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Geikielite and perovskite in serpentine-brucite marble from Baltistan, Northern Areas (Kashmir), Pakistan

IN his 1901 memoir, McMahon described a greenish yellow calcareous serpentine from the Skiu valley, Shigar, Baltistan, as bowenite (or pseudo-jade) which, because of its hardness (H5), has been used extensively in the local manufacture of cups and vases, and is known as Zehirmora. A specimen of this rock (BM 1985,P39), recently donated to the British Museum (Natural History) by Dr A. G. Stewart, has been examined and shown to contain the rare ilmenite-group mineral geikielite ($MgTiO_3$).

The sample consists of completely serpentinized, sub-idioblastic olivine, together with rounded aggregates of fibrous brucite (after periclase?) in calcite matrix. Near-opaque grains of geikielite occur as tiny clots in the matrix between serpentine pseudomorphs. The high proportion of Mg-phases relative to calcite probably resulted from the segregation of Mg-rich minerals during metamorphism of impure dolomite. Lizardite, brucite, calcite, chlorite, perovskite and geikielite were identified by X-ray powder diffractometry. In order to reduce background radiation substantially and allow the positive identification of geikielite and perovskite, a small hand-separated opaque-grain sample (approximately 100 μg) was powdered and mounted on a single-crystal silicon substrate for diffractometry. Electron microprobe analysis of the geikielite-rich phase (Table I) indicates a solid-solution composition between the end-members geikielite ($MgTiO_3$), pyrophanite ($MnTiO_3$) and ilmenite ($FeTiO_3$), with atomic proportions $Mg_{79}Mn_{14}Fe_7$. No significant compositional variation or zoning is present within geikielite grains.

Perovskite, almost pure $CaTiO_3$ in composition, occurs as mantling overgrowths around geikielite (fig. 1) and also as small ($\sim$ 10 μm) isolated cubes in the serpentine and calcite near to geikielite grains. The perovskite mantles consist of fine-grained aggregates of individual ($\sim$ 10 μm) crystals of near-cubic shape. Clearly, perovskite crystallized later than geikielite, probably during the serpentinization episode, but it is uncertain whether this involved Ti diffusion through calcite, resulting in perovskite nucleation and growth around geikielite, or whether a reaction occurred between calcite and geikielite to produce perovskite with the loss of Mg, Mn, and Fe, by diffusion from the reaction zone during geikielite breakdown. The observations that geikielite is nowhere in contact with calcite or serpentine, and that the serpentine pseudomorphs (after olivine) are not embayed, suggest that a reaction took place in which perovskite grew at the expense of calcite and geikielite.

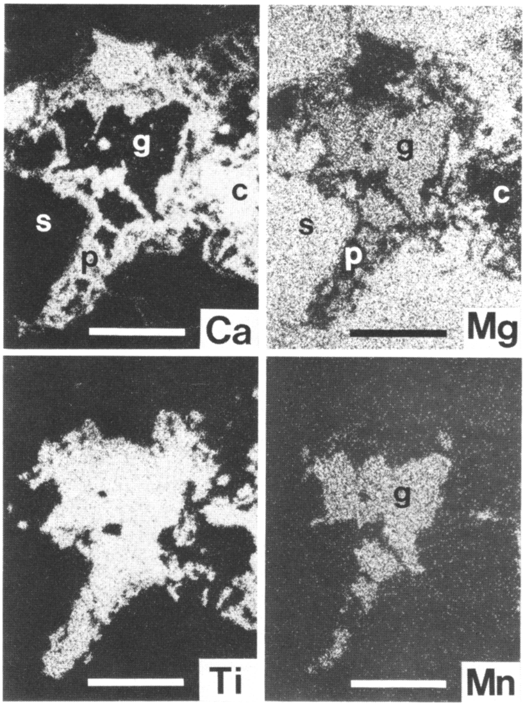

FIG. 1. Scanning electron microprobe X-ray images of geikielite (g) with perovskite mantle (p), surrounded by calcite (c) and serpentine (s), showing distribution of Ca, Mg, Ti, and Mn. Scale bars 100 μm.

In transmitted plane-polarized light, very thin sections of the geikielite are weakly pleochroic with *e* pinkish brown and *o* yellow-brown. In reflected plane-polarized light the mineral is strongly bireflectant from *e* brown-grey to *o* silvery grey, with no reflectance pleochroism. Quantitative reflectance data obtained by microscope photometry in the range 400 to 700 nm are given in Table II. Refractive indices (*n*) and absorption values were calculated using the Koenigsberger equations. At 590 nm $n_o = 2.23$ and $n_{e'} = 2.00$. It is interesting to note that calculations based on these reflectance data indicate that absorption increases towards the red end of the spectrum, becoming strong at 700 nm. However, since geikielite appears deep red-brown in transmitted light, absorption probably decreases rapidly at wavelengths slightly greater than 700 nm (just outside measurement range). A similar phenomenon was observed for ilmenite, measured for comparison, where the calculated strong absorption towards the red end of the spectrum suddenly decreases at 700 nm, thus providing a transmission window in the spectrum which will contribute significantly to the deep orange-red appearance of ilmenite in transmitted white light. Reflectance data, presented by Cervelle (1967) between 420 and 640 nm for a range of ilmenite-geikielite solid solutions, indicate a decrease in reflectance values with an increase in Mg content. Reflectance values reported here are close to those given by Cervelle for a geikielite with 25.7 wt. % MgO.

