reading the manuscript. Prof. Gustaf Arrhenius of the University of California provided the use of one of the electron microprobe x-ray analyzers. Part of this investigation was supported by the National Aeronautics and Space Administration, Grant NsG-541.

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CENOSITE FROM PORTHILL, IDAHO[1]

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Cenosite, a hydrous calcium yttrium carbonate-silicate mineral, has been discovered in a thorium vein 4 miles east-southeast of Porthill, Idaho. This mineral has been reported from only a few localities in the world, and the Porthill occurrence is the second known in the United States. Because cenosite is one of a small group of minerals in which yttrium is a major constituent, its occurrence is both of scientific and economic interest. Furthermore, as cenosite at Porthill closely resembles quartz, it may be overlooked in other thorium veins.

Cenosite, originally called kainosite, was first described by Norden-

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[1] Publication authorized by the Director, U. S. Geological Survey.

skiöld (1886) from a granite pegmatite on Hitterö Island, Norway. Since its original discovery, it has been found in the Ko iron mine in Sweden (Sjögren, 1897); from four veins in the Grimsel area, Switzerland (Parker and de Quervain, 1940, 1956; Beck, 1956); in a vein in North Burgess township, Ontario (Graham and Ellsworth, 1930); and in pegmatites near Bancroft, Ontario, and Cotopaxi, Colorado (Heinrich *et al.*, 1962).

The thorite vein in which the cenosite occurs is on the property of the Northwest Prospecting and Development Company, and is approximately on the center of the southern boundary of the NW ¼ Sec. 13, T. 65N, R. 1W. on Hall Mountain just south of the Canadian border. The vein is intruded into a diorite sill (Le Moine, 1960, p. 15). It is made up chiefly of quartz and thorite, strikes N. 16° E., and dips 62° SE. It is exposed for 350 feet along strike and ranges from 1 to 2½ feet in width. Thorite is irregularly distributed and constitutes from 5 to 60 per cent of the vein. Other minerals include calcite, chlorite, magnetite, allanite, apatite, and cenosite, of which the first four minerals, although also irregularly distributed, make up several percent of the vein.

Cenosite was found only in the vein material having the highest radioactivity. It is commonly either adjacent to or intergrown with allanite, although in places it is intergrown with calcite. The cenosite grains are all anhedral.

The cenosite was first noted during examination with a microspectroscope of a thorite-rich sample of the vein material; the erbium absorption bands having indicated the presence of a species containing the yttrium group rare earths. The mineral was then isolated and identified by optical and *x*-ray methods.

The Porthill cenosite differs somewhat from cenosite from other localities in being colorless or white. Cenosite from Cotopaxi and North Burgess township is rose or pink, and that in Sweden, yellow brown to chestnut brown. (Heinrich *et al.*, 1962). Such variation in color is due in part to included hematite (Heinrich *et al.*, 1962). The specific gravity of the Porthill cenosite, as measured by pycnometer, is 3.65, whereas that from other areas may be considerably lower (Table 1).

The optical properties of the Porthill cenosite, however, correspond closely, except for color (Table 1), to those from Cotopaxi, North Burgess township and Switzerland. The indices of the cenosite from Porthill were measured in Na light, and the 2V was measured on a universal stage.

The *x*-ray diffraction data of the Porthill cenosite compare well with those for cenosite from Cotopaxi, Hitterö Island, North Burgess township, and Bancroft, as given by Heinrich *et al.* (1962). The three strongest peaks on the graph of an *x*-ray diffractometer are at 6.56, 4.85, and 2.76 d Å (Table 2).

TABLE 1. OPTICAL PROPERTIES AND SPECIFIC GRAVITY OF CENOSITE

	Porthill, Idaho	Cotopaxi, Colorado (Heinrich, *et al.* 1962)	North Burgess township, Ontario (Graham and Ellsworth, 1930)	Guttannen, Grimsel area, Switzerland (Parker and de Quervain, 1940)
Color	Colorless	Rose to light red	Deep pink	Light brown
Indices				
α	1.663	1.662	1.664	1.658
β	1.687	1.686	1.689	1.682
γ	1.689	1.692	1.691	1.687
Sign, 2V	(−)39°30′	(−)40°	(−)39°59′	(−)40°
Specific gravity	3.65	3.41	3.61	3.54

Under the microspectroscope the Porthill cenosite shows line-like absorption bands due to erbium, in the green region of the spectrum between 520 and 524 mμ. The appearance of these bands varies somewhat with the orientation of the mineral, and an additional erbium band is visible in the blue region at 491 mμ when the mineral is oriented for

TABLE 2. *X*-RAY POWDER DIFFRACTION DATA FOR CENOSITE FROM PORTHILL, IDAHO

(Cu radiation, Ni filter)

dÅ	I	dÅ	I
7.20	30	2.85	30
6.56	100	2.76	80
6.37	20	2.56	40
5.61	20	2.44	20
4.85	80	2.40	40
4.62	10	2.23	10
3.66	10	2.17	30
3.56	40	2.10	40
3.47	40	1.95	20
3.30	50	1.93	30
3.20	50	1.87	10
3.15	30	1.77	10
3.07	20	1.75	10
3.05	20	1.67	20
2.94	40	1.64	10
2.89	20	1.62	10

measurement of the α refractive index. Cenosite from other localities would expectably show similar absorption effects.

Five chemical analyses of cenosite have been published (Heinrich *et al.*, 1962) In four of these the rare earth elements are reported only as total cerium group oxides and yttrium group oxides. In the analysis of the Cotopaxi cenosite, however, the content of yttrium and three of the most abundant lanthanides is also given (Heinrich *et al.*, 1962).

