SEVERAL SPINELS FROM THE SKALLEVIKHALSEN REGION, EAST COAST OF LÜTZOW-HOLMBUKTA, EAST ANTARCTICA

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Abstract: Mineralogical studies of six spinels from calcareous metamorphic rocks of the Skallevikhalsen region, east coast of Lützow-Holmbukta, East Antarctica, were performed. These spinels show a variety of colors with the unaided eye. The unit cell dimensions calculated from the powder X-ray diffraction data are $a_0=8.09$ Å to 8.13 Å. The quantitative chemical analysis of these minerals was made with an electron probe X-ray microanalyzer. Their compositions are spinel molecule ($MgAl_2O_4$) 90.3% to 97.3%, hercynite molecule ($Fe^{2+}Al_2O_4$) 2.7% to 7.8%, and gahnite molecule ($ZnAl_2O_4$) 0.0% to 5.9%. Pink spinel contains a high percentage of spinel molecule ($MgAl_2O_4$ =97.3%), purplish spinels include a small percentage of hercynite molecule ($Fe^{2+}Al_2O_4$=3.8–4.5%) and gahnite molecule ($ZnAl_2O_4$=4.2–5.9%), and greenish spinels include a small percentage of hercynite molecule ($Fe^{2+}Al_2O_4$ =5.8–7.8%). These are identified as the spinel, ferro-zincian spinel and ferroan spinel, respectively.

1. Introduction

The Skallen and Skallevikhalsen regions lie on the east coast of Lützow-Holmbukta, East Antarctica, and are situated about 60 km south of Syowa Station, East Ongul Island. The geological survey of these regions was performed by a Japanese geologist in 1957, and since then some members of the Japanese Antarctic Research Expeditions visited the regions with various scientific objectives.

The geology and geomorphology of these regions were outlined by TATSUMI and KIKUCHI (1959) and the brief petrography was presented by TATSUMI *et al.* (1964). The geological map (1:25000) of the Skallen and Skallevikhalsen regions was compiled by M. YOSHIDA *et al.* (1976). In addition to that, YOSHIDA (1977, 1978) reported that among the geologic structures of these regions, the first major fold is characteristically of recumbent type. On the other hand, SUWA *et al.* reported on pargasite and zincian spinel in calcareous metamorphic rocks from these regions (SUWA and TATSUMI, 1969).

In August 1975, spinel crystals of various colors seen with the unaided eye were discovered from calcareous metamorphic rocks of the Skallevikhalsen region by the author. These samples were collected by the author and Mr. M. FUNAKI in the geoscientific party of the 16th Japanese Antarctic Research Expedition 1974–

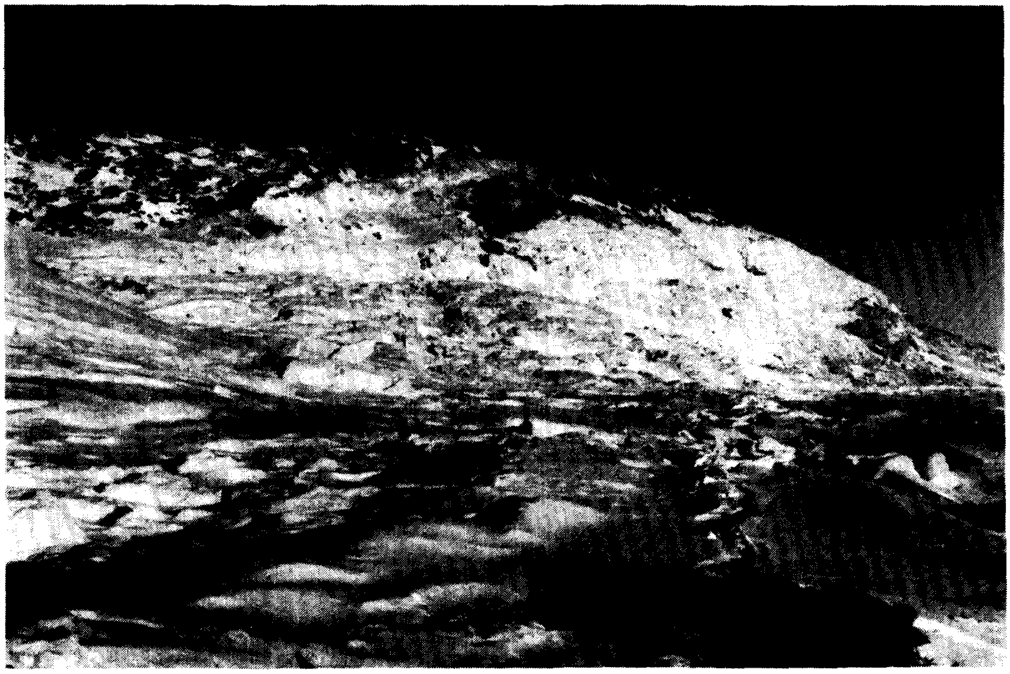

Fig. 1. Alternating beds of spinel-bearing calcareous metamorphic rocks (white part) and gneissose rocks (black part) in the Skallen Group, northeast of the Lake Dairi of the Skallevikhalsen region.

