ON THE TRAP ROCKS OF THE CHITALDRUG SCHIST BELT.

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1. Introduction.

The object of this paper is to present the petrological characters of the group of rocks occurring in the Chitaldrug Schist Belt which have been described in the Records of the Mysore Geological Department as the Bellara trap, the Jogimardi trap, the Chitaldrug grey trap and the trappoidal hornblende schist. These names were provisionally given by the several officers of the Department who were mapping the country and an attempt is made in this paper to make a comparative study of the different occurrences and to correlate them. The investigation had to be confined to the examination of microsections, museum specimens, and rock chips preserved in the office of the Department. Frequent use was made of the field note-books of the departmental geologists, because only a very few of the rocks collected by the several officers are referred to in the published reports.

My thanks are due to Prof. P. Sampat Iyengar, M.A., the Director of Geology in Mysore, for facilities accorded to me for working in the Department, and for valuable help in the course of this investigation. I am also indebted to Mr. E. R. Tirumalachar, B.A., the Chemist of the Mysore Geological Department who analysed specimens of trap rocks for me.

2. The Jogimardi Trap.

The existence of these rocks was first recorded by Bruce Foote (1, 2) who considered them to be a series of contemporaneous trap flows of great thickness and extent.

Mr. Sambasiva Iyer (3) also visited this area but he makes only a passing reference to these rocks. He considered them to occur as trap flows, dykes and interbedded sheets.

Dr. Smeeth (4) cursorily examined this area but apart from collecting a few specimens he did not study the field relationships or petrological characters of these trap rocks.

The area was worked out in detail by Mr. P. Sampat Iyengar (5) who found this trap intrusive into the chlorite schists of the Chitaldrug series. He came to the conclusion that these rocks belonged to a volcanic series which intruded and flowed out over the top of the schists. The patches of chlorite schist that were found in their midst were considered by him to represent such portions as were not covered by the flow or that were covered but subsequently had the lava cap removed by denudation.

Later, Dr. Smeeth (6) visited the area once again. As a result of this examination, he came to the conclusion that the grey traps were not lava flows but that they occurred as dykes and intrusive sheets in the Chitaldrug schists ; as lenses or huge bosses with inclusions and patches of the chlorite schist resting on them. Even if there were such flows he argued that they were probably at a much higher level than the present surface and all traces of them must have been removed by denudation.

These rocks are also designated as the Chitaldrug Grey Traps in the Records of the Mysore Geological Department. No useful purpose is served and much confusion arises by describing the same set of rocks under two different names. The term Jogimardi trap was first used by Bruce Foote and though it is now seen that only the southern flanks of the Jogimardi hill are formed of this rock, yet this name should be retained for the grey traps. Another objection to using the term Chitaldrug grey trap is, that the environs of the town of Chitaldrug are not on the grey trap but on the dark hornblendic traps.

A great variety of texture is met with in these rocks. Many of them are very compact and fine-grained (Z_2/151, J_4/961) and some of the sections could be described as a glass. The coarse rocks exhibit ophitic or sub-ophitic textures (Z_2/349, Z_2/564, J_4/956). Porphyritic types are also met with, big phenocrysts of felspar usually being found undergoing alteration (Z_2/282, Z_2/486, Z_2/490, Z_2/555, J_4/958).

Augite relicts are seen in several sections (Z_2/276, Z_2/288, Z_2/465, Z_2/498, Z_2/499, Z_2/543, J_4/952, J_4/953, J_4/959, J_4/960). Some of the slides contain idiomorphic crystals (Z_2/469, Z_2/485, Z_2/537). The augite is usually found altering to a pale hornblende and chlorite. Beginning with the augite which in thin sections is practically colourless, it is found that it alters first into a yellowishbrown hornblende with very faint pleochroism. This is changed at the periphery to a green or pale-green hornblende which sometimes has more pronounced pleochroism from yellow to yellowish-green to green (J_4/952). This green hornblende is however often formed directly from the augites. These colour changes are supposed by Bonney (7) to be due to the development of some ultramicroscopic iron salt (perhaps a slightly hydrous iron oxide which with a little manganese is the main constituent of the umber-brown tints) from which by a further action of water a hydrous iron silicate (which is green) is formed.

