Effect of dyke structure on ground water in between Sangamner and Sinnar area: A Case study of Bhokani Dyke.

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Abstract
In semi-arid regions, particularly in hard rock areas, shallow aquifers are a major source of potable groundwater. These aquifers are indiscriminately exploited to meet the growing demand of water for domestic, irrigation as well as industrial uses. Therefore, peoples in this area are continuously pumping ground water from the well and in most of the days they found empty. Due to the over pumping through tube wells and dug wells, the ground water level is goes down below day to day. Therefore, due to such situation, people move to search the water from one place to another. In this situation, presence of a dyke is gives a new avenue to recharge the wells in the concern area.

Dykes in the Deccan Trap areas are to a great extent, known to control the movement of groundwater, and success or otherwise of the well in the field area depends very much upon its location. The Bhokani dyke area has opened the door of excellent irrigation. Those wells which are taken on dyke are giving good yield and therefore farmers are pumping water continuously.

In short, in areas of harsh Ground water situation, presence of dyke is an good as avenue for the ground water in the said region. This avenue acts as a source for the supply for irrigation and drinking water needs of the study area. Therefore this is an important factor in deciding the socio-economical conditions of the farmers in this area. This paper deals with study of such dyke which occurs near Sangamner area.

Introduction:
Failure of open dug wells and tube wells in most of parts of the hard rock areas in Deccan Traps is a common phenomenon. This problem usually arises, either because of the over exploitation / pumping of water from the existing wells or due to missing of the exact water potential zones in this terrain. As on the hard rock region water mainly exists in fracture and joints, locating such zones and predicting the flow processes is a difficult process.

Draught in the semiarid areas of hard rock is mainly due to low rate of precipitation and results into low irrigation in dry regions. Therefore, in this region, there is a growing demand for ground water resource as the surface water resources are not available adequately.

In semi-arid regions where groundwater occurs in shallow weathered zones, the rise in groundwater level is a direct consequence of precipitation, particularly in the monsoon season, when the groundwater withdrawal is minimum (Mondal et al., 2011).

India is seventeenth largest country in the world with diverse climate, topography, geology; soil types, land cover and land use pattern (National Institute of Hydrology, Report, 1998-99). The water resources of India are enormous but they are unevenly distributed in several terms. Seasonally, regionally, basin wise cultivator cross wise and crop wise.

In general, the ground water potential of hard rock’s is poor, though relatively high yields may be obtained from in restricted locations under favorable circumstances of topography and rainfall. The size and the frequency of opening s in the fractured rocks are normally restricted to shallow depth resulting in low void ratio and hydraulic conductivity.

Draught in the semiarid area of hard rock is due to low rainfall and low irrigation in dry regions. Therefore, during summer groundwater from the basaltic aquifers is the prime source of water (Kale and Kulkarni, 1992).

Failure of tube well and open well in many parts of the hard rock regions are common phenomenon. This problem usually arises, either because of the over abstraction in existing wells or due to the missing of the exact water potential zone. As on the hard rock region water mainly exists in fracture and joints, locating such zones and predicting the flow processes are a difficult process.

The geometry of the joint and fracture set is determined by the types of rock and the stress to which they have been subjected, besides the effect of weathering and relief which makes the void space constituting the system progressively larger and approaching the surface. The study area is also parts of hard rock terrain and the same situation is observed in this area. The population in the rural area is mainly dependent on the ground water as a source of drinking and irrigation (Srikanth, 2009). But, successful wells in study area are also become dry because of the over pumping practices.

In hard rock region, there is a growing demand for ground water resource as the surface water resources are not available adequately (National Institute of Hydrology, Report, 1998-99).

Study Area:
Study area is southern boundaries of Sinnar and northern boundaries of Sangamner and is belongs to a severe part of draught prone regions of Ahmednagar and Nasik district respectively of Maharashtra (Fig. 1). This area lies between latitude 19° 40' 04" N to 19°51'05' and longitude 74° 04'11"E to 74°14'10"E on Survey of India (SOI) toposheet No. 47I/1 and 2. This region is located 10 miles from east of Sinnar (Nasik) and 16 miles from Sangamner (Ahmednagar district).

