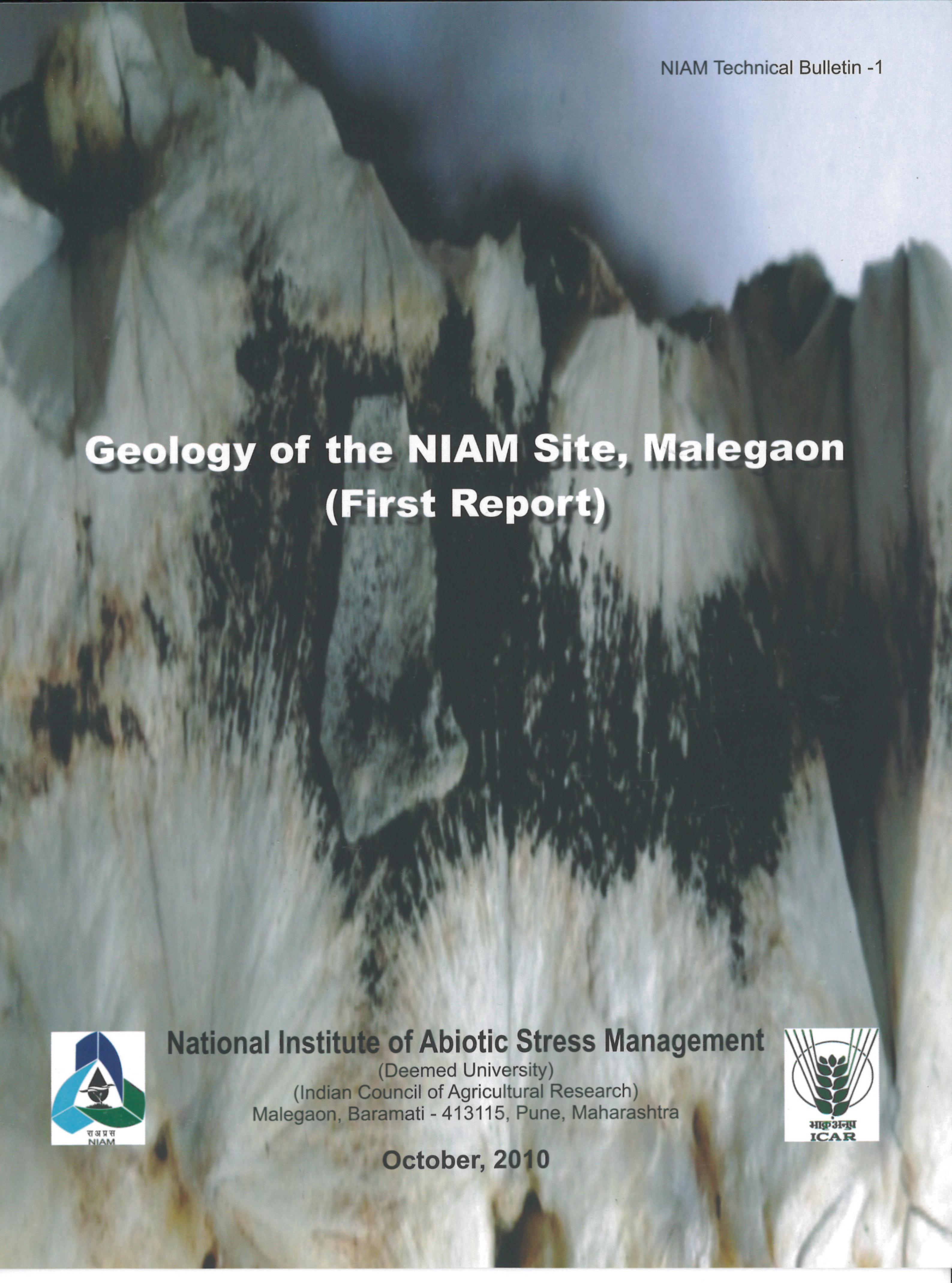

NIAM Technical Bulletin -1

Geology of the NIAM Site, Malegaon (First Report)

National Institute of Abiotic Stress Management
(Deemed University)
(Indian Council of Agricultural Research)
Malegaon, Baramati - 413115, Pune, Maharashtra