Sometimes this secondary hornblende is replaced by a group of small crystals of hornblende, the outline of which does not correspond with the original one. These smaller crystals are commonly prismatic or acicular in form. Such pale-green acicular crystals are occasionally found as a fringe to the larger crystals when these present a somewhat frayed appearance. In some of the schistose types the whole of the new mineral is seen to be formed of a bundle of fibrous crystals. Some of these stages are well seen in specimens of the Bellara trap, a description of which is given later. The hornblende is generally of a very pale green colour with feeble pleochroism. In some of the sections the hornblendes are twinned (Z_2/496, J_4/954, J_4/955). Since the twin planes in both pyroxenes and amphiboles are the same, a paramorphic change of augite to hornblende seems to preserve the twinning as well in some cases. In J_4/955 the twins are interpenetrating. Dana (8) does not mention the occurrence of cruciform twins in hornblendes whereas he records them in the case of pyroxenes. So the occurrence of these cruciform twins in hornblende might not be due to the original mineral but to the secondary uralite derived by the alteration of penetrating twins of augite.

The plagioclases are usually turbid due to saussuritisation. According to the texture of the rock, the felspars are found either as minute laths or as coarse grains and sometimes as idiomorphic crystals. In some of the rocks which have been recrystallised, there is a partial clarification but in other cases they are altering usually into a low polarising epidote, probably clinozoisite. In Z_2/521 radiate aggregates of felspar crystals intersecting one another at the middle are found.

Quartz occurs in several sections (Z_2/481, Z_2/493, Z_2/496, Z_2/535, Z_2/550, Z_2/559, J_4/955, J_4/956). Abundant inclusions are found in them and sometimes they occur in certain definite planes (J_4/955). In this slide these xenocrysts possess a reaction rim of what is at present a ring of tufts and radiating needles of fibrous hornblende. The colour of these crystals of hornblende near the quartz grains are found to be much paler than those away from them.

Pale yellow epidotes polarising in bright colours are seen in a few sections (Z_2/151, Z_2/465, Z_2/492). They exhibit a faint pleochroism sometimes. Some of the idiomorphic epidotes found in patches of chlorite show zoning, the borders being usually more ferriferous than the core. The more common variety, however, is colourless and both zoisite and clinozoisite have been recognized. These minerals have been abundantly formed by the decomposition of the felspars.

Calcite is not common but in rock types such as Z_2/554, where the alteration is advanced, plenty of this mineral is found along with chlorite and leucoxene.

Sphene is found as small grains in several sections. Grains of ilmenite are sometimes seen altering at the periphery to this mineral.

Of the iron ores, ilmenite is the most common and abundant. It was noticed in practically every one of the slides. It is invariably accompanied by leucoxene. In J_4/955 a crystal of ilmenite is found which reveals its rhombohedral character from the regular manner in which it is altering into leucoxene. They are sometimes seen segregated into tiny spherical dots (Z_2/151, Z_2/287) and this is possibly due to the devitrification of the basic glass (9, p. 384). Among the other iron ores, pyrites is present in a few sections (Z_2/275, Z_2/276, Z_2/555, J_4/957).

No olivine or rhombic pyroxenes were met with in any of the sections.

From the above petrological description, it will be seen that the Jogimardi trap is an altered doleritic rock which can best be described as a diabase.

The following analyses made by the Chemist of the Geological Department give an idea of the chemical composition of the Jogimardi traps. The first analysis is that of a fine-grained type, the second that of a porphyritic type with phenocrysts of plagioclase felspars, and the third that of a medium-grained rock.

	1	2	3
	$Z_4/90$	$Z_4/96$	$J_4/957$
SiO_2	48·52	47·44	47·56
Al_2O_3	13·80	16·28	18·40
Fe_2O_3	3·65	3·27	2·04
FeO	9·83	9·76	10·00
MgO	5·88	5·20	6·66
CaO	10·92	11·22	13·28
Na_2O	3·70	2·94	2·29
K_2O	0·32	0·34	0·31
TiO_2	1·04	0·90	0·68
P_2O_5	0·10	0·09	—
MnO	0·14	0·18	0·05
Loss on ignition	2·12	2·19	0·52
	100·02	99·81	101·79
Specific Gravity	3·12	3·06	3·05

3. The Dark Hornblendic Trap of Chitaldrug.

The early observers considered the Jogimardi trap to extend right up to the Chitaldrug granite. It was Mr. Sampat Iyengar (5, p. 71) who first recognized the existence of two types of rocks in this area—an inner zone of dark hornblendic trap next to the granite and an outer zone of the grey Jogimardi trap. The northern flanks of the Jogimardi hill △3722 and the western slopes of △3060 north of Guddadrangavanhalli are entirely composed of these rocks which are in parts schistose.

