MAHADEVITE—A NEW SPECIES OF MICA

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1. INTRODUCTION

"DURING the regular geological survey of the 'Bison hill range' (Eastern Ghats) to the south of the Godavari, in the eastern parts of Warangal district in the month of February 1944 (20th Feb. 1944), sheets of bronze-coloured mica, up to about 18″ × 14″ were found in a pegmatite vein which cuts through a band of micaceous schists in the Khondalites (sillimanite-garnet gneiss). Almost parallel to the band of micaceous schists in this area, there are persistent runs of crystalline limestones. The sheets of mica occur on the flank of a hill called 'Racha Konda' (Lat. 17° 28′ long. 81° 20′) at an elevation of about 500 ft. above the bed of the Godavari (*i.e.*) at about 650 ft. M.S.L. It was discovered almost at the surface in the pegmatite vein, and a trial pit to a depth of about 10 ft. showed a thick pocket of the mica amidst these pegmatites".

The above is reproduced from a note by Prof. C. Mahadevan, now of the Andhra University, of a find made by him during his work as an Officer of the Hyderabad State Geological Survey. A few sheets of the mica were sent by him to Sir C. V. Raman and the examination of the same by both physical and chemical means was entrusted to the present writer. It was found that the properties and composition of the mica were different from those of the usual varieties (*i.e.*, muscovite, phlogopite and biotite). The differences are so marked as to justify its recognition as a new species of mica, the name of the discoverer being associated with it.

The mica has the usual vitreous lustre and thick sheets of it are bronze-coloured and are practically opaque. Thin flakes of about 1 mm., however, are transparent and exhibit a greenish yellow hue. The cleavage is highly perfect, producing thin elastic laminæ. Mention must be made of the fact that the transparency, pliability and homogeneity of the flakes preclude the possibility of the mica being considered an altered or decomposed product.

The pleochroism in this mica is definitely more than that in muscovite but is much less than that in biotite. Like all micas, this specimen is optically negative and the acute bisectrix is practically normal to the plane of cleavage. The optic axial angle as measured in air, *i.e.*, 2 E, is 13° 48′. This value approximates to that in phlogopite and biotite but is much less than that in muscovite.

A six-rayed percussion figure can be easily obtained in a cleavage plate of the mica by striking it with a sharp pointed instrument. It is well known that in micas the most prominent of the rays is parallel to the clino-pinacoid or the plane of symmetry. The above method was used for determining the plane of symmetry of the mica. The interference figures formed by convergent polarised light show that the plane of the optic axes (*i.e.*, the plane containing the two melatropes) is at right angles to the plane of symmetry. In muscovite and some exceptional biotites (called anomites) the plane of the optic axes is perpendicular to the plane of symmetry. Thus, the mica under study resembles muscovite as far as the orientation of the optic axial plane is concerned. Thus the physical characteristics of Prof. Mahadevan's mica do not fit in with those of the usual micas.

2. Chemical Analysis

A complete chemical analysis of the mica was undertaken and the methods adopted were those advocated by Washington (1910). A small sheet of mica free from any inclusions was ground well in an agate mortar and about 0·5 gm. of the powder was mixed with 5 gms. of sodium carbonate and fused in a platinum crucible. When the fusion was complete, the mass was extracted with dilute hydrochloric acid. Silica was rendered insoluble by evaporating the solution to dryness. Silica is filtered off and in the filtrate alumina and iron oxides (ferrous oxide being converted into ferric by oxidation with bromine water) are precipitated with ammonia water in the presence of excess of ammonium chloride. The precipitate is ignited and weighed and brought into solution by fusion with potassium pyrosulphate. The melt is dissolved in water and ferric iron is reduced by granulate zinc and the total iron is determined by titration against potassium permanganate solution.

The filtrate from ammonia precipitation is precipitated with ammonium oxalate. The precipitate of calcium oxalate is dissolved and reprecipitated and lime determined by titrating the solution of calcium oxalate in dilute sulphuric acid against potassium permanganate solution.

In the filtrate from calcium oxalate, magnesia is determined by precipitation as ammonium magnesium phosphate which after solution and reprecipitation is ignited and magnesia weighed as pyrophosphate

The alkalies are determined by the Lawrence-Smith method and the combined water by the Penfield method. No attempt was made to estimate the individual alkalies present. All the necessary precautions against undue errors creeping in were taken. The value obtained for alumina may be too high because no attempt was made to determine the TiO_2 present.

Three different samples were analysed independently and the results of two are given in Table I. Table I also contains typical results of analyses of other varieties of mica. The values for anomite are those of Tschermak (1879).

TABLE I

Name		SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	Others	Total
Mahadevite—												
Analysis	I ..	38·98	29·94	4·12		13·2	0·49	9·6		3·8	..	100·13
Analysis	II ..	38·24	29·20	3·86		14·4	0·50	9·2		3·8	..	99·20
Muscovite	I ..	45·57	36·72	0·95	1·28	0·38	0·21	0·62	8·81	5·05	0·34	99·93
,,	II ..	43·67	36·70	2·10	0·55	..	..	1·95	8·57	5·50	0·35	99·39
Phlogopite	I ..	39·66	17·00	0·27	0·20	26·49	..	0·60	9·97	2·99	3·42	100·60
,,	II ..	42·56	12·18	2·73	0·90	22·40	0·20	0·44	10·70	2·35	6·20	100·66
Biotite	I ..	32·49	12·34	6·56	25·13	5·29	..	0·88	9·59	2·42	5·64	100·34
,,	II ..	35·75	14·70	4·65	14·08	12·37	0·17	0·32	9·19	4·67	4·	99·9
Anomite	I ..	40·00	17·28	0·72	4·88	23·91	..	1·47	8·57	1·37	1·60	100·00
,,	II ..	40·84	16·47	2·16	5·92	21·08	..	I·55	9·01	2·19	..	99·22

