

The residue from the ethyl acetate fraction was taken up in hot methanol and left in an ice-chest. The dull yellow solid that deposited was purified on cellulose column and crystallized twice from methanol, when pale yellow needles, m.p. 258–60°, yield, 0.1%,  $\lambda_{\max}$  (MeOH) 221 (sh), 275, 343; (AlCl<sub>3</sub>) 220 (sh), 276, 301 (sh), 396; (NaOAc) 235 (sh), 273, 310 (sh), 393; (H<sub>3</sub>BO<sub>3</sub>) 235 (sh), 273, 375 nm;  $[\alpha]_D^{28} = -20^\circ$  (c, 0.5% py.) were obtained. It answered Molisch's test and gave an olive green Fe<sup>3+</sup> reaction. On hydrolysis with 7% H<sub>2</sub>SO<sub>4</sub> for 1 hour in 50% alcoholic medium, it yielded 6-hydroxy luteolin, C<sub>15</sub>H<sub>10</sub>O<sub>7</sub>, m.p. 283–85° (penta-acetate, m.p. 211–13°) and galactose in 1:1 proportion. The identity of the products of hydrolysis was confirmed by direct comparison with authentic samples. The glycoside was not hydrolysable by  $\beta$ -glucosidase. On methylation (Me<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>CO<sub>3</sub> in acetone medium, 40 hr) and acid hydrolysis, it gave a flavone, m.p. 218–20°, which was found to be identical with 5:6:3':4'-tetramethoxy-7-hydroxy flavone<sup>5</sup>. From the above data, the glycoside was identified as 6-hydroxy luteolin-7-galactoside.

Some more of the glycoside was obtained from the MEK fraction. The mother liquor after removal of the glycoside was divided into two portions. One portion was hydrolysed (7% H<sub>2</sub>SO<sub>4</sub>, 2 hr) and the hydrolysate shaken with ether and ethyl acetate in succession. The residue from the ethyl acetate was taken up in aqueous alcohol and left in an ice-chest. The pale yellow solid that came out on crystallisation from MeOH yielded very pale yellow needles, m.p. 210–12°, yield, 0.01%. It answered tests for flavonoids, and could not be hydrolysed by alcoholic 7% H<sub>2</sub>SO<sub>4</sub>; but on boiling with 10% H<sub>2</sub>SO<sub>4</sub> in glacial HOAc medium for 5 hr, it was hydrolysed to yield diosmetin, identified by colour reactions, acetate, m.p. 194–96°, R<sub>f</sub> and co-chromatography with an authentic sample and glucuronic acid (co-PC). The pigment was therefore identified as diosmetin-7-glucuronide, and the identity confirmed by direct comparison with an authentic sample from *Pedaliium murex*<sup>6</sup>.

The second portion of the mother liquor was refluxed with alcoholic KOH (1N) for an hr and the hydrolysate diluted with water, acidified to Congo-red and extracted with ether. The solid from the ether layer on crystallisation from MeOH came out as colourless

needles, m.p. 213–15°. It was acidic and exhibited characteristic blue fluorescence in U.V. It gave a single spot on PC, the R<sub>f</sub> values in different solvent systems agreeing with those for *p*-coumaric acid. Its identity was further confirmed by m.p., mixed m.p. and acetate m.p. 203–05°.

This is the first record of the isolation of 6-hydroxy luteolin-7-galactoside. The earlier known glycosides of this flavone are its 7-glucoside from *Catalpa bignonioides*<sup>7</sup> and *Coreopsis mutica*<sup>8</sup> and its 7-diglucoside from *Globularia cordifolia*<sup>8</sup>.

We thank Dr. J. B. Harborne, The University, Reading, for the spectral data, enzyme hydrolysis and an authentic sample of 6-hydroxy luteolin, and Mr. G. Sivakumaraswamy, Bangalore University, for supply of the plant material.

Dept. of Chemistry, S. SANKARA SUBRAMANIAN,  
J.I.P.M.E.R., S. NAGARAJAN,  
Pondicherry-6, (MRS.) N. SULOCHANA.  
October 6, 1971.