The line of junction between the grey trap and the dark hornblendic trap has not been exactly made out, but that the grey trap is intrusive into the latter has been observed both by Mr. Sampat Iyengar and Dr. Smeeth (6, p. 21). $Z_2/476$ collected at the contact of these two rocks shows clearly the intrusive relationships. Two of the sections cut from this specimen are very interesting in that they show patches of the hornblendic rock caught up in a glassy grey trap which shows fluxion structure. The grey trap in these sections is composed of small laths and skeleton crystals of felspar in a matrix full of spherical dots of leucoxene. The caught-up portions are recrystallised with the result that the hornblendes are quite clear having yellow to green to blue pieochroism.

In hand specimens these two types can be distinguished by the darker colour of the hornblendic trap, a character mainly due to the colour of the hornblende, which is deep tinted with well-marked pleochroism from yellow to green to greenish-blue. In Z_2/473 a few of the hornblende crystals are twinned.

Remnant augites are not present in any of the slides of the hornblendic trap. The felspars are quite turbid due to decomposition. The chief iron ore is magnetite. Sometimes a little iron pyrites is found. Ilmenite is not so abundant as in the Jogimardi trap.

In a few slides the ophitic texture is just discernible, making it clear that the original rock from which this was derived was of a doleritic nature. Fine-grained types are common.

Z_2/472 is a contact altered rock. The felspars are clarified, the hornblende also is clear but is crowded with magnetite grains, a feature which is characteristic of contact metamorphism of diabasic rocks (10, 11). The original ophitic texture has also been obliterated.

Thus it will be seen that this trap rock can be described as an epidiorite with the ophitic texture just recognizable in a few sections and the original augites completely transformed into deep coloured hornblendes which are sometimes found recrystallised at the contact zones.

The following is an analysis of a fairly fine-grained specimen :—

SiO_2	52·60
Al_2O_3	10·12
Fe_2O_3	3·84
FeO	12·73
MgO	6·17
CaO	9·36
Na_2O	2·27
K_2O	trace
H_2O	1·60
TiO_2	1·12
MnO	0·03
CO_2	trace
	99·84
Specific Gravity ..	2·94

4. The Bellara Trap.

The main exposure of the Bellara trap is found to the south of the Jogimardi trap in the form of a lens between the villages of Bellara and Bukkapatna. The first mention of these rocks was made by Mr. Sambasiva Iyer (3, p. 101) who considered them to be basic trap flows.

Later, Mr. Wetherell (12) surveyed this area. He noticed that the rock was greenish grey, fairly coarsely crystalline and non-fissile. The exposure was fine-grained at the edges and tongues of this were found penetrating the chlorite schists. The rocks were usually much decomposed.

The area was examined by Mr. Jayaram (13) in 1917. He found that in some places the rock presented two distinct looking phases—a greenish-grey type and a dark green type which was however different from the dark hornblendic rocks of the lower Dharwars. Between the 10th and 17th milestones on the Chiknayakanhalli and Yelladkere road the trap was found to be well exposed. He obtained sufficient evidence for the fact that the Bellara trap was distinctly intrusive into the dark hornblendic schists (14).

The only specimen mentioned by Mr. Wetherell is $W_3/69$, collected east of the village of Bellara and from the main mass of the outcrop. This is a coarse rock which under the microscope is found to be distinctly ophitic. Augites giving extinction angles of about 44° occur but they are found only as remnant cores, the periphery being converted into a very pale green or practically colourless hornblende and chlorite. The extinction angle of the hornblende is 16°. The felspars are very turbid due to alteration. Grains of iron pyrites are found scattered throughout the section. Ilmenite or its alteration products were not present in this section, but it occurs in the rock as can be seen from the chemical analysis given later.

