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Geological Observations in the Bergell Area (SE-Alps)

II. Contact Minerals from Mt. Sissone—Cima di Vazzeda (A Mineralogical Note)

By *Hans-Rudolf Wenk* (Berkeley)* and *Remo Maurizio* (Vicosoprano)

With 2 figures and 3 tables in the text

Abstract. Chemical data and unit cell dimensions are given for some newly found minerals occurring in the contact zone of carbonate and calc-silicate rocks and amphibolites with the Bergell granite in the Sissone-Vazzeda area. Diopsides show a linear relation between lattice constants and Mg/Fe ratio. Of special interest are a deep blue diopside and scheelite.

The northern contact zone of the granitic rocks of the Bergell with metamorphic rocks of the Margna nappe has been studied geologically by GYR (1967). Discordant contacts of calc-silicates and amphibolites with granite and well preserved lenses of marble which are floating in the granite are the most conspicuous features. These rocks belong to the amphibolite metamorphic facies and show mineral assemblages labradorite-hornblende (E. WENK and KELLER, 1969), and anorthite-diopside-calcite with wollastonite and clinohumite (E. WENK, 1962; E. WENK, 1963; TROMMSDORFF, 1966; SCHWANDER and E. WENK, 1967; E. WENK et al., 1967). The Bergell is known for its abundance of rare minerals, some of them unique for Switzerland. It is surprising that they have been treated only superficially. In addition to the papers mentioned above STAUB (1920), DÉVERIN (1937), NIGGLI et al. (1940), WEIBEL and LOCHER (1964) are the only references we were able to find in the literature on the mineralogy of the area. In recent years (1966–1969) some unusual finds have been made in the area Val Sissone–Cima di Vazzeda–Vadrec del Forno which warrant a description in a short note. Localities are listed in Table 1. Most of the specimens were found in moraines. The original samples are in the mineralogical collection of the museum in Stampa (Ciäsa Granda). The results reported in

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Table 1. *Localities* (coordinates of Swiss maps are used)
All specimens were found in blocks in local moraines

Diopside	1	Val Sissone, 2000 m	777.9/129.5
	2	Alpe Sissone, 2600 m	777.1/130.9
	3	Val Sissone, 2200 m	777.4/129.4
	4	Val Sissone, 2200 m	777.4/129.4
	5	Alpe Vazzeda, 2600 m	777.2/131.8
	6	moraine from Pizzo Vazzeda, Vadrec del Forno, 2600 m	774.7/132.4
Tremolite		same specimen as diopside 4	
Spinel		moraine from Pizzo Vazzeda, Vadrec del Forno, 2600 m	774.7/132.4
Scheelite		Val Sissone, 2500 m	777.0/130.0

this study include microprobe analyses (done by F. Brown at Berkeley: Table 2), and precise determination of lattice constants with a Jagodzinski-type Guinier camera (Fe $K\alpha_1$ -radiation, Si as internal standard, least squares refinement: Table 3).

This short mineralogical note is meant as part of a series of contributions of data to the geology of the Bergell. No effort for completeness is made, nor do we try to propose ultimate interpretations. (See also WENK, 1970a.)

Diopside

TROMMSDORFF (1966) shows a map of the distribution of diopside associated with calcite in the Lepontine Alps. Its occurrence coincides with the zone of highest regional metamorphism. The Bergell is located in the peripheral part of this metamorphic complex. We describe six finds of diopside of various chemical compositions in this area.

1. Dark green prismatic crystals, up to two inches long. Good cleavage. Inclusions in pegmatitic dykes cutting across amphibolites.

2. Tabular idiomorphic crystals in a cavity associated with quartz, feldspar and calcite. Light green color. Many crystals clear. $\frac{1}{8}$ – $1\frac{1}{2}$ ". These crystals were used by LEUNG (1969) to study deformation effects. Under nonhydrostatic stress submicroscopic twinning on (100) was produced (cf. WENK, 1970b).

3. Aggregate of prismatic greyish-green milky crystals in a cavity. Individual crystals reach a size of $1\frac{1}{2}$ ". They are chemically very heterogeneous. The diopside is associated with calcite.

4. Fine-grained turquoise blue diopside intermixed with coarser-grained colorless diopside occurs as the central part of a concentrically zoned lens 2' long and 3" wide (Fig. 1). The blue diopside is surrounded by 1" of white pure tremolite (cf. WENK, 1970c) and 1–2" dark green diopside, rich in Fe. The zoned lens is included in white calcite marble. Due to its conspicuous color the diopside has first been mistaken for lazulite which occurs in the lower metamorphic rocks of the Suretta nappe along the north side of the Bergell Valley.