3. Place in the Scheme of Micas

A study of Table I shows that the specimen has too much magnesium oxide to be muscovite, too little iron to be biotite and too much alumina to be phlogopite. The fact that the mica has a low optic axial angle and that it has the plane of the optic axes perpendicular to the plane of symmetry may lead one to the conclusion that the mica is similar to the anomites described by Tschermak (*loc. cit.*). The enormous differences in the chemical-composition of the two varieties is sufficient proof to show that such a conclusion is wrong. A search of the literature [Hintze (1897), Dana (1911), etc.] has failed to reveal any mica or altered mica (such as steatite, serpentine, etc.) having approximately this composition.

Micas exhibit a bewildering variation of chemical composition and many attempts have been made to explain this variation (Iddings, 1911). The most successful and useful theory is that put forward by Pauling (1930). According to him, the structure of mica consists of two sheets of hexagonal net-work of linked SiO_4 tetrahedra placed with vertices pointing inwards. These vertices are cross-linked by Al atoms in muscovite and by Mg and Fe atoms in phlogopite and biotite. (OH) groups are linked to Al, Mg and Fe alone. The structure is a succession of such double sheets with K and Na atoms placed between them. In this structure, Al can replace Si forming aluminium-oxygen tetrahedra ; Al, Mg and Fe occupy positions of six co-ordination and K, Na, Ca, etc. are in positions of 12 co-ordinations. Mauguin (1928) has suggested that instead of taking continuous chemical substitution, the number of atoms in a unit cell (*a*) forming linked tetrahedra, (*b*) in 6 co-ordination position and (*c*) in 12 co-ordination position should only be considered.

Mauguin's analysis shows that the number of oxygen atoms in the structural unit (which is ¼ of the unit cell) is always twelve within errors of analysis. Assuming this fact, the number of atoms of different elements in the structural unit of the mica under investigation has been calculated.

TABLE II*

		Biotite	Muscovite	Phlogopite	Anomite	Mahadevite
I.	O	11·85	11·99	12·2	12·0	12·0
	F	0·0	0·03	0·0	..	..
	O + F	11·85	12·02	12·2	12·0	12·0
II	Si	2·80	3·00	2·79	2·95	2·68
	Al	1·17	1·00	1·21	1·05	1·32
	Si + Al	4	4	4	4	4
III	Al	..	1·84	0·28	0·45	1·10
	Fë	0·4	0·05	.. }	0·35	0·20
	Fë	0·8	0·07	0·14 }		
	Mg	1·49	0·04	2·60	2·60	1·36
	Others	0·09	0·05	0·00	..	..
	No. of atoms in 6 co-ordination	2·78	2·05	3·06	3·40	2·66
IV	Ca	..	0·01	..	..	0·04
	Na	0·06	0·08	0·12 }	1·018	0·93
	K	1·07	0·74	0·94 }		
	No. of atoms 12 co-ordination	1·13	0·83	1·06	1·018	0·97
V	H	1·75	2·20	2·08	0·66	1·73

* The values for biotite, muscovite and phlogopite have been obtained from *Atomic Structure of Minerals* by W. L. Bragg, 1937, p. 213. The values for anomite have been calculated from Tschermak's analysis.

Table II shows the number of atoms of different elements in the structural unit of the well-known varieties of mica and the specimen under study. The atoms have been divided into 4 groups. The first consists of fluorine and oxygen atoms and the second contains Si with sufficient Al atoms to make the total in this group equal to four. This represents the Si and Al in sheets of linked tetrahedra. The next group consists of atoms in positions of six co-ordination and the fourth of atoms in positions of twelve co-ordination.

The study of Table II shows that the total number of atoms in position of six co-ordination in the new mica is nearly the same as that in biotite but larger than that in muscovite. If one considers the numbers of atoms of the individual elements in the 6 co-ordination position, it is found that they do not fit in with any of the known varieties. One can say that in a general way the values lie midway between those for muscovite and phlogopite. In muscovite, there is a large proportion of aluminium and very little of magnesium, while the reverse is the case with phlogopite. In the present specimen, the two elements occur to nearly the same extent.

It may be remarked that while a continuous variation in the relative proportions of iron and magnesium has been noticed (Clarke, 1924), the partial replacement of magnesium by aluminium is not so common. In particular, the relative proportion of approximately 1 : 1 of the Al and Mg atoms in six co-ordination found in the present mica has never been observed before.

In conclusion, the author wishes to express his thanks to Prof. Sir C. V. Raman for his guidance during this investigation.

Summary

The physical properties and chemical composition of a species of mica from the Warangal district in Hyderabad have been studied. Thick sheets are bronze-coloured and opaque, while thin sheets transmit light of a greenish yellow tint, the pleochroism being weak but distinct. The optic axial angle is 13° 48′. Th plane of the optic axes is perpendicular to the plane of symmetry. The composition is SiO_2 38·98%, Al_2O_3 29·94%, Fe_2O_3 and FeO 4·12%, Mgo 13·2%, K_2O 9·6% water 3·8%. On the basis of Pauling's model of the mica structure, the numbers of atoms of various elements in six, and twelve co-ordination positions are calculated. Approximately equal number of Al and Mg atoms are found in six co-ordination. The mica appears to be of a type intermediate between muscovite and phlogopite.

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