October, 2010

About Us

Recognizing the importance of influence of climatic change on the already mounting adverse effects of abiotic stresses of climate, water, edaphic factors etc. on various sectors of agriculture, horticulture, livestock, fisheries, birds etc., on 19 January 2009, the Union Cabinet approved in XI plan the establishment of National Institute of Abiotic Stress Management (NIAM), with a status of deemed-to-be university. Its foundation stone was laid by Shri Sharadchandraji Pawar, Hon' Minister of Agriculture & Consumer Affairs, Food & Public Distribution, GOI on 21 February 2009, at Malegaon Khurd, Baramati, Pune District, Maharashtra.This is a 'dream project' of the Council. Wisely the Council vested the responsibility with Natural Resource Management Division to define the target areas to bio and other technologists to meet the mandate. The mandate of the institute is

- To undertake basic and strategic research on management of abiotic stresses of crop plants, animals, fishes and micro-organisms through genetic, biotechnological and nano technological tools and agronomic methods for enhanced sustainable productivity, food/feed quality and farm profitability adopting integrated interdisciplinary approaches
- To develop a Global Center of Excellence by establishing linkages and networking with national and international Institutes/agencies, and
- To act as repository of information on abiotic stress and management

The primary objective is to develop agricultural commodities neutral or adoptable to mounting abiotic stresses under climate change using bio-nano-technologies and other scientific frontier tools without reducing on productivity.

Presently the science is progressing from the functions of individual genes to behaviours of complicated systems that emerge from the interactions of a multitude of factors. These recent developments necessitate the promotion of a combination of approaches collectively called "Systems Biology." The final goal is to develop an insight into background, hypotheses to mitigate, strategies to incorporate with a foresight to practice climatically adaptable farming systems for building sustainable and profitable livelihood in stressed environments and constitutionally acceptable policy issues.

* * *

Geology of the NIAM Site, Malegaon

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Cover Photo :
Radiating crystals of Zeolite (stilbite)

Back cover photo :
Spheroidal weathering of trap rocks

C O N T E N T S

1. Introduction

i. Abiotic Stresses and Geology

Abiotic stresses are natural and borne from atmosphere (temperature-heat, cold chilling; frost; radiation - UV, ionization; gasses - CO2 and other green house gases, toxic gases), water (drought, flooding/ hypoxia, water logging, sea water inundation declining water quality etc.), soil (lack of soil depth, salinity, alkalinity, sodicity, acidity, wind, soil shifting, mineral deficiency/ excess, other degradations, etc), pollutants (heavy metals/ pesticides, aerosols, etc) and others. In the edaphic factors, geology plays an important role in the development of multiplier effects of abiotic stresses since most of the nutrient reserves in the soil is controlled by nature and composition of parent rock. The effects of country rock/ terrain, particularly a limestone country is badlands because of their elemental content which has an important bearing on the crop growth. Physical properties of the soil / underlying rocks also have important effects on the edaphic stress if the soils are fine grained, permeability and porosity is low and the underlying rocks are partially altered / unaltered.

The nutrient deficiencies in the soil can be correlated with the exposure and type of parent materials. In recent years it has been observed the hazardous effects of Cd, As, Se, Mo, Hg due to their presence, above and below the threshold level in both plant, animals and human beings causes different types of abiotic stresses. The effects of As has drawn the attention of scientists world over. The source of these elements is governed by the inherited geological formation.

Presently, the impact of climate change on land degradation has drawn worldwide attention wherein the importance of geological formation has been taken as an important stress parameter to define the quantum of degradation due to change in short-variation as well as long term gradual change mostly covering temperature and precipitation.

In the world only 9% of the area is conducive for crop production, while 91% is under stress. This includes 24% under drought, 21% has got shallow depth, 21% is under mineral stress and 14% is under freezing stress and 11% is waterlogged. Similarly, in India also 67% of the area is rainfed and crops in these areas invariably experience droughts of different magnitudes. Although in the country 33% of the cropped area is under irrigation, yet here crop production is constrained by environmental stresses like thermal. The abiotic stresses are estimated to responsible for over 50% reduction in agricultural production. Further, due to climate change the levels of stresses may further increase that may adversely influence the crop yields. Being a tropical country, India is more challenged with penultimate combinations of abiotic stresses spatially and temporally. The country is experiencing productivity declines due to droughts, floods, and high and low temperatures, etc. which are major limitations in maintaining food security. The climate change is resolutely expected to aggravate the adverse impacts of abiotic stresses further.

