Punagarh volcanism and initial phase of Malani volcanism However, the Punagarh volcanism took place in a reactivated rift (Pali lineament) probably at the periphery of plume and did not last long On the other hand, a parallel rift generated on the head of the sample plume was long lived in which outpouring of vast quantities of lavas took place (Malani magmatism)

References

BANERJEE, A K and SINGH, S P (1978) Pillow lava in Pali district, Rajasthan GSI News, v 9, No 2

BHUSHAN, S K (2000) Neoproterozoic magmatism of the Malani Igneous Suite, Western Rajasthan, India Geol Surv India, Spec Publ No 55, pp 319-332

BHUSHAN, S K (2000) Malani Rhyolites – A Review Gondwana Res , v 3, pp 65-77

BOSE, U (1989) Correlation problems of the Proterozoic stratigraphy of Rajasthan Indian Minerals, v 43, pp 183-193

CHORE, S A and MOHANTY, M (1988) Stratigraphy and tectonic settings of the Trans-Aravalli Neoproterozoic sequences in Rajasthan Jour Geol Soc India, v 51, pp 57-68

CHOUDHARY, A K , GOPALAN, K and SASTRY, C A (1984) Present status of the geochronology of the Precambrian rocks of Rajasthan Tectonophysics, v 105, pp 131-140

COULSON, A L (1933) The Geology of the Sirohi State, Rajasthan Mem Geol Surv India, v 63, 166p

CRAWFORD, A R and COMPSTON, W (1970) The age of the Vindhyan system of Peninsular India Quat Geol Soc London, v 125, pp 351-372

GATHANIA, R C , CHOWDE, M P , GOSH, S P and CHANDRASHEKHARAN, V (1984) A report on systematic geological mapping of the Malani Igneous Suite in parts of Barmer, Jodhpur, Jalore and Pali districts, Rajasthan Unpubl Geol Surv India Rept for FS 1981-82

LA TOUCHE, T H D (1902) Geology of Western Rajputana Mem Geol Surv India, v 35, 116p

RACULT, P (1933) Geology of Sirohi State Mem Geol Surv India, v 63(1), 117p

ROY, A B and JAKHAR, S R (2002) Geology of Rajasthan (NW India) Scientific Publishers, Jodhpur, 421p

SHYAM NARAIN (1988) Report on base metal investigation in Punagarh group of rocks, Pali district, Rajasthan Unpublished Geol Surv India Report

SINGH, S P (1983) Pillow lavas from Delhi Supergroup near Bambholai, Pali district, Rajasthan Jour Geol Soc India, v 24, pp 208-211

SEISMOGEOLOGY OF KUTCH AND ADJOINING REGION WITH SPECIAL REFERENCE TO 26th JANUARY 2001 EARTHQUAKE IN THE VICINITY OF BACHAU, GUJARAT by K.S Misra, R. Bhutani and R. Sonp Jour Geol Soc India, Aug 2004, v 64, pp.153-164

(1)

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Lineaments, indeed, have great significance in interpreting various geological features and problems Remote sensing through satellite imagery as well as topographic sheet is considered as a convenient method of mapping lineaments formed on account of traces of bedding, master joints, faults, dykes and other geological structures The lineaments traced, however, have to be confirmed by the ground reality In the paper under discussion Misra et al have traced several '*major*' faults '*remotely sensed data particularly using IRS images on 1 250 000 and 1 50 000 scale*' (p 163) Several ENE-WSW, NE-SW, E-W, NW-SE '*major active*' faults have been traced in western India particularly in the region of Kachchh (Figs 2, 4 and 6 of Misra et al 2004) Using this data, seismology of Kachchh and adjoining region has been interpreted by the authors Especially NW-SE and curvilinear ENE-WSW faults dominate in the region of Kachchh according to the authors (Fig 2, *op cit*) The NW-SE, NE-SW major faults have been traced in to the Great Indian (Thar) Desert in the northern region These faults conveniently cut across the geomorphic divide, Nagar Parkar ridge, which incidentally is, suppose to be the northern limit of the Kachchh rift According to the authors the Kachchh Mainland Fault along which five devastating earthquake epicenters have been located, extends from Lakhpat through Bhachau-Lakadya to southeastward and terminates near Morbi (Fig 4)

Extensive field mapping by the ONGC team lead by Biswas (1987; Figs. 2, 4 and 5) reveals only E-W tectonic trends in Kachchh (Nagar Parkar- Tharad ridge/fault, Island Belt ridge/fault, Wagad ridge/fault, Mainland ridge/fault and North Kathiawar fault). But for the Median High no major N-S and other cross cutting lineaments have been recognised by him in Kachchh. The latter represents only the Mesozoic sedimentary basinal configuration, controlling the facies and thickness of Mesozoic sediments, but does not represent a surficial fault or ridge.

