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CHEMICO-MINERALOGICAL AND PETROGRAPHICAL STUDY OF NATURAL ZEOLITES AND APOPHYLLITE IN BASALTS FROM DECCAN TRAP, NORTHERN MAHARASHTRA (INDIA)

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ABSTRACT

Natural Zeolites filling amygdales and veins in stone quarries of basaltic rocks near Village Savada, Jalgaon districts, Maharashtra on the Deccan Trap, India have been studied by using Microscope, X-ray diffraction (XRD) techniques and Scanning Electron Microscope (Fe-SEM). As of foregoing studies, the varieties of Zeolites viz. Stilbite and Mordenite and Apophyllite occur in the study area and their applications which are widely useful for various purposes are discussed in this paper. The field study and the overview are much more beneficial for society and planners where Zeolites can be used. The element composition data shows that descending trends were observed as O followed by C, Te, Ca, Si, Br, Na and K in Stilbite. Whereas in Apophyllite O is followed by Ca, Te, C, Si, K, Na and Br. On the other hand in mineral Mordenite trend observed as O followed by Si, Ca, Br, C, Na, K and Te. Mordenite shows orthorhombic crystals, Apophyllite shows tetragonal crystals and Stilbite exhibits monoclinic crystals.

Keywords: XRD, FESEM, Thin Section, Zeolite, Deccan Trap, India

1. INTRODUCTION

Commonly speaking, the Zeolites are colourless to white, and occur in fibrous and radiate aggregates (Hatch, 1912). Zeolites are formed during aqueous fluids reaction with rocks in a variety of geological environments (Breck, 1974; Weisenberger and Spurgin, 2009; Juan et al., 2012). Most of the Zeolites were formed during diagenetic processes in sedimentary rocks which can be grouped into several geological environments and hydrological systems (Hay and Sheppard, 2001), such as hydrologically open systems (Hay and Sheppard, 2001), hydrologically closed systems (Langella et al., 2001), soil and surficial deposits (Ming and Mumpton, 1989), deep marine sediments (Boles and Coombs, 1977) and marine sediments from arc-source terrains (Boles and Coombs, 1977). Zeolites occurring in volcanic lava flow cavities are formed either during lava pile burial metamorphism (Neuhoff et al., 1999), continental basalts hydrothermal alteration (Walker, 1960) or diagenesis in areas of high heat flow caused by active geothermal systems (Weisenberger and Selbekk, 2008). Zeolites, as products of hydrothermal crystallisation, are generally formed from active volcanic rock associated geothermal systems. Very little work has been published on Zeolite occurrences related to late stage pegmatite crystallisation (Orlandi and Scortecci, 1985) in hydrothermal ore veins (Deer et al., 2004) as alteration products along fault planes (Vincent and Ehlig, 1988) and in hydrothermal fractures and veins in granites and gneisses (Weisenberger and Bucher, 2010). Zeolites are crystalline, micro porous, hydrated aluminosilicates of alkaline or alkaline earth metals. The framework consists of $[SiO_4]^{4-}$ and $[AlO_4]^{5-}$ tetrahedra, which corner share to form open structures; such tetrahedra are linked to each other by sharing all of the oxygen to form interconnected cages and channels containing mobile water molecules and alkali and / or alkaline earth cations (Breck, 1974 and Szoztak, 1998).

Zeolites have been widely used as catalysts, adsorbents and ion exchangers in many technical applications due to their exceptional properties (Breck, 1974; Booker et al., 1996; Dixit and Prasada, 1998; Misaelides, 2011; Loiola et al., 2012). Zeolites are widely used as ion exchange beds in domestic and commercial water purification, and softening. Zeolites are also widely used as catalysts and absorbents (Vjunov et al., 2014). Zeolites have uses in advanced reprocessing methods, where their micro porous ability to capture some ions while allowing others to pass freely allow many fission products to be efficiently removed from nuclear waste (N Y Times, 2011). Biomedical applications of Zeolites include their use as detoxicants and decontaminants, as vaccine adjuvant, and as antibacterial agents (Scott et al., 2003). Zeolites can act as water moderators, in which they will adsorb up to 55% of their weight in water and slowly release it under plant demand. This property can prevent root decompose and moderate drought cycles (Mumpton, 1985).

Although Zeolites have been used for many years in Japan as soil amendments, they are becoming the subject of serious investigation in the United States as slow release fertilizers, moisture control additives to low clay soils, traps for heavy metals, carriers of pesticides, fungicides and herbicides, and decaying agents in fertilizer storage (Mumpton, 1985). As soil amendments they appear to retain moisture and improve the overall ion-exchange capacity of sandy and volcanic soils. Studies are being carried out on both pure Zeolite and on Zeolite that has been pretreated with nutritive elements, such as potassium or ammonium (Mumpton, 1985). In either case, the Zeolite appears to act as a slow release fertilizer, selectively holding such elements in its structure for long periods of time, thereby increasing the efficiency of such additives and reducing the total cost of fertilization in agricultural sectors (Mumpton, 1999). They have become worthy of being called the mineral of the future several countries around the world have made significant progress in the exploring and exploiting of this mineral.

However, only a few of the natural Zeolites in the world are found in sufficient quantities and having the purity required by industry (Juan et al., 2012). The U.S. Geological Survey has reported natural Zeolites worldwide occurrence in the USA, Japan, Korea, Bulgaria, Czechoslovakia, Romania, Hungary, Russia, Yugoslavia, South Africa, Italy, Germany, Turkey and China, the latter having the greatest worldwide production (Juan et al., 2012). Clinoptilolite, mordenite, heulandite, chabazite, phillipsite, stilbite, stibnite, amethyst and laumontite are some of the more than 40 known natural Zeolites occurring in reasonably high quantities and purity (Juan et al., 2012).