As a first step to start repository of information on abiotic stress, this attempt is being made.

ii. Geology of the Deccan Trap area and the Site

The close of Mesozoic era (Upper Cretaceous) was marked by the outpouring of enormous lava flows through fissures and was continued till the end of Early Eocene that is about 75 million years was the period of active volcanism in Indian subcontinents. These lava-flows spread out as nearly horizontal sheets, ranging in thickness from a few to over 100 feet, form flat-topped plateau with step-like terraces and covering an area of about 200,000 square miles. These are commonly called as traps rocks with dominantly basaltic composition and the formation as a whole is known as Deccan Traps. The traps have been divided into three groups - Upper (450m), Middle (1,200m) and Lower (150m thick) with Intra-trappean beds at their base and are unevenly distributed in the Deccan Plateau. NIAM site is a part of the Middle Trap formation with intertrappeans and paleosols in the lower horizon. A preliminary field survey has been carried out along the periphery of the site boundary of 3.6 km to a depth of 100-150 cm to know the nature of exposure and their orientation, geomorphological / topographical and structural control, likely mineralogical make up, development of weathering profiles and relation with soils. All these parameters have been dealt in detail with supporting field photographs.

2. Location and Access

Site is located between 18°09' 18.86N to 74°30'01.33"E at Malegaon Khurd, Baramati in Pune District of Maharashtra State in the semi-arid tract of the plains of Western Ghats. It is well connected by road with major cities in the State and also by Central Rail Network to Pune via Daund Junction (Fig. 1).

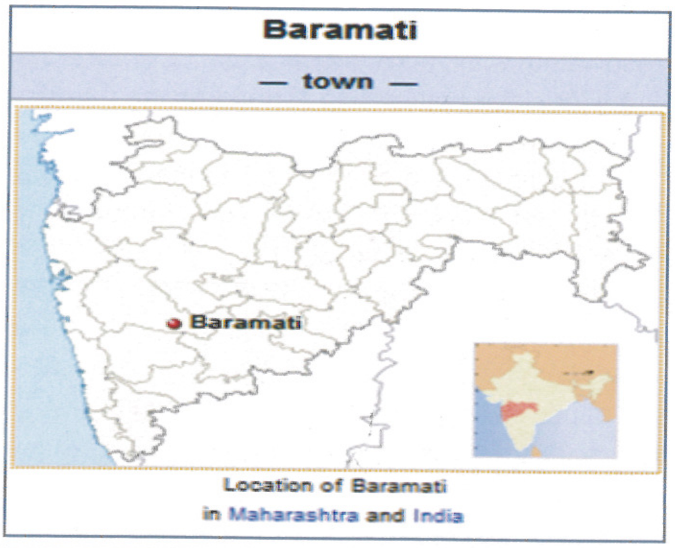

Fig.1 Location Map of the NIAM site

3. Topography of the Site

The site is a basaltic subdued plateau with an elevation ranging from 547 to 565 m sloping towards south. The landscape is divided into summit, side slopes, shoulder slopes and backslopes. The radial drainage in all the directions owing to lesser length of slope leads to severe stony surface cover and gully formation in north-west and north-east of the landscape causing headward erosion. The ground natural features associated in nose slope parts are gullies wherein sparse scrub/grass cover on weathering front or soft sheet rock with rock outcrops (>40% surface cover) is common. In eastern side, 1/3 rd part is excavated for murrum with breakup slopes of convex and concave pattern. The south-east part is under quarry wherein landscape is totally disturbed. The summit and backslopes are associated with 1-3% slope and side slope and shoulder slope upto 5-10%. The terracing (bunding - 5-8 m apart depending upon slope) on summits and backslopes has been modified natural slopes. Panoramic view of landscape features as observed is shown in figs.2 to 5.

