CHAPTER IV

DECCAN TRAP AS DIMENSION STONE

Deccan Trap is the most extensive geological formation in the State of Gujarat. It covers an area of 57457 sq.km. (approx.) i.e. about 1/3 of the total area of the State. The enormous lava flows which poured out through fissures and localized vents during upper cretaceous to lower eocene period, because of their spreading over greater part of peninsular India (Deccan) and because of their step like terraced appearance (Trap) are called Deccan Trap. Radiometric age determination has indicated that the earliest Traps is of late-Cretaceous age. This activity continued during

upper-Eocene and Oligocene.

In stone industry, this stone is popularly known as 'Trap' which is mainly used as crushed aggregate for construction. In all, there are about 890 Trap quarries out of which 426 quarries are located in mainland Gujarat, 451 quarries in Saurashtra region and 13 in Kachchh district. This stone is used in number of irrigation projects in the State. Ukai dam on Tapi river is one of the biggest masonry dams in which Trap is used as dimension stone for construction purposes, saving valuable foreign exchange (Plate 4.1). Total annual production of Trap rock is about 3.7 million tonnes worth 21.8 million rupees.

Trap is a general commercial term for the trade group which includes all basic igneous rocks. However, Gujarat stone industry includes basalt, dolerite, gabbro, rhyolite, trachyte, dacite etc. having different petrological characters but having more or less similar colour. This rock occurs in all districts of Gujarat except those of Mehsana and Gandhinagar (Fig. 4.1).

DISTRIBUTION

The geographical distribution of Deccan trap in the State of Gujarat can be divided into three regions

(1) Mainland Gujarat (2) Saurashtra region (3) Kachchh district.

(1) Mainland Gujarat: Trap rock occurs throughout South Gujarat covering most of the areas of Dang, Valsad, Surat and Bharuch districts. In the alluvial track of Central and north Gujarat, Trap occurs as inliers near Timba (Panchmahals district), Thasra (Kheda district), Sevalia (Vadodara district), and Vadgam and Dhansura (Sabarkantha district). Near Halol and Kalol (Panchmahals district) this rock is exposed in hills. Over and above, this rock occurs also near Dhandhuka (Ahmedabad district) and Balaram (Banaskantha district).

In Dang district Deccan Trap, represented by amygdaloidal and fine grained basalt and fine grained basic intrusives, occupies extensive areas. The general trend of the intrusive is ENE-WSW, though ESE-WNW and NNE-SSW directions are not uncommon.

In Valsad district, Deccan Trap is represented by amygdaloidal and massive basalts occupying extensive area. Network of dykes varying in thickness from a few cms to over 10 m in width are found commonly intruding

Plate 4.2: Basalt quarry, Areth, Surat district.

Plate 4.3:

Norite Boulders in river bed, Chitrasani, Banaskantha district.

the different lava flows and forming knife edge ridges. These dykes are mostly basic but few of them are also acidic in composition. The thicker dykes are usually of dolerite. Generally the trend of dyke is north-south.

In Surat district, Trap is represented by amygdaloidal and fine grained basalts. Occupying vast area of the district (Plate 4.2). Number of dykes of basalt, dolerite and gabbros are reported from Ukai, Songadh and Vyara areas.

Massive and amygdaloidal basalts occur in Bharuch district. Porphyritic basalt also occurs in some part of the distrct. Some tuffs are noticed near Rajpipla and to the south of Mota Amba. Prominent exposures of trachytic rocks are seen at Karia hill, Ashavi and between Pathar and Koylivav. These rocks appear to have intruded the Trap flows. Dolerite dykes are oriented in east-west direction in this district.

Massive basalt occupies part of Vadodara district. It occurs around Savli, Samlaya and Jarod. Intrusion of dolerite and gabbro are present in the areas of Panchwada and Phenaimata hills.

In Kheda district, basalt occurs mainly in Kapadvanj taluka. It also occurs below a thin soil cover in Balasinor and Thasra talukas. Outcrops of traps are also there in Mahi river course near Sevalia and Galteshwar.

Basalt occurs in southern part of Sabarkantha district around Wadagam, Akrund and Watrak. The rock shows typical columnar jointing and Spheroidal weathering.

