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Revision of the lanthanite group and new data for specimens from Bastnäs, Sweden, and Bethlehem, USA

LANTHANITE was described for the first time from Bastnäs, Sweden (Berzelius, 1825). The formula $(\text{La,Ce})_2\text{CO}_3 \cdot 8\text{H}_2\text{O}$ was attributed following the more complete chemical analysis of the mineral from Bastnäs by Lindström (1910):

$(\text{La,Di})_2\text{O}_3 =$	28.34%
$\text{Ce}_2\text{O}_3 =$	25.52%
$\text{Y}_2\text{O}_3 =$	0.79%
$\text{CO}_2 =$	21.95%
$\text{H}_2\text{O} =$	23.40%
Insol. =	0.13%
Total =	100.13%

Di represents 'didymium', a name applied to several rare earth elements (*REE*), including Nd, Pr, etc., which could not be chemically differentiated at that time; accordingly the value of 28.34% represents not only La_2O_3 , but also (Di_2O_3) . The true percentage of La_2O_3 could therefore be lower than that of Ce_2O_3 in this analysis, and the predominant *REE* would then be Ce (or Nd) and not La. More recent work has established the existence of a Ce-poor, Nd-rich species of lanthanite from several localities including Curitiba, Paraná, Brazil (Roberts *et al.*, 1980); Santa Isabel, São Paulo, Brazil (Coimbra *et al.*, 1989); Kiringo, Japan (Nagashima *et al.*, 1986), and Bethlehem, Pennsylvania, USA (this work).

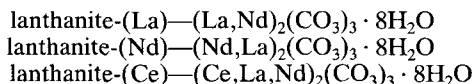
In order to establish the mineral species name of lanthanite from the type locality Bastnäs, a sample from the National Museum of Natural History of the Smithsonian Institution (catalogue number B10531) was obtained and analysed by energy-dispersive X-ray fluorescence at São Paulo, Brazil, and by utilizing both a scanning electron microscope with an attached energy-dispersive analyser, and by a wavelength-dispersive electron microprobe at the British Museum (Natural History), London, UK. Ce-poor lanthanite, from Bethlehem, Pennsylvania, USA, was also obtained from the Smithsonian Institution (catalogue number R2740) for analysis at the

BM(NH) and for comparison with material from Bastnäs.

Problems with specimen damage by the electron beam during electron microprobe analysis and the associated analytical difficulties reported by Ansell *et al.* (1976) and Bevins *et al.* (1985) were also encountered in this study. However, the proportions of individual *REE* in the mineral are expected to remain essentially constant during analysis, allowing the mineral species to be named according to the nomenclature procedure of Bayliss and Levinson (1988). The data obtained at the BM(NH) on the material from Bastnäs are presented in Table 1 (analysis 15), and show the species to be lanthanite-(Ce); and material from Bethlehem (analysis 16) to be lanthanite-(Nd). SiO_2 , CaO and Y_2O_3 were the only other elements detected by electron microprobe: $\text{SiO}_2 = 0.42\%$ and 0.56% ; CaO = 2.08% and 1.22% , and $\text{Y}_2\text{O}_3 = 2.27\%$ and 1.80% from Bastnäs and Bethlehem respectively.

Current rules of nomenclature for rare earth minerals (Bayliss and Levinson, 1988) state that the mineral name be suffixed with the predominant member of the *REE* group. Accordingly, examples of lanthanite analyses in the literature have been revised following the recalculation of the atomic percentages of the *REE* to 100%. These data, and the new data obtained in this study, are presented in Table 1, and show that the lanthanite structure accommodates the light *REE* (La to Nd).

On the basis of the Bayliss and Levinson (1988) revised nomenclature system the lanthanite mineral group constitutes three species:



However, from the data plotted in the La-Nd-Ce ternary diagram (Fig. 1), lanthanite separates into

