CHAPTER ONE

GEOLOGICAL SETTING
General Geology of Aravalli Mountain Belt

The Aravalli mountain belt is the principal physiographic feature in Rajasthan, which fringes the northwestern margin of the Indian shield and runs for more than 700 Km from Delhi in the north to Palanpur in the south with a variable width of 30 to 200 Km (Figure 1). This belt comprises a number of fold belts of early and middle Proterozoic ages. These fold belts evolved through the development of a series of basins in which several unconformity bounded metasedimentary and metavolcanic units deposited successively over an Archaean basement (3300-2500 m.y., Roy 1990; Gopalan et al. 1990) referred to as Banded Gneissic Complex or BGC (Heron 1953). The BGC has principally served as basement for two sets of younger supracrustal units i.e. the early Proterozoic supracrustals of Aravalli Supergroup (2500-1900 m.y., Roy 1990) and middle Proterozoic supracrustals of Delhi Supergroup (1900-1450 m.y., Roy 1990).

On the basis of lithological, structural, metamorphic and geochronological considerations the Precambrian rocks of Aravalli mountain belt can be divided into following tectonostratigraphic domains.

1. Archaean basement - Banded Gneissic Complex (BGC)
2. Paleoproterozoic - Udupur-Jharol belt, Bhilwara belt Supracrustals
Archaean basement

Banded Gneissic Complex (BGC)

BGC is a composite, structurally complex, gneissic terrain showing great lithological similarity to Archaean gneissic complex occurring in other parts of the shield (Naqvi and Rogers 1987). This complex is composed of a great variety and intermixture of rock types. It is a heterogeneous rock assemblage which includes biotite/hornblende gneisses, amphibolites, aluminous paragneisses, quartzites, marbles, calc-gneisses and pegmatites intruded by a number of granitic plutons. However, the major rock types are the granitoid gneisses of different compositions and amphibolites which constitute the bulk of the basement.

Heron (1953) described the BGC as the basement on which the successively younger supracrustals were deposited with clear unconformities. Although some workers (Crookshank 1948; Naha and Halyburton 1974; Naha and Roy 1983) have suggested that much of the BGC formed by the migmatisation of Aravalli sediments. Presence of local clear angular unconformities between the BGC and younger supracrustals (Roy and Paliwal 1981; Roy et al. 1988) confirm the basement status of the BGC.
Gupta et al. (1980) have grouped the pre-Aravalli rocks under Hindoli Group (metagreywackes, basic volcanics and semipelites), Mangalwar Complex (mostly gneisses) and Sandmata Complex (mostly granulite facies rocks), the later two complexes forming the BGC. The Sm-Nd isochron data suggest that the BGC contains the rocks as old as 3.3 b.y. (Gopalan et al. 1990). The youngest component of the BGC is a large body of Berach granite that is K-rich and has yielded a Rb-Sr (whole rock) isochron age of 2.6 b.y. (Crawford 1970).

**Paleoproterozoic supracrustals**

The Paleoproterozoic sequences in Aravalli mountain belt are widespread in the central part where they are well developed and exposed in Aravalli and Bhilwara belts.

**Udaipur-Jharol belt**

One of the best studied belt in this region is the Udaipur-Jharol belt which may be considered as the type area of the early Proterozoic linear basins which overlies the BGC. It is developed in an inverted 'V' shaped area with a tapering end near Nathdwara. This belt is characterised by occurrences of Aravalli Supergroup of rocks which show the development of two distinct lithofacies associations (Roy and Paliwal 1981) i.e. a carbonate bearing shelf facies and a carbonate-free deep water facies. The
shelf sequence constitutes the Udaipur belt which passes through the Udaipur city of Rajasthan. The deep water sequence constitutes the Jharol belt which occurs adjacently to the west of Udaipur belt. The metasedimentary rocks of Jharol belt are considered to be deep water distal-turbidite facies of shallow water sediments of Udaipur belt (Roy and Paliwal 1981). Since the two belts display similarity in tectonic trends and deformation history, they are considered to represent two separate segments of a single early Proterozoic sedimentary basin which developed on the Archaean basement of BGC (Deb and Sarkar 1990). Although the geology of the area is based on pioneering work of Heron (1953), the detailed stratigraphic evolution of the basin has been worked out by Gupta et al. (1980) and Roy and Paliwal (1981). Generally, the rocks of Udaipur - Jharol belt have been metamorphosed upto the grade of greenschist facies. However, in some areas particularly in the northern part the grade of metamorphism has reached upto the grade of amphibolite facies (Sharma 1988).

