samples is given in Table I, from which it is apparent that the composition is variable within each specimen, the Cr_2O_3 content lying between 4 and 8%. The latter is high for a muscovite, as most analyses in the literature do not exceed 5% Cr_2O_3 unless the mica is phengitic. Thus Rumyantseva *et al.* (1984) report 17.93% Cr_2O_3 but with only 4.00% Al_2O_3 and 51.70% SiO_2 (i.e. Si : Al 22 : 1) in a chromium phengite. Deer *et al.* (1962) report the highest Cr_2O_3 on record up to that date as 6.08% (Whitmore *et al.*, 1964). The association of the present fuchsite matches best with the ankerite-quartz-sulphide-gold grouping of Whitmore *et al.* (1946) although the carbonate is not ankerite. The high content of K in the fushsite means that even if the modal proportions of the mineral were only 0.5%, the K content of the rock, assuming no other mineral contains K, would be 0.055% K_2O, which is too high to be derived isochemically from most ultramafic igneous rocks (Wedepohl, 1969). The implication is that some K was introduced in the fluids that carbonated the original igneous rock. The relatively high Ni content of the fuchsite, reaching a maximum of over 1% NiO is also unusual and is linked with a small phengitic substitution giving the highest ratio of Si : Al of 1.60 : 1 which is still a long way from the 3 : 1 lowest ratio of phengite (Deer *et al.*, 1962). Ni is a relatively unusual component of muscovites but was presumably derived from the original ultramafic rock.

The variegated green colour of the virginite therefore largely derives from the composition of the breunnerite with a small contribution from the unusually high, but varied, Cr content of the fuchsite. It seems likely that a more extensive search in the Baie Verte fracture zone would identify fuchsite with even more Cr and Ni.

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Department of Geology, University of Glasgow, Glasgow G12 8QQ
and
Department of Geology, University of Western Australia, Nedlands, WA 6009

F. CHAO
C. M. FARROW
B. E. LEAKE

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High potassium-chlorine-bearing hastingsites in skarns from Primorye, Far East USSR

CHLORINE-BEARING potassium amphiboles are typical of metasomatites from ore deposits, particularly iron-ores, but sometimes occur in granites, potassic syenites, and gneisses (Krutov, 1936; Hallimond, 1947; Ontoev, 1958: Geijer, 1960; Serdyuchenko, 1960; Kalinin, 1983; Lobanova, 1963; Pavlov, 1964; Deer *et al.*, 1965; Vakhrushev, 1965; Knyazev, 1966; Kostyuk, 1970; Leake, 1978; Dick and Robinson, 1979; Minerals, 1981; Sharma, 1981; Kamineri and Bonardi, 1982). A high chlorine content is the most typical feature of amphiboles from metasomatites of iron-ore deposits (Minerals, 1981). The initial discovery was a Cl-K amphibole with chlorine content of 7.24 wt. % in the Dashkesan skarn-ore deposit (Krutov, 1936). About twenty further occurrences are known at the present time.

Geological setting. Cl-K amphiboles appear to be widespread in the Primorye skarns. They were recognized in skarns of the Pershinskoe skarn-magnetite deposit (the Olginsky district), Novogorbushinskoe skarn deposit (the Dalnegorsk region), and skarns of the Komsomolsk ore region (fig. 1).

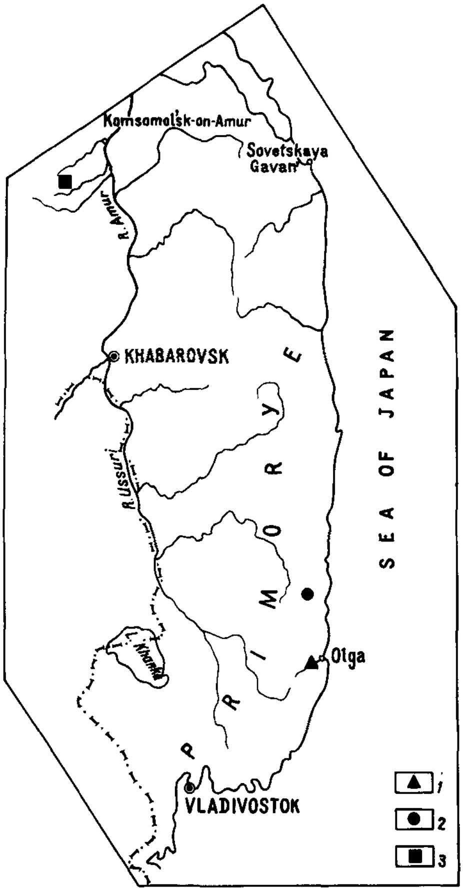

FIG. 1. Cl-K amphibole location map: (1) the Pershinskoe deposit (the Olginsky region); (2) the Novogorbushinskoe deposit (the Dalnegorsk region); (3) the Magnetite zone (the Komsomolsk ore region).

