

## SHORTER COMMUNICATIONS

### CHEMICO-MINERALOGIC RELATIONSHIP IN RAJMAHAL BASALTS—BIHAR

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*Introduction:* Recently the writer in association with Sinha has elsewhere described the sequence of crystallisation in relation to mineral paragenesis, the geology and the geochemistry of the Rajmahal Traps and the distribution and behaviour of the trace elements in the Rajmahal Traps (Sinha and Sastri, 1967, 1969).

The present paper deals with the chemico-mineralogic relationships of two of the Rajmahal basalt flows—a normal basalt and a palagonitic basalt. Such a study needs a quantitative assessment of the chemical and mineralogical changes both in terms of weight and volume. Chemical work was carried out using the rapid analysis techniques of Shapiro and Brannock (1952, 1956 and 1962), and the modal analysis of the rocks was done using the Leitz integrating stage, and not by the automatic point counter since the rocks are fine grained in nature.

*Chemico-mineralogic relationships:* The chief constituents which show variations are magnesia, lime, total iron and the alkalies. The ferromagnesian minerals in these rocks are represented by the pyroxenes and the felsics by the plagioclases. Table I gives the abstract summary of the rock analysis, mode and the constituent mineral analysis of the rocks of both the flows with reference to the layers from which the rocks are sampled.

*Western Region Flow I (normal basalt):* Magnesia varies from 7.12 per cent to 7.52 per cent and the chief mineral which carries this oxide—the pyroxene—varies from 29.44 to 42.96 and it does not follow the magnesia pattern. Even the MgO content of the pyroxenes does not justify the increased amount of this oxide in the rocks containing more pyroxenes. From Table I it may be seen that in their MgO content the pyroxenes of the bottom and the top layers are similar though in one case the total pyroxene is only 29.44 per cent as against 42.96 per cent in the other. Progressive enrichment or depletion of the pyroxenes in Mg with advancement in differentiation does not seem to have taken place in this case. When at this stage the total pyroxene and glass content of the rocks from the mode is compared with their total MgO content, both the data agree well showing that MgO is distributed not only in the pyroxenes but also in the glassy-phase of the rock.

The data for  $\text{Fe}_2\text{O}_3$  and FeO taken together show a variation from 9.87 per cent in the rocks of the bottom layer of this flow to 11.43 per cent in the rocks of the middle layer. The minerals in which iron may be distributed are the iron oxides which form a small percentage and the pyroxenes which do not follow the pattern of iron in the rocks. However, it is strange that despite the enrichment of the pyroxenes in iron, the latter does not show any variation and remains more or less constant. When the total FeO is compared with the total sum of pyroxene, glass and the iron ore content of the rocks, the data exactly fits in indicating that just like MgO, iron ores also are associated with the glassy phase.

Lime varies from 8.04 per cent in the middle layer to 11.12 per cent in the bottom layer. The mineral which carries the bulk of this oxide is plagioclase though

it may as well be contained in the pyroxenes as is especially the case in the present instance (Table I). However, in general, the CaO content of the rocks and total percentage of plagioclases in the mode are well correlated; but this gives only a very partial picture of the entire chemico-mineralogical adjustments and it would be necessary to consider the CaO content of the minerals also.