Bhilwara belt

The Bhilwara belt is exposed as a N-S trending wedge shaped area between Karera in the west and Great Boundary Fault (GBF) in the east. It is about 100Km wide in the north, tapering to about 10 Km in the south. Its southern end meets the eastern boundary of the Udaipur belt.
In fact this belt comprises several sub-parallel linear belts separated from each other by zones of BGC gneisses. Some of these belts are bordered by ductile shear zones with a high components of strike-slip movement (Sinha -Roy 1988). The important belts of Bhilwara terrain from east to west are Hindoli-Jahazpur, Pur-Banera and Dariba-Bhinder. In general these belts consist of metapelites, quartzite, dolomite, BIF (10-40m), metagreywacke and metavolcanics. A shallow platformal environment of sedimentation is indicated by sedimentary associations and structures. The grade of metamorphism increases gradually from east (greenschist facies) to west (amphibolite facies) and also towards north. The Pb isotopic data on base metal deposits (Deb and Sarkar 1990) and structural trends suggest a contemporaneity of Aravalli and Bhilwara belts.

Mesoproterozoic supracrustals

Delhi fold belt

The Mesoproterozoic supracrustal rocks of Aravalli mountain belt are represented by the rocks of Delhi Supergroup (1900-1450 m.y., Roy 1990) which constitute the main edifice of this great mountain range. The Delhi fold belt, extends all along the length of Aravalli mountains covering the parts of Gujarat, Rajasthan, Haryana and Delhi states. It is narrow in central Rajasthan and fans out considerably in its northern and southern parts.
rocks of Delhi fold belt rests unconformably over BGC in northeastern portion. In southern region the rocks of Delhi Supergroup show a tectonic contact with those of Aravalli Supergroup. This contact is considered to be a major tectonic suture representing the site of ocean basin closure and continental collision (Sugden and Windley 1984; Sinha-Roy 1988; Sugden et al. 1990). Heron (1953) subdivided his "Delhi System" into two major stratigraphic units i.e. lower Alwar 'Series' and upper Ajabgarh 'Series'. Although this classification has been questioned by some workers (DasGupta 1964, Sen 1981), it is still maintained in literature except in the axial section of central Rajasthan where these series are renamed as Gogunda and Kumbalgarh Groups respectively (Gupta et al. 1980). The Alwar Group is dominantly arenaceous consisting arkosic quartzite, conglomerate and mafic volcanics. The Ajabgarh Group is mainly calcareous comprising biotite schists, calc-schists and calc-gneisses with abundant interlayered metavolcanics and tectonised bodies of mafic-ultramafic rocks, the later are considered as Phulad ophiolites of central Rajasthan (Gupta et al. 1980; Sinha-Roy 1988; Volpe and MacDougall 1990). In this manner the Alwar Group appears to be more terrestrial in nature but rocks of Ajabgarh Group are more calcareous or pelagic. Gupta et al. (1980) are of the opinion that Gogunda (Alwar) and Kumbalgarh (Ajabgarh)
metasediments are time transgressive, reflecting contemporaneous sedimentation in a coupled basin comprising miogeosyncline and eugeosyncline respectively.

Several regional longitudinal faults and shear zones occur all along the length of Delhi fold belt (Sen 1981, 1983; Sychanthavong and Merh 1984). Along some of these faults and shear zones there are sporadic occurrence of high grade granulitic bodies comprising pyroxene granulite, hornblende granulite, serpentinite and gabbros (Desai et al. 1978; Sychanthavong and Merh 1984; Fariduddin et al. 1991). At some places in the southern part of the belt the xenoliths of grosubydite are found to occur in the close association with serpentinite and pyroxene granulite (Sychanthavong and Merh 1984).

The rocks of Delhi belt to the north and south of Ajmer show a marked difference in the radiometric ages of intrusive granites (Chaudhary et al. 1984) and model ages of sulphides (Deb and Sarkar 1990). Till date no satisfactory explanation has been given for this difference. This may be interpreted as two tectono-thermal episodes within the Delhi belt or the development of Delhi rocks in two different basins that were widely separated in time and space (Naqvi and Rogers 1987). In view of these contrasts some workers have suggested that the northern and southern parts of Delhi fold belt have been evolved in different
tectonic setup (e.g. Sinha-Roy 1984, 1988), However, a continuous stratigraphy (Singh 1988), an identical structural history (Naha et al. 1984) and a similar metamorphic history (Sharma 1988) of the northern and southern parts suggest the continuity of Delhi fold belt from south to north.

