MANGANOAN SPHENE FROM GARRA BALAGHAT DISTRICT, MADHYA PRADESH, INDIA

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At Garra, Balaghat Districht, Madhya Pradesh, India, regionally metamorphosed manganese orebodies and manganese silicate rocks (gondite) occur as interbanded bodies in Precambrian Sausar Group and these are often cut across by pegmatite veins and dikes of different dimensions. The gondites and manganese orebodies occupy the Lohangi zone at the contact of Mansar and Lohangi Formations of the Sausar Group and are made up of spessartite-quartz-rhodonite and the lower oxides of manganese, respectively. The discordant pegmatite bodies of calcalkaline composition, at their contact with gondite and manganese orebodies, show concentration of manganese-bearing silicate minerals such as blanfordite, winchite, spessartite, tirodite and brown manganiferous pyroxene. The manganoan sphene belongs to the assemblage blanfordite-winchite-quartz-sodic plagioclase-microcline-apatite, developed by the interaction of the pegmatite fluid with the manganiferous country rock.

OPTICAL PROPERTIES

The sphenes are developed as well formed wine-red crystals that show, under the microscope, the following scheme of pleochroism:

α = pale yellow with a greenish tinge
β = pale pink with greenish tinge
γ = salmon pink.

The refractive indices of the mineral are very high. $\alpha = 1.847 \pm .006$. γ could not be measured (due to nonavailability of liquids with $n > 1.90$) though it is much higher than 1.90. The birefringence, as apparent from interference colour, is also very high. $2\dot{V}_\gamma = 38°$; $\gamma:[001] = 45°$.

CHEMICAL COMPOSITION

A separated and cleaned sample of sphene was chemically analysed and the results are given in Table 1. The X-ray powder data of the mineral has been given in Table 2.

The manganese content of this sphene is unusually high and it apparently replaces Ca in the structure. The TiO_2 content is slightly low and the Al_2O_3 and Fe_2O_3 content high and these, together with the high value of optic axial angle and relatively

TABLE 1

Chemical composition of manganoan sphene

	wt%	No. of ions on the basis of 24(O, OH, F)	
SiO_2	29.94	3.87	
		0.13	4.00
Al_2O_3	9.20	1.26	
TiO_2	30.20	2.95	
Fe_2O_3	3.16	0.31	4.63
FeO	0.56	0.06	
MgO	0.30	0.05	
MnO	1.82	0.20	
CaO	23.97	3.33	3.63
Na_2O	0.23	0.05	
K_2O	0.35	0.05	
H_2O^+	0.42		0.38 OH
H_2O-	0.14		
TOTAL	100.29		

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TABLE 2

X-ray powder data of manganoan sphene, Cu/Ni radiation

d(Å)	I	*d*(Å)	I	*d*(Å)	I	*d*(Å)	I
4.93	5	2.364	w	1.806	2	1.503	4
3.247	10	2.277	5	1.729	5VB	1.421	4B
3.00	8	2.113	1	1.645	5	1.35	3
2.831	VW	2.071	5	1.561	3	1.308	3
2.611	10	1.953	1	1.531	2	1.28	1

low R. I. (within the range for sphene), indicate that the mineral corresponds to the manganoan grothite variety [DEER, HOWIE and ZUSSMAN, 1963, p. 71].

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MINERALOGY AND CHEMISTRY OF A PEGMATITIC FELDSPAR FROM HAFAFIT, EGYPT

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ABSTRACT

This pegmatitic feldspar is a perthite composed of microcline and low albite roughly in the ratio of 2:1. The microcline is of high triclinicity (0.84). Chemically this alkali feldspar contains 10.58% K_2O, 3.37% Na_2O and 0.25% CaO. These are equivalent to 62,6% microcline, 28,5% albite and 1.2% anorthite. The plagioclase intergrown with microcline is albite with 4% An. The feldspar in question shows enrichment in Rb and Y with depletion in Sr, Ba and Zr, these characterize strongly fractionated rocks. The enclosing pegmatite is shown to be most probably one of the latest residues of a fractionally crystallizing magma directly formed at low temperature range.

The present pegmatite is to be contrasted, on mineralogical and geochemical grounds, with the garnetiferous pegmatite of W. Gemal area. Thus two distinctive types of pegmatites are recognized in the south Eastern Desert of Egypt.

INTRODUCTION

Acid pegmatites, generally of granitic composition, occur at the Hafafit area, south Eastern Desert of Egypt. Some of these pegmatites show abnormal coarse development of their alkali feldspars. It was thought that detailed mineralogical and chemical study of these feldspars might be useful and serve as multipurpose. In the first place it may help in solving problems related to the genesis of the enclosing pegmatite. Secondly feldspars start to have wide applications in the fields of waste disposal of nuclear materials as well as in ion exchange studies. Before testing such possibilities, a mineralogical and chemical study of the feldspars in question is prerequisite. Thirdly to examine the possiblity of using these feldspars as natural silicate standards.