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#### MINERALOGY AND GEOCHEMISTRY OF AMPHIBOLES FROM THE AMPHIBOLITES AROUND MYSORE CITY

HART and Aldrich<sup>1</sup> and Griffin and Rama Murthy<sup>2</sup> drew attention to the implications arising out of the possible presence of amphiboles in the upper mantle. The present communication describes the mineralogy and geochemistry of three amphiboles from amphibolites occurring amidst Peninsular gneisses around Mysore City<sup>3</sup>. The amphibolites are medium to coarse-grained, schistose or granulitic, with hornblende and plagioclase as the principal minerals. The parallel alignment of hornblendes in the schistosity plane has resulted in a megascopic lineation. The amphiboles were separated by a combination of heavy media and electro-magnetic separations. The biotite impurity was got rid of by a simple

TABLE I  
Location, geological setting and mineralogy of the amphiboles

	Blue-green amphibole	Yellow-green amphibole	Brown amphibole
Location	76° 40' 6" E 12° 15' 12" N (Near Yennehole at Kadkola)	76° 41' 42" E 12° 18' 30" N (Near Rifle Range, Chamundi Hill)	76° 45' 42" E 12° 16' 12" N (Near Varuna Village)
Geological setting	Amphibolite host occurs as xenoliths in the gneisses	Amphibolite host occurs amidst injection gneisses	Amphibolite host associated with schists
Description	Euhedral to subhedral; associated with plagioclase, iron ores, epidote and sphene	2-4 mm in size plagioclase is the principal mineral	Resembles amphiboles found in charnockites; acicular habit
Mineralogy:			
Refractive indices			
α	1.654	1.659	1.631
β	1.665	1.671	1.652
γ	1.664	1.679	1.657
(γ-α)	0.021	0.020	0.026
(-2V)	77°	65°	57°
Z∧c	16°	23°	15°
Pleochroism			
X	Light-yellow	Colourless to light yellow	Brownish-yellow
Y	Yellowish-green	Light-green	Yellowish-green
Z	Bluish-green	Emerald-green	Dirty green
Specific gravity	3.126	3.228	3.203

TABLE II  
Major element composition of the amphiboles

Constituents	Analysed Amphiboles			Analyses for Comparison		
	Blue-green (A)	Yellow-green (B)	Brown (C)	Blue-green 1	Yellow-green 2	Brown 4642 A
SiO <sub>2</sub>	44.01	43.97	41.30	42.70	46.65	41.67
Al <sub>2</sub> O <sub>3</sub>	11.53	11.40	11.68	9.96	10.01	11.42
TiO <sub>2</sub>	0.62	0.77	1.02	0.80	0.85	1.72
Fe <sub>2</sub> O <sub>3</sub>	0.68	1.64	3.49	2.38	0.48	4.71
FeO	13.49	11.56	11.89	14.70	8.98	14.92
MnO	0.18	0.28	0.12	0.26	0.89	0.13
MgO	10.86	13.10	13.87	12.76	15.09	9.46
CaO	12.62	12.74	12.20	12.23	15.29	11.04
Na <sub>2</sub> O	3.14	2.82	2.90	2.82	0.93	1.54
K <sub>2</sub> O	1.04	0.56	0.35	0.73	0.49	2.13
H <sub>2</sub> O <sup>+</sup>	1.22	1.39	1.42	0.91	0.94	1.01
H <sub>2</sub> O <sup>-</sup>	0.10	0.20	0.20	0.21		0.03
F	0.06	0.10	0.09	..	..	1.40
Total	99.55	100.53	100.53	100.50	100.60	101.24
Less O≡F	0.03	0.04	0.04	..	..	0.59
	99.52	100.49	100.49	100.50	100.60	100.69
Niggli values				A, B, C: Analyst—S. K. Babu		
Si	84.67	81.66	73.43	1: From amphibolite associated with Closepet granite, Analyst—S. K. Babu (Unpublished)		
Al	13.07	12.47	12.21	2: From amphibolite associated with Closepet granite, Analyst—S. K. Babu (Unpublished)		
Fm	55.84	56.61	59.16	4642 A: Hornblende Ultra basic dyke, Pammal, Madras. <sup>6</sup> Analyst—R. A. Howie		
C	25.98	25.31	23.23			
Alk	0.18	0.11	0.07			
K	7.10	5.73	5.39			
Mg	0.57	0.63	0.62			
Oxide Ratios						
SiO <sub>2</sub> /Al <sub>2</sub> O <sub>3</sub>	4.2	3.9	3.5			
Fe <sub>2</sub> O <sub>3</sub> /Fe <sub>2</sub> O <sub>3</sub> + FeO	0.05	0.12	0.22			
FeO/MgO	1.24	0.88	0.86			
MgO/CaO	0.86	1.03	1.14			
Na <sub>2</sub> O/K <sub>2</sub> O	2.95	5.04	8.29			



