

Vigezzite, $(\text{Ca,Ce})(\text{Nb,Ta,Ti})_2\text{O}_6$, a new aeschynite-type mineral from the Alps

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SUMMARY. A new mineral species, vigezzite $(\text{Ca,Ce})(\text{Nb,Ta,Ti})_2\text{O}_6$, was found near Orcesco, Valle Vigezzo, Prov. Novara, Northern Italy. It forms flat prismatic crystals up to 2-3 mm length of an orange-yellow colour. The crystals are elongated along the *a*-axis and flattened on (010). Cleavage at right angles to the prism axis is distinct, fracture conchoidal. Vickers hardness $\text{VHN} = 396 \text{ kp/mm}^2$, corresponding to 4½-5 in the Mohs scale. Refraction indices are high: $\alpha = 2.14$, $\gamma = 2.315$ (NaD, 589 μm), birefringence is 0.175. Optic angle $2V\gamma$ is large. Though intensively yellow coloured, the mineral shows no pleochroism. $\alpha = c$, $\beta = b$, $\gamma = a$; optic axial plane is parallel to (010).

Vigezzite is orthorhombic with space group *Pmnb* or *P2₁nb*; $a = 7.559 \pm 0.01$, $b = 11.028 \pm 0.01$, $c = 5.360 \pm 0.004$ Å, $Z = 4$. The six strongest lines of the X-ray powder pattern are 4.821 (9) (011), 3.784 (8) (200), 3.036 (10) (031), 2.974 (10) (211), 1.7129 (6) (242), 1.6018 (7) (431).

Electron microprobe analyses lead to the empirical formula $(\text{Ca}_{0.82}\text{Ce}_{0.24})_{\Sigma 1.06}(\text{Nb}_{0.9}\text{Ta}_{0.62}\text{Ti}_{0.5})_{\Sigma 2.02}\text{O}_6$. The mineral is not completely homogenous, the ratio $\text{Nb}/(\text{Nb}+\text{Ta})$ varies from 0.55-0.62. Rynersonite $\text{Ca}(\text{Ta,Nb})_2\text{O}_6$, may represent the Ta-dominant equivalent of vigezzite. Vigezzite occurs together with several other Nb-minerals such as pyrochlore, columbite and fersmite, whose crystallographical and chemical data are reported, in an albitic rock of presumably pegmatitic origin.

MINERAL samples collected by V. Mattioli near Orcesco in Valle Vigezzo (Northern Italy) were sent to Basle for identification. Among these we determined a number of uncommon minerals, one of which turned out to be a new species. Of special interest were Nb-bearing minerals such as pyrochlore, columbite, fersmite, and the new mineral vigezzite.

The name vigezzite was chosen to draw attention to the locality that has produced the first occurrence of a Ca-Nb-Ta-mineral with Nb-dominance over Ta, crystallizing with the aeschynite structure. The description and name of the new mineral were approved before publication by the

Commission on New Minerals and Mineral Names, IMA.

Several specimens of the type-material have been deposited in the Natural History Museum in Basle; the samples prepared for the study are retained in the Mineralogical Institute, University of Basle.

Mineral description. Vigezzite occurs as well-shaped crystals in cavities of an albitic rock. It forms long prismatic crystals up to 2-3 mm in length, elongated along their *a*-axis and flattened on (010).

The crystals are strongly striated on (010) parallel to prism axis. The prisms are terminated by the pinacoids (100) only, which may provide a

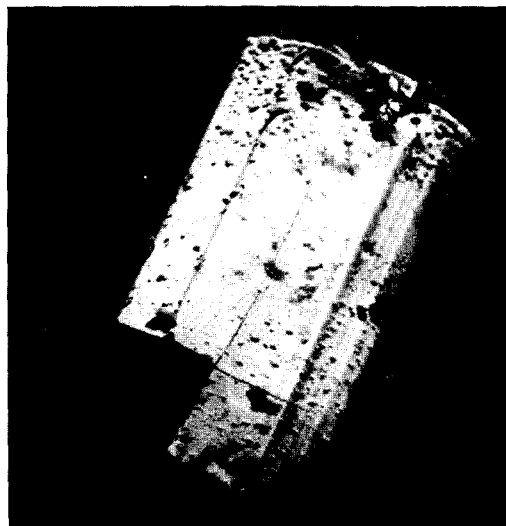


FIG. 1. Morphology of vigezzite: striation parallel to prism axis and distinct cleavage vertical to elongation. SEM picture $500\times$ (length of crystal c. 0.1 mm). [Courtesy of Renato Marsetti.]

means of distinguishing between vigezzite and the associated fersmite, which always displays several bipyramidal faces as termination of the prism.