Signatures of major lineaments are expected to be represented conspicuously on the surface such as E-W trending Nagar Parkar ridge/fault, Island Belt ridge/fault, Wagad ridge/fault and Kachchh Mainland ridge/fault in the form of hill ranges/ridges and lithological variations. The authors should explain in which form the NW-SE major lineaments (as spelt out by them "major faults") in Kachchh are expressed in the field. It is difficult to understand how all these faults cut through Kachchh Mainland Fault and Katrol Hill Range Fault without disturbing them. Some of the major faults are shown to extend into the dunes of Thar Desert (Fig.2). Are the epicenters of >6 M earthquakes 1 to 5 placed at the intersections of the major faults or major faults are drawn to make them intersect Kachchh Mainland Fault at the said epicenters? Locating the epicenters as well as determining the magnitude of earthquakes that took place prior to the 20th century (non-instrumental era) could not have been very precise.

The authors have not explained why the Kachchh Mainland Fault has been extended by turning it in SE direction up to Morbi. Extending the Kachchh Mainland Fault into Morbi, Saurashtra has never been considered by any author earlier. Such a feature is required to be substantiated adequately. Some of the NW -SE faults are seen extending from Kachchh Mainland deep into Saurashtra (Fig.2). It is doubtful whether such lineaments with geological or geomorphological expression exist in Saurashtra (Karanth and Sant, 1995).

The *'horseshoe' pattern of the aftershock* (Fig.6 of Misra et al. 2004) appears to have been over-dramatised. How this '*horseshoe*' has been considered by the authors? The isoseismal lines modified after Ravi Shanker and Pande (2001; Fig.1, p.205) appear to have been modified into a horseshoe shape. For the sake of convenience. In fact, at the time of main shock Bhuj and surrounding that lie out side the western part of horseshoe was affected much more than Rapar, Desalpar and Lodrani that lie within the horseshoe's eastern part.

If lineaments/faults can be drawn just by remote sensing techniques, is there any necessity of field geologists, that too to work in a semiarid region which is known to be climatically unfavourable with scanty vegetation and water resources? No doubt remote sensing is a very powerful tool in recognising various regional geologic structures. Nonetheless, the essentials of geology lie in the field. Seeing in field is believing!

K.S. Misra, R. Bhutani and **R. Sonp**, Geological Survey of India, Bandlaguda, Hyderabad - 500 068, reply:

We thank **Prof. Karanth** for keeping alive the debate on the subject of image interpretation *versus* field studies. Most of the geologists have started to appreciate the importance of image interpretation and indispensability of field studies. In first paragraph the findings of the paper by Misra et al. (2004) are reproduced. In second para the classical work done by Biswas (1987) is highlighted. In the third para the exercises done by Misra et al. (2004) are commented upon. We have well demonstrated in this paper that most of the mapped lineaments are directionally parallel to either ENE-WSW trending Kutch rift or NW-SE trending Cambay structure. Figs. 3A and 3B depict typical geomorphological features generally associated with these sets of lineaments. It is suggested that interpretation of available IRS imagery and plotting of earthquake epicenters from the published data (Guha and Basu, 1993) would have convinced anyone about the repeatability or reproducibility of results, which is of prime importance in any branch of science. Casting aspersions on the work done by the authors without doing the required exercise is unwarranted and detrimental to the growth of science. In fact both NW-SE and ENE-WSW trending lineaments from Kutch and adjoining region have been published by Misra (1999) much before the 26th January 2001 earthquake. The importance of these two lineaments in seismicity of Western India has further been elaborated by Misra (2001). The extension of Kutch Mainland faults in SE direction is mapped on the basis of associated geomorphological features.

The pattern of the aftershocks and limiting lines in Fig.6 is totally misunderstood by Prof. Karanth with the isoseismal lines. The isoseismal lines are drawn by Ravi Shanker and Pande (2001) are based on the damage pattern caused by the 26th January 2001 earthquake, while Fig.6 demonstrates the epicenters of aftershocks plotted by using the USGS data with precise latitudes and longitudes. Same exercise can be simply repeated and doubts can be cleared.