1.1 Sources of Zeolites

Currently, the world's annual production of natural Zeolites is about 4 million tons. Of this quantity, 2.6 million tons are shipped to Chinese markets to be used in the concrete industry. Eastern Europe, Western Europe, Australia, and Asia are world leaders in supplying the world's demand for natural Zeolites (U.S.G.S., 2011). Green apophyllite with mesolite from Poona, soft white okenite puffballs from Mumbai, water clear apophyllite from Jalgaon, pale golden powellite from Nashik and intensely blue Cavansite from Wagholi (Pune) are the paragons of Indian basalt minerals. These and other fine minerals have been mined in vast quantities since the 1970's. Only a few regions in the world have produced in such a short time such great numbers of superb mineral specimens as has the Deccan Trap rock region in India.

Certainly, Zeolites, of which the commonest representatives are heulandites and stilbite, are an important group among the amygdaloidal cavity minerals, but this locality also produces equally significant non zeolitic minerals, such as apophyllite, okenite and calcite, which are members of other silicate groups or of other chemical classes. For the great majority of these mineral specimens, the actual localities are far from Poona. The total area of the Deccan Traps is about 5, 00,000 square kilometers, and even the region where specimens have been found measures fully 2, 50,000 square kilometers. The Quarries at Mumbai, Pune, Ahmadnagar, Nashik, Jalna, Aurangabad, Buldhana, Dhule and Jalgaon have delivered far more quality specimens. Indian gems, therefore, constitute the lengthy introduction to Indian mineralogy, leading up to the rather late blooming appreciation for zeolitic cavity minerals and for that reason are worth briefly reviewing here.

The presence of vesicles in the lava flows is due to escape of gases during the process of cooling and solidification. These vesicles are either empty or host many varieties of secondary minerals such as Zeolites, quartz, calcite etc. in them**.** These secondary mineral are originate two ways viz. igneous and sedimentary. During the last 3 decades Zeolite minerals have been recognized with increasing regularity as common constituents of Cenozoic volcanogenic sedimentary rocks and altered pyroclastic rocks (Ming and Mumpton, 1989). Zeolites have also been reported as secondary minerals in the Deccan flood basalt of the Western Ghats in the state of Maharashtra, India. The compound lava flows comprising the lower lithostratigraphic formations of the Deccan Volcanic Province are extensively zeolitised and are mostly confined to the western and northern parts of Western Maharashtra. An account of Zeolites and other cavity minerals in Deccan Volcanic Province has been given by Phadke and Kshirsagar (1981). In the vesicular or amygdular top of the compound lava flows, some of the amygdules are partly filled while some are completely filled. Though the occurrence of Zeolites is maximum in the upper amygdular part of a compound flow (Phadke and Kshirsagar, 1981), larger cavities occur at the base of the highly amygdular part of the flow units, with quartz being common in the central massive part. Zeolites have abilities to hydrate and dehydrate reversibly and to exchange some of their constituent cations and thus can influence the pedochemical environment during the formation of soils. Significance of these Zeolites has recently been realised in the formation of shrink swell soils. It has been shown that Zeolites can provide sufficient bases to prevent the transformation of smectite to kaolinite and thus making the formation of shrink–swell soils possible in micro depressions even in a humid tropical climate of the Western Ghats (Bhattacharyya et al., 1993). Now days, the cavity minerals hosted by the lava flows have attracted the attention of mineral collectors and many of these minerals have been displayed in museums world over.

1.2 Study area

The study area is lying between latitudes 20°59' N to 21° 00' N and longitudes 75°45' E to 75°47' E in northwestern part of the Deccan Volcanic Province, Jalgaon District, Maharashtra (India). Savda is a small village located 4 km south of small town Paldhi which is in turn about 10 kilometers to the west of Jalgaon City, Maharashtra (India). The area is well connected by National Highway No. 6 connecting Mumbai with Nagpur passing in the northern part of an area. Location map of the study area has depicted in Figure 1. Quarries are excavated in basaltic flow which is located at Savda area of Jalgaon District (Fig. 2). The climatological area comes under semi arid zone. The average annual rainfall in the study area is about 650 mm. The mean maximum temperature ranges from 29.5 to 48°C. The minimum temp ranges from 12 to 24°C the high relative humid value 83.63% occurs in rainy season viz. Jun to December.