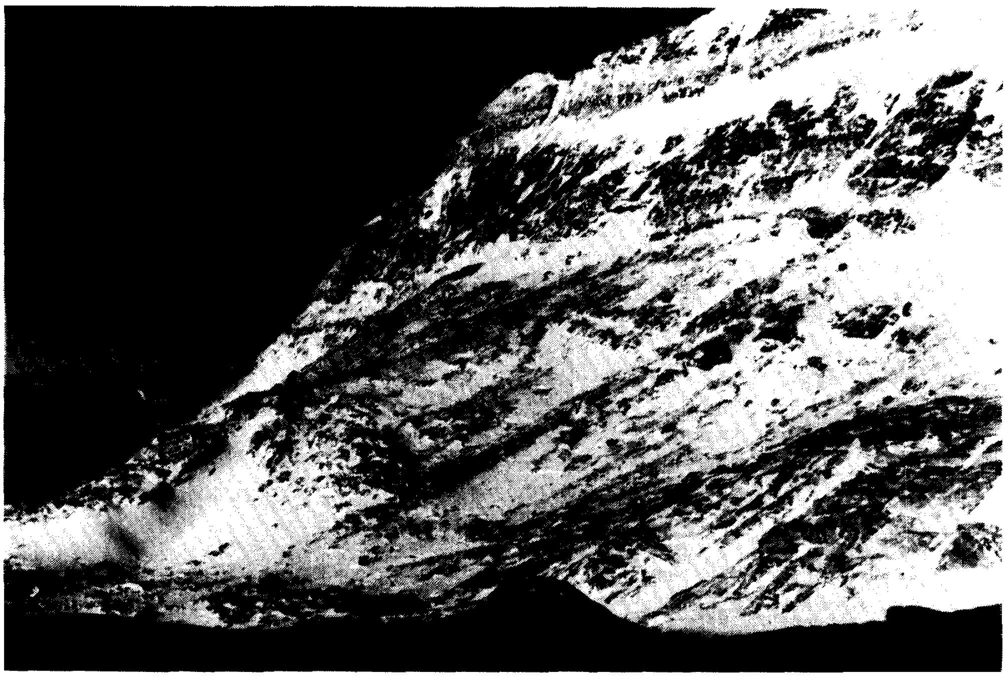

Fig. 2. Outcrop of calcareous metamorphic rocks (gray part) in the Skallen Group, northeast of the Lake Dairi of the Skallevikhalsen region.

Fig. 3. Photomicrograph of forsterite in calcite from calcareous metamorphic rocks. Crossed nicols. Long dimension of photograph = 1.3 mm.

1976 (JARE-16).

Mode of occurrence and mineralogical description of several spinels are given in the present paper.

2. Geological Sketch and Mode of Occurrence of Spinels

In the Skallevikhalsen region, the crystalline basement rocks consist of paragneisses, metabasites, marbles, karns and allied rocks, quartzite, garnet gneissose granite, charnockites, and minor intrusives (Figs. 1 and 2). Most of these rocks belong to the Skallen Group of YOSHIDA (1977, 1978). These basement rocks are gently or moderately inclined to the north or the south with the east-west trend. Complicated and superposed folds are developed throughout the regions.

The host rocks of spinels are calcareous metamorphic rocks, which are leucocratic marbles with scattered colored minerals on the northeastern side of the Lake Dairi of the Skallevikhalsen region. These rocks are coarse-grained, and equigranular, being composed of calcite, forsterite (Fig. 3), phlogopite, dolomite, spinel, monoclinic pyroxene and amphibole, with apatite and scapolite as accessories. Serpentine is generally associated with forsterite.

Generally, phlogopite rock occurs as small-sized (5 cm to 30 cm) irregular xenolithic blocks in the marble zone. The rock is characterized by the predominance of golden brown phlogopite, monoclinic pyroxene, amphibole, scapolite and spinel, with such accessories as pale blue or pale green apatite, wollastonite and pale blue corundum. This rock is coarse or very coarse-grained and inequigranular. Compositional banding parallel to the margin of the xenolithic block is developed.