Table 1. Analyses of lanthanite-group minerals calculated to REE = 100% (in atomic percentages)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
La	27.3	33.3	22.0	27.3	40.4	41.8	41.8	39.1	39.9	37.4	37.4	31.6	35.4	30.9	20.1	33.4
Ce	55.1	50.0	51.0	38.7	0.5	—	0.1	—	—	—	0.1	0.2	0.1	2.2	46.2	—
Pr	5.0	6.0	5.6	—	7.0	8.3	9.1	6.1	5.8	6.5	9.8	10.7	9.7	10.0	6.1	14.6
Nd	10.8	9.8	18.1	27.0	40.0	40.1	38.3	42.3	41.3	40.7	40.6	44.1	42.8	44.5	21.3	42.2
Sm	0.9	0.9	1.3	4.4	6.0	5.9	6.6	12.5	13.0	8.8	7.4	7.6	6.9	6.8	3.0	5.7
Eu	—	—	0.1	—	0.6	1.0	1.2	—	—	1.3	1.1	1.2	1.4	1.5	—	1.1
Gd	0.9	—	0.8	2.6	3.6	2.9	1.8	—	—	5.3	2.9	3.6	2.8	3.1	2.4	2.5
Tb	—	—	0.8	—	0.2	—	0.2	—	—	—	—	0.3	0.3	0.2	—	—
Dy	—	—	0.2	—	0.9	—	0.7	—	—	—	0.7	0.6	0.6	0.7	0.6	0.5
Ho	—	—	—	—	0.5	—	0.1	—	—	—	—	—	—	—	—	—
Er	—	—	—	—	0.3	—	—	—	—	—	—	—	—	0.1	0.3	—
Tm	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Yb	—	—	0.1	—	—	—	0.1	—	—	—	—	—	—	—	—	—
Lu	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

1. Vuoriyarvi, Kola Peninsula, USSR (Kapustin, 1966)
2. Vuoriyarvi, Kola Peninsula, USSR (Kapustin, 1971)
3. Bayan Obo, China (Zhang and Tao, 1986)
4. Wales, United Kingdom (Bevins et al., 1985)
5. Santa Isabel, São Paulo, Brazil (Coimbra et al., 1989)
6. Curitiba, Paraná, Brazil (JCPDS 30-678)
7. Curitiba, Paraná, Brazil (Svisero and Mascarenhas, 1981)
8. Curitiba, Paraná, Brazil (Fujimori, 1981)
9. Curitiba, Paraná, Brazil (Fujimori, 1981)
10. Curitiba, Paraná, Brazil (Ansell et al., 1976)
11. Curitiba, Paraná, Brazil (Cesbron et al., 1979)
12. Curitiba, Paraná, Brazil (Trescases et al., 1986)
13. Curitiba, Paraná, Brazil (Trescases and Fortin, 1988)
14. Kirigo, Japan (Nagashima et al., 1986)
15. Bastnäs, Sweden (this work)
16. Bethlehem, Lehigh County, Pennsylvania, USA (this work)

only two groups based on the presence or absence of Ce. It is likely that the plotted positions of Ce-poor lanthanite, which cross-cut the nomenclature-derived boundary of Bayliss and Levinson (1988) simply reflect the ratio of La to Nd in the fluid at the time of crystallization: indeed, lanthanite from one locality (Curitiba, Brazil—analyses and positions 7 to 13, Table 1 and Fig. 1) can be classified as either lanthanite-(La), or lanthanite-(Nd). A more fundamental difference is the Ce content of lanthanite from different localities. Remarkably low Ce abundances (Ce < 0.5%) are observed for Ce-poor lanthanites compared with Ce abundances >20% for Ce-present (i.e. 'normal') lanthanites. This extreme fractionation of Ce from the other REE is rare in naturally-occurring minerals, and must represent a significantly different paragenesis than that for 'normal' lanthanites. Fortin (1989) describes Ce-poor lanthanite from Curitiba, Brazil, as being secondary in origin, where Ce was selectively fractionated from the other REE in a lateritic environment. In order to establish the reasons for extreme Ce fractionation in some other lanthanites, three of us (REB, CTW and PAW) are now investigating lanthanite parageneses from other localities in the USA (Canton Mine, Georgia and Sanford Mine, New York—Lindström, 1910, and Rowley, 1962; Baringer Hill, Texas—Palache et al., 1951; Bearpaw Mountains, Montana—Pecora and Kerr, 1953; and Manitou, Colorado—Roberts et al., 1974), and

in Norway (Hobøl, Østfold—Saebø, 1961; and Holmestrand—Neumann, 1985).