Geomorphology of the area:
Geomorphologically the terrain shows plain to undulating topography. The highest elevation in this area is 2824 mts. at east of Chas i.e. southern end while lowest elevation is 1836 mts. at north of Panchale i.e. northern boundary of study area.

The main drain in this area is Deo river, which is right side tributary of Godavari, confluences at Somathane village, NW of Kopargaon. In this study area, the locations of the tributaries of Deo River are shows good network of drainage. Along the channel of this river, the surface shows moderate to stiff slope.

Geology of the area:
The study area is a part of Deccan Volcanic Province (DVP). This region consists of alternate flows of compact and amygdaloidal basalt. Compact basalt flows are thick, tabular and shows more lateral extent while amygdaloidal basalt flows are thin, irregular and shows less extent than compact basalt flows.

Study area is a part of Deccan Volcanic Province (DVP) which generally shows (i) pipe amygdale flows shows irregular vesicles, weak tabular, glassy and sub horizontal sheet joints at the bottom (ii) compact, absence of vesicles, joints and fractures, and (iii) sub horizontal sheet joints with spheroidal amygdales (unfilled with vesicles) at the top (Kale and Kulkarni, 1992). The relative thickness in between these three layers is varying place to place.

These flows are characterized by variable thickness, irregularity, local dips, small extent , and lateral variation (Chaubey, 1973, Sukheswala and Polder Vaart, 1958; West, 1958, Gupte, 2007). In addition to the above predominant flows, at places some pocket deposit or cluster of volcanic breccias observed which might be outpoured in the volcanic activity during post – Deccan Trap period (Gupte et al., 1984).

Weathering and Erosion in Deccan Trap:
Due to the effect of physical weathering agents, rock found degraded condition and micro cracks are developed. Therefore, due to such continuous disintegration on the exposure of the rock, resulting depth of weathering goes deep and deep. Resulting, up to this weathered portion, surface water is penetrating down and ground water is formed. Here the trough shaped upper portion of the dyke is filled and surrounded by thick or thin blanket of black cotton soil, followed by deeply weathered, moderately weathered and finally fresh rock at the bottom. A typical stratigraphical section in study area is shown in (Fig. 2). Amygdaloidal basalt gives better response than compact to such kind of activity (Sabale, 2005). And the study area is more dominant region of Amygdaloidal basalt than compact.

Water bearing characters of Deccan Trap:
As stated above, in the Deccan Trap, water table conditions occurs under in weathered and jointed traps, and under confined conditions in weathered and jointed traps, and under confined conditions in the zeolitic and vesicular traps. Wells in valleys nearer to nallas and zeolotic traps yielded better than those located on elevated areas. The saturated fractures and joints found in the relatively unweathered bed rock are capable of yielding a substantial quantity of water at greater depth. The fractures and joints are mostly sheet type, sometimes are having good lateral extent and interconnected with each other. Therefore, groundwater level in this zonesis not readily affected by seasonal changes.

In dry draught prone areas, in harsh situation, presence of dyke is get as a avenue for the ground water Supply for drinking situation. This paper deals with study of such dyke which occur Deccan Volcanic Province (DVP) of draught prone region near Sangamner – Shirdi area.

The groundwater possibilities in the three groups viz.1.Numerous dolerite dykes in Deccan Traps of Dhulia district (2) Areally extensive trap flows resulting from slow and quiescent type of flood eruption occupying the gently undulating terrain, of Sholapur and Osmanabad districts and (3) the traps characterised by intertrappean sediments, dolerite dykes and volcanic ash beds, indicative of violent outbursts resulting in the Sahyadri geomorphologic unit of Kolaba, Thana and Bombay-Poona regions, are to a great extent governed by the nature and constitution of the individual flows. This character is given by Adyalkar and Mani(1971), based on their mode of emplacement, geomorphic setting and hydro geological of the Deccan Traps of western Maharashtra.