Fig.2. Exposure of rock outcrops on the backslopes of western side

Fig. 3. Panoramic view of side slopes, shoulder slopes and backslopes on the eastern side of the site

Fig.4. Panoramic view of summit, side slopes, shoulder slopes and backslopes side of the site of eastern part

Fig. 5. Panoramic view of northern side of the site showing summit and side slopes, shoulder slopes and back slopes

4. Structural features

Site is characterized by flat-topped hills and step-like terraces which is visible in the sections along the boundary wall. The topography is a result of the variation in hardness of the different flows, the hard portions forming the tops of the terraces and plateau. Two type of flows have been recognized at the site.

i. Amygdular (Vesicular) flows

In this type of flows the upper portion is highly vesicular, the middle fairly compact and bottom layer filled up with secondary minerals. These features can be observed in different field and sample photographs. The photographs reveals that at some places lower horizon of the flows has been exposed indicating the weathering and erosion of upper and middle part (Fig.6).In other section only two horizons are exposed (Fig.7) and in a few sections only all the three horizons are exposed (Fig. 8).Some of rocks show the magmatic differentiation resulting in two types of fluids and crystallization of magma. The more viscous liquid has resulted the segregation of coarser grain with zeolite precipitates (Fig.9). Other important features observed in these flows have been shown in figs.10 to 17.

With intensive leaching the lower trap which is exposed to the surface at many places also resulted in the development of laterite like features with increase in ferruginous component (Figs.18 and 19).

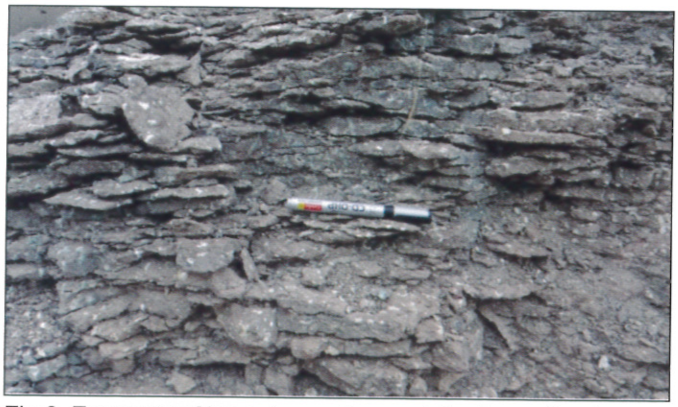

Fig.6. Exposure of lower layer of amygdular flows showing layered structures and cavities are filled up with secondary minerals

Fig.7. Amygdular flow showing highly vesicular top layer with fairly compact middle layer

Fig. 8. Amygdular flow showing vesicular top layer with fairly, compact middle layer and lower layer with coarse grained and cavities are filled up with secondary minerals

Fig.9. Sample from the junction of middle and lower layer of amygdular flows clearly showing magmatic differentiation of lava flows and hydrothermal activi-ties, cavities are filled up with secondary minerals (Zeolites)

Fig.10. Sample from lower part of amygdular flows showing late hydrothermal activities, cavities are filled up with secondary minerals (Zeolites) with the coating of malachite green mineral

Fig.11. Sample from lower part of amygdular flows and cavities are filled up with different types of zeolite minerals

Fig.12.Sample from lower part of amygdular flows, cavities are very small and many and filled up with zeolite minerals indicating that lava was cooled down very quickly with lots of gaseous emanations which also indicates the hydrothermal activities were highly active

Fig. 13. Sample from lower part of amygdular flows, cavities are filled up with zeolite minerals, brownish colour of the sample indicates the effects of leaching

Fig.14. Sample from lower part of amygdular flows with increase in ferromagnesian minerals it is tending towards the formation of laterite, cavities are filled up with different types of zeolite minerals

Fig. 15. Sample from lower part of amygdular flows, cavities are filled up with different types of zeolite minerals

Fig.16. Sample from lower part of amygdular flows, cavities are filled up with secondary mineral zeolite and green colour malachite mineral indicating the nature of hydrothermal fluid during the cooling and crystallization of magma