In Panchmahals district, basic lava flow occurs as irregular and isolated exposures surrounded by alluvium along south western and eastern margins of the district and extends for in N-S direction between Jhalod and Dohad. Massive, porphyritic and amygdaloidal variety of basalt occurs in this district. Among the several outcrops of Trap in the SW, the most outstanding and important is the Pavagadh hill which is 829 m above the surrounding plains.

In Banaskantha district basic rocks such as gabbro and epidiorite occupy area around Chitrasani, Kansara, Mandla and Zat. A tributary of river Banas filled with boulders of norite near Chitrasani (Plate 4.3).

In Ahmedabad district basalt occurs around Dhandhuka at the western boundary of the district. This rock is an

extension from Bhavnagar district.

(2) Saurashtra Region: In this region Trap occurs mainly in districts of Rajkot, Bhavnagar, Amreli, Junagadh and Jamnagar. It occupies part of the Surendranagar district. It covers more than 2/3 part of the total Saurashtra region.

Basaltic rocks occupy almost the entire Rajkot district. Massive and amygdaloidal varieties occupy the northern part of the district. Varieties of these basalts such as felsites, rhyolites, pitchstones, obsidian etc. have also been found in the Osham and Alecha hills.

In Bhavnagar district, lowermost flows are comparatively more decomposed and appear agglomeratic at places while the later flows are trachytic, felsite or dioritic with occasional lenticular masses and thin veins of pitchstones. The basaltic flows are generally massive or amygdaloidal. Trap flows have been intruded by numerous dolerite dykes. The dominant trend of dykes is east-west.

The lava flows of Junagadh district vary from medium grained to aphanitic and porphyritic types which are occasionally amygdaloidal. Girnar hill is an unique example

Plate 4.4 : Rhyolite Quarry, Rajula, Amreli district.

of magmatic differentiation and assimilation giving rise to a variety of rock types, such as nepheline-syenite, alkali syenites, quartz porphyry, andesite, gabbro, lamprophyre, dolerite, obsidian, rhyolite etc. Several parallel basic dykes, at times intersecting each other, are conspicuous along the eastern and south eastern margins of the district. Dykes generally show two trends NNW-ESE and WNE-ESE.

In Jamnagar district the Deccan lava flows are mostly massive or amygdaloidal. Scoriaceous breccia, agglomerates, tuff, ash beds etc. are occasionally noticed. A number of dykes are associated with the Trap flows in the district. NE-SW trends are generally noticed in the district.

The trap occupies whole of the Amreli district except for the southern and south-eastern coastal tracts where Tertiary or post Tertiary sediments are exposed. Trap rock is generally basalt and dolerite, though at places trachyte, rhyolite and diorite are also present. Between Rajula and Asrana Mota, rhyolite is exposed in the form elongated to crescent shaped hillocks with steep escarpment slopes (Plate 4.4). Massive as well as amygdaloidal basalts are present. Trap flows are intruded

Plate 4.5: Columnar jointing in Basalt, Sevalia, Kheda district.

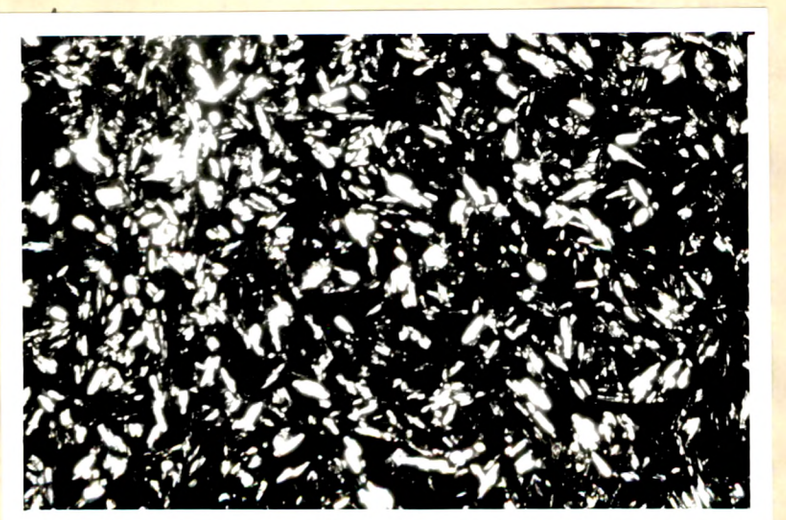

Plate 4.6: Photomicrograph of fine grained Basalt showing flow structure (Crossed Nicols, X50).

by numerous doleritic dykes which also intersect one another. These dykes in general, exhibit NE-SW to N-S and E-W trends.

