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LEONHARDITE AND LAUMONTITE IN DIABASE
FROM DILLSBURG, PENNSYLVANIA[1]

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INTRODUCTION

A detailed survey of the laumontite-leonhardite relation was presented
by Coombs (1952) and subsequently incorporated into the ASTM x-ray
powder data file. The principal difference between the two minerals is a
variation in hydration from the full hydrated laumontite to less hydrous

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leonhardite. This variation is accompanied by a decrease in the indices of refraction and by minor lattice variations. Coombs (1952, p. 816–819) showed that original crystals of laumontite dehydrate easily to the more common modification of leonhardite. The dehydration-hydration reaction is reversible.

Powder x-ray patterns of crystals from Dillsburg resembling laumontite could not be identified from the three strongest lines of Coombs' data in the ASTM file. The strongest reflection in the Dillsburg material occurs at 9.49 Å, and is not present in the patterns given by Coombs (1952, p. 822). However, the remainder of the x-ray pattern, as well as subsequent optical and chemical analyses, confirmed that the Dillsburg material belongs to the laumontite-leonhardite group. Coombs (personal communication, 1962) agrees that there is a strong (110) reflection about 9.5 Å, which he was unable to detect with the equipment available to him at that time. In the belief that other workers may have had difficulty identifying similar samples from x-ray powder data, it was thought that this new information would be a useful addition to Coombs' work. In fact, Kaley and Hanson (1955, p. 923–925) have published a laumontite powder pattern which they state agrees "closely with the data reported by Coombs for laumontite and leonhardite," but which contains an unexplained strong reflection at 9.42 Å.

Geologic Occurrence

Leonhardite and laumontite occur in fractures throughout the top 300 feet of a south-dipping Triassic diabase sheet on U. S. Route 15, $\frac{1}{2}$ mile south of Dillsburg, Pennsylvania. Both diabase pegmatite and small granophyric segregates are present. A more detailed study of the Dillsburg diabase and granophyre was published by Hotz (1953). A fifty-foot thick, chilled margin is deeply weathered, but appears to contain no zeolite minerals. The exposures from which the zeolites were taken are near the surface of a newly exposed road cut, and, as a result, natural dehydration of the laumontite to leonhardite is partially completed. This change is illustrated by a decrease in the indices of refraction along crystal margins. In many specimens the dehydration is complete.

Calcite and natrolite are the two minerals most closely associated with leonhardite, the latter mineral having crystallized later than the leonhardite-laumontite. Other associated minerals are: quartz, chlorite, montmorillonite, fluorite, analcite, chalcopyrite, pyrite, apophyllite and sphalerite (?). Although no single fracture contains all of these minerals, it may be inferred that all of them are closely related in origin. The presence of fluorite and sulfides, both in scant amounts, suggests that low

temperature hydrothermal solutions have played a part in their formation.

X-Ray Data

Diffractometer and Debye-Scherrer powder data are presented in Table I. Film intensity measurements were estimated by visual comparison. Diffractometer intensity values were calculated from the area under the peak ($\frac{1}{2}$ bh). Both are presented in Table I because preferred orientation of planes parallel to (110) enhanced the diffractometer values somewhat from those observed in powder patterns. The d Å values in Table I are an average of two diffractometer traces standardized with Si.

The reflections in Table I are compared with those given by Coombs (1952) and match his data for leonhardite very well. One notable exception is the strongest line at 9.49 Å in addition to several weak reflections. Using a beta angle of 112° and unit cell constants (Table II) calculated from the indexed reflections given by Coombs (1952, p. 822–823), the strongest line was indexed as a (110). Other weak reflections were indexed as (020), (120) and (310) although some ambiguity may be present because no single crystal photographs were taken. The cell constants and axial ratios in Table II agree with the data of Coombs within the limits of experimental error. From these data and those of Kaley and Hanson (1955) it would appear that these modified x-ray patterns are typical of laumontite and leonhardite.

Optical Properties

A summary of the optical properties is presented in Table II. The optical properties were measured at room temperature in blue filtered white light with .005-interval index liquids calibrated at room temperature. The indices of refraction for the Dillsburg samples match those given by Coombs (1952, p. 818) for the upper range of leonhardite, but are lower than values for laumontite. As he has noted, the indices, optic angle and extinction angle are variable, depending on the variability of the water content. In addition, distorted isogyres of the biaxial negative figure are common, suggesting strained crystal domains resulting from the partial or complete dehydration of laumontite to leonhardite. In some cases the crystals are zoned with an inner core of laumontite and an outer rim of leonhardite, although generally the alteration is less regular.

