustin (1977), fenite, Novopoltavskii, Ukraine; (475) Vasil'eva (1976), kimberlite, Yakutia; (476) Kholodnov et al. (1975b), gabbro, western slopes, Urals, U.S.S.R.; (477) Rass (1968), calcite-olivine-magnetite rock, Kovdor massif, Karelia, U.S.S.R.; (478) Starkov et al. (1973), adamellite-granite, eastern Mugodzhar, Urals; (479) Rass (1968), apatite-olivine-magnetite rock, Kovdor massif, Karelia; (480) Kapustin (1966), carbonatite, Namo-vaara, Karelia.

Table 1. Rare Earths in Apatite, atomic percent

No.	481	482	483	484	485	486	487	488	489	490
La	16.8	26.4	11.9	15.2	20.7	20.0	25.6	25.1	15.0	17.6
Ce	45.9	40.4	53.4	50.4	42.7	44.4	42.6	40.9	46.8	46.0
Pr	6.8	2.7	4.3	4.0	6.2	5.2	1.4	3.7	7.9	6.1
Nd	22.4	24.3	17.7	21.6	21.6	22.5	25.6	18.2	21.8	24.4
Sm	3.2	2.4	4.0	4.0	4.0	3.9	1.8	2.9	4.3	3.5
Eu	0.3	0.9	–	0.2	a	–	a	–	0.3	–
Gd	2.8	2.5	3.0	2.8	3.4[a]	3.2	3.0[a]	3.4	1.5	2.4
Tb	0.4	–	–	–	–	–	b	–	–	b
Dy	1.0	–	2.2	1.3	–	0.5	–	2.9	1.2	–
Ho	–	0.3	0.5	–	0.3	–	–	0.6	0.1	–
Er	0.4	–	1.6	0.5	0.7	0.2	–	0.2	0.8	–
Tm	–	–	0.2	–	–	–	–	0.9	–	–
Yb	–	0.1	1.0	–	0.4	0.1	–	1.2	0.3	–
Lu	–	–	0.2	–	–	–	–	–	–	–
Y/(Y+Ln)x100	–	–	(14.8)	–	(7.3)	(5.2)	(33.9)[b]	(24.6)	(7.2)	(2.9)[b]
Method	XF	OS	OS	XF	CH	CH	CH	OS	XF	CH
Σ = La+Ce+Pr	69.5	69.5	69.6	69.6	69.6	69.6	69.6	69.7	69.7	69.7
La-Nd	91.9	93.8	87.3	91.2	91.2	92.1	95.2	87.9	91.5	94.1
Sm-Ho	7.7	6.1	9.7	8.3	7.7	7.6	4.8	9.8	7.4	5.9
Er-Lu	0.4	0.1	3.0	0.5	1.1	0.3	–	2.3	1.1	–
RE_2O_3	0.25	1.03	1.34	0.55	0.18	0.15	11.0	0.52*	–	0.39
La/Nd	0.75	1.08	0.68	0.70	0.96	0.89	1.00	1.38	0.69	0.72

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(481) Lyakhovich and Barinskii (1961), granite, Konev massif, Urals, U.S.S.R.; (482) Marchenko et al. (1980), carbonatite, Ukrainian Shield; (483) Kholodnov et al. (1975a), migmatite, Il'men Mts., Urals; (484) Mikhailov and Mineev (1970), metasomatic diopside rock, Aldan massif; (485) Rimskaya-Korsakova et al. (1979), apatite-forsterite-magnetite ore, Kovdor massif, Kola peninsula, U.S.S.R.; (486) Rass (1973), carbonatite, Kovdor massif, Karelia; (487) Kovalenko et al. (1971), vein granite, Ongan Khairkan, Mongolia; (488) Dodge and Mays (1972) and private communication, average of 22 granodiorites, Sierra Nevada Mts., Calif.; (489) Sobolev quoted by Semenov (1963), quartz diorite, Rai-Iz, Polar Urals; (490) Rass (1968), pyroxene-rich rock, Kovdor massif, Karelia.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	491	492	493	494	495	496	497	498	499	500
La	21.3	20.0	18.5	21.0	20.5	17.9	19.9	18.8	18.0	19.6
Ce	43 i	44.8	46.1	43.6	43.7	47.1	42.9	45.8	46.6	44.3
Pr	5.4	5.0	5.2	5.2	5.7	4.9	7.1	5.4	5.4	6.2
Nd	17.2	19.4	20.3	22.4	13 7	18.0	21 4	20.0	20.7	22.2
Sm	3 3	6.1	3 4	2.9	3.8	2.8	3 1	3.5	3 7	2.7
Eu	0 8	—	—	—	0.8	0.8	0 4	0.6	0.9	0.4
Gd	4.0	4.7	4.8	3.9	3.9	2.7	2.8	3 2	1 9	2.6
Tb	—	c	b	b	—	0.5	0.4	—	0.4	0.4
Dy	1.9	c	1 1	0.7	3.8	2.4	1.0	1.4	1.3	1.0
Ho	0 5	—	0.2	0.1	0.1	0.5	0.2	—	—	0.1
Er	1.4	—	0 4	0 2	2 1	1.3	0.4	0 8	0.7	0,3
Tm	0.1	—	—	—	0.3	0.1	—	—	—	—
Yb	0.8	—	—	—	1.2	0.9	0.4	0.5	0 4	0.2
Lu	0.2	—	—	—	0.4	0.1	—	—	—	—
Y/(Y+Ln)x100	(14.8)	(7.6)[c]	(15.2)[b]	(12.1)[b]	(26.8)	(31 6)	(12 9)	(11.6)	(11 3)	(7.3)
Method	0S	CH	CH	CH	0S	XF	XF	XF	XF	XF
Σ = La+Ce+Pr	69.8	69.8	69 8	69.8	69.9	69 9	69.9	70.0	70.0	70.1
La-Nd	87.0	89.2	90.1	92.2	83 6	87.9	91.3	90.0	90.7	92 3
Sm-Ho	10.5	10.8	9.5	7.6	12.4	9.7	7.9	8.7	8.2	7.2
Er-Lu	2 5	—	0.4	0.2	4.0	2.4	0.8	1 3	1 1	0.5
RE_2O_3	0.28	0.25	2.38	0.49	0.08	0.46	0.35	0 40*	0.54*	1.79
La/Nd	1 24	1.03	0.91	0.94	1.50	0.99	0.93	0.94	0.87	0.88

* = % R.E.
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(491) Kholodnov et al. (1975b), granodiorite, Suunduksii, Urals, U.S.S.R.; (492) Vasil'eva (1976), kimberlite Urals; (493) Borutskii et al. (1975) vein in shonkinite, Mt. Petrelius, Kola Peninsula, U.S.S.R.; (494) Afanas'ev et al.(1976), diorite, Caucasus, U.S.S.R.: (495) Kholodnov et al. (1975a), biotite-amphibole granite-gneiss, Gubenskii massif, Urals, (496) Parak (1973), iron ore, Rektorn, Lappland; (497) Lyakhovich and Barinskii (1961), peridotite, Inagli massif, Aldan; (498-499) Balashov and Pozharitskaya (1968), carbonatites, W. Siberia; (498) 2nd stage; (499) 3rd stage; (500) Zolotarev (1963), olivinite, Kola Peninsula

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.—	501	502	503	504	505	506	507	508	509	510
La	25.5	16.3	20.9	25.6	18.7	19.3	21.8	19.8	19.1	27.3
Ce	38.3	48.4	49.6	39.9	41.4	45.2	42.1	43.2	44.6	40.6
Pr	6.4	5.6	—	4 8	10 3	5.9	6.5	7.4	6.8	2.7
Nd	19.5	15.4.	15.3	19.8	12.6	20.5	21.1	23.2	22.5	11.0
Sm	4.5	6.0	7.1	3.8	9.7	3 5	3.1	3 2	3.9	16 8
Eu	0.2	—	—	0.3	—	a	0.2	0.5	—	1 6
Gd	2 8	3.6	4.9	2.9	0.5	2.4[a]	2.7	1.9	2.8	—
Tb	0.2	—	—	—	—	—	0.5	0.3	c	—
Dy	1.5	1.6	1.4	1.1	6.4	2.6	1.1	0.4	c	—
Ho	0.2	0 6	—	0.4	—	—	0.3	—	0.1	—
Er	0 4	—	—	0.8	—	0.3	0.2	—	0.2	—
Tm	0.2	—	—	0.1	—	—	0.1	—	—	-
Yb	0 3	—	0.5	0.5	6.4	0.3	0.3	0.1	—	—
Lu	—	2.5	—	—	—	—	—	—	—	—
Y/(Y+Ln)x100	—	(15.8)	(8.6)	(11.2)	(2.2)	(4.1)	(9.0)	—	(6.0)[c]	(22.1)
Method	XF	XF	-	OS	XF	CH	OS	XF	CH	MS
Σ = La+Ce+Pr	70.2	70.3	70.3	70.3	70.4	70.4	70.4	70.4	70.5	70.6
La-Nd	89.7	85.7	86 1	90.1	83.0	90 9	91.5	93 6	93 0	81 6
Sm-Ho	9 4	11.8	13 4	8.5	16.6	8 5	7.9	6.3	6 8	18.4
Er-Lu	0.9	2.5	0.5	1.4	0.4	0.6	0.6	0 1	0.2	—
RE_2O_3	0.40	0.33*	2.0	1.53	5.00	0.23	0.71	—	0.29	0.265*
La/Nd	1 30	1.06	1.31	1 30	1 49	0.94	1.03	0.85	0.85	2.49

* = % R.E.
(a) Eu+Gd calcd. as Gd
(c) Tb+Dy+Y calcd. as Y

(501) Lyakhovich (1968), diorite associated with gabbro, Urals, U.S.S.R.; (502) Aleksiev et al. (1969) leucogabbro, Plana pluton, Bulgaria; (503) Nurlybaev (1976), nepheline syenite, Esil'skii massif, Kazakhstan; (504) Kholodnov et al. (1975a), biotite granite, Ambulakaisk, Urals; (505) Portnov et al. (1967), fluorite vein, Burpala massif, Baikal; (506) Rimskaya-Korsakova et al. (1979), apatite-forsterite-magnetite ore, Kovdor massif, Karelia; (507) Kapustin (1977), fenite, Vuorijarvi, Karelia; (508) Borodin (1960), pyroxenite, Karelia; (509) Rass (1968), olivinite, Kovdor massif, Karelia; (510) Wilson (1978), vug in vesicular quartz-latite porphyry dike, Bingham, Utah

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.	511	512	513	514	515	516	517	518	519	520
La	21.8	21.8	19.6	27.1	29.8	18.3	23 8	19.5	19.5	19.9
Ce	42.8	40.8	46.9	36.7	35.4	48.5	40.9	45.8	45.7	44.8
Pr	6.1	8.1	4.2	7.0	5.6	4.0	6.1	5.6	5.9	6.2
Nd	17.9	20.2	23.7	16.7	19.2	19.7	20.7	21.7	21.9	22.3
Sm	4.0	6.6	2.9	3.9	5.4	2.9	3.7	3.5	3.9	3.9
Eu	0.5	-	-	-	-	0.9	-	a	a	0.5
Gd	3 9	2.2	2.4	3 7	4.6	3.7	2.1	3.3[a]	3 1[a]	1.9
Tb	-	-	c	-	-	0.5	-	-	-	0.1
Dy	1.4	-	c	1.9	-	0.9	1.3	-	-	0.4
Ho	0.3	-	0.1	0.5	-	0.2	-	-	-	-
Er	0.9	-	0.2	1.4	-	0.2	0.8	0.4	0.1	-
Tm	0 1	-	-	0.2	-	-	-	-	-	-
Yb	0 3	0.3	-	6.8	-	0.2	0.6	0.2	0.1	-
Lu	-	-	-	0.1	-	-	-	-	-	-
Y/(Y+Ln)x100	(11.6)	(8.0)	(7.4)[c]	(16.0)	(4.4)	-	(13.9)	(6 6)	(4.8)	-
Method	OS	XF	CH	OS	CH	XF	XF	CH	CH	XF
Σ = La+Ce+Pr	70.7	70.7	70.7	70.8	70.8	70.8	70.8	70.9	70.9	70.9
La-Nd	88.6	90.9	94.4	87.5	90.0	90.5	91.5	92.6	92 8	93.2
Sm-Ho	10.1	8 8	5.4	10.0	10.0	9.1	7.1	6.8	7.0	6.8
Er-Lu	1.3	0.3	0.2	2 5	-	0.4	1.4	0.6	0.2	-
RE_2O_3	2.01	0.34*	0.56	0.46	0.20	0.83	0.71*	0 27	0.15	0.06
La/Nd	1.21	1.08	0.83	1.63	1.55	0.93	1.15	0.90	0.89	0.89

* = % R.E.
(a) Eu+Gd calcd. as Gd
(c) Tb+Dy+Y calcd. as Y

(511) Kholodnov et al. (1975a), subalkalic syenite, Kushvinsk, Urals, U.S.S.R.; (512) Plaksenko (1979), amphibolitized gabbro, Pudkolovno intrusive; (513) Rass (1970), carbonatite, Bolshesayansk massif, E. Siberia; (514) Kholodnov et al. (1975a), tonalite, Krasuinsk, Urals; (515) Rass (1973), apatite-calcite rock, Kovdor massif, Karelia, U.S.S.R.; (516) Kapustin (1977), magnetite-olivine rock, Vuorijarvi, Karelia; (517) Balashov and Pozharitskaya, (1968), carbonatite, 1st stage, W. Siberia; (518) Rimskaya-Korsakova et al. (1979), calcite carbonatite, Kovdor massif, Karelia; (519) Rimskaya-Korsakova et al. (1968), carbonatite, Kovdor massif (same as 518 (?)); (520) Kapustin (1977), calcite carbonatite, Vuorijarvi, Karelia

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. ~	521	522	523	524	525	526	527	528	529	530
La	23.3	24.0	18.5	20.0	23.3	19.3	20.7	19.1	19.0	19.4
Ce	43.7	42.9	47.3	46.0	43.6	47.4	44.6	45.5	47.2	47.1
Pr	3.9	4.1	5.2	5.0	4.2	4.4	5.8	6.5	5.0	4.8
Nd	22.4	13.4	20.9	22.1	15.8	18.2	20.7	23.0	23.2	17.5
Sm	2.5	2.0	4.7	2.8	7.1	2.5	3.9	3.1	2.7	2.5
Eu	a	-	-	-	1.5	0.7	a	a	a	0.8
Gd	2.4[a]	2.8	2.6	2.8	2.5	2.3	2.9[a]	2.5[a]	2.4[a]	2.0
Tb	b	4.6	b	b	0.2	0.4	-	-	-	0.4
Dy	0.9	5.1	0.6	1.0	0.7	1.9	0.8	-	-	1.9
Ho	0.2	1.1	0.1	0.1	0.2	0.5	0.2	-	-	0.6
Er	0.5	-	0.1	0.1	0.4	1.3	0.2	0.2	0.3	1.8
Tm	-	-	-	-	0.1	0.1	-	-	-	0.1
Yb	0.2	-	-	0.1	0.4	0.9	0.2	0.1	0.2	1.0
Lu	-	-	-	-	-	0.1	-	-	-	0.1
Y/(Y+Ln)x100	(5.1)[b]	(6.9)	(6.2)[b]	(6.2)[b]	(8.2)	(21.5)	(3.8)	(4.1)	(3.9)	(20.2)
Method	CH	CH	CH	CH	OS	XF	CH	CH	CH	XF
Σ = La+Ce+Pr	70.9	71.0	71.0	71.0	71.1	71.1	71.1	71.1	71.2	71.3
La-Nd	93.3	84.4	91.9	93.1	86.9	89.3	91.8	94.1	94.4	88.8
Sm-Ho	6.0	15.6	8.0	6.7	12.2	8.3	7.8	5.6	5.1	8.2
Er-Lu	0.7	-	0.1	0.2	0.9	2.4	0.4	0.3	0.5	3.0
RE_2O_3	2.72	-	0.88	0.62	1.07	0.67	0.19	0.88	0.22	0.59
La/Nd	1.04	1.79	1.12	0.90	1.48	1.06	1.00	0.83	0.82	1.11

(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(521) Dudkin (1969), nepheline syenite, Synnyr massif, U.S.S.R.; (522) Nadezhdina (1968), subalkalic rocks, Bolshaya Botubiya River; (523-524) Rass (1970), carbonatites, Bolshesayansk massif, E. Siberia; (525) Kapustin (1977), calcite carbonatite, Lower Sayan; (526) Parak (1973), iron ore, Nutusvaara, Lappland; (527) Rimskaya-Korsakova et al. (1979), apatite-magnetite-forsterite ore, Kovdor Massif, Karelia, U.S.S.R.; (528-529) Rimskaya-Korsakova et al. (1968), phlogopite-olivine-diopside rocks, Kovdor massif; (530) Parak (1973), iron ore, Lappmilnen, Lappland

Table 1 - Rare Earths in Apatite, atomic percent - continued

No —	531	532	533	534	535	536	537	538	539	540
La	18.1	22.2	18.6	20.8	21.0	11.9	20.7	16.2	20.1	18.8
Ce	49.2	43.3	48.4	45.0	44.0	53.5	45.4	48.4	45.2	46.3
Pr	4.0	5.9	4.4	5.7	6.5	6.1	5.5	7.0	6.3	6.5
Nd	23.4	22.5	22.8	20.1	20.6	20.6	11.7	17.7	21.5	23.9
Sm	2.8	2.9	3.0	2.8	4.5	4.0	8.1	2.9	4.0	2.7
Eu	–	a	0.6	0.1	–	–	0.5	1.0	0.5	–
Gd	2.0	2.6[a]	1.8	2.8	3.1	3.9	1.2	2.3	1.9	1.7
Tb	b	–	–	0.3	b	c	–	0.1	0.1	c
Dy	0.5	–	0.3	1.5	0.3	c	6.5	0.2	0.4	c
Ho	–	–	–	0.1	–	–	–	–	–	–
Er	–	0.3	0.1	0.5	–	–	0.2	–	–	0.1
Tm	–	–	–	–	–	–	0.1	–	–	–
Yb	–	0.3	–	0.3	–	–	0.1	0.2	–	–
Lu	–	–	–	–	–	–	–	–	–	–
Y/(Y+Ln)x100	(4.4)[b]	(3.8)	(5.2)	–	(5.3)[b]	(1.8)[c]	–	–	–	(11.1)[c]
Method	CH	CH	XF	XF	CH	CH	OS	XF	XF	CH
Σ = La+Ce+Pr	71.3	71.4	71.4	71.5	71.5	71.5	71.6	71.6	71.6	71.6
La-Nd	94.7	93.9	94.2	91.6	92.1	92.1	83.3	89.3	93.1	95.5
Sm-Ho	5.3	5.5	5.7	7.6	7.9	7.9	16.3	6.5	6.9	4.4
Er-Lu	–	0.6	0.1	0.8	–	–	0.4	0.2	–	0.1
RE_2O_3	1.26	0.36	–	1.85	0.32	0.41	2.14	0.90	0.06	0.52
La/Nd	0.77	0.99	0.82	1.03	1.02	0.58	1.77	0.91	0.94	0.78

(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(531) Vasil'eva (1976), kimberlite, Yakutia; (532) Rimskaya-Korsakova et al. (1979), apatite-calcite-magnetite ore, Kovdor massif, Karelia, U.S.S.R., (538) Puustinen (1971), mica carbonatite, Sillinjarvi complex, E. Finland; (534) Lyakhovich (1968), alkali syenite, E. Sayan; (535) Rass (1968), olivinite, Kovdor massif; (536) same as (531); (537) Spasskii (1970), feldspar-biotite-pyroxene rock, Synnyr massif, Cisbaikal; (538) Kapustin (1977), calcite carbonatite, Afrikanda, Kola Peninsula, U.S.S.R.; (539) Kapustin (1966), carbonatite, Vuojarvi, Karelia; (540) Vasil'eva (1976), carbonatized kimberlite, Yakutia

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	541	542	543	544	545	546	547	548	549	550
La	26.2	21.1	28.9	21.3	18.3	26.4	21.3	19.3	22.4	21.2
Ce	45.5	44.8	35.8	44.8	48.6	40.6	44.8	46.5	49.5	46.3
Pr	—	5.8	7.3	5.7	5.0	4.9	5.8	6.1	—	4.5
Nd	16.9	21.8	16.4	21.2	18.8	20.3	21.3	21.7	25.4	20.3
Sm	6.1	3.2	2.0	3.5	3.8	3.1	3.1	3.0	—	2.6
Eu	—	a	0.8	a	0.9	—	a	a	—	—
Gd	2.9	2.7[a]	4.8	2.6[a]	2.7	3.1	3.0[a]	3.0[a]	2.2	2.8
Tb	—	—	0.5	—	0.2	—	—	—	—	—
Dy	1.9	—	2.8	0.3	0.9	1.6	—	—	—	0.7
Ho	—	—	—	0.2	0.2	—	—	—	—	0.2
Er	—	0.3	0.9	0.2	0.3	—	0.4	0.3	0.2	1.0
Tm	—	—	—	—	0.1	—	—	—	0.1	—
Yb	0.5	0.3	—	0.2	0.2	—	0.3	0.1	0.2	0.4
Lu	—	—	—	—	—	—	—	—	—	—
Y/(Y+Ln)x100	(9.1)	(4.1)	(4.4)	(3.1)	—	—	(5.9)	(6.3)	(13.2)	(8.9)
Method	—	CH	XF	CH	XF	XF	CH	CH	—	CH
Σ = La+Ce+Pr	71.7	71.7	71.8	71.8	71.9	71.9	71.9	71.9	71.9	72.0
La-Nd	88.6	93.5	88.2	93.0	90.7	92.2	93.2	93.6	97.3	92.3
Sm-Ho	10.9	5.9	10.9	6.6	8.7	7.8	6.5	6.0	2.2	6.3
Er-Lu	0.5	0.6	0.9	0.4	0.6	—	0.3	0.4	0.5	1.4
RE_2O_3	0.95	0.36	—	0.40	0.60	7.1	0.30	0.24	—	0.61
La/Nd	1.55	0.97	1.75	1.01	0.98	1.30	1.00	0.89	0.88	1.04

(a) Eu+Gd calcd. as Gd
(c) Tb+Dy+Y calcd. as Y

(541) Nurlybaev (1976), nepheline syenite, Esil'skii massif, Kazakhstan; (542) Rimskaya-Korsakova et al. (1979), apatite-calcite-magnetite ore, Kovdor massif, Karelia, U.S.S.R.; (543) Borovskii and Gerasimovskii (1945), Kirov mine, Kola Peninsula, U.S.S.R.; (544) same as (542); (545) Kapustin (1966), magnetite-olivine-apatite rock, Kovdor massif; (546) Balashov and Turanskaya (1960), ijolite-urtite, Lovozero, Kola Peninsula; (547) Rimskaya-Korsakova et al. (1979), apatite-forsterite-magnetite ore, Kovdor massif; (548) same as (547); (549) Rudnitskaya (1970), exocontact of alkalic intrusive, Aldan; (550) Rass (1964), ore pyroxenite, Koksharov complex, Maritime Province, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	551	552	553	554	555	556	557	558	559	560
La	21.6	21.3	20.4	24.4	19.7	46.1	23 8	22 5	18.5	20.9
Ce	44.7	46.4	46.2	43.1	46.9	26.0	43.6	45.2	48.1	46 1
Pr	5.7	4.3	5.5	4.6	5.5	–	4.8	4.5	5.6	5.2
Nd	20.9	21.8	18.6	19.6	20.8	24.9	19.5	20.6	22.2	22.3
Sm	3 3	3.0	3 4	3.8	4.0	2.3	3.5	3.2	2.9	3.0
Eu	a	–	–	1.1	a	0.4	–	0.8	a	a
Gd	3.0[a]	2.4	2.8	1.7	2.9[a]	–	3.6	1 6	2.4[a]	2.0[a]
Tb	–	b	–	–	–	0.2	–	o 2	b	–
Dy	–	0.5	1.0	0.7	–	–	0.5	0.7	0.1	–
Ho	0.2	–	0.3	0.4	–	–	0 1	0.1	–	–
Er	0.3	0.2	0.8	0.4	0.1	–	0.4	0.2	0.1	0.3
Tm	–	–	0.1	–	–	–	–	–	–	–
Yb	0.3	0.1	0.7	0.2	0.1	0.1	0.2	0.3	0.1	0.2
Lu	–	–	0.2	–	–	–	–	0.1	–	–
Y/(Y+Ln)x100	(7.5)	(6.9)[b]	(13.0)	(1.7)	(5.2)	–	(15.4)	—	(2.5)[b]	(4.1)
Method	CH	CH	OS	OS	CH	NA	CH	OS	CH	CH
Σ = La+Ce+Pr	72.0	72.0	72 1	72.1	72.1	72.1	72.2	72 2	72.2	72.2
La-Nd	9 9	93.8	90.7	91.7	92.9	97.0	91.7	92.8	94.4	94.5
Sm-Ho	6.5	5.9	7.5	7 7	6.9	2 9	7.7	6.8	5.4	5.0
Er-Lu	0.6	0.3	1 8	0.6	0.2	0.1	0.6	0.4	0.2	0.5
RE_2O_3	0.20	0.43	1.08	1.17	0.20	0.126*	0.28	0.75	0.52	0.24
La/Nd	1.03	0.97	1.10	1.24	0.95	2.05	1.22	1.09	0.84	0.94

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(551) Rimskaya-Korsakova et al. (1979), apatite-forsterite-magnetite ore, Kovdor massif, Kola Peninsula, U.S.S.R.; (552) Rass (1970), pyroxenite, Bolshesayansk massif, E. Siberia; (553) Kholodnov et al. (1975a), alaskite, Chelyabinsk, Urals, U.S.S.R.; (554) Marchenko et al. (1980), dolomite-calcite carbonatite, Ukrainian Shield; (555) same as (551); (556) Puchelt and Emmermann (1976), dioritic gneiss, Black Forest, Germany; (557) Rass (1964), carbonate rock, Koksharov complex, Maritime Province, U.S.S.R.; (558) Knubovets et al., (1979), ijolite, Meimech-Kotui province, Siberia; (559) Kurbatova (1972) apatite-olivine rock, Kovdor massif, Karelia; (560) same as (551)

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	561	562	563	564	565	566	567	568	569	570
La	24.7	24.9	18.6	20.9	20.0	19.9	13.1	23.6	21.3	19.1
Ce	42.7	43.2	49.3	46.3	47.6	47.0	56.7	43.4	44.3	45.1
Pr	4.8	4.1	4.3	5.1	4.7	5.5	2.6	5.5	6.9	8.3
Nd	22.5	24.1	25.2	22.5	23.2	19.2	22.5	17.2	17.5	21.4
Sm	1.9	1.9	1.2	2.3	2.7	3.7	-	3.5	2.3	2.7
Eu	-	0.4	0.2	-	0.4	0.8	1.7	-	0.6	-
Gd	2.9	0.7	0.7	2.5	-	1.8	1.4	3.9	2.8	2.7
Tb	-	0.3	-	-	-	-	-	-	1.1	b
Dy	0.5	0.4	0.5	0.3	1.4	1.3	-	1.2	2.1	0.4
Ho	-	-	-	-	-	-	-	0.3	0.2	-
Er	-	-	-	0.1	-	0.5	1.4	1.0	0.3	0.3
Tm	-	-	-	-	-	-	0.3	-	0.2	-
Yb	-	-	-	-	-	0.3	0.3	0.4	0.4	-
Lu	-	-	-	-	-	-	-	-	-	-
Y/(Y+Ln)x100	(8.2)	-	-	(6.2)	-	(8.2)	(4.1)	(12.7)	(7.1)	(4.6) b
Method	CH	XF	XF	CH	XF	XF	-	CH	OS	CH
Σ = La+Ce+Pr	72.2	72.2	72.2	72.3	72.3	72.4	72.4	72.5	72.5	72.5
La-Nd	94.7	96.3	97.4	94.8	95.5	91.6	94.9	89.7	90.0	93.9
Sm-Ho	5.3	3.7	2.6	5.1	4.5	7.6	3.1	8.9	9.1	5.8
Er-Lu	-	-	-	0.1	-	0.8	2.0	1.4	0.9	0.3
RE_2O_3	0.19	0.68	1.18	-	0.86	0.56*	1.29*	0.97	0.29	0.76
La/Nd	1.10	1.03	0.74	0.93	0.86	1.04	1.42	1.37	1.22	0.89

* = % R.E.