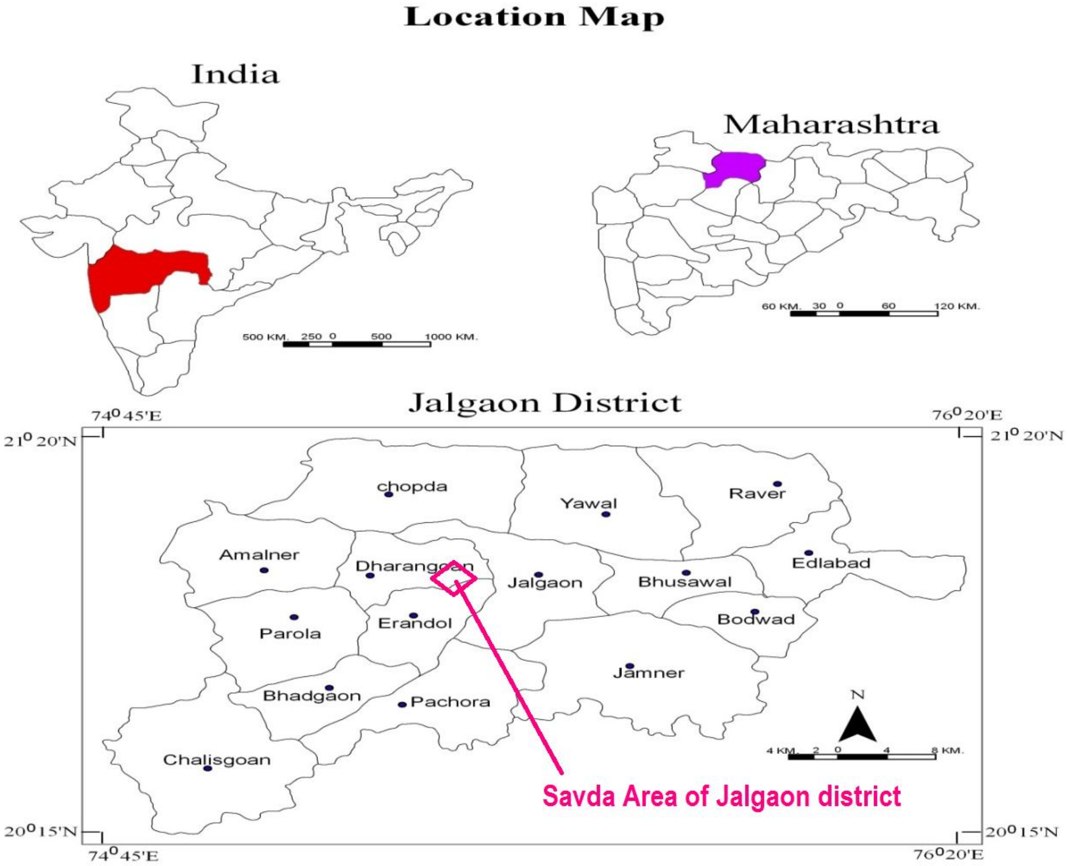


Fig. 1: Location Map of the study area

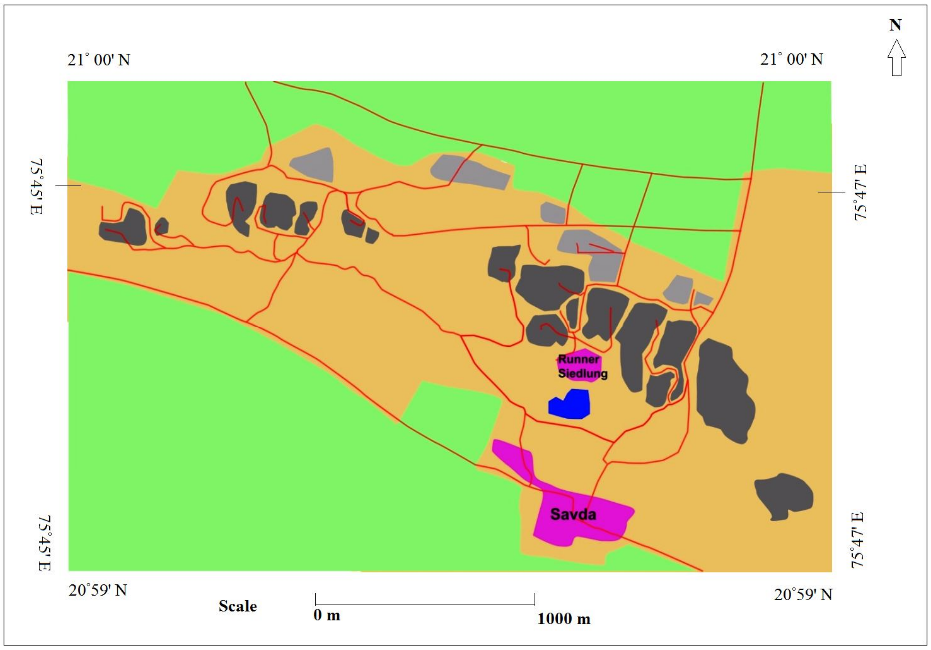


Fig. 2: Outline of Savda stone Quarry from Jalgaon, Maharashtra (India)

1.3 Geology of the study area

The Deccan Volcanic Provenance is one of the largest flood basalt provinces in the world, covering an area of more than 500,000 km^2 in the western and central parts of India during upper Cretaceous to the Lower Eocene Period come out through fissure eruption of volcanoes. At places along the western part of the province, a continuous vertical succession of basaltic flows with a thickness of more than 1,200 m can be observed, and geophysical studies have indicated that the thickness attained by the lava pile is over 2,000 m in the western part of the province (Kaila, 1988). Kalsubai, a prominent peak in the western parts of Ahmadnagar district bordering Thane district of Maharashtra is the tallest peak of the Deccan Volcanic Province. On the periphery of this Province around Nagpur, the lava pile decreases considerably in thickness to as little as 10 m. It has been postulated that the Deccan Volcanic Province formed around 65 Ma in response to the passage of the Indian plate over the Reunion hotspot (Beane et al., 1986; Courtillot et al., 1986; Cox and Hawkesworth 1985; Morgan 1971).

The Deccan Volcanic Province is constituted dominantly of tholeiitic basaltic lava flows, nearly horizontal, stacked one above the other. The basaltic flows are intruded at a number of locations by essentially doleritic dykes, some of which are speculated to represent feeders. The lava flows are classified aa, pahoehoe, simple and compound type (GSI, 2000). These lava flows are predominantly contains compact, vesicular and amygdaloidal basalt. The area is lying in Ajanta formation in Sahydri Group, which consist 11 aa type and 5 pahoehoe type lava flows (Golekar et al., 2013). Stratigraphic successions of the Deccan Volcanic Province were presented in Table 1.

Table 1: Stratigraphic succession of the Deccan Volcanic Province

(Source: Vaidyanadhan and Radhakrishna, 2008)

Super Group	Sub- Group	Formation
Deccan Basalt	Wai	Desur
		Panhala
		Mahabaleshwar
		Ambenali
		Poladpur
	Lonavala	Bushe
		Khandala
	Kalsubai	Bhimashankar
		Thakurwadi
		Neral
		Igatpuri
		Jawhar

Due to effect of temperature and climate, upper part of basalt was weathered. Newly identified aa lava flows outcrop intermittently over an area of ~110 km^2 in the western Deccan Volcanic Province (DVP), India. They occur in the upper Thakurwadi formation in the south of Sangamner, District Ahmadnagar (Bondre et al., 2004). The flows, one of which is compound, are 15-25m thick, and exhibit well-developed basal and flow-top breccias. The lavas have microcrystalline groundmasses and are porphyritic or glomerocrystic and contain phenocrysts of olivine, clinopyroxene or plagioclase feldspar. They are chemically similar to compound pahoehoe flows at a similar stratigraphic horizon along the Western Ghats. Petrographic and geochemical differences between aa flows at widely spaced outcrops at the same stratigraphic horizon suggest that they are the product of several eruptions, potentially from different sources. Their presence in the Deccan Volcanic Province could suggest relative proximity to vents. This discovery is significant because aa lavas are generally scarce in large continental flood basalt provinces, which typically consist of numerous inflated compound pahoehoe lobes and sheet lobes. Their scarcity is intriguing, and may relate to either their occurrence only in poorly preserved or exposed proximal areas or to the flat plateau-like topography of flood basalt provinces that may inhibit channelization and aa formation, or both. In this context, the aa flow fields described here are inferred to be the products of eruptions that produced unusually high-effusion-rate lavas compared to typical flood basalt eruptions. Whether these phases were transitional to lower intensity, sustained eruptions that fed extensive low effusion rate pahoehoe flow fields remains unclear.