Vigezzite crystals have an intense orange-yellow colour; fersmite, in contrast, is lemon-yellow in thin crystals and brown-yellow in thicker aggregates. Cleavage at right angles to the prism axis, along (100), is very distinct and can easily be seen under the microscope.

Physical and optical properties. The thin crystals of vigezzite are very brittle. The Vickers hardness was tested on a polished section with a Leitz Durimet microscope and was found to be about 396 kp/mm^2 (with a 50 g load), corresponding to a hardness of $4\frac{1}{2}$ -5 in the Mohs scale.

Under the microscope, vigezzite is completely transparent with yellow colour but shows no pleochroism. It is strongly birefringent and displays extreme dispersion (no complete extinction attainable for white light). The refractive indices lie far above 2.0 and were determined therefore from reflectivity measurements on a polished section with the Leitz MPV photometer microscope. Reflectivity was measured with two different wavelengths (589 μm and 546 μm); sphalerite was used to standardize the photometer.

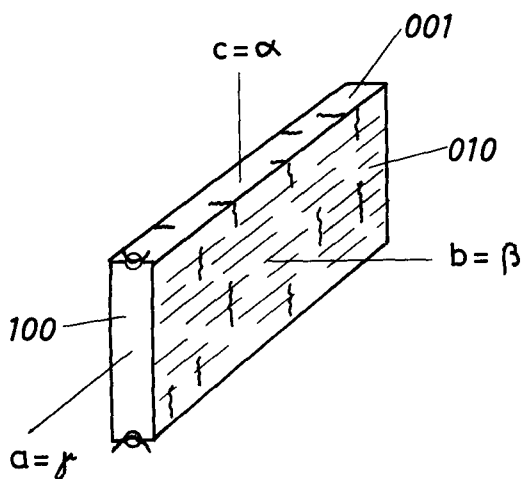


FIG. 2. Crystallographical and optical orientation of vigezzite crystals.

No fluorescence effects could be detected, either for short-wave or for long-wave ultraviolet radiation. Yet, when using the radiation of a common quartz-lamp, a brilliant green fluorescence colour could be observed, as is characteristic for cerium-bearing minerals (Kipfer, 1975). We hoped that this fluorescence effect would make a quick and clear

TABLE I. Physical and optical properties of vigezzite

Hardness:	VHN = 396 kp/mm^2 (= $4\frac{1}{2}$ -5 Mohs's scale)	
Specific gravity:	5.54 g/cm^3 (calculated)	
Refractive indices:	for 589 μm	for 546 μm
	$\alpha = 2.14 \pm 0.02$	$\alpha = 2.23 \pm 0.02$
	$\gamma = 2.315$	$\gamma = 2.385$
Birefringence	= 0.175	= 0.155
Optic angle: $2V\gamma$	= large	$\alpha // [001]$
Elongation l = (+)		$\beta // [010]$
		$\gamma // [100]$

distinction between vigezzite and fersmite, but unfortunately the small Ce-content in fersmite (see Table V) is sufficient to produce a green fluorescence similar to that in vigezzite.

Chemical composition. Preliminary X-ray powder diagrams of the material were not identifiable with any hitherto known pattern and so we decided to study the mineral in a comprehensive chemical and crystallographical investigation. A small idiomorphic crystal was prepared as a polished section for chemical determinations with an ARL electron microprobe. From single crystal photographs and qualitative microprobe analyses it became obvious that the mineral belongs to the group of aeschynite minerals. For quantitative determinations the following minerals were chosen as standards; tantalite, columbite, rutile, monazite (synthetic), albite, hornblende, wollastonite, quartz, etc. Point analyses revealed that the mineral is not really homogeneous but that several elements show variations; particularly variable are Nb and Ta. The values in Table II are the mean of 12 point analyses, the sum of 100.0% was reached accidentally.