(b) Tb+Y calcd. as Y

(561) Rass (1973), nepheline-pyroxene rock, Guli massif, Karelia, U.S.S.R.; (562) Meliksetyan (1963), granosyenite, Megrin massif, Armenian S.S.R.; (563) Mikhailov and Mineev (1970), metasomatic diopside rock, Aldan massif; (564) Rass (1973), nepheline-pyroxene rock, Kovdor massif, Karelia; (565) same as (563); (566) Balashov and Pozharitskaya (1968), carbonatite, 3rd stage, W. Siberia; (567) Portnov and Gorobets (1969), urtite, Khibina massif, Kola Peninsula, U.S.S.R.; (568) Rass (1973), ankaratrite, Guli massif, Karelia; (569) Kapustin (1977), fenite, Lower Sayan; (570) Rass (1968), nepheline-pyroxene rock, Kovdor massif, Karelia

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	571	572	573	574	575	576	577	578	579	580
La	24.4	20.4	20.7	21.0	20.3	21.9	21.8	19.2	23.0	7.0
Ce	46.2	46.8	46.2	46.2	46.4	47.4	44.3	48.4	45.1	39.0
Pr	1.9	5.4	5.8	5.5	6.0	3.5	6.8	5.3	4.8	27.0
Nd	21.6	20.5	20.6	21.0	23.6	21.6	21.2	21.6	21.7	4.2
Sm	4.0	3.2	3.0	3.2	0.9	2.2	3.6	3.1	2.6	5.1
Eu	—	a	—	a	0.1	—	0.3	—	0.7	1.0
Gd	1.9	2.8[a]	3.7	2.7[a]	1.4	2.7	1.1	2.1	1.7	1.4
Tb	b	—	b	—	0.2	0.4	0.1	b	—	—
Dy	—	0.3	—	—	0.9	0.1	0.3	0.2	0.4	13.4
Ho	—	0.2	—	—	—	—	—	—	—	—
Er	—	0.2	—	0.3	0.2	0.2	0.3	0.1	—	0.9
Tm	—	—	—	—	—	—	—	—	—	0.1
Yb	—	0.2	—	0.1	—	—	0.2	—	—	0.9
Lu	—	—	—	—	—	—	—	—	—	—
Y/(Y+Ln)x100	(3.0)[b]	(3.3)	(9.7)[b]	(4.3)	—	(9.7)	(4.3)	(3.6)[b]	—	—
Method	CH	CH	CH	CH	XF	CH	XF	CH	XF	—
Σ = La+Ce+Pr	72.5	72.6	72.7	72.7	72.7	72.8	72.9	72.9	72.9	73.0
La-Nd	94.1	93.1	93.3	93.7	96.3	94.4	94.1	94.5	94.6	77.2
Sm-Ho	5.9	6.5	6.7	6.2	3.5	5.4	5.4	5.4	5.4	20.9
Er-Lu	—	0.4	—	0.1	0.2	0.2	0.5	0.1	—	1.9
RE_2O_3	0.001	0.26	0.09	0.26	—	1.67	12.0	0.69	0.71	1.00
La/Nd	1.13	1.00	1.01	1.00	0.86	1.01	1.03	0.89	1.06	1.65

(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(571) Rass (1972), phlogopite-olivine rock, Kovdor massif, Karelia, U.S.S.R.; (572) Rimskaya-Korsakova et al. (1979), apatite-forsterite-magnetite ore, Kovdor massif, Karelia; (573) Rass (1968), olivinite, Kovdor massif; (574) Rimskaya-Korsakova et al. (1968), magnetite-olivine rock, Kovdor massif (same as (572)(?), (575) Vasil'eva quoted by Semenov (1963), apatite-magnetite rock, Lebyazhin, Urals, U.S.S.R.; (576) Rass (1968), olivine-magnetite-apatite rock, Kovdor massif; (577) Semenov and Barinskii (1958), nepheline-syenite pegmatite, Lovozero massif, Kola Peninsula; (578) Rass (1968), nepheline-pyroxene rock, Kovdor massif; (579) Khomyakov and Frantsesson (1971), carbonatite, Kuonapki River, Yakutia; (580) Portnov and Gorobets (1969), gabbro, Kragerö, Norway

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.—	581	582	583	584	585	586	587	588	589	590
La	18.4	17.8	22.0	19.3	21.1	19.5	20.7	28.3	20.7	19.6
Ce	48.3	51.9	45.2	47.5	46.0	47.7	45.9	42.1	45.8	48.0
Pr	6 3	3.3	5.8	6 2	6.0	5.9	6.6	2.8	6.7	5.6
Nd	20.6	20.6	20.7	25.6	19.5	21.2	18.0	19.8	20.3	20.3
Sm	2.7	2.9	3.2	0.2	3 8	3.0	4 3	2.0	2.8	2.9
Eu	1.0	–	a	–	0.9	a	–	0.4	–	–
Gd	1.8	2.6	2.4[a]	0.7	1.8	2.3[a]	2.9	2.3	3.0	3 2
Tb	0.1	b	–	0.1	–	–	b	–	b	c
Dy	0.7	0.6	–	0.3	0.9	–	1.5	1.3	0.6	c
Ho	–	–	–	–	–	–	0.1	0.2	–	0.1
Er	0.1	0.2	0.4	0.1	–	0.2	–	0.4	0.1	0.2
Tm	–	–	–	–	–	–	–	0.1	–	–
Yb	–	0.1	0.3	–	–	0.2	–	0.3	–	0.1
Lu	–	–	–	–	–	–	–	–	–	–
Y/(Y+Ln)x100	–	(5.2)[b]	(3.8)	–	–	(4.3)	(3.5)[b]	(6.2)	(6.2)[b]	(7.5)[c]
Method	XF	CH	CH	XF	XF	CH	CH	OS	CH	CH
Σ = La+Ce+Pr	73.0	73.0	73.0	73.0	73.1	73.1	73 2	73.2	73.2	73 2
La-Nd	93.6	93 6	93.7	98.6	92.6	94.3	91.2	93.0	93.5	93.5
Sm-Ho	6.3	6.1	5.6	1.3	7.4	5.3	8.8	6.2	6.4	6.4
Er-Lu	0.1	0.3	0.7	0.1	–	0.4	–	0.8	0.1	0.1
RE_2O_3	0.55	0.83	0.39	–	0.01	0.30	3 3 4	3.60*	0.98	0.98
La/Nd	0.89	0.86	1.06	0.75	1.08	0.92	1.15	1.43	1.02	1.02

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(581) Khomyakov and Frantsesson (1971), kimberlite, Kuonapki River, Yakutia; (582) Rass (1963), pyroxene-rich rock, Kovdor massif, Karelia, U.S.S.R.; (583) Rimskaya-Korsakova et al. (1979), apatite-calcite-magnetite ore, Kovdor massif; (584) Khvostova (1962), diopside rock, Leglier, Yakutia; (585) Kapustin (1977), supergene, Lower Sayan; (586) Rimskaya-Korsakova et al. (1968), olivine-diopside-phlogopite rock, Kovdor massif; (587) Borutskii et al. (1975), aegirine-diopside-feldspar pegmatite, Mt. Chashechorr, Kola Peninsula, U.S.S.R.; (588) Hildebrand and Conklin (1974), magnetite-apatite breccia dike, Iron Hill, Colo; (589-590) Rass (1970), Bolshesayansk massif, E. Siberia; (589) diopside-augite carbonatite; (590) olivine carbonatite

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.—	591	592	593	594	595	596	597	598	599	600
La	18.5	22.0	26.0	28.0	15.6	17.4	18.2	25.6	25.3	24.4
Ce	48.4	45.4	46.3	40.0	48.5	51.5	48.2	41.7	44.3	44.4
Pr	6.3	5.8	0.9	5.3	9.2	4.5	7.0	6.1	3.8	4.7
Nd	20.6	21.3	22.1	19.5	19.5	18.5	20.6	19.9	24.6	17.0
Sm	2.6	2.7	1.1	2.9	4.9	2.9	2.8	2.9	0.8	4.5
Eu	1.0	0.2	—	—	0.8	—	0.3	0.2	0.1	—
Gd	1.8	1.8	2.9	1.8	0.9	2.4	1.4	1.8	0.8	4.5
Tb	0.1	—	b	—	—	0.5	0.6	0.3	0.1	c
Dy	0.7	0.6	0.6	1.2	—	1.9	0.6	0.7	0.2	c
Ho	—	—	—	—	—	—	0.1	0.2	—	0.1
Er	—	0.2	0.1	0.9	0.4	0.4	0.2	0.4	—	0.2
Tm	—	—	—	—	0.1	—	—	—	—	0.1
Yb	—	—	—	0.4	0.1	—	—	0.2	—	0.1
Lu	—	—	—	—	—	—	—	—	—	—
Y/(Y+Ln)x100	—	—	(3.3)[b]	(12.5)	(3.2)	—	—	(1.2)	—	(5.0)[c]
Method	XF	XF	CH	XF	—	XF	XF	XF	XF	CH
Σ = La+Ce+Pr	73.2	73.2	73.2	73.3	73.3	73.4	73.4	73.4	73.4	73.5
La-Nd	93.8	94.5	95.3	92.8	92.8	91.9	94.0	93.3	98.0	90.5
Sm-Ho	6.2	5.3	4.6	5.9	6.6	7.7	5.8	6.1	2.0	9.1
Er-Lu	—	0.2	0.1	1.3	0.6	0.4	0.2	0.6	—	0.4
RE_2O_3	—	0.59	—	1.00	1.00	0.02*	0.19	0.80	0.51	0.16
La/Nd	0.90	1.03	1.17	1.43	0.80	0.94	0.94	1.29	1.03	1.43

(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(591) Ilupin et al. (1971), kimberlite, Prilenskii region, Yakutia; (592) Lyakhovich (1968), granite, Voronezh massif, U.S.S.R.; (593) Rass (1968), carbonatite, Kovdor massif, Karelia, U.S.S.R.; (594) Vasil'eva and Kalinin, quoted by Semenov (1963), granite pegmatite, S. Baikal; (595) Portnov and Gorobets (1965), carbonatite, Vuorijarvi, Karelia; (596) Ignat'eva (1973), Abovyan magnetite deposit, Armenian S.S.R.; (597) Kapustin (1966), carbonatite, Afrikanda, Karelia; (598) Khvostova (1962), diopside-rich rock, S. Yakutia; (599) Lyakhovich and Barinskii (1961), granite, Megrin pluton, Armenian S.S.R.; (600) Rass (1968), mica-rich rock, Kovdor massif, Karelia

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	601	602	603	604	605	606	607	608	609	610
La	20.8	22.3	20.6	16.3	23.0	21.5	13.7	23.6	20.7	21.4
Ce	46.1	47.2	48.5	48.0	44.8	47.8	56.3	44.4	47.7	47.3
Pr	6.6	4.1	4.5	9.3	5.8	4.3	3.6	5.7	5.3	5.1
Nd	18.1	17.3	17.7	19.5	20.7	20.8	21.8	20.5	21.2	18.4
Sm	4.3	2.8	2.1	1.0	2.5	3.1	4.6	2.8	2.8	4.4
Eu	a	0.6	0.6	1.2	0.7	–	–	0.4	a	–
Gd	2.9[a]	2.7	1.7	1.5	2.0	2.0	–	1.7	1.8[a]	2.0
Tb	b	–	0.3	–	–	b	–	0.1	–	–
Dy	1.2	1.1	1.6	–	0.5	0.3	–	0.6	–	–
Ho	–	0.4	0.3	–	–	0.1	–	–	–	0.3
Er	–	0.8	1.2	2.7	–	0.1	–	0.2	0.3	0.7
Tm	–	0.3	0.1	0.2	–	–	–	–	–	–
Yb	–	0.3	0.7	0.3	–	–	–	–	0.2	0.4
Lu	–	0.1	–	–	–	–	–	–	–	–
Y/(Y+Ln)x100	(3.6)[b]	(8.4)	(17.8)	(5.5)	–	(2.8)[b]	–	(4.5)	(2.9)	(10.0)
Method	CH	OS	XF	–	XF	CH	XF	XF	CH	XF
Σ = La+Ce+Pr	73.5	73.6	73.6	73.6	73.6	73.6	73.6	73.7	73.7	73.8
La-Nd	91.6	90.9	91.3	93.1	94.3	94.4	95.4	94.2	94.9	92.2
Sm-Ho	8.4	7.6	6.6	3.7	5.7	5.5	4.6	5.6	4.6	6.7
Er-Lu	–	1.5	2.1	3.2	–	0.1	–	0.2	0.5	1.1
RE_2O_3	–	0.32	0.66	0.70	0.60	3.77	1.63	1.3*	0.46	0.86*
La/Nd	1.15	1.29	1.17	0.84	1.11	1.03	0.63	1.15	0.98	1.16

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(601) Varshal et al. (1967), alkalic pegmatite, Chasnachorr, Kola Peninsula, U.S.S.R.; (602) Kholodnov et al. (1975a), diorite, Briensk, Urals, U.S.S.R.; (603) Parak (1973), iron ore, Kirunavaara, Lappland; (604) Portnov and Gorobets (1969), carbonatite, Kovdor massif, Karelia, U.S.S.R.; (605) Khomyakov and Frantsesson (1971), carbonatite, Kuonapki River, Yakutia; (606) Borutskii et al. (1975), aegirine-diopside-feldspar pegmatite, Mt. Chasnachorr, Kola Peninsula; (607) Vorontsov (1972), amphibole syenite, Kholderminsk massif, E. Sayan; (608) Eby (1975), carbonatite, Oka, Quebec; (609) Rimskaya-Korsakova et al. (1968), olivine-magnetite-apatite rock, Kovdor massif; (610) Plaksenko (1979), gabbro-norite, Elan'skaya intrusive, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	611	612	613	614	615	616	617	618	619	620
La	21.6	18.3	21.9	23.9	18.5	21.6	21.8	24.4	21.4	20.0
Ce	46.2	49.5	46.4	44.7	50.5	47.4	43.2	42.7	46.8	48.9
Pr	6.0	6.0	5.5	5.3	4.9	4.9	8.9	6.8	5.7	5.0
Nd	19.0	19.7	20.4	15.8	16.1	17.6	18.7	20.1	20.7	22.0
Sm	3.5	2.4	2.8	3.5	2.3	3.2	6.5	3.0	3.2	2.3
Eu	a	0.3	a	0.7	0.8	0.8	0.4	a	–	–
Gd	2.7[a]	2.4	2.3[a]	3.4	1.9	2.2	–	2.2[a]	1.9	1.8
Tb	–	0.3	–	–	0.4	0.3	–	b	–	c
Dy	0.9	0.7	–	1.2	1.7	1.2	–	0.8	–	c
Ho	–	0.1	–	0.3	0.4	0.2	–	–	–	–
Er	0.1	0.2	0.4	0.8	1.5	0.4	0.4	–	–	–
Tm	–	–	–	0.1	0.1	–	–	–	–	–
Yb	–	0.1	0.3	0.3	0.8	0.2	0.1	–	0.3	–
Lu	–	–	–	–	0.1	–	–	–	–	–
Y/(Y+Ln)x100	(3.9)	–	(3.5)	(11.2)	(17.8)	–	(5.7)	(3.4)[b]	(10.9)	(2.5)[c]
Method	CH	XF	CH	OS	XF	OS	OS	CH	XF	CH
Σ = La+Ce+Pr	73.8	73.8	73.8	73.9	73.9	73.9	73.9	73.9	73.9	73.9
La-Nd	92.8	93.5	94.2	89.7	90.0	91.5	92.6	94.0	94.6	95.9
Sm-Ho	7.1	6.2	5.1	9.1	7.5	7.9	6.9	6.0	5.1	4.1
Er-Lu	0.1	0.3	0.7	1.2	2.5	0.6	0.5	–	0.3	–
RE_2O_3	0.81	0.43	0.38	1.50	0.53	0.10	–	2.08	0.67*	0.40
La/Nd	1.13	0.93	1.07	1.51	1.15	1.23	1.16	1.22	1.04	0.91

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(611) Rimskaya-Korsakova et al. (1979), dolomitic carbonatite, Kovdor massif, Karelia, U.S.S.R. (612) Kapustin (1966), carbonatite, Vuorijarvi, Karelia; (613) Rimskaya-Korsakova et al. (1979), apatite-calcite-magnetite ore, Kovdor massif; (614) Kholodnov et al. (1975a), syenite-diorite, Kushvinsk, Urals, U.S.S.R.; (615) Parak, (1973), iron ore, Haukivaraa, Lappland; (616) Knubovets et al. (1979), fenite, Meimech-Kotui province, Siberia; (617) Spasskii (1970), Synnyr alkalic massif, N. Cisbaikal; (618) Dudkin (1969), magnetite-apatite rock, Synnyr massif; (619) Plaksenko (1979), hornblende gabbro-norite, Shiryeeva intrusive, U.S.S.R.; (620) Vasil'eva (1976), kimberlite, Yakutia

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	621	622	623	624	625	626	627	628	629	630
La	25.3	20.4	23.2	24.6	20.3	21.8	23.7	20.3	26.9	18.5
Ce	44.2	48.1	45.4	43.8	47.4	45.5	44.7	46.4	44.3	49.8
Pr	4.4	5.5	5.4	5.7	6.4	6.8	5.7	7.4	3.0	5.9
Nd	22.6	20.1	20.1	17.6	20.0	20.1	20.4	20.7	15.1	21.0
Sm	1.7	2.8	2.8	3.4	2.7	3.5	1.9	2.2	3.4	2.6
Eu	0.2	0.8	0.8	–	–	0.3	0.2	0.4	0.8	0.4
Gd	1.0	1.8	1.5	4.1	3.1	1.1	–	1.4	6.0	1.4
Tb	0.2	–	0.1	b	c	0.1	–	0.5	–	0.1
Dy	0.4	0.5	0.4	0.7	c	0.3	3.4	0.5	0.4	0.3
Ho	–	–	0.2	–	–	–	–	–	–	–
Er	–	–	0.1	0.1	0.1	0.3	–	0.1	–	–
Tm	–	–	–	–	–	–	–	–	–	–
Yb	–	–	–	–	–	0.2	–	0.1	0.1	–
Lu	–	–	–	–	–	–	–	–	–	–
Y/(Y+Ln)x100	(0.1)	–	(4.2)	(9.5)[b]	(6.6)[c]	(4.3)	–	–	(1.8)	–
Method	XF	XF	XF	CH	CH	XF	XF	XF	CH	XF
Σ = La+Ce+Pr	73.9	74.0	74.0	74.1	74.1	74.1	74.1	74.1	74.2	74.2
La-Nd	96.5	94.1	94.1	91.7	94.1	94.2	94.5	94.8	89.3	95.2
Sm-Ho	3.5	5.9	5.8	8.2	5.8	5.3	5.5	5.0	10.6	4.8
Er-Lu	–	–	0.1	0.1	0.1	0.5	–	0.2	0.1	–
RE_2O_3	2.4	0.54	1.92*	0.02	0.42	2.9	0.05*	0.73	0.23	0.77
La/Nd	1.12	1.02	1.15	1.40	1.02	1.08	1.17	0.98	1.77	0.88

* = % R.E.
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(621) Lyakhovich and Barinskii (1961), quartz syenite, Megrin pluton, Armenian S.S.R.; (622) Khomyakov and Frantsesson (1971), carbonatite, Kuonapki River, Yakutia; (623) Eby (1975), carbonatite, Oka, Quebec; (624) Rass (1972), melilite-nepheline rock, Kovdor massif, Karelia, U.S.S.R.; (625) Rass (1970), diopside-augite carbonatite, Bolshesayansk massif, E. Siberia; (626) Semenov (1962), natrolite zone, Mt. Nepkha, Lovozero massif, Kola Peninsula; (627) Ignat'ev (1973), Abovyan magnetite deposit, Armenian S.S.R.; (628) Zolotarev (1963), nepheline pyroxenite, Karelia; (629) Kirillov and Ryzhova (1968), carbonatite, Kovdor massif, Karelia; (630) Ganzeev et al. (1966), carbonatized biotite-feldspar rock, Vishnevye Mts., Urals, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No —	631	632	633	634	635	636	637	638	639	640
La	36.5	20.4	20.2	34.3	24.7	17.1	8.3	23.2	14.2	25.6
Ce	31.9	46.5	49.2	37.1	43.1	51.0	65.1	45.6	53.5	43.9
Pr	5.9	7.4	4.9	3.0	6.6	6.3	1.0	5.6	6.8	5.0
Nd	18.2	20.7	20.7	15.1	17.0	19.7	20.0	20.7	14.3	18.7
Sm	3.0	2.2	1.7	5.8	4.5	2.0	2.9	2.3	7.1	3.1
Eu	0.6	0.4	–	1.1	–	0.2	1.0	0.6	–	a
Gd	2.0	1.4	2.6	2.8	3.0	2.4	0.7	1.6	3.1	2.7[a]
Tb	–	0.2	b	–	b	0.1	–	b	–	b
Dy	1.0	0.5	0.6	0.5	0.4	0.7	–	0.4	–	1.0
Ho	0.2	–	–	–	0.1	–	–	–	–	–
Er	0.4	0.2	0.1	0.2	0.6	0.2	0.9	–	–	–
Tm	–	–	–	–	–	–	–	–	–	–
Yb	0.3	0.1	–	0.1	–	0.3	0.1	–	1.0	–
Lu	–	–	–	–	–	–	–	–	–	–
Y/(Y+Ln)x100	(6.6)	(4.2)	(6.2)[b]	(2.3)	(6.9)[b]	(7.2)	(3.3)	(1.6)[b]	(24.6)	(4.6)[b]
Method	OS	XF	CH	CH	CH	OS	–	XF	XF	CH
Σ = La+Ce+Pr	74.3	74.3	74.3	74.4	74.4	74.4	74.4	74.4	74.5	74.5
La-Nd	92.5	95.0	95.0	89.5	91.4	94.1	94.4	95.1	88.8	93.2
Sm-Ho	6.8	4.7	4.9	10.2	8.0	5.4	4.6	4.9	10.2	6.8
Er-Lu	0.7	0.3	0.1	0.3	0.6	0.5	1.0	–	1.0	–
RE_2O_3	0.62	0.73	0.72	0.16	2.27	0.35	0.88	0.453*	0.19	1.70
La/Nd	2.01	0.99	0.97	2.28	1.45	0.87	0.42	1.12	1.00	1.37

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(631) Kholodnov et al. (1975a), granodiorite, Nova Buranovsk, Urals, U.S.S.R.; (632) Lyakhovich and Barinskii (1961), aegirine syenite, Inagli massif, Aldan; (633) Rass (1970) olivine carbonatite, Bolshesayansk massif, E. Siberia; (634) Kirillov and Ryzhova (1968), dolomitic carbonatite, Kovdor massif, Karelia, U.S.S.R.; (635) Borutskii et al. (1975), albitized fenite, Mt. Valepakh, Khibina massif, Kola Peninsula, U.S.S.R.; (636) Kapustin (1977), calcite carbonatite, Vuojarvi, Karelia; (637) Portnov and Gorobets (1969), kimberlite, Yakutia; (638) Kaminskii et al. (1978), av. of 8, from carbonatites, India; (639) Aleksiev et al. (1969), granodiorite, Plana pluton, Bulgaria, (640) Dudkin (1969), pyroxene-biotite-apatite rock, Synnyr massif, N. Cisbaikal

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	641	642	643	644	645	646	647	648	649	650
La	22.0	24.6	20.6	116 3	25.4	32.2	21.2	20.4	20.3	35.3
Ce	49 3	46.0	49.4	54.7	45.5	39.4	47.4	40.9	48.4	35.5
Pr	3 2	3.9	4.6	3.6	3 7	3.1	6.1	5.3	6.0	4.0
Nd	19.5	22.9	13.7	18.1	20.4	13.5	18.6	18.7	19.7	13.1
Sm	1.5	0.9	9.8	2.4	2.9	3.0	3.2	2.3	2.8	2.5
Eu	a	0.2	0.6	1.0	-	1.1	a	0.2	0.5	0.8
Gd	2.3[a]	0.8	0.8	1.8	2.1	3.6	2.4[a]	2.7	1.5	5.2
Tb	b	-	-	0.3	c	0.4	-	0.4	0.2	0.3
Dy	0.8	0.5	-	1.1	c	2.0	0.7	1.0	0 4	2 2
Ho	0.3	0.2	-	0.1	-	0.4	0.1	_	-	0 3
Er	0.7	-	0.2	0.3	-	0.7	0.2	-	0.1	0 6
Tm	-	-	0.1	-	-	0.1	-	-	-	-
Yb	0.4	-	0.2	0.3	-	0.4	0.1	-	0 1	0.2
Lu	-	-	-	-	-	0.1	-	-	-	-
Y/(Y+Ln)x100	(11.4)[b]	-	-	(5.5)	(10.3	-	(4.8)	(6.9)	-	(10.1)
Method	CH	XF	OS	XF	CH	OS	CH	XF	XF	OS
Σ = La+Ce+Pr	74.5	74.5	74.6	74.6	74.6	74.7	74.7	74.7	74.7	74.8
La-Nd	94.0	97.4	88.3	92.7	95.0	88.2	93 3	93 4	94.4	87 9
Sm-Ho	4 9	2.6	11.2	6.7	5.0	10.5	6.4	6.6	5.4	11.3
Er-Lu	1.1	-	0.5	0.6	-	1 3	0.3	-	0.2	0.8
RE_2O_3	0.44	0.40	-	0.84	0.59	0.31	0.39	0.42	0.81	0.23
La/Nd	1.13	1.08	1.51	0.90	1.25	2 39	1.14	1.09	1.03	2 69

(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(641) Rass (1964), ore pyroxenite, Koksharov complex, Maritime Prov., U.S.S.R.; (642) Semenov (1967), ijolite pegmatite, Tuva A.S.S.R.; (643) Spasskii (1970), biotite-pyroxene-feldspar rock, Synnyr massif, N. Cisbaikal; (644) Parak (1973), iron ore, Kirunavaara, Lappland; (645) Afanas'ev et al. (1976), plagioclase gneiss, Mahropidzh River, Causasus, U.S.S.R.; (646) Zhirova and Lyagushkin (1979), phologpite metasomatite, Meimech-Kotui province, Siberia; (647) Rimskaya-Korsakova et al. (1979), apatite-calcite-magnetite ore, Kovdor massif, Karelia; U.S.S.R.; (648) Lyakhovich and Barinskii (1961), malignite, Inagli massif, Aldan; (649) Kapustin (1966), carbonatite, Sallanlatra, Karelia; (650) Knubovets et al. (1979), phologpite-metasomatite, Meimech-Kotui province

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	651	652	653	654	655	656	657	658	659	660
La	22.4	23.6	23.4	25.8	25.1	23.4	23.6	22.4	20.1	22.6
Ce	43.7	45.7	46.4	44.5	46.8	45.5	46.7	46.6	48.9	48.9
Pr	8.7	5.5	5.0	4.6	3.0	6.0	5.2	6.0	6.0	3.6
Nd	18.4	18.7	23.6	16.4	18.2	18.6	20.3	14.8	18.6	15.7
Sm	5.8	2.5	0.6	2.6	2.9	2.5	2.6	1.9	2.8	2.5
Eu	0.4	0.3	0.1	0.5	1.0	0.3	0.7	—	0.3	1.0
Gd	—	1.5	0.4	2.2	2.2	2.1	1.1	3.7	1.8	3.4
Tb	—	0.2	—	0.1	—	0.3	—	0.5	0.2	0.3
Dy	—	1.1	0.4	1.4	0.7	0.7	0.4	2.7	0.6	1.3
Ho	—	0.2	—	0.3	—	0.1	—	0.4	0.2	0.2
Er	0.4	0.4	0.1	0.8	—	0.2	—	0.9	0.3	0.4
Tm	0.1	0.1	—	0.2	—	0.1	—	0.1	—	—
Yb	0.1	0.2	—	0.5	0.1	0.2	—	—	0.2	0.1
Lu	—	—	—	0.1	—	—	—	—	—	—
Y/(Y+Ln)x100	—	—	—	—	(2.0)	(6.3)	—	—	—	(8.8)
Method	OS	—	XF	—	CH	OS	XF	—	XF	OS
Σ = La+Ce+Pr	74.8	74.8	74.8	74.9	74.9	74.9	74.9	75.0	75.0	75.1
La-Nd	93.2	93.5	98.4	91.3	93.1	93.5	95.2	89.8	93.6	90.8
Sm-Ho	6.2	5.8	1.5	7.1	6.8	6.0	4.8	9.2	5.9	8.7
Er-Lu	0.6	0.7	0.1	1.6	0.1	0.5	—	1.0	0.5	0.5
RE_2O_3	1.40	0.66	—	0.78	0.64	0.35	0.56	0.20	0.42	0.50
La/Nd	1.22	1.26	0.99	1.57	1.36	1.26	1.13	1.51	1.09	1.44

(651) Spasskii (1970), magnetite-apatite rock, Synnyr massif, N. Cisbaikal; (652) Kravchenko and Vlasova (1962), shonkinite, central Aldan; (653) Khvostova (1962), diopside-rich rock, Smezhnoe, S. Yakutia; (654) Ovchinnikova (1973), apatite-pyroxene-magnetite rock, Lebyazhinsk, Urals, U.S.S.R.; (655) Kirillov and Ryzhova (1968), carbonatite, Vuojarvi, Karelia, U.S.S.R.; (656) Kapustin (1977), alnoite, Alnö, Sweden; (657) Khomyakov and Frantsesson (1971), carbonatite, Kvonapki River, Yakutia; (658) Vlasova and Kutukova, quoted by Semenov (1963), granite pegmatite, Urals, U.S.S.R.; (659) Kapustin (1966), carbonatite, Sebel'yavr, Karelia; (660) Kapustin (1977), calcite carbonatite, Vuojarvi, Karelia

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	661	662	663	664	665	666	667	668	669	670
La	22.9	16.3	28.5	21.3	27.4	22.6	28.1	22.3	25.0	24.3
Ce	46.6	55.0	41.7	53.9	43.8	47.3	43.3	49.8	44.9	45.5
Pr	5.6	3.8	4.9	-	4.0	5.3	3.9	3.2	5.4	5.5
Nd	17.2	17.5	19.0	11.3	18.7	18.9	13.1	16.0	19.2	19.3
Sm	2.1	2.3	2.7	6.9	3.8	2.5	2.2	2.3	2.6	2.7
Eu	0.3	1.0	-	-	-	-	0.4	1.1	0.4	0.4
Gd	2.2	1.9	2.3	4.8	2.3	1.8	4.3	3.1	1.4	1.5
Tb	0.7	0.3	-	-	-	-	3.5	0.3	0.2	0.2
Dy	1.6	1.1	0.9	1.4	-	0.8	0.7	1.1	0.6	0.5
Ho	0.3	0.1	-	-	-	-	0.2	0.2	0.1	-
Er	0.1	0.4	-	-	-	0.5	0.3	0.4	0.2	0.1
Tm	0.2	0.1	-	-	-	-	-	-	-	-
Yb	0.2	0.2	-	0.4	-	0.3	-	0.2	-	-
Lu	-	-	-	-	-	-	-	-	-	-
Y/(Y+Ln)x100	(6.1)	(7.0)	-	(8.4)	-	(8.7)	-	(8.3)	(6.3)	(4.4)
Method	OS	XF	XF	-	-	XF	XF	OS	XF	XF
Σ = La+Ce+Pr	75.1	75.1	75.1	75.2	75.2	75.2	75.3	75.3	75.3	75.3
La-Nd	92.3	92.6	94.1	86.5	93.9	94.1	88.4	91.3	94.6	94.6
Sm-Ho	7.2	6.7	5.9	13.1	6.1	5.1	11.3	8.1	5.3	5.3
Er-Lu	0.5	0.7	-	0.4	-	0.8	0.3	0.6	0.2	0.1
RE_2O_3	0.49	0.89	6.8	0.90	-	0.60*	0.82	0.56	2.6*	1.38*
La/Nd	1.34	0.93	1.50	1.88	1.47	1.20	2.14	1.39	1.80	1.26

* = % R.E.