Distribution of Mafic Rocks in Aravalli Mountain Belt

The Aravalli mountain belt preserves a continuous record of mafic magmatism which occurred during its long geological history. The oldest mafic magmatic activity recorded in this belt is represented by 3.3 b.y. old (Gopalan et al. 1990) metabasic enclaves which are enclosed within the BGC. The enclaves consist mainly of amphibolite, norite and metagabbros. The geochemical studies of amphibolites from various parts of the BGC between Udaipur in the south and Ajmer in the north reveal that most of them are ortho-amphibolites and have been derived from tholeiitic lavas or intrusives, under amphibolite or upper amphibolite facies metamorphism (Pandya 1967; Chauhan 1976; Goel 1976; Kataria 1981; Sharma 1983; Ahmad and Rajamani 1988; Ahmad and Tarney 1994).

The next phase of mafic magmatism is represented by Komatiitic-tholeiitic lava flows occurring at the base of Aravalli Supergroup in Udaipur belt. These basal volcanics are well exposed in two N-S trending linear belts
occurring in the east and west of Udaipur city (Khan and Raza 1993; Raza and Khan 1993). On the basis of geochemical evidence the basal Aravalli volcanics have been considered as rift related komatiite-tholeiite association (Ahmad and Rajamani 1991; Raza and Khan 1993). Equivalents of these rocks are found in basal parts of all sub belts in Bhilwara belt (Roy et al. 1981; Sinha-Roy 1988; Deb et al. 1989). In Jharol belt this volcanic activity is represented by mafic rocks of Kaliguman lineaments in its central part (Abu-Hamatteh 1994).

The next younger phase of mafic magmatism in Aravalli mountain belt is represented by mafic volcanic rocks of Delhi Supergroup where they occur at two stratigraphic levels. The older magmatic event manifests itself in the form of basic flows which occur at the base of Alwar Group. The younger one occurs within Ajabgarh Group. The volcanic rocks of Alwar Group occur as lava flows in Bayana and Tehla areas of north Delhi fold belt in northeastern Rajasthan (Singh 1982, 1985).

The Ajabgarh mafic magmatism appears to be more intensive in nature as indicated by its reasonably wide occurrence along a linear belt approximately 450 Km long and upto 30Km wide extending from Khetri in the north to Deri-Ambaji in the south (Srivastava 1988). Some mafic rocks of this belt, exposed to the south of Ajmer, have been
referred to as 'Phulad ophiolite suite' (Gupta et al. 1980; Sinha-Roy 1988).

The youngest mosaic volcanics in this region are minor basic components associated with 740 m.y. old Malani rhyolite (Srivastava 1988). The Malani igneous suite of rocks occupies vast tracts to the west of Aravalli mountain belt.

**Geology of North Delhi Fold Belt**

The northern part of the Delhi fold belt is broadly constituted by three sedimentational domains (Singh 1984a, 1988). These are from east to west the Bayana basin, the Alwar basin and the Khetri basin. The first two basins taper out towards the south whereas the third one appears to extend into the south Delhi belt although its physical continuity is interrupted by a vast expanse of alluvium around Jaipur. These domains are considered (Singh 1982) to have been developed as grabens in a gneissic basement and individually they differ from each other significantly in their stratigraphic development. These volcano-sedimentary infills of north Delhi fold belt have been classified into Alwar and Ajabgarh Groups in each basin (Deb and Sarkar 1990). The grade of metamorphism and intensity of deformation increase from east to west.

The metasedimentary rocks of north Delhi belt are commonly intruded by granitic rocks which have yielded
their age (Rb-Sr whole rock) in the range of 1700-1500 m.y. (Chaudhary et al. 1984). Some of these granites are synkinematic with the two folding phases of the Delhi rocks (Roy and Das 1985). The age of granitic intrusions decreases from about 1600 m.y. in the east (Bairat, Dadikar and Harsora granites) to 1400 m.y. in the west (Saladipura, Udaipur and Seoli granites).