It is well understood by every geologist that lineaments and faults can better be identified by interpretation of aerial photographs and satellite imagery. These can be verified in field and other associated features can be recorded This approach does not in any way reduce the indispensability of field studies Many major basement faults such as those bordering Kutch rift and Cambay structure, were responsible for the development of elongated basins to accommodate several kilometer thick sedimentary rocks that have no pronounced field characters This is because these faults have tendency to bifurcate upward and when they reach to surface the incremental displacements are very minor (Fig 3E) However, these minor displacements can also be mapped in Quaternary sediments provided we are looking for them

(2)

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The paper under discussion is very interesting as it throws new light on the tectonics of this region The occurrence of major earthquakes and a high seismicity in the Kutch and Saurashtra region is well known as this region has already been classified seismically as Zone V and as such calls for detailed studies for understanding its complex geotectonic history In this context, the delineation of the structural fabric and major lineaments and faults from Landsat imagery and related geomorphological studies and their correlation with the seismicity of the region by Misra and others is timely and significant

The authors have clearly brought out NW-SE, ENE-WSW to NE-SW and E-W structural trends and their correspondence with the trends of isoseismals and their interrelationship It is interesting to note that these mega lineaments are also reflected in the gravity images of India (Sreedhar Murthy, 1999, Sreedhar Murthy and Raval, 2000) The gravity images of India have not only identified all the known structures and tectonic features but also brought out several new trends and features, which are not seen on any of the conventional geological or geophysical analogue maps A case in point which has a bearing on the tectonics of the Kutch region is the delineation of the NW-SE trending linear starting from Chennai on the east coast and passing through the Proterozoic Cuddapah basin, Deccan traps and north of Mumbai and extending further towards NW into Saurashtra peninsula Towards east it also extends in to Bay of Bengal as seen from the marine gravity data The subsequent studies have clearly brought out the close correspondence of the Latur, 1993, Bhuj, 2001 and the Pondicherry, 2001 earthquakes with this mega lineament (Sreedhar Murthy, 2002) In fact this mega lineament has a varying width extending over a few tens of kilometers and it must have been reactivated many several times in the geological past The Kukdi-Ghod lineament zone (Fig 1 of Misra et al 2004) appears to be a part of this mega lineament

Another feature which has relevance to the present study is the Raval Line (Sreedhar Murthy, 2002) The gravity images have brought out a N-S trending linear starting from Karakorum region and passing through Rajasthan and Gujarat and further south off west coast up to Laccadive and Chagos islands It is to be observed that the gas fields of Pakistan and hydrocarbon bearing structures in Rajasthan, Gujarat and the 'Bombay high' and the recently discovered gas hydrates off Laccadive, Chagos ridges are aligned along this lineament (Avinash Chandra, 2004) For too long in India, we have explored for hydrocarbons in the Tertiary formations This is baffling especially when the world over significant deposits of hydrocarbons are known to be associated with Mesozoics Starting with the discovery of Barmer find in Rajasthan in 1998-99, sizeable hydrocarbon deposits are discovered in Mesozoic formations in India during the last five years The hydrocarbon deposits discovered in Gujarat call for a detailed study of the interrelationship between the different fault systems and their correlation, if any, with such systems In this context, it is felt that the study of Misra and others (2004) could have thrown some light on the relative antiquity of different fault sets so that one can ascertain which set is relevant for oil exploration

The preferential propagation of seismic energy of the Bhuj Earthquake and the associated damage in the far-flung areas and the associated after shock activity in the NE-SW direction is well brought out by the authors This study under reference strengthens the concept of wave guides in the propagation of seismic waves, which probably explains the fact that Bhuj Earthquake was felt in Chennai while not so in Hyderabad, which is farther north of this lineament This aspect and its implications to the region need to be further investigated by the seismologists

The structural trends inferred by Misra and others are also reconfirmed in an independent study based on the analysis of detailed gravity and lineament data as reported by D C Mishra and others of NGRI (Mishra et al 2001) It is in this background the observation "It is time to draw up multi-disciplinary and mutli-institutional programmes aimed at gaining a better understanding of the infinite variety presented by planet earth" (B P Radhakrishna, 2004) assumes great significance and underlines the importance of integrated geoscientific studies in India