(661) Kapustin (1977), fenite, Kovdor, Karelia; (662) Parak (1973), iron ore, Kirunavaara, Lappland; (663) Balashev and Turanskaya (1960), urtite, Lovozero massif, Kola Peninsula; (664) Nurlybaev (1976), nepheline syenite, Esil'skii massif, Kazakhstan; (665) Sin'kova and Turanskaya (1968), Precambrian metamorphosed rocks, Krivoi Rog; (666) Balashov and Pozharitskaya (1968), carbonatite, 1st stage, W. Siberia; (667) Lyakhovich and Barinskii (1961), Edygei massif, W. Tuva; (668) Kapustin (1977), calcite carbonatite, Upper Sayan; (669) Eby (1975), carbonatite, Oka, Quebec; (670) Eby (1975), augite-apatite rock, Oka, Quebec

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	671	672	673	674	675	676	677	678	679	680
La	20.1	20.3	24.4	23.0	19.4	48.3	27.6	22.9	25.5	23.4
Ce	47.6	49.0	45.2	47.7	51.9	27.1	43.8	48.2	44.6	46.4
Pr	7.6	6.0	5.8	4.7	4.1	—	4.0	4.4	5.4	5.7
Nd	19.9	20.7	15.9	18.1	19.0	21.8	21.9	15.5	16.6	17.7
Sm	2.7	2.2	4.1	2.4	2.2	1.8	1.0	0.3	1.5	2.4
Eu	0.2	a	1.8	a	—	0.6	0.5	1.4	0.1	—
Gd	—	1.6[a]	1.6	1.8[a]	2.7	—	1.1	5.1	1.0	1.7
Tb	0.7	—	0.4	b	—	0.2	—	0.3	0.1	—
Dy	0.6	—	0.5	0.6	0.7	—	0.1	1.3	5.2	0.3
Ho	—	—	—	0.4	—	—	—	0.1	—	0.1
Er	0.2	0.1	0.2	0.6	—	—	—	0.4	—	0.2
Tm	0.2	—	0.1	—	—	—	—	—	—	—
Yb	0.2	0.1	—	0.7	—	0.2	—	0.1	—	0.1
Lu	—	—	—	—	—	—	—	—	—	—
Y/(Y+Ln)x100	—	(3.5)	(4.7)	(3.2)[b]	—	—	—	(8.2)	—	(3.0)
Method	OS	CH	XF	CH	XF	NA	XF	OS	XF	CH
Σ = La+Ce+Pr	75.3	75.3	75.4	75.4	75.4	75.4	75.4	75.5	75.5	75.5
La-Nd	95.2	96.0	91.3	93.5	94.4	97.2	97.3	91.0	92.1	93.2
Sm-Ho	4.2	3.8	8.4	5.2	5.6	2.6	2.7	8.5	7.9	4.5
Er-Lu	0.6	0.2	0.3	1.3	—	0.2	—	0.5	—	0.3
RE_2O_3	—	0.32	1.69	1.00	2.51	0.663*	1.44	0.39	0.12*	0.62
La/Nd	1.01	0.98	1.54	1.28	1.02	2.22	1.26	1.47	1.54	1.32

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(671) Spasskii (1970), pyroxene-biotite-feldspar rock, Synnyr massif, N. Cisbaikal; (672) Rimskaya-Korsakova et al. (1968), olivine-magnetite-apatite rock, Kovdor massif, Karelia, U.S.S.R.; (673) Lee, et al. (1973), augite monzonite, Elko Co., Nev.; (674) Kurobatova (1972), ijolite, Kovdor massif; (675) Denisov et al. (1961), alkalic rock, Kola Peninsula U.S.S.R.; (676) Puchelt and Emmermann (1976), carbonatite, Kaiserstuhl, Germany; (677) Dudkin (1957), alkalic rock, Khibina massif, Kola Peninsula; (678) Kapustin (1977), calcite carbonatite, Vuojarvi, Karelia; (679) Ignat'ev (1973), Abovyan magnetite deposit, Armenian S.S.R.; (680) Rass (1973), phologpite carbonatite, Kovdor massif, Karelia

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	681	682	683	684	685	686	687	688	689	690
La	21.3	20.4	22.5	10.4	25.0	19.6	51.5	20.3	22.1	20.0
Ce	47.4	47.8	48.1	65.1	46.3	49.6	17.9	48.4	47.9	49.6
Pr	6.8	7.3	4.9	–	4.3	6.4	6.3	7.0	5.7	6.1
Nd	19.2	19.8	20.5	24.5	16.2	18.9	16.8	17.7	19.1	19.3
Sm	2.4	2.4	2.7	–	2.5	2.0	2.4	2.9	2.7	2.2
Eu	0.3	0.3	–	–	–	0.3	a	0.9	a	0.3
Gd	1.5	1.0	1.3	–	3.1	1.9	2.8[a]	2.3	2.5[a]	1.5
Tb	0.1	0.1	c	–	–	0.1	b	0.1	–	0.1
Dy	0.7	0.6	c	–	1.2	0.6	1.8	0.2	–	0.5
Ho	0.1	0.1	–	–	0.3	0.1	0.1	–	–	0.1
Er	0.1	0.1	–	–	0.6	0.2	0.2	–	–	0.3
Tm	–	–	–	–	0.5	–	–	–	–	–
Yb	0.1	–	–	–	–	0.3	0.2	–	–	–
Lu	–	–	–	–	–	–	–	0.2	–	–
Y/(Y+Ln)x100	–	–	(2.5)[c]	(0.2)	(7.3)	(9.5)	(10.0)[b]	–	(3.8)	–
Method	XF	XF	CH	XF	CH	OS	CH	XF	CH	XF
Σ = La+Ce+Pr	75.5	75.5	75.5	75.5	75.6	75.6	75.7	75.7	75.7	75.7
La-Nd	94.7	95.3	96.0	100.0	91.8	94.5	92.5	93.4	94.8	95.0
Sm-Ho	5.1	4.5	4.0	–	7.1	5.0	7.1	6.4	5.2	4.7
Er-Lu	0.2	0.2	–	–	1.1	0.5	0.4	0.2	–	0.3
RE_2O_3	0.70	0.80	0.19	1.31	0.45	0.42	–	0.90	0.37	0.70
La/Nd	1.11	1.03	1.09	0.42	1.55	1.03	3.07	1.15	1.15	1.03

(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(681-682) Es'kova and Ganzeev (1964), alkalic pegmatites, Vishnevye Mts., Urals, U.S.S.R.; (683) Rass (1968), olivine-magnetite-apatite rock, Kovdor massif, Karelia, U.S.S.R.; (684) Vorontov (1972), amphibole syenite, Kholderminsk massif, E. Sayan; (685) Rass (1973), ijolite, Guli massif, Karelia; (686) Kapustin (1977) calcite carbonatite, Lower Sayan; (687) Varshal et al. (1967), rischorrite, Obmanny, Kola Peninsula, U.S.S.R.; (SrO 23.7%); (688) Kapustin (1966), carbonatite, Afrikanda, Karelia; (689) Rimskaya-Korsakova et al. (1979), calcite carbonatite, Kovdor massif, Karelia; (690) same as (681)

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	691	692	693	694	695	696	697	698	699	700
La	21.3	25.0	30.0	19.3	28.1	29.8	24.4	25.3	23.5	21.2
Ce	47.4	36.9	39.9	48.0	41.9	41.2	48.3	45.0	47.7	49.5
Pr	7.0	13.8	5.9	8.5	5.8	4.9	3.2	5.6	4.7	5.2
Nd	19.6	24.3	15.3	17.7	19.7	14.4	17.4	17.5	18.3	20.6
Sm	2.2	-	3.0	2.3	2.4	3.4	3.0	2.5	2.4	1.5
Eu	0.3	-	0.7	0.4	0.3	-	-	0.5	-	0.1
Gd	1.2	-	3.2	1.5	1.1	2.6	3.2	1.8	2.2	0.6
Tb	0.1	b	-	0.2	0.1	-	-	-	-	0.1
Dy	0.4	-	1.0	0.9	0.4	1.4	0.5	0.5	-	0.5
Ho	0.1	-	0.2	0.2	-	0.4	-	0.1	0.1	0.1
Er	0.2	-	0.4	0.4	0.1	1.1	-	0.7	0.7	0.4
Tm	-	-	0.1	0.1	-	0.1	-	0.1	-	0.1
Yb	0.2	-	0.3	0.4	0.1	0.7	-	0.3	0.4	-
Lu	-	-	-	0.1	-	-	-	0.1	-	0.1
Y/(Y+Ln)x100	-	(46.9)[b]	(9.9)	-	(3.2)	(13.6)	(11.7)	(6.2)	(17.1)	(6.5)
Method	XF	CH	OS	XF	XF	OS	CH	OS	CH	XF
Σ = La+Ce+Pr	75.7	75.7	75.8	75.8	75.8	75.9	75.9	75.9	75.9	75.9
La-Nd	95.3	100.0	91.1	93.5	95.5	90.3	93.3	93.4	94.2	96.5
Sm-Ho	4.3	-	8.1	5.5	4.3	7.8	6.7	5.4	5.4	2.9
Er-Lu	0.4	-	0.8	1.0	0.2	1.9	-	1.2	0.4	0.6
RE_2O_3	0.88	0.02	1.19	3.30	1.29*	1.38	0.32	0.68	0.69	-
La/Nd	1.08	1.03	1.97	1.09	1.42	2.07	1.40	1.44	1.28	1.03

* = % R.E.
(b) Tb+Y calcd. as Y

(691) Kapustin (1966), carbonatite, Kovdor massif, Karelia, U.S.S.R.; (692) Bel'kov (1979), porphyroblastic granite, Ponoi River, Kola Peninsula, U.S.S.R.; (693) Kholodnov et al. (1975b), alaskite, Murzinsk, Urals, U.S.S.R.; (694) Ganzeev et al. (1966), biotite fenite, Vishnevye Mts., Urals; (695) Eby (1975), ijolite, Oka, Quebec; (696) Kholodnov et al., (1975a), granodiorite, Urals; (697) Rass (1973), pyroxene-calcite rock, Guli massif, Karelia; (698) Kholodnov et al. (1975a), migmatite, Il'men Mts., Urals; (699) Rass (1964), carbonatized pyroxenite, Koksharov complex, Maritime Prov., U.S.S.R.; (700) Zhabin and Svyazhin (1962), alkalic rock, Vishnevye Mts., Urals

Table 1 - Rare Earths in Apatite, atomic percent - continued

No —	701	702	703	704	705	706	707	708	709	710
La	23 3	20.8	36.5	126.0	28.2	21 6	25.3	21.7	29.7	28.8
Ce	46.2	49.2	35.2	44.5	44.8	46.4	46.1	50.2	42.7	43.7
Pr	6.4	6.0	4.3	5.5	3 0	8.1	4.7	4.2	3.7	3.7
Nd	21.1	12.6	17.0	17.6	19.5	17.3	17.3	21.7	21.8	14.9
Sm	1.2	7.0	2.5	33	2.5	2.6	2.4	0.8	0.3	3.6
Eu	0.3	—	—	—	—	—	a	—	—	a
Gd	0.9	3 1	4.5	2.8	1 6	2.5	2.6[a]	0.8	0.9	34[a]
Tb	0.2	—	—	—	—	—	b	b	0.2	b
Dy	0.4	—	—	0.3	0.4	1.5	1.3	0.6	0.3	1.1
Ho	—	—	—	—	—	—	—	—	—	0.2
Er	—	—	—	—	—	—	0.1	—	0.2	0.5
Tm	—	—	—	—	—	—	—	—	—	—
Yb	—	1.3	—	—	—	—	0.2	—	0.2	0.1
Lu	—	—	—	—	—	—	—	—	—	—
Y/(Y+Ln)x100	—	(21.5)	—	(4.4)	(3.1)	(6.7)	(5.6)[b]	(10.0)[b]	—	(6.9)[b]
Method	—	XF	—	CH	CH	CH	CH	CH	XF	CH
Σ = La+Ce+Pr	75.9	76.0	76.0	76.0	76.0	76.1	76.1	76 1	76 1	76.2
La-Nd	97.0	88.6	93.0	93 6	95.5	93 4	93.4	97 8	97.9	91.1
Sm-Ho	3 0	10.1	7.0	6.4	4.5	6.6	6.3	2 2	1.7	8.3
Er-Lu	—	1.3	—	—	—	—	0.3	—	0.4	0.6
RE_2O_3	1.21	0.26*	—	0.44	0.29	2.4	2 53	0.40	0 47	—
La/Nd	1.10	1.66	2 15	1.48	1.45	1.25	1.46	1.00	1 36	1.93

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(701) Meliksetyan, quoted by Nurlybaev (1976), nepheline syenite, Tezhsarskii; (702) Aleksiev et al. (1969), diorite, Plana pluton, Bulgaria; (703) Sin'kova and Turanskaya (1968), Precambrian metamorphic rock, Krivoi Rog, U.S.S.R.; (704-705) Rass (1973), Kovdor massif, Karelia, U.S.S.R.; (704) ijolite; (705) apatite-calcite rock; (706) Nadezhdina (1963), subalkalic rock, Bolshaya Botuobiya River, U.S.S.R.; (707) Dudkin (1969), calcite lens, Synnyr alkalic massif, N. Cisbaikal; (708) Rass (1970), picrite porphyrite, Bolshesayansk massif, E. Siberia; (709) Lyakhovich and Barinskii (1961), granite pegmatite, Megrinsk pluton, Armenian S.S.R.; (710) Varshal et al. (1967), apatite-nepheline rock, Mt. Rasvumchorr, Kola Peninsula, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No –	711	712	713	714	715	716	717	718	719	720
La	24.9	21.1	27.6	25.9	22.2	22.3	27.8	23.6	20.3	22.4
Ce	45.7	49.3	46.1	47.4	48.8	50.3	44.8	47.2	49.9	45.6
Pr	5.6	5.8	2.6	3.0	5.4	3.8	3.9	5.7	6.3	8.6
Nd	19.9	20.4	16.5	22.5	18.1	20.6	18.1	18.5	18.6	12.0
Sm	2.8	1.5	2.0	0.7	2.0	1.5	2.8	1.1	2.0	9.7
Eu	0.5	0.1	–	–	0.1	–	–	0.2	0.2	0.5
Gd	1.7	0.6	2.6	0.4	1.8	1.5	2.6	0.8	1.7	1.0
Tb	0.1	0.1	–	–	0.1	–	–	–	0.1	–
Dy	0.6	0.4	1.0	0.1	0.8	–	–	2.9	0.4	–
Ho	–	0.1	0.2	–	0.2	–	–	–	0.1	–
Er	0.2	0.4	1.0	–	0.3	–	–	–	0.2	0.1
Tm	–	0.1	–	–	–	–	–	–	–	–
Yb	–	–	0.4	–	0.2	–	–	–	0.2	0.1
Lu	–	0.1	–	–	–	–	–	–	–	–
Y/(Y+Ln)x100	(6.8)	(7.1)	(11.4)	–	–	–	–	–	(6.9)	–
Method	XF	XF	CH	XF	XF	XF	–	XF	OS	OS
Σ = La+Ce+Pr	76.2	76.2	76.3	76.3	76.4	76.4	76.5	76.5	76.5	76.6
La-Nd	96.1	96.6	92.8	98.8	94.5	97.0	94.6	95.0	95.1	88.6
Sm-Ho	5.7	2.8	5.8	1.2	5.0	3.0	5.4	5.0	4.5	11.2
Er-Lu	0.2	0.6	1.4	–	0.5	–	–	–	0.4	0.2
RE_2O_3	2.7*	5.33	0.40	2.03	2.65	0.44	–	0.38*	0.70	1.72
La/Nd	1.25	1.03	1.68	1.15	1.23	1.08	1.54	1.28	1.09	1.87

* = % R.E. | (711) Eby (1975), carbonatite, Oka, Quebec; (712) Es'kova (1976), alkali metasomatite, Urals, U.S.S.R.; (713) Rass (1964), pyroxenite, Koksharov complex, Maritime Province, U.S.S.R.; (714) Mikhailov and Mineev (1970), metasomatic diopside rock, Aldan massif; (715) Lyakhovich (1968), granodiorite, E. Sayan; (716) Khomyakov and Frantsesson (1971), carbonatite, Kuonapki River, Yakutia; (717) Sin'kova and Turanskaya (1968), Precambrian metamorphosed rock, Krivoi Rog, U.S.S.R.; (718) Ignat'eva (1973), Abovyan iron-ore deposit, Armenian S.S.R.; (719) Kapustin (1977), calcite carbonatite, Kovdor massif, Karelia, U.S.S.R.; (720) Spasskii (1970), pyroxene-biotite-feldspar rock, Synnyr alkalic massif, N. Cisbaikal

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.—	721	722	723	724	725	726	727	728	729	730
La	22.6	29.3	23.9	29.4	29.4	23.3	17.6	24.1	23.4	22.2
Ce	48.9	40.3	47.3	42.8	45.1	46.4	57.4	46.8	46.4	47.6
Pr	5.1	7.0	5.5	4.5	2 2	7.0	1.7	5.9	7.0	7.0
Nd	18.8	20.0	17.8	17.9	18.2	19.7	20.9	17.8	19.6	19.7
Sm	1 1	2.0	2.1	–	1.8	1.7	0.6	2.3	1.7	2 2
Eu	–	–	0.2	–	–	0.3	–	0.1	0.3	0.3
Gd	2.8	1.4	1.4	1.8	2.4	1.1	1.0	1.7	1.1	0.3
Tb	–	c	0.2	–	0.1	0.2	0.1	0.1	0.2	0.1
Dy	0.5	c	0.8	1.9	0.8	0.3	0.6	0.6	0.3	0 2
Ho	–	–	0.2	0 4	–	–	–	0.1	–	–
Er	0.1	–,	0.3	0.9	–	–	0.1	0.2	–	0.2
Tm	–	–	–	–	–	–	–	0.1	–	–
Yb	0.1	–	0.3	0 4	–	–	–	0.2	–	0 2
Lu	–	–	–	–	–	–	–	–	–	–
Y/(Y+Ln)x100	(3.1)	(28)[c]	(6.9)	(7.4)	–	–	–	–	–	–
Method	CH	CH	XF	–	XF	XF	XF	XF	XF	XF
Σ = La+Ce+Pr	76.6	76.6	76.7	76.7	76.7	76.7	76.7	76.8	76.8	76.8
La-Nd	95.4	96.6	94.5	94.6	94.9	96.4	97.6	94.6	96.4	96.5
Sm-Ho	4.4	3.4	4.9	4.1	5.1	3.6	2.3	4 9	3 6	3.1
Er-Lu	0 2	–	0.6	1 3	–	–	0.1	0.5	–	0.4
RE_2O_3	0.69	0.70	0.73	1.60	1.11	0.32	1.06	0.86	5.42	0.88
La/Nd	1.20	1.46	0.99	1.64	1 62	1.18	0.84	1.36	1.19	1.13

(c) Tb+Dy+Y calcd.as Y

(721) Rass (1973), pyroxene carbonatite, Kovdor massif, Karelia, U.S.S.R.; (722) Vasil'eva (1976), carbonatite, Yakutia; (723) Lyakhovich and Barinskii (1961), aegirine syenite, Inagli massif, Aldan; (724) Ovchinnikova (1973), magnetite ore, Lebyazhinsk, Urals, U.S.S.R.; (725) Denisov et al. (1961), alkalic rock, Kola Peninsula, U.S.S.R.; (726) Lyakhovich and Barinskii (1961), alkali syenite, Lovozero massif, Kola Peninsula; (727) Es'kova and Ganzeev (1964), fenitized granite pegmatite, Vishnevye Mts., Urals; (728) Lyakhovich (1968), granite, Voronezh massif, U.S.S.R.; (729) Tikhonenkova and Tikhonenkov (1962), pegmatite nepheline syenite, Lovozero massif, Kola Peninsula; (730) Kapustin (1977), calcite carbonatite, Kovdor massif, Karelia

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.—	731	732	733	734	735	736	737	738	739	740
La	25.3	25.2	27.3	23.1	25.7	23.9	35.8	24.9	20.7	17.7
Ce	47.3	47.7	47.1	50.4	46.7	47.6	39.8	47.3	50.4	52 1
Pr	4.3	4.0	2.7	3.6	4.7	5.6	1.6	5.0	6 1	7.4
Nd	16.7	22.1	17.1	17.2	17.8	17.	12.7	14.3	18.1	19.6
Sm	2.8	-	2.2	2.0	2.7	2.1	2.3	3.2	1.9	1 9
Eu	0.4	-	0.7	-	2.4	0.2	-	0.5	0.5	-
Gd	1.5	-	2.4	2.9	-	1.4	3.9	2.4	1.4	1.0
Tb	0.2	-	-	b	-	0.2	-	0.3	0.1	-
Dy	1.0	-	0.5	0.6	-	0.3	3.9	0.8	0.6	0.3
Ho	0.2	-	-	-	-	0.2	-	0.2	-	-
Er	0.3	-	-	0.2	-	0.3	-	0.5	0.1	-
Tm	-	-	-	-	-	0.3	-	0.2	-	-
Yb	-	1.0	-	-	-	-	-	0.4	0.1	-
Lu	-	-	-	-	-	-	-	-	-	-
Y/(Y+Ln)x100	(7.0)	(13.7)	(2.3)	(8.8)[b]	(2.3)	-	(17.1)	(11.1)	-	-
Method	XF	-	CH	CH	CH	-	-	OS	XF	XF
Σ = La+Ce+Pr	76.9	76.9	77.1	77.1	77 1	77.1	77.2	77.2	77.2	772
La-Nd	93.6	99.0	94.2	94.3	94.9	95.0	89.9	91.5	95.3	96.8
Sm-Ho	6.1	-	5.8	5.5	5.1	4.4	10.1	7.4	4.5	3.2
Er-Lu	0.3	1 0	-	0.2	-	0.6	-	1.1	0.2	-
RE_2O_3	0.26	0.68	0.83	0.12	1.94	1 68	0.30	0.26	0.26	0.03*
La/Nd	1.52	1 14	1.60	1.35	1.58	1.34	2 81	1.75	1.15	0.90

* = % R.E.
(b) Tb+Y calcd. as Y

(731) Lyakhovich and Barinskii (1961), pyroxenite, Inagli massif, Aldan; (732) Ovchinnikova (1973), magnetite ore, Lebyazhinsk deposit, Urals, U.S.S.R.; (733) Kirillov and Ryzhova (1968), carbonatite, Vuorijarvi, Karelia, U.S.S.R.; (734) Rass (1968), mica-rich rock, Kovdor massif, Karelia; (735) Borutskii et al. (1975), albitized pegmatite in khibinite, Mt. Takhtarvumchorr, Kola Peninsula, U.S.S.R.; (736) Kravchenko and Vlasova (1962), miaskite, central Aldan; (737) Ivanova et al. (1970), ijolite, Yukspor Mt., Kola Peninsula; (738) Kapustin (1977), olivinite, Afrikanda, Kola Peninsula; (739) Kapustin (1966), Kovdor massif, Karelia; (740) Ignat'eva (1973), Abovyan iron-ore deposit, Armenian S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.-	741	742	743	744	745	746	747	748	749	750
La	39.5	40.6	26.3	22.5	25.8	22.0	27.2	28.1	20.2	21.2
Ce	31.2	33.7	46.7	49.8	46.4	50.0	44.7	45.0	51.9	50.2
Pr	6.5	3.0	4.3	5.0	5.1	5.3	5.4	4.3	5.3	6.0
Nd	20.4	13.1.	16 9	16.9	17.2	18.4	19.4	15.7	18.0	18.6
Sm	–	5.1	2.0	1.9	2.6	1.1	3.3	2.0	2.1	1.9
Eu	–	–	0.4	0.1	0.3	–	–	0.6	0.8	0.5
Gd	1.2	2.7	2.2	1.8	1.6	2.7	–	2 0	1.3	1 0
Tb	–	–	0 4	0.2	–	b	–	0.2	–	0.1
Dy	1.2	–	0.3	1.6	–	0.5	–	1 2	0.4	0 4
Ho	–	–	0.1	–	0.2	–	–	0.2	–	–
Er	–	1.7	0.2	0.2	0.5	–	–	0.5	–	0 1
Tm	–	–	–	–	0.1	–	–	–	–	–
Yb	–	0.1	0.2	–	0.2	–	–	0.2	–	–
Lu	–	–	–	–	–	–	–	–	–	–
Y/(Y+Ln)x100	(3.7)	(2.4)	(10.2)	–	(3.5)	(3.0)[b]	–	–	–	–
Method	XF	CH	OS	XF	OS	CH	XF	–	XF	XF
Σ = La+Ce+Pr	77 2	77.3	77.3	77.3	77.3	77.3	77.3	77.4	77.4	77.4
La-Nd	97 6	90.4	94.2	94.2	94.5	95.7	96.7	93 1	95.4	96.0
Sm-Ho	2 4	7.8	5.4	5.6	4.7	4.3	3 3	6.2	4 6	3 9
Er-Lu	–	1.8	0.4	0 2	0.8	–	–	0.7	–	0.1
RE_2O_3	3 95	0.15	0.33	0.40	0.40	–	–	0.84	0.30	0.55
La/Nd	1.94	3 10	1.55	1.34	1.50	1.20	1.40	1.79	1.12	1.14

(b) Tb+Y calcd. as Y

(741) Girault (1966), carbonatite, Oka, Quebec; (742) Kirillov and Ryzhova (1968), dolomitic carbonatite, Kovdor massif, Karelia, U.S.S.R.; (743-744) Kapustin (1977), Karelia; (743) fenite, Afrikanda; (744) calcite carbonatite, Sallanlatva; (745) Kholodnov et al., (1975a), granodiorite, Nova-Buranovsk, Urals, U.S.S.R.; (746) Rass (1968), carbonatite, Kovdor massif; (747) Vainshtein et al. (1956), alkalic rock, Khibina massif, Kola Peninsula; (748) Ovchinnikova (1973), apatite-pyroxene rock, Lebyazhinsk magnetite deposit, Urals; (749) Khomyakov and Frantsesson (1971), Kuonapki River, Yakutia; (750) Kapustin (1977), dolomitic carbonatite, Lesnaya Varaka, Karelia

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. –	751	752	753	754	755	756	757	758	759	760
La	22.2	40.1	24.8	25.3	25.7	25.3	26.8	27.8	23.6	22.9
Ce	49.8	31.8	47.3	46.8	46.5	47.0	46.9	47.2	49.1	51.3
Pr	5.4	5.5	5.4	5.4	5.3	5.3	3.9	2.6	4.9	3.4
Nd	18.7	21.5	16.7	16.8	18.2	16.5	17.2	17.3	17.9	18.2
Sm	2.0	–	2.0	2.5	2.4	2.0	2.2	1.8	2.4	2.2
Eu	0.4	–	0.3	a	0.2	0.4	–	–	a	–
Gd	0.9	0.6	1.9	2.5[a]	0.9	2.3	2.2	2.4	1.6[a]	1.7
Tb	0.1	–	0.2	b	0.1	0.3	–	–	b	c
Dy	0.4	0.5	0.9	0.7	0.4	0.5	0.4	0.9	0.5	c
Ho	–	–	0.1	–	0.1	–	0.1	–	–	–
Er	0.1	–	0.3	–	0.1	0.2	0.2	–	–	0.2
Tm	–	–	–	–	–	–	–	–	–	–
Yb	–	–	0.1	–	0.1	0.2	0.1	–	–	0.1
Lu	–	–	–	–	–	–	–	–	–	–
Y/(Y+Ln)x100	–	(2.6)	–	(4.4)[b]	(4.3)	(6.4)	(2.5)	–	(3.4)[b]	(4.7)[c]
Method	XF	XF	–	CH	XF	OS	–	XF	CH	CH
Σ = La+Ce+Pr	77.4	77.4	77.5	77.5	77.5	77.6	77.6	77.6	77.6	77.6
La-Nd	96.1	98.9	94.2	94.3	95.7	94.1	94.8	94.9	95.5	95.8
Sm-Ho	3.8	1.1	5.4	5.7	4.1	5.5	4.8	5.1	4.5	3.9
Er-Lu	0.1	–	0.4	–	0.2	0.4	0.4	–	–	0.3
RE_2O_3	1.03	8.35	0.59	2.19	3.0*	0.86	2.46	1.09	2.07	2.57
La/Nd	1.18	1.86	1.48	1.50	1.41	1.53	1.56	1.61	1.32	1.26