Geology of Bayana basin

The Bayana basin forms the eastern most limit of north Delhi fold belt covering the parts of northeastern Rajasthan (between Lat. 26°.53' and 27°.02': Long. 77°.00' and 71°.18'). Although a comprehensive account of stratigraphy of Bayana basin has been documented by Hacket (1877, 1881) and Heron (1917), a detailed stratigraphic evolution of the basin has been worked out by Singh (1977, 1982). A five fold stratigraphic classification has been proposed by pioneer workers (Hacket 1877, 1881) Heron (1917), who assigned each unit the status of a 'stage' belonging to Alwar 'Series' of Delhi 'System'. The five units are Nithar, Badalgarh, Bayana, Damdama and Weir. Singh (1977) maintained this classification and assigned the status of Formation to each of these units with a modification that the first four included in Alwar Group and the last one correlated with Ajabgarh Group of main Delhi basin. In a later publication, Singh (1982) modified his
classification and identified the rocks of Nithar Formation and basal part of the Badalgarh Formation as Raialo Group. Although, Heron (1917) was the first to classify the sedimentary sequence of Delhi belt into 'Raialo Series', 'Alwar Series' and 'Ajabgarh Series', the status of his 'Raialo Series' as an independent unit was questioned by later workers. In southern Rajasthan the conformable relationship between rocks of Aravalli Supergroup and that of 'Raialo Series' is found at many places by many workers (e.g. Naha and Halyburton 1974; Naha and Roy 1983) and thus two groups have been mapped as a continuous sequence (e.g. Raja Rao et al. 1977). Similarly in northern part of Delhi fold belt the rocks of 'Raialo Series' are generally considered as part of Alwar Group (Sychanthavong and Merh 1984). In view of these facts, the Nithar Formation, which constitutes the basal part of Bayana basin fill, is considered herein as basal part of Alwar Group.

The Bayana basin as a whole is filled with about 3000m thick package of volcano-sedimentary rocks (Figure 2A,B). The volcanic rocks, which are subject of this study are confined only to its basal part. The sequence in Bayana basin consists of about 55 percent quartzite, 30 percent conglomerate 1.50 percent shale and 14 percent volcanic products (Singh 1977). On the whole the conglomerate-quartzite association constitutes about 85
Figure 2A Simplified geological map of Bayana basin (after Singh 1982) showing different lithological formations of Delhi Supergroup. Inset shows outline map of Aravalli Mountain Belt, illustrating various Precambrian rock units of the region.
Figure 2B Columnar section showing lithological units of Bayana basin (Scale 1 Cm = 200 Meters), Data: Singh (1982). Note the occurrence of a thick conglomerate unit underlying the volcanics and an unconformity overlying the Bayana volcanics.
percent of the total thickness. The stratigraphic classification of the area is given in table 1.

Nithar Formation consists of basal conglomerate and quartzite with interfingering thin lenses of conglomerate and pebbly quartzite. The basal conglomerate is composed of quartz and quartzite phenoclasts set in quartzose matrix with rare pebbles of jasper and tourmaline-quartz rock. In general the sorting of the conglomerate is poor. The quartzite member of this formation is white and grey, fine to coarse grained, gritty, at places pebbly, conglomeratic and feldspathic. It is composed of quartz and minor amount of K-feldspar, sericite and muscovite. The maximum thickness of this formation is 200m.

Overlying the Nither Formation is a series of basic volcanics and associated metasedimentary interbeds of Jahaj-Govindpura volcanics. Ker-Govindpura-Jahaj area forms the type section for this formation where its total thickness is about 1000m. A total number of eighteen flows are encountered in this area, which have been classified into three members on the basis of pyroclastic contents (Banerjee and Singh 1977).

The conglomerate and quartzites of Jogipura Formation conformably rest over Jahaj-Govindpura volcanics. This formation comprises Sita Conglomerate and Quartzite members. The pebbles of conglomerate are well rounded.
Quartzite is medium grained to coarse grained and associated with sparsely distributed pebbles, well developed cross beds and ripple marks.

The Badalgarh Formation conformably overlies the Jogipura Formation and is composed of an interlayered sequence of thinly bedded feldspathic quartzite, micaceous quartzite, thinly laminated shale, sandstone and thinly bedded quartzite. The rock types of this formation are subdivided into two members viz. Baghrain sandstone and Alapuri quartzite.