MINERALOGY

The pegmatitic rock is very coarse grained, composed exclusively of big feldspar crystals sometimes with intergrown quartz. It is white in color with specific gravity 2.57. The rock shows signs of being subjected to pressure. The feldspar is potash feldspar because it is stained yellow with sodium cobaltinitrite test.

Under the microscope, the rock is composed of microcline, albite and quartz. The microcline develops two prominent sets of cleavage, but so far no crosshatched twinning is observed. This microcline is intergrown with plagioclase strings giving rise to perthitic texture. The latter texture is as well visible in hand specimen. There are small quartz inclusions showing undulatory extinction and assuring that the rock was subjected to strain.

The material is ground to pass 150 mesh, the powder is then subjected to diffrac-

TABLE 1

Partial diffraction pattern of the analysed feldspar

d (Å)	I/I.	Mineral	d (Å)	I/I.	Mineral
6.57	9	Ab	2.90	6	M
6.41	7	Ab	2.76	2	M
4.23	8	M+Qz	2.62	2	M+Ab
4.04	4	M+Ab	2.57	4	Ab
3.98	4	M	2.53	2	M
3.85	5	M	2.43	2	M+Ab
3.80	5	Ab	2.34	2	M+Ab
3.72	4	?	2.16	9	M+Ab
3.68	5	M+Ab	2.13	1	M+Ab
3.60	2	M	1.99	1	M+Ab
3.50	9	M	1.93	1	M+Ab
3.38	8	M	1.86	2	M+Ab
3.30	10	Qz	1.81	7	M+Ab+Qz
3.27	100	M	1.62	1	M
3.22	47	Ab	1.57	2	Ab
3.03	3	M	1.51	1	M+Ab
2.96	6	M+Ab	1.46	2	M+Ab

tion analysis. The instrument used is a Philips chart recorder diffractometer (type PW—1010) with the following instrumental settings: radiation Cu (K_α) with wavelength 1.5418 Å, filter Ni, current 20 mA, tension 36 KV, range of 2Θ: 5—65°, scale 4. Table 1 gives partial diffraction pattern of the analyzed alkali feldspar. The following symbols are used to designate the corresponding minerals: M: microcline, Ab: albite and Qz: quartz.

The diffraction pattern shows clearly that the analyzed alkali feldspar is microcline mixed with certain amount of low albite in order to form perthite. The ratio of microcline to albite is roughly 2:1. There are minor amounts of quartz appearing most probably as inclusions. The triclinicity of this microcline is measured on $131/1\bar{3}1$ faces and found to be 0.84 indicating that it is of high triclinicity *i. e.* high ordering of Si and Al atoms.

MAJOR CONSTITUENTS

Table 2 gives the chemical analysis of the analyzed feldspar rock expressed in weight per cent of the oxides. Analytical techniques are described elsewhere [EL SOKKARY, 1970]. It will be noticed that K_2O content (10.58%) is the highest among the other alkali and alkaline earth elements which give for Na_2O 3.37% and for CaO 0.25%. This assures that the investigated felspar is mainly potassic. Sodium on the other hand is present to a much lesser extent than K and contributes in making the plagioclase intergrown with the potash feldspar. The small amount of CaO appearing in the analysis comes from the plagioclase. If both the quantities of Na_2O and CaO are recalculated as albite and anorthite molecules respectively, it is seen that An/(Ab+An) = 4% roughly, assuring that the plagioclase feldspar intergrown with the potash feldspar is albite.

The K, Na and Ca contents of the analyzed feldspar are converted into the corresponding weigh contents of microcline, albite and anorthite, these are found to be: 62.6%, 28.5% and 1.2% respectively. The quantity of SiO_2 calculated on the

TABLE 2

Chemical analysis of major and minor elements in the analyzed feldspar

Oxide	Weight %
SiO_2	65.90
Al_2O_3	18.97
Fe_2O_3 (total iron)	0.10
MnO	0.01
CaO	0.25
Na_2O	3.37
K_2O	10.58
TiO_2	0.02
P_2O_5	0.01
H_2O^-	0.05
	99.26

basis of the standardized formulae of these three minerals and their percentage composition in the analyzed feldspar is found to be 61.23% as compared with 65.09% given by the chemical analysis. The difference which is equal to 4.67% is attributed to free silica present most probably as inclusions in the feldspar or may be in association with it.

It seems that the amount of total iron (Fe_2O_3=0.10%) is too small to affect the original white color of the feldspar. Quite minor amounts of MnO, TiO_2 and P_2O_5 appear as well in the analysis.