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(751) Es'kova and Ganzeev (1964), calcite-biotite-apatite vine, Vishnevye Mts., Urals, U.S.S.R.; (752) Girault (1966), carbonatite, Oka, Quebec; (753) Kravchenko and Vlasova (1962), malignite, central Aldan; (754) Dudkin (1969), sericitized rock, Synnyr alkalic massif, N. Cisbaikal; (755) Eby (1975), carbonatite, Oka, Quebec; (756) Kapustin (1977), turjaite, Kovdor massif, Karelia, U.S.S.R.; (757) Ivanova et al. (1970), rischorrite, Khibina massif, Kola Peninsula, U.S.S.R.; (758) Denisov et al. (1961), alkalic rock, Kola Peninsula; (759) Dudkin (1969), epileucite syenite, Synnyr alkalic massif, N. Cisbaikal; (760) Borutskii et al. (1975), exocontact rocks, Khibina massif, Kola Peninsula

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. –	761	762	763	764	765	766	767	768	769	770
La	21.3	25.4	31.6	29.0	23.8	26.9	21.5	28.8	24.1	18.3
Ce	50.3	45.0	39.9	44.7	47.5	45.6	49.7	45.9	48.8	53.3
Pr	6.0	7.2	6.1	4.0	6.5	5.3	6.6	3.3	5.2	6.5
Nd	18.6	19.0	20.4	13.6	13.9	18.0	18.8	15.5	14.8	15.2
Sm	1.9	1.7	1.0	2.3	3.4	1.9	1.0	2.2	2.5	3.2
Eu	0.3	–	–	0.4	0.5	0.4	–	0.6	0.3	1.0
Gd	1.0	1.6	1.0	4.4	2.4	1.1	2.0	1.5	2.5	1.7
Tb	0.1	c	c	0.4	–	–	–	–	0.3	0.2
Dy	0.4	c	c	0.7	0.9	0.6	0.4	1.4	0.6	0.6
Ho	–	–	–	0.2	0.2	–	–	–	0.1	–
Er	0.1	0.1	–	0.3	0.6	0.2	–	0.5	0.4	–
Tm	–	–	–	–	0.1	–	–	–	0.1	–
Yb	–	–	–	–	0.2	–	–	0.3	0.3	–
Lu	–	–	–	–	–	–	–	–	–	–
Y/(Y+Ln)x100	–	(1.9)[c]	(3.0)[c]	–	(8.1)	–	–	–	(11.2)	–
Method	XF	CH	CH	XF	OS	–	OS	–	OS	XF
Σ = La+Ce+Pr	77.6	77.6	77.6	77.7	77.8	77.8	77.8	78.0	78.1	78.1
La-Nd	96.2	96.6	98.0	91.3	91.7	95.8	96.6	93.5	92.9	93.3
Sm-Ho	3.7	3.3	2.0	8.4	7.4	4.0	3.4	5.7	6.3	6.7
Er-Lu	0.1	0.1	–	0.3	0.9	0.2	–	0.8	0.8	–
RE_2O_3	0.55	0.36	0.17	1.03	1.65	1.79	0.28	0.71	0.59	0.70
La/Nd	1.08	1.34	1.55	2.13	1.71	1.49	1.14	1.86	1.66	1.20

(c) Tb+Dy+Y calcd. as Y

(761) Kapustin (1966), carbonatite, Lesnaya Varaka, Karelia, U.S.S.R.; (762) Rass (1970), nepheline syenite, Bolshesayansk massif, E. Siberia; (763) Afanas'ev et al. (1976), migmatite-granite, Vzhni, Little Caucasus, U.S.S.R.; (764) Lyakhovich (1968), quartz vein, Tuva; (765) Kholodnov et al. (1975a), syenodiorite, Tagilsk, Urals, U.S.S.R.; (766) Ovchinnikova (1973), magnetite ore, Lebyazhinsk, Urals; (767) Kapustin (1977), calcite carbonatite, Upper Sayan; (768) Ovchinnikova (1973), apatite-pyroxene rock, Lebyazhinsk deposit, Urals; (769) Kapustin (1977), olivinite, Lesnaya Varaka, Karelia; (770) Ganzeev et al. (1966), carbonatized biotite-feldspar rock, Vishnevye Mts., Urals

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. -	771	772	773	774	775	776	777	778	779	780
La	30.2	24.6	28.7	25.5	25.0	23.8	26.7	27.2	27.3	18.3
Ce	44.2	48.9	45.0	47.4	47.3	49.4	47.5	46.5	46.2	55.7
Pr	3.9	4.8	4.7	5.5	6.1	5.3	4.4	4.9	5.2	4.7
Nd	14.6	16.6	14.2	14.6	18.1	16.7	16.3	17.1	16.7	18.0
Sm	2.6	2.2	3.0	3.1	1.6	1.8	2.9	2.2	2.4	1.4
Eu	a	0.2	-	-	0.2	0.2	a	0.3	0.1	0.7
Gd	2.5[a]	2.0	2.4	3.4	0.9	2.0	1.8[a]	1.0	1.5	0.7
Tb	b	0.2	-	-	-	0.2	b	0.1	-	-
Dy	1.2	0.4	1.6	0.4	0.5	0.3	0.4	0.5	0.5	0.5
Ho	0.2	-	0.2	0.1	0.1	-	-	-	-	-
Er	0.4	-	0.2	-	0.2	0.1	-	0.1	0.1	-
Tm	-	-	-	-	-	-	-	-	-	-
Yb	0.2	0.1	-	-	-	0.2	-	0.1	-	-
Lu	-	-	-	-	-	-	-	-	-	-
Y/(Y+Ln)x100	(7.3)[b]	(7.7)	(6.6)	(11.7)	-	(9.7)	(4.1)[b]	(4.1)	-	-
Method	CH	OS	CH	CH	XF	OS	CH	XF	-	-
Σ = La+Ce+Pr	78.3	78.3	78.4	78.4	78.4	78.5	78.6	78.6	78.7	78.7
La-Nd	92.9	94.9	92.6	93.0	96.5	95.2	94.9	95.7	95.4	96.7
Sm-Ho	6.5	5.0	7.2	7.0	3.3	4.5	5.1	4.1	4.5	3.3
Er-Lu	0.6	0.1	0.2	-	0.2	0.3	-	0.2	0.1	-
RE_2O_3	-	0.42	-	0.21	1.09	0.81	3.15	2.91*	1.17	0.42
La/Nd	2.07	1.48	2.02	1.75	1.38	1.42	1.63	1.59	1.64	1.01

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(771) Varshal et al. (1967), apatite-nepheline rock, Mt. Kuelpov, Kola Peninsula; U.S.S.R.; (772) Kapustin (1977), melteigite, Turii mys, Kola Peninsula; (773) Borutskii et al. (1975), apatite-nepheline rock, Mt. Kukisvumchorr, Kola Peninsula; (774) Rass (1973), phologpite-calcite rock, Guli massif, Karelia, U.S.S.R.; (775) Semenov and Barinskii (1958), apatite-nepheline rock, Mt. Kukisvumchorr; (776) Kapustin (1977), pyroxenite, Arbarastakh, Aldan; (777) Dudkin (1969), biotite-apatite rock, Synnyr alkalic massif, N. Cisbaikal; (778) Eby (1975) melilite-biotite rock, Oka, Quebec; (779) Ifantopulo and Kravchenko, quoted by Nurlybaev (1976), fenite, Esil'skii massif, Kazakhstan; (780) Ovchinnikova (1973), magnetite ore, Lebyazhin deposit, Urals

Table 1 - Rare Earths in Apatite, atomic percent - continued

No.	781	782	783	784	785	786	787	788	789	790
La	22.1	24.6	21.6	26.7	24.8	23.2	26.5	27.7	26.5	27.3
Ce	51.4	48.9	52.2	46.8	49.9	51.4	47.3	46.7	48.0	46.4
Pr	5.3	5.3	5.0	5.3	4.2	4.3	5.1	4.5	4.4	5.2
Nd	12.8	15.6	16.6	17.0	10.4	13.9	14.4	14.5	16.3	17.3
Sm	1.8	3.0	2.0	2.1	3.6	1.8	4.1	3.2	1.9	2.1
Eu	0.6	0.3	a	–	–	–	–	a	0.3	0.3
Gd	1.7	1.9	1.9[a]	2.0	2.5	3.5	1.8	2.4[a]	1.2	0.9
Tb	0.3	0.2	b	b	–	–	b	b	0.2	0.1
Dy	1.5	–	0.7	0.1	3.2	1.7	0.6	0.4	0.4	0.3
Ho	0.5	–	–	–	0.3	–	0.1	0.2	0.1	–
Er	1.0	–	–	–	–	0.2	0.1	0.4	0.3	0.1
Tm	0.1	–	–	–	–	–	–	–	0.1	–
Yb	0.8	0.2	–	–	–	–	–	–	0.2	–
Lu	0.1	–	–	–	1.1	–	–	–	0.1	–
Y/(Y+Ln)x100	(14.7)	(7.6)	(4.4)[b]	(5.6)[b]	(10.2)	(5.1)	(2.2)[b]	(6.4)[b]	–	(2.6)
Method	XF	OS	CH	CH	XF	CH	CH	CH	–	XF
Σ = La+Ce+Pr	78.8	78.8	78.8	78.8	78.4	78.9	78.9	78.9	78.9	78.9
La-Nd	91.6	94.4	95.4	95.8	89.3	92.8	93.3	93.4	95.2	96.2
Sm-Ho	6.4	5.4	4.6	4.2	9.6	6.0	6.6	6.2	4.1	3.7
Er-Lu	2.0	0.2	–	–	1.1	0.2	0.1	0.4	0.7	0.1
RE_2O_3	0.33	0.33	2.33	1.28	0.43*	0.63	4.10	2.21	1.60	0.92*
La/Nd	1.72	1.58	1.30	1.57	1.66	1.67	1.84	1.91	1.63	1.58

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(781) Parak (1973), iron ore, Rektorn, Lappland; (782) Kapustin (1977), picrite, Vuorijarvi, Karelia, U.S.S.R.; (783) Dudkin (1967), veinlet in alkalic rock, Synnyr massif, N. Cisbaikal; (784) Borutskii et al. (1975), shonkinite porphyry, Mt. Petrelius, Kola Peninsula, U.S.S.R.; (785) Aleksiev et al. (1967), diorite, Plana pluton, Bulgaria; (786) Rass (1968), olivine-magnetite-apatite rock, Kovdor massif, Karelia; (787) Borutskii et al. (1975), albitized alkalic pegmatite, Mt. Petrelius; (788) Varshal et al. (1967), ijolite pegmatite, Rasvumchorr, Kola Peninsula; (789) Ovchinnikova (1973), magnetite ore, Lebyazhinsk deposit, Urals, U.S.S.R.; (790) Eby (1975), biotite rock, Oka, Quebec

Table 1 - Rare Earths in Apatite, atomic percent - continued

No —	791	792	793	794	795	796	797	798	799	800
La	26.2	27.0	22.9	24.9	25.7	26.3	21.4	22.2	28.5	25.9
Ce	47.9	46.8	50.2	49.4	48.9	47.6	45.7	51.1	46.3	49.1
Pr	4.9	5.2	5.9	4.7	4.5	5.2	12.2	6.0	4.5	4.4
Nd	15.3	17.0	17.1	17.5	14.7	17.5	15.5	16.6	19.0	15.9
Sm	1.9	2.0	1.6	1.4	2.2	1.8	4.6	1.7	1.7	2.1
Eu	0.2	0.4	0.2	0.2	0.2	0.2	0.3	0.2	—	—
Gd	2.1	0.9	1.5	1.1	1.9	0.8	—	1.4	—	2.4
Tb	0.4	0.1	0.2	0.1	0.5	0.1	—	0.5	—	—
Dy	0.5	0.4	0.4	0.4	0.8	0.3	—	0.3	—	0.2
Ho	—	0.1	—	—	—	—	—	—	—	—
Er	0.2	0.1	—	0.2	0.2	0.1	0.3	—	—	—
Tm	0.1	—	—	—	—	—	—	—	—	—
Yb	0.3	—	—	0.1	0.4	0.1	—	—	—	—
Lu	—	—	—	—	—	—	—	—	—	—
Y/(Y+Ln)x100	(7.6)	(3.6)	—	—	(13.6)	(2.3)	(5.4)	—	(5.5)	(2.7)
Method	OS	XF	XF	XF	OS	XF	OS	—	—	CH
Σ = La+Ce+Pr	79.0	79.0	79.0	79.0	79.1	79.1	79.3	79.3	79.3	79.4
La-Nd	94.3	96.0	96.1	96.5	93.8	96.6	94.8	95.9	98.3	95.3
Sm-Ho	5.1	3.9	3.9	3.2	5.6	3.2	4.9	4.1	1.7	4.7
Er-Lu	0.6	0.1	—	0.3	0.6	0.2	0.3	—	—	—
RE_2O_3	0.70	2.0*	7.7	1.01	0.44	2.44*	0.44	—	1.55	5.55
La/Nd	1.71	1.59	1.34	1.43	1.75	1.51	1.38	1.34	1.50	1.63

* = % R.E.

(791) Kapustin (1977), turjaite, Turii mys, Karelia, U.S.S.R.; (792) Eby (1975), ijolite, Oka, Quebec; (793) Semenov and Barinskii (1958), ijolite, Lovozero massif, Kola Peninsula, U.S.S.R.; (794) Es'kova et al. (1964), biotite-calcite vein in miaskite, Vishnevye Mts., Urals, U.S.S.R.; (795) Kapustin (1977), olivinite, Kovdor, Karelia; (796) Eby (1975), carbonatite, Oka, Quebec; (797) Spasski (1970), pyroxene-biotite-feldspar rock, Synnyr alkalic massif, N. Cisbaikal; (798) Vlasov et al. (1959), Lovozero massif, Kola Peninsula; (799) Ovchinnikova (1973), magnetite ore, Lebyazhinsk deposit, Urals; (800) Borutskii et al. (1975), exocontact rock, near Lake Dlinne, Kola Peninsula

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	801	802	803	804	805	806	807	808	809	810
La	25.1	26.6	32.4	24.9	26.4	26.9	29.9	22.3	25.9	24.4
Ce	48.9	47.8	42.9	50.8	47.9	49.9	44.3	51.3	49.0	50.7
Pr	5.4	5.0	4.2	3.8	5.2	2.8	5.4	6.0	4.7	4.6
Nd	16.9	17.0	14.7	14.8	17.3	16.6	16.6	16.7	16.7	16.7
Sm	1.1	2.0	2.0	2.9	1.9	1.4	1.9	1.7	1.8	1.8
Eu	0.2	0.3	a	0.5	0.1	–	0.2	0.2	0.2	a
Gd	2.0	0.8	1.9[a]	1.4	0.7	1.9	1.0	1.4	0.9	1.1[a]
Tb	0.2	0.1	b	–	0.1	–	0.1	0.1	–	b
Dy	–	0.2	–	–	0.3	0.5	0.4	0.3	0.5	0.4
Ho	–	–	1.9	0.2	–	–	–	–	–	–
Er	0.1	0.1	–	0.5	0.1	–	0.2	–	0.2	0.3
Tm	–	–	–	–	–	–	–	–	–	–
Yb	0.1	0.1	–	0.2	–	–	–	–	0.1	–
Lu	–	–	–	–	–	–	–	–	–	–
Y/(Y+Ln)x100	(10.3)	(1.6)	(5.9)[b]	(4.2)	(2.3)	–	(5.1)	–	–	(2.3)[b]
Method	OS	XF	CH	OS	XF	XF	XF	XF	–	CH
Σ = La+Ce+Pr	79.4	79.4	79.5	79.5	79.5	79.6	79.6	79.6	79.6	79.7
La-Nd	96.3	96.4	94.2	94.3	96.8	96.2	96.2	96.3	96.3	96.4
Sm-Ho	3.5	3.4	5.8	5.0	3.1	3.8	3.6	3.7	3.4	3.3
Er-Lu	0.2	0.2	–	0.7	0.1	–	0.2	–	0.3	0.3
RE_2O_3	0.65	1.91*	–	0.65	1.6*	1.45	2.6*	–	1.55	1.02
La/Nd	1.48	1.57	2.21	1.68	1.52	1.62	1.80	1.34	1.55	1.46

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(801) Kapustin (1977), pyroxenite, Vuojarvi, Karelia, U.S.S.R.; (802) Eby (1975), carbonatite, Oka, Quebec; (803) Varshal et al. (1967) apatite-nepheline rock, Mt. Kukisvumchorr, Kola Peninsula, U.S.S.R.; (804) Kholodnov et al. (1975a), granodiorite, Nova-Buanovsk, Urals, U.S.S.R.; (805) same as (802); (806) Denisov et al. (1961), alkalic rock, Kola Peninsula; (807) same as (802); (808) Es'kova (1959), malignite, Karnasurt Mt., Kola Peninsula, SrO 6.1%; (809) Ovchinnikova (1973), magnetite ore, Lebyazhinsk deposit, Urals; (810) Kurbatova (1972), olivinite, Kovdor massif, Karelia

Table 1 - Rare Earths in Apatite, atomic percent - continued

No —	811	812	813	814	815	816	817	818	819	820
La	50.9	28.1	27.9	22.6	25.5	28.9	24.5	25.0	24.5	26.5
Ce	28.8	46.6	46.4	52.9	49.5	46.5	50.8	50.5	47.0	49.3
Pr	-	5.1	5.0	4.3	4.9	4.6	4.7	4.5	3.6	4.3
Nd	18.5	15.2	16.4	16.6	15.0	13.5	15.1	16.7	13.4	13.9
Sm	1.0	1.6	2.0	1.6	2.3	2.0	1.8	1.3	2.4	2.0
Eu	0.2	0.2	0.3	0.5	0.3	0.3	0.2	0.2	0.7	0.4
Gd	-	1.6	0.8	0.9	1.8	2.0	1.8	1.0	1.8	2.5
Tb	0.5	0.2	0.1	-	0.2	0.5	0.3	0.1	0.2	-
Dy	-	0.6	0.4	0.4	0.3	1.4	0.4	0.3	0.8	0.5
Ho	-	-	0.1	-	-	0.1	0.1	-	0.1	-
Er	-	0.4	0.1	0.2	-	0.1	0.1	0.2	0.3	0.4
Tm	-	-	-	-	-	-	-	0.1	-	-
Yb	0.1	0.4	-	-	0.2	0.1	0.2	0.1	0.2	0.2
Lu	-	-	-	-	-	-	-	-	-	-
Y/(Y+Ln)x100	-	(6.9)	(4.6)	-	(12.0)	(5.4)	(12.4)	-	-	(11.3)
Method	NA	XF	XF	-	OS	OS	OS	XF	OS	OS
Σ = La+Ce+Pr	79.7	79.8	79.8	79.8	79.9	80.0	80.0	80.0	80.1	80.1
La-Nd	98.2	95.0	96.2	96.4	94.9	93.5	95.1	96.7	93.5	94.0
Sm-Ho	1.7	4.2	3.7	3.4	4.9	6.3	4.6	2.9	6.0	5.4
Er-Lu	0.1	0.8	0.1	0.2	0.2	0.2	0.3	0.4	0.5	0.6
RE_2O_3	1.68	-	4.0*	2.30	0.79	0.53	0.49	-	1.06	0.47
La/Nd	2.74	1.85	1.69	1.36	1.70	2.14	1.62	1.50	2.20	1.91

* = % R.E.

(811) Puchelt and Emmermann (1976), phonolite, Obershaffhausen, Kaiserstuhl, Germany; (812) Lyakhovich and Barinskii (1961), pulaskite, Illimakh massif, Karelia, U.S.S.R.; (813) Eby (1975), carbonatite, Oka, Quebec; (814) Ovchinnikova (1973), magnetite ore, Lebyazhinsk, Urals, U.S.S.R.; (815) Kapustin (1977), pyroxenite, Vuojarvi, Karelia; (816) Kapustin (1977), fenite, Novopoltavskii, Ukraine; (817) Kapustin (1977), olivinite, Kovdor, Karelia; (818) Es'kova and Ganzeev (1964), biotite-calcite vein, Vishnevye Mts., Urals; (819) Zhirova and Lyagushkin (1979), carbonatite, 2nd stage, Guli; (820) Kapustin (1977), olivinite, Guli, Karelia

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	821	822	823	824	825	826	827	828	829	830
La	31.3	24.3	32 2	22.7	25.0	29.3	26.3	27.8	25.0	22.2
Ce	43.4	53.4	44.2	53.0	51.7	47.4	48.1	47.3	48.1	52.7
Pr	5.4	2.4	3 8	4.5	3.5	3 6	5.9	5.2	7 2	5.5
Nd	16.2	18.5	14.0	16.0	16.2	13 2	16.7	17.7	19.7	15.3
Sm	1.8	0.8	2.4	2.1	1 4	1.4	1.8	-	-	2.2
Eu	0.1	-	a	0.1	-	-	0.3	-	-	-
Gd	0.9	0.5	2.3[a]	1.0	1.8	2.0	0 1	1.7	-	1.4
Tb	0.1	-	b	-	-	-	-	-	-	-
Dy	0.5	0.1	1.1	-	0.4	1.5	0.3	-	-	0.7
Ho	0.1	-	-	0 3	-	0.4	0.2	-	-	-
Er	0.1	-	-	0.1	-	0.8	0.1	-	-	-
Tm	-	-	-	-	-	-	-	-	-	-
Yb	0.1	-	-	0.2	-	0.4	0.2	0.3	-	-
Lu	-	-	-	-	-	-	-	-	-	-
Y/(Y+Ln)x100	(5.6)	-	(19)[b]	(99)	-	(4.8)	-	(5.4)	-	-
Method	XF	XF	CH	-	XF	XF	XF	-	XF	XF
Σ = La+Ce+Pr	80.1	80 1	80.2	80.2	80.2	80.3	80.3	80.3	80 3	80.4
La-Nd	96.3	98.6	94 2	96.2	96.4	93.5	97.0	98.0	100 0	95.7
Sm-Ho	3.5	1.4	5.8	3.5	3.6	5.3	2.7	1.7	-	4.3
Er-Lu	0.2	-	-	0.3	-	1.2	0.3	0.3	-	-
RE_2O_3	24*	0.03*	-	1.20	1.39	1.55	0.85	1 36	~ 1	0 16*
La/Nd	1 94	1.32	2.30	1 41	1.54	2.22	1.57	1.57	1 27	1.45

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(821) Eby (1975), carbonatite, Oka, Quebec; (822) Ignat'eva (1973), Abovyan iron-ore deposit, Armenian S.S.R.; (823) Varshal et al. (1967), apatite-nepheline rock, Mt. Kukisvumchorr, Kola Peninsula, U.S.S.R.; (824) Portnov and Gorobets (1969), granite pegmatite, Kazakhstan; (825) Denisov et al. (1961), alkalic rock, Kola Peninsula; (826) Borovskii and Gerasimovskii (1945), nepheline syenite, Kufutai, Lovozero massif, Kola Peninsula; (827) Lyakhovich (1968), granite, Voronezh massif, U.S.S.R.; (828) Ovchinnikova (1973), magnetite ore, Lebyazhinsk deposit, Urals, U.S.S.R.; (829) Borovskii and Gerasimovskii (1945), nepheline syenite, Kufutai, Lovozero massif; (830) Ignat'eva (1973), Abovyan iron-ore deposit, Armenian S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No —	831	832	833	834	835	836	837	838	839	840
La	25.0	26.2	34.0	26.2	22.3	28.0	32.7	25.6	27.0	28.3
Ce	52.5	50.5	43.8	49.5	54.5	48.9	45.1	50.8	48.5	47.8
Pr	2.9	3.7	2.7	4.8	3.7	3.7	2.8	4.3	5.2	4.7
Nd	15.9	15.9	14.8	16.0	17.9	13.4	15.3	14.5	14.7	15.9
Sm	1.6	1.4	–	1.6	–	2.2	1.7	1.9	2.1	1.4
Eu	–	–	–	–	–	0.6	–	0.2	a	0.3
Gd	1.6	1.8	3.3	1.2	–	1.7	1.5	1.8	1.8[a]	0.9
Tb	–	–	–	b	–	0.2	–	0.2	b	–
Dy	0.5	0.5	–	0.5	1.6	0.8	0.9	0.4	0.6	0.5
Ho	–	–	0.8	0.1	–	0.1	–	0.1	0.1	–
Er	–	–	–	0.1	–	0.2	–	–	–	0.1
Tm	–	–	–	–	–	–	–	–	–	–
Yb	–	–	0.6	–	–	0.2	–	0.2	–	0.1
Lu	–	–	–	–	–	–	–	–	–	–
Y/(Y+Ln)x100	–	–	(13.4)	(4.5)[b]	(0.3)	–	–	(7.4)	(2.2)[b]	–
Method	XF	XF	–	CH	XF	OS	XF	OS	CH	–
Σ = La+Ce+Pr	80.4	80.4	80.5	80.5	80.5	80.6	80.6	80.7	80.7	80.8
La-Nd	96.3	96.3	95.3	96.5	98.4	94.0	95.9	95.2	95.4	96.7
Sm-Ho	3.7	3.7	4.1	3.4	1.6	5.6	4.1	4.6	4.6	3.1
Er-Lu	–	–	0.6	0.1	–	0.4	–	0.2	–	0.2
RE_2O_3	1.60	1.37	0.74	0.62	2.41	1.16	0.97	0.29	–	1.90
La/Nd	1.57	1.65	2.29	1.63	1.24	2.10	2.14	1.77	1.84	1.77

(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(831-832) Denisov et al. (1961), alkalic rock, Lovozero massif, Kola Peninsula, U.S.S.R.; (833) Ovchinnikova (1973), pyroxene-apatite rock, Lebyazhnsk iron-ore deposit, Urals, U.S.S.R.; (834) Rass (1970), nepheline syenite, Bolshesayansk massif, E. Siberia (835) Vorontsov (1972), amphibole syenite, Kholderminsk massif, E. Sayan; (836) Zhirova and Lyagushkin (1979), carbonatite, 1st stage, Guli, U.S.S.R.; (837) same as (831); (838) Kapustin (1977), alnöite, Turii mys, Karelia; (839) Varshal et al. (1967), albitized alkalic pegmatite, Mt. Petrelius, Khibina massif, Kola Peninsula; (840) Ovchinnikova (1973), magnetite ore, Lebyazhinsk deposit, Urals, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	841	842	843	844	845	846	847	848	849	850
La	32.9	26.4	30.4	30.2	32.2	31.0	22.7	27.4	34.4	27.1
Ce	44.5	50.2	47.3	45.0	44.6	46.3	52.2	48.7	42.4	49.6
Pr	3.5	4.3	3.3	5.8	4.2	3.7	6.1	4.9	4.3	4.5
Nd	12.1	13.8	10.8	14.0	14.6	15.0	15.1	16.7	16.3	13.4
Sm	2.4	2.2	2.1	2.8	2.0	1.5	3.9	1.0	1.8	2.1
Eu	0.7	0.2	1.2	a	a	—	—	0.2	a	0.3
Gd	2.1	2.1	2.4	2.2[a]	1.9[a]	2.5	—	0.7	0.8[a]	1.9
Tb	0.2	0.2	0.3	b	b	—	—	—	c	0.2
Dy	0.8	0.3	1.1	—	0.4	—	—	0.4	c	0.6
Ho	0.1	—	0.2	—	—	—	—	—	—	—
Er	0.3	0.1	0.4	—	0.1	—	—	—	—	0.1
Tm	0.1	—	0.1	—	—	—	—	—	—	—
Yb	0.3	0.2	0.3	—	—	—	—	—	—	0.2
Lu	—	—	0.1	—	—	—	—	—	—	—
Y/(Y+Ln)x100	—	(11.0)	(6.7)	(4.2)[b]	(5.8)[b]	(10.8)	—	—	(1.4)[c]	(9.5)
Method	OS	OS	OS	CH	CH	—	XF	—	CH	OS
Σ = La+Ce+Pr	80.9	80.9	81.0	81.0	81.0	81.0	81.0	81.0	81.1	81.2
La-Nd	93.0	94.7	91.8	95.0	95.6	96.0	96.1	97.7	97.4	94.6
Sm-Ho	6.3	5.0	7.3	5.0	4.3	4.0	3.9	2.3	2.6	5.1
Er-Lu	0.7	0.3	0.9	—	0.1	—	—	—	—	0.3
RE_2O_3	0.23	0.74	0.24	—	—	0.85	0.03	1.20	2.40	0.67
La/Nd	2.72	1.91	2.80	2.16	2.21	2.07	1.50	1.65	2.11	2.02