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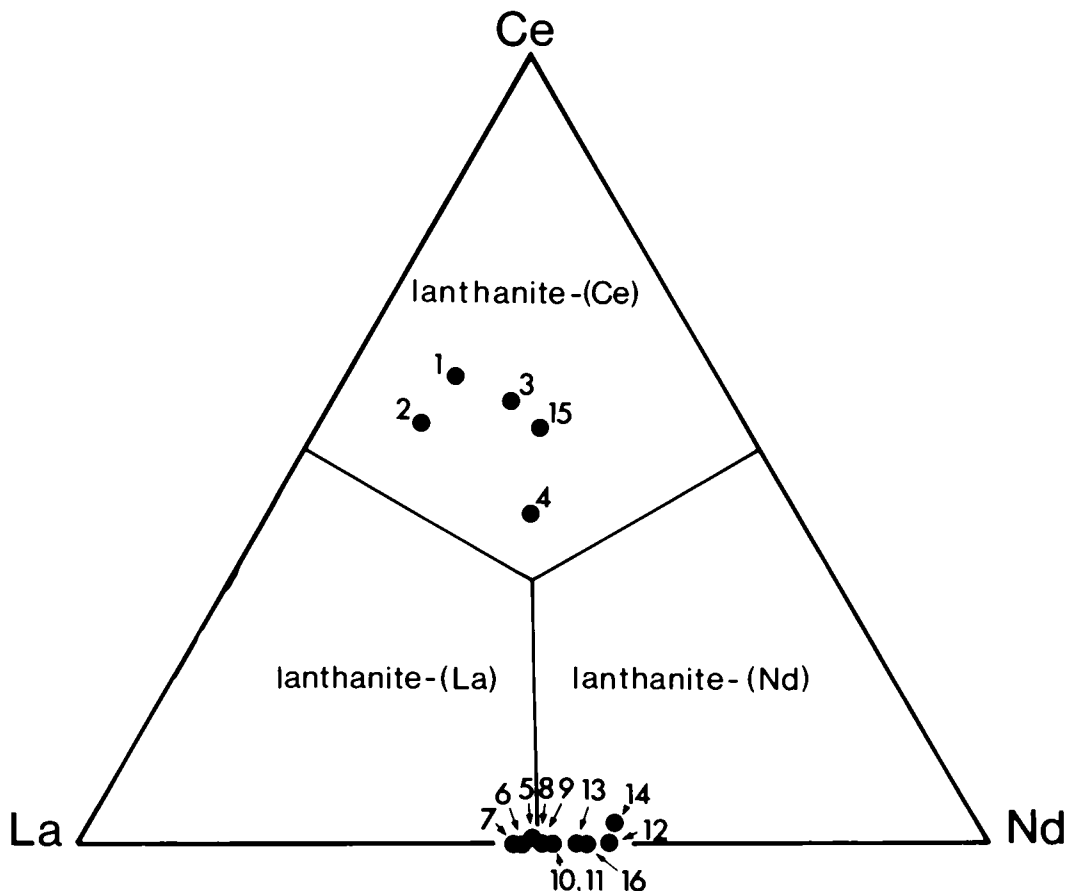


FIG. 1. La-Nd-Ce atomic proportions for lanthanite-group minerals. Sample numbers are those given in Table 1.

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Instituto de Geociências, Universidade de São Paulo, Caixa Postal 20899, 01498—São Paulo, SP, Brasil

DANIEL ATENCIO

Department of Geology, National Museum of Wales, Cardiff, CF1 1XL, Wales, UK

RICHARD E. BEVINS

Department of Mineral Sciences, Smithsonian Institution, Washington, DC 20560, USA

MICHAEL FLEISCHER

Department of Mineralogy, British Museum (Natural History), Cromwell Road, London SW7 5BD, England, UK

C. TERRY WILLIAMS

Department of Chemistry, University College, PO Box 78, Cardiff, CF1 1XL, Wales, UK

PETER A. WILLIAMS

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Comments on 'The Tertiary Kærven syenite complex, Kangerdlugssuaq, East Greenland: mineral chemistry and geochemistry' by P. M. Holm and N.-O. Prægel

IN a recent paper Holm and Prægel (1988) have described the syenites and alkaline granites of the Kærven syenite complex from the lower Tertiary magmatic province of East Greenland. The province developed during the early stages of the opening in the North Atlantic (e.g. Brooks and Nielsen, 1982; Nielsen, 1987). Holm and Prægel conclude that the syenites and granites of the Kærven syenite complex constitute a comagmatic suite, which developed by mixing of end-members from a common basic parent of T-MORB affinity. They find very limited evidence for interaction with crustal material. These conclusions are not consistent with their own observations and, furthermore, Holm and Prægel have not considered their results in the light of the petrogenic models proposed for comparable syenite com-

plexes in the immediate neighbourhood (see Nielsen, 1987, for references).

Age of the Kærven syenite complex. The Kærven complex is one of several, both older and younger, satellite intrusions to the 800 km² 50 ± 1 Ma old syenitic Kangerdlugssuaq intrusion (Kempe *et al.*, 1970; Pankhurst *et al.*, 1976). Holm and Prægel quote an Ar⁴⁰/Ar³⁹ age of 58 Ma for the Kærven syenite complex. This is older than other hitherto reported lower Tertiary intrusive complexes in the Kangerdlugssuaq area, which has prompted Holm and Prægel to single out the complex and to try to identify the mantle sources for the initial lower Tertiary magmatic activity in East Greenland in the syenites and granites at Kærven. However, the age of the syenite is not conclusively documented and a zircon fission