K.S. Misra, R. Bhutani and **R. Sonp**, Geological Survey of India, Bandlaguda, Hyderabad - 500 068, reply

We are glad to note that Prof **Y. Sreedhar Murthy** has found our paper (Misra et al 2004) very interesting, timely and significant The correspondence of mega lineaments and isoseismals brought out by our work is corroborated with the trends observed by him in the gravity images is really very satisfying Similar findings from the gravity data and support in favour of mega lineaments by Mishra et al (2001) is also very significant In fact, all the mega lineaments and faults have directional parallelism with the major geological structures of the peninsular shield (Misra, 2001) An intimate tectonic relationship between vertical faulting, development of basins, sedimentation, volcanism and dyke emplacement has been brought out recently by Misra (2004) In this paper it has been emphasized as suggested by Prof Murthy that exploration of Mesozoic hydrocarbons below the Deccan and associated volcanics is very much required

The support our work has got from the concept of wave guides is also very encouraging Misra (2004) illustrated that the damage pattern is controlled by mega lineaments and faults Attenuation of the seismic waves while crossing major geological structures and channelization of seismic energy along them is very significant contribution I agree with the concluding remarks of Prof Murthy that multidisciplinary approach for better understanding of geological structures is very much needed

(3)

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My congratulations to Dr K S Misra and associates of the Geological Survey of India for the long awaited distinct and understandable relationship between the geological structures and seismicity of Kutch region The regional tectonic framework presented by the authors needs appreciation, since the geological studies by different workers in localized areas have not been successful in answering the questions related to the seismicity of Kutch region By carrying out simple exercises of interpreting the faults with neotectonic movements and plotting the epicenters of earthquakes and aftershocks of 26th January, 2001 earthquake, the authors have clearly brought out the relationship between them and rightfully suggested that both are the products of active tectonism involved in the Kutch region

It would be more interesting to understand the relationship between major geological structures brought out by the authors, and volcanism in western India The important questions for which I would like to get the answers are — where did the magma chamber exist that supplied the lavas for Deccan traps? Where are the major effusive zones and centres located? Whether these zones and centres continued outpouring of lava from the beginning to the end of volcanism and did lavas travel to long distances such as Rajahmundry, Mandla and Rajmahal areas? If the volcanism is of multicentral nature is it worthwhile to work on unified lava stratigraphy for the entire Deccan Volcanic Province?

K.S. Misra, R. Bhutani and **R. Sonp**, Geological Survey of India, Bandlaguda, Hyderabad - 500 068, reply

We are happy to note that **Prof. A.V. Phadke** has found the work distinct and it has brought out understandable relationship between geological structures and seismicity of Kutch region Certainly regional study has its own advantages in understanding the seismotectonics of the area Prof Phadke has indeed asked very pertinent questions concerning Deccan volcanism, which have been engaging the attention of geologists for over a century The replies to these very important questions are summed up briefly as under

1. Where did the magma chamber exist, which has supplied the lavas for Deccan traps ?

According to earlier views it was believed that Deccan volcanics have erupted from a huge magma chamber There were raging controversies concerning the nature of parent magma One group suggested it to be tholeitic in nature while other group believed it to be alkaline–olivine type No geological or geophysical evidences in support of such a magma chamber have been found below the volcanic province Misra (2001, 2004) on the basis of interpretation of airborne and other geophysical data sets reported that the Archaean and Proterozoic basement along with major structures continues below the volcanics Continued studies by Misra (1980, 1999, 2001a, 2002, 2004) have further suggested that lavas were generated mainly due to decompressional melting caused by extensional tectonics along major geological structures, more pronounced in their intersectional areas These structures include grabens, rifts, faults, lineaments and tectonic zones (Fig 1) It is proposed that the faults related to these geological structures progressively reached to critical depths and caused decompressional melting of lithosphere generating felsic