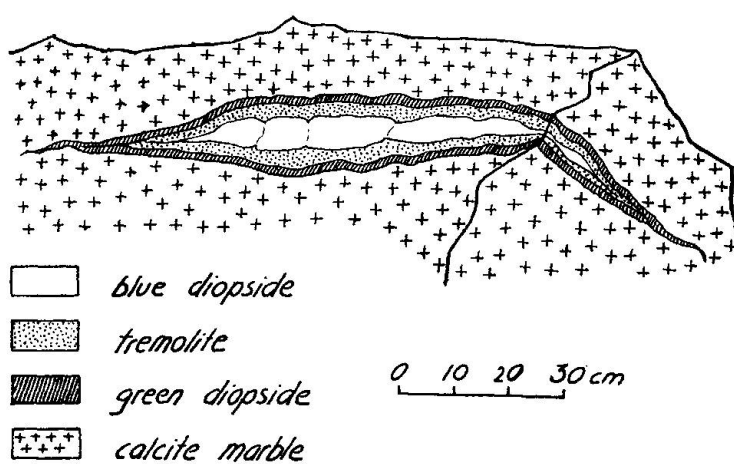


Fig. 1. Schematic sketch of the lens of blue diopside in Val Sissone.

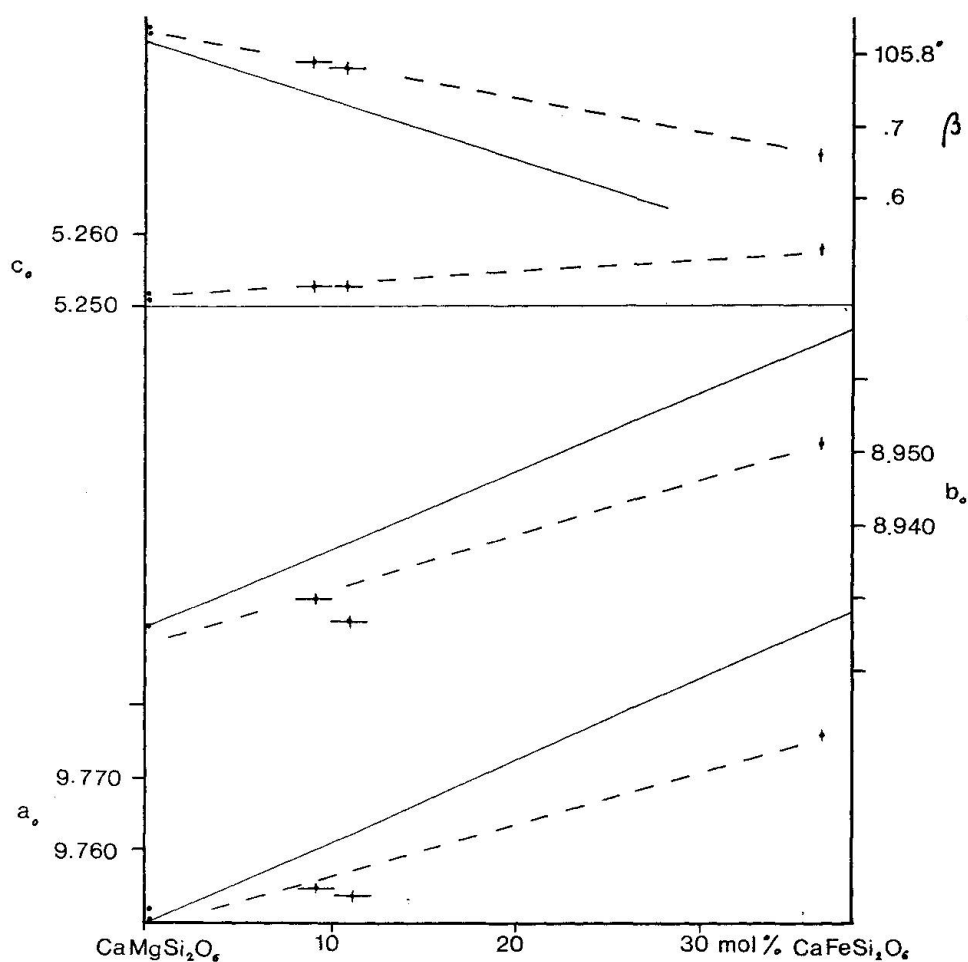


Fig. 2. Relation between lattice constants and Fe/Mg ratio. The fine lines are the ones given by RUTSTEIN and YUND (1969); the dashed lines indicate the dependence found in this study.

Microprobe analyses showed that the coexisting colorless and blue diopside are very similar in chemical composition, almost Fe and Al free. However, there is a significant difference in the vanadium content. The electron beam of the microprobe produces bright blue fluorescence in the blue diopside and a pale pink one in the colorless-type. It is not impossible that this minute chemical difference be due to metasomatic replacement of fossiliferous limestone, as trace elements are often enriched in organic material.

5. In the moraine east of Passo di Vazzeda which is rich in calc-silicate rocks, large white crystals up to 1' long are common. The mineral which could be mistaken for wollastonite with which it is associated, has been identified by GYR (1967) as diopside. It is chemically extremely pure.