Lenticular skarn-magnetite bodies of the Pershinskoe deposit are localized at the contact of the Upper Cretaceous granites of the Vladimirsky massif with sandstones and Upper Palaeozoic limestones. Dykes of aplites and potassium-granosyenite (61.33 wt. % SiO_2, 2.26 wt. % Na_2O, 11.02 wt. % K_2O) cut skarns. Magnetite, manganese (apophyllite, cuspidine, etc.), fluorine (fluorite, etc.), and quartz-cassiterite-sulphide mineralization is superimposed upon the skarns (Gulyaeva and Shcheka, 1984).

A horizontal metasomatic zonation is clearly observed in skarn zones of the Pershinskoe deposit: (1) garnet skarn with rare magnetite and pyroxene inclusions (at the contact with sandstones); (2) magnetite-garnet and garnet-magnetite skarns with, in places, garnet-pyroxene and pyroxene-amphibole skarns (the central part); (3) garnet-pyroxene skarn with magnetite (the contact with limestones, sometimes with hornfels).

Chlorine-bearing potassic amphibole, belonging to the hastingsite series, is widespread in the central part and is confined to exocontacts of potassic granosyenite veins. It shows a relationship between potassic metasomatism of rocks in the Pershinskoe deposit and the origin of post-skarn veins and dykes of potassic granosyenite.

The growth of Cl-K-bearing amphibole followed the formation of skarns and magnetite mineralization; it replaced garnet of the andradite-grossular series and pyroxene of the diopside-hedenbergite series and was replaced in turn by actinolite, epidote, and chlorite.

Some cores have been drilled in the Novogorbushinskoe skarn polymetallic deposit, the geology of which is still poorly studied. Hedenbergite, garnet, and hedenbergite-magnetite skarns with superimposed ore mineralization are represented in that deposit. Chlorine-bearing potassic amphiboles were recognized in the cores recovered from a depth of 658 m. Amphibole forms nests and impregnations of black grains (as much as 1 cm in size) in hedenbergite skarn, replacing pyroxene.

The magnetite zone located in the south-western part of the Komsomolsk ore district in highly amphibolized Jurassic rocks is represented by a lenticular body some tens of metres in length. It occurs in highly silicified greywackes, the composition and structure of which suggest their tuffaceous origin.

Chemical composition and features of amphiboles. The composition of the Cl-K amphiboles was determined using a JXA-5A microprobe. Sodalite (5.47 wt. % Cl) was used as standard for Cl. Fe_2O_3, FeO, and H_2O^+ contents were determined chemically by V. G. Kokhanova, and (sample M-9) by E. A. Lagovskya (the Far East Geological Institute).

In the Pershinskoe deposit Cl-K amphibole is most widespread in garnet skarn where it forms short and thin veinlets of jet-black colour (fig. 2). It includes small admixtures of TiO_2, MgO, ZnO and is enriched in MnO (Table I, P-4). In the garnet-

Table I. Chemical composition of amphiboles

Oxides Sample N	P-35	P-4	P-50	5577	M-9
SiO_2	37.02	37.16	37.31	36.09	38.10
TiO_2	0.68	0.27	1.17	0.19	0.35
Al_2O_3	11.95	11.66	14.77	11.86	10.05
Fe_2O_3	n.d.	9.02	n.d.	13.09	4.77
FeO	31.07	18.41	19.65	21.38	23.85
MnO	1.92	1.99	1.87	0.67	0.85
MgO	0.43	2.41	6.48	0.38	1.48
CaO	11.18	11.79	12.09	11.03	9.46
Na_2O	1.54	1.59	0.60	1.41	1.00
K_2O	2.62	3.00	4.21	2.56	2.98
ZnO	0.20	0.12	0.35		
Cl	0.59	0.46	0.50	1.42	2.68
F	n.d.	0.56	n.d.		
H_2O^+	n.d.	2.00	n.d.	0.70	2.99
	99.20	100.44	99.00	100.78	98.56
Less O=F,Cl	0.13	0.34	0.11	0.32	0.60
Total	99.07	100.10	98.89	100.46	97.96

Notes to Table I: P-35 - P-50, the Pershinskoe deposit; 5577, the Novogorbushinskoe skarn deposit; M-9, the Komsomolsk ore district. f = Fe/(Fe+Mg) at.%.