(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(841) Zhirova and Lyagushkin (1979), phlogopite metasomatite, Guli, U.S.S.R.; (842-843) Kapustin (1977), (842) pyroxenite, Lower Sayan; (843) calcite carbonatite, Sallanlatva, Karelia, U.S.S.R.; (844-845) Varshal et al. (1967) Kola Peninsula, U.S.S.R.; (844) ijolite-urtite, Mt. Petrelius; (845) apatite-nepheline rock, Mt. Kukisvumchorr; (846) Ivanova et al. (1970), urtite, Rasvumchorr, Kola Peninsula, (847) Kapustin (1966), carbonatite, Kovdor, Karelia, U.S.S.R.; (848) Ovchinnikova (1973), magnetite ore, Lebyazhinsk deposit, Urals, U.S.S.R.; (849) Borutskii et al. (1975), rischorrite, Mt. Petrelius; (850) Kapustin (1977), pyroxenite, Zhidoisk, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. -	851	852	853	854	855	856	857	858	859	860
La	31.1	26.6	29.9	29.0	30.7	28.8	34.3	25.7	26.4	26.7
Ce	47.2	51.6	44.0	48.0	46.2	49.8	44.0	52.9	50.7	51.0
Pr	3.0	3.1	7.5	4.4	4.6	3.0	3.4	3.1	4.6	4.2
Nd	15.2	15.4	9.9	15.6	13.5	15.7	14.5	15.5	15.9	12.4
Sm	1.4	1.3	2.0	1.4	2.2	1.3	1.8	1.2	1.1	1.9
Eu	-	-	0.4	0.2	a	-	0.4	-	0.2	0.2
Gd	1.4	1.6	2.7	0.7	1.8[a]	0.9	1.1	1.3	0.8	2.3
Tb	-	-	1.3	0.1	b	-	-	-	-	0.3
Dy	0.7	0.4	1.2	0.5	0.4	0.5	1.3	0.3	0.3	0.4
Ho	-	-	-	-	0.1	-	-	-	-	-
Er	-	-	0.6	0.1	0.3	-	0.1	-	-	0.2
Tm	-	-	-	-	-	-	-	-	-	0.1
Yb	-	-	0.4	-	0.2	-	0.1	-	-	0.3
Lu	-	-	0.1	-	-	-	-	-	-	-
Y/(Y+Ln)x100	-	-	(9.6)	-	(4.7)[b]	-	-	-	-	(5.8)
Method	XF	XF	CH	-	CH	XF	XF	XF	XF	OS
Σ = La+Ce+Pr	81.3	81.3	81.4	81.4	81.5	81.6	81.7	81.7	81.7	81.9
La-Nd	96.5	96.7	91.3	97.0	95.0	97.3	96.2	97.2	97.6	94.3
Sm-Ho	3.5	3.3	7.6	2.9	4.5	2.7	3.6	2.8	2.4	5.1
Er-Lu	-	-	1.1	0.1	0.5	-	0.2	-	-	0.6
RE_2O_3	1.70	1.51	0.76	1.96	-	2.16	14.7	2.75	0.44*	0.40
La/Nd	2.05	1.73	3.02	1.85	2.27	1.83	2.36	1.66	1.65	2.15

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(851-852) Denisov et al. (1961), alkalic rocks, Kola Peninsula, U.S.S.R. (853) Kuts (1971), biotite granite, Staraya Laspa, W. Azov region, U.S.S.R.; (854) Ovchinnikova (1973), magnetite ore, Lebyazhinsk deposit, Urals, U.S.S.R.; (855) Borutskii et al. (1975), apatite-nepheline rock, Mt. Kuelpor, Khibina massif, Kola Peninsula; (856) same as (851); (857) Khomyakov (1972), albitized syenite pegmatite, Burpala massif, Baikal; (858) same as (851); (859) Ignat'eva (1973), Abovyan iron-ore deposit, Armenian S.S.R.; (860) Kapustin (1977), melteigite prophyry, Turii mys, Karelia, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. –	861	862	863	864	865	866	867	868	869	870
La	32.5	33.6	29.2	31.3	26.9	30.5	31.7	27.0	34.0	27.9
Ce	44.6	45.1	48.4	46.9	50.3	47.8	46.3	51.0	44.8	51.6
Pr	4.8	3.2	4.3	3.9	4.9	3.8	4.2	4.2	3.5	2.8
Nd	14.4	15.0	17.4	13.9	14.3	15.4	12.1	17.1	14.2	14.4
Sm	1.5	1.2	–	2.0	1.9	2.1	2.0	–	1.6	1.2
Eu	–	a	–	a	0.1	–	a	–	0.4	–
Gd	1.2	1.2[a]	–	1.7[a]	1.0	–	2.3[a]	–	1.0	1.7
Tb	–	b	–	b	0.1	–	b	–	–	–
Dy	0.4	0.5	–	0.3	0.4	–	1.3	–	0.3	0.4
Ho	0.1	0.1	0.4	–	–	0.2	0.1	0.4	–	–
Er	0.3	0.1	–	–	0.1	–	–	–	0.1	–
Tm	–	–	–	–	–	–	–	–	–	–
Yb	0.2	–	0.3	–	–	0.2	–	0.3	0.1	–
Lu	–	–	–	–	–	–	–	–	–	–
Y/(Y+Ln)x100	(5.4)	(1.4)[b]	(6.6)	(5.6)[b]	–	(5.0)	(2.6)[b]	(8.0)	–	–
Method	OS	CH	–	CH	CH	–	CH	–	XF	XF
Σ = La+Ce+Pr	81.9	81.9	81.9	82.1	82.1	82.1	82.2	82.2	82.3	82.3
La-Nd	96.3	96.9	99.3	96.0	96.4	97.5	94.3	99.3	96.5	96.7
Sm-Ho	3.2	3.0	0.4	4.0	3.5	2.3	5.7	0.4	3.3	3.3
Er-Lu	0.5	0.1	0.3	–	0.1	0.2	–	0.3	0.2	–
RE_2O_3	1.79	2.78	1.44	–	2.10	1.90	3.45	1.51	12.7	1.43
La/Nd	2.26	2.23	1.68	2.25	1.87	1.99	2.62	1.58	2.38	1.94

(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(861) Kholodnov et al. (1975b), nepheline syenite, Il'men Mts., Urals, U.S.S.R.; (862) Varshal et al. (1967), rischorrite, Mt. Petrelius, Khibina massif, Kola Peninsula, U.S.S.R.; (863) Ovchinnikova (1973), magnetite ore, Lebyazhinsk deposit, Urals; (864) Borutskii et al. (1975), apatite-nepheline rock, Mt. Yukspor, Khibina massif; (865) Ganzeev et al. (1966), pyroxene fenite, Vishnevye Mts., Urals; (866) same as (863); (867) Borutskii et al. (1975), shonkinite, Mt. Petrelius, Khibina massif; (868) same as (863); (869) Khomyakov (1972), albitized syenite pegmatite, Burpala massif, Baikal; (870) Denisov et al. (1961), alkalic rock, Kola Peninsula

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. –	871	872	873	874	875	876	877	878	879	880
La	31.4	29.7	31.3	36.1	25.1	23.1	21.0	23.9	16.8	25.9
Ce	46.9	46.3	47.1	46.6	52.8	55.4	51.0	46.7	45.9	52.8
Pr	4.0	6.4	4.0	–	4.8	4.3	10.9	12.5	20.6	4.6
Nd	14.7	12.4	14.7	12.9	15.6	16.8	11.5	12.7	9.7	14.2
Sm	0.9	2.7	0.8	1.4	0.9	–	4.4	2.8	5.4	2.5
Eu	–	a	–	0.2	0.1	–	0.3	0.3	0.6	–
Gd	1.5	2.5[a]	1.5	0.8	0.5	–	0.4	0.6	0.4	–
Tb	0.2	–	0.2	0.2	–	–	–	–	–	–
Dy	0.4	–	0.4	0.8	0.2	–	–	–	–	–
Ho	–	–	–	0.1	–	–	–	–	–	–
Er	–	–	–	0.6	–	–	0.3	0.3	0.4	–
Tm	–	–	–	–	–	–	0.1	0.1	0.1	–
Yb	–	–	–	0.3	–	–	0.1	0.1	0.1	–
Lu	–	–	–	–	–	0.4	–	–	–	–
Y/(Y+Ln)x100	–	(5.7)	–	–	–	(7.2)	(5.0)	(3.6)	(4.9)	(6.8)
Method	–	CH	XF	NA	XF	–	–	–	–	–
Σ = La+Ce+Pr	82.3	82.4	82.4	82.7	82.7	82.8	82.9	83.1	83.3	83.3
La-Nd	97.0	94.8	97.1	95.6	98.3	99.6	94.4	95.8	93.0	97.5
Sm-Ho	3.0	5.2	2.9	3.5	1.7	–	5.1	3.7	6.4	2.5
Er-Lu	–	–	–	0.9	–	0.4	0.5	0.5	0.6	–
RE_2O_3	–	1.00	–	0.90	2.41	1.18	2.20	3.00	0.60	1.96
La/Nd	2.13	2.50	2.13	2.81	1.61	1.38	1.83	1.87	1.74	1.83

(a) Eu+Gd calcd. as Gd

(871) Kravchenko and Vlasova (1962), alkali syenite, central Aldan; (872) Ivanova et al. (1970), juvite, Mt. Koashva, Khibina massif, Kola Peninsula, U.S.S.R.; (873) Lyakhovich and Barinskii (1961), syenite, Dzezhkondin massif, Aldan; (874) Brunfelt and Roelandts (1974), Cerro de Mercado, Durango, Mexico; (875) Tikhonenkova and Tikhonenkov (1972), contact zone of fenite, Lovozero massif, Kola Peninsula; (876) Ovchinnikova (1973), magnetite ore, Lebyazhinsk deposit, Urals, U.S.S.R.; (877-879) Portnov and Gorobets (1964); (877) alkalic pegmatite, Il'men Mts., Urals; (878) fenite, Vishnevye Mts., Urals; (879) Alpine vein, Polar Urals, (880) same as (876)

Table 1 - Rare Earths in Apatite, atomic percent - continued

	881	882	883	884	885	886	887	888	889	890
La	36.0	26.4	25.8	31.0	20.2	28.2	30.9	29.1	27.5	36.0
Ce	44.4	52.3	54.9	47.3	59.7	52.1	48.8	50.1	51.1	43.9
Pr	3.1	4.8	2.9	5.3	3.9	3.5	4.2	4.7	5.4	4.3
Nd	11.6	14.1	14.2	14.2	12.6	14.9	11.9	16.1	8.5	11.9
Sm	1.5	1.1	1.1	1.3	1.1	0.9	1.9	-	2.1	1.6
Eu	-	0.1	-	-	0.4	0.4	0.3	-	0.3	0.3
Gd	1.3	0.7	1.1	0.9	2.0	-	0.8	-	2.1	1.0
Tb	-	0.1	c	c	-	-	-	-	0.2	-
Dy	0.9	0.4	c	c	-	-	0.4	-	1.1	0.5
Ho	0.2	-	-	-	-	-	0.1	-	0.2	0.1
Er	0.6	-	-	-	-	-	0.4	-	0.6	0.3
Tm	-	-	-	-	-	-	-	-	0.2	-
Yb	0.4	-	-	-	0.1	-	0.3	-	0.5	0.1
Lu	-	-	-	-	-	-	-	-	0.2	-
Y/(Y+Ln)x100	(7.2)	-	(2.1)[c]	(1.3)[c]	-	-	(11.6)	-	(0.9)	(4.6)
Method	CH	XF	CH	CH	XF	-	OS	XF	CH	OS
Σ = La+Ce+Pr	83.5	83.5	83.6	83.6	83.8	83.8	83.9	83.9	84.0	84.2
La-Nd	95.1	97.6	97.8	97.8	95.8	98.7	95.8	100.0	92.5	96.1
Sm-Ho	4.5	2.4	2.2	2.2	3.5	1.3	3.5	-	6.0	3.5
Er-Lu	0.4	-	-	-	0.7	-	0.7	-	1.5	0.4
RE_2O_3	0.97	1.23	1.72	4.52	1.00	1.50	1.00	-	1.87	2.7
La/Nd	3.11	1.87	1.82	2.20	2.59	1.89	2.59	1.81	3.23	3.03

(c) Tb+Dy+Y calcd. as Y

(881) Rass (1964), pegmatitic nepheline syenite, Koksharov complex, Maritime Prov., U.S.S.R.; (882) Ganzeev et al. (1966), miaskite, Vishnevye Mts., Urals, U.S.S.R.; (883-884) Borutskii et al. (1975), Khibina massif, Kola Peninsula, U.S.S.R.; (883) apatite-nepheline rock, Mt. Kukisvumchorr; (884) arfvedsonite-aegirine-feldspar pegmatite; (885) Dudkin (1959), alkalic rock, Kola Peninsula; (886) Ovchinnikova (1973), magnetite ore, Lebyazhinsk deposit, Urals, (887) Kholodnov et al. (1975b), nepheline syenite, Vishnevye Mts., Urals; (888) Vainshtein et al. (1956), nepheline syenite pegmatite, Khibina massif; (889) Kuts (1971), biotite granite, Staraya Laspa, W. Azov region, U.S.S.R.; (890) Kholodnov et al. (1975b), nepheline syenite pegmatite, Il'men Mts., Urals

Table 1 - Rare Earths in Apatite, atomic percent - continued

No -	891	892	893	894	895	896	897	898	899	900
La	28.2	30.9	30.3	26.0	31.2	19.0	36.9	34.5	32.0	32.5
Ce	51.0	49.4	48.0	55.5	50.0	49.1	42.6	45.5	52.9	48.6
Pr	5.1	4.0	6.1	3.0	3.4	16.6	5.2	4.7	—	3.9
Nd	13.7	13.7	13.3	14.4	13.1	12.2	12.2	13.8	13.4	13.8
Sm	1.3	0.8	1.0	1.1	1.6	1.5	0.5	1.5	1.3	0.6
Eu	0.1	—	0.1	—	0.2	0.6	—	—	0.2	0.3
Gd	0.4	0.8	0.7	—	0.4	0.6	0.8	—	—	0.3
Tb	-	b	0.1	c	0.1	—	0.3	—	0.1	—
Dy	0.2	0.4	0.4	c	-	—	0.6	—	—	—
Ho	-	—	—	—	-	—	0.1	—	—	—
Er	-	—,	—	—	—	0.3	0.4	—	—	—
Tm	-	—	—	—	—	—	0.1	—	—	-
Yb	-	—	—	—	—	0.1	0.3	—	0.1	—
Lu	-	—	—	—	—	—	—	—	—	—
Y/(Y+Ln)x100	—	(6.3)[b]	—	(2.2)[c]	(7.6)	(5.7)	(9.3)	—	—	-
Method	XF	CH	XF	CH	OS	—	OS, XF, AA	XF	NA	-
Σ = La+Ce+Pr	84.3	84.3	84.4	84.5	84.6	84.7	84.7	84.7	84.9	85.0
La-Nd	98.0	98.0	97.7	98.9	97.7	96.9	96.9	98.5	98.3	98.8
Sm-Ho	2.0	2.0	2.3	1.1	2.3	2.7	2.3	1.5	1.6	1.2
Er-Lu	—	—	—	—	—	0.4	0.8	—	0.1	—
RE_2O_3	2.14	—	0.98	—	0.74	1.50	1.7	—	—	0.31
La/Nd	2.07	2.20	1.81	1.80	2.38	1.55	3.02	2.50	2.38	2.36

(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(891) Hofmann (1964), syenite, Plauen, Germany; (892) Borutskii et al. (1975), apatite-nepheline rock, Mt. Kukisvumchorr, Khibina massif, Kola Peninsula, U.S.S.R.; (893) Ganzeev et al. (1966), sandyite, Vishnevye Mts., Urals, U.S.S.R.; (894) Varshal et al. (1967), same as (892); (895) Kapustin (1977), calcite carbonatite, Turii mys, Karelia, U.S.S.R.; (896) Portnov and Gorobets (1969), gabbro, Kushva, Urals; (897) Young et al. (1969), iron ore in latite and rhyolite, Durango, Mexico; (898) Balashov and Turanskaya (1960), alkalic pegmatite, Inagli massif, Aldan; (899) Henderson (1980), feldspar-arfvedsonite-apatite-titanite rock, Kangerdlugssuaq, E. Greenland; (900) Ovchinnikova (1973), apatite-pyroxene rock, Lebyazhinsk deposit, Urals, U.S.S.R.

Table 1 - Rare Earths in Apatite, atomic percent - continued

	901	902	903	904	905	906	907	908	909	910
La	32.7	26.3	32.4	35.9	32.7	31.2	34.7	26.2	26.1	27.4
Ce	48.2	53.9	49.4	46.6	49.4	50.4	45.9	55.6	57.5	54.4
Pr	4.2	5.0	3.5	2.9	3.4	3.9	5.1	4.2	2.5	4.3
Nd	13.7	13.5	12.1	11.5	11.9	13.1	10.0	11.6	11.2	13.0
Sm	0.8	0.6	0.9	1.4	0.8	0.9	2.2	1.2	1.0	0.7
Eu	-	0.1	0.3	a	0.1	-	-	0.2	-	-
Gd	0.4	0.3	0.6	1.1[a]	0.8	0.5	2.1	0.8	1.1	0.2
Tb	b	-	-	b	0.1	c	-	-	-	c
Dy	-	0.1	0.4	0.4	0.4	c	-	0.2	0.4	c
Ho	-	-	-	0.1	-	-	-	-	-	-
Er	-	0.1	0.2	0.1	0.2	-	-	-	0.1	-
Tm	-	-	-	-	-	-	-	-	-	-
Yb	-	0.1	0.2	-	0.2	-	-	-	0.1	-
Lu	-	-	-	-	-	-	-	-	-	-
Y/(Y+Ln)x100	(0.7)[b]	-	-	(2.1)[b]	-	(0.6)[c]	(6.0)	-	(6.4)	(4.2)[c]
Method	CH	-	XF	CH	XF	CH	-	XF	OS	CH
Σ = La+Ce+Pr	85.1	85.2	85.3	85.4	85.5	85.5	85.7	86.0	86.1	86.1
La-Nd	98.8	98.7	97.4	96.9	97.4	98.6	95.7	97.6	97.3	99.1
Sm-Ho	1.2	1.1	2.2	3.0	2.2	1.4	4.3	2.4	2.5	0.9
Er-Lu	-	0.2	0.4	0.1	0.4	-	-	-	0.2	-
RE_2O_3	2.94	3.73	6.30	0.70	5.94	5.52	0.95	0.04*	2.92	1.37
La/Nd	2.39	1.95	2.69	3.11	2.75	2.38	3.45	2.25	2.33	2.11

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y
(c) Tb+Dy+Y calcd. as Y

(901) Borutskii et al. (1975), vein in aegirine-feldspar pegmatite, Khibina massif, Kola Peninsula, U.S.S.R.; (902) Efimov et al. (1962), alkalic pegmatite, Inagli massif, Aldan (SrO 6.1%); (903) Khomyakov (1972) nepheline metasomatite, Burpala massif, Baikal; (904) Varshal et al. (1967), rischorrite pegmatite, Mt. Kukisvumchorr, Khibina massif; (905) same as (903); (906) Borutskii et al. (1975), albitite vein cutting alkalic pegmatite, Khibina massif; (907) Ivanova et al. (1970), malignite, Mt. Kukisvumchorr; (908) Ignat'eva (1973), Abovyan iron-ore deposit, Armenian S.S.R.; (909) Sarukhyan and Mkrtchyan (1968), veinlet in Abovyan iron-ore deposit; (910) Vasil'eva et al. (1978), biotite-titanomagnetite-apatite ore in mudstone near syenite, Mushugai Khukuk, Mongolia

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	911	912	913	914	915	916	917	918	919	920
La	31.9	26.6	36.7	29.3	27.4	42.2	33 8	27.5	24.9	38.0
Ce	50.9	57.7	45.6	53.2	52.4	41.3	49.7	54.6	60.1	47.3
Pr	3.4	2.0	4.0	3.8	6.9	3 3	3.4	4.9	2.2	1.9
Nd	12.3	11.2	12.6	12.7	13.3	10.4	12 1	12.0	10.5	11.3
Sm	0.7	0.8	0.6	0.6	-	0 9	0.6	0.8	0.7	0.8
Eu	-	-	-	-	-	-	0.1	-	-	-
Gd	0.5	1.1	0.5	0.3	-	1.2	0.2	0.2	1.0	0.6
Tb	-	-	-	-	-	-	0.1	-	-	-
Dy	0.3	0.4	-	0.1	-	-	-	-	0.4	0.1
Ho	-	-	-	-	-	0.1	-	-	-	-
Er	-	0.1	-	-	-	0.3	-	-	0.1	-
Tm	-	-	-	-	-	0.1	-	-	-	-
Yb	-	0.1	-	-	-	0.2	-	-	0 1	-
Lu	-	-	-	-	-	-	-	-	-	-
Y/(Y+Ln)x100	-	(6.1)	(0.9)	-	(6.4)	(5.6)	-	-	(6.1)	-
Method	XF	OS	CH	XF	XF	OS	OS	XF	OS	XF
Σ = La+Ce+Pr	86.2	86.3	86.3	86.3	86.7	86.8	86.9	87.0	87 2	87.2
La-Nd	98.5	97.5	98.9	99.0	100 0	97.2	99.0	99 0	97 7	98.5
Sm-Ho	1.5	2.3	1 1	1 0	-	2 2	1.0	1.0	2.1	1 5
Er-Lu	-	0.2	-	-	-	0.6	-	-	0.2	-
RE_2O_3	0.71*	2.54	1.23	0.28*	1 09	1.92	0.39	2 95	2.80	0.85
La/Nd	2.59	2.37	2.91	2.31	2 06	4.04	2.79	2.28	2 36	3 36

* = % R.E.

(911) Ignat'eva (1973), Abovyan iron-ore deposit, Armenian S.S.R.; (912) Sarukhyan and Mkrtchyan (1968), altered andesite, Abovyan magnetite deposit, Armenian, S.S.R.; (913) Borutskii et al. (1975), nepheline syenite porphyry, Khibina massif, Kola Peninsula, U.S.S.R.; (914) same as (911); (915) Shilin and Yanchenko (1962), apatite-nepheline rock, Khibina massif; (916) Kholodnov et al. (1975b), nepheline syenite, Il'men Mts., Urals, U.S.S.R.; (917) Knubovets et al. (1979), phlogopite-metasomatite, Meimech-Kotui province, Siberia; (918) Ganzeev et al. (1966), pyroxene fenite, Vishnevye Mts., Urals, U.S.S.R.; (919) Sarukhan and Mkrtchyan (1968), Abovyan magnetite deposit, Armenian S.S.R.; (920) Denisov et al. (1961), alkalic rock, Kola Peninsula

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	921	922	923	924	925	926	927	928	929	930
La	29.2	39.1	27.7	34.0	35.9	35.2	36.9	31.3	36.1	35.5
Ce	53.7	44.5	57.5	48.4	41.1	49.6	47.9	52.0	48.1	51.2
Pr	4.3	3.7	2.2	5.0	10.4	2.9	3.0	4.7	3.8	1.8
Nd	12.8	9.7	10.7	10.8	12.1	10.1	10.4	11.7	12.0	10.4
Sm	-	1.8	0.7	1.4	-	0.9	0.5	0.2	-	0.6
Eu	-	a	-	0.2	-	0.1	0.3	-	-	-
Gd	-	1.2[a]	0.7	0.1	-	0.5	0.4	0.1	-	0.4
Tb	-	b	-	-	-	-	-	-	-	-
Dy	-	-	0.4	-	-	0.3	0.4	-	-	0.1
Ho	-	-	-	-	-	-	-	-	-	-
Er	-	-	-	0.1	-	0.2	0.4	-	-	-
Tm	-	-	-	-	-	-	-	-	-	-
Yb	-	-	0.1	-	0.5	0.2	0.1	-	-	-
Lu	-	-	-	-	-	-	-	-	-	-
Y/(Y+Ln)x100	-	(1.9)[b]	(5.2)	(0.9)	(17.2)	-	-	-	-	-
Method	-	CH	OS	-	XF	XF	XF	XF	XF	XF
Σ = La+Ce+Pr	87.2	87.3	87.4	87.4	87.4	87.7	87.8	88.0	88.0	88.5
La-Nd	100.0	97.0	98.1	98.2	99.5	97.8	98.2	99.7	100.0	98.9
Sm-Ho	-	3.0	1.8	1.7	-	1.8	1.8	0.3	-	1.1
Er-Lu	-	-	0.1	0.1	0.5	0.4	0.4	-	-	-
RE_2O_3	1.22	-	4.16	4.30	0.56*	4.16	4.16	-	3.16	0.80
La/Nd	2.29	4.04	2.59	3.14	2.97	3.48	3.48	2.68	3.01	3.40

* = % R.E.
(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(921) Polyakov (1972), alkali syenite, Kurginsk massif, Kola Peninsula, U.S.S.R.; (922) Varshal et al. (1967), apatite-wollastonite rock, Khibina massif, Kola Peninsula; (923) Sarukhan and Mkrtchyan (1968), magnetite ore, Abovyan deposit, Armenian S.S.R.; (924) Portnov and Gorobets (1969), alkalic pegmatite, Lovozero massif, Kola Peninsula; (925) Plaksenko (1979), gabbro-norite, Elen'skaya intrusive, U.S.S.R.; (926-927) Khomyakov (1972), Burpala massif, Baikal; (926) metasomatite with fluorite; (927) metasomatite with aegirine; (828) Semenov (1962), alkalic pegmatite, Mt. Nepkha, Lovozero massif, Kola Peninsula; (929) Vainshtein et al. (1956), alkalic rock, Khibina massif; (930) Khomyakov (1972), trachytoidal syenite, Burpala massif, Baikal

Table 1 - Rare Earths in Apatite, atomic percent - continued

No. —	931	932	933	934	935	936	937	938	939	
La	33.5	36.9	34.5	39 6	49.0	37.0	28.2	31.5	49.8	
Ce	53.4	47.8	50.8	50.0	36.9	48.0	60 4	56.8	39.7	
Pr	1.6	3.8	3.4	—	4.1	5.0	2.5	2.9	2.9	
Nd	10.4	11.5	9.6	10.4	7.1	9.3	8.9	8.2	6.	
Sm	0.6	-	0.9	-	2.3	0.5	-	0.4	0.5	
Eu	-	-	-	-	a	-	-	-	a	
Gd	0.4	-	0.8	-	0.6[a]	0.2	-	-	0.4[a]	
Tb	-	-	b	-	b	-	-	-	b	
Dy	0.1	-	-	-	-	-	-	0.2	-	
Ho	-	-	-	-	-	-	-	-	-	
Er	-	-	-	-	-	-	-	-	-	
Tm	-	-	-	-	-	-	-	-	-	
Yb	-	-	-	-	-	-	-	-	-	
Lu	-	-	-	-	-	-	-	-	-	
Y/(Y+Ln)x100	-	-	(1.7)[b]	(4.0)	(2.9)[b]	(0.4)	-	-	(26)[b]	
Method	XF	XF	CH	OS	CH	CH	-	XF	CH	
Σ = La+Ce+Pr	88.5	88.5	88.7	89.6	90.0	90.0	91 1	91 2	92.4	
La-Nd	98.9	100.0	98.3	100.0	97.1	99.3	100.0	99.4	99.1	
Sm-Ho	1.1	-	1.7	-	2.9	0.7	-	0 6	0.9	
Er-Lu	-	-	-	-	-	-	-	-	-	
RE_2O_3	1.72	-	4.54	-	0.79	4.76	2.20	1.20	0.39	
La/Nd	3 23	3.21	3.59	3 81	6.90	3 98	3.16	3.85	7 46	

(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(931) Khomyakov (1972), massive syenite, Burpala massif, Baikal; (932) Vainshtein et al. (1956), alkalic rock, Khibina massif, Kola Peninsula, U.S.S.R.; (933) Borutskii et al. (1975), foyaite, Umbozer, Khibina massif; (934) Rose et al. (1958), carbonatite, Magnet Cove, Ark.; (935) Varshal et al. (1967), rischorrite pegmatite, Mt. Eveslogchorr, Khibina massif; (936) Borutskii et al. (1975), aegirine-arfvedsonite-feldspar pegmatite, Mt. Takhtarvumchorr, Khibina massif; (937) Polyakov (1972), alkalic syenite, Kurginsk massif, Kola Peninsula; (938) Mikhailov and Mineev (1970), metasomatic diopside rock, Aldan massif; (939) Varshal et al. (1967), rischorrite pegmatite, Mt. Eveslogchorr, Khibina massif

Table 2 - Rare earths in Phosphorites, atomic percent

	1	2	3	4	5	6	7	8	9	10
La	6.1	2.1	6.8	21.8	11.0	10.8	24.8	7.1	14.3	16.0
Ce	8.1	3.2	23.9	14.0	26.7	25.9	16.0	30.7	29.5	25.5
Pr	1.3	16.6	7.8	4.6	4.1	6.1	4.5	8.1	3.3	6.6
Nd	10.5	75.5	26.4	30.4	14.0	23.5	23.9	29.5	21.0	23.4
Sm	5.7	1.8	12.7	5.2	5.1	7.9	5.3	9.2	6.0	5.6
Eu	0.9	0.3	1.9	0.9	-	1.3	0.9	1.6	0.8	0.9
Gd	18.9	0.4	12.2	5.9	3.8	12.6	8.5	8.1	8.0	8.5
Tb	3.0	-	1.9	0.9	3.8	1.5	0.8	1.3	1.0	1.1
Dy	13.7	0.1	3.8	5.0	9.9	5.5	5.8	3.7	6.1	4.7
Ho	2.9	-	0.7	1.5	1.9	1.0	1.0	0.8	1.1	1.3
Er	12.8	-	1.2	3.9	3.7	1.9	3.6	1.3	4.0	3.6
Tm	2.2	-	0.1	1.7	1.9	0.4	0.4	0.2	0.7	0.5
Yb	11.8	-	0.5	3.7	8.6	1.4	3.7	0.4	3.7	2.0
Lu	2.1	-	0.1	0.5	5.5	0.2	0.8	-	0.5	0.3
Y/(Y+Ln)x100	-	-	-	-	(31.2)	-	-	-	-	-
Method	XF	XF	XF	OS	XF	XF	XF	XF	XF	XF
Σ = La+Ce+Pr	15.5	21.9	38.5	40.4	41.8	42.8	45.3	45.9	47.1	48.1
La-Nd	26.0	97.4	64.9	70.8	55.8	66.3	69.2	73.4	68.1	71.5
Sm-Ho	45.1	2.6	33.2	19.4	24.5	29.8	22.3	24.7	23.0	22.1
Er-Lu	28.9	-	1.9	9.8	19.7	3.9	8.5	1.9	8.9	6.4
RE_2O_3, %	0.14	0.07	0.10	0.59*	0.014*	0.20	.004	0.11	0.05	0.13
La/Nd	0.59	0.03	0.26	0.72	0.79	0.46	1.04	0.26	0.68	0.68
% P_2O_5	-	-	-	-	-	-	23.0	-	11.8	-

* = % R.E.