Although ilmenites with substantial geikielite components (picroilmenites) occur in kimberlites (Wyatt, 1979), phases with > 70% $MgTiO_3$ end-member component have been reported only from metamorphosed magnesian limestones (Murdoch and Fahey, 1949; Wise, 1959) or associated with chromite in serpentinites (Efremov, 1954). The occurrence of geikielite reported here is in accord with the metamorphosed Mg-limestone paragenesis, but this geikielite has a composition much richer in the pyrophanite component ($MnTiO_3$) than geikielites previously described.

TABLE I. GEIKIELITE: MICROPROBE ANALYSIS

	wt%	cations per 3 oxygens	
MgO	25.0	Mg	0.783
MnO	8.1	Mn	0.144
FeO	3.9	Fe	0.068
CaO	0.3	Ca	0.007
SiO_2	0.2	Si	0.004
TiO_2	63.0	Ti	0.995
	100.5		

Energy dispersive analysis at 15kV

TABLE II. GEIKIELITE: REFLECTANCE DATA

	Air		Oil	
λnm	R_o	$R_{e'}$	R_o	$R_{e'}$
400	17.7	13.9	5.51	3.25
420	17.25	13.5	5.19	3.09
440	16.8	13.1	4.97	2.91
460	16.4	12.75	4.76	2.74
480	16.1	12.45	4.58	2.60
500	15.8	12.2	4.40	2.49
520	15.5	12.0	4.29	2.42
540	15.4	11.85	4.23	2.37
560	15.3	11.8	4.20	2.36
580	15.2	11.75	4.20	2.37
600	15.2	11.7	4.24	2.40
620	15.2	11.8	4.31	2.48
640	15.3	11.8	4.44	2.59
660	15.3	11.8	4.56	2.71
680	15.35	11.8	4.72	2.84
700	15.4	11.8	4.78	2.92
Colour values relative to illuminant C				
x	0.304	0.303	0.302	0.301
y	0.307	0.306	0.300	0.296
Y%	15.4	11.9	4.3	2.4
λ_d	469	468	449	c567
P_e%	3.6	3.9	5.6	6.7
Colour values relative to illuminant A				
x	0.442	0.442	0.443	0.444
y	0.404	0.403	0.399	0.396
Y%	15.3	11.8	4.3	2.4
λ_d	482	481	c578	c576
P_e%	1.5	1.6	2.2	3.5

c = complementary wavelength in oil. This may result from the contribution of a blue/red (purple) component from internal reflections. This effect is more marked in the less reflective e' direction.

All R% values measured relative to SiC standard, Zeiss no.472, using conditions and equipment described in detail by Criddle et al. (1983).

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An occurrence of the hydrous lead-copper-iron silicate creaseyite in South Africa

CREASEYITE, a hydrous lead-copper-iron silicate $Cu_2Pb_2(Fe,Al)_2Si_5O_{17}\cdot 6H_2O$ was first described by Williams and Bideaux (1975) from Arizona and Sonora, Mexico, followed by a later report from the Rio Negro province in Argentina by Hayase and Dristas (1978). During a recent investigation of the iron formations and gossans of Bushmanland in Proterozoic metamorphites from the Namaqua mobile belt, creaseyite and other rare secondary minerals were identified. Creaseyite from the iron-formation of the Aggeneys Mountains is, as far as known, the fourth reported occurrence in the world and is the first to be described on the African continent.

Occurrence. The minerals occur in the oxidation zone of the lead-zinc-copper ore body at Black Mountain, near Aggeneys. Creaseyite is found in close association with other secondary silicates (such as dioptase and chrysocolla), sulphates, phospho-sulphates, and sulpho-carbonates (anglesite, linarite, beaverite, brochantite, plumbojarosite, pyromorphite, corkite, leadhillite, and caledonite), as well as the chlorides atacamite, paratacamite, and diaboleite. Creaseyite seems to have been one of the last minerals to form and occurs in veinlets (fig. 1*a*) together with blue anglesite as a fine earthy, yellowish-green powdery substance on magnetite/hematite. Two varieties, one yellowish-green (analysis no. 1) and the other (no. 2) slightly darker green in colour, were observed. The material is, however, only obtainable in minute quantities.