(3) Kachchh district: Trap rock occurs mainly around Matanomadh, Nakhtrana and along the southern fringe of Bhuj and Umia formation. The lava flows are massive and sometimes porphyritic and amygdaloidal. Numerous dykes which may be genetically related to the Deccan lavas are noticed in the district. They include all varieties of dolerite, trachyte and basalt.

PROPERTIES

Deccan Trap is generally grey to black in colour. It ranges in texture from completely aphenitic to porphyritic and compact to amygdaloidal. Joint pattern play an important role in quarrying of this stone. Generally, it shows two sets of vertical joints at right angles to each other representing rift and grain direction. Columnar jointing is also commonly observed (Plate 4.5). At most of the places joints are spaced from few centimeters to few meters. Joint spacing more than 30 cm is advantageous for quarrying dimension stone. However, spacing less than

Plate 4.7: Photomicrograph of porphyritic Olivine Basalt (Crossed Nicols, X50).

Plate 4.8: Photomicrograph of porphyritic Basalt showing plagioclase phenocryst (Crossed Nicols, X50).

30 cm is helpful for quarrying crushed and broken stone.

Deccan Trap is generally attacked along joint planes by water. On weathering this rock is stained or skinned with iron oxide along joint planes, leading eventually to spheroidal weathering.

The mineral composition of Deccan Trap consist essentially of plagioclase, feldspars and pyroxenes. The petrological characters of some of the important varieties of Deccan Trap are described in following paragraphs.

Basalt: This is an important variety of Deccan Trap. Generally, fine grained in nature and shows flow structure (Plate 4.6). In some basalt, when olivine is present in notable amount the term olivine basalt is applied (Plate 4.7). The phenocrysts of olivine and augite are seen embedded in groundmass consisting of plagioclase feldspar and augite. Some basalt exhibits porphyritic texture, in such ase, the term porphyritic basalt is applied (Plate 4.8). In amygdaloidal basalt amygdules are generally filled with secondary minerals like zeolite, calcite, crypto-crystalline silica, quartz etc. Amygdaloidal basalt is generally not preferred as dimension stone due to presence of amygdules which will

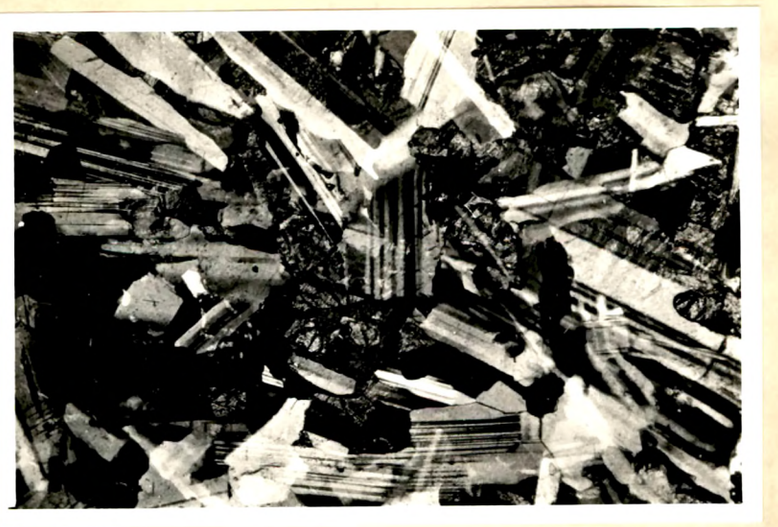

Plate 4.9: Photomicrograph showing ophitic texture in Dolerite (Crossed Nicols, X50).

