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Celsian in leucocratic gneisses of the Berisal-complex, Central Alps, Switzerland

by *Erik Frank**

Abstract

The unusual occurrence of the Ba-feldspar celsian in crystalline basement rocks of the Berisal-nappe (Pennine zone, Switzerland) is described. Celsian occurs as a rock forming mineral in light-colored, fine grained zoisite-plagioclase-gneisses, which are distributed as bands or lenses of cm- to meter thickness in granitic k-feldspar augengneisses. Celsian is associated with α-zoisite, quartz, Ba-white mica (oellacherite) and traces of plagioclase (An_{43}).X-ray and chemical data are reported.

INTRODUCTION

Celsian ($BaAl_2Si_2O_8$) is a very rare mineral and has a restricted paragenesis, occuring mainly in skarns or veins in association with manganese deposits (DEER, HOWIE and ZUSSMANN 1967). Various Ba-rich feldspars, including celsian, have also been described from lenses and streaks in acid gneisses at Broken Hill, New South Wales (NOCKOLDS S.R. and ZIES E.G. 1933, SEGNIT E.R. 1946, SPENCER L.J. 1942). The present occurrence reveals remarkable similarity to this latter locality.

FIELD RELATIONS

Celsian could be detected as a rock forming mineral in leucocratic, fine grained zoisite-gneisses which form continuous layers or bands of cm- to meter thickness within granitic k-feldspar augengneisses of the Bersial-nappe in the Simplon area (Lepontine Alps, Switzerland). The contacts are clearly overprinted by Alpine tectonic events. The polymetamorphic Berisal-complex consists mainly of garnet-mica schists, feldspatic gneisses, amphibolites and k-feldspar augengneisses. Relicts of related aplitic and lamprophyric dikes in the augengneisses suggest a granitic origin for these rocks.

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Fresh zoisite-gneiss samples show characteristic white colour, are typically fine grained and look not unlike aplitic rocks. Two distinct types of mineral assemblages can be observed (Table 1): In assemblage A, which is the common one, zoisite can be present with up to 70% in modal content. Plagioclase, having an unusual high anorthite content of 40–60 mol percent, often shows strong inverse zoning. Besides these two minerals margarite, sericite and minor amounts of quartz are present. In a few samples, green hornblende and garnet are also present.

Celsian could be found only in samples with low modal content of plagioclase (assemblage B in Table 1). Obviously, this Ba-feldspar takes the place of anorthite-rich plagioclase in these rocks. Ceslian shows significant higher refractive indices (1.589–1.591) than plagioclase. Twinning in celsian could not be observed in any samples (cf. Fig. 1).

Table 1:

Observed mineral assemblages in zoisite-gneisses

A	B
α-zoisite	α-zoisite
plagioclase (an 30–60%)	celsian
margarite	white mica (oellacherite)
sericite	
quartz	quartz
	± plagioclase

From the metamorphic texture it is evident that zoisite and margarite were formed at the expense of anorthite-rich plagioclase according to the following replacement reaction:

an-rich plagioclase + water = an-poorer plagioclase + zoisite + margarite

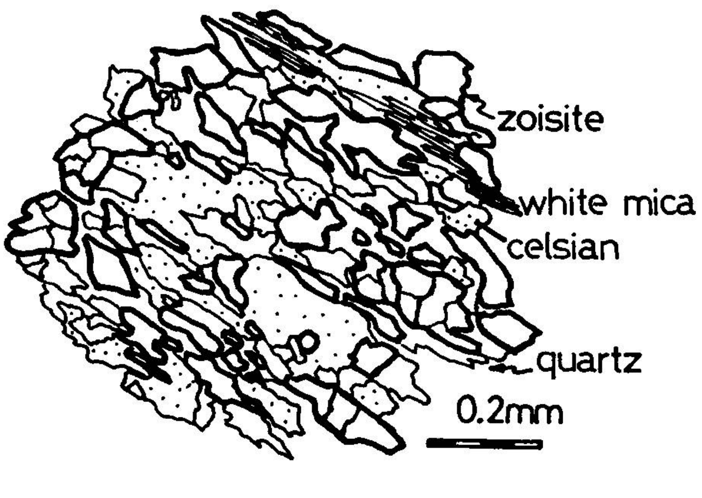

Fig. 1 Textural relationship between zoisite, white mica (oellacherite), celsian and quartz in sample EF 49.

On the other hand the formation of celsian is less clear. The mineral assemblage typically comprises celsian, zoisite, Ba-white mica (oellacherite) and some quartz, whereas plagioclase seems to be nearly absent. The chemistry of anorthite may be quite favourable for the formation of celsian, both having the same Al/Si ratio. However the large differences in ionic size between Ca^{2+} and Ba^{2+} makes such a replacement impossible or requires quite high temperatures for maximum dilatation of the alkalisites.