The Havana Formation which conformably overlies the Badalgarh Formation has been subdivided into two members i.e. Mor Talab quartzite and Mahloni conglomerate. The former is composed of massive quartzite, with sparsely distributed pebbles and thin lenses of conglomerates. Prominent sedimentary structures observed in these quartzites are ripple marks and current bedding. The bedding is not very clear in these quartzites. Mahloni conglomerate overlies the Mor Talab quartzite and is composed of conglomerate and massive quartzite. The conglomerate with disrupted framework contains phenocrysts of grey, white and black quartzites. The intercalated quartzite is pink in colour, coarse grained and pebbly.

The Damdama Formation which constitutes the uppermost unit of Alwar Group conformably overlies the
Bayana Formation. It is composed of conglomerate, quartzite, sandstone and shale. This formation is subdivided into three members i.e. Umraind conglomerate, Kanawar quartzite and Lakhanpur sandstone. The Umraind conglomerate is poorly sorted but at places contains bands of very rounded and perfectly sorted pebbles. The Kanawar quartzite is coarse grained preserving well developed ripple marks and cross-bedding. It consists of large sub-angular grains of quartz set in an arenaceous matrix, fine flakes of sericite-muscovite and altered grains of feldspar. The Lakhanpur sandstone consists of thinly bedded, dark feldspathic sandstone, quartzitic sandstone and brown shale.

The youngermost geological unit of Bayana basin, that is correlated with Ajabgarh Group of main Delhi basin by Singh (1982), shows disconformable relationship with the underlying Damdama Formation. It consists of carbonaceous shale, phyllite, ferruginous quartzite and white quartzite. This group has been subdivided into two formations i.e. Kushalgarh Formation consisting of shale phyllite, and minor quartzite, and Weir Formation consisting of ferruginous quartzite and white massive quartzite that is cherty at places.

Field occurrence of mafic volcanic rocks in Bayana basin

The mafic volcanic rocks in Bayana basin occur in the form of flows, agglomerates, volcanic breccia
and tuffs. They cover an extensive area of about 100 Sq Km between Aund and Khareri attaining a maximum thickness of about 1000m including sedimentary interbeds with thickness variation of the individual flows from 1.20m to 123m (Banerjee and Singh 1977). Total number of eighteen flows identified in this area, have been classified into three groups (Banerjee and Singh 1977) i.e. lower group containing seven flows, the middle group with three to five members consisting agglomerates with spatter, volcanic breccia, bombs, lapilli blocks and tuffs, and upper group with maximum of eight flows. The distribution of volcanic products suggests that the volcanism occurred in three phases. The lower seven flows indicate comparatively mild explosion, the middle three units represent highly explosive phase and the upper eight flows suggest mainly quite eruption. The maximum thickness of these volcanics as well as the thickness of individual flows is maximum around Kei. It shows a gradual decrease both towards east and west.

The volcanic flows are mostly fine to medium grained, dark grey to greenish black coloured massive basalts, containing well preserved vesicles and amygdules. The vesicles are generally rounded and their size varies from very fine to more than 5mm and sometimes upto 3cm. The vesicularity decreases from top to bottom of individual flows.
Geology of Khetri basin

The well known Khetri copper belt is located at 170 Km SSW of Delhi in the northern Rajasthan, which extends over a strike length of about 80 Km from Singhana (28° 06' : 75° 04' ) in the north to Ragunathgarh (27° 39' : 75° 21' ) in the south. It is regarded to extend further south into the south Delhi fold belt (Sychanthavong and Desai 1977; Roy et al. 1988; Singh 1988). The general geology and the stratigraphy of the area have been described by many workers (Heron 1923, 1925; DasGupta 1964, 1968, 1974; Roychowdhary and Das Gupta 1965 a,b; Roychowdhary et al. 1968; Ray 1974). The rock types found in the area are chiefly sedimentary metamorphites comprising various types of schists, phyllites interlayered with massive quartzites, metagreywackes, marbles, calc-silicate rocks and amphibolites. Although the stratigraphic relationships between various lithounits are not very much clear, the sequence is divided into Alwar (dominantly arenaceous) and Ajabgarh (argillaceous and calcareous) groups (Table 2).