The study area, rock shows vesicular characters which are generally filled with a secondary minerals and silica i.e. agate etc. Given rise to amygdaloidal character. Pipe amygdales are also observed. The lower part of flow unit is usually of massive character which passes upwards into a vesicular or amygdaloidal (Zeolite) horizon. In this Zeolite horizon different type of varieties and stalactites and stalagmites are the conical deposits that from at roof of the cave and huge downward while stalagmites are those that from on the bottom of the cave and grow upward as water drips down from above. Following some varieties of Zeolite and silicate minerals are distinctive occurrence in the study area i.e. Apophyllite, Stilbite, Stibnite, Mordenite, Chabazite, Quartz, Amethyst, Agate and Chalcedony.

The zonal distribution of Zeolite in the Deccan Trap was recognized by studied Zeolite and associated secondary mineral in Deccan Traps of western parts. The study area comes under Deccan Trap which is geologically covered by the compact with jointed and fractured basalt. The present study area is stone Quarries of basaltic rock from Savda village of Jalgaon district and its coordinate between latitude 20.98 N and longitude 75.45 E. These Zeolite are porous crystalline and associated with vesicular and weathered basalt Zeolites are group of silicate containing the water of crystallization these mineral are porous crystalline solids and they are associated with vesicular weathered basalt. Field work carried out by ourselves and drawn the lithological section (Fig. 3) on the basis of field observation. The lithological section shows that the soil overburden (0.3 m) followed by weathered basalts (11.6 m), compact basalt (10.2 m), basalts with zeolitic cavities (7.9 m) and compact basalts are present at the base.

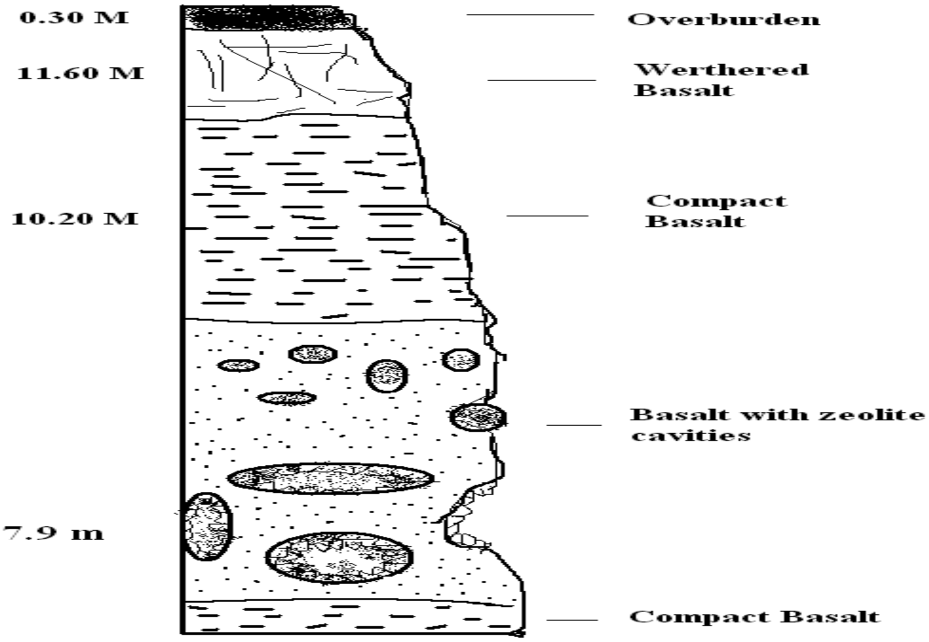


Fig. 3: Lithological section of the Savda area of Jalgaon

1.4 Geomorphology of the study area

The area shows East-West trending hillocks ranges of Ajanta subgroup from Deccan Volcanic Province. These hillocks are mostly concave topped. Hillocks are rise approximately above 240 - 256m amsl. The overall drainage pattern is sub-dendritic. The major streams are flowing towards the westward. Tapi is a main river flowing through the district. The study area comes under Girna river basin which is major tributary of River Tapi. The district is divided into three main physiographic divisions i.e., Satpura hill ranges in the Northern part with dense forest; Tapi valley consisting of alluvial plain in the central part of the district and Ajanta hill ranges, flanking the hill ridges and small valley in the southern part of the district. On the basis of land form assemblages, slope characters, nature of drainage and its pattern and sediment generation or deposition, present area to be divided into two distinct geomorphic zones which from the North to the South area (i) Satpura hills and (ii) Alluvial complex. An area extending for a distance of about 1.5 km. on North and 1 km in South of the Girna river is highly dissected by numerous streams giving rise to a badland type of topography. The alluvial stretch in the area is observed for a distance of about 6 km, south of the River Tapi. The outcrops of hard rocks, the Deccan Traps are found at a few places in the bed of Anjani and Jhiri River which are tributary streams of the River Girna. The River Girna, forming the main drainage of the area and its two tributaries Anjani and Jhiri flow in northerly direction.

2. MATERIALS AND METHODOLOGY

2.1 Field data methods

Detail field study was carried out in stone Quarry form Savda area of Jalgaon district which is part of Deccan Volcanic Provinces, Maharashtra, India. A systematic sampling was also taken up. All field work carried out in the month February and March 2013. Field work was carried out in 2 steps,

i) Observing all quarries in Savada area
ii) Collecting the mineral samples and detailed mineralogical study of collected samples.