Conditions of Alpine metamorphism can best be estimated from mineral assemblages of the surrounding Mesozoic cover rocks (Bündnerschiefer). Pelitic rocks (Simplonpass) typically contain staurolite, kyanite, garnet and biotite. In Triassic dolomitic marbles (Steinental) the isobaric "invariant" assemblage talc-tremolite-calcite-dolomite-quartz can be found (FRANK 1979). These observations suggest temperatures of about 470–500 °C at 3–5 kb total pressure.

The extensive occurence of zoisite-quartz and zoisite-margarite-quartz indicate the presence of H_2O-rich fluids in our gneisses (NITSCH and STORRE 1972). The observed replacement reaction of anorthite by zoisite and margarite involves a net addition of water-rich fluids into this rock system. Barium may have therefore been mobilized during Alpine times by fluid phases. Such a migration is also indicated by the occurrence of the Ba-mineral hyalophane in Alpine fissures in this area (GRAESER 1965).

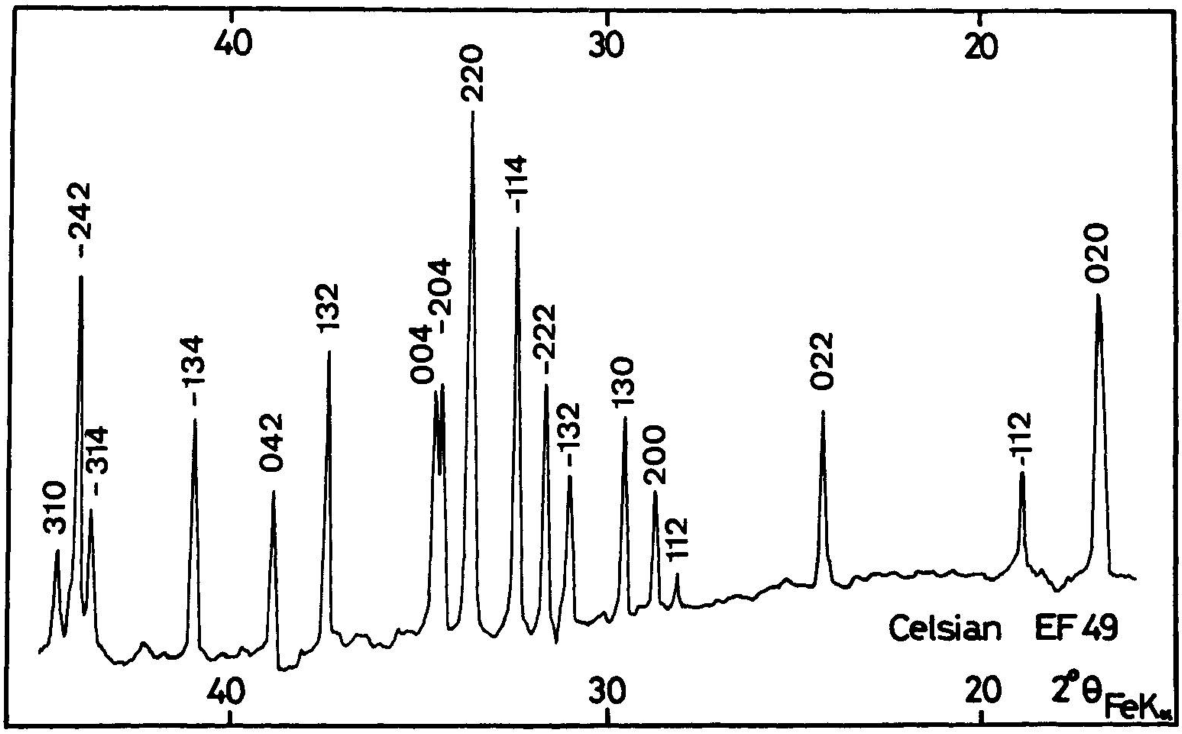

Fig. 2 Recorded intensities of celsian EF 49 (Guinier-film), using a double-beam microdensitometer.

X-RAY ANALYSES

X-ray powder diffraction data were obtained using a Guinier-De Wolff camera (FeKα-radiation). Intensities were recorded by a Joyce Loeble double-beam microdensitometer (Fig. 2). The X-ray powder data of sample EF 49 are listed in Table 2. Both d-values and intensities correspond very well with calculated X-ray data for celsian $(Ba_{0.84}K_{0.18})Al_2Si_2O_8$ reported by BORG and SMITH (1969), and the lines were therefore indexed according to this reference.