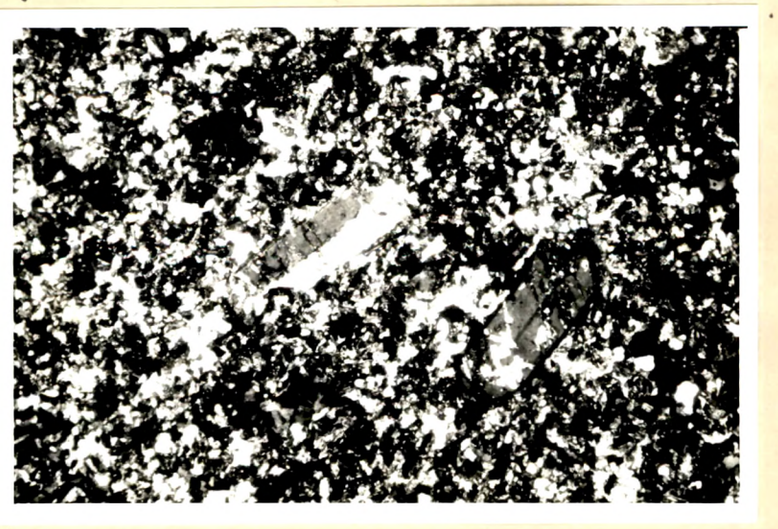

Plate 4.10: Photomicrograph showing textural characters of Andesite (Crossed Nicols, X50).

Plate 4.11 : Photomicrograph showing textural characters of coarse grained Gabbro. (Crossed Nicols, X200).