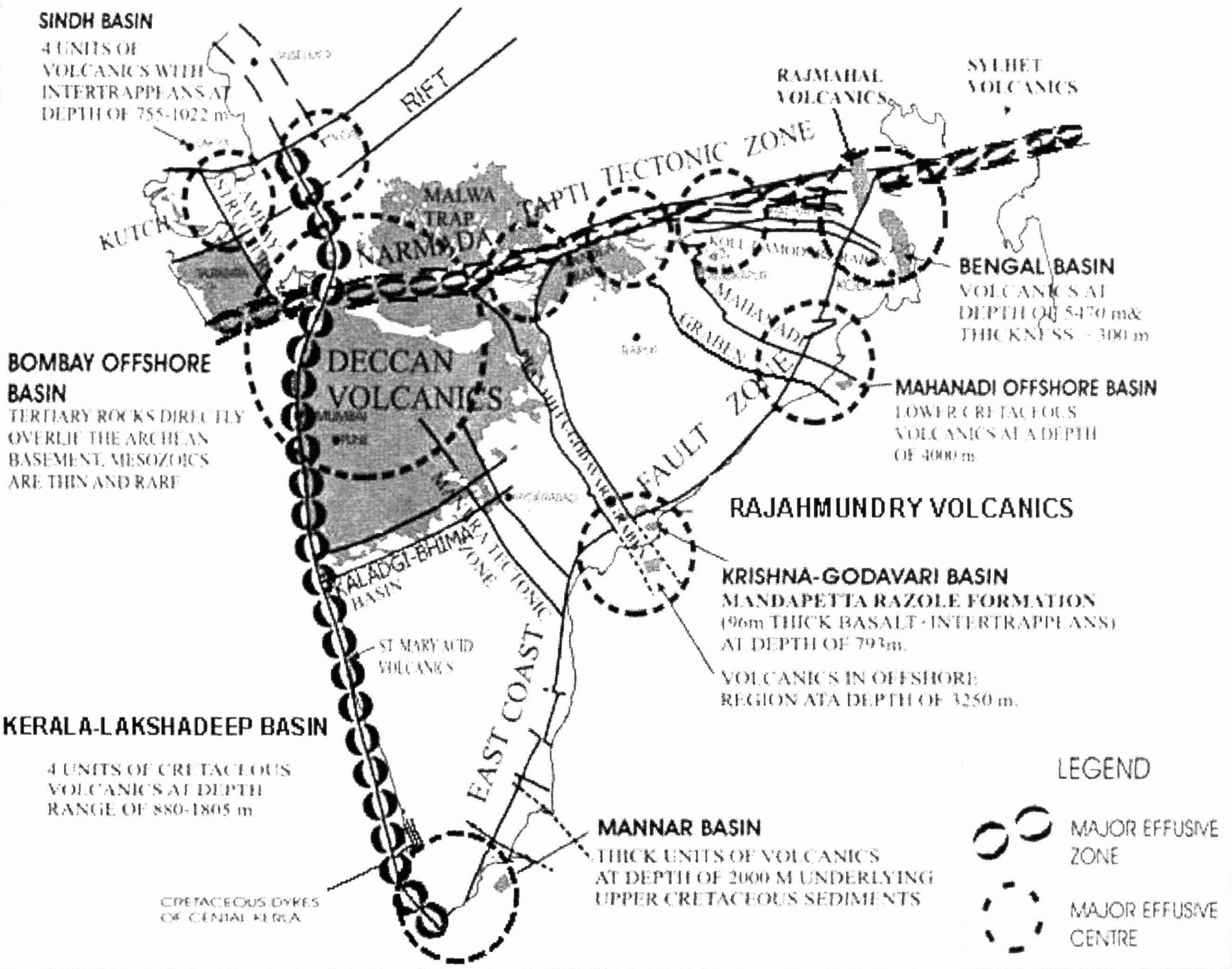

Fig.1. Map showing the relationship of Deccan and associated volcanics with the major geological structures of peninsular India. It can be seen that large circular effusive regions are located in the proximity of intersectional areas of major geological structures. The Narmada – Tapti tectonic zone and Cambay structure seems to have outpoured lavas from the beginning to the end of volcanic event. Main mass of Deccan volcanics is located in the region where several subsurface structures are found to be converging.

lavas in the initial phase of volcanism. These volcanics are mainly exposed along the west coast and interior parts between present day mean sea level and 300 m elevation. The significant ones are Alec, Barda and Osam hills near Porbandar, Rajula acid volcanics in southern Saurashtra, Chamardi and Chogat granophyres near Bhaunagar, trachytes and rhyodacites of Daman, Dadra – Nagar Haveli and St. Mary's Island. Explosive volcanism was also common during this phase. The prominent sites identified are near Loingdi in southern Saurashtra (Misra, 1999), Akarpatti near Tarapur (Misra, 2001b). Unfortunately all these factors and early volcanic sequence have not been considered by other workers while describing and modeling different aspects of Deccan volcanics in totality. Even when they were considered they were thought to be either younger felsic differentiates from the parent magma or older volcanics unrelated to the Deccan event. Tectonic deformation in the form of regional and local dips and volcanic plugs, cones, necks, pipes and domes are also recognized within this sequence (Misra, 2004).