TABLE II. Chemical composition of vigezzite

	Wt. %	Cations per 6 (O)		*)	
CaO	12.0	0.82	} 1.06	12.0	CaO
Ce ₂ O ₃	10.5	0.24		10.3	Ce ₂ O ₃
TiO ₂	10.5	0.50		10.5	TiO ₂
Nb ₂ O ₅	31.0	0.90	} 2.02	31.3	Nb ₂ O ₅
Ta ₂ O ₅	36.0	0.62		35.9	Ta ₂ O ₅
	100.0				
		Nb/(Nb + Ta) = 0.59 (total variation 0.55-0.62)			

* Wt. % calculated for vigezzite formula.

Relationship to similar minerals and synthetic crystals will be discussed below. In contrast to vigezzite, analyses of an associated fersmite crystal showed it to be fully homogeneous in chemical composition (Table V).

Crystallography. The crystallographical properties of the mineral were studied by combined Weissenberg and precession techniques. As the mineral occurs in small but well-shaped single crystals, the X-ray photographs were of excellent quality. Weissenberg diagrams were obtained using Cu- K_{α} radiation, while precession diagrams were taken with Mo- K_{α} radiation. The results from both cameras are identical. The lattice parameters in Table III are listed for the condition $c < a < b$ in the orthorhombic case. From this study we found that the morphological prism axis parallels the crystallographical a -axis. The extinctions [$h0l:h+l=2n$; $hko:k=2n$; hoo, oko, ool only for $h, k, l=2n$] indicate a space group symmetry $Pmnb$ or $P2_1nb$, respectively. From the close relationship with the mineral aeschynite it was obvious that $Pmnb$ is the correct space group.

TABLE III. Crystallographic properties of aeschynite-type minerals

	Vigezzite* (Ca,Ce)(Nb,Ti,Ta) ₂ O ₆	CeTiNbO ₆ †	Rynersonite‡ Ca(Ta,Nb) ₂ O ₆
Crystal system	orthorhombic		
a	7.559	7.538	7.595
b	11.028	10.958	11.063
c	5.360	5.396	5.370
$a:b:c$	0.685:1:0.486	0.688:1:0.492	0.678:1:0.484
Space group	$Pmnb$	$Pmnb$	$Pmnb$

* this study.

† aeschynite (synth.) Natl. Bur. Stds. (1964).

‡ Foord and Mrose (1978).

The preliminary study of the unknown mineral by the Debye-Scherrer-technique produced very clear powder diagrams, which were not identifiable with those of any other mineral. This is a remarkable fact, especially when the single-crystal-study proved that the mineral belongs to the aeschynite group. At that time, the mineral rynersonite was not yet published, otherwise the close relations between the two minerals would have led to the false conclusion that they are identical.

The powder diffraction data were obtained from powder spheres in 90-mm-cameras and Fe- K_{α} radiation. In order to check the influence of orientation effects, small single crystal fragments were studied with a Gandolfi camera (114.6 mm, Fe- K_{α}), but no remarkable change of the intensities could be observed. In Table IV, the d -values of vigezzite

TABLE IV. Powder diffraction data for vigezzite, synthetic aeschynite, and rynersonite

Vigezzite (Ca,Ce)(Nb,Ti,Ta) ₂ O ₆			CeTiNbO ₆ †		Rynersonite‡ Ca(Ta,Nb) ₂ O ₆		
hkl	d_{calc}^*	d_{obs}	I/I_1	d_{obs}	I/I_1	d_{obs}	I/I_1
011	4.821	4.821	90	4.841	6	4.835	91
021	3.843	3.854	10	3.847	4	3.856	8
200	3.780	3.784	80	3.773	6	3.754	71
220	3.117	3.117	10	3.106	35	—	—
031	3.032	3.036	100	3.024	80	3.038	100
211	2.974	2.974	100	2.975	100	2.964	91
131	2.814	2.802	20	2.808	20	—	—
040	2.757	2.763	30	—	—	2.767	35
002	2.680	2.684	40	2.698	30	2.683	50
231	2.365	2.367	40	—	—	2.359	50
240	2.227	2.229	30	2.215	10	2.225	25
202	2.186	2.187	5	—	—	2.178	18
212	2.144	2.145	20	—	—	2.138	6
042	1.9220	1.9226	20	1.922	6	1.925	18
400	1.8897	1.8885	30	1.885	20	1.877	25
242	1.7130	1.7128	60	1.712	20	1.711	35
431	1.6037	1.6018	70	—	—	1.596	35
252	1.5527	1.5512	40	—	—	1.552	30
071	1.5115	1.5112	30	—	—	1.518	15
271	1.4034	1.4028	40	—	—	1.406	21

* Calculation based on single crystal data of vigezzite.