6. Similar crystals as are found on the Italian part of P. Vazzeda are carried down to the Forno glacier: they are very common in the northeastern moraine near Cap. Forno which is characterized by colorful carbonate and calc-silicate rocks originating from P. Vazzeda.

The chemical composition of diopsides from the same region varies considerably. A plot of chemical composition (Mg/Fe ratio) versus lattice constants of these genetically related specimens shows a nearly linear correlation which resembles but nevertheless differs from the results of RUTSTEIN and YUND (1969) for synthetic diopsides. It is uncertain whether these differences are caused by conditions during formation or by a more complicated chemistry in the natural crystals (e. g., Al). It indicates, however, that the curves should be used with caution. It is obviously unjustified to generalize results from these few observations, but it appears that:

- the diopsides from carbonate rocks are extremely pure and homogeneous;
- diopsides in cavities (Alpine-type fissures) have an average of 15% Mg (by weight) and show even in clear single crystals large variations in chemical composition;
- diopsides in amphibolites have a composition of close to 50% hedenbergite (see also WENK, 1970b).

Spinel

In marbles and calc-silicate rocks of the Vazzeda region very pure Al-Mg-Zn spinels occur quite frequently. Octahedral crystals which are associated with anorthite, calcite and grossularite are black or dark green and approximately $\frac{1}{8}$ " in size. The marble is fairly coarse-grained.

Scheelite

Scheelite is rare in the Alps. NIGGLI et al. (1940) describe finds of scheelite in the Aarmassiv and in the Simplon railway tunnel. The mineral was so far unknown in the Bergell. In 1967 a specimen of yellow scheelite with idio-

Table 2. Chemical data (determined with an ARL microprobe by F. BROWN). Values are in weight percent

	TiO ₂	SiO ₂	Al ₂ O ₃	FeO	CaO	MgO	MnO	V ₂ O ₃	ZnO
<i>Diopside</i>									
1 Sissone	0.02	52.6	0.8	11.4	24.2	10.8	0.5		
2 Vazzeda	0	55.0	±0.5	2.9	25.0	±16.3	0.4		
3 Sissone	0.1	54.4	0.73	3.46	25.4	15.9	0.2		
4a Sissone blue ¹⁾	0.03	55.2	0.1	0.08	25.7	18.8	0	0.11	
4b Sissone colorless ²⁾	0	55.3	0.1	0.1	25.9	18.6	<0.01	0.03	
5 Vazzeda-Sissone	0.11 (0.03-0.12)	55.4	0.83 (0.49-1.3)	0.14 (2.9-4.0)	25.3 (25.2-25.5)	18.0 (15.2-16.2)	0.03 (0.19-0.27)		
<i>Tremolite</i>	0.01	56.8	0.1	0.24	13.8 ₅	25.5	0		
<i>Spinel</i>	0.02	0.00	69.3	2.97	0.01	24.7			³⁾

¹⁾ bright blue fluorescence ²⁾ pale purple fluorescence ³⁾ corresponds to 3.29% Fe₂O₃

Table 3. Lattice constants determined with a Jagodzinski-type Guinier camera (error is ±0.01%)

	X-ray Nr.	Number of observations	Direct lattice constants		Cell volume V (Å ³)	Reciprocal lattice constants		
			a ₀ (Å)	b ₀ (Å)		a* (Å ⁻¹)	b* (Å ⁻¹)	c* (Å ⁻¹) - β*
<i>Diopside</i>	1a	369	9.775	8.951	443.0	0.10624	0.11172	0.19754
	1b	379	9.777	8.954	443.2	0.10622	0.11169	0.19750
	1a+b	39	9.776	8.952	443.1	0.10623	0.11171	0.19752
	2	378	9.755	8.930	440.4	0.10653	0.11198	0.19785
	3	474	9.754	8.931	440.4	0.10653	0.11197	0.19782
	4a	316	9.750	8.927	439.7	0.10660	0.11202	0.19793
	4b	375	9.751	8.925	439.7	0.10661	0.11204	0.19793
	4a+b	41	9.750 ₃	8.926 ₀	439.7 ₀	0.10660 ₅	0.11203 ₂	0.19793
	5	476	9.752	8.926	439.8	0.10659	0.11203	0.19791
	6	475	9.751	8.924	439.7	0.10658	0.11205	0.19793
<i>Tremolite</i>								
with diopside	4	325	9.844	18.053	907.2	0.10505	0.05539	0.19489
<i>Scheelite</i>								
	346	13	5.2450		312.95	0.19066		0.08791
<i>Spinel</i>								
	322	20 (2 film)	8.089		529.3			0.12360

morphic pyramidal forms, $1/2''$ in size was found in a quartz vein in Val Sissone. It seems to be a product of hydrothermal activity possibly related to the formation of molybdenite in the Forno granite. This hydrothermal activity produced a system of quartz, aplite and pegmatite dykes which penetrate the granite and caused alteration in metamorphic rocks in the vicinity (WENK, 1970a).

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