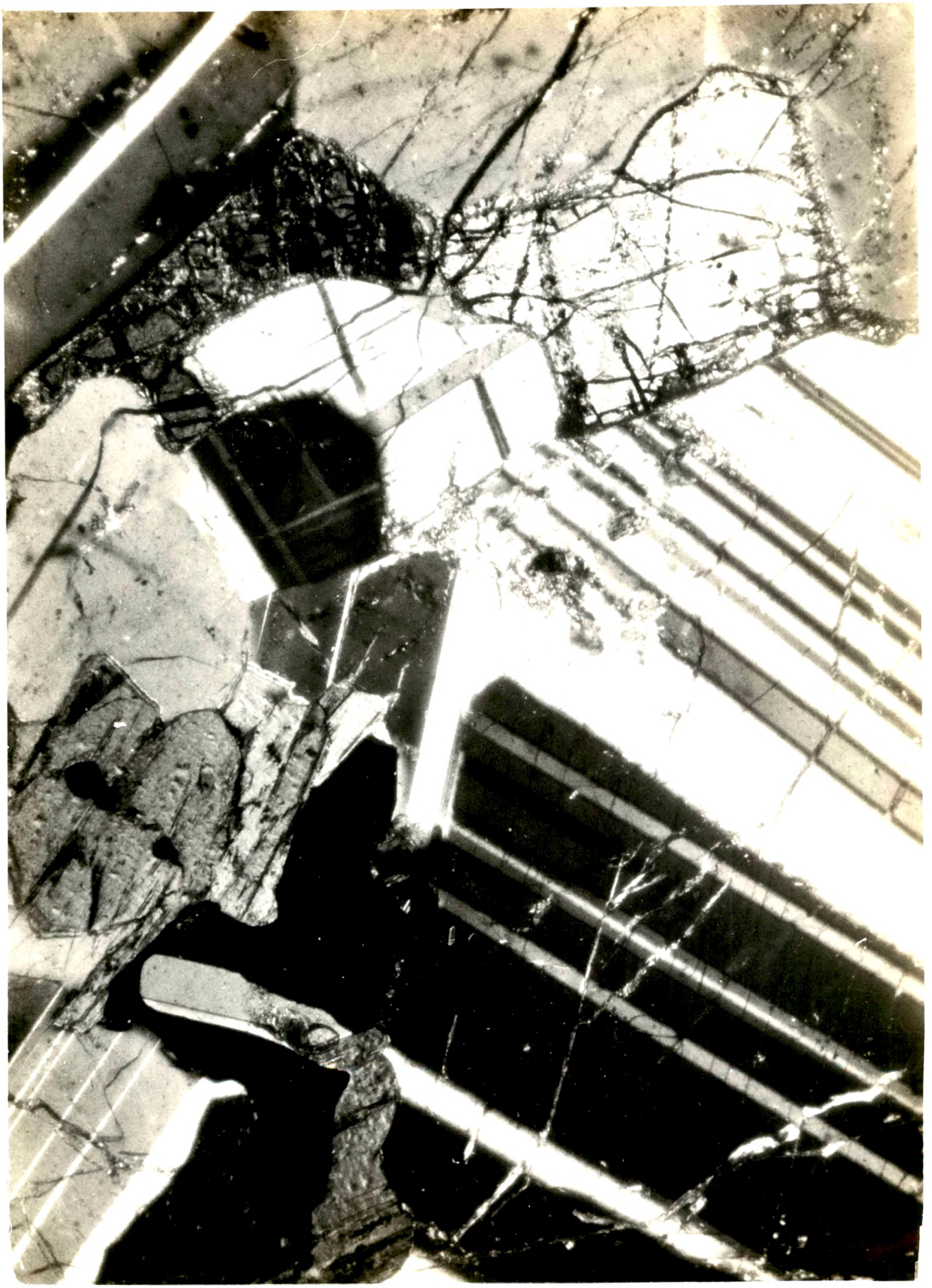

Plate 4.12: Photomicrograph showing coroded quartz and plagioclase in Rhyolite (Crossed Nicols, X50).

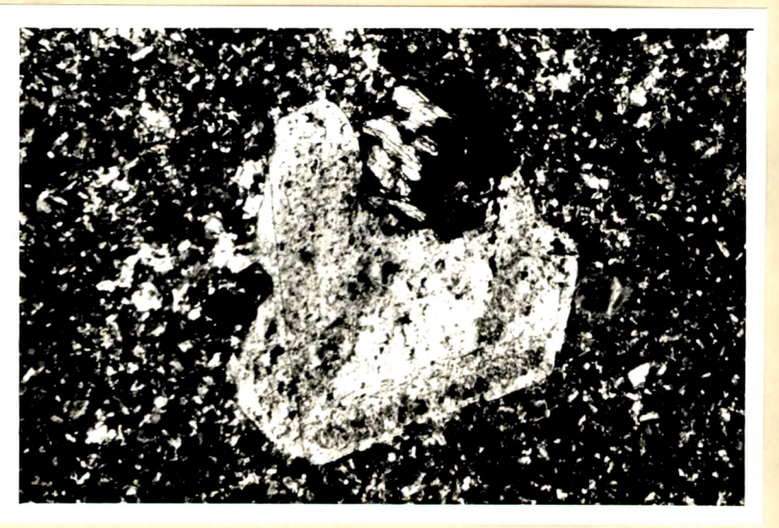

Plate 4.13: Photomicrograph showing lobed plagioclase phenocryst in Dacite (Crossed Nicols, X50).

have an adverse effect on the strength of the rock e.g. Crypto-crystalline silica is chemically deleterious in nature. If this mineral is present as amygdule then it will react with lime mortar to form 'Gel'. This will loosen the bonding between two stones and ultimately effect on the strength of structure.

Dolerite: This rock is dark grey, fresh, compact and massive. This rock exhibits ophitic texture in which laths of augite and olivine are seen enclosing laths of plagioclase feldspars (Plate 4.9).

Andesite: This rock is fine grained, compact and light grey in colour. Phenocrysts of andesine and hornblende are enclosed in plagioclase microlites (Plate 4.10).

Gabbro: This rock is coarse grained and compact in nature. It shows granular texture. Hypersthine bearing gabbro is termed as norite (Plate 4.11).

Rhyolite: This rock is grey to brown in colour and compact in nature. Phenocrysts of coroded quartz and plagioclase are embedded in a groundmass consisting of minute grains of grains of quartz, plagioclase and glassy material (Plate 4.12).

Dacite: This rock is generally whitish grey in colour, compact and massive. It exhibits medium grained porphyritic texture. Phenocrysts of plagioclase feldspar, orthoclase, quartz are found embedded in usually glassy groundmass (Plate 4.13).

Trachyte: This rock is fine grained and dark grey in colour. It shows porphyritic texture. It generally consists of phenocrysts of feldspars embedded in groundmass consisting of feldspars.

Agglomerate: This rock is coarse grained and exhibits coarse grained texture. Pieces of basalt are welded together with volcanic groundmass.

Diabase: This rock is dark grey in colour and compact. The random orientation of plagioclase feldspar laths is a distinctive feature, otherwise it exhibits doleritic texture.