Representative samples of Zeolite minerals collect from the Savada Quarry area. These samples were collected by ourselves and show the variety of samples present in the area. Zeolites deposit is exposed in the Quarry from the basaltic rocks. A rock hammer was used for the collection of the samples and these samples were stored in a plastic bag. Each collected sample was labelled. Fieldwork was primarily focused on localities presenting excellent samples of natural Zeolites. The sampling scheme consisted of collect the natural Zeolite minerals filling in amygdule and veins from outcrops in fresh road cuts and new quarries. Petrographical and geochemical studies were made of specimens of Zeolite mineral; this show the way to clarifying and confirming field observations.

2.2 Sample preparation for XRD and SEM

Representative samples collected from the area were gently crushed into powder by a mortar and pestle. These powdered samples were used for X-ray diffraction (XRD) and FESEM analyses to determine mineralogy and major elemental composition, respectively. The sample mount for the X-ray diffraction were prepared using the back fill techniques to produce a random oriented mount (Moore and Reynolds 1997; Patel et al, 2014). The Powder X-ray diffraction and FESEM analysis were conducted in the University Department of Chemical Technology, North Maharashtra University, Jalgaon (M.S, India).

X-ray diffraction (XRD)

The XRD pattern were obtained using the Brucker D8 Advanced powder diffractometer operating in the reflection mode with Cu Ka radiation (40KV,40 mA) and diffracted beam monochromatometer, using a step scan mode with the step of 0.020 and 0.5s per step. Divergence slit 1.200 and antiscatter slit 0.600 were used in University Department of Chemical Technology, North Maharashtra University, Jalgaon (M.S, India). Diffraction patterns of powders were compared with ICCD (International centre for diffraction data) reference database. Powder X-ray diffraction analyses were conducted on the randomly oriented Zeolite minerals samples using a Philips X-ray diffractometer at University Department of Chemical Technology, North Maharashtra University, Jalgaon. Random back filled mounts were scanned from 10 degrees 2θ to 60 degrees 2θ, X-rays were generated at 35KV and 15mA. The mineralogical identification from the diffraction pattern was conducted by comparison to earlier researcher results (Moore and Reynolds 1997).

Scanning Electron Microscope (Fe-SEM)

The 'mineral phases' morphological features were examined in a scanning electron microscope (Fe-SEM), using the following analytical conditions. The SEM micrograms were obtained using Hitachi High Tech S-4800 II equipped with EDX Brucker X Flash Detector 5030. The powder samples were studied in native form without coating by conductive metal layers. The samples for electron microscopy prepared by dispersing the powder in propanol by sonication and applying a drop of very dilute suspension on carbon coated grids. The suspensions were dried by slow evaporation at ambient temperature.

2.3 Trinocular Microscope

A trinocular transmitted light microscope was used to observe the minerals optical properties in thin sections. Thin section and polished section slides of corresponding samples were prepared and studied in the laboratory of Post Graduate Department of Geology, Institute of Science, Aurangabad (M. S., India).

3. RESULTS AND DISCUSSION

3.1 Mineralogy

Physical and optical properties have been identified from the collected minerals in Departmental laboratory of Applied Geology, North Maharashtra University, Jalgaon. Physical and optical properties of the minerals were described in Table 2 and Table 3, respectively. Megascopic features illustrating the occurrence of several types of Zeolites in amygdales and veins (Fig. 4 to 6). Plane polarized light (XPL) and between Cross Nicols photomicrographs of the occurrence of several types of Zeolites in amygdales and veins (Fig. 7 to 9).

Table 2: Physical properties of the minerals from the study area

Name of the minerals	Apophyllite	Stilbite	Mordenite
Chemical Composition	(K, Na) $Ca_4Si_8O_{20}(F,OH)\cdot 8H_2O$ (Hatch, 1912)	(Ca, Na_2, K_2) $(Al_2Si_7O_{18})$ $7H_2O$ (Hatch, 1912)	(Ca, Na_2, K_2) (Al_2Si_7) O_{18} H_2O (Hatch, 1912)
Crystal System	Tetragonal	Monoclinic	Orthorhombic
Form	Crystalline	Acicular	Radiating
Color	Colorless, Pale Green	Brownish	White, Colorless
Luster	Vitreous	Vitreous to Pearly	Vitreous Silky
Streak	White	White	Colourless
Fracture	Uneven	Uneven	Uneven
Cleavage	Perfect on {001}, imperfect on {110}	{010} Perfect	{010} Perfect
Hardness	4.5 to 5.0	2.1 to 2.2	5
Specific Gravity	2.33 to 2.37	3.5 to 4.0	2.12

Table 3: Optical properties of the minerals

Name of the mineral	**Apophyllite**	**Mordenite**
Plane Polarized Light		
Form	Platy	Platy
Color	Colorless	White
Relief	Low	Low
Cleavage	Absent	None
Pleochroism	None	None
Between Cross Nicols		
Isotropic / Anisotropic	Anisotropic	Anisotropic
Interference Color	1st order	2nd order

3.2 Petrographical analysis

Fig. 4 to 6 shows Zeolites general macroscopic characteristics, as seen in the field. Zeolites appear filling cavities in a no uniform way; sometimes they just line cavities and sometimes they fill them completely. Pink coloured Stilbite occurs in an amygdaloidal cavity. Apophyllite occurs as tetragonal crystal system, crystalline form and colourless (Fig. 4). Stilbite occurs as vitreous sheaves or plates, ranging from colourless to green to white (Fig. 5). Mordenite occur in fibrous form (Fig. 6). Fig. 7 to 10 illustrates the microscopic features of the Zeolites investigated. The optical properties making it clearly distinguishable from other Zeolites are the extinction of fibers parallel to its length between crossed nicols and the absence of an optical figure in convergent polarized light. The optical properties making it clearly distinguishable from other Zeolites are the extinction of the fibers parallel to its length between crossed nicols and the absence of an optical figure in convergent polarized light. This suggests that Zeolite has a moderate relief.