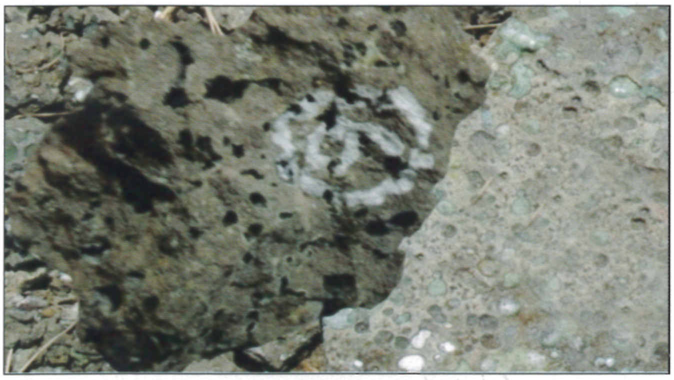

Fig.17. Upper portion of amygdular (vesicular) flows

Fig.18. Upper portion of amygdular (vesicular) flow showing weathering and lateritization effects

Fig.19. Sample from lower part of amygdular flows, cavities are filled up with secondary mineral zeolite and it is tending towards the formation of laterite due to increase in ferromagnesian minerals

ii. Ordinary (Nonvesicular) flows

In the ordinary flows the top layer is fine-grained and the lower portion coarser with sometimes a concentration of basic ferromagnesian minerals. Both these horizons are exposed in few sections only (Fig.20) whereas in most of the section only upper part of the flow is exposed (Figs.21-25).The samples collected from some of these sections also indicate the magamatic differentiation (fig. 26). Other characteristic features observed in these rocks are shown in the figs. 27 & 28.

Fig.20. Normal (nonvesicular) flow showing coarse grained in the lower part and fine grained basalt in the upper part, which also has been altered due to leaching effects

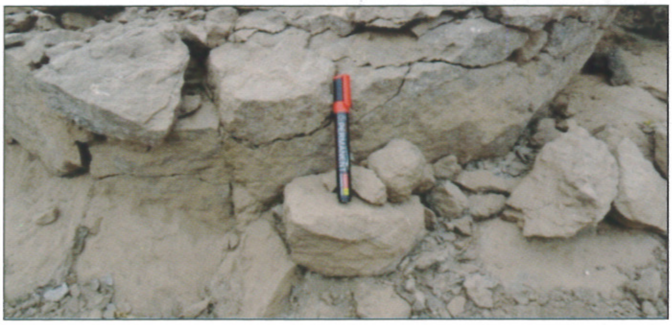

Fig.21. Upper part of normal (nonvesicular) flow consisting of fine grained, hard and compact basalt showing leaching effects

Fig.22.Upper part of normal (nonvesicular) flow consisting of fine grained, hard and compact basalt

Fig.23. Upper part of normal (nonvesicular) flow consisting of fine grained basalt

Fig.24. Upper part of normal (nonvesicular) flow consisting of fine grained weathered basalt

Fig.25. Upper part of normal (nonvesicular) flow consisting of fine grained weathered basalt

Fig. 26. Upper part of normal (nonvesicular) flow consisting of fine grained basalt, colour gradation is due to differential leaching or magmatic fractionation

Fig.27. Sample from upper part of normal (nonvesicular) flow consisting of fine grained basalt, cracks filled up with secondary precipitates of silica

Fig.28. Sample from upper part of normal (nonvesicular) flow consisting of fine grained basalt, the brown colour of the rind and light brown colour at the periphery is due to differential leaching

From the field study it has been established that these two different types of flows (vesicular and nonvesicular) which occurred during Upper Cretaceous to Lower Eocene are alternate with each other (Fig.29).

Fig 29. Middle part of vesicular and upper part of nonvesicular flow occurs together, vesicular flows are hard and massive while nonvesicular flow showing the weathering effect

These are also separated by thin beds of intertrappeans, as observed at several places in the section cuttings (Fig. 30). These intertrappeans have been converted to soil and can be referred as paleosols.