(1,3,6, and 10) Semenov et al. (1962), (1) bedded, Khoper; (3) concretion, Podolskoye, Ukraine; (6) nodular, Germany; (10) nodular, Germany; (2) Loog and (8) (1968), obolid phosphorite, Mardu, Esthonia; (4) Altschuler et al. (1967), average of 2, Khouribga, Morocco; (5) Akelsiev and Arnaudov (1965), Oligocene, W. Bulgaria; (7) and (9) Bliskovskii et al. (1969), secondary; (7) Talmalyk, U.S.S.R.; (a) Seybersk, U.S.S.R.

Table 2 - Rare Earths in Phosphorites, atomic percent - continued

	11	12	13	14	15	16	17	18	19	20
La	27.0	19.1	20.2	11.2	14.5	24.4	10.2	19.9	11.1	24.5
Ce	18.8	25.6	19.0	36.4	31.8	22.4	39.8	28.0	39.9	27.5
Pr	2.7	4.4	11.9	4.7	6.1	7.0	4.2	6.3	3.7	3.7
Nd	26.1	27.7	21.9	23.2	24.3	20.0	20.7	20.8	29.7	11.9
Sm	2.5	5.3	6.5	6.3	8.8	6.6	7.2	6.6	4.5	5.6
Eu	2.5	0.7	2.2	1.7	1.7	0.6	0.8	2.4	0.4	0.6
Gd	2.4	7.5	-	7.6	5.1	5.2	7.7	4.9	5.1	7.2
Tb	0.5	0.6	-	0.8	0.7	0.6	0.7	0.6	0.2	0.8
Dy	4.6	4.5	13.3	3.9	2.6	5.1	4.5	4.4	2.8	6.4
Ho	0.9	0.9	-	0.3	0.9	1.2	-	1.1	1.3	1.5
Er	7.9	2.0	3.5	2.1	1.6	3.2	2.1	2.2	0.4	5.1
Tm	0.2	0.3	0.9	0.4	0.3	0.5	-	0.5	-	0.6
Yb	3.2	1.1	0.6	1.0	1.4	2.7	1.4	2.0	0.7	3.8
Lu	0.7	0.3	-	0.4	0.2	0.5	0.7	0.3	0.2	0.8
Y/(Y+Ln)x100	-	-	(24.0)	-	-	-	-	-	(17.0)	-
Method	OS	XF	OS	XF	XF	XF	XF	XF	XF	XF
Σ = La+Ce+Pr	48.5	49.1	51.1	52.3	52.4	53.8	54.2	54.2	54.7	55.7
La-Nd	74.6	76.8	73.0	75.5	76.7	73.8	74.9	75.6	84.4	67.6
Sm-Ho	13.4	19.5	22.0	20.6	19.8	19.3	20.9	20.0	14.3	22.1
Er-Lu	12.0	3.7	5.0	3.9	3.5	6.9	4.2	5.0	1.3	10.3
RE_2O_3, %	-	0.06	0.25*	0.075	0.012*	0.08	0.20	0.03*	0.514*	0.019
La/Nd	1.04	0.69	0.92	0.49	0.60	1.22	0.49	0.96	0.37	2.06
P_2O_5, %	33.9	-	16.9	6.55	-	-	12.3	-	-	7.3

* = % R.E.

(11) Cook (1972), pelletal, Georgina Basin, Queensland, Australia; (12 and 16) Semenov et al. (1962), bedded, U.S.S.R.; (12) Kara-Tau; (16) Khoper; (13) Substyk (1978), nodular, Poland; (14,17, and 20) Bliskovskii et al. (1969); (14 and 17) oolitic shell, Guryevsk, U.S.S.R.; (20) bedded, Talmalyk, U.S.S.R.; (15) Ilin and Ratnikova (1976), microsporite, Ukhalol'sk, Mongolia; (18) Ilin and Ratnikova (1976), microsphorite, Tsagennarsk, Mongolia; (19) Aleksiev and Arnaudov (1965), Jurassic, W. Bulgaria

Table 2 - Rare Earths in Phosphorites, atomic percent - continued

	21	22	23	24	25	26	27	28	29	30
La	33.5	13.3	24.1	12.1	17.9	23.6	34.1	30.6	42.2	25.4
Ce	19.9	37.2	27.5	34.8	30.0	28.1	18.4	22.2	8.9	27.3
Pr	2.3	5.3	4.3	9.3	8.5	4.7	4.1	4.0	5.9	5.4
Nd	25.8	16.6.	18.4	30.0	22.6	31.5	23.6	10.3	21.6	20.2
Sm	2.2	13.9	2.8	5.4	6.6	3.5	3.4	5.4	2.3	4.3
Eu	2.4	0.3	-	0.9	1.5	0.4	1.0	0.7	2.4	-
Gd	2.1	5.3	4.6	-	4.9	-	4.8	8.0	4.1	4.6
Tb	0.4	0.5	-	-	0.4	-	1.0	0.8	0.7	0.2
Dy	5.7	3.0	3.0	4.0	2.8	3.6	2.8	6.6	4.7	3.6
Ho	0.8	0.3	0.8	-	1.0	-	1.0	1.8	1.2	0.9
Er	1.7	1.8	7.2	2.3	1.6	1.6	2.4	5.1	3.0	2.6
Tm	0.3	0.4	5.0	0.4	0.4	1.5	0.7	0.8	0.3	0.2
Yb	2.1	1.8	1.3	0.8	1.6	1.5	2.4	3.6	2.0	4.5
Lu	0.8	0.3	1.0	-	0.2	-	0.3	0.1	0.7	0.9
Y/(Y+Ln)x100	-	-	(22.5)	(26.5)	-	(20.3)	-	-	(46.1)	-
Method	OS	XF	XF	OS	XF	OS	OS	XF	-	XF
Σ = La+Ce+Pr	55.7	55.8	55.9	56.2	56.4	56.4	56.6	56.8	57.0	58.0
La-Nd	81.5	72.4	74.3	86.2	79.0	87.9	80.2	67.1	78.6	78.2
Sm-Ho	13.6	23.3	11.2	10.3	17.2	7.5	14.0	23.3	15.4	13.6
Er-Lu	4.9	4.3	14.5	3.5	3.8	4.6	5.8	9.6	6.0	8.2
RE_2O_3, %	-	0.14*	0.074*	0.013*	0.027*	0.026*	-	0.005	0.3-0.5	0.09
La/Nd	1.30	0.80	1.31	0.40	0.79	0.75	1.45	2.97	1.95	1.26
P_2O_5, %	36.6	-	-	20.4	-	23.95	-	3.81	-	-

* = % R.E.

(21) Cook (1972), pelletal, Georgina Basin, Australia; (22) Loog (1968), obolid, Esthonia; (23) Aleksiev and Arnaudov (1965), Baremian, N. Bulgaria; (24) Substyk (1978), nodular, Poland; (25) Il'in and Ratnikova (1976), pelletal, Khubsugal, Mongolia; (26) same as (24); (27) Altschuler et al. (1967), Phospheria formation; (28) Bliskovskii et al. (1969), oolitic, El Mohammad, United Arab Republic; (29) Lozinski (1971), fossil dinosaur bones, mainly carbonate-fluor-apatite, Mongolia; (30) Semenov et al. (1962), bedded, Kara-Tau

Table 2 - Rare Earths in Phosphorites, atomic percent - continued

	31	32	33	34	35	36	37	38	39	40
La	21.1	23.4	19.9	36.4	33.0	29.2	14.3	24.9	19.2	22.6
Ce	30.8	29.6	34.7	19.2	20.8	25.5	39.3	29.6	35.8	32.3
Pr	6.2	5.4	4.9	2.9	4.9	5.1	5.4	4.9	4.4	4.6
Nd	29.1	22.5	19.4	23.4	26.4	23.0	16.5	15.2	18.4	21.4
Sm	4.6	4.8	3.8	2.2	2.8	4.1	5.7	6.6	5.2	3.3
Eu	0.7	1.5	0.9	1.8	0.4	0.4	0.7	0.9	0.5	-
Gd	-	-	5.2	1.5	4.3	5.3	9.0	6.3	6.4	4.4
Tb	-	1.0	0.7	0.4	0.4	0.3	0.6	0.5	0.8	2.7
Dy	4.5	5.6	4.2	4.1	2.7	3.5	4.1	4.9	4.5	2.0
Ho	-	-	1.1	0.6	1.5	1.0	-	1.1	0.7	1.3
Er	1.8	4.1	3.1	5.0	1.2	1.8	1.6	2.9	2.3	1.8
Tm	0.3	0.7	0.4	-	-	0.3	-	0.5	0.4	1.0
Yb	0.9	1.4	2.3	2.3	1.6	1.2	2.2	1.2	1.1	1.8
Lu	-	-	0.4	0.2	-	0.3	0.6	0.5	0.3	0.8
Y/(Y+Ln)x100	(27.3)	(10.3)	-	-	(27.1)	-	-	-	-	(15.3)
Method	OS	OS	NA, XF	OS	XF	XF	XF	XF	XF	XF
Σ = La+Ce+Pr	58.1	58.4	58.5	58.5	58.7	58.8	59.0	59.4	59.4	59.5
La-Nd	87.2	80.9	77.9	81.9	85.1	81.8	75.5	74.6	77.8	80.7
Sm-Ho	9.8	12.9	15.9	10.6	12.1	14.6	20.1	20.3	18.1	13.9
Er-Lu	3.0	6.2	6.2	7.5	2.8	3.6	4.4	5.1	4.1	5.4
RE_2O_3, %	.0127*	0.041*	0.295*	-	0.19*	0.06	0.16	0.15	0.025	0.04*
La/Nd	0.73	1.04	0.18	1.55	1.25	1.23	0.87	1.64	1.04	1.06
% P_2O_5	-	28.07	-	36.4	-	-	-	12.1	21.6	-

* = % R.E.

(31-32) Substyk (1978), nodules, Poland; (33) Goldberg et al. (1963), continental shelf north of Magdalena Bay, Calif.; (34) Cook (1972), pelletal, Georgina Bay, Queensland, Australia; (35) Aleksiev and Arnaudov (1965), Albian, N. Bulgaria; (36) Semenov, et al. (1962), bedded, Kara-Tau; (37) Loog (1968), obolid, Esthonia; (38-39) Bliskovskii et al. (1969), U.S.S.R.; (38) concretionary, Kharaulakh, Yakutia; (39) shell, Maardu, Esthonia; (40) same as (35)

Table 2 - Rare Earths in Phosphorites, atomic percent - continued

	41	42	43	44	45	46	47	48	49	50
La	21.3	14.9	13.5	25.1	33.2	25.5	27.9	21.9	15.6	20.2
Ce	33.8	41.4	42.0	28.6	24.0	28.2	27.7	33.2	40.8	36.3
Pr	4.8	3.7	4.5	7.0	3.8	7.4	5.6	6.3	5.5	5.4
Nd	23.3	19.1	31.1	21.4	22.9	25.3	24.2	18.9	15.7	19.5
Sm	5.1	5.1	-	3.8	3.9	4.8	4.3	4.8	5.2	5.1
Eu	1.1	0.7	0.4	0.8	0.6	0.7	2.0	0.5	0.6	0.9
Gd	4.0	5.5	3.9	3.8	4.4	-	-	5.1	7.1	3.2
Tb	0.5	0.8	0.2	0.5	0.6	-	-	0.5	1.1	-
Dy	3.1	4.2	1.9	3.5	3.2	4.2	3.7	3.2	3.2	3.2
Ho	0.6	0.8	1.0	0.8	0.4	-	-	0.9	0.5	1.6
Er	1.2	2.1	0.4	2.5	1.8	1.6	1.9	2.2	1.5	3.1
Tm	0.3	0.3	0.1	0.2	0.2	0.4	0.9	0.4	0.3	-
Yb	0.7	1.1	0.6	1.6	0.9	1.9	1.8	1.7	2.5	1.5
Lu	0.2	0.3	0.4	0.4	0.1	-	-	0.4	0.4	-
Y/(Y+Ln)x100	-	-	(11.7)	(38.1)	-	(13.6)	(11.5)	-	-	-
Method	XF	XF	XF	OS	XF	OS	OS	XF	XF	XF
Σ = La+Ce+Pr	59.9	60.0	60.0	60.7	61.0	61.1	61.2	61.4	61.9	61.9
La-Nd	83.2	79.1	91.1	82.1	83.9	86.4	85.4	80.3	77.6	81.4
Sm-Ho	14.4	17.1	7.4	13.2	13.1	9.7	10.0	15.0	17.7	14.0
Er-Lu	2.4	3.8	1.5	4.7	3.0	3.9	4.6	4.7	4.2	4.6
RE_2O_3	0.011	0.35	0.425*	0.07*	0.11	0.03*	0.031*	0.05	0.06	0.03
La/Nd	0.91	0.78	0.44	1.18	1.45	1.01	1.15	1.16	1.00	1.03
P_2O_5, %	-	35.2	-	-	31.1	13.3	13.45	-	-	-

* = % R.E.

(41) Il'in and Ratnikova (1976), clayey-siliceous, Ukhagol'sk, Mongolia; (42) Bliskovskii et al. (1969), purified oolitic shell, Angara-Ilim region; (43) Aleksiev and Arnaudov (1965), Jurassic, W. Bulgaria; (44) El-Kammar et al. (1979), Nile Valley, Egypt; (45) Bliskovskii et al. (1969), bedded, metamorphosed, Nasyn-Kul, U.S.S.R.; (46-47) Substyk (1978), nodular, Poland; (48) Semenov et al. (1962), nodular, Polpinsk, U.S.S.R.; (49) Loog (1968), obolid, Esthonia; (50) Semenov et al. (1962), Shchigrov, U.S.S.R.

Table 2 - Rare Earths in Phosphorites, atomic percent - continued

	51	52	53	54	55	56	57	58	59	60
La	19.8	24.6	25.7	21.1	20.4	16.7	18.0	25.6	23.2	31.5
Ce	37.8	31.6	30.7	36.7	38.0	44.2	42.9	33.7	31.2	25.5
Pr	4.5	6.1	6.1	4.7	4.5	2.3	2.5	4.1	9.1	6.6
Nd	22.2	19.9	21.9	22.4	21.1	20.1	15.7	22.0	19.2	14.8
Sm	4.6	5.3	4.1	3.2	3.1	-	-	3.1	7.3	5.7
Eu	1.1	0.6	0.4	-	-	-	-	0.7	2.2	0.9
Gd	4.9	3.8	3.1	5.2	4.2	5.5	9.5	5.1	-	3.2
Tb	0.4	0.6	0.5	1.3	0.8	3.1	-	0.4	-	0.9
Dy	2.7	3.1	2.9	-	3.8	2.8	3.7	2.6	4.8	3.1
Ho	0.2	0.6	0.6	1.6	1.3	1.2	1.5	0.2	-	0.9
Er	1.0	2.1	1.4	1.1	0.9	2.1	2.4	1.5	2.1	4.4
Tm	-	0.3	0.3	-	-	-	1.8	6.2	0.3	0.3
Yb	0.6	1.2	2.0	1.8	1.9	2.0	2.0	0.8	0.6	1.6
Lu	0.2	0.2	0.3	0.9	-	-	-	-	-	0.6
Y/(Y+Ln)x100	-	-	-	(22.8)	(20.4)	(28.9)	(37.2)	-	-	(18.8)
Method	XF	XF	XF	XF	XF	OS	OS	XF	OS	OS
Σ = La+Ce+Pr	62.1	62.3	62.5	62.5	62.9	63.2	63.4	63.4	63.5	63.6
La-Nd	84.3	82.2	84.4	84.9	84.0	83.3	79.1	85.4	82.7	78.4
Sm-Ho	13.9	14.0	11.6	11.3	13.2	12.6	14.7	12.1	14.3	14.7
Er-Lu	1.8	3.8	4.0	3.8	2.8	4.1	6.2	2.5	3.0	6.9
RE_2O_3	0.005	0.04	0.10	0.07*	0.08*	0.001	0.004	0.019	0.028*	0.06
La/Nd	0.89	1.24	1.17	0.94	0.97	0.83	1.15	1.16	1.20	2.13
P_2O_5, %	20.3	-	-	-	-	-	-	15.1	14.6	-

* = % R.E.

(51) Bliskovskii et al. (1969), bedded, Belkinsk, U.S.S.R.; (52-53) Semenov et al. (1962), bedded, Kara-Tau, U.S.S.R.; (54-55) Aleksiev and Arnaudov (1965), N. Bulgaria, (54) Hauterivian; (55) Albian; (56-57) Altschuler (1973), (56) carbonate-fluorapatite, supergene replacement of limestone, Dunellon, Fla.; (57) hydroxylapatite, guanitized limestone, Mona Island, Caribbean; (58) Bliskovskii et al. (1969), bedded, In River basin, E. Sayan; (59) Substyk (1978), nodular, Poland; (60) Altschuler et al. (1967), average of 3, Bone Valley formation, Fla.

Table 2 - Rare Earths in Phosphorites, atomic percent - continued

	61	62	63	64	65	66	67	68	69	70
La	15.7	11.5	25.6	9.7	31.6	11.2	23.0	22.8	17.2	19.8
Ce	45.6	45.2	36.5	52.0	29.8	46.7	38.4	38.2	45.2	42.3
Pr	3.0	7.9	2.5	3.0	3.4	7.3	3.9	4.3	3.0	3.5
Nd	16.0	21.5	21.6	16.0	17.5	20.9	18.7	22.8	22.7	20.7
Sm	4.3	5.3	3.2	4.2	3.6	5.0	4.5	3.2	3.1	3.7
Eu	1.6	0.8	0.8	2.1	-	0.8	0.5	0.6	0.1	0.2
Gd	4.9	3.5	6.1	4.7	4.0	2.9	4.1	3.9	3.1	3.3
Tb	0.5	0.5	-	-	1.7	0.5	0.5	0.4	0.3	0.5
Dy	4.3	2.1	2.2	5.9	2.0	2.3	3.0	2.2	2.4	2.6
Ho	0.4	0.4	-	0.6	1.2	0.4	0.4	-	0.4	0.4
Er	1.7	0.7	1.5	-	1.6	1.0	1.6	1.0	1.3	1.4
Tm	0.4	0.1	-	-	0.6	0.2	0.3	-	0.3	0.3
Yb	1.2	0.4	-	1.2	2.9	0.7	0.9	0.5	0.8	1.1
Lu	0.4	0.1	-	0.6	-	0.1	0.2	0.1	0.1	0.2
Y/(Y+Ln)x100	-	-	-	-	(22.8)	-	-	-	-	-
Method	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF
Σ = La+Ce+Pr	64.3	64.6	64.6	64.7	64.9	65.2	65.3	65.3	65.4	65.6
La-Nd	80.3	86.1	86.2	80.7	82.4	86.1	84.0	88.1	88.1	86.3
Sm-Ho	16.0	12.6	12.3	17.5	12.5	11.9	13.0	10.3	9.4	10.7
Er-Lu	3.7	1.3	1.5	1.8	5.1	2.0	3.0	1.6	2.5	3.0
RE_2O_3	0.025	0.15	0.035	0.29	0.074*	0.36	0.21	0.03	0.042	0.024
La/Nd	0.98	0.54	1.19	0.61	1.81	0.54	1.23	1.00	0.76	0.96
P_2O_5, %	26.9	-	17.85	15.5	-	-	33.0	18.4	1.72	7.65

* = % R.E.

(61) Bliskovskii et al. (1969), bedded, Seybinsk, U.S.S.R.; (62) Semenov et al. (1962), nodular, Moscow dist., U.S.S.R.; (63-64) Bliskovskii et al. (1969), U.S.S.R.; (63) secondary, Belkinsk; (64) oolitic shell, Angara-Ilim, matrix of no. 42; (65) Aleksiev and Arnaudov (1965), Turonian, N. Bulgaria; (66) same as (62); (67-70) Bliskovskii et al. (1969), U.S.S.R.; (67) secondary, Belousinsk; (68) nodular, Bogdanov; (69) nodular, Kimovsk; (70) oolitic, Guru-Fatminsk

Table 2 - Rare Earths in Phosphorites, atomic percent - continued

	71	72	73	74	75	76	77	78	79	80
La	16.7	22.8	21.5	21.8	18.0	23.1	14.9	18.4	38.5	29.8
Ce	45.9	39.0	41.1	41.2	46.4	40.0	46.4	42.6	23.2	39.8
Pr	3.3	4.3	3.8	3.5	2.8	4.2	6.1	6.4	6.2	-
Nd	22.4	21.3	18.8	21.1	18.9	21.4	19.8	20.8	17.1	24.4
Sm	3.3	3.2	3.7	3.2	0.5	3.1	4.1	3.8	2.2	3.4
Eu	0.4	0.6	0.3	0.6	0.1	0.6	0.6	0.3	-	0.2
Gd	3.0	3.9	3.5	2.7	1.7	3.6	3.2	3.7	3.3	-
Tb	0.5	0.4	0.5	0.5	0.3	0.4	0.3	0.5	1.0	-
Dy	2.1	2.0	2.8	2.2	2.2	1.9	2.1	1.8	2.5	2.4
Ho	0.4	0.1	0.5	0.4	0.4	0.1	0.4	0.3	1.2	-
Er	1.0	1.0	1.6	1.0	1.7	0.9	1.0	0.9	1.9	-
Tm	0.2	0.3	0.3	0.2	0.3	0.1	0.3	0.1	0.3	-
Yb	0.7	0.8	1.3	1.4	6.0	0.5	0.6	0.3	1.9	-
Lu	0.1	0.3	0.3	0.2	0.7	0.1	0.2	0.1	0.7	-
Y/(Y+Ln)x100	-	-	-	-	-	-	-	-	(21.2)	-
Method	XF	XF	XF	XF	XF	XF	XF	XF	XF	NA
Σ = La+Ce+Pr	65.9	66.1	66.4	66.5	67.2	67.3	67.4	67.4	67.9	69.6
La-Nd	88.3	87.4	85.2	87.6	86.1	88.7	87.2	88.2	85.0	94.0
Sm-Ho	9.7	10.2	11.3	9.6	5.2	9.7	10.7	10.4	10.2	6.0
Er-Lu	2.0	2.4	3.5	2.8	8.7	1.6	2.1	1.4	4.8	-
RE_2O_3	0.03	0.027	0.055	0.028	0.03	0.018	0.1	0.13	0.17*	-
La/Nd	0.74	1.07	1.14	1.03	0.95	1.08	0.75	0.89	2.26	1.22
P_2O_5, %	23.4	23.8	25.1	23.3	-	16.0	-	-	-	-

* = % R.E. | (71-74) Bliskovskii et al. (1969); (71) nodular, Vyatka-Kama, U.S.S.R.; (72) nodular, Shchigrov, U.S.S.R.; (73) Gulibsk, oolitic, U.S.S.R.; (74) bedded, metamorphosed, Viet-Nam; (75) Semenov et al. (1962), nodular, Egor'evskoye, Moscow dist., U.S.S.R.; (76) same as (72); (77-78) Semenov et al. (1962), nodular, U.S.S.R.; (77) Vyatka-Kama; (78) Sumsk dist.; (79) Aleksiev and Arnaudov (1965), Oligocene, Bulgaria; (80) Nigmatova and Orestova (1979), Kara-Tau

Table 2 - Rare Earths in Phosphorites, atomic percent - continued

	81	82	83	84	85	86	87	88	89	90
La	24.6	18.0	17.6	15.2	18.6	22.0	20.3	20.9	20.7	41.8
Ce	42.1	49.4	50.1	51.1	48.2	48.4	46.6	47.7	49.4	27.4
Pr	3.2	5.9	3.7	6.1	5.8	3.2	7.3	6.2	6.1	7.4
Nd	19.2	18.7	18.9	17.1	17.3	18.3	9.9	18.2	18.1	14.5
Sm	2.8	3.2	2.8	3.7	3.3	2.4	5.0	2.9	2.9	2.3
Eu	0.3	0.5	0.4	0.4	0.5	0.5	1.3	0.4	0.2	0.6
Gd	3.6	3.1	3.3	1.8	2.5	2 8	-	2.8	2.0	-
Tb	0.3	0.5	0.3	0.4	0.4	0.2	-	0.1	-	-
Dy	2.1	1.3	1.7	1.8	1.3	1.5	5.5	0.5	0.3	3.6
Ho	0 1	0.2	-	0 4	0 3	-	-	-	-	-
Er	1.0	0.6	0.8	0.8	0.9	0.5	2.3	0.2	0.2	1.2
Tm	0.1	0.1	-	0.2	0.1	-	0.6	-	-	0 3
Yb	0.6	0.4	0.3	0.5	0.7	0.2	1.2	0.1	0.1	0.9
Lu	-	0.1	0.1	0.5	0.1	-	-	-	-	-
Y/(Y+Ln)x100	-	-	-	-	-	-	(23.8)	(3.9)	(2.9)	(22.1)
Method	XF	XF	XF	XF	XF	XF	OS	OS	OS	OS
Σ = La+Ce+Pr	69.9	71.3	71.4	72.4	72.6	73.6	74.2	74.8	76.2	76.6
La-Nd	89.1	90.0	90.3	89.5	89.9	91.9	84.1	93.0	94.3	91.1
Sm-Ho	9.2	8.8	8.5	8.5	8.3	7.4	11.8	6.7	5.4	6.5
Er-Lu	1.7	1.2	1.2	2 0	1.8	0.7	4.1	0.3	0.3	2.4
RE_2O_3	0.025	0.02	0.044	0.15	0.05	0.033	0.054*	0.02	0.01	0.015*
La/Nd	1.28	0.97	0.93	0.89	1.08	1.21	2.04	1.15	1.15	2.82
P_2O_5, %	16.1	-	20.5	-	-	21.2	-	-	-	14.05

* = % R.E. | (81) Bliskovskii et al. (1969), nodular, Polpinsk, U.S.S.R.; (82) Semenov et al. (1962), nodular, Vyatsko-Kama, U.S.S.R.; (83) Bliskovskii et al. (1969), nodular, Egor'evsk, U.S.S.R.; (84-85) Semenov et al. (1962), nodular, U.S.S.R.; (84) Moscow dist.; (85) Egor'evsk; (86) same as (83); (87) Substyk (1978), nodular, Poland; (88-89) Kapustin (1977), staffelite breccia, Kovdor, Karelia; (90) same as (87)

Table 2 - Rare Earths in Phosphorites, atomic percent - continued

	91	92	93	94	95	96	97	98	A	B
La	21.3	34.3	22.3	22.3	34.0	19.4	30.3	17.5	16.1	30.1
Ce	50.3	42.5	51.2	52.2	56.7	72.6	62.4	75.3	32.9	23.3
Pr	6.0	1.5	6.0	6.0	-	-	-	-	7.2	4.7
Nd	19.6	16.2	16.7	16.7	-	-	-	-	23.1	21.4
Sm	1.9	1.4	3.8	2.8	5.0	3.2	3.4	4.6	5.0	4.2
Eu	0.9	-	-	-	1.2	0.3	1.3	0.2	0.7	1.3
Gd	-	1.4	-	-	-	-	-	-	5.4	2.5
Tb	-	-	-	-	0.5	0.5	0.5	0.4	0.7	0.6
Dy	-	1.3	-	-	-	-	-	-	3.4	3.7
Ho	-	-	-	-	-	-	-	-	0.7	0.8
Er	-	0.7	-	-	-	-	-	-	2.0	4.4
Tm	-	-	-	-	0.5	-	0.2	-	0.3	0.2
Yb	-	0.7	-	-	1.7	3.4	1.5	1.7	2.2	2.3
Lu	-	-	-	-	0.4	0.6	0.4	0.3	0.3	0.5
Y/(Y+Ln)x100	-	-	-	-	-	-	-	-	-	(49.3)+
Method	XF	XF	XF	OS	NA	NA	NA	NA	XF	-
Σ = La+Ce+Pr	77.6	78.3	79.5	80.5	90.7	92.0	92.7	92.8	56.2	58.1
La-Nd	97.2	94.5	96.2	97.2	90.7	92.0	92.7	92.8	79.3	79.5
Sm-Ho	2.8	4.1	3.8	2.8	6.7	4.0	5.2	5.2	15.9	13.1
Er-Lu	-	1.4	-	-	2.6	4.0	2.1	2.0	4.8	7.4
RE_2O_3, %	0.06	-	0.03	0.01	0.0042	0.0007	0.0037	0.0012	0.08	0.80*
La/Nd	1.08	2.12	1.34	1.34	-	-	-	-	0.70	1.41
P_2O_5, %	-	15.1	-	-	11.1-19.4, av. 16.2	28.5-31.4 av. 30.1	16.9-28.4, av 22.3	19.0-33.7, av. 27.8	-	-