With further downward continuation of extensional faults, large volume of lavas started outpouring and their nature changed from felsic to rather mafic. They form the middle sequence mainly occurring between 30 0m and 800 m and largely comprises compound pahoehoe flows. These lavas could travel to long distances through the arterial system of lava channels and tubes (Misra, 2002).

The upper sequence exposed largely above 800 m, mainly along the *Sahyadri* and Satpura mountain ranges is generally composed of simple flows. This sequence is transected by two great dyke swarms of doleritic composition. The ENE-WSW trending dyke swarm is directionally parallel to the Narmada–Tapti tectonic zone. The dykes are thicker and more in number in the western part and their thickness and number gradually dwindles to the east. The N-S trending dyke swarm is parallel to the west coast. It is more than 200 km wide S of the Narmada–Tapti tectonic zone, and gradually tapers in a southerly direction and the dykes are almost absent south of 18° latitude.

The present work in totality done by interpretation of satellite imagery, aerial photographs, field study of physical volcanological features, regional structures, drill hole and geophysical data sets has thus suggested that the huge magma chamber could never exist anytime; rather most of lava for Deccan volcanics was generated due to decompressional melting along major geological structures. Small pools of magma could have formed in cases when melting would have been faster than the rate of eruption. The faults developed during the extensional tectonics acted as fissures for upward movement and eruption of lavas. Presence of felsic volcanics along the shoulders of these structures has intrigued the geophysicists in the past., since high gravity anomalies were observed over these areas. The present study has revealed that the felsic volcanics which have erupted earlier and represent part of lower sequence have moved away from the central axis during long period of extensional tectonics. The room created due to this outpouring of lavas was occupied by the denser rocks moving from the deeper parts of the earth. This view is substantiated by the high density gravity anomalies observed along these structures.

2. Where are the major effusive zones and centres located?

By the study of field characters of physical volcanological features a new approach for identification of effusive centres and zones is formulated. A number of direct and indirect criteria have facilitated in the identification of nearly thirty effusive zones and centres. Direct evidences included emanation of lava tubes/channels from a common centre, presence of craters, craterlets, explosive volcanism and presence of a variety of interlayered volcanic rocks such as obsidian, rhyolites, trachyte, ignimbrite and granophyres. Indirect evidences included profusion of ropy structures, lava toes, squeeze ups, extensive induration, and the patterns of columnar joints. Presence of several of these indirect evidences has further helped to identify the effusive centres and zones with certainty.

From the emanating pattern of these lava channels and tubes, several effusive centres have been identified within the main mass of Deccan volcanics, suggesting multi-central effusive activity (Misra, 2001c, 2002, 2004). Furthermore, the huge size of these physical volcanological features indicates that certain pulses of volcanism were really of very large magnitude. The remnants of lava channels/tubes criss-cross and exhibit multitier disposition at different levels. This multitier disposition indicates that many of these volcanoes were ephemeral and new effusive centres kept on popping up in certain regions, had local stratigraphic influence and were covered by younger flows. Many of these volcanoes are found to be aligned along subsurface geological structures. These structures are seen continuing from exposed Archaean terrain and are also directionally parallel to the main rifts and grabens.

Identifiction of a cluster of volcanoes along these hidden rifts has been a very rewarding experience. Lonar crater (Fig. 2A) of Buldhana district is one such volcanoe which has several circular craters in its vicinity (Fig. 2B). A number of remnants of lava channels/tubes are also mapped around it (Fig. 2C). The volcanic debris material found around this crater is found to represent vulcanian and ultravulcanian (non lava) phase of eruption (Fig. 2D). Red tuffs are mapped within this debris material. These tuff bands are associated with the Deccan volcanics as integral part of the lava stratigraphy, suggesting that the formation of Lonar is related to Deccan volcanism. Furthermore, it will be very difficult to explain the presence of red tuff band within the debris which has been believed by several workers to represent broken material formed due to impact event in very recent times. Further, the Rare Earth Elements (REE), which do not get altered due to any known geological processes including vaporization do not exhibit any difference in the rocks forming the Lonar crater. The Neutron Activation Analysis performed for REE of two red tuff bands, one within the volcanic debris material and the other within the basaltic flows which occupy the rim portion of Lonar crater did not show any dissimilarity. Furthermore, no REE anomaly such as iridium is noticed within the rocks found either forming the Lonar crater or its vicinity, rather they all represent typical signatures found within the average quartz normative tholeiites. Apart from this, the alkaline – volcanism which is generally associated with the rift systems contains sodic minerals. It is interesting to note that the alkaline lake located in this Lonar crater has history of extracting washing soda for centuries.