Chemical Composition

The results of the chemical analysis (by Spectrochemical Laboratories, Inc., Pittsburgh, Pennsylvania) on 8.3 grams of hand-picked crystals and

TABLE I. X-RAY POWDER DIFFRACTION DATA FOR
LEONHARDITE (CuK_α)

Dillsburg, Pennsylvania			Hungary (Coombs, 1952)		(hkl)		
I[1]	d Å	I/I₁[2]	I/I₁	d Å			
100	9.49	100				(110)	
36	6.86	50	6	6.88		(200)	
2	6.54					(020)	
2 P	6.19	15	2	6.21	$(\overline{2}01)$	(011)	
1.7	5.91					(120)	
6 P	5.052	20	2	5.07		(111)	
19.6 P	4.731	18	1	4.75		(220)	
8 P	4.500	30	3	4.51		$(\overline{2}21)$	
2.6	4.314					(310)	
61	4.156	95	10	4.18	(130)	(201)	
2.4	3.768		<1	3.77		(131)	
13	3.667	30	4	3.67		$(\overline{4}01)$	
31.7 P	3.510	90	10	3.52	(002)	(221)	
7.7 P	3.411		<1	3.42	(400)	(131)	
3.7 P	3.367	15	1	3.36	$(\overline{3}12)$	(012)	
21	3.272	25	3	3.28		(040)	
7.8	3.205	⎰12	2	3.21	$(\overline{3}31)$	(311)	$(\overline{4}21)$
16 P	3.152	⎱	1	3.16		(320)	
			<1	3.09		$(\overline{4}02)$	
27	3.033	35	4	3.04	(420)	(112)	
3.4	2.950		<1	2.95	(240)	(041)	
13.7	2.881	38	3	2.88	$(\overline{5}11)$	$(\overline{2}41)$	
2.7	2.798	18	2	2.80			
			<1	2.73			
3	2.629		<1	2.64			
14	2.575	20	3	2.58			
4	2.521	10	2	2.52			
3	2.463		1	2.46			
14 P	2.439	40	4	2.440			
			<1	2.394			
12.3	2.361	25	2	2.361			
2.7	2.278		⎰1	2.272		(600)	
6.5	2.268	2	⎱				
4.6	2.217	2	2	2.216			
5.4	2.180		1	2.183		(060)	
18.6	2.153	10	3	2.155			
1.5	2.082	2	1	2.090			
1.5	2.060		<1	2.059			
1.5	2.042		<1	2.041			
4.8	1.991	1	1	1.994			
11.6	1.955	5	2	1.961			

[1] Diffractometer, calculated by ($\frac{1}{2}$ base) × (peak height); some preferred orientation (P).
[2] Debye-Scherrer powder camera estimated visually.

TABLE I.—(*Continued*)

Dillsburg, Pennsylvania			Hungary (Coombs, 1952)		(hkl)
I[1]	d Å	I/I$_1$[2]	I/I$_1$	d Å	
			<1	1.910	
3.4	1.887	1	<1	1.888	
3.4	1.870		1	1.869	
6	1.851	5	1	1.852	
			<1	1.826	
2.2	1.800		<1	1.796	
5.7	1.760	2	1	1.762	
			<1	1.733	
6	1.710	1	1	1.706	
4.4	1.683	2	<1	1.677	
6	1.634	1	2	1.635	
6	1.623	1	2	1.623	
2	1.589		<1	1.596	
2	1.573				
	1.563	1	1	1.566	
7.2	1.539		<1	1.544	
2.2					
3.4	1.521		2	1.523	
3.0	1.517				

formula calculations are presented in Table III. The formula was calculated on the basis of 48 oxygen ions per unit cell according to the general formula

$$Ca_x(Na, K)_y(Al, Mg, Fe^3)_{2x+y}Si_{24-(2x+y)}O_{48} \cdot 16H_2O,$$
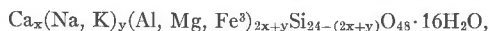
which may be idealized as

$$Ca_4Al_8Si_{16}O_{48} \cdot 16H_2O \text{ (Coombs, 1952, p. 825, 828)}.$$

The traces of Mg and Fe^{3+} have been arbitrarily placed in the Al site because of the deficiency of Al and the slight excess of Ca, K and Na.