Deccan Trap essentially composed of plagioclase feldspars and pyroxenes. During the course of weathering these minerals are converted to clay and ultimate weathering product is often a soil. Plagioclase feldspars alters into kaolinite. These feldspars are hard but cleavage is well marked which probably allows rapid attrition and

penetration by water. Alternationof plagioclase feldspars to Kaolinite expressed by Trefethen (1960).

$$2NAAlSi_3O_8 + CO_2 + 2H_2O = H_4Al_2Si_2O_9 + 4SiO_2 + Na_2CO_3$$

Albite Kaolinite

$$CaAl_2Si_2O_8 + CO_2 + 2H_2O = H_4Al_2Si_2O_9 + CaCO_3$$

Anorthite Kaolnite

The commonest member of pyroxene group is augite. Augite weathers by ion exchange and lattice alteration to clay minerals but may be first alter to hornblende, epidote, chlorite and other minerals. Chlorite is common product of the weathering.

Olivine, a common constituent of basic igneous rocks. It has no cleavage but it often traversed by irregular cracks. It is very weatherable mineral. Its alteration to serpentine is expressed by Trefethen (1960) as:

$$6MgFeSiO_4 + 4H_2O + O_2 = 2H_4Mg_3Si_2O_9 + 2Fe_3O_4 + 2SiO_2$$

Olivine Serpentine Magnetite

In case of basalt all the minerals are converted to clay and as there is no quartz in the original rock the

ultimate weathering, product is often a brown, base rich and heavy soil. Dolerite also weathers in a similar fashion. Rhyolite, on acid effusive igneous rock containing quartz, gives rise to sand upon weathering. However it is not weatherable as basalt.

Engineering properties of Deccan Trap are given in Table 4.1. Compressive strength of Deccan Trap is very high. According to Hakes and Mellore's (1970) strength classification this rock is strong to very strong (Appendix A). Chemical weathering of this rock is very slow compared to the life of structure. Deccan Trap is generally compact because of which it is notably impervious to moisture. This rock can be safely used in any structure.

QUARRY METHOD

All the existing quarries of Deccan Trap are shown in Fig. 4.1 and list of quarries is given in Table 4.2. In this chapter the present author has taken important town near cluster of quarries as one quarry e.g. Angdi village where about 15 quarries are located, they have been represented in the map by one quarry number. Normally all quarries of Deccan Trap are approachable in all seasons by motorable road. During the heavy rainfall period quarries

Plate 4.14:

Air compressor drilling with Jack hammer, Deccan Trap Quarry, Udwada, Valsad district.

Plate 4.15: Mundani prepared out of Amygdaloidal Basalt, Gondal, Rajkot district.

are closed for one or two days (Fig. 1.2). Some of the quarries which are established for exclusive use of irrigation projects are not shown in the map. In South Gujarat and Saurashtra areas most of the irrigation projects have established their own quarries for the construction of dams.

Open pit quarrying of Trap rock is carried out on large scale because it occupies large areas and has great thickness. The rock is drilled, broken by explosives and transported to the crusher where it is crushed and sized according to the specifications of the consumers. The market of crushed aggregate is more than that of dimension stone.

Normally overburden is absent, but if present, it is removed by shovel. Some times surface rock is to be removed because of its weathered nature. However quarry owners are using this rock for crushed aggregate. For use as dimension stone the surface layer of the rock if found inferior, is removed by chisel and hammer. Joints are taken advantage of in splitting rocks.

Holes are drilled with compressed air drills for primary drilling (Plate 4.14). Holes of 3 to 5 cm in

diameter and 50 to 150 cm in depth are drilled. The distance between the holes vary from 50 to 150 cm. However spacing and depth of hole is determined by nature and spacing of joints.

Blasting is one of the most important aspect in quarrying of Trap rock. Gelatin 80% cartridges capped by detonators are used extensively for blasting. Sand or local soil is used for stemming purposes. Firing is done by using electric exploder. Now-a-days Gelatin 80% cartridge are generally replaced by Ammonium nitrate and fuel oil mixture hardly costing 1/3 of high explosive.

The present author would like to suggest some improvement in quarrying method. Holes for blasting should not be drilled vertical. Inclined holes with an angle of 15° to 20° to horizontal will increase blasting efficiency resulting into more recovery of stones. Quarrying operation can be modernized with the help of Jet piercing method and wire-saw method as in the case of granite.

The rock to be used as dimension stone is cut and dressed into required size and shape at quarry site by chisel and hammer. Production of dimension stone is normally in accordance with consumer's demand.