Fig.30. Amygdular (vesicular) and normal (nonvesicular) flows are separated with thin beds of scoriae or inter-trappean beds, upper portion (vesicular flows) of the trap is showing weathering effects

The thickness of the individual flows has not been measured at present since the lower horizons has not been exposed completely in any flows. But information gathered indicate that the individual flows vary in thickness from a few feet to over 100 feet with an average thickness of 40 feet, and recorded in a borehole at Bhusawal which revealed 29 flows. Individual flows have been traced for distances of 100 km and more between Chhindwara and Nagpur.

4. Petrological features

Traps are uniform in composition over much the greater part of the area and correspond to basalt. They are generally dark-grey to dark-greenish grey, but brownish to purplish tints are also met with (Fig. 31-32).

Fig.31. Sample from upper part of normal (nonvesicular) flow, dark gray in colour, consisting of fine grained basalt filled up with secondary precipitates of silica

Fig. 32. Sample from upper part of normal (nonvesicu lar) flow, light gray colour, consisting of fine grained basalt

These rocks are composed of labradorite and clinopyroxene (augite), the two forming the bulk of formation with minor amount of olivine & magnetite. The minerals of late hydrothermal activity or secondary minerals are often developed in the traps, either as fillings in the amygdular cavities or as products of alteration and replacement are zeolite (stilbite), calcite and quartz (Figs. 33 & 34).

Fig.33. Sample from lower part of amygdular flows with strong growth of secondary mineral zeolite, the growth and development is due to differential accumulations of hydrothermal precipitates and exposure to the atmosphere

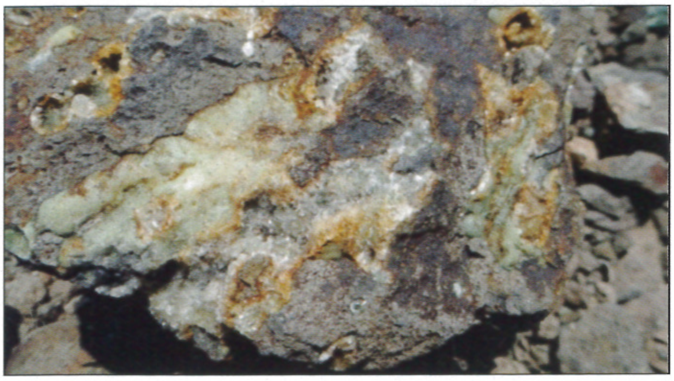

Fig.34. Sample from lower part of amygdular flows showing the growth of secondary mineral zeolite and iron leaching in the cavities

Amongst the zeolites, sheaf-like aggregates of stilbite are the most common widely distributed (Fig.35).

Fig.35. Sample showing the growth of sheaf-like aggregates of well developed zeolite crystals

Besides this divergent and radiating forms of stilbite are also present (Figs. 36 - 38).

Fig.36. Sample from lower part of amygdular flow shows the growth of well developed stilbite (zeolite) twin crystals in divergent forms of on the surface of vesicular basalt

Fig.37. Sample showing the growth of well developed radiating crystals of Stilbite (zeolite)

Fig. 38. Enlarge view of the above sample

In some other cases growth and development of amorphous to crystalline zeolite can be observed from the matrix of vesicular basalt as shown in figs. 39 & 40.

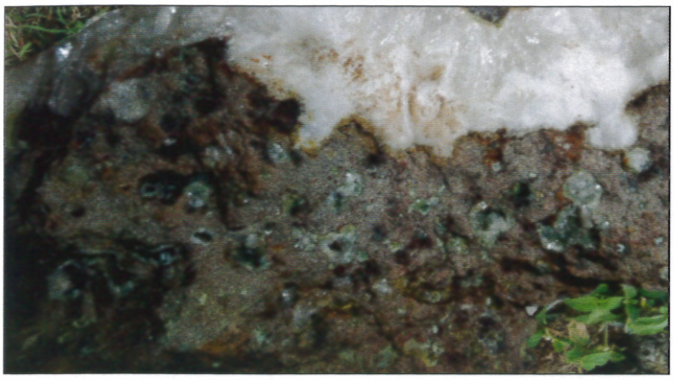

Fig. 39. Association and growth of zeolite crystals over the matrix of lower part of vesicular lavas