* = % R.E.; (a) Semenov, Kholodnov, and Barinskii (1962), av. all phosphorites; (b) Altschuler (1980), av. sedimentary marine apatite; + = perhaps too high (Altschuler, 1980)

(91) Kapustin (1977), staffelite breccia, Vuorijarvi, Karelia; (92) Bliskovskii et al. (1969), Rasvumchorr, Khibina massif, Kola Peninsula, U.S.S.R.; (93-94) Kapustin (1977), staffelite breccia, U.S.S.R.; (93) Kovdor, Karelia; (94) Lower Sayan; (95-98) Tambiev et al. (1979); (95) av. of 3 concretions, shelf off coast of Peru; (96) av. of 6 coprolites, shelf off coast, S.W. Africa; (97) av. of 3 concretions, shelf off coast of Chile; (98) av. of 11 concretions, shelf off coast of S.W. Africa

Table 3 - Rare Earths in the Britholite-Britholite-(Y) Series, atomic percent

	1	2	3	4	5	6	7	8	9	10
La	–	0.7	0.8	2.	2.7	8.1	5.7	7.1	21.4	6.9
Ce	–	3.3	3.7	7.	10.4	18.8	21.0	21.5	5.3	23.2
Pr	–	0.3	0.3	1.	2.4	3.3	4.2	4.8	3.2	5.0
Nd	–	2.2	2.4	12.	11.7	13.6	13.9	12.8	26.1	18.4
Sm	–	0.5	0.6	8.	7.6	7.3	7.6	7.0	7.3	9.7
Eu	–	0.3	0.3	–	–	0.3	0.6	0.7	–	2.8
Gd	21.1	2.0	2.2	13.	13.7	9.1	9.0	12.0	8.9	11.7
Tb	–	0.1	0.1	3.	3.2	1.5	1.7	1.7	1.1	1.9
Dy	20.4	6.9	7.9	24.	17.7	15.0	14.3	13.0	8.1	8.6
Ho	–	5.3	6.0	1.	2.0	1.9	3.1	2.5	1.8	1.7
Er	29.7	14.5	16.6	14.	14.9	8.8	10.3	9.5	5.7	4.3
Tm	-	5.6	6.5	3.	1.1	1.9	1.4	1.3	0.6	0.8
Yb	28.8	44.5	51.1	12.	11.3	8.6	6.2	5.2	4.6	4.7
Lu	–	13.8	1.5	–	1.3	1.8	1.0	0.9	0.9	0.3
Y/(Y+Ln)x100	(98.5)	(76.4)	(76.9)	–	–	(43.8)	–	–	–	(34.6)
Method	XF	EP	EP	–	EP	XF	XF	XF	XF	XF
Σ = La+Ce+Pr	0	4.3	4.8	10.	15.5	30.2	30.9	33.4	34.9	35.1
La-Nd	0	6.5	7.2	22.	27.2	43.8	44.8	46.2	61.0	53.5
Sm-Ho	41.5	15.1	17.1	49.	44.2	35.1	36.3	36.9	27.2	36.4
Er-Lu	58.5	78.4	75.7	29.	28.6	21.1	18.9	16.9	11.8	10.1
RE_2O_3	–	–	–	–	38.9*	54.4	–	–	47.5	58.96
La/Nd	-	0.31	0.48	0.17	0.23	0.60	0.41	0.55	0.82	0.37

* = % R.E. | (1) Vorma et al. (1966), granite pegmatite, Pyronmaa, Kangasala, Finland; (2) Griffin et al. (1979), granite pegmatite, Reiaisdal, Norway; (3) Vasil'eva (1978), "lessingite", quartz-feldspar vein, metamorphic rock, Mochalin Log. Urals, U.S.S.R.; (4) Nagashima et al. (1971), granite pegmatite, Fukushima Pref., Japan (as read from graph); (5) Siivola (1975), pegmatite, Kangasala, Finland; (6) Pletneva et al. (1962), pegmatite, eastern Baltic Shield, U.S.S.R.; (7-8) Kalita (1969), pegmatites, eastern Baltic Shield, U.S.S.R.; (9) Demchenko et al. (1965), metasomatite of subalkalic granite, Far Eastern S.S.R.; (10) Nekrasova and Nekrasov (1980), pegmatites and metasomatites, Tommotski gabbroid massif

Table 3 - Rare Earths in the Britholite-Britholite-(Y) Series, atomic percent - continued

	11	12	13	14	15	16	17	18	19	20
La	8.1	10.5	9.1	6.6	9.5	10.4	8.7	21.4	13.1	25.5
Ce	24.0	22.4	24.6	27.0	25.7	28.1	32.5	18.2	32.6	18.7
Pr	3.6	3.2	4.9	5.2	4.9	4.5	3.7	7.7	5.4	8.3
Nd	17.3	17.1	15.3	16.6	17.0	17.1	14.8	24.6	17.9	13.4
Sm	8.5	8.3	7.2	7.7	5.2	5.1	31.8	6.4	6.7	6.3
Eu	–	–	1.9	1.8	a	–	0.2	–	1.9	a
Gd	10.1	8.8	10.5	8.2	8.0[a]	7.8	2.6	7.9	6.9	10.1[a]
Tb	1.5	1.6	2.1	1.8	b	1.7	0.3	0.9	1.2	5.5
Dy	13.3	12.0	10.9	10.5	14.8	9.9	2.6	3.5	5.6	2.4
Ho	1.3	3.0	2.1	2.0	3.2	3.9	0.3	1.4	1.3	2.3
Er	5.6	7.5	5.0	5.6	7.1	6.8	1.3	4.5	2.9	3.4
Tm	1.2	1.2	0.9	0.9	0.7	1.2	0.2	0.3	0.6	2.3
Yb	5.5	3.5	4.3	4.9	3.6	3.2	0.9	2.7	3.1	0.7
Lu	–	0.9	1.2	1.2	0.3	0.3	0.1	0.5	0.8	1.1
Y/(Y+Ln)x100	(20.4)	(65.8)	(31.8)	(34.6)	(56.6)[b]	(59.8)	(14.8)	(65.3)	(25.2)	(29.1)
Method	XF	–	XF	XF	CH	XF	–	XF	XF	CH
Σ = La+Ce+Pr	35.7	36.1	38.6	38.8	40.1	43.0	44.9	47.3	51.1	52.5
La-Nd	53.0	53.2	53.9	55.4	57.1	60.1	59.7	71.9	69.0	65.9
Sm-Ho	34.7	32.1	34.7	32.0	31.2	28.4	37.8	20.1	23.6	26.6
Er-Lu	12.3	14.7	11.4	12.6	11.7	11.5	2.5	8.0	7.4	7.5
RE_2O_3	43.8	38.9	51.37	54.74	56.85	–	48.6	49.7	56.68	52.5
La/Nd	0.47	0.63	0.60	0.40	0.56	0.61	0.59	0.87	0.73	1.90

(a) Eu+Gd calcd. as Gd
(b) Tb+Y calcd. as Y

(11) Pletnova et al. (1962), alteration product of no. 6; (12) Kostin and Volzhenkova (1965), albite-quartz veins in granite, U.S.S.R.; (13-14) Nekrasova and Nekrasov (1980), pegmatites and metasomatites, Tommotski grabbroid massif; (15) Vasil'eva (1978), granite pegmatite, N.W. U.S.S.R.; (16) Lunts (1972), av. of 2, pegmatite of alkalic granite N.W. U.S.S.R.; (17) Batieva (1976), alkalic granite, Kola Peninsula, U.S.S.R.; (18) Demchenko et al. (1965), metasomatite of alkalic granite, Far Eastern U.S.S.R.; (19) same as (13); (20) Leventov (1964), aegirine-microcline metasomatite, U.S.S.R.

Table 3 - Rare Earths in the Britholite-Britholite-(Y) Series, atomic percent - continued

	21	22	23	24	25	26	27	28	29	30
La	14.2	12.5	11.1	16.6	12.0	15.5	23.2	17.7	25.6	20.5
Ce	34.2	35.5	37.5	40.9	45.7	40.9	37.0	44.7	39.7	42.9
Pr	5.0	7.2	7.2	3.8	5.0	7.3	7.2	5.9	4.1	6.0
Nd	17.4	18.7	22.8	18.6	21.6	20.0	15.2	24.4	12.8	15.7
Sm	5.5	7.8	6.3	8.1	4.4	4.9	3.1	-	2.8	3.5
Eu	1.8	0.5	0.6	0.1	0.2	0.6	-	2.6	-	-
Gd	7.0	7.2	5.7	4.0	3.5	1.9	2.0	-	2.6	2.9
Tb	1.1	0.7	0.9	0.8	0.6	0.3	0.6	0.3	-	-
Dy	5.5	5.0	4.6	3.1	3.3	1.8	3.7	-	3.5	-
Ho	1.4	0.6	0.6	0.7	0.5	0.3	1.1	-	1.0	1.7
Er	2.5	1.7	1.5	1.7	1.4	0.5	3.4	-	2.8	2.2
Tm	0.5	0.2	0.3	0.2	0.4	-	0.4	-	-	-
Yb	3.2	2.2	0.8	1.3	1.2	5.1	2.6	-	5.1	2.9
Lu	0.7	0.2	0.1	0.1	0.2	0.1	0.5	-	-	1.7
Y/(Y+Ln)x100	(26.1)	(33.2)	(27.2)	(16.9)	(19.1)	(27.1)	(39.6)	(1.8)	(25.0)	(13.6)
Method	XF	XF	CH	OS	-	XF	XF	XF	XF	CH
Σ = La+Ce+Pr	53.4	55.2	55.8	61.3	62.7	63.7	67.4	68.3	69.4	69.4
La-Nd	70.8	73.9	78.6	79.9	84.3	83.7	82.6	92.7	82.2	85.1
Sm-Ho	22.3	21.8	18.7	16.8	12.5	9.8	10.5	7.3	9.9	8.1
Er-Lu	6.9	4.3	2.7	3.3	3.2	6.5	6.9	-	7.9	6.8
RE_2O_3	56.91	61.8	61.8	36.7	48.57	-	56.9	33.4	-	60.45
La/Nd	0.81	0.67	0.49	0.89	0.55	0.77	1.52	0.72	2.00	1.31

(21) Nekrasova and Nekrasov (1980), pegmatites and metasomatites, Tommotski grabboid massif; (22) Proshchenko (1967), albitite, E. Siberia; (23) Vasil'eva (1978), feldspar vein, exocontact zone of gabbro-syenite, E. Siberia; (24) Lindberg and Ingram (1963), britholite-apatite (SiO_2 12.9, P_2O_5 17.3%), Adirondack Mts., N.Y.; (25) Bel'kov (1979), pegmatite in alkali syenite, Sakhariok massif, Kola Peninsula; (26) Semenov (1963), carbonatite, Oka, Quebec; (27) Demchenko et al. (1965), metasomatite of alkalic granite, Far Eastern U.S.S.R.; (28) Hughson and Sen Gupta (1964), carbonatite, Oka, Quebec; (29) Pavlenko et al. (1959), vein in alkalic pegmatite, Dugdin massif, E. Tuva; (30) Vasil'eva (1978), metasomatic, in alkalic rocks, Siberia

Table 3 - Rare Earths in the Britholite-Britholite-(Y) Series, atomic percent - continued

	31	32	33	34	35	36	37	38	39	40
La	26.0	29.4	27.1	21.6	13.2	28.0	24.7	22.7	21.2	21.0
Ce	40.1	35.9	39.0	44.2	49.5	35.1	42.1	44.2	47.2	46.1
Pr	4.1	5.1	4.6	5.3	8.4	8.3	4.8	4.8	3.6	5.0
Nd	12.6	18.7	11.7	15.3	23.6	12.0	14.2	12.7	10.3	19.3
Sm	2.6	4.3	2.3	2.4	2.6	5.8	3.3	3.5	1.7	3.1
Eu	-	-	-	0.3	0.4	-	-	-	0.1	-
Gd	2.3	3.2	3.2	2.7	1.5	4.5	3.1	2.5	2.8	2.3
Tb	-	-	-	0.4	0.1	2.9	[b]	-	0.4	-
Dy	3.0	3.4	3.8	2.9	0.4	[c]	3.3	2.8	3.4	1.5
Ho	0.8	-	1.1	0.7	-	[c]	1.3	1.2	0.2	-
Er	2.8	-	3.3	2.2	0.3	3.4	-	1.4	2.5	1.0
Tm	0.6	-	-	0.3	-	-	3.2	1.0	0.3	-
Yb	4.2	-	3.3	1.4	-	-	-	1.4	6.3	0.7
Lu	0.9	-	0.6	0.3	-	-	-	1.8	-	-
Y/(Y+Ln)x100	(34.7)	(21.3)	(32.0)	(22.9)	-	(8.9)[c]	(9.4)[b]	(17.2)	(27.2)	(5.5)
Method	XF	XF	XF	XF	XF	CH	CH	CH	-	-
Σ = La+Ce+Pr	70.2	70.4	70.7	71.1	71.1	71.4	71.6	71.7	72.0	72.1
La-Nd	82.8	89.1	82.4	86.4	94.7	83.4	85.8	84.4	82.3	91.4
Sm-Ho	8.7	10.9	10.4	9.4	5.0	13.2	11.0	10.0	8.6	6.9
Er-Lu	8.5	-	7.2	4.2	0.3	3.4	3.2	5.6	9.1	1.7
RE_2O_3	-	-	-	56.7	-	-	50.9	58.0	-	56.2
La/Nd	2.06	1.57	2.32	1.41	0.56	2.34	1.74	1.77	2.06	1.09

(b) Tb+Y calcd. as Y
(c) Dy+Ho+Y calcd. as Y

(31) Kudrina et al. (1961), "alumobritholite", pegmatite of alkalic granite, Siberia; (32) Kupriyanova, quoted by Aleksandrova et al. (1966), Siberia; (33) Semenov (1963), nepheline syenite, Kola Peninsula, U.S.S.R.; (34) Korkin et al. (1960), alkalic rock, S.E. Tuva; (35) Semenov (1963), "fynchenite", nepheline syenite, Dunbei, China; (36) Kudrina quoted by Aleksandrova et al. (1966), Siberia; (37) Vasil'eva (1978), nepheline syenite pegmatite, Tuva; (38) Vasil'eva (1978), metasomatite of alkalic rock, Siberia; (39) Bel'kov quoted by Aleksandrova et al. (1966), N.W. U.S.S.R.; (40) Valter and Eremenko (1964), nepheline syenite, Azov region, U.S.S.R.

Table 3 - Rare Earths in the Britholite-Britholite-(Y) Series, atomic percent - continued

	41	42	43	44	45	46	47	48	49	50
La	23.3	23.1	20.2	24.0	28.2	21.0	28.3	30.1	27.6	26.8
Ce	43 2	43.7	48.1	44.6	41.0	48.5	42 9	41.3	43.7	44.7
Pr	5 9	5.8	5.3	5.4	5.1	5.4	4.8	4.8	5.2	5.7
Nd	20.5	20.3	17.1	19.1	25.3	14.6	12.1	12.4	16.8	13.6
Sm	3 6	3.5	2.3	3.1	0.3	2.6	3.0	2.9	2.5	2.2
Eu	-	-	0.5	-	-	-	-	1.0	0.4	-
Gd	2 1	2.1	2.4	2.0	0.1	6.2	2 8	4.7	1.7	2.1
Tb	-	-	0.3	-	-	-	-	-	0.3	0.4
Dy	1.0	1.1	1.6	1.4	-	1.7	-	0.5	1.0	1.9
Ho	-	-	0.2	-	-	-	1.8	1.6	0.1	0.4
Er	0 4	0.4	0.8	0.4	-	-	-	0.4	0.3	1.4
Tm	-	-	0.2	-	-	-	2.4	-	0.1	-
Yb	-	-	0.8	-	-	-	-	0.3	0.2	0.8
Lu	-	-	0.2	-	-	-	1.9	-	0.1	-
Y/(Y+Ln)x100	(5.8)	-	-	(10.0)	-	(12.5)	(15.2)	(1.1)	(6.9)	(20.6)
Method	XF	XF	-	XF	-	EP	CH	EP	XF	XF
Σ = La+Ce+Pr	72.4	72.6	73.6	74.0	74.3	74.9	76 0	76.2	76 5	77.2
La-Nd	92.9	92.9	90.7	93.1	99.6	89.5	88.1	88.6	93.3	90.8
Sm-Ho	6.7	6.7	7 3	6.9	0.4	10 5	7.6	10.7	6.0	7.0
Er-Lu	0.4	0.4	2 0	-	-	-	4.3	0.7	0.7	2.2
RE_2O_3	-	-	-	-	-	47.4	57.85	60.5	-	-
La/Nd	1.14	1.14	1.18	1.26	1.12	1.44	2.35	2 43	1.65	1.97

(41) Semenov (1963), albitized nepheline syenite, Ukraine; (42) Kudrina et al. (1961), "beckelite", alkalic rock, Mariupol, Ukraine; (43) Khomyakov (1972), aegirine-albite metasomatite, Burpala massif, N. Baikal; (44) Kupriyanova et al. (1962), britholite-melanocerite, metasomatic albite veins; (45) Es'kova and Ganzeev (1964), fenitized granite pegmatite, Vishnevye Mts., Urals; (46) Kieft and Burke (1970), Madagascar; (47) Vasil'eva (1978), metasomatic rock, alkalic massif, Siberia; (48) Nash (1972), alkalic rock, Shonkin Sag, Mont.; (49) Portnov et al. (1967), syenite, Burpala massif, N. Baikal; (50) Kupriyanova, quoted by Aleskandrova et al. (1966), Siberia

Table 3 - Rare Earths in the Britholite-Britholite-(Y) Series, atomic percent - continued

	51	52	53	54	55	56	57	58	59	60
La	25.6	21.5	23.2	27.6	25.5	27.4	41.9	34.7	28.0	31.7
Ce	49.7	49.8	50.9	52.1	54.3	48.2	25.3	43.4	48.5	46.6
Pr	4.0	7.1	5.2	–	–	5.2	4.5	3.8	5.6	3.9
Nd	13.8	13.8	20.1	18.7	9.1	14.5	18.6	10.8	15.0	11.8
Sm	4.8	2.7	0.6	1.5	0.5	2.4	3.6	2.6	1.1	1.6
Eu	a	–	–	–	–	–	–	–	0.2	0.4
Gd	2.4[a]	1.3	–	0.1	9.4	2.3	3.4	1.7	0.8	2.5
Tb	–	0.1	–	–	–	–	–	–	0.2	–
Dy	1.7	1.2	–	–	1.2	–	2.7	1.4	0.3	0.5
Ho	–	0.4	–	–	–	–	–	–	0.1	0.3
Er	–	1.2	–	–	–	–	–	1.1	0.1	0.4
Tm	–	–	–	–	–	–	–	–	–	0.1
Yb	–	0.9	–	–	–	–	–	0.5	0.1	0.2
Lu	–	–	–	–	–	–	–	–	–	–
Y/(Y+Ln)x100	(4.9)	(9.4)	–	(7.4)	–	(1.7)	(10.7)	(20.7)	–	(10.7)
Method	CH	XF	XF	OS	XF	CH	XF	XF	–	–
Σ = La+Ce+Pr	77.3	78.4	79.3	79.7	79.8	80.8	81.7	81.9	82.1	82.2
La-Nd	91.1	92.2	99.4	98.4	88.9	95.3	90.3	92.7	97.1	94.0
Sm-Ho	8.9	5.7	0.6	1.6	11.1	4.7	9.7	5.7	2.7	5.3
Er-Lu	–	2.1	–	–	–	–	–	1.6	0.2	0.7
RE_2O_3	–	–	33.1	18.4	57.5	44.3	–	–	59.4	45.3
La/Nd	1.86	1.55	1.15	1.47	2.81	1.90	2.26	3.22	1.87	2.68

(a) Eu+Gd calcd. as Gd

(51) Kudrina et al. (1965), pegmatite cutting nepheline syenite, Burpala massif, N. Baikal, (52) Kupriyanova, quoted by Aleksandrova et al. (1966), Siberia; (53) Peng and Liu (1962), "fenghuangite", urtite, Fenghuang, China; (54) Nurlybaev (1962), "pravdite", nepheline syenite pegmatite, Ishim complex, U.S.S.R.; (55) Nurlybaev (1976), pegmatite, Esil'sk massif, Kazakhstan; (56) Vasil'eva (1978) metasomatite of syenite and granosyenite; (57-58) Kupriyanova, quoted by Aleksandrova et al. (1966), Siberia; (59) Es'kova and Ganzeev (1964), fenite, Vishnevye Mts., Urals; (60) Glushchenko and Li (1966), syenite pegmatite, N. Baikal

Table 3 - Rare Earths in the Britholite-Britholite-(Y) Series, atomic percent - continued

	61	62	63	64	65	66	67	68	69	70
La	29.6	31.0	32.6	29.2	31.8	32.0	29.9	27.8	29.6	29.0
Ce	49.9	51.2	48.2	52.7	48.8	49.5	55.2	52.9	51.8	51.1
Pr	4.3	2.0	3.6	2.7	4.1	5.6	-	5.0	4.5	5.9
Nd	12.2	15.0	10.5	12.0	8.1	13.7	14.9	11.5	12.1	13.1
Sm	1.4	-	1.6	1.8	0.6	0.6	-	1.9	1.0	0.4
Eu	-	-	0.3	0.1	0.1	-	-	-	-	-
Gd	1.6	0.4	1.6	1.0	-	0.4	-	0.5	0.6	0.4
Tb	b	-	-	-	0.1	b	-	-	0.4	0.1
Dy	0.7	0.4	0.7	0.3	2.8	0.2	-	0.4	-	-
Ho	0.1	-	0.2	0.1	-	-	-	-	-	-
Er	0.2	-	0.3	0.1	-	-	-	-	-	-
Tm	-	-	0.1	-	-	-	-	-	-	-
Yb	-	-	0.3	-	3.6	-	-	-	-	-
Lu	-	-	-	-	-	-	-	-	-	-
Y/(Y+Ln)x100	(2.4)[b]	(0.3)	(9.8)	(2.7)	(2.6)	(6.1)[b]	-	-	-	-
Method	CH	-	XF	-	XF	CH	XF	CH	-	XF
Σ = La+Ce+Pr	83.8	84.2	84.4	84.6	84.7	85.1	85.1	85.7	85.9	86.0
La-Nd	95.9	99.2	94.9	96.6	92.8	98.8	100.0	97.2	98.0	99.1
Sm-Ho	3.8	0.8	4.4	3.3	3.6	1.2	-	2.8	2.0	0.9
Er-Lu	0.2	-	0.7	0.1	3.6	-	-	-	-	-
RE_2O_3	61.6	50.0	45.0	-	34.7	49.1	-	-	63.3	-
La/Nd	2.43	2.06	3.10	2.42	3.94	2.33	2.01	2.42	2.45	2.21

(b) Tb+Y calcd. as Y

(61) Borutskii et al. (1975), albitized nepheline syenite, Khibina massif, Kola Peninsula; (62) Nurlybaev (1976), pseudo-leucite syenite, Esil'sk massif, Kazakhstan; (63) Portnov et al. (1967), syenite, Burpala massif, N. Baikal; (64) Ganzeeva (1972), alkali metasomatite; (65) Nurlybaev (1976), pegmatite, Esil'sk massif, Kazakhstan; (66) Vasil'eva (1978), alkalic rock, N. Baikal; (67) Pavlenko et al. (1959), fluorite vein in vesuvianite skarn, Dugdin massif, Tuva; (68) Kudrina et al. (1961), nepheline syenite pegmatite, Siberia; (69) Tikhonenkova and Skosyreva (1967), fenite, Khibina massif, Kola Peninsula; (70) Semenov and Barinskii (1958), alkali syenite pegmatite, Kodzha-Ashkan River, Turkestan Range

Table 3 - Rare Earths in the Britholite-Britholite-(Y) Series. atomic percent - continued

	71	72	73	74	75	76	77	78	79	80
La	32.1	37.2	28.6	32.4	28.2	30.7	32.5	35.2	33.0	35.3
Ce	56.3	47.0	54.1	54.4	55.9	52.8	50.4	49.0	50.1	49.0
Pr	4.1	2.4	3.9	-	2.8	3.5	4.1	3.3	4.1	3.3
Nd	11.7	10.8	11.4	11.5	9.6	9.5	11.4	9.1	10.9	9.1
Sm	1.8	1.0	1.3	0.7	-	1.2	1.6	1.6	1.4	1.6
Eu	-	0.1	-	0.4	-	0.8	-	-	-	-
Gd	-	0.2	0.7	0.3	-	0.5	-	0.8	-	0.8
Tb	-	-	c	-	-	0.1	-	-	-	-
Dy	-	1.1	c	0.1	-	0.5	-	1.0	0.4	0.9
Ho	-	-	-	-	-	0.1	-	-	-	-
Er	-	-	-	-	-	0.3	-	-	-	-
Tm	-	0.2	-	0.2	-	-	-	-	-	-
Yb	-	-	-	-	-	-	-	-	0.1	-
Lu	-	-	-	-	3.5	-	-	-	-	-
Y/(Y+Ln)x100	-	(0.5)	(0.4)[c]	(0.4)	(22.2)	-	-	(9.5)	(0.3)	(10.2)
Method	XF	-	CH	-	XF	XF	CH	XF	XF	XF
Σ = La+Ce+Pr	86.5	86.6	86.6	86.8	86.9	87.0	87.0	87.5	87.2	87.6
La-Nd	98.2	97.4	98.0	98.3	96.5	96.5	98.4	96.6	98.1	96.7
Sm-Ho	1.8	2.4	2.0	1.5	-	3.2	1.6	3.4	1.8	3.3
Er-Lu	-	0.2	-	0.2	3.5	0.3	-	-	0.1	-
RE_2O_3	-	52.3	32.9	49.0	57.0	-	-	-	51.7	55.3
La/Nd	2.74	3.43	2.51	2.83	2.94	3.23	2.84	3.86	3.02	3.89

(c) Tb+Dy+Y calcd. as Y

(71) Pavlenko et al. (1959), metasomatic aegirine albitite, Dugdin massif, Tuva; (72) Tarkhanova et al. (1964), alkalic rock, Ishim complex, Urals; (73-74) Nurlybaev (1976), pegmatites, Esil'sk alkalic massif, Kazakhstan; (75) Nechaeva and Borneman-Starynkevich (1956), skarn, W. Transbaikal; (76) Zhabin and Svyazhin (1962), alkalic rock, Vishnevye Mts., Urals; (77) Kudrina, quoted by Aleksandrova (1966), Siberia; (78) Kupriyanova, quoted by Aleksandrova (1966), Siberia; (79) Nurlybaev (1976), nepheline syenite, Esil'sk massif, Kazakhstan; (80) Andreev et al. (1969), recrystallized syenite, Siberia

Table 3 - Rare Earths in the Britholite-Britholite-(Y) Series, atomic percent - continued

	81	82	83	84	85	86	87	88	89
La	37.6	33.0	28.3	33.6	36.2	31.7	27.8	42.6	41.8
Ce	47.6	51.4	55.0	51.8	49.2	53.7	58.7	45.1	46.9
Pr	2.4	3.5	4.7	3.2	3.6	4.3	3.4	3.3	2.8
Nd	10.4	9.2	11.3	8.4	7.1	9.9	8.7	8.3	6.9
Sm	0.8	0.6	0.4	2.1	0.5	0.2	0.7	0.4	0.9
Eu	-	0.2	0.2	-	0.1	-	0.6	a	-
Gd	0.1	0.6	-	0.9	-	0.1	-	0.2[a]	0.7
Tb	-	0.1	c	c	0.1	-	c	0.1	-
Dy	1.1	0.5	c	c	0.6	0.1	c	-	-
Ho	-	0.1	-	-	-	-	-	-	-
Er	-	0.3	0.1	-	-	-	0.1	-	-
Tm	-	0.1	-	-	-	-	-	-	-
Yb	-	0.3	-	-	2.6	-	-	-	-
Lu	-	0.1	-	-	-	-	-	-	-
Y/(Y+Ln)x100	(0.3)	-	(0.6)[c]	(0.6)[c]	(1.3)	-	(0.6)[c]	-	(11)
Method	-	-	CH	CH	XF	-	CH	CH	CH
Σ = La+Ce+Pr	87.6	87.9	88.0	88.6	89.0	89.7	89.9	91.0	91.5
La-Nd	98.0	97.1	99.3	97.0	96.1	99.6	98.6	99.3	98.4
Sm-Ho	2.0	2.1	0.6	3.0	1.3	0.4	1.3	0.7	1.6
Er-Lu	-	0.8	0.1	-	2.6	-	0.1	-	-
RE_2O_3	51.2	-	47.7	32.2	55.6	50.4	34.1	62.6	62.55
La/Nd	3.61	3.58	2.51	3.99	5.10	3.20	3.22	5.13	6.05

(a) Eu+Gd calcd. as Gd
(c) Tb+Dy+Y calcd. as Y

(81) Nurlybaev (1976), pegmatite, Esil'sk massif, Kazakhstan; (82) Khomyakov (1972), aegirinized syenite pegmatite, Burpala massif, N. Baikal; (83-87) same as (81); no. 86 is nearly identical with Kravchenko and Ifantopoulo (1969), from nepheline-feldspar pegmatite, Ishim complex; (88) Svyazhin (1965), "lessingite", gravels, Urals, (89) Vasil'eva (1978), "lessingite", quartz-feldspar vein in metamorphic rock, Mochalin Log, Urals

Table 4 - Lanthanides in Other Members of the Apatite Group (1-3) Belovite, (4) Pyromorphite; (5-10) Tritomite-(Y)("Spencite")

	1	2	3	4	5	6	7	8	9	10
La	26.3	25.3	22.8	10.6	4.0	4.9	5.0	7.3	9.4	5.6
Ce	43.5	48.7	51.0	15.8	13.7	15.8	19.2	27.0	24.9	30.5
Pr	8.7	4.5	7.7	2.8	3.8	3.5	4.7	3.0	3.1	4.6
Nd	21.5	19.5	18.7	17.3	15.3	11.9	18.0	9.5	12.2	21.8
Sm	-	2.0	0.5	10.4	7.1	6.7	6.0	5.4	6.0	5.9
Eu	-	-	-	-	1.3	0.9	0.9	0.8	1.3	1.1
Gd	-	-	-	10.6	9.0	9.7	8.8	8.5	11.3	9.0
Tb	-	-	-	-	1.9	2.0	1.5	1.6	1.8	1.2,
Dy	-	-	-	12.5	12.4	11.2	11.3	10.0	9.8	7.8
Ho	-	-	-	4.9	3.4	2.9	2.9	3.0	2.5	1.5
Er	-	-	-	9.7	11.2	11.4	9.3	10.2	7.8	5.1
Tm	-	-	-	0.7	3.0	1.7	2.4	1.4	0.8	0.7
Yb	-	-	-	4.1	12.3	16.0	9.0	11.1	8.2	4.5
Lu	-	-	-	0.6	1.6	1.4	1.0	1.2	0.9	0.7
Y/(Y+Ln)x100	-	-	-	(42.3)	(53.1)	(63.2)	(68.4)	(55.2)	(41.5)	(38.2)
Method	XF	XF	XF	XF	XF	OS	XF	OS	OS	XF
Σ = La+Ce+Pr	78.5	78.5	81.5	29.2	21.5	24.2	28.9	37.3	37.4	40.7
La-Nd	100.0	98.0	99.5	46.5	36.8	36.1	46.9	46.8	49.6	62.5
Sm-Ho	-	2.0	0.5	38.4	35.1	33.4	31.4	29.3	32.7	26.5
Er-Lu	-	-	-	15.1	28.1	30.5	21.7	23.9	17.7	11.0
RE_2O_3	24.0	-	-	1.00	36.84	33.4	33.72	-	27.10	35.11
La/Nd	1.22	1.30	1.27		0.26	0.41	0.28	0.76	0.77	0.26

(1) Borodin and Kazakova (1954), nepheline syenite pegmatite, Pankaruaiv Mt., Kola Peninsula, U.S.S.R.; (2) Balashov and Turanskaya (1960), alkalic pegmatite, Kola Peninsula; (3) Semenov and Barinskii (1958), alkali syenite pegmatite, Kola Peninsula; (4) Semenov et al. (1967), quartz-fluorite pegmatite, Karkarlinsk, Kazakhstan; (5) Hogarth et al. (1973), fluorite vein, Cardiff Township, Ont.; (6) Joensuu and Ingamells (1966), granite pegmatite, Haliburton Co., Ont.; (7) same as (5); (8-9) Kapustin (1975), cancrinite syenite, Kadyrosskii massif, Tuva; (10) Hogarth et al. (1973), granite pegmatite, Faraday mine, Ont.