TABLE III  
Trace element composition of the amphiboles

Elements	Analysed Amphiboles			Analyses for comparison		
	Blue-green (A) (ppm)	Yellow-green (B) (ppm)	Brown (C) (ppm)	2270 (ppm)	115 (ppm)	4645 (ppm)
Cr	150	130	500	125	10	500
Ni	20	40	500	25	15	1000
V	100	250	100	25	80	35
Yr	<100	< 20	50	220	200	50
Sc	75	20	< 50	150	100	80
Rb	< 10	tr	< 10	tr	10	10
Sr	20	10	70	30	10	300
Li	tr	< 10	< 10	tr	14	4
Pb	n.d	< 10	tr	tr	n.d	25
Co	100	50	20	150	80	35
Zr	20	30	50	50	80	175
B	< 20	< 10	20	n.d	n.d	n.d

A, B, C: Analyst—S. K. Babu

Elemental Ratios:	2270:	115:	4645:
K/Rb	863	..	290
K/Sr	432	465	41
Cr/Ni	7.5	3.3	1
TiO <sub>2</sub> /Cr	41	59	204
TiO <sub>2</sub> /Ni	310	193	204

Analyst: (2270, 115, 4645) R. A. Howie<sup>5</sup>

X-ray structural formula on the basis of 24 (O, OH, F)

Amphiboles	(Ca, Na, K)	(Fe <sup>3</sup> , Fe <sup>2</sup> , Mn, Mg, Ti, Al)	(Si, Al)	(OH, F)	O
Blue-green	3.16	5.00	8.00	1.26	22.74
Yellow-green	2.93	4.93	8.00	1.42	22.58
Brown	2.86	5.47	8.00	1.47	22.53

adaptation of the Wilfley table principle. The final separate was 98% pure. The major elements were determined by the methods of Shapiro and Brannock<sup>4</sup>. Among the trace elements, Rb, Sr, Sc, Li, Pb and B were determined by atomic absorption spectrophotometry (Perkin-Elmer Model 303) and Cr, Ni, V, Yr, Co and Zr were determined by emission spectroscopy. The optical parameters were determined, after the method described by Naidu<sup>5</sup>, on Universal stage. The data are listed in Tables I-III.

An analysis of the data presented leads to the following conclusions:

1. The amphiboles may be described as calciferous amphiboles with alkalic affinities. The blue tint of the bluish-green amphibole is attributed to the presence of soda (derived from the surrounding granitic intrusions?) and the state of oxidation of the mineral. The increase in soda and the decrease in Fe<sub>2</sub>O<sub>3</sub> from the yellow-green to blue-green amphibole may correspond to the successive stages in the development of amphibolites. 2 V value of the amphiboles is related to the FeO/MgO<sup>6</sup> ratio.

The colour of the brown amphibole is traceable to its TiO<sub>2</sub> content<sup>7</sup>. The extent of replacement of silicon by aluminium in the formula calculated on the basis of 24(O, OH, F) indicates that the amphibolites were formed at a fairly high temperature<sup>8</sup> which is consistent with the mineral assemblage of the amphibolite facies. The major and trace element compositions of the amphiboles studied are comparable to those of the amphiboles from the amphibolites (associated with Closepet granites) and charnockites from the adjoining areas (Tables I and II).

2. All the three amphiboles have FeO/MgO ratios of less than 2 and more than 0.5. They could hence be designated as femag-hastingsites according to the criteria developed by Billings<sup>9</sup>.