The Dillsburg material is low in alkalies and thus closely approaches the alkali-free end member. However, there is a notable deficiency of Si and to a lesser extent of Al. As a result, this analysis does not conform to a first-class zeolite analysis as given by Hey (1932, p. 57) for which (Al $+Si$) $= 24 \pm 0.12$ for 48 oxygen atoms per unit cell. Several of the analyses summarized by Coombs (1952, p. 826–827) exhibit a similar deficiency, but none as great as in the Dillsburg samples. Leonhardite from Baveno (Coombs' sample analysis #14) approaches the Dillsburg leonhardite with respect to its Si deficiency, but is compensated by a corresponding increase in Al. In all other aspects, the Dillsburg leonhardite conforms to the requirements for a first-class zeolite analysis.

Because of the correspondence of distinctive x-ray powder and optical data between leonhardite and the majority of the Dillsburg zeolite, it has been referred to as leonhardite. However, a glance at the chemical analysis shows that the water content conforms to the fully hydrated form of laumontite. There are two possible explanations: 1) in selecting the 8.3 grams for chemical analysis a large proportion of the undehydrated material was obtained, or 2) the sample became rehydrated in the process of chemical analysis. The author prefers the latter explanation merely be-

TABLE II. UNIT CELL AND OPTICAL CONSTANTS OF LEONHARDITE

	Dillsburg, Pa	Hungary (Coombs, 1952)
a	14.75 Å ± .05	14.75 Å ± .03
b	13.083 Å ± .02	13.10 Å ± .02
c	7.57 Å ± .05	7.55 Å ± .01
	approx. 112°	112° ± .2°
$a:b:c$	1.127:1:0.578	1.126:1:0.576
α	1.508–1.509 ± .003	1.507 ± .002
β		1.516 ± .002
γ	1.518–1.519 ± .003	1.518 ± .002
(−) 2V	20°–30°: variable	26° ± 4°
Ext.	35–45°: variable	40° ± 2°

TABLE III. CHEMICAL ANALYSIS OF DILLSBURG LAUMONTITE[1]

	%	%	M/48 oxygens	Formula	
SiO_2	49.85	49.88	15.20	Calc. $(Ca_{3.82}Na_{.27}K_{.07})(Al_{7.65}Mg_{.11}Fe^3_{.07})Si_{15.2}O_{48} \cdot 16.34H_2O$	
Al_2O_3	21.30	21.31	7.65	Ideal $Ca_x(Na,K)_y (Al,Mg,Fe)_{2x+y} Si_{24-(2x+y)}O_{48} \cdot 16H_2O$	
MgO	0.18	0.18	0.11	Dillsburg	Ideal end-member
Fe_2O_3	0.21	0.21	0.07	In which: x = 3.82	4
CaO	11.74	11.75	3.82	y = 0.34	0
Na_2O	0.36	0.36	0.27	x+y = 4.16	4
K_2O	0.22	0.22	0.07	2x+y = 7.98	8
H_2O	16.08	16.09	32.68	x+y/2 = 3.99	4
	99.94	100.00		Al+Si = 22.85	24

[1] Analysis on 8.3 grams by Spectrochemical Laboratories Inc. Pittsburgh, Pennsylvania.

cause the x-ray and the majority of optical examinations conform to leonhardite rather than to laumontite.

Conclusions

Leonhardite crystals with lesser amounts of the fully hydrated laumontite, are associated with calcite, quartz, and other Na-Ca zeolites filling fractures near the top of a diabase sheet. Although conforming to previously published data on leonhardite in most respects, the x-ray powder pattern is distinguished by a (110) reflection of 100 intensity at 9.49 Å, and by a notable deficiency in silica which does not appear to be counterbalanced by alkali or aluminum substitution for calculations based on 48 oxygen atoms per unit cell.

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SOME PROPERTIES OF PLATINUM MONOTELLURIDE (PtTe)

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There is confusion in the literature over the existence of the compound PtTe. Roessler (1897) claims synthesis of PtTe by melting PtTe₂ in the oxidizing flame of a blowpipe on charcoal. Thomassen (1929) was unable to prepare the monotelluride of platinum by direct fusion of the elements. Groeneveld Meijer (1955) showed that a naturally occurring platinum telluride (niggliite) has the formula PtTe and probably has a hexagonal unit cell of $a = 4.11$ Å, $c = 5.446$ Å.

The existence of the compound PtTe has been shown in a recent investigation of the platinum-tellurium system (Gimpl *et al.*, to be publ.). The compound, PtTe, is formed by a peritectic reaction of PtTe₂ and liquid at 920° C.

A platinum monotelluride sample weighing approximately 3 grams was prepared by reacting a stoichiometric ratio of the elements at 1150° C. in