Table 4 - Lanthanides in Other Members of the Apatite Group (10-13) Tritomite-Y ("Spencite"); (14-15) secondary aggregates after Spencite; (16-) Tritomite

	11	12	13	14	15	16	17			
La	18.4	21.9	20.9	17.3	23.7	20.7	30.4			
Ce	41.1	43.4	46.3	44.3	48.3	50.2	53.1			
Pr	3.0	4.1	3 9	4.3	3 7	3.8	3.0			
Nd	10.7	15.9	15.3	13.9	10.9	16.1	11.7			
Sm	3.0	2.2	2.2	2.7	2.3	1.9	0.7			
Eu	0.8	0.5	0.4	-	-	0.3	0.1			
Gd	8.0	3.7	3.2	7.7	4.7	2.7	0.4			
Tb	1.5	0.2	0.3	-	-	0.2	-			
Dy	4.1	2.6	3.1	3 8	3.5	2.2	0.5			
Ho	0.9	0.4	0.6	-	-	0.2	-			
Er	3.1	1.5	.9	2.4	1.1	1.0	0 1			
Tm	0.3	0.1	0.2	-	-	0.1	-			
Yb	4.7	3.3	1.5	3.6	1.8	0.5	-			
Lu	0.4	0.2	0.2	-	-	0.1	-			
Y/(Y+Ln)x100	(41.4)	(31.9)	(32.4)	(36.8)	(24.3)	(32.8)	(24.2)			
Method	OS	OS	XF	OS	OS	XF	XF			
Σ = La+Ce+Pr	62.5	69.4	71.1	65.9	75.7	74.7	86.5			
La-Nd	73.2	85.3	86.4	79.8	86 6	90.8	98.2			
Sm-Ho	18.3	9.6	9.8	14.2	10.5	7.5	1.7			
Er-Lu	8.5	5.1	3.8	6.0	2 9	1.7	0.1			
RE_2O_3	30.70	35.00	50 68	-	-	44.13	41.45			
La/Nd	1.75	1.38	1.37	1.24	2.18	1.28	2.59			

(11-12) Kapustin (1975), nepheline syenite pegmatite, Dugdu massif, Tuva; (13) Hogarth et al. (1973), fluorite vein, Cardiff Township, Ont.; (14-15) Kapustin (1975), secondary aggregate after tritomite-(Y); (14) Kadyrosskii massif, Tuva; (15) Dugda massif, Tuva; (16-17) Hogarth et al. (1973), (16) same as (13); (17) tritomite, Langesundfjord, Norway

Table 5. Rare earths in apatites, atomic percent
Averages for rock types, in order of increasing values of Σ (except for no. 14)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Type of Rock	Granite Pegmatite	Granite	Apatite Phosphor- (a)	Granodior- ites,etc.	Gabbro	Kimber- lite	Syenite (b)	Carbonatite	Alkalic Ultra- mafic	Fe ores	Ultra- mafic	Alkalic	Alkalic Pegma- tite	Gneisses and Migmatites
No. of Analyses	55	100	13	50	30	15	10	111	15	110	27	131	28	52
La	9.3	12.5	30.1	16.2	14.5	17.7	20.5	22.4	21.4	21.6	24.5	27.0	28.6	10.3
Ce	25.1	31.7	23.3	38.8	38.5	45.9	42.5	45.1	46.6	47.9	47.1	47.1	47.4	29.0
Pr	4.7	5.4	4.7	5.7	8.0	5.0	5.9	5.5	5.3	4.8	4.9	4.7	5.0	5.8
Nd	19.3	22.5	21.4	19.7	21.6	21.9	20.8	18.7	20.2	17.9	17.4	16.2	15.1	26.1
Sm	10.3	6.6	4.2	5.4	5.9	4.0	3.8	3.6	3.2	2.5	2.4	2.0	2.1	7.4
Eu	0.2	0.6	1.3	0.4	0.5	0.5	0.6	0.7	0.1	0.4	0.3	0.2	0.3	0.9
Gd	11.9	7.5	2.6	5.5	5.2	3.0	2.9	2.5	2.1	2.1	2.1	1.7	0.9	8.0
Tb	1.3	1.0	0.6	0.2	0.4	0.2	0.1	0.2	0.1	0.2	0.2	0.2	-	0.5
Dy	9.3	5.3	3.7	3.5	3.4	1.1	1.4	0.8	0.8	1.1	0.6	0.6	0.4	4.7
Ho	1.8	1.1	0.8	0.8	0.3	-	0.3	0.1	-	0.2	0.1	0.1	0.1	1.1
Er	3.2	2.8	4.4	1.7	0.9	0.5	0.7	0.3	0.1	0.7	0.2	0.1	0.1	3.0
Tm	0.6	0.4	0.2	0.4	0.1	-	0.1	-	-	-		-	-	0.5
Yb	2.6	2.3	2.3	1.5	0.5	0.2	0.4	0.1	0.1	0.5	0.2	0.1	-	2.4
Lu	0.4	0.3	0.4	0.2	0.2	-	-	-	-	-	-	-	-	0.3
100Y/(Y+Ln)	(37.7)	(29.9)	(49.3)*	(17.8)	(20.6)	(5.8)	(13.6)	(6.3)	(6.1)	(6.5)	(8.8)	(6.4)	(3.2)	(27.7)
No. Analyses for Y	50	80		41	14	13	6	70	12	47	23	74	18	37
Σ = La+Ce+Pr	39.1	49.6	58.1	60.7	61.0	68.6	68.9	73.0	73.3	73.4	76.5	78.8	81.0	45.1
La-Nd	58.4	72.1	79.5	80.4	82.8	90.5	89.7	91.7	93.5	92.2	93.9	95.0	96.1	71.2
Sm-Ho	34.8	22.1	13.2	15.8	15.6	8.8	9.1	7.9	6.3	6.6	5.7	4.8	3.8	22.6
Er-Lu	6.8	5.8	7.3	3.8	1.6	0.7	1.2	0.4	0.2	1.2	0.4	0.2	0.1	6.2
RE_2O_3,%	0.73	0.86	0.80*	0.66	0.75	0.58	1.10	0.82	0.81	1.34	0.66	1.69	5.15	0.41
Re_2O_3, no of analyses	38	92	-	44	22	15	8	96	13	61	26	74	23	47
La/Nd	0.51	0.62	1.41	0.90	0.67	0.81	1.12	1.20	1.10	1.20	1.43	1.67	1.96	0.44

*= % R.E.

(a) includes quartz monzonites, adamellites, tonalites (b) not including nepheline syenites which are included in (12), alkalic rocks
*perhaps too high (Altschuler, 1980)

Table 6. Rare earths in apatites normalized to chondrite averages of Haskin et al. (1966)

	1	2	3	4	5	6	7	8	9	10	11	12	13
Type of rock	Granite Pegmatite	Granite	Phos-phorite	Granodior-ites, etc.	Gabbro	Kimber-lite	Syenite	Carbonatite	Alkalic Ultramafic	Fe ores	Ultra-mafic	Alkalic	Alkalic Pegmatite
No. of Analyses	55	100	-	50	30	15	10	111	15	110	27	126	28
La	0.86	1.16	2.79	1.55	1.34	1.64	1.90	2.07	1.98	2.05	2.27	2.50	2.65
Ce	0.88	1.11	0.82	1.34	1.35	1.61	1.49	1.58	1.63	1.66	1.65	1.65	1.66
Pr	1.49	1.49	1.30	1.58	2.21	1.38	1.63	1.52	1.47	1.33	1.36	1.30	1.38
Nd	1.02	1.19	1.13	1.04	1.14	1.16	1.10	0.99	1.06	0.97	0.92	0.85	0.80
Sm	1.88	1.21	0.77	0.99	1.08	0.73	0.69	0.66	0.58	0.42	0.44	0.37	0.38
Eu	0.1	0.29	0.63	0.19	0.24	0.24	0.29	0.34	0.05	0.19	0.15	0.10	0.15
Gd	1.91	1.20	0.42	0.88	0.83	0.48	0.46	0.40	0.34	0.32	0.34	0.27	0.14
Tb	1.08	0.83	0.51	0.17	0.33	0.17	0.09	0.17	0.08	0.17	0.17	0.17	-
Dy	1.05	0.60	0.42	0.39	0.38	0.12	0.16	0.09	0.09	0.12	0.17	0.07	0.05
Ho	0.93	0.57	0.41	0.44	0.17	-	0.16	0.06	-	0.11	0.06	0.06	0.06
Er	0.59	0.52	0.81	0.31	0.17	0.09	0.13	0.06	0.02	0.13	0.04	0.02	0.02
Tm	0.75	0.50	0.25	0.50	0.13	-	0.12	-	-	-	-	-	-
Yb	0.49	0.44	0.44	0.29	0.10	0.04	0.08	0.02	0.02	0.08	0.04	0.02	-
Lu	0.44	0.33	0.45	0.22	0.22	-	-	-	-	-	-	-	-
Y	0.75	0.60	0.99	0.36	0.41	0.12	0.27	0.13	0.12	0.13	0.18	0.13	0.06

Table 7--Lanthanides in apatites, atomic percent

Type of rocks No. of analyses	1 Granite Pegmatite 55	2 Granites 100	4 Granodiorites, etc.* 50	5 Gabbros 30	6 Kimberlites 15
	Range of composition				
La	1.4 - 22.0	2.6 - 30.0	1.5 - 36.5	1.8 - 23.9	8.3 - 25.6
Ce	4.5 - 53.0	9.0 - 51.1	5.0 - 56.7	21.9 - 49.1	29.4 - 65.1
Pr	0.6 - 12.1	1.0 - 14.0	2.0 - 9.4	3.1 - 27.0	1.0 - 7.1
Nd	4.4 - 30.3	8.5 - 49.8	10.4 - 31.2	4.2 - 29.3	19.4 - 25.4
Sm	0.3 - 24.5	0.8 - 14.4	2.0 - 11.7	1.5 - 11.2	2.3 - 8.7
Eu	0 - 1.5	0 - 4.6	0 - 2.4	0 - 1.4	0 - 1.2
Gd	0.9 - 28.6	0.1 - 16.3	0.9 - 14.9	0.6 - 12.8	0.7 - 6.9
Tb	0 - 6.2	0 - 7.1	0 - 1.7	0 - 2.7	0 - 0.7
Dy	0 - 21.6	0 - 17.6	0 - 19.1	0 - 13.4	0 - 2.6
Ho	0 - 16.1	0 - 4.7	0 - 6.3	0 - 1.1	0 - 0
Er	0 - 19.1	0 - 14.3	0 - 9.2	0 - 2.1	0 - 1.9
Tm	0 - 3.8	0 - 5.4	0 - 7.2	0 - 0.7	0 - 0
Yb	0 - 24.3	0 - 9.7	0 - 9.9	0 - 1.4	0 - 1.2
Lu	0 - 6.4	0 - 4.1	0 - 1.1	0 - 2.5	0 - 0
100Y/(Y+Ln)	9.9 - 64.4	2.0 - 65.2	3.5 - 40.8	4.4 - 41.1	0.5 - 14.0
No of detns. of Y	50	80	41	14	13
Σ	7.2 - 80.2	14.1 - 81.4	9.4 - 79.5	48.9 - 84.7	59.0 - 74.4
La-Nd	11.6 - 97.9	32.1 - 98.0	31.4 - 94.5	70.2 - 96.9	84.4 - 95.9
Sm-Ho	1.7 - 66.4	2.0 - 46.4	4.7 - 49.5	2.7 - 26.1	4.1 - 15.6
Er-Lu	0.3 - 48.0	0 - 29.1	0 - 19.1	0 - 3.7	0 - 3.1
RE_2O_3	0.06- 2.40	0.08- 3.40	0.02- 1.69	0.06- 2.34	0.33- 1.26
No. of detns. of RE_2O_3	38	92	44	22	15
La/Nd	0.08- 1.51	0.10- 3.02	0.07- 2.07	0.07- 1.65	0.42- 1.03

* includes quartz monzonites, adamellites, tonalites

Table 7 Continued

Type of rocks No. of analyses	7 Syenites 10	8 Carbonatites 111	9 Alkalic Ultramafic 15	10 Fe Ores 82	11 Ultramafic 27
a	8.1 - 31.3	10.3 - 40.6	17.6 - 24.4	10.1 - 36.9	18.6 - 34.0
Ce	34.8 - 51.0	31.2 - 52.2	42.7 - 51.9	35.2 - 60.1	41.2 - 50.8
Pr	4.0 - 9.9	2.7 - 9.8	1.9 - 7.6	2.2 - 8.7	2.6 - 7.4
Nd	13.7 - 30.0	10.8 - 30.0	11.7 - 24.4	10.5 - 24.5	13.4 - 23.2
Sm	0.8 - 7.1	0 - 9.8	1.9 - 8.1	0 - 5.9	0 - 4.5
Eu	0 - 1.4	0 - 3.5	0 - 0.5	0 - 1.8	0 - 1.9
Gd	0.4 - 5.3	0 - 6.7	0 - 3.2	0 - 7.1	0.3 - 3.7
Tb	0 - 0.5	0 - 1.3	0 - 3.2	0 - 0.8	0 - 0.8
Dy	0.2 - 3.1	0 - 3.6	0 - 0.7	0 - 4.5	0 - 2.2
Ho	0 - 0.9	0 - 0.6	0 - 6.5	0 - 0.9	0 - 0.8
Er	0 - 1.7	0 - 1.7	0 - 0.1	0 - 8.9	0 - 1.3
Tm	0 - 0.4	0 - 0.3	0 - 0.7	0 - 0.3	0 - 0.4
Yb	0 - 1.2	0 - 0.8	0 - 0.4	0 - 2.9	0 - 0.8
Lu	0 - 0.2	0 - 0.2	-	0 - 0.4	0 - 0.1
100Y/(Y+Ln)	(0.1 - 27.7)	(0.7 - 25.3)	2.4 - 17.1	0.2 - 31.6	2.1 - 13.4
No of detns. of Y	6	76	12	58	23
Σ	52.7 - 84.3	54.5 - 97.7	69.7 - 75.9	57.2 - 87.4	64.6 - 85.0
La-Nd	80.8 - 98.0	76.0 - 98.9	83.3 - 95.2	76.5 - 99.6	87.5 - 98.8
Sm-Ho	2.0 - 15.0	1.1 - 21.5	4.2 - 16.3	0 - 17.6	1.2 - 10.4
Er-Lu	0 - 3.0	0 - 2.5	0 - 0.6	0 - 12.1	0 - 2.1
RE_2O_3	0.5 - 2.14	0.06-4.66	0.001-2.14	0.03 -13.70	0.09 - 3.41
No. of detns. of RE_2O_3	8	96	13	80	26
La/Nd	0.35 - 2.13	0.35 - 3.10	0.72 - 2.14	0.52 - 3.02	0.49 - 2.80

Table 7 Continued

Type of rocks No. of analyses	12 Alkalic 131	13 Alkalic Pegmatites 28	14 Gneisses and Migmatites 52		
La	13.1 - 51.5	10.3 - 49.8	2.3 - 29.3		
Ce	17.9 - 60.4	36.0 - 60.4	7.2 - 45.0		
Pr	1.6 - 12.5	2.5 - 10.9	0 - 10.9		
Nd	8.9 - 30.8	6.7 - 24.3	7.9 - 41.3		
Sm	0 - 10.0	0 - 6.9	0 - 25.6		
Eu	0 - 1.7	0 - 2.4	0 - 2.6		
Gd	0 - 5.4	0 - 2.6	0 - 17.7		
Tb	0 - 1.1	0 - 0.2	0 - 2.6		
Dy	0 - 3.9	0 - 2.6	0 - 16.2		
Ho	0 - 1.9	0 - 0.2	0 - 5.9		
Er	0 - 1.4	0 - 0.6	0 - 12.9		
Tm	0 - 0.5	0 - 0.1	0 - 2.8		
Yb	0 - 0.7	0 - 0.4	0 - 16.0		
Lu	0 - 0.1	0	0 - 2.8		
100Y/(Y+Ln)	0.8 - 17.1	0.2 - 9.5	6.2 - 57.6		
No of detns. of Y	76	18	-		
Σ	65.2 - 91.1	66.1 - 92.4	12.1 - 75.9		
La-Nd	88.2 - 100	88.3 - 100	29.1 - 98.8		
Sm-Ho	1.0 - 10.9	0 - 11.4	0.6 - 51.1		
Er-Lu	0 - 2.0	0 - 0.5	0 - 30.7		
RE_2O_3	0.08- 10.59	0.35- 14.7	0.12- 0.99		
No. of detns. of RE_2O_3	79	23	-		
La/Nd	0.71 - 4.04	0.43 - 7.46	0.14 - 1.44		

Table 8 Rare Earths in Apatites from Iron Ores

Averages, atomic percent

	1	2	3	4	5	6	7	8	9	10
La	12.5	16.3	21.7	20.4	19.2	28.7	26.3	25.2	29.9	21.6
Ce	40.2	45.1	45.7	48.4	50.3	44.5	48.9	53.5	53.9	47.9
Pr	0.8	5.1	5.3	4.8	5.0	3.7	4.5	3.9	2.4	4.8
Nd	26.4	19.4	20.6	16.7	16.6	15.9	17.3	14.2	11.6	17.9
Sm	6.1	3.2	3.0	3.1	3.1	1.8	1.2	1.2	0.8	2.5
Eu	0.6	0.8	0.2	0.4	0.2	0.5	0.2	0.1	-	0.4
Gd	5.0	3.3	2.4	2.6	2.4	1.8	0.7	0.9	0.9	2.1
Tb	0.7	0.4	-	0.3	0.3	0.1	-	-	-	0.2
Dy	3.7	2.4	0.5	1.5	1.4	1.3	0.4	1.0	0.1	1.1
Ho	0.5	0.6	0.1	0.2	0.2	0.3	0.1	-	-	0.2
Er	1.5	2.0	0.3	0.8	0.7	0.6	0.2	-	0.2	0.7
Tm	-	0.1	-	0.1	0.1	0.2	-	-	-	-
Yb	0.9	1.1	0.2	0.6	0.4	0.5	0.2	-	0.2	0.5
Lu	0.1	0.2	-	0.1	0.1	0.1	-	-	-	-
Y/(Y+Ln)x100	(20.1)	(21.0)	(5.4)	-	-	(12.4)	(5.1)	(6.0)	(6.6)	(6.5)
No of samples	5	19	31	17	7	6	20	17	6	110
Σ = La+Ce+Pr	53.5	66.5	72.7	73.6	74.4	76.9	79.7	82.6	86.2	74.3
La-Nd	79.9	85.9	93.3	90.3	91.2	92.8	97.0	96.8	97.8	92.2
Sm-Ho	16.6	10.7	6.2	8.1	7.4	5.8	2.6	3.2	1.8	6.6
Er-Lu	2.5	3.4	0.5	1.6	1.4	1.4	0.4	-	0.4	1.2
RE_2O_3	-	0.59	0.59	1.79	1.82	-	1.89	-	2.51	1.34
La/Nd	0.48	0.8.4	1.05	1.22	1.14	1.81	1.79	1.96	2.58	1.20

(1) Ilmenite-apatite ores associated with gabbro-anorthosite; (2) Kiruna-type ores, Lappland (Parak, 1973); (3) alkalic-ultramafic rocks with Fe oxides, mostly from Kola Peninsula, U.S.S.R.; (4) Magnetite-apatite ore in hydrous Mg silicates, Chador-Malya, Iran, Gerasimovskii and Mineev (1981); (5) same as (4), Chakhgaz, Iran; (6) Evstyunin magnetite deposit, Urals; (7) Lebyazhin magnetite deposit, Urals (Ovchinnikova, 1973); (8) Abovyan magnetite deposit, Armenian S.S.R. (Ignat'eva, 1973; Sarukhyan and Mkrtchyan, 1968); (9) Fe ores associated with andesite, latite, or rhyolite; (10) average of 110 apatites from iron-ore deposits of all types.

Table 9. Distribution of analyses of apatite by type of host rock and value of Σ (= La+Ce+Pr) by % of total

Analyses no.	Nos. 1-100	101-200	201-300	301-400	401-500	501-600	601-700	701-800	801-900	901-939
Granite pegmatite	38	33	7	5	1	1	1	1	1	-
Granite	25	28	28	15	8	4	2	1	3	-
Granodiorite etc.	7	6	13	7	15	2	5	5	1	-
Gabbro	-	3	12	16	1	3	2	-	1	2
Kimberlite	-	-	-	3	5	5	2	1	-	-
Syenite	-	-	3	1	2	2	5	1	2	3
Carbonatite	-	-	1	17	31	17	28	18	8	3
Alkalic Ultramafic	-	-	-	-	2	4	5	4	2	-
Fe ores	-	2	8	10	6	18	14	10	19	23
Ultramafic	-	-	-	-	7	15	1	8	6	-
Alkalic	-	-	-	2	8	15	19	36	43	46
Alkalic Pegmatite	-	-	-	-	1	2	5	4	12	23
Gneisses and Migmatites	15	17	16	9	3	2	2	1	-	-
Other	15	10	12	15	10	10	8	10	2	-
Range of Σ	7.2-36.7	36.7-46.4	46.7-58.8	58.8-65.4	65.4-70.1	70.2-73.5	73.5-75.9	75.9-79.4	79.4-85.0	85.1-92.4

Table 10

Previously published averages (atomic percent) for apatites

No. -	1	2	3	4	5	6	7	8	9	10	11
La	2.1	6.6	8.2	23.3	14.0	16.7	21.8	19.6	26.7	27.0	35.1
Ce	6.5	26.6	26.4	37.6	35.1	40.6	38.5	40.3	49.1	48.7	48.2
Pr	1.7	3.8	5.7	3.4	6.5	6.8	4.9	6.0	4.0	4.5	-
Nd	5.4	28.2	31.5	19.7	22.3	22.0	19.6	20.0	13.6	16.6	13.7
Sm	4.4	8.6	6.8	3.8	6.5	4.9	4.0	4.5	2.0	1.3	2.1
Eu	0.7	-	0.4	0.7	0.6	0.5	0.2	0.3	0.3	0.1	0.6
Gd	10.5	11.1	8.4	5.2	7.1	4.0	3.6	4.3	2.4	1.0	-
Tb	1.9	1.1	0.5	0.5	0.9	0.6	0.6	0.6	-	0.2	0.2
Dy	17.7	4.9	5.3	2.5	3.9	1.9	3.4	2.3	0.9	0.4	-
Ho	4.9	1.6	0.9	0.3	0.6	0.3	0.6	0.4	0.2	-	-
Er	17.0	4.1	3.0	1.5	1.2	0.9	1.1	0.9	0.3	0.1	
Tm	2.7	0.8	0.5	0.1	0.2	0.1	0.2	0.1	-	-	-
Yb	19.2	3.1	2.2	1.1	1.0	0.6	1.3	0.6	0.5	0.1	0.1
Lu	5.3	0.1	0.2	0.3	0.1	0.1	0.2	0.1	-	-	-
Y/(Y+Ln)x100	-	-	-	-	-	-	-	-	(4.8)	-	-
Method	-	-	-	XF	-	-	-	-	-	-	NA
Σ = La+Ce+Pr	10.3	36.4	40.3	64.3	55.6	64.1	65.2	65.9	79.8	80.2	83.3
La-Nd	15.7	64.6	71.8	84.0	77.9	86.1	84.8	85.9	93.4	96.8	97.0
Sm-Ho	40.1	27.3	22.3	13.0	19.6	12.2	12.4	12.4	5.8	3.0	2.9
Er-Lu	44.2	8.1	5.9	3.0	2.5	1.7	2.8	1.7	0.8	0.2	0.1
RE_2O_3	-	-	-	-	-	-	-	-	4.15	-	0.91*
La/Nd	0.38	0.23	0.26	1.18	0.63	0.74	1.10	0.98	1.96	1.62	2.56
No. of Analyses averaged	2	7	14	-	19	22	2	43	-	13	29

* %R.E. (1)Mineev (1968), Y-apatite: (2-3 and 5-7) Lyakhovich and Balanova(1971), (2) metasomatic, autochtonous granites; (3) gneisses and migmatites; (4) Loginova (1977), av. of mixt. of 500 phosphatic bone deposits; (5) granites of palingenetic intrusives; (6) basic rocks; (7) pegmatites; (8) Mineev (1968), apatite; (9) Tikhonenkova (1977), nepheline syenites; (10) Lyakhovich and Balanova (1971); (11) Kravchenko et al. (1979), ijolite-urtite, Khibina massif.

Table 11. Rare Earths in Britholite and Britholite-(Y)

Average Compositions for Various Types of Rocks

	1	2	3	4	5					
La	7.9	17.0	16.6	27.3	30.2					
Ce	19.2	23.1	42.8	47.3	51.3					
Pr	3.2	6.0	6.6	4.7	3.3					
Nd	12.3	19.6	22.2	14.9	11.1					
Sm	5.6	11.4	4.6	1.8	1.3					
Eu	0.2	-	0.3	0.2	0.1					
Gd	10.7	6.0	2.3	1.5	1.2					
Tb	1.4	0.9	0.2	-	-					
Dy	14.7	6.0	1.0	1.0	0.7					
Ho	2.0	1.5	0.2	0.3	0.1					
Er	11.5	4.5	0.2	0.6	0.1					
Tm	1.2	0.5	-	-	0.2					
Yb	9.2	2.9	3.0	0.4	0.4					
Lu	0.7	0.6	-	-	-					
Y/(Y+Ln)x100	(56.7)	(46.4)	(14.4)	(7.7)	(3.3)					
No. of samples for Y	5	4	2	10	12					
Σ = La+Ce+Pr	30.4	46.1	66.0	79.3	84.8					
La-Nd	42.7	65.7	88.2	94.2	95.9					
Sm-Ho	34.6	25.8	8.6	4.8	3.4					
Er-Lu	22.7	8.5	3.2	1.0	0.7					
RE_2O_3	50.0	50.7	33.4	53.1	43.1					
La/Nd	0.65	0.87	0.75	1.98	2.92					

1. Av. of 9 from granitic pegmatites (Britholite-(Y)
2. Av. of 5 from granites
3. Av. of 2 from carbonatites
4. Av. of 14 from alkalic rocks
5. Av. of 17 from alkalic pegmatites

Table 12

Locality Index of Analyses

Locality Index

Locality Index

U.S.S.R. - contd.