3. The Niggli values of the amphiboles analysed correspond to those given by Burri and Niggli<sup>10</sup> for common hornblendes from eruptive rocks.

4. The K/Rb ratios of the blue-green and brown amphiboles are of the right order of magnitude, but because of the uncertainty in regard to Rb concentration, the K/Rb ratio

cannot be employed to throw light on the mode of genesis of the amphibolites concerned.

5. The  $\text{Fe}_2\text{O}_3/(\text{FeO} + \text{Fe}_2\text{O}_3)$  ratio indicates that the brown amphibole is characterised by a higher state of oxidation than the other two amphiboles.

6. According to Leake<sup>11</sup> and Walker *et al.*<sup>12</sup>, amphibolites with more than about 250 ppm of Cr and 200 ppm of Ni, low Niggli k values, and high amount of  $\text{TiO}_2$  are likely to be ortho-amphibolites. The brown amphibole satisfies the requirement fully, and is most likely an ortho-amphibolite. That the blue-green and the yellow-green amphiboles do not satisfy this requirement does not, however, unambiguously indicate their original sedimentary nature.

7. When the present data are plotted on  $\text{TiO}_2$  vs Cr, and  $\text{TiO}_2$  vs Ni scatter plot of Leake<sup>11</sup>, the blue-green and yellow-green amphiboles fall in the range of pelites, indicating that they might be para-amphibolites. The brown amphibole falls in the ortho-amphibolites range (and plots along with the Karroo dolerites). Both para and ortho-amphibolites show similar trends in the Ni vs Cr scatter plot<sup>11</sup> and hence no conclusion could be drawn from this plot.

8. The  $\text{Na}_2\text{O}/\text{K}_2\text{O}$ , K/Sr and  $\text{TiO}_2/\text{Cr}$  ratios of the brown amphibole are markedly different from the other two amphiboles and may be used as criteria for derivation from igneous parentage. It should, however, be pointed out that as observed by Leake<sup>11</sup>, individual analysis cannot be employed to determine uniquely whether a given amphibolite is of igneous or sedimentary origin.

The first author (S. K. B.) thanks the Heads of Analytical, Health Physics and Spectroscopy Divisions of the Bhabha Atomic Research Centre, Bombay, for giving laboratory facilities to carry out the chemical work. Our thanks are also due to Sri N. K. Dutta for helping in calculations.

S. K. BABU.

U. ASWATHANARAYANA.

Dept. of Applied Geology  
and Centre of Advanced  
Study in Geology,  
University of Saugar,  
Sagar, M.P., September 15, 1971.

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#### APPLICATION OF PALAEOMAGNETISM IN ESTIMATING THE AGE OF THE DOLERITE DYKES OF THE PENINSULAR INDIA

DOLERITE dykes traverse the granites and gneisses in almost every part of the Peninsula. Their ages have been discussed from time to time by several workers, and different conclusions have been drawn. Foote (1880), Hatch (1902), Rama Rao (1940), Pichamuthu (1959), Janardan (1964), and Kripanidhi (1968) relegated them to pre-Cuddapah age. Holand (1897), Wetherel (1904), Smeeth (1915) Coulson (1933), Pascoe (1950), Ramathan (1955) and Ziauddin (1969) are of the opinion that the dykes were contemporaneous with the Cuddapah traps, and hence of Cuddapah age. Murthy (1955) argues that these dykes belong to two ages, (1) those intruded immediately after the formation of the charnockites and (2) those intruded during the Cuddapah period. Sadasivaiah and Ikramuddin (1966) assigned the Deccan trap age for the dykes of Bidadi-Harohalli area. Palaeomagnetic results obtained on the dyke samples of the Tirupati area, by the present author, have furnished data for solving the problem of the age of the Peninsular dykes.

Oriented samples were collected from 25 dykes for palaeomagnetic work. The intensity and direction of remanent magnetization of the dyke samples were measured using astatic magnetometers of suitable sensitivity at Tata Institute of Fundamental Research, Bombay. Out of 25 dykes, 14 yielded consistent directions and 10 yielded inconsistent directions. One dyke is very weak and its remanent magnetization could not be measured even with the most sensitive magnetometer avail-

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