The rocks of Alwar Group are considered to be found in the cores of anticlines, which are dominantly arenaceous and consists of a thick pile of metasediments comprising magnetite quartzite, feldspathic quartzite with or without cummingtonite and anthophyllite quartzite. The Ajabgarh Group is composed of mica schist and phyllite
containing andalusite - staurolite, chlorite schist - (garnet) and calc-silicate rocks with calcite and actinolite. The sulphide mineralization appears to be associated with the Ajabgarh sequence (Ray, 1992). At places these rocks are interlayered with amphibolite sheets which are the subject of present study (Figure 3). DasGupta (1968, 1974) observed that the rocks of Alwar Group possess certain features which distinguish them from those of Ajabgarh Group. In the Alwar quartzites comprising such lithotypes as arkose, quartzites, orthoquartzites, protoquartzites, various types of ripple marks and current bedding are distinguishable. Such features are strikingly absent in most of the Ajabgarh quartzites. The pale cream coloured Alwar quartzites are gritty and in general more coarse grained than the Ajabgarh quartzites which are white or grey and also fine grained and massive. The Ajabgarhs sometimes, contain sericite or spangles of mica lying flat along the bedding planes and quartzites locally pass into mica schists. The Alwars are relatively free from the schistose rocks except in the basal part of the quartzites where a schistose-phyllite horizon is noted. Locally the Alwar quartzites pass into thin lenses and bands of schists and phyllites.

The amphibolites occur as sheets in different rocks and also as rafts in granites. These bodies are
Figure 3 Simplified geological map of Khetri Copper Belt (after Das Gupta 1974) illustrating the lithological succession of the area. Inset shows the distribution of various Archean-Proterozoic rock suites in an outlined map of Aravalli Mountain Belt.
considered to have been emplaced as mafic sills during early stage of deformation (DasGupta 1968). A younger generation of basic dykes cut across the major structures and also related pegmatites and quartz veins, which are succeeded by younger basic dykes.

Geochronological data (Chaudhary et al. 1984) suggest that the granite intruding Delhi succession, north of Ajmer, yield an age range of about 1700-1500 m.y. Rb/Sr isochron age. Most granites in Khetri Copper belt are emplaced during late phase of first Delhi deformation (Das Gupta 1968). Granite from southern part of Khetri belt i.e. Chhapolí Granite, Saladipura Granite and Bairat Granite have yielded Rb/Sr isochron age about 1600 m.y. (Choudhary et al. 1984). This suggests an upper limit of 1600 m.y. for the Delhi sequence in northern part of Delhi fold belt. The amphibolites are found as inclusions (rafts) in these granites and thus suggest their emplacement during or just after the deposition of Ajabgarh sediments.

On the basis of mineral assemblages found in the rocks, it has been observed that the highest grade of metamorphism noted in the southern half of the belt is beyond the amphibolite facies whereas the rocks of northern half of the belt (present area) are metamorphosed up to the grade of upper amphibolite facies (Roychowdhary et al. 1968). The mineral assemblages of basic rocks and
metasediments indicate that the rocks were regionally metamorphosed up to the grade of amphibolite facies (Ray 1974).

Field occurrence of Khetri amphibolites

The amphibolites in the Khetri belt occur in the form of sills of metamorphosed dolerites. Heron (1923) considered the amphibolite sheets as intrusive sills but acknowledged the possibility that contemporaneous lava flows and tuffs may also be present. However, there is no unequivocal evidence attesting the eruptive nature of amphibolite suites. The tabular bodies of amphibolites appear to emplace along the bedding planes (of pelites and quartzites) and sometimes along fault planes. In the northern part of the belt these amphibolites are found mainly in schists and phyllites of Ajabgarh Group. They occur as sheets of about few meters to as much as 10 km length with a width of 5 to 60 meters. In quartzites the width of these amphibolites is variable from place to place but within the pelites it is more or less constant. They also occur as discontinuous lenses. Usually the sills of these amphibolites have sharp and straight contact with the country rocks, sometimes showing central bulge. At places short tongues locally cut across the country rocks. At places the sheets of larger bodies taper off at either end. They are mostly co-folded with the country rocks during the
later fold movements. These amphibolite sheets dip westerly
(parallel to bedding) in the western part, and vertically
in the central part, whereas in the eastern part the dip is
subvertical either to the southeast or to the northwest.

These rocks are mostly medium to coarse
grained and grey to greenish black in colour. They contain
no primary features such as vesicles and amygdules, which
may support their emplacement as lava flows.