Fig. 4: Image of Apophyllite

Fig. 5: Image of Stilbite

Fig. 6: Image of Mordenite

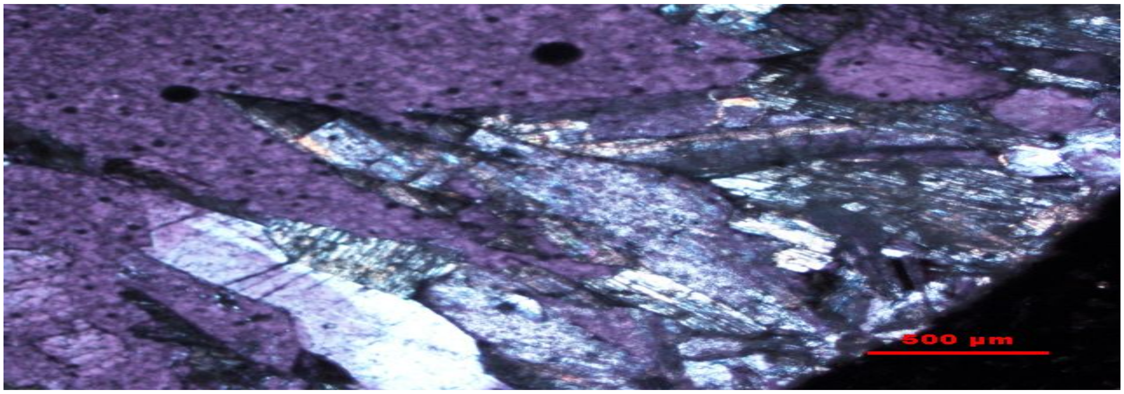


Fig. 7: Plane Polarized Light (Apophyllite)

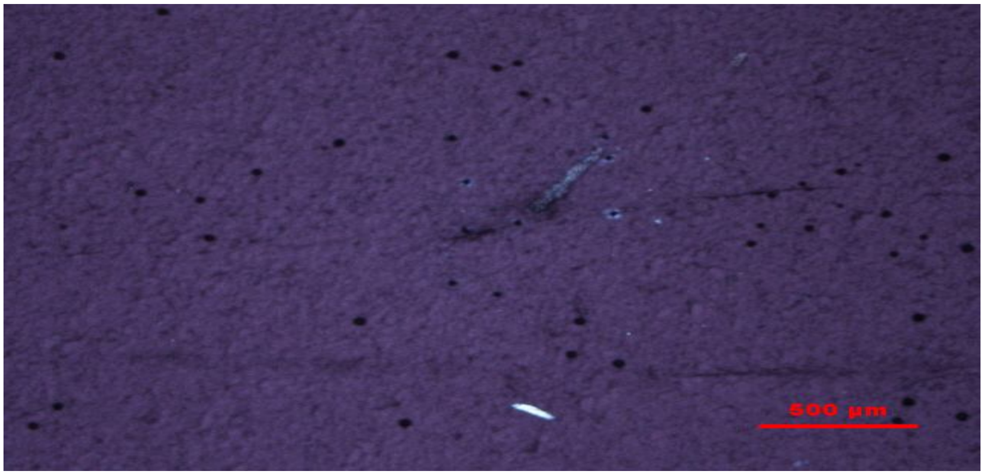


Fig. 8: Between Cross Nicol (Apophyllite)

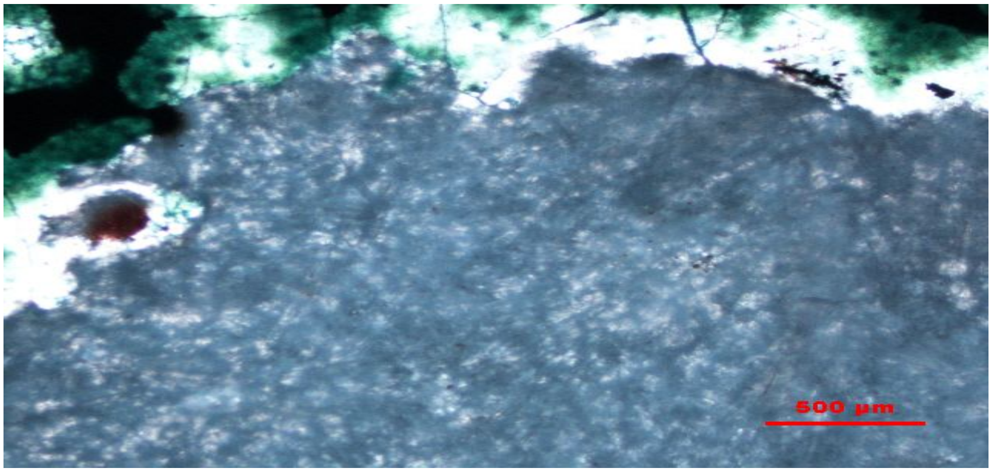


Fig. 9: Plane Polarized Light (Mordenite)

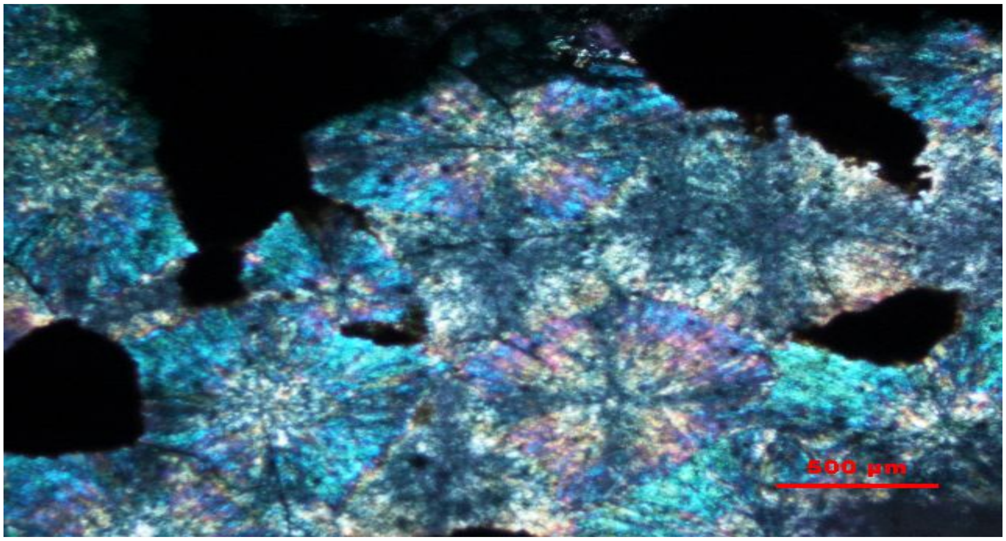


Fig. 10: Between Cross Nicols (Mordenite)