In the world, spinel occurs typically as a product of contact metamorphism of impure dolomitic limestone, often with forsterite and diopside (SERDYUCHENKO and MOLEVA, 1958). It is found in a similar association in regionally metamorphosed limestone where it may occur with calcite and phlogopite (ECKERMANN, 1922).

3. Mineralogical Properties of Spinels

The spinels from the Skallevikhalsen region are a variety of colors with the unaided eye, *viz.* pink, pinkish purple, clear purple, green, blackish green and dark green (Fig. 4). Individual spinels in octahedral crystal are 1 mm to 10 mm in diameter. In these spinels, distinct octahedral (111) parting is developed (Fig. 5). Specific gravity is 3.6 to 3.7 at 17°C, and hardness is 7.5 to 8.0. Refractive index is $n_D = 1.721 + 0.003$.

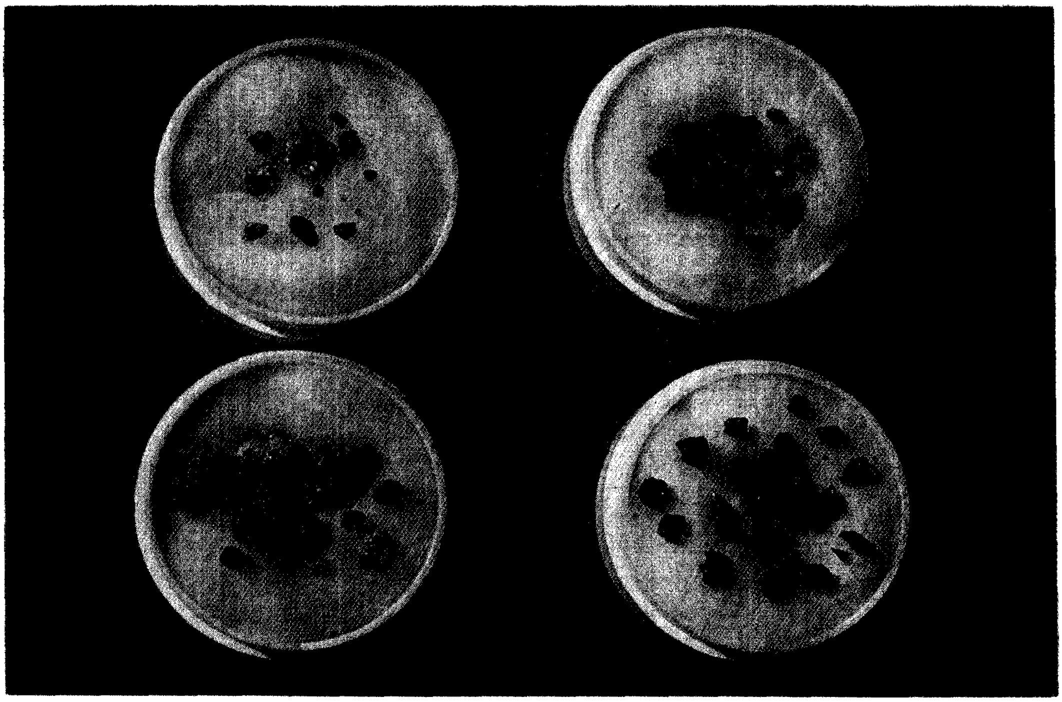

Fig. 4. Photograph of spinels from the Skallevikhalsen region. These are a variety of colors with the unaided eye, viz. upper: from left to right pink, pinkish purple, and lower: clear purple, green.