USES

Deccan Trap is being used as dimension stone as well as crushed and broken stone. As dimension stone it is used as rubble in masonry dam and as rubble and ashlar blocks in building construction due to its high compressive strength and durability. This stone is most popular stone amongst builders. It is also used as paving blocks, guard stone, boundary stone etc. It can be used as Kilometer stone and curbing stone.

The stone can be used as monumental stone after polishing. The dense, fine grained and dark colour rock can be polished and which will show colour contrast between the inscription and the polished surface. Polishing of this rock if taken up on a commercial scale it will have a good market here as well as in foreign countries. This rock can be obtained large size by selecting such exposures where joints are very wide.

This rock is also used as Mundani in Rajkot district (Plate 4.15). Simultaneous production of dimension stone and crushed and broken stone will help in economy of quarry operation. At present generally all quarries are more interested in production of crushed and broken stone as compared to that with dimension stone.

Table 4.1 : Engineering Properties of Deccan Trap.

Sr. No.	Location		Compressive Strength Kg/cm^2	Water Absorption %	Specific Gravity	Durability
			IS 1121 : (Part I) - 1974	IS 1124-1974	IS 1124-1974	IS 1126-1974
1.	Dhanduka	(13)	1134	0.41	2.79	0.10/30 cycles
2.	Dhari	(17)	1049	0.41	2.78	0.11/30 cycles
3.	Kothdapitha	(19)	1282	0.27	2.68	0.09/30 cycles
4.	Rajula	(21)	820	0.23	2.42	-
5.	Chitrasani	(23)	950	0.30	2.95	-
6.	Garudeshwar	(25)	840	0.73	2.8	0.1/30 cycles
7.	Rajpardi	(27)	663.3	2.56	2.78	0.8/30 cycles
8.	Bhavnagar	(29)	1577	0.4	2.70	-
9.	Botad	(30)	1011	0.55	2.81	-
10.	Gariyadhar	(33)	644	1.33	2.91	-
11.	Khambaliya	(44)	1060	3.03	2.7	-
12.	Und	(48)	1325	2.40	2.79	0.29/30 cycles
13.	Jargadi	(50)	1109	1.02	2.9	0.25/30 cycles

contd...

Table 4.1 (contd.)

Sr. No.	Location		Compressive Strength Kg/cm^2 IS 1121 : (Part I) - 1974	Water Absorption % IS 1124-1974	Specific Gravity IS 1124-1974	Durability IS 1126-1974
14.	Keshod	(52)	820	1.47	2.88	-
15.	Semalia	(55)	702	0.87	2.73	-
16.	Anjar	(57)	1040	0.68	2.94	-
17.	Mandvi	(62)	1120	0.44	2.94	-
18.	Sevaliya	(69)	1300	0.21	2.58	0.11/30 cycles
19.	Halol	(73)	1283	1.18	2.95	0.15/30 cycles
20.	Timba	(74)	1600	0.73	2.85	0.76/30 cycles
21.	Usra	(75)	1300	0.5	2.80	-
22.	Aji	(76)	1297	0.29	2.73	-
23.	Kotharia	(82)	1163	2.17	2.90	-
24.	Morvi	(83)	1200	0.55	2.96	0.22/30 cycles
25.	Paddhari	(85)	1150	0.46	2.97	0.072/30 cycles
26.	Rajpur	(95)	1140	0.47	2.57	0.12/30 cycles

contd...

Table 4.1 (contd.)

Sr. No.	Location		Compressive Strength Kg/cm^2 IS 1121 : (Part I) - 1974	Water Absorption % IS 1124-1974	Specific Gravity IS 1124-1974	Durability IS 1126-1974
27.	Vadagam	(96)	907	1.27	1.82	-
28.	Areth	(97)	1549	0.22	2.78	0.06/30 cycles
29.	Songadh	(102)	1420	2.38	2.80	0.44/30 cycles
30.	Valod	(104)	1280	0.52	3.02	0.20/30 cycles
31.	Vyara	(106)	1068	0.22	2.92	0.18/30 cycles
32.	Sayala	(112)	1080	0.98	2.91	-
33.	Savali	(120)	1600	2.0	2.65	0.16/30 cycles
34.	Vaghodia	(121)	1300	0.5	2.8	-
35.	Alipur	(123)	1200	0.65	2.59	0.085/30 cycles
36.	Atul	(124)	1325	1.79	2.91	0.19/30 cycles
37.	Chikhali	(125)	1573	0.53	3.07	0.20/30 cycles
38.	Gandevi	(128)	1393	0.92	2.85	0.23/30 cycles
39.	Udwada	(132)	1132	0.18	3.2	0.28/30 cycles
40.	Valwada	(134)	1413	0.67	2.82	-