3.3 Interpretation of Fe-SEM EDS

Fe-SEM and EDS analyses for identification of different mineral phases taken up and amethyst, Apophyllite, Stilbite and Mordenite minerals have been identified in most of the basaltic samples. The Fe-SEM and EDS used to qualitative and quantitative analysis of elemental composition in zeolitic minerals in basaltic samples. Figure 11, 12 and 13 illustrates that the SEM images of the natural Apophyllite and Zeolites viz. Stilbite and Mordenite respectively crystals. SEM results reveal that the mixed layer appears as small plates or flakes, reaching up to 800 µm. It usually occurs as tetragonal crystals (Fig. 11), monoclinic crystals (Fig. 12) and orthorhombic crystals developing interpenetration twinning (Fig. 13).

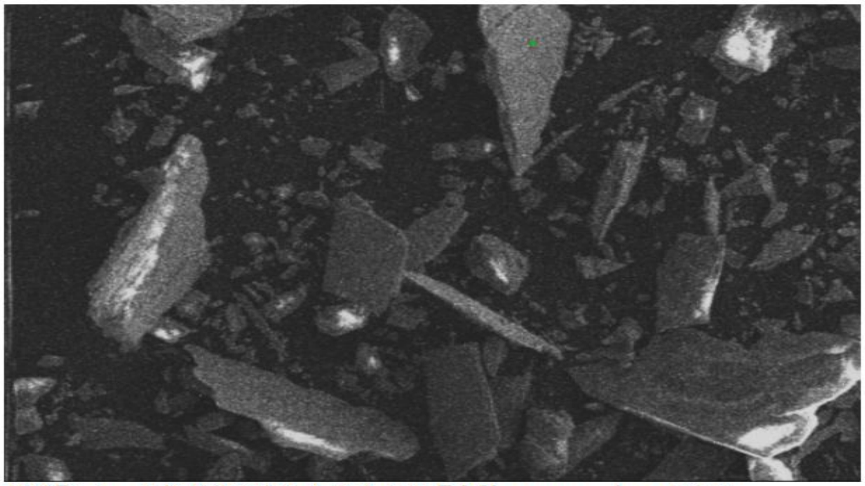

1 734Date:5/29/2013 1:24:20 PMImage size:512 x 384Mag:3000xHV:15.0kV

Fig. 11: Fe-SEM Image Apophyllite

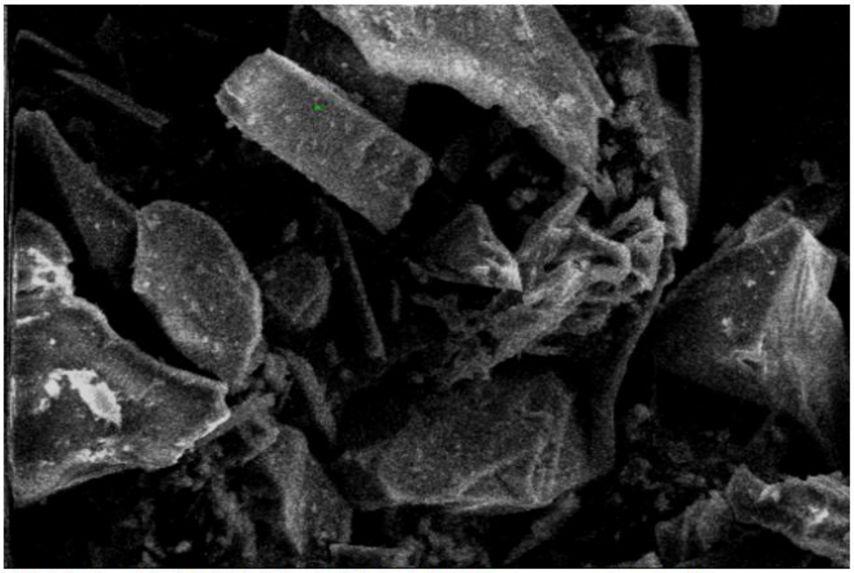
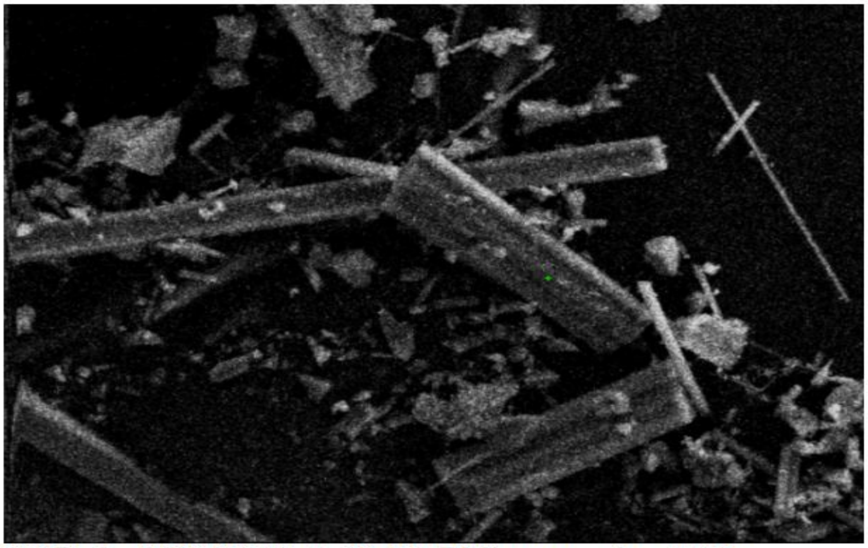

1 733Date:5/29/2013 1:21:34 PMImage size:512 x 384Mag:3000xHV:15.0kV

Fig. 12: Fe-SEM Image of Stilbite



1 736Date:5/29/2013 1:29:20 PMImage size:512 x
384Mag:3000xHV:15.0kV

Fig. 13: Fe-SEM Image of Mordenite

The elemental composition was obtained using Fe-SEM EDS (Fig. 14, 15 and 16). The elemental composition in Zeolite minerals has depicted in Table 4. The data shows that the descending trends were observed O followed by C, Te, Ca, Si, Br, Na and K in Stilbite. Whereas in Apophyllite O followed by Ca, Te, C, Si, K, Na and Br. On other hand O followed by Si, Ca, Br, C, Na, K and Te observed in mineral Mordenite. On comparison of silica percentage in Zeolite mineral samples with those of the standards available, it is seen that the silica percentage in mineral samples was found to be less while carbon percentage is comparatively high, except mineral Mordenite.