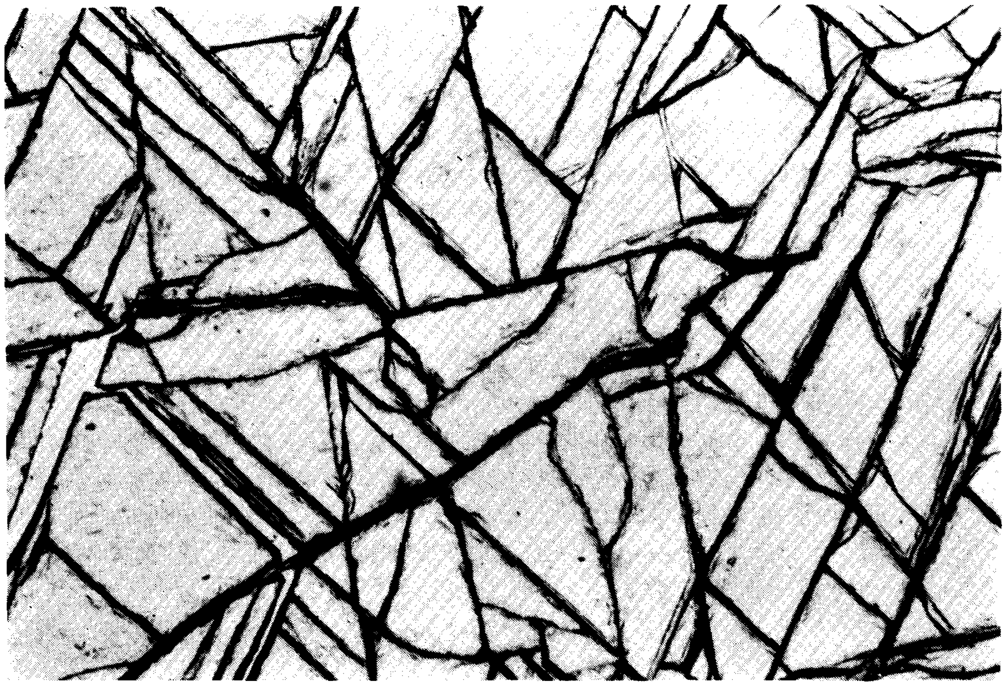

Fig. 5. Photomicrograph of clear purple spinel in carcareous metamorphic rocks. Distinct octahedral (111) parting is developed. One nicol. Long dimension of photograph =1.3 mm.

Powder patterns were taken up by a Norelco Geiger counter X-ray diffractometer using Kα radiation. Pure silicon was used as the internal standard. Table 1 shows the results of measurement of X-ray diffraction on these spinels. The unit cell dimensions calculated from the powder X-ray diffraction data are a_0 = 8.09 Å to 8.13 Å, *viz.* pink spinel = 8.09 Å; purplish spinel = 8.10 Å and 8.11 Å; greenish spinel = 8.10 Å, 8.10 Å and 8.13 Å. These results indicate that are not recognized as distinct relation between the colors and the unit cell dimensions. These values of unit cell dimension are only slightly larger as compared with synthetic pure spinel (a_0 = 8.0831 Å), which is based on ASTM card, and are exactly in harmony with SUWA's data of zincian spinel (a_0 = 8.09 Å) (SUWA and TATSUMI, 1969).

The quantitative chemical analysis of six spinels was made with a JEOL JXA-5A electron probe X-ray microanalyzer. And the chemical compositions are given in Table 2, in which the numbers of ions on the basis of 4 oxygens and molecular proportions for these spinels are also given. These compositions are spinel molecule ($MgAl_2O_4$) 90.3% to 97.3% (mol. prop.), hercynite molecule ($Fe^{2+}Al_2O_4$) 2.7% to 7.8%, gahnite molecule ($ZnAl_2O_4$) 0.0% to 5.9%, and galaxite molecule ($MnAl_2O_4$) 0.0%. According to SUWA and TATSUMI (1969), compositions for zincian spinel from the Skallevikhalsen region are spinel molecule 87.3% to 89.8%,

Table 1. X-ray diffraction powder patterns and unit cells for spinels from the Skallevikhalsen, East Antarctica.

ASTM card			1	2	3	4	5	6	7	
Color			Pink	Pinkish purple	Clear purple	Green	Blackish green	Dark green	Clear purple	
hkl	*I*	*d* (Å)	*d* (Å)	*d* (Å)	*d* (Å)	*d* (Å)	*d* (Å)	*d* (Å)	*d* (Å)	*I*
		—	10.09	10.27	—	—	—	—		5
111	35	4.66	4.68	4.71	4.68	4.70	4.68	4.69		30
220	40	2.858	2.862	2.875	2.864	2.873	2.864	2.862		80
311	100	2.437	2.439	2.445	2.444	2.448	2.442	2.440		100
222	4	2.335	—	—	2.341	—	—	—		3
400	65	2.020	2.020	2.025	2.025	2.026	2.025	2.023		90
422	10	1.650	1.652	1.654	1.653	1.655	1.653	1.652		5
511	45	1.5554	1.5565	1.5594	1.5580	1.5579	1.5575	1.5575		80
440	55	1.4289	1.4304	1.4316	1.4304	1.4324	1.4304	1.4308		40
531	4	1.3662	—	—	1.3682	—	—	—		5
Unit cell (Å)	a_0	8.0831	8.09	8.11	8.10	8.13	8.10	8.10	8.09	