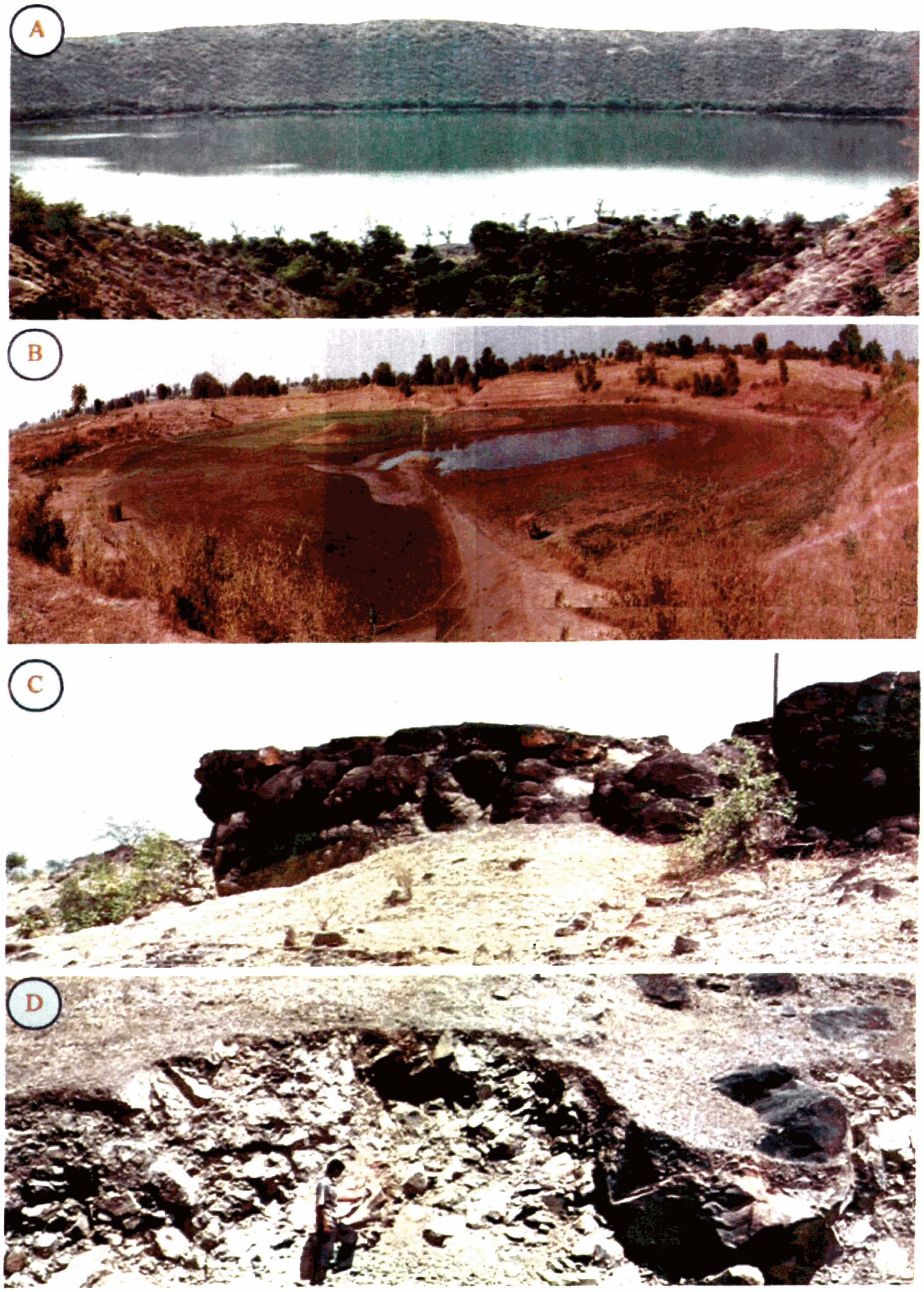

Fig.2. **