TRACE ELEMENTS

Table 3 gives some trace elements data expressed in ppm in the analyzed feldspar as compared with corresponding values of: (1) K-feldspars separated from strongly fractionated granites from Gebel El Dibai in the Eastern Desert and from Wadi Sidri in Sinai [EL SOKKARY, 1970] (2) Garnetiferous pegmatite from Wadi Gemal

TABLE 3

Some trace elements (ppm) of the analyzed feldspar as compared with those of: (1) Feldspars derived form strongly fractionated granites (2) Garnetiferous pegmatite

Element	Analyzed feldspar	Sibai feldspar	Sidri feldspar	Garnetiferous pegmatite
Ba	Tr*	—	—	—
Rb	420	200	466	31
Sr	<5	14	36	315
Y	21	19	29	502
Zr	32	25	25	168

* Tr = Trace.

area in the south Eastern Desert [KHALIL and EL SOKKARY, 1971]. Trace elements are analyzed by a modified X-ray fluorescence technique [DAMON, 1966].

It is clear from Table 3 that the content of trace elements in the analyzed feldspar and the two feldspars separated from strongly fractionated granites shows general parallelism. The chief characteristic in the three feldspars is an enrichment in Rb together with an impoverishment in Sr. However, Sr in the analyzed feldspar still shows more lowering quantities. Moreover, Y is relatively enriched in these feldspars while Zr tends to be depleted. Barium (Ba) in the analyzed feldspar shows quite dropping quantities.

Thus the analyzed feldspar shows enrichment in Rb and Y together with depletion in Sr, Ba and Zr. These characterize strongly differentiated rocks. Therefore the white pegmatitic feldspar rock from Hafafit is a strongly differentiated acid pegmatite. This is to be contrasted with the garnetiferous pegmatite from W. Gemal area which shows a quite different pattern of distribution of its trace elements as is evident from Table 3. The latter pegmatite is indexed by dropping values of Rb with enrichment trends in Sr, Y and Zr.

It is plausible to say that these two pegmatites, that is to say, the white pegmatitic feldspar rock from Hafafit and the garnetiferous pegmatite from W. Gemal area are the products of two different processes with different times of emplacement.

DISCUSSION

The alkali feldspar under investigation is shown to be a perthite. This perthite is composed of microcline with high triclinicity and low albite in the ratio of 2:1. Quantitative determination of major constituents of this feldspar revealed that $K_2O = 10.58\%$, $Na_2O = 3.37\%$ and $CaO = 0.25\%$. Thus K_2O is the main constituent among alkali and alkaline earth elements. This assures on chemical grounds that the feldspar is mainly potassic, while the intergrown plagioclase is albite with 4% An. Total iron (as $Fe_2O_3 = 0.10\%$) is present in minor amounts, that is why the feldspar keeps a white coloration. From trace elements point of view, the microcline perthite under investigation shows enrichment in Rb and Y together with depletion in Sr, Ba and Zr. This distribution pattern indicates that the pegmatite enclosing the mentioned microcline perthite is a strongly fractionated rock.

It is already argued [EL SOKKARY, 1970] that K-feldspars with low triclinicity characterize metasomatic rocks or rocks undergoing chemical change or local redistribution to form porphyroblasts. Since the K-feldspar under investigation is revealed to be microcline, in the form of perthite, with high triclinicity (0.84), therefore metasomatic processes and any chemical changes are excluded from its formation. Most probably the pegmatite containing the microcline perthite is formed as one of the latest residues of a fractionally crystallizing magma. The distribution of trace elements in this pegmatite as previously outlined adds an additional evidence to this conclusion.

HEIER [1957] could correlate the triclinicity of potash feldspars with their temperature of formation. On the basis of his study, the present microcline perthite with high triclinicity (0.84) has a lower temperature range of formation (400—500 °C). Moreover, the complete absence of crosshatched twinning from this microcline as mentioned in the section on mineralogy may be taken to indicate its direct formation at low temperatures.

In conclusion the microcline pegmatite is most probably one of the latest residues of a fractionally crystallizing magma directly formed at low temperature range. On

the other hand the garnetiferous pegmatite of W. Gemal area is shown to be formed through metamorphic processes [KHALIL and EL SOKKARY, 1971]. Thus two distinctive types of pegmatites are recognized in the south Eastern Desert of Egypt.

An example is choses here to evaluate the applied side of this investigation. TCHELISHCHEV and BORUTZKAYA [1972] were able to show that the maximum exchange capacity sharply increases with the decrease of the X-ray triclinicity from the maximum microcline to orthoclase. Since the present microcline shows maximum triclinicity of 0.84, therefore it is not quite suitable for ion exchange purposes.

The microcline pegmatite contains some quartz in association with the feldspar. This quartz is not homogeneously distributed, a matter which may introduce difficulties in preparing the pegmatite as a local standard silicate rock.

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