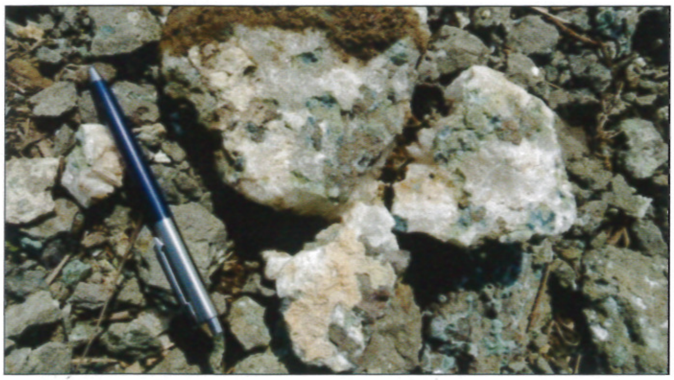

Fig.40. Sample from lower part of amygdular flow shows the development of secondary zeolite and green colour malachite mineral on the surface of vesicular basalt

Fig.41. Calcite mineral with well developed crystal face

5. Features of alteration and weathering

Spheroidal weathering is the characteristic of the traps which gives rise to ex-foliation on the outcrops. The weathering starts along the well - developed joints, first rounding off the angles and corners and then producing thin concentric shells or layers which become soft and fall off gradually. The interiors of the spheroidal masses are however, quite fresh (Figs. 42 & 43).

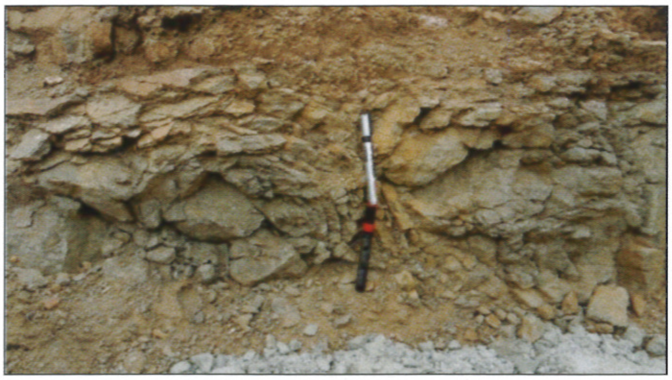

Fig.42 Spheroidal weathering showing the exfoliation of trap rocks with hard portion remains intact

Fig.43 Enlarge view of the spheroidal weathering showing the hard unaltered core of trap rocks

In other vesicular and nonvesicular flow weathering starts through fractures, cracks and joints in the rocks (Fig. 44) resulting the the gradual dissolution of hard rocks into smaller blocks which facilitate the movement of solutions.

Fig.44.Upper part of normal flow showing the differential dissolution and leaching and development of fractures and cracks in basalt

In most of the places of backslopes with lower contour height the upper part of the trap has been weathered. The lower horizon also shows the sign of alteration. The intensity of weathering varies as per the location, rock types and contour height of the site (Figs. 45 & 46).

Fig.45. Weathering of upper horizon of vesicular flow where rocks have been weathered along the fractures and cracks

Fig.46. Weathering of rocks along the fractures and cracks from upper to lower horizon of vesicular flow

At some places weathering resulted in the development skeletal box work structures (Figs. 47-48), a very common feature developed due to differential dissolution of material.

Fig.47. Formation of skeletal box work structure during the weathering of profile, soft portion has been removed and harder portion forming the skeletal like structure, the profile is intercalated with soil matrix

Fig.48. Enlarge view of above

It has also been observed that at the base of some of the profile soils are present as buried horizons (paleosols) (Fig. 49), which makes the study a very interesting and further research is required. Due to intensive leaching laterite is developed at some places as shown in above figure.

