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(RESEARCH ARTICLE)

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Geological investigation in the Bhuleshwari River Basin, Amravati District, Maharashtra

Sumit D Ingle [1,*] and Shripad P Tohare [2]

[1] *Department of Geology, G. S. Tompe Arts, Commerce and Science College, Chandur Bazar, Dist. Amravati, Maharashtra, India.*
[2] *Groundwater Surveys and Development Agency, Amravati, Maharashtra, India.*

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Abstract

The Bhuleshwari river basin covers an area about 380 Sq. Km. from Bhatkuli and Achalpur Taluka, Amravati district, Maharashtra. It flows over varied geological formation from Deccan trap to Alluvium with groundwater quality varying from fresh water to saline water. The area has been studied to evaluate the impact of geomorphology on groundwater occurrence and its impact on hydrogeochemical evolution of groundwater. Number of field traverses and observation in the bank sections of the river and dug wells has been done in the given basin. The nature and lateral and vertical extent of aquifers are controlled by lithology, stratigraphy and structure of rock formations. Lithological characteristics of rocks are reflected in their storage and yield properties. The present work deals with the regional as well as local geological set of the area and its Stratigraphic position. It also deals with the lithological characteristics of the 'basalt flows' and structural features of the area. The detailed geology of the Bhuleshwari river basin has been discussed and presented in chapter two. Based on number of field traverses, in the geological map eight lavaflows has been identified in northern region and alluvium in southern region can be divided into younger and older alluvium. The Deccan trap is separated by alluvium with fault, boulder alluvium is seen to occur in this zone. The geological map of Bhuleshwari river basin modified from geological survey of India map, GSI (2001) is presented. Geologically the study area consists of 420 m thick Alluvium. Only the top 40 m is accessible for direct observation in the bank sections of the river and dug wells.

Keywords: Bhuleshwari River Basin; Geological Investigation; Regional Geology; Alluvium; Deccan Trap; 55H/5

1. Introduction

Water is one of the main resources essential for the overall socio-economic development of any region and it requires careful planning and appropriate exploration. Groundwater potential of any region can be revealed through detailed geological, geo morphological, geophysical, hydro geological, geophysical and hydro geochemical investigations. The Bhuleshwari river basin flows over varied geological formations right from the Deccan trap to Alluvium of recent age. Hence it gives the opportunities to study the interrelationship of geology, lithology and geomorphology on the occurrence of groundwater and its hydrochemistry. The basin covers an area of about 380 sq kms from Bhatkuli Taluka and Achalpur Taluka of Amravati District, Maharashtra. The basin is bounded by longitude 78^0 17'E to 78^0 28'E and latitudes 20^0 55'N to 21^0 20' N falling in the Survey of India toposheets No. 55 H/5, 55 G/7 and 55 G/8.

* Corresponding author: Sumit D Ingle

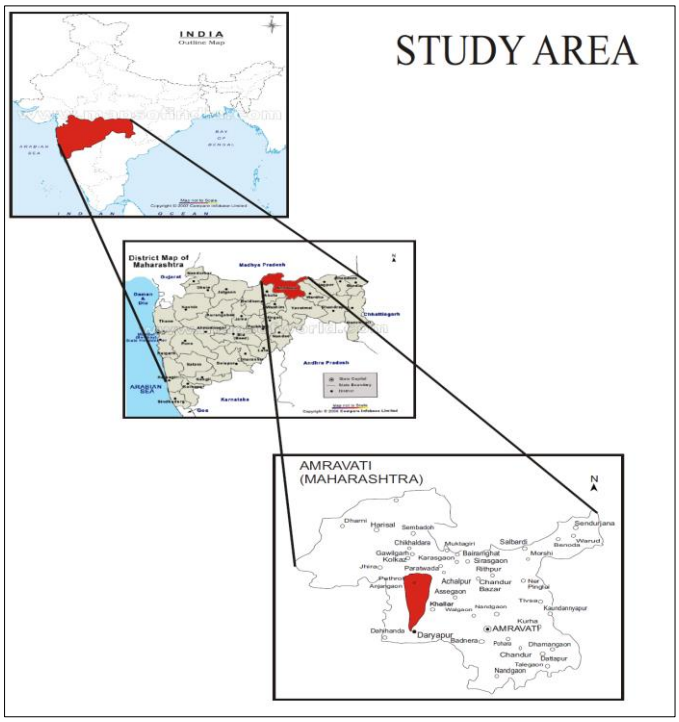

Figure 1 Location of study area

2. Materials and Methods

Number of field traverses and observation in the bank sections of the river and dug wells has been done in the given basin. The nature and lateral and vertical extent of aquifers are controlled by lithology, stratigraphy and structure of rock formations. Lithological characteristics of rocks are reflected in their storage and yield properties. Stratigraphy gives the chronological order in which the rock formations were laid down on the surface of the earth, that is, the order of superposition of rocks from which the presence or absence of aquifers below a rock formation can be predicted.

The present work deals with the regional as well as local geological set of the area and its Stratigraphic position. It also deals with the lithological characteristics of the 'basalt flows' and structural features of the area.

3. Result and Discussion

3.1. Regional geology

The State of Maharashtra is mainly covered by the lava flows of Deccan Volcanic Province, which is about 82% of the total area of the state. Rest includes the Archeans and Proterozoics (11%), Gondwanas (2.5%), and Alluviums (4.5%).The Study area is situated in the eastern part of the Deccan Volcanic Province.

The Deccan volcanic province is a vast expanse spanning over 5, 00,000 km^2 in west-central India, and is commonly believed to have erupted during the upper cretaceous to lower eocene period (around 65 +/-10 Million years ago).

In Deccan volcanic province compound flows are exposed around an elliptical region (Nashik-Igatpuri) and simple flows are dominant in peripheral region (Deshmukh, 1988) (Fig. No. 2). The study area is situated in the eastern part of the province in which is a 'simple' or 'aa' flow dominated area. The thickness of this stack of sub horizontal basaltic lava flows is variable and attain a thickness in the range of 0.36 to 1.3 km (Hooper, 1999).The constituent flows, primarily of basalts, with thickness varying from less than a meter to almost 100 m individually, are presumed to have a flat, tabular geometry and have been traced to extend across long distances (Mitchell and Cox, 1988).

Lithological description of the Deccan basalt range from general terminology, such as weathered and massive basalt (Narayanpethkar et al.1993), or pervious and impervious formations, to specific descriptions, such as vesicular, amygdaloidal, and compact (Adyalkar and Mani,1971; Central Groundwater Board of India,1982; Dhokarikar,1984) and

even terminology of Hawaii basalts-aa and pahoehoe (Rana and Vishwakarma,1990; Thorat and Sable,1990).The Widespread occurrence of alternating layers of vesicular amygdaloidal basalt and compact basalt is well established in the Deccan region (Gupte,1971;Kulkarni and Deolankar,1989,1995; Kulkarni et al.2000).

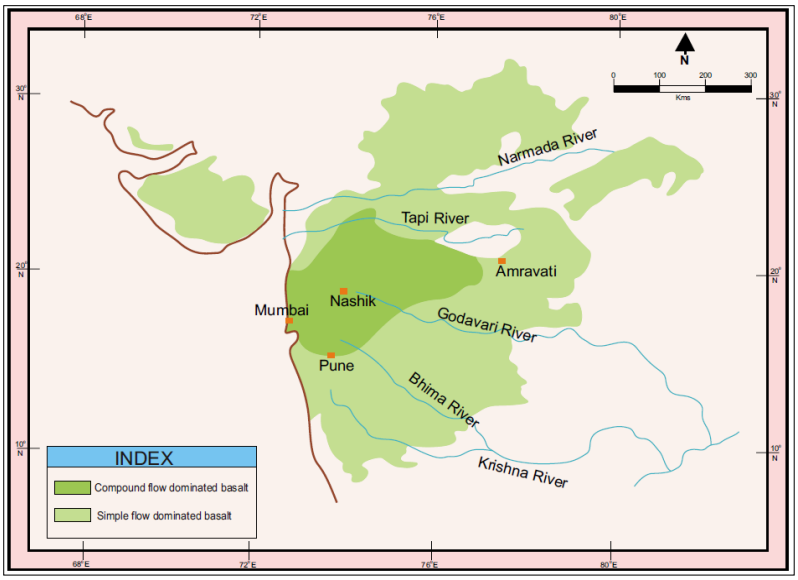

Figure 2 The Deccan Trap Volcanic Province of Western India (After Deshmukh, 1988)

3.2. Geology of the Amravati District

Table 1 Geology and Stratigraphy of the Amravati district (After GSI, 2001)

Group	Formation	Age	General characters / Litho logy
Quaternary		Cenozoic	Alluvium
			Laterite
North of the Tapi lineament/ Salburdi fault			
Satpura group (Deccan Basalts)	Golai	Upper Cretaceous to Palaeogene	Group of 'Aa' flows (6 to 8 lava flows,170 m thick)
	Bargonda		Group of 'Aa' flows (6 to 10 lava flows,160-340 m thick)
	Indore		Group of 'Aa' and 'Pahoehoe' flows (16 to 22 lava flows,300-400 m thick)
	Kankariya		Group of flows with megacryst flow (8 lava flows,120 m thick)
	Kalisindh		Group of 'Aa' and 'Pahoehoe' flows with one megacryst horizon (11 lava flows,440 m thick)
Lameta	Lameta	Upper Cretaceous	Limestone , Sandstone
Upper Gondwana	Panchmari	Lower Triassic to Cretaceous	Sandstone
South of Tapi lineament / Salburdi fault			
Sahyadri group (Deccan Basalts)	Ritpur	Upper Cretaceous to Palaeogene	7 Simple 'Aa' flows ,55-117 m thick, non-porphyritic
	Inter trappean		Limestone, Impure clay

	Karanja		Moderately Porphyritic 8 to 14 flows,148-366 m thick)
	Chikhli		Non Porphyritic 6 flows,45-130 m thick)
	Unclassified basalts		Sparsely to moderately Porphyritic

Geologically in Amravati district 75% of the area is covered by Deccan Trap and 25% area is covered by Purna alluvium. Out of the total area of 2053 sq kms alluvium covers 1562 sq. km. Ever since the nature of the saline tract of the Purna valley was recorded by Wynne (1869) it has engaged the attention of the geologist. Purna valley was recognized as the faulted alluvial valley; but its nature, pattern of sedimentation and paleageographic remain to be worked out fully even up to the present date.

Adyalkar (1975) analyzed palaeogeographic frame work of sedimentation and groundwater potentialities of the uplands alluvial valleys of the Purna River. Geology in parts of Amravati district, Maharashtra was studied by Bhai H. Y. and Saha D (1989), Bhai, H. Y. (1990), Tiwari, M. P. (1990). Geomorphological characters in the region were worked out by Tiwari, M. P. and Mukhopadhyay, P. K. (1989). Geomorphological characters in the region was worked out by Tiwari, M. P. and Mukhopadhyay, P. K. (1989), Khadse S.P. (2003), Bhoyar P.R (2008), Jaipurkar (2010), Gadewar (2008) Srivastava, A.K. et.al (2009), Siddique M. A. (2004).

3.2.1. Deccan trap

Basalt flows of the district are classified under Sahyadri and Satpura groups respectively, confined to south and north of the Tapi lineament/ Salburdi fault. Purna alluvium of Pleistocene to Recent age occurs in the intervening areas. The Sahyadri group is further sub divided into the lower Chikhli formation, middle Karanja formation and the upper Ritpur formation. The Chikhli formation is exposed in the southeastern part of the district and comprises a maximum of six flows of non-porphyritic to moderately porphyritic nature. Its exposed thickness varies from 45 meters to 130 meters. The Karanja formation includes eight to fourteen 'aa' flows of non-porphyritic to highly porphyritic nature. Its maximum exposed thickness is up to 366 meters and it occupies maximum area of the district. This formation has both 'aa' and 'pahoehoe' type of flows.

3.2.2. Purna Alluvium

Purna alluvium occupies about 1/3 area of the district having a maximum thickness of 185 m in the Amravati district. Alluvium with Kankar and associated with sub-recent calcareous conglomerate under-lying the black cotton soil cover extensive areas in the district, the conglomerate being more persistent along the river courses. The alluvium covers areas of superficial "rain-wash" and is finely laminated sandy deposits extending to a thickness of about one meter is noted in the alluvial banks of the Purna River near Paruth. These extensive accumulations of the alluvium in the Purna valley is homotaxial with Narmada and Tapi valley alluvium and are considered to have formed in the Pleistocene period.

On the banks of Purna alluvial matter is very less, and this does not extend far from the river at either side. The alluvium on its south side seldom extends beyond an average of ten kms from the river and nearly coinciding along its southern boundary with the Nagpur extension of the Indian Peninsula Railway, while on the north it reaches nearly to the base of the mountains. On the east its rather arbitrary and indefinite boundary closely approaches the basin, and bending southward traverses undulating country, eventually reaching the flanks of the hills near Amravati.

All round the margin of this alluvial tract is a belt of country that might or might not with propriety be included within it, although the surface deposits there do not conceal the underlying rock, the exposure of which was taken as the chief guide in determining the line of boundary. On the north and east, this tract of country is very stony, and it may be supposed that streams descending from the mountains and hills have frequently traveled across this space their courses subject to lateral deviation, covering the whole of it with coarser fragment brought down by floods at a time perhaps when the water of a lake or the sea occupied the basin of the finer alluvium and arrested the boulder-bearing velocity of these mountain streams.

In every part of the alluvium calcareous conglomerate is of common occurrence. It occasionally contains fragments of bone or fossil teeth of ruminants, but although sought for, no large accumulation or even a large fragment of these fossils was observed.

The alluvium of the valley is of considerable depth may be perhaps inferred from the absence of numerous exposures of rock, as well as from the depth of nullahs and height of the river cliffs. The conglomerate, as usual, occurs in its lower portions. Its constant or frequent occurrence beneath the rest of the alluvium would not prove its being contemporaneous in all places, as the trap-rocks, upon which these deposits. Certainly the stream through most of this is sluggish, but it seems to be a rather strong assumption, that no greater fall than the height of the river banks where it enters this rocky tract-perhaps on an average not more than 30 feet-takes place within so great a distance as extends between this and the upper end of the alluvium, about south-west of Amravati.

3.2.3. Structure

Structurally the area of the district is quite disturbed as evidenced from the faults, lineaments and some neo tectonic activity. The area shows a distinct E-W to ENE-WSW structural trend. The Salburdi fault is a major fault having southerly down throw of 1000 meters. The faults at the foot hills of Satpura hills have tilted the basaltic flows to the north with a maximum dip of about 30^0.

3.3. Geology and Stratigraphy of the Bhuleshwari river basin

Detailed geological mapping is undertaken in the Bhuleshwari river basin with the aim to reveal the physical set up of the different geological units and groundwater occurrence. Nomenclature based on petrologic and hydro geological characters of the basalt flows, as suggested by Gupte (1971), Kulkarni and Deolankar (1989), (1995), Kulkarni et al. (2000), is followed. The Bhuleshwari river basin is occupied by the basalt flows of Karanja formation as named by G.S.I. (2001), and shallow river alluvium in the southern part of the basin. Geology and Stratigraphic succession of the Bhuleshwari river basin, based on the field observation is shown Table No. 2. The geological map of Bhuleshwari River is modified from geological survey of India map is represented in Fig. No.3

3.3.1. Alluvium deposit

Geologically the study area consists of 420 m thick Alluvium. Only the top 40m is accessible for direct observation in the bank sections of the river and dug wells. The upper cover of the alluvial deposit comprises three lithostratigraphic formations (i) Virul formation (ii) The Kural Formation (iii) The Purna Formation (Tiwari and Mukhopadhyay, 1989; Tiwari, 1990).

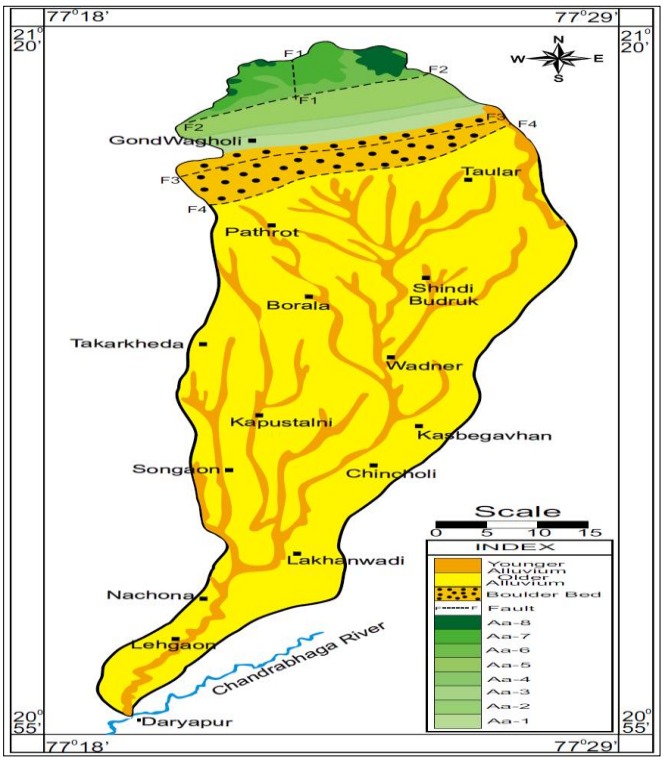

Figure 3 Geological map of the Bhuleshwari river basin (Modified from geological survey of India map, 2001)

Table 2 Geology and Stratigraphy of the Bhuleshwari river basin

Group	Formation	Age	Flow number		Average altitude of flow contact in m.msl	Description
Quaternary		Recent	Younger Alluvium	Purna Formation		Black Cotton soil, Dark grey, fine sand, silt and clay deposits with a few lenses of pebble beds.
			Older Alluvium	Kural Formation		Light colored brown and light yellow calcified clay and silt. Thin pebble bed with pebbles and coarse sands, grading upwards into fine sand, silt and clay.
				Virul Formation		
Sahyadri group (Deccan Trap Basalts)	Karanja Formation	Upper Cretaceous to Palaeogene	Boulder bed		370-400	Disposed as thick- beds, with varying proportions of sub-rounded to rounded boulders and pebbles size clasts, embedded in finer matrix.
			VIII		510 (474 to 564)	Simple aa flow
			VII		480 (454 to 564)	Simple aa flow
			VI		500 (450 to 532)	Simple aa flow
			V		440 (427 to 445)	Simple aa flow
			IV		420 (418 to 421)	Simple aa flow
			III		405 (403 to 413)	Simple aa flow
			II		400 (399 to 402)	Compound pahoehoe flow
			I		390 (382 to 294)	Simple aa flow

The Virual Formation and the Kural Formation form morpho stratigraphic units referable to the older and younger flood plains of the Purna respectively, while the Purna formation is observed only in the bank sections. All these formations comprise boulders, pebbles, and gravels, coarse to fine sand, silt and clay in various proportions. The northern part of the basin is occupied by the quaternary sediments which falls in three units i.e. Boulder bed, Older alluvium and younger alluvium. The boulder bed deposits represent fan deposits in piedmont zone, having a thickness of about 30 m. they are generally disposed as thick- beds, with varying proportions of sub-rounded to rounded boulders and pebbles size clasts, embedded in finer matrix. This unit's forms potential water bearing horizon in the area. The older alluvium is a predominant unit and is well exposed. It comprises yellowish brown calcareous concretions, with a variable amount of sand silt sized sediments and forming a hard, compact, tabular and vesicular horizon having a thickness of about 80 m. The younger alluvium is confined to the present day drainage. It overlies the older alluvium with a distinct unconformity, marked by the presence of 1 to 2 m thick pebble bed. The pebble zone and coarse sands grade upwards into fine sand, silt and clay which exhibit sedimentary feature like cross lamination and graded bedding, representing typical fluvial environment. The characteristic of the sediments reveal that they were mainly transported as bed-load and rapidly deposited under very high but fluctuating energy conditions.

Deep weathering along the river lead to the deposition of river alluvium, the thickness of which ranges from 4 to 20 m. Overall 4 traverses were taken and litho logs of 30 wells have been observed to delineate the alluvial deposition in the basin. The Electrical resistivity surveys are also conducted to trace the direction of buried fracture zone.

The alluvium succession consist sands, gravels, pebbles, cobbles, 'kankars'(calcium concretions) and admixture of these in varying proportions. Sand and gravels are loosely cemented by calcareous matrix thus forming lithified sands or gravels. The loose or cemented pebbles or cobbles occurring at the bottom of the alluvium succession give it the appearance of conglomerate. A schematic vertical section of alluvium deposit is shown in Fig. No. 4

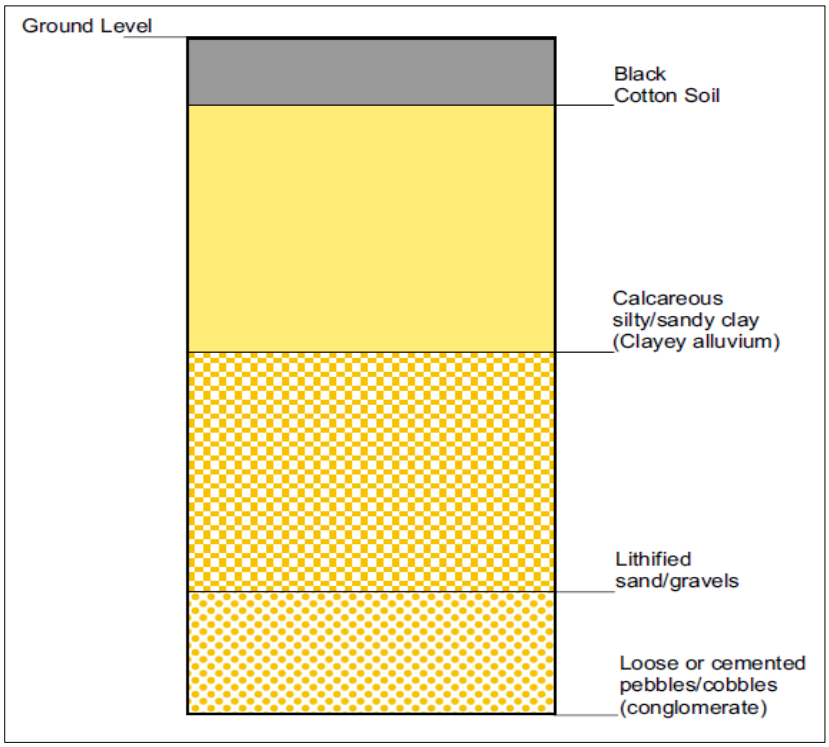

Figure 4 A schematic vertical section of alluvium deposit of the Bhuleshwari river basin (Not to scale)

3.3.2. Deccan trap

The northern part of the study area consists of hill ranges formed of compact basalt. At many places we find columnar jointed basalt and at places it appears stratified-the summits of several ravines presenting a continued stratum of many hundreds of meter in length. The basalt frequently and suddenly changes into every variety of composition usually found among trap-rock. An interesting feature of this range is the existence all along its southern edge of a marked northerly dip up to 15° in the lavas of which it is composed. This is very rare in occurrence of the Deccan Trap, which is almost everywhere horizontal. This is due to the fault that brings up the Gondwana inliers.

The hills and portion of the valley of the Purna river have been stated to consist of trap similar to that of the Deccan. All the usual varieties of amygdaloid, zeolitic, columnar, hard, gray, and softer ashy-looking traps occur, their stratification being very perceptible and always nearly horizontal.'

3.3.3. Basalt Flows

Overall 07 'aa' (simple) types of basalt flows and one Pahoe flow have been identified and mapped in the Bhuleshwari river basin. The red boles at the interflow contacts are very thin and are found at a few places only.

Typically the physical set up of a basalt flow of Aa' type consists of a vertical succession beginning with the distinct red , green, or brown horizon of soft clayey, tachylitic, tuffaceous and fragmentary top layer referred as 'red bole' or 'green bole', depending on its colour. It represents the contact or 'interflow horizon' between two successive basalt flows. The thickness of this horizon ranges from 0.50 to 1.50 meters in the study area.

The inter flow horizon is followed by a vesicular or vesicular amygdaloidal basalt flow unit, the upper part of which is very glassy and rich in amygdales and pyroclastic materials, the middle part is relatively homogeneous and has less pyroclastic material and amygdales, and the lower part is characterized by unfilled vesicles and is mainly traversed by a network of sheet joints. The thickness of vesicular basalt unit generally ranges from 05 to 08 m.

The vesicular amygdaloidal basalt unit is vertically followed by compact basalt unit which is a fine grained and aphanitic. The contact of these two units is marked with the development of sub horizontal 'sheet joints'. The compact basalt unit exhibits the well-developed jointing patterns of sub horizontal to vertical or polygonal columnar joints. They commonly deviate from their perpendicular orientation and may form radiating patterns. Such structures are called colonnade. Well-developed colonnade structures are usually seen in the lower portions of most simple flows. Columns are

commonly perpendicular to the base of the flow and their column width range from 0.50 to 2.0 m. In some flows an upper colonnade zone is also present. The thickness of jointed compact basalt unit ranges from 03 to 10 m. The jointed compact basalt grades downward into massive compact basalt, which continues for more than 15-20 m. depending upon the thickness of individual flow. The massive compact basalt unit ends with the basal clinker zone which is then followed by red/green bole, the interflow horizon.

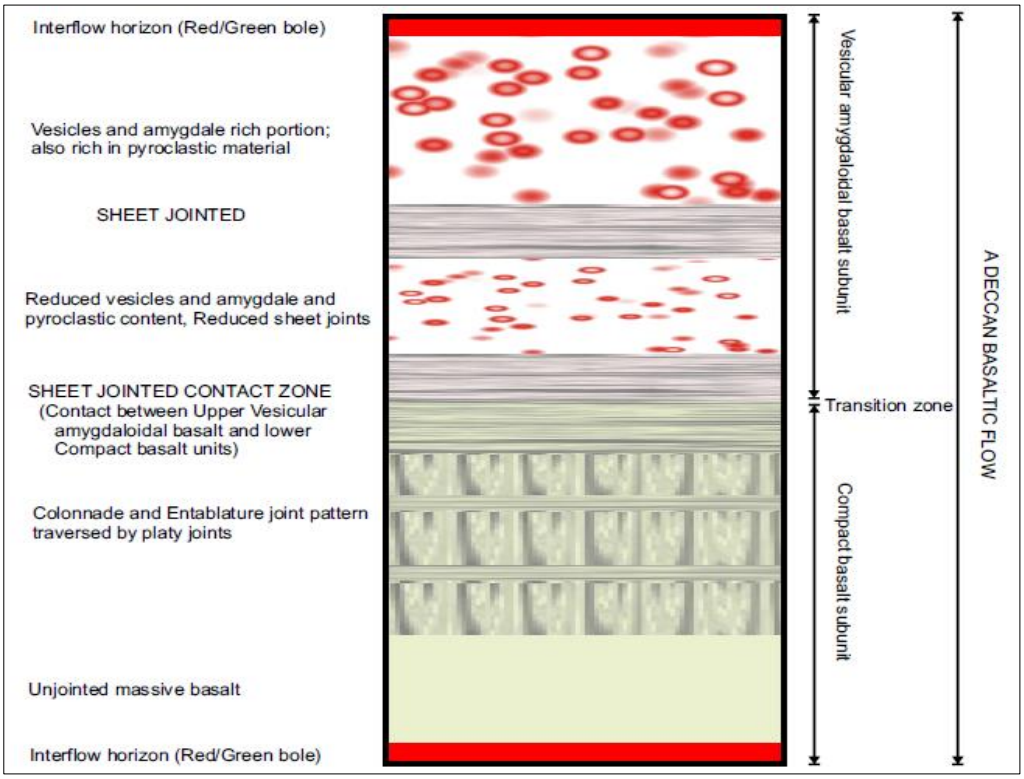

Figure 5 A schematic vertical section of a basalt flow as observed in the study area (Modified after Kulkarni and Deolankar, 1995 for the study area)

The relative thickness of any individual flow and its sub units vary significantly from flow to flow. The thickness of individual basalt flow in the Bhuleshwari river basin ranges from 04 to 90 m. The thickness of vesicular basalt unit ranges from 03 to 06 m., whereas that of compact unit ranges up to 25 m., depending upon the thickness of individual flow.

The flow no I is exposed in the southern part of deccan trap which occupies the northern fringe of the Bhuleshwari river basin. It is moderately to highly porphyritic in nature having megacrysts of feldspar. Its anticipated thickness from resistivity data is about 15-18 m. It begins with the green bole (0.50-1.00 m), followed by weathered vesicular basalt (3 - 4 m), and compact basalt unit (10 - 11 m). Sheet joints are exposed along the contact of these two units.

Flow no. II is compound pahoehoe flow. Its thickness is about 3-4 m. Average thickness of flow nos. III in the basin is about 10 m. The vesicular amygdaloidal basalt unit of these flows is more zeolitic and less weathered; having thickness of 4 to 5 m. Sheet joints are exhibited along the contact of compact unit. The compact basalt unit shows irregular development of vertical joints at its top, and grades downward into massive compact basalt.

The vesicular unit of flow no IV is more vesicular and weathered too. It pinches in the middle (central) part and swells towards the east-west boundaries of the basin. Its thickness ranges from 5 to 8 meters.

The flow no V has an average thickness of 25 m and it occurs at the northern part of the basin. The vesicular unit is relatively thin (3-4 m) than that of the lower compact unit (20-25m). The compact basalt unit of exhibits sheet joints, vertical columnar joints, and 'colonnade' jointing patterns with 3-4 levels of platy joints.

The flow nos. I, III, V, VI and VII has a average thickness of about 25m than the other flows and are exposed in steeply sloping northern part of the basin are exposed in the hilly area of the basin. All the flows are relatively massive, but wherever exposed in the intermittent valleys and plain area are subjected to weathering and jointing.

4. Conclusion

The Purna sub-basin is the deepest basin, comprising the thickest alluvium deposits (420 m). Roy (1956) delineated the saline tracts in some details. Adyalkar (1975) had proposed an incursion of a sea water stretch up to the Purna sub-basin and considered its exceptional salinity to be due to the influence of such marine sources. Mutthuraman et al. (1992) gave the cause of salinity of groundwater in the Purna river basin as evaporation and enrichment instead of earlier belief of ingress of sea water. Tiwari et al. (1996) classified the quaternary sediments of Purna river valley. Siddiqui, M. A. (2004) and Shivastava et al. (2009) studied the hydrogeochemical characteristics of Purna river basin. Khadse and Ingle (2011) on the basis of geophysical technique and pumping test gave the aquifer parameter in the Bhuleshwari river basin.

The detailed geology of the Bhuleshwari river basin has been discussed and presented in chapter two. Based on number of field traverses, in the geological map eight lavaflows has been identified in northern region and alluvium in southern region can be divided into younger and older alluvium. The Deccan trap is separated by alluvium with fault, boulder alluvium is seen to occur in this zone. The geological map of Bhuleshwari river basin modified from geological survey of India map, GSI (2001) is presented. Geologically the study area consists of 420 m thick Alluvium. Only the top 40m is accessible for direct observation in the bank sections of the river and dug wells. The upper cover of the alluvial deposit comprises three lithostratigraphic formations (i) Virul formation (ii) The Kural Formation (iii) The Purna Formation (Tiwari and Mukhopadhyay, 1989; Tiwari, 1990). The Virual Formation and the Kural Formation form morpho stratigraphic units referable to the older and younger flood plains of the Purna respectively, while the Purna formation is observed only in the bank sections. All these formations comprise boulders, pebbles, and gravels, coarse to fine sand, silt and clay in various proportions.

Compliance with ethical standards

Acknowledgments

The authors wish to acknowledge our masters, friends and researchers worked on this area.

Disclosure of conflict of interest

The authors declare no conflict of interest.

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