As the distribution of yttrium and the lanthanides in minerals is of increasing interest in the study of the geochemistry of the rare earths, a quantitative spectrographic analysis was made on these elements as well as a semiquantitative analysis for other elements in the Porthill cenosite (Table 3). The quantitative analysis, so far as we can determine, is the first that has been made of the complete rare earth assemblage of cenosite.

We have plotted the relative percentages of the lanthanide elements (Fig. 1) in the form suggested by Semenov and Barinskii (1958). In the graph, one curve connects the values of elements of even atomic number;

TABLE 3. SPECTROGRAPHIC ANALYSES, IN PER CENT, OF CENOSITE FROM PORTHILL, IDAHO

[Analyst: R. G. Havens]

Quantitative spectrographic analysis			
Y	19.5	Tb	.50
La	<.007	Dy	3.4
Ce	<.03	Ho	.79
Pr	<.07	Er	3.0
Nd	<.02	Tm	.34
Sm	<.02	Yb	1.9
Eu	.11	Lu	.24
Gd	1.3		
Semiquantitative spectrographic analysis[1,2]			
Si, Ca	Major (>10 per cent)	Be	.01
Fe	.2	Sc	.007
Al	.15	B	.003
Mg	.05	Sr	.002
Mn	.02		

[1] Elements looked for but not detected: Na, K, Ti, P, Ag, As, Au, Ba, Bi, Cd, Co, Cr, Cu, Ga, Ge, Hf, Hg, In, Li, Mo, Nb, Ni, Pb, Pd, Pt, Re, Sb, Sn, Ta, Te, Th, Tl, U, V, W, Zn, Zr.

[2] Due to interference by rare-earth lines, usual sensitivities do not apply for some elements.

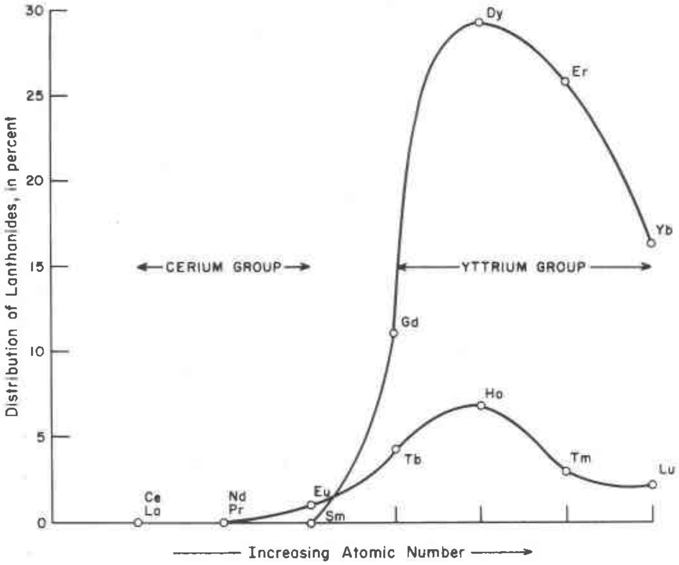

FIG. 1 Relative percentages of lanthanides in the Porthill cenosite *vs.* atomic number.

the other curve those of the elements of odd atomic number. The elements are so arranged that pairs of lanthanides that are adjacent in the periodic table fall on the same ordinate line.

The Porthill cenosite (Fig. 1) contains dominantly yttrium group lanthanides with maximums for the even-odd pair dysprosium and holmium. The cerium group is essentially absent except for europium whose anomalous relationship with samarium results in the crossing of the even-odd curves in the graph. This excess of europium over samarium is unusual, as may be noted from the 93 analyses of rare-earth-bearing minerals given by Semenov and Barinskii (1958), in which samarium and europium were determined. In all these analyses europium was markedly subordinate to samarium.

Cenosite, therefore, appears to represent an extremely selective yttrium-group mineral, with little capacity for acceptance of cerium group lanthanides. This selectivity is suggested by the very low values reported for the cerium group in the analyses of five cenosites given by Heinrich *et al.* (1962) and by the analysis of the Porthill material.

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DIFFERENTIAL THERMAL ANALYSIS IN CLOSED SYSTEMS AT HIGH HYDROSTATIC PRESSURES

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Investigations of phase transitions at elevated pressures in various systems can often be conveniently carried out by quenching techniques when the phases on either side of the transition can be preserved and identified by subsequent *x*-ray and/or optical examination. Many subsolidus enantiotropic transitions, and melting relations (where the liquid phase cannot be quenched as a glass) have to be detected by indirect evidence such as the presence or absence of twinning, a meniscus, or bubbles. The accuracy of such methods is often somewhat low and sometimes quite misleading (Wyllie and Tuttle, 1963).

During an investigation of the liquidus in the systems $Ca(OH)_2$-Ca_2SiO_4 and $Ca(OH)_2$-Ca_2SiO_4-CaO by quench techniques, the need arose for more direct data in support of the petrographic and *x*-ray evidence. In systems such as these, dehydration has to be prevented by the application of elevated pressures and the proportions of the components have to be maintained, by completely enclosing the sample in sealed malleable noble-metal capsules, for example, to which the desired pressure is applied externally.

Conventional differential thermal analysis techniques at low pressures are not applicable to such closed systems, but it was found possible to pick up the latent heat effects on both melting and freezing by a rather simple device. This consisted of folding the base of a noble-metal capsule