$W_3/70$, though its exact locality is not known, must presumably be another specimen from this area. In this slide, the alteration is seen to have proceeded further. There is no residual augite but the ophitic texture is still visible.

$Z_2/92$ collected by Mr. Sampat Iyengar from this area represents a further stage in the metamorphism of the Bellara trap. The hornblende is fibrous, no residual augite is present and the felspars are quite turbid. In this slide there are a few empty cavities and some lens-shaped segregations of chlorite with crystals of epidote in them.

The schisted type of this trap rock is represented by $Z_2/89$. The rock is almost an amphibolite. The hornblende is pale green and fibrous. There is plenty of calcite and leucoxene is present.

$J_4/885$ and $J_4/886$ are specimens of Bellara trap collected by Mr. Jayaram on the 42nd mile of the Bellara-Bukkapatna road. In hand specimens the two types look different, the former being greenish-grey and the latter dark green. The first resembles $W_3/69$ in colour and texture. But these two distinct looking phases have been found in one and the same mass without showing any perceptible contacts (13). I have examined sections of both these rocks under the microscope and find that there is practically no difference between them. They have a sub-ophitic texture, with no residual augite, the mineral being completely converted into a pale fibrous hornblende which is altered in places to green chlorite. The felspars are completely decomposed. Big grains of ilmenite are found changing into leucoxene.

The Bellara trap is, therefore, a coarse diabasic rock characterized by an ophitic texture and the presence of relict augites surrounded by secondary pale-green hornblende.

The following is an analysis of $W_3/69$ made by the Chemist of the Geologieal Department :—

SiO_2	47.53
Al_2O_3	19.97
Fe_2O_3	2.86
FeO	8.74
MgO	2.14
CaO	12.59
Na_2O	1.53
K_2O	0.18
TiO_2	1.93
MnO	0.30
Loss on ignition	2.03
	99.80
Specific Gravity	3.14

5. The Mode of Occurrence of the Trap Rocks.

The question whether these trap rocks are superficial lava flows or whether they are only sub-surface intrusions has got to be next investigated.

In the collections of the Bellara rocks found in the Mysore Geological Department there is not even one specimen which shows a glassy phase. They are all coarse-grained. Fine-grained types are met with in the dark hornblendic trap of Chitaldrug and glassy rocks are seen in the Jogimardi trap. There are also very compact rocks which have all the characters of basalt but the occurrence of these in any well-defined sheets has not been proved by the field geologists. These fine-grained types must only be considered to be marginal variations, an inference suggested by $Z_2/476$ which is at the boundary between the grey trap and the dark green epidiorite, and which is glassy with fluxion structure and skeleton crystals. Flow structure is not a distinctive character of surficial lavas as perfect examples have been noticed in intrusive rocks (15).

The presence of amygdales though they are not uncommon in intrusive rocks (9, 16, 17, 18), is certainly a characteristic feature of superficial lava flows and so several slides which showed structures similar to that of amygdales were carefully examined.

The only specimen collected in the Bellara trap area which resembles an amygdaloid is $Z_2/92$. In this slide a few patches of chlorite with crystals of epidote are found. The absence of well-defined boundaries for these patches, and the lack of a zonal arrangement of minerals, make it improbable that these are amygdales. A segregation of these secondary minerals into patches implies that the rock had become sufficiently viscous for diffusion to have taken place (19).

In the dark hornblendic rocks, $Z_2/473$ has certain patches which contain clear granules of quartz or felspar and chlorite with wisps of hornblende and in $Z_2/475$ there are irregular segregations of epidote, hornblende and quartz. There is no zonal arrangement of these minerals. Somewhat similar patches in the Green Schists of South Devonshire (20) and in the greenstones of the Lake Superior region (21) have been considered to be metamorphosed amygdales but this inference is supported by the presence in those areas of rocks which are admittedly of tufaceous origin or are basic ashes. No such evidence is obtained from the Chitaldrug area. These chloritic patches are therefore to be considered as due to the alteration of felspars and pyroxenes and formed by solid diffusion and segregation, similar to the nodules found in the dolerites of Snowdon (9, p. 408).