TABLE I  
ABSTRACT SUMMARY OF CHEMICAL, MODAL AND MINERAL ANALYSIS

	Western Region Flow I. Normal Basalt			Eastern Region Flow I./Palagonitic Basalt		
	Bottom	Middle	Top	Bottom	Middle	Top
Fe <sub>2</sub> O <sub>3</sub>	3.34	4.64	3.28	2.51	4.34	3.33
FeO	6.53	6.79	6.84	8.42	6.82	7.31
MgO	7.12	7.52	7.15	8.90	6.45	5.98
CaO	11.12	8.04	9.89	9.60	10.65	9.97
Na <sub>2</sub> O	2.46	2.51	2.48	2.55	2.65	2.67
K <sub>2</sub> O	0.48	0.64	0.61	0.41	0.40	0.33
OXIDE RATIO						
FeO/MgO	0.91	0.90	0.96	0.95	1.12	1.22
MODAL ANALYSIS (Volume per cent)						
Plagioclase	53.24	48.15	46.40	26.25		28.67
Pyroxene	29.44	34.49	42.96	19.70		9.94
Glass	13.94	13.00	5.87	49.53		57.76
Iron ores	3.41	4.39	4.75	4.52		3.63
MINERAL ANALYSES						
PLAGIOCLASES						
Total FeO	0.91	1.39	1.18	1.14		2.00
CaO	14.37	13.27	16.03	13.37		14.53
Na <sub>2</sub> O	3.66	3.49	3.33	3.62		3.62
K <sub>2</sub> O	0.15	0.14	0.13	0.22		0.20
PYROXENES						
TiO <sub>2</sub>	2.61	3.09	2.09	2.23		2.60
Total FeO	15.26	15.64	15.49	13.38		14.71
MgO	15.44	10.53	14.24	12.35		13.90
CaO	7.63	11.05	11.58	8.08		8.37

Analyst: J. C. V. Sastri

\* The detailed rock analysis of these rocks is given in the paper by Sinha & Sastri (1969).

From the following calculations it can be observed that except in case of the bottom layer of Flow I in which the values observed are more than those obtained from calculations on the basis of ideal composition (Johannsen, 1962), in the other two layers of this flow the observed values are lesser than the calculated values.

This is suggestive of three important petrogenic features viz., (1) the plagioclases contained in the groundmass are far less calcic than considered, (2) there are other elements like Ba, Sr, K, Na in the plagioclase lattice and (3) that some of the lime being present in the undifferentiated phase of the rocks.

DISTRIBUTION OF CaO IN DIFFERENT LAYERS OF FLOW I (WESTERN REGION)

	Bottom	Middle	Top
per cent CaO in plagioclases from analysis	14.37	13.27	16.03
per cent plagioclase in volume from modal analysis	53.24	48.15	46.40
Total plagioclase by weight (mode $\times$ sp. gr. of plagioclase)	53.24 $\times$ 2.71 $= 144.18$	48.15 $\times$ 2.71 $= 130.50$	46.40 $\times$ 2.71 $= 125.70$
Total CaO in plagioclase (calculated)	9.95	10.17	12.75
CaO in rock observed (from analysis)	11.42	8.04	9.89
per cent CaO in pyroxene from analysis	7.63	11.05	11.58
per cent pyroxene in volume from modal analysis	29.44	34.49	42.96
Total pyroxene by weight (mode $\times$ sp. gr. of pyroxene)	29.44 $\times$ 3.33 $= 98.02$	34.49 $\times$ 3.33 $= 114.80$	42.96 $\times$ 3.33 $= 143.10$
Total CaO in pyroxene (calculated)	7.71	9.62	8.09
CaO in rock observed from analysis	11.42	8.04	9.89

Total alkalies vary from 2.94 to 3.15 per cent. The mineral which carries the alkalies in these rocks is plagioclase. But it can be observed from Table I that when the alkalies increase in the rocks, the plagioclases in the mode are decreasing. The analysis of the plagioclases separated from these rocks as given in the above mentioned table shows that to a small extent there is a decrease in their total alkalies content from the bottom towards the top layers of the flow. In other words, while the total alkalies in the rocks increase, that in the plagioclase decrease; and if this is taken into consideration with the decrease of plagioclases themselves there would come a large disparity in the results. When these results are seen in the light of CaO content also which constitute the plagioclases along with the alkalies this difference can be to a large extent minimised because the plagioclases from the top layers are richer in lime than the bottom layers. Even this seems to be a partial explanation; the present writer thinks that it is the progressive substitution of Ca by Na that such a behaviour is observed.

*Eastern Region Flow I (palagonitic basalt):* MgO decreases from 8.90 per cent in the rocks of the bottom layer to 5.98 per cent in the rocks of the top layer of this flow. Pyroxene, the chief carrier of this constituent follows this trend if the figures in the Table are compared in the absence of the data from the middle layer because of the glassy-nature of the rocks.