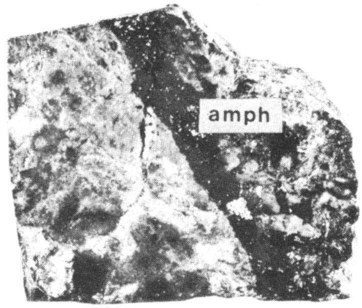

FIG. 2. Veinlet of Cl-K amphibole in garnet skarn from the Pershinskoe deposit. Full size.

pyroxene skarn Cl-K amphibole occurs as tiny black grains (up to 1 mm) and impregnates veinlets of epidote-actinolite rock, where it is replaced by epidote. It differs from the former Cl-K amphibole in having a higher iron content (f = 97.5 wt. %; Table I, P-35) but has similar chlorine and alkali contents. This Cl-K amphibole is associated with another rare ferruginous amphibole—ferroactinolite (f = 89 wt. %), with a high MnO content (3.77 wt. %) (Table II, P-35).

Chlorine-bearing potassium amphibole from the contact of the pyroxene skarn with potassium granosyenite differs from those described above by higher Ti, Al and Mg contents. This amphibole is also characterized by the highest potassium content and lowest sodium content of all the amphiboles we studied (Table I, P-50). The chlorine content is the same as in the Cl-K amphiboles described above (0.50%). This amphibole is associated with manganoan ilmenite, pyroxene, biotite (Table II, P-50 *a–c*), chlorite and hydromuscovite. Hornblende of similar composition was recognized earlier in skarns from the Pershinskoe deposit (Lobanova, 1963).

Chlorine-bearing potassic amphibole from the Novogorbuchinskoe deposit is associated with hedenbergite, grossular (Table II, 5577 *a*, *b*), and chlorite. It is the most highly ferruginous variety of those studied (f = 98.2 wt. %), with small Ti and Mg contents and significant Mn (Table I, 5577). The composition of this amphibole is similar to that from garnet-pyroxene skarns of the Pershinskoe

Table II. Chemical composition of minerals associated with Cl-K-bearing amphiboles

Oxides Sample N	P-35	P-4	P-50a	P-50b	P-50c	5577a	5577b	M-9
SiO_2	49.21	37.31	51.67	36.80		49.37	37.95	48.08
TiO_2	0.10	0.62	0.13	0.61	50.04		0.30	0.16
Al_2O_3	2.19	5.46	1.32	23.26		0.63	12.44	2.65
Fe_2O_3	n.d.	24.00	n.d.	n.d.		n.d.	14.21	n.d.
FeO	26.66	n.d.	17.01	17.58	38.66	25.91	1.58	26.75
MnO	3.77	2.85	1.69	1.12	9.15	1.51	0.72	1.27
MgO	3.13		7.53	10.49	0.16	1.43		5.06
CaO	11.56	30.49	21.57	0.08	0.05	22.02	33.68	11.57
Na_2O	0.26		0.15	0.10		0.05		0.22
K_2O	0.13			7.84				0.33
ZnO	0.14			0.36				
Cl	n.d.							0.13
Total	97.15	100.73	101.07	98.24	98.06	100.92	100.88	96.22

Note: P-35, M-9 - ferroactinolite; P-4, 5577b - garnet; P-50a, 5577a - pyroxene; P-50b - biotite; P-50c -ilmenite.

Table III. Cell dimensions of the Cl-K amphiboles

Sample N	a Å	b Å	c Å	β°	V Å³
P-4	9.97(±0.02)	18.17(±0.03)	5.37(±0.1)	105.23(±0.1)	939.03
5577	9.95(±0.01)	18.26(±0.03)	5.37(±0.01)	104.88(±0.03)	939.44
M-9	9.94(±0.04)	18.36(±0.09)	5.37(±0.03)	104.82(±0.1)	925.90

Notes. Errors in calculation are given in brackets.

deposit (Table I, P-35), differing by a higher chlorine content (1.42 wt. %).

In the magnetite zone of the Komsomolsk ore district Cl-K amphibole is most widespread in quartz-amphibole veins and as small separations in magnetite and garnet-magnetite skarns, forming coarse-crystalline radiating fibrous aggregates. Cl-K amphibole is largely replaced by ferro-actinolite, actinolite epidote, and chlorite. This amphibole differs from all other amphiboles we studied in having the highest chlorine content (2.68 %; Table I M-9). Associated ferroactinolite (replacing Cl-K amphibole) is also enriched in chlorine (0.13 wt. %; Table II, M-9), probably removed from Cl-K amphibole.