The Jogimardi trap presents similar structures in some of the slides (Z_2/498, Z_2/499, Z_2/550), and the explanation given above holds good for these also. In Z_2/498 and Z_2/499 the epidote present in the patches is the pale yellow variety with bright interference colours whereas in Z_2/550 it is the rhombic zoisite exhibiting ultra-blue polarization colours.

Due to their compact nature and consequent resistance to weathering, certain nodules are sometimes found standing out as small rounded prominences on exposures of the Jogimardi trap (Z_2/485). Sometimes these have dropped out leaving smooth ovoid cavities which on casual inspection look like steam cavities. The presence of nodules is not uncommon in felsitic lavas (pyromerides) and andesites. These are mostly derived from original spherulites by a process of alteration as every successive stage from the original structure of the rock into a flinty or agate-like material has been traced. This nodular structure is not confined to lava flows, but has been detected in intrusive rocks also (15, p. 232). The nodules found in the Jogimardi trap are of similar character. Z_2/484 is a section of one such. Small idiomorphic crystals of augite and felspar are found in a matrix full of acicular crystals which may have been originally pyroxenes but are now uralitized. A well-marked radial arrangement is not seen. The felspars are altering into colourless epidotes and in one or two cases pseudomorphs of epidote after felspar are found. The borders of these nodules are set off by a segregation of specks of leucoxene. Z_2/466 is a very compact rock with numerous radial groups of crystals not giving perfect black extinction crosses but only irregular dark brushes. Z_2/486 which was considered by Mr. Sampat Iyengar to be an amygdaloid (5) is also only a variolite.

It will thus be seen that the spots, patches and nodules met with in these trap rocks are not amygdales, but are due either to the segregation of alteration products or to the presence of varioles.

6. Conclusion.

The Bellara and Jogimardi traps have a great many points of resemblance especially in the presence in both of a pale hornblende and the occurrence of relict augites. They are both usually coarse-grained with marked ophitic texture except in such of the types as have been metamorphosed considerably or which are at the contact zones. A series of small exposures of trap connect the main occurrences of the Jogimardi a nd Bellara traps and these in all probability belong to the same age.

The dark hornblendic trap of Chitaldrug, however, is different in that there is no residual augites met with and the hornblende is deep coloured with well-marked pleochroism. It has a higher percentage of silica and lower specific gravity than the Bellara and Jogimardi traps. The ophitic texture is discernible in a few cases but is generally obliterated. The contact relationships make it plain that this rock is distinctly older than the Jogimardi trap rocks.

There is sufficient proof to show that the Bellara trap is intrusive into the schists of the Chitaldrug Belt and that the Jogimardi trap is intrusive both into the schists and the dark hornblendic traps of Chitaldrug ; but there is neither microscopic nor field evidence to show that any of these traps are surficial lava flows.

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EXPLANATION OF PLATES.

Plate I.

Fig. 1. Jogimardi Trap. Completely uralitized. Ilmenite crystals abundant, undergoing alteration to leucoxene.

Fig. 2. Nodule found in the Jogimardi trap. Variolitic texture. Traversed by thin veins of quartz. Idiomorphic augites are present.

Fig. 3. Jogimardi Trap. Groups of epidote crystals are seen in irregular chlorite patches. Relict augite present next to the big ilmenite grain.

Fig. 4. Jogimardi trap, near contact with the dark hornblendic trap of Chitaldrug. Numerous skeleton and rodshaped crystals of felspar are seen in a practically glassy groundmass.

Plate II.

Fig. 1. Chitaldrug Trap. Hornblendic trap with numerous grains of magnetite, a feature characteristic of contact metamorphosed diabasic rocks.

Fig. 2. Contact rock. The Jogimardi trap is glassy with fluxion structure. The lighter portion is the Chitaldrug trap re-crystallized into clear greenish-blue hornblendes.

Fig. 3. Contact rock. Patches of coarse hornblendic rock are seen caught up in the glassy Jogimardi trap. Skeleton crystals of felspar are present in the glass.

Fig. 4. Bellara Trap. Coarse rock with ophitic texture. The dark crystals are felspars which have become almost opaque due to alteration. The lighter portions are augites undergoing alteration to hornblende and chlorite.