Table 4.2 : List of Deccan Trap Quarries (Fig. 1.2)

District		Location
Ahmedabad	(13)	Dhandhuka
	(14)	Dhorpipla
	(15)	Khambada
Amreli	(16)	Amreli
	(17)	Dhari
	(18)	Ghontvad
	(19)	Kothdapitha
	(20)	Motirala
	(21)	Rajula
	(22)	Vadiya
Banaskantha	(23)	Chitrasani
Bharuch	(24)	Dholi
	(25)	Garudeshwar
	(26)	Jitgadh
	(27)	Rajpardi
Bhavnagar	(28)	Bhadraval
	(29)	Bhavnagar
	(30)	Botad
	(31)	Dhosa
	(32)	Gadhad
	(33)	Gariyadhar
	(34)	Mahuva
	(35)	Palitana

contd...

Table 4.2 (contd.)

District		Location
	(36)	Savarkundla
	(37)	Shihor
	(38)	Talaja
Jamnagar	(39)	Chela
	(40)	Dhrol
	(41)	Jamjodhpur
	(42)	Jamnagar
	(43)	Jodiya
	(44)	Khambaliya
	(45)	Padan
	(46)	Sidsar
	(47)	Sikka
	(48)	Und
Junagadh	(49)	Adwana
	(50)	Jargadi
	(51)	Junagadh
	(52)	Keshod
	(53)	Mitdi
	(54)	Panindra
	(55)	Semalia
Kachchh	(56)	Abdasa
	(57)	Anjar (Vidi)
	(58)	Bhachau (Darima)
	(59)	Bhujay
	(60)	Kera
	(61)	Kumbhardi

contd...

Table 4.2 (contd.)

District		Location
	(62)	Mandvi (Dhuna)
	(63)	Mundra
	(64)	Nakhtrana
	(65)	Vandh
Kheda	(66)	Angdi
	(67)	Balasinor
	(68)	Pali
	(69)	Sevaliya
	(70)	Thasra
Panchmahals	(71)	Chalali
	(72)	Gothada
	(73)	Halol
	(74)	Timba
	(75)	Usra
Rajkot	(76)	Aji
	(77)	Atkot
	(78)	Daldi
	(79)	Dhoraji
	(80)	Gondal
	(81)	Jetpur
	(82)	Kotharia
	(83)	Morvi
	(84)	Motimadar
	(85)	Paddhari

contd...

Table 4.2 (contd.)

District		Location
	(86)	Rajkot
	(87)	Tanbara
	(88)	Upleta
	(89)	Vasavad
Sabarkantha	(90)	Akrund
	(91)	Bayad
	(92)	Khedbrahma
	(93)	Modasa
	(94)	Prantij
	(95)	Rajpur
	(96)	Vadagam
Surat	(97)	Areth
	(98)	Bardoli
	(99)	Mahuva
	(100)	Mandvi
	(101)	Mangrol
	(102)	Songadh
	(103)	Umara
	(104)	Valod
	(105)	Valvada
	(106)	Vyara
Surendranagar	(107)	Chotila
	(108)	Chuda
	(109)	Daseda
	(110)	Halvad

contd...

Table 4.2 (contd.)

District		Location
	(111)	Muli
	(112)	Sayala
	(113)	Sudamada
	(114)	Vastadi
	(115)	Wadhwan
Vadodara	(116)	Chotaudepur (Dhanpari)
	(117)	Jambugoral
	(118)	Kanadu
	(119)	Nasvadi
	(120)	Savli
	(121)	Vaghodia
	(122)	Varsada
Valsad	(123)	Alipore
	(124)	Atul
	(125)	Chikhali
	(126)	Degam
	(127)	Dharampur
	(128)	Gandevi
	(129)	Khundh
	(130)	Orwad
	(131)	Sadakpor
	(132)	Udwada
	(133)	Valsad
	(134)	Valwada

Plate 5.1 : Taranga Temple (Mehsana district), made up of Himatnagar Sandstone.