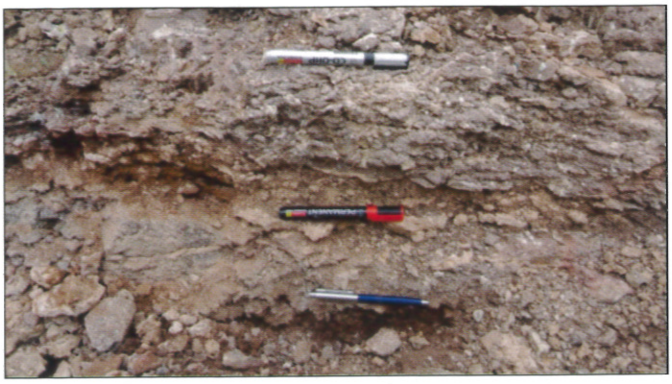

Fig.49. Weathering from upper to lower horizon of vesicular flow and development of laterite, upper and lower horizons are separated by the intertrappeans which itself is weathered, lower side of the profile indicates the presence of buried soil (paleosols)

Profile Development

Field characteristics of soils at the site were studied in a catenary sequence from higher to lower elevation (summit to backslopes) towards eastern side of the site to understand the nature of soil, depth and their geological control. All these soils are shallow to very shallow (5-21 cm deep), brown to pale brown colour with texture of loamy sand, gravelly sandy loam to sandy clay loam and are associated with severe erosion, gravels and stones and rock out crops and occur on gently sloping summit to backslopes. These soils are classified as Loamy-skeletal, mixed, isohyperthermic (calcareous), Lithic Ustarthents and belong to the subgroups of Entisols.

Association of the soil with the underlying rock on the summit and side slope show the gradation from lower to upper horizon indicating the insitu development (Figs. 50-51) whereas the soils developed on shoulder and back slope show no any gradation relationship and indicate that these soils were transported (Figs. 52-53).

Fig.50. Profile developed on summit. 24 cm deep, A horizon 10-12cm underlain by AC horizon of 11 cm and followed by C horizon with sandy loam texture (Profile 1)

Fig.51. Profile developed on side slope, 24 cm deep, A horizon 14-15 cm underlain by AC horizon of (15-23 cm) 8 cm and followed by C horizon, with sandy clay loam texture (Profile 2)

Fig.52. Profile developed on shoulder slope, 23 cm deep, A horizon 8-10 cm underlain by C horizon of 12 cm (10-22cm) and followed by R horizon with gravelly sandy loam in texture (Profile 3)

Fig.53. Profile developed on backslope, 12 cm deep, A horizon 4-6 cm underlain by R horizon with gravelly loamy sand texture (Profile 4)

7. Summary

From the study it has been observed that in most of the areas under observation, soils are very shallow to shallow and underlain by altered horizons mostly without the intercalation / development of soils and followed by hard rocks. In the north part of the site, hard rocks are exposed on the surface with / without alteration. In this situation the moisture retention of the soil, porosity, permeability and hydraulic conductivity is very much restricted and thereby inhibiting the plant growth. The topography of the site and the nature of parent rock just below the A horizon is not permitting to hold the water at the shoulder slopes and back slopes and therefore the area will experience a combination of abiotic stresses like edaphic, atmospheric and drought. Even the secondary minerals zeolites in the vesicular trap are highly prone to alteration and are rich source of calcium to the soils and plants.

Press Releases

Thursday, January 29, 2009

Ministry of Agriculture

Establishment of National Institute of Abiotic Stress Management

16:9 IST

The Union Cabinet has approved the establishment of a new institute "National Institute of Abiotic Stress Management" costing Rs. 73.50 crores in the 11th Plan.

Abiotic stresses like drought, temperature extremes, flood, salinity, mineral toxicity and nutritive deficiency are threatening agriculture production globally. India being a tropical country faces such abiotic stresses to a significant degree which has implications for maintaining national food security.

The National Institute of Abiotic Stress Management shall have a comprehensive mandate of characterization of the occurrence of various abiotic stresses in the country impacting agriculture on a continuous basis and carry out basic and strategic research that will lead to development of technologies for mitigation and adoptation of crops, livestock, horticulture, fisheries and micro organisms to such stresses. The important research programs would be in a matrix mode. Organizationally it is proposed that the institute shall conduct its research programmes through four schools viz; schools of drought stress management, atmospheric stress management, edaphic stress management and policy support research.

The institute, which will be located at Malegaon (Baramati) in Maharashtra will have a deemed to be university status.

AKT/AD/GC

Spheroidal weathering of trap rocks