Table 2: X-ray powder data for celsian EF 49

$d_{obs.}$	$d_{calc.}$ (BORG + SMITH) a = 8.627 b = 13.045 c = 14.408	hkl	$d_{obs.}$	$d_{calc.}$ (BORG + SMITH) a = 8.627 b = 13.045 c = 14.408	hkl
6.523	6.522	020	2.584	2.584	-242
5.865	5.864	-112	2.580	2.582	114
4.612	4.610	022	2.550	2.551	310
3.998	3.997	112	2.421	2.425	-152
3.903	3.902	200	2.396	2.398	-332
3.800	3.799	130	2.330	2.332	-116
3.626	3.625	-132	2.268	2.269	-334
3.556	3.553	-222	2.214	2.216	152
3.471	3.472	-114	2.171	2.174	060
3.350	3.349	220	2.148	2.148	242
3.280	3.282	-204	2.095	2.097	312
3.261	3.259	004	2.014	2.015	-424
3.020	3.021	132	1.950	1.951	400
2.914	2.916	042	1.798	1.801	-208
2.772	2.774	-134	1.784	1.787	-442
2.604	2.606	-314			

CHEMICAL ANALYSES

Chemical analyses were performed using an ARL-SEMQ electron microprobe supplied with an additional energy-dispersive detector system (TRACOR NORTHERN) at the Mineralogisches Institut University of Basel. All data were corrected using the ZAF computer program. Bulk rock composition was analyzed by XRF- and wet chemical technique.

The chemistry of celsian and coexisting minerals (zoisite, white mica and plagioclase) is listed in Table 3. Our Ba-feldspar revealed nearly pure celsian-endmember composition. No chemical variation could be detected in individual grains. Two analyses, representative for all points (26) measured in sample EF 49, are listed, which give the following formula:

$$(Ba_{0.92}Na_{0.06}K_{0.01}Ca_{0.01})(Al_{1.95}Si_{2.05}O_8)$$

Table 3: Chemistry of celsian, associated minerals and bulk rock composition of sample EF 49.

	celsian	celsian	plagio-clase	white mica	white mica	zoisite
SiO_2	33.70	33.42	57.45	38.10	36.47	39.62
Al_2O_3	27.01	27.20	27.15	37.54	37.44	33.58
FeO				.40	.35	
Fe_2O_3						.43
CaO	.12	.11	9.10			24.81
Na_2O	.51	.57	6.62	1.76	1.69	
K_2O	.10	.14		3.37	2.74	
BaO	38.66	38.52		13.36	15.42	
total	100.10	99.96	100.32	94.53	94.11	98.44
number of ions on the basis of		32(O)	32(O)	22(O)	22(O)	12.5(O)
Si	8.23	8.18	10.27	5.53	5.39	2.99
Al	7.77	7.84	5.72	2.47	2.61	.01
	16.00	16.02	15.99	8.00	8.00	3.00
Al				3.94	3.91	2.98
Fe^{+2}				.05	.05	
Fe^{+3}						.02
				3.99	3.96	3.00
Ca	.02	.03	1.74			2.01
Na	.22	.26	2.29	.50	.48	
K	.03	.04		.62	.52	
Ba	3.70	3.69		.76	.89	
	3.97	4.02	4.03	1.88	1.89	

	bulk
SiO_2	49.96
Al_2O_3	29.72
TiO_2	.05
FeO_{tot}	.39
MgO	.17
CaO	12.96
Na_2O	.20
K_2O	.26
BaO	3.65
P_2O_5	.40
H_2O	2.03
total	99.79

Coexisting white mica turned out to have substantial barium contents ranging up to 15.42 wt% BaO. These micas are known as oellacherite (DEER, HOWIE + ZUSSMANN). However, the present analyses seem to show the highest BaO content ever found in white mica. They show furthermore characteristic high Al/Si ratios, leading to the following structural formula:

$(Ba_{0.89}K_{0.52}Na_{0.48})Al_{3.91}Fe_{0.05}(Si_{5.39}Al_{2.61}O_{20})(OH)_4$

Obviously this Ba-mica contains considerable paragonite in solid solution. No margarite component is present.

Only few grains of plagioclase are present in sample EF 49, showing anorthite contents of 40–46 mol percent. No BaO could be detected in these grains.

The bulk composition of the zoisite-gneisses shows very high aluminium and calcium contents, pointing to an anorthositic chemistry. We find in sample EF 49 a noticeable BaO content of 3.65 wt%. Conclusions concerning the genetic origin of these rocks and possible relations to the granitic augengneisses must remain open until further results are available.

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