Table 4: Normative weight percentage of elemental composition in minerals

Element	Stilbite	Apophyllite	Mordenite
C	21.45	13.27	4.47
O	29.74	36.63	50.28
Na	0	0	0.82
Si	11.85	11.27	24.21
K	0	3.49	0
Ca	16.45	20.78	11.78
Br	6.96	0	8.43
Te	17.56	14.58	0
Total	104.01	100.02	99.99

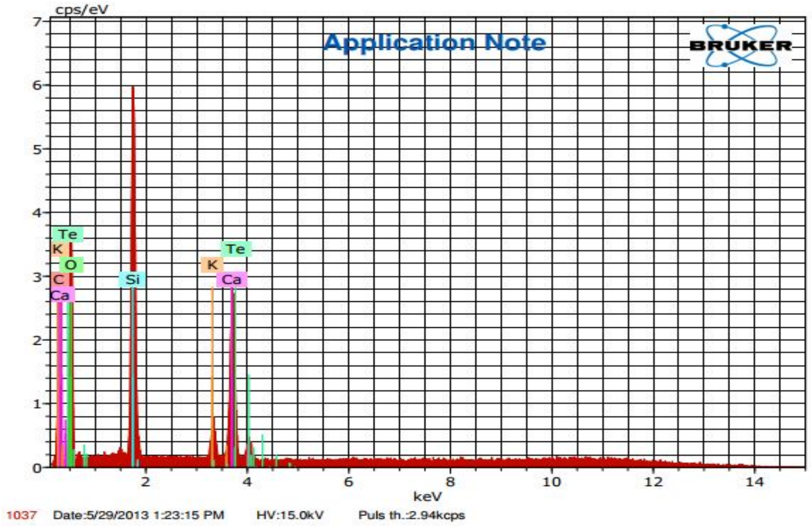


Fig. 14: Fe-SEM EDS of Apophyllite

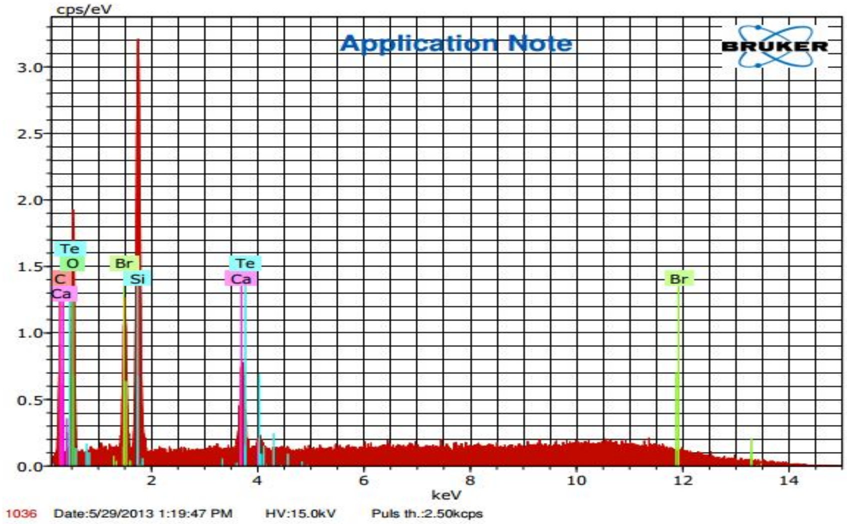


Fig. 15: Fe-SEM EDS of Stilbite

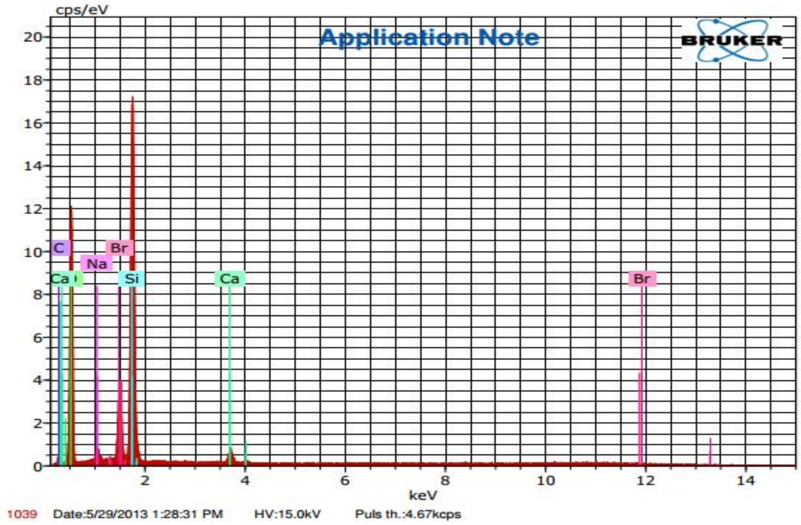


Fig. 16: Fe-SEM EDS of Mordenite

4. CONCLUSIONS

The study area is occurring in the Deccan Basalt of late Cretaceous age and little part occupy by the alluvium of Quaternary age. It contains 11 aa type and 5 pahoehoe type different lava flows. These different lava flows contain different cavities and vesicles with Zeolites and apophyllite minerals. Zeolites group shows Stilbite and Mordenite minerals. The size of cavities is about few mili-meters to several meters with Zeolite and Apophyllite minerals in it. These Zeolites cavities are found single lava flow but two different generation and mineral associations. XRD and Fe-SEM analysis of minerals describe crystallography perfectly, elementary distribution and percentage of element.

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