† Natl. Bur. Stds. (1964).

‡ Foord and Mrose (1978).

are listed; indexing and calculation of d -values are based on the single crystal data.

Obviously, the powder patterns of the three compounds are very close and would not be helpful for determination purposes. However, it should be stated that natural aeschynite from neighbouring areas (e.g. Binntal, Switzerland, Graeser *et al.* 1976) is clearly distinguishable from vigezzite as well as from rynersonite.

Related minerals. Within a short time two closely related minerals, so far unknown in nature, were described as new species, rynersonite and vigezzite, both belonging to the aeschynite group with identical space group symmetry $Pmnb$ and with similar chemical composition. In agreement with our own belief, Foord and Mrose (1978) in their publication speak of the mineral vigezzite as the Nb-dominant analogue of rynersonite. However, if we consider the fact that the compound with the chemical composition CaNb₂O₆ (the real Nb-analogue of rynersonite) could be synthesized only in a different structure type with space group $Pbcn$ (euxenite group) (Stanley and Simonsen, 1970), then this relationship becomes somewhat doubtful. On the other hand, Komkov (1959) synthesized crystals with chemical composition CeTiNbO₆ and found that they crystallize in the aeschynite space group $Pmnb$. Considering these facts, it seems likely that

vigezzite represents a Ca-analogue of aeschynite rather than a Nb-analogue of rynersonite.

Occurrence and paragenesis. Vigezzite and associated minerals occur in miarolitic cavities of an uncommon albitic rock. According to Italian authors (e.g. Laghi, 1970), it was originally a pegmatite dike in which the potassium feldspar had been changed completely into sodic feldspar (albite) by an albitization process. This dike, formerly more than 100 m long with a thickness of 3–5 m, has been mined for the ceramic industry and is almost completely exhausted today. The pegmatite itself and the surrounding rocks (amphibolite and biotite-gneiss) were influenced by alpidic metamorphism of greenschist to amphibolite facies.

The albitite pegmatite is very rich in minerals which generally have grown in miarolitic cavities and therefore exhibit fine euhedral forms. More than twenty-five different species have been recorded so far (Mattioli, 1978). The most interesting minerals are Be-silicates such as green beryl (emerald) (Boscardin *et al.*, 1976) and colourless bavenite together with the Nb-Ta-minerals such as pyrochlore, columbite, fersmite, and vigezzite. Presumably this locality is the first European occurrence of fersmite.

TABLE V. Crystallographic and chemical data of fersmite, V. Vigezzo

	Wt. %	Cations per 6(O)	
Space group: <i>Pcan</i>	CaO	16.4	1.01
$a = 5.755(3)$	FeO	0.4	—
$b = 14.991(6)$	Ce ₂ O ₃	0.5	—
$c = 5.229(6)$	TiO ₂	0.5	0.02
	Nb ₂ O ₅	66.0	1.72
	Ta ₂ O ₅	16.9	0.26
		100.7	2.0
Nb/(Nb + Ta) = 0.87			

As in the case of vigezzite, the mineral fersmite is free of U and Th and therefore is non-metamict. It occurs in crystals of flat prismatic habit, elongated and striated parallel to the *c*-axis. In contrast to vigezzite, the prisms are always terminated by bipyramidal faces, the colour is always lemon-yellow to brown-yellow.

As mentioned above, there occur at this locality four different Nb-Ta-minerals each belonging to a special structure type: pyrochlore is a cubic mineral, columbite forms a group of its own, fersmite crystallizes in the euxenite type, and vigezzite has the aeschynite structure. From the occurrence in the rock, with pyrochlore and columbite mostly appearing as rock-forming minerals, it seems probable that these two members are the primary minerals from which the other Nb-minerals fersmite and vigezzite were formed by metamorphic processes. A further study is in preparation dealing with problems in geochemistry and petrography of the albitite and the formation of its minerals.

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