It may be recalled here that in the case of the rocks of the western region flow such a behaviour of MgO and pyroxenes could not be obtained; and it was concluded that the latter fact was due to the incorporation of some of the MgO in the glassy phase as well. This seems to be a very significant observation as it shows how under different rates of cooling and differentiation, the molecules of the different crystalline-phases distribute themselves between the then existing solid and liquid phases. The present data shows that when the rate of cooling is rapid only such phases can possibly exist which are stable over a wider range of compositional gradient as against a slow differentiation where even the shortened or transitory phases may be left over. This appears, at first sight, a contrary observation than that obtained by the previous workers who hold that with slower rate of cooling there is a stronger differentiation. But, as the present results demonstrate it is not so, and in the context of the chemical differences which might exist between the solid and the liquid phases at any one particular time of magmatic activity. The present writer holds, that when the rate of cooling is very slow there is enough opportunity for inter-adjustments of the chemical composition of the solid and liquid phases so much so that the chemical balance removes gradient existent originally when from the magma only few crystals were formed; but, on the other hand, if the rate of cooling is rapid and the differentiation process a rapid one, there is not sufficient time for mutual adjustments of the solid and liquid phases; and as such a sharp contrast is left over between them represented either by the phenocrysts and the groundmass or the former and the glassy-matter. In such an event, obviously, quite a good amount of the material now constituting the minerals may be in the glassy phase of the groundmass as well. This explains well, the present distribution of MgO in pyroxenes in all the flows of these areas. Table I shows that the pyroxenes separated from the rocks of the top layer are richer in Mg content though when compared to the pyroxenes of the western region flow their Mg content is lower. A higher Mg content of the pyroxenes while a lower MgO in the rock once again points to the same feature as noted above viz., a rapid fractionation does not provide enough opportunities for the mineral phases to adjust their chemical composition with the surrounding liquid and hence the appearing phases are more or less of identical composition.

CaO in these rocks is more or less evenly distributed, though the rocks of the middle layer are slightly richer than those of the bottom and the top layers. Plagioclase and pyroxene both carry this constituent. Plagioclase shows a similar trend as lime, if the rocks of the middle layer, whose modal analysis could not be done due to their fine grained nature, are left out. The pyroxenes show not only an altogether different trend but the disparity is also quite large. If the increased CaO content of both the plagioclases and pyroxenes as met with in the rocks of the top layer in comparison to those found in the bottom one is taken into consideration, even then the chemical and modal variations will not strictly correspond. However, if the percentage of glass is also added to that of plagioclase and pyroxene the present behaviour of CaO can be explained. It, therefore, appears that some of the CaO is contained in the still undifferentiated portions of the rocks.

The next constituent which is significant from the point of view of the present mineralogy is soda, which shows a progressive increase, though of a very low order from the bottom towards the top layer of the flow. This behaviour of soda is quite in keeping with the modal variation found in the case of plagioclases occurring in the bottom and top layers. To confirm this it is of interest to note that the Na<sub>2</sub>O

content of the plagioclases obtained from rocks of the bottom and top layer are similar.

*Conclusions:* From a study of the chemico-mineralogical correlations of the Rajmahal basalts it is concluded that the index of differentiation and the ratio of crystallines to non-crystallines are the two important factors which control such correlations. Further, when the rate of cooling is rapid there is not enough time for mutual adjustments of the solid and liquid phases, and as such a sharp contrast is left over between them represented by the phenocrysts and the groundmass or the former and the glassy-matter.

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#### THE SHELL STRUCTURE OF *INOCERAMUS* FROM THE UPPER CRETACEOUS BEDS NEAR ARIYALUR, SOUTH INDIA

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*Introduction:* A study of the shell structure of the giant pelecypod *Inoceramus*, collected from the grits and sandstones of Upper Cretaceous age at a depth of about 5 metres in a recently dug well, located at a distance of about 1300 metres west of Sillakkudi village (58 M/4; Lat. 11°4'27" and Long. 79°0'4") near Ariyalur, forms the subject matter of this paper. The specimen is incomplete; the length of the shell is about 25 cm, the height about 21 cm and the thickness about 9 cm. It is inequilateral and inequivaled. The shell material, which is at places broken and interrupted, is found on both the valves and is represented by thin calcareous material of 2 to 4 mm thickness.