No. 1. Spinel, No. 75082617.
No. 2. Ferro-zincian spinel, No. 75082618.
No. 3. Ferro-zincian spinel, No. 75082619.
No. 4. Ferroan spinel, No. 75082620.
No. 5. Ferroan spinel, No. 75082623.
No. 6. Ferroan spinel, No. 75082624.
No. 7. Ferro-zincian spinel (zincian spinel by SUWA and TATSUMI, 1969), No. JARE-75102734.

hercynite molecule 5.9% to 6.9%, gahnite molecule 4.3% to 5.6%, and galaxite molecule 0.0% to 0.2%. Consequently, as compared with SUWA's data, spinels in this paper have a slightly higher content of spinel molecules.

On the basis of the above results, pink spinel contains high percentage of spinel molecule ($MgAl_2O_4$=97.3%), clear purple and pinkish purple spinels include a small percentage of hercynite molecule ($Fe^{2+}Al_2O_4$=3.8–4.5%) and gahnite molecule ($ZnAl_2O_4$=4.2–5.9%). Green, blackish green and dark green spinels include a small percentage of hercynite molecule ($Fe^{2+}Al_2O_4$=5.8–7.8%). Consequently, pinkish, purplish and greenish spinels are distinctly identified with the spinel, ferro-zincian spinel and ferroan spinel respectively.

Generally, the zincian spinels are blue in color and sometimes anomalously pleochroic, the blue color being due to ferrous iron (ANDERSON and PAYNE, 1937). According to SCHLOSSMACHER and MAYER (1931), analytical work on colored

Table 2. Chemical compositions, atomic ratios and molecular proportions for spinels from the Skallevikhalsen, East Antarctica.

No.	1	2	3	4	5	6	7	8
Color	Pink	Pinkish purple	Clear purple	Green	Blackish green	Dark green	Clear purple	Clear purple
SiO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00
Al_2O_3	70.79	70.99	68.44	69.58	70.12	70.29	69.28	69.36
Cr_2O_3	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00
FeO	1.32	1.83	2.36	3.98	2.85	3.04	3.35	2.99
MnO	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00
MgO	27.29	24.00	27.16	26.88	26.60	26.66	23.78	25.31
ZnO	0.00	3.24	2.51	0.00	0.00	0.00	3.09	2.46
NiO	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
CoO	—	—	—	—	—	—	0.05	—
Total	99.40	100.40	100.47	100.44	99.57	99.99	99.85	100.12
Numbers of ions on the basis of O=4.00								
Al	2.004	2.009	1.951	1.997	1.997	1.994	1.998	1.986
Fe^{2+}	0.027	0.038	0.048	0.081	0.058	0.062	0.067	0.060
Mg	0.967	0.890	0.980	0.953	0.947	0.946	0.867	0.917
Zn	0.000	0.058	0.045	0.000	0.000	0.000	0.056	0.044
Fe+Mg+Zn	0.994	0.986	1.073	1.034	1.005	1.008	0.990	1.021
Mol. prop. (%)								
$MgAl_2O_4$	97.3	90.3	91.3	92.2	94.2	93.8	87.3	89.8
$FeAl_2O_4$	2.7	3.8	4.5	7.8	5.8	6.2	6.9	5.9
$ZnAl_2O_4$	0.0	5.9	4.2	0.0	0.0	0.0	5.6	4.3
$MnAl_2O_4$	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0

Nos. 1–7 are same as Table 1.
No. 8. Ferro-zincian spinel (zincian spinel by SUWA and TATSUMI, 1969).

spinels from Ceylon has shown the red color to be due to chromium, the blue to Fe^{2+} and the brown to Fe^{3+}, with the intermediate shades of reddish brown and violet due to mixture of these ions.

According to SUWA and TATSUMI (1969), zincian spinels have a clear purple color with the unaided eye, and include a small percentage of hercynite molecule ($Fe^{2+}Al_2O_4$=5.9–6.9%) and gahnite molecule ($ZnAl_2O_4$=4.3–5.6%). Accordingly, these are recognized as ferro-zincian spinel in this paper.

Acknowledgments

The author wishes to express his gratitude to Prof. T. HOSHIAI of the National Institute of Polar Research, for his kind suggestion and valuable advice on the survey by the winter geoscientific party of JARE-16. The author is much indebted to Mr. M. FUNAKI of the National Institute of Polar Research for his help in collecting samples. The author is grateful to Dr. K. SUWA of Nagoya University for his help with the experiments.

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(*Received September 11, 1981*; *Revised manuscript received November 30, 1981*)