PLATE I

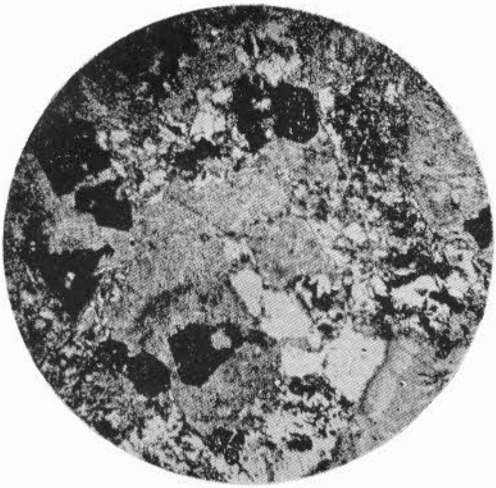

FIG. 1

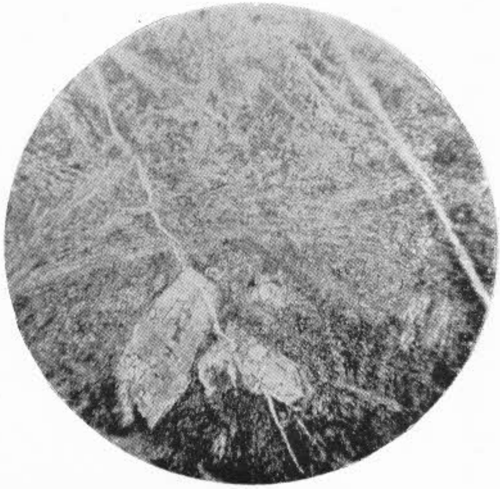

FIG. 2

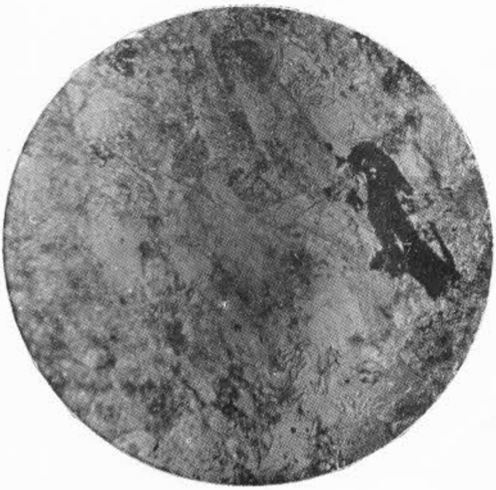

FIG. 3

FIG. 4

PLATE II

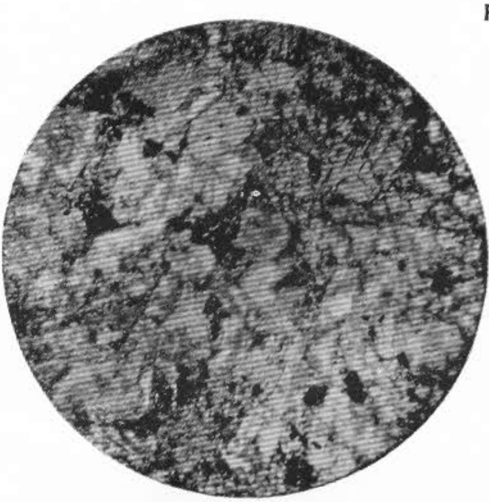

FIG. 1

FIG. 2

FIG. 3

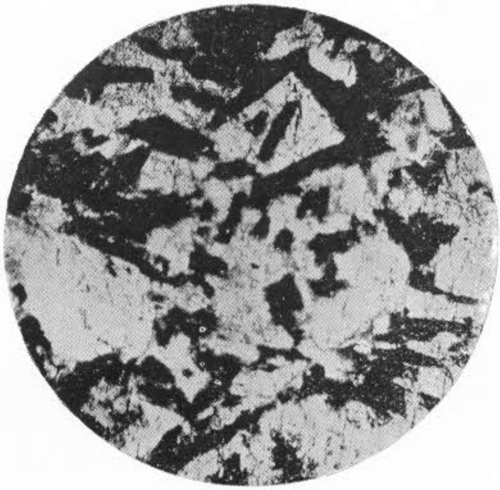

FIG. 4