All the studied Cl-K amphiboles belong to the hastingsite-ferrohastingsite series. The grains are homogeneous and chlorine is uniformly distributed.

Three samples of Cl-K amphiboles were examined using a DRON-1.5 X-ray diffractometer with Cu-*Kα* emission and NaCl as internal standard. Cell dimensions were calculated using a Mir-2 computer. The results obtained are in good agreement with published data (Table III).

Discussion. There is a clear relationship between Cl and total Fe contents in these amphiboles: it is directly proportional up to chlorine values of 0.25 formula units, then becomes inversely proportional for high Cl-K amphiboles (dashkesanites) (fig. 3). The reasons for this relationship are still obscure; they seem to be due to both specific composition of primary solutions and a higher stability of iron-chlorine compounds compared with iron-fluorine compounds, that bear affinity to magnesium. As the diagram shows, the lattice of all chlorine amphiboles (0.2 formula units of Cl) has more than three iron atoms.

With rare exceptions, in the chlorine-bearing amphiboles potassium greatly exceeds sodium, and the K/(K+Na) ratio is usually greater than 0.3 (fig. 3). This may be due to the fact that potassic granosyenites occur as a rule in all deposits containing potassic amphiboles (Pavlov, 1964; Vakhrushev, 1965; Minerals, 1981; and others). The chlorine content in Cl-K amphiboles does not correlate with potassium content.

Many chlorine-bearing potassic amphiboles contain small amounts of fluorine, but no clear correlation was observed between F and Cl contents. In high-Cl potassic amphiboles, in which the sum of anions in OH($OH^- + Cl^- + F^-$) group exceed 3 atoms per formula unit, the chlorine structural position is uncertain. The few reports of

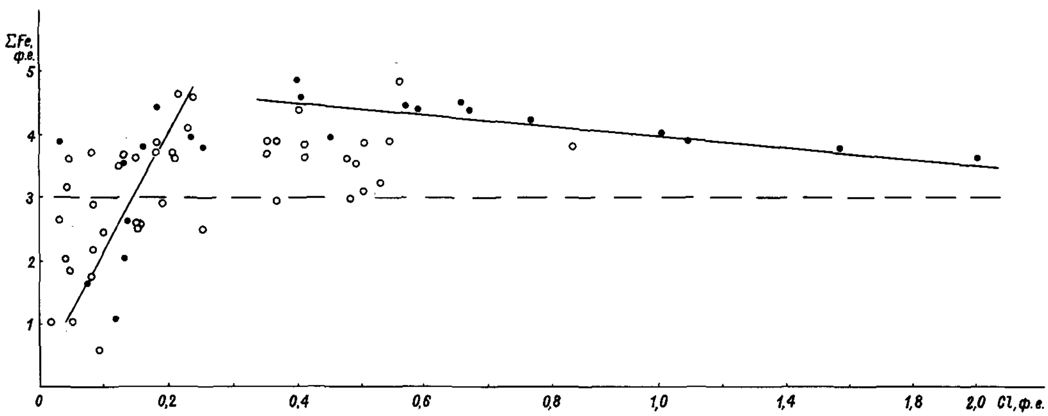

FIG. 3. Relationship between chlorine and total iron contents in Cl-K amphiboles. Filled circles represent Cl-K amphiboles, circles represent Cl-bearing amphiboles (K/(K+Na) 0.5).

Cl-K amphiboles seem to be due to the difficulties in chlorine chemical analysis rather than to their limited distribution.

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Far East Geological Institute,
Far East Science Centre, Vladivostok 690022, USSR

T. YA. GULYAEVA
N. V. GORELIKOVA
A. A. KARABTSOV

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Lead chromate minerals from the Argent lead-silver mine, Transvaal, South Africa: crocoite, vauquelinite, and a possible second occurrence of embreyite

THE disused Argent lead-silver mine is situated on the farms Brakfontein 559 IR., Dwarsfontein 209 IR. and Boschpoort 211 IR., about 80 km east of Johannesburg in the Transvaal Province of the Republic of South Africa. A series of sub-parallel siderite-galena-sphalerite veins cuts an outlier of Bushveld Complex rocks comprising diabase, gabbro, and minor pyroxenite (Willemse, 1944). The geology of the deposit was described by Wagner (1924), who noted the presence of several supergene minerals including crocoite, in the near-surface zone. Willemse (1942) gave a detailed account of the ore assemblage, and noted the presence of galena, sphalerite, pyrite, chalcopyrite, pyrrhotite, arsenopyrite, gudmundite, argentite, bournonite, boulangerite, and tetrahedrite. The principal gangue minerals are quartz, siderite, and calcite.