Single Unit of Deccan Trap Groundwater Province into 3 Sub-Provinces, based on geomorphological, geological and geohydrological setting in the region of western Maharashtra of the present investigation.

The dolerite dykes most of the time control the movement of groundwater, and success or otherwise of the well field area depends very much upon its location with reference to adjacent dykes, found in the Dhulia district.Thick vesicular, extensive traps with their gentle dips towards east have to be explored for possible artesian conditions in the down dip directions of the trappean units to be tapped, in Sholapur district (GSDA & CGWB Report, 2007-08).

The Bhokani Dyke Areas:
Bhokani dyke is doleritic type, width ranging from 7 ft. to 16 ft and 28.50 kilometers in length. This dyke is having N07°E strike and showing N-NE to S-SW trend. Dyke rock is black colored doleritic rock with well prismatic joints. The local people used term 'KAR' in Marathi for dyke in this area. It is move through Dodi, Khambale, Bhokani, Tamaswadi, Dambra, Chauri, Mendi villages etc. from S-SW to N-NE trend. At the beginning at S-SW portion, it is crossing Mhaladevi river and at the N-NE side it confluence in the Godavari river.

As per as the dug well and tube wells are concern, the maximum number of wells are present on the dyke alignment. Most of the wells (of about 95%) are yielding good amount of water. Therefore, the green zone is observe along the whole alignment of dyke, while rest of the area is found dry and partly green (only rainy and autumn season) due to the less irrigation. Because most of the wells in this area are dry of seasonal. Therefore, farmers are pumping day-night water from these wells with one or at some places two pumps of 5 or 10 HP are set up on the well.

Well Inventory:
In India, ground water has been exploited substantially during the past few decaded for irrigation. Most of the ground water utilization in India is from shallow depth aquifer zones at depth less than 100 m (Khepar and Chaturvedi, 1982, Rangnath, 1982). But the dykes which are constructed on dyke are yielding good amount of ground water. Therefore, to know the ground water conditions of such wells, a detailed well inventory survey was carried out in central part of the study area i.e. especially at Bhokani and Khambale area. In this survey well inventory work for 22 wells were carried out. To know the exact water carrying capacity and ground water situation, for this study the wells are selected in middle reaches or central zone out of total extension in this area of dyke.

During this survey well number, name of owner, whether it is lined or unlined (i.e. whether it is constructed or non-constructed) is reported. If it is lined the type and nature of material, cement or mortar, with the help of dressed stone, which are available in the surrounding area. In addition to this, the important ground water information such as depth of ground water from ground level and pumping hours for respective well in summer etc. is given in the following table.

Trend	Well No.	Name of owner / farmer	Constructed / Non-constructed	Well dimension Width (ft.)	Depth (ft.)	Water level From bottom (ft.)	Width of dyke (ft.)
S-SW	1.	Kisan S. Sabale	Masonry constructed	17	47	4	14-16
	2.	Trimbak G. Sabale	Masonry constructed	16	45	6	17-19
	3.	Chandrakant	Masonry	12	34	2	10-12

		Domaji Ranshivre	constructed				
	4.	Chandrakant D. Ranshivre	Masonry constructed	12	46	4	8-10
	5.	Eknath Ranshivre	Masonry constructed	10	42	5	8-10
	6.	Dr. Ranshivre	Masonry constructed	10	40	5	6-8
	7.	Ranshivre	Masonry constructed	12	42		7-10
Centre							
	1.	Mahadu Y. Sirsat	Masonry constructed	14	42	5	10-12
	2.	Chandrabhan S. Shirole	Masonry constructed	15	44	6	12-14
	3.	ChandrabhanP. Walekar	Masonry constructed	14	36	4	10-12
	4.	Chandrabhan P. Walekar	Masonry constructed	16	46	5	10-12
	5.	NamdeoMalhariWalekar	Masonry constructed	11	34	2.5	8-10
	6.	Trimbak N. Shirole	Masonry constructed	18	47	4.5	10-12
	7.	Bibhishen N. Walekar	Masonry constructed	17	42	6	14-16
	8.	Rahadu A. Shirole	Masonry constructed	12	35	2	12-14
	9.	Navnath K. Shirole	Masonry constructed	16	44	4	10-12
	10.	Ramchandra Shirole	Masonry constructed	16	44	4.5	10-12
	11.	Ramchandra Shirole	Masonry constructed	17	45	3.5	11-12
	12.	Bhima K. Kale	Masonry constructed	17	46	5	15-16
	13.	Datta S. Kale	unconstructed	14	37	2.5	10-12
	14.	Narayan B. Shirole	Masonry constructed	12	48	4	8-10
	15.	Bhaskar B. Shirole	Masonry constructed	14	44	5	7-8
	16.	Pandurang K. Shirole	Masonry constructed	12	36	4.5	8-10

Ground water condition in the well along the dyke:

As we know, dyke is having prismatic joints, which acts as an avenue for ground water flows, just like is leaky pipe. The water carrying capacity of a dyke is depend upon a. nature of joints (whether it is tight or open) b. presence of type of joints c. Dimension of the dyke. Slope of the area e. Water body in the path of the dyke. As describe above, the of Bhokani dyke is from Northern region of Akola and south of Sinnar from Ahmednagar and Nasik district respectively. In this area, at the beginning, the dyke is crossing a percolation tank. Therefore, this dyke is become recharge and it carries water from south to north part.

Crop Yield / Production of crop in the study area:

During the well inventory survey, type of crops, their yield and production of crop in the zone of dyke and outside the dike area for one acre area is collected from the local farmers. Then this crop wise production data is compared to each other in the study area.

Season	Sr. No.	Name of the crop	Production in the zone of dyke area (Ton/acre).	Production outside of the dyke area (Ton/acre).
Rainy	1	Legume / ground nut	20	16
	2	onion	30	16
	3	Bajar	25	17
	4	Maize	20	10
Summer	1	Wheat	27	15

The table data reveals that, crop production (in ton/acre) in the zone of dyke area is roughly double than production outside of the dyke area. This excess production in the zone of dyke area is only due to the good recharge of the well.

Improvement in the standard of living of peoples:

Ground water recharging conditions in the wells of the study areas farmers could able to good practice of irrigation. The production of food in the zone is high as compare to the peripheral areas. Therefore, standards of living of the farmers are increasing day to day in this area. In addition to this, very important change observed here is in the 'Standard of living' of the people. The main reason for the up gradation of these peoples in this area because i. wells are constructed up to deeper level and therefore they store large amount of water can store. ii. Water level in the wells which are located on dyke is rise due to good recharge conditions due to the presence prismatic joints of dyke.iii. Due to the presence of dyke the wells in the villages have enough of water. iv. Farmers have sufficient work on the farm and they are fully involved in taking more crops. v. The fodder is enough available for their cattle. vi. Milk production has increased drastically. vii.Resulting, women do not have to go to long distance for drinking water and viii. Due to good irrigation practices, milk production, and scheme for women development the economical condition of the people is increased and standard of living has also increased.

Results and discussion:

According to Bondre et al. (2006), numerous large dimensional mafic dyke outcrops are generally shows NE-SW to E-W trending in outcrop around Sangamner in the Western Deccan Volcanic Province. He also argued that, this area is a part of broader region of postulated to be a shield like feature and major eruption centre. But as per as the Bhokani dyke is concern, whether it is concern with the same dyke swarm, that has to check. Because, as per as the distribution of dykes identified and given by Bondre et al. (2006), northern extension of his Fig. 2, is up to Dapur (North of Akole), while southern extension of this dyke is up to Godavari river. These dykes are compositionally similar to the south western Deccan formations, although most of them can be best related to either Poladpur formation or Khandala formation. While geochemical composition is not necessarily correlated with location, in this area (Bondre, et al., 2006).

While much of the previous work pertains to lava flows, a few workers (e.g. Deshmukh and Sehgal, 1988, Bhattacharji et al. 1996; Mellusco et al.1999; Subbarao et al. 1999) have also studied the two principal dike swarm in this province, where the dike occur with high frequency. The West Coast Dike Swarm (WCDS) trending N-S to NNW –SSE, consist of tholeitic and alkaline compositions. The Narmada-Tapi Dike Swarm (NTDS) also contains tholeitic as well as alkaline dikes has predominant ENE-WSW trend (Sheth, 1998; Molluso et al. 1999).

Beane et al. (1986) observed that their compositions are similar to those of the associated flows. Bhattacharji et al. (1996) considered the random orientation to the result of stress regime dictated by large crustal magma chambers. Sheth (2000) argued that true feeder dikes in central volcanoes usually have a radial arrangement, not random arrangement.

Conclusion:

The dolerite dykes most of the time control the movement of groundwater, and success or otherwise of the well field area depends very much upon its location with reference to adjacent dykes, found in the Dhulia district.

Bhokani dyke is doleritic type, with sufficient dimensions and extensions. Due to the presence of prismatic joints, those wells which are found on the dyke and side of the dyke yielding good amount of ground water. Therefore, this dyke throughout his length giving recharge to the connecting and adjacent wells along its N-NE to S-SW trend. Resulting, the farmers are able to take more crops with good yield. Therefore, the green zone is observe along the whole alignment of dyke, while rest of the area is found dry and partly green (only rainy and autumn season) due to the less irrigation. Good irrigation practices, milk production, etc. activities are responsible for improvement of the economiccondition of people in this area. Many social changes took place and especially the women's groups became independent in decision making and their involvement has increased in day to day activities. Due to education, the number of students has increased. Awareness tendency has been generated in the minds of illiterate village people.

This results into the improvement of the economic condition of the peoples in this area.

References:

[1.] Adyalkar, P. G. and Mani, V. S. (1971) Paleogeography, geomorphological setting and groundwater possibilities in the Deccan Traps. *Bulletin Volcanologique, 35 (3), pp.696-708.*

[2.] Beane J E, Turner C A, Hooper P R, Subbarao K V and Walsh J N 1986 Stratigraphy, composition and form of the Deccan basalts,Western Ghats, India; *Bull. Volcanol*. **48,** pp.61-83

[3.] Bhattacharji S, Chatterjee N, Wampler J M and Gazi M 1994 Ma_c dikes in Deccan volcanics - indicator of India intraplate rifting, crustal extension and Deccan flood basalt volcanism. In: *Volcanism*, ed. K V Subbarao *Geol.Soc. India*, 253, pp.27.

[4.] Bondre, N. R., Hart, W. K., Sheth, H. C. (2006) Geology and geochemistry of the Sangamner mafic dike swarm, western Deccan volcanic province, India: Implications for regional stratigraphy. J. Geol., v. 114, pp. 155-170.

[5.] Chaubey,V.D.(1973). Long Distance Correlation of Deccan Flow, Central India, Geological Society of America, Bulletin 84, pp.2785-2790.

[6.] Khepar, S. D. and Chaturvedi, M. C.: 1982, 'Optimum cropping and groundwater management', Water Resources Bulletin 18 (4), 655–660.

[7.] Deshmukh, S. S., Sehgal, M. N. (1988) Mafic dyke swarms in Deccan Volcanic Province of Madhya Pradesh and Maharashtra. In: Subbarao, K. V. (Ed.), Deccan Flood Basalts. Geol. Soc. Ind. Mem., v. 10, pp. 323-340.

[8.] DYNAMIC GROUNDWATER RESOURCES OF MAHARASHTRA ABRIDGED REPORT (AS ON 2007-08) .Prepared by -Groundwater Surveys and Development Agency, GoM & Central Ground Water Board, Central Region, Nagpur, GoI.

[9.] Gupte, R.B. (2008). Indian Geology. A Text of Engineering Geology. Third Edition (Revised), Pune Vidyarthi Griha Publication, Pune. pp.105-148.

[10.] Gupte, R.B., Kulkarni, S.R. and Marathe, S.S. (1984). Post –Deccan Trap Volcanic Activity in Western Maharashtra. Indian Mineralogist. pp. 69-74.

[11.] Kale, V. S. and Kulkarni, H. (1992) IRS-1A and LANDSAT data in mapping Deccan Trap flows around Pune, India: Implications in hydrogeological modeling. *Archives Int. Soc. Photogramm. and Rem. Sensing, 29(B-7): 429-435.*

[12.] Melluso, L., Sethna, S. F., Morra, V., Khateeb, A., Javeri, P. (1999) Petrology of the mafic dyke swarm of the Tapti River in the Nandurbar area (Deccan Volcanic Province). In: Subbarao, K. V.

[13.] (Ed.), Deccan Volcanic Province. Geol. Soc. Ind. Mem., v. 43, pp. 735-755.

[14.] Mondal, Nepal C, Singh, Vijay P. and Somayaji Sankaran (2011). Demarcation of prospective groundwater recharge zones in hard rock area from Southern India. Scientific Research and Essays Vol. 6(16), pp. 3539-3552.

[15.] National Institute of Hydrology, Report, (1998-99). Hydrological Problems of Hard Rock Region- State of Art Report. National Institute of Hydrology. Roorki.

[16.] Peshwa A, V. and Kale, V. S. (1988). Role of remote sensing in the detection of potential sites for landslides / rockfalls in the Deccan Trap lava terrain of western India. Environmental Geotechnics and Problematic Soils and Rocks; Balkema, Rotterdam;, pp.367 - 374.

[17.] Sabale, P.D. (2005). "Watershed Development and Management in Siddheshwarwadi: A Review". ICEM, Vol.5, Editor-Anji Reddy, B.S.Publ., J.N.T.U., H'bad. Pp. 318-325.

[18.] Rangnath, 1982

[19.] Sheth, 1998. Geochemistry, petrogenesis,Stratigraphy and structure of Deccanflood basalts of the western Satpura-Tapi region,india. Ph.D dissertation, Indian Institute of Technology, Bomboy.

[20.] Subbarao et al. 1999 Narmada dyke. In Subbarao, K.V., ed. Deccan Volcanic Province. Geol. Soc. India Mem. 43, pp.891-902.

[21.] Srikanth, R. (2009). Challenges of sustainable water quality management in rural india Current Science, Vol.97, No.3, pp.317-325.

[22.] Sukheswala R N and Poldervaart A 1958 Deccan basalts of the Bombay area, India: *Bull. Geol. Soc. Am.* 69, pp.1475-1494.

[23.] West W D 1958 The petrography and petrogenesis of forty- eight flows of Deccan Traps penetrated by borings in western India; *Trans. Nat. Inst. Sci. India* 4**,** pp.1-56.

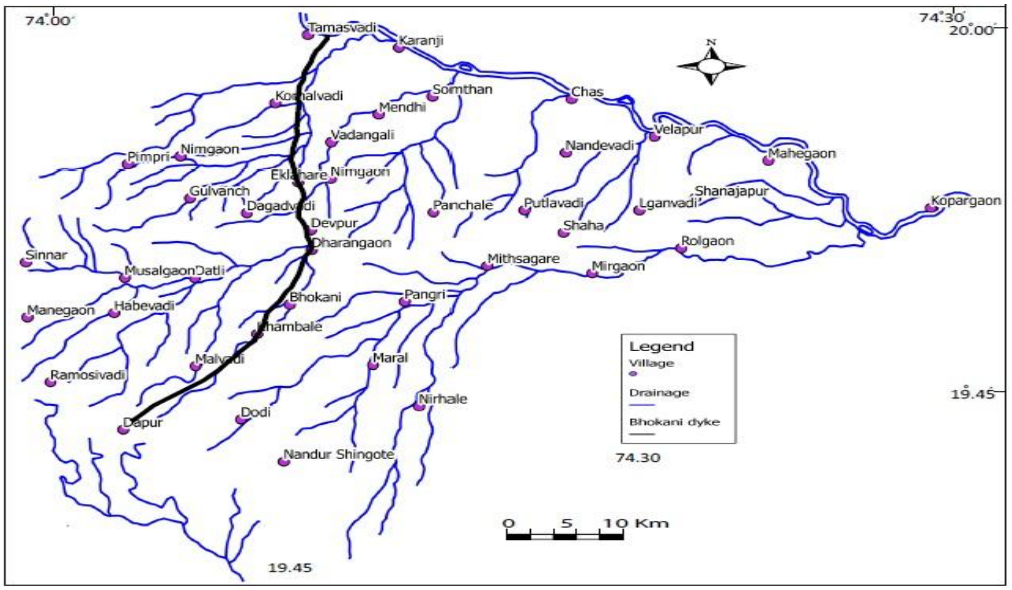

Fig. 1 Location map of the study area.

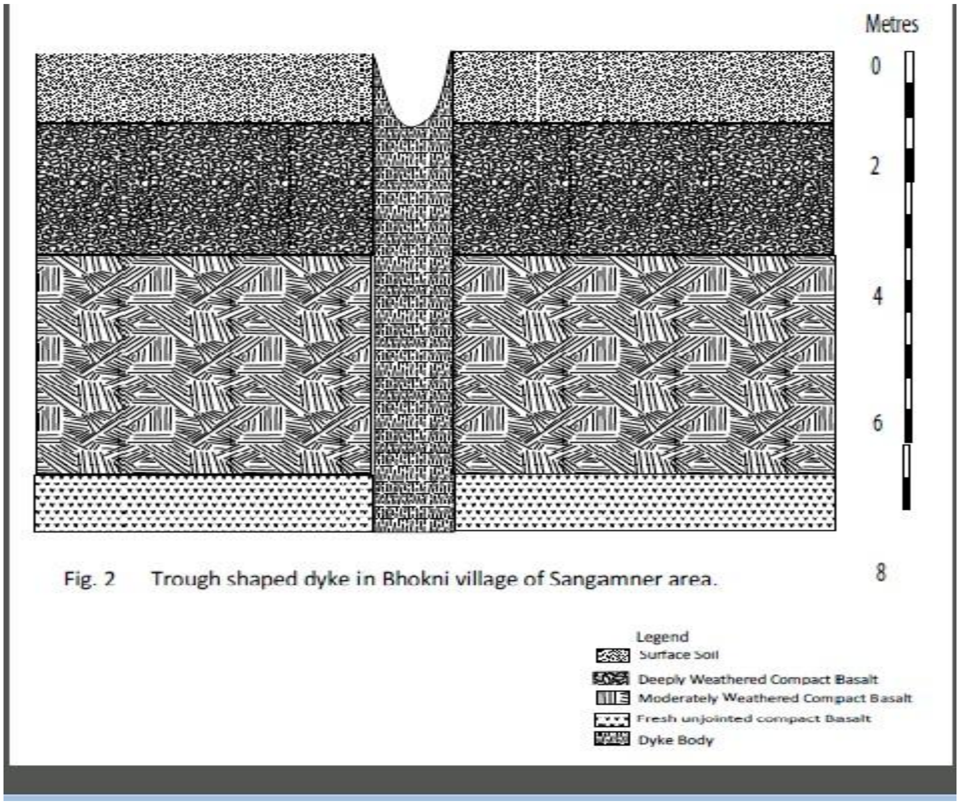

Fig. 2 Trough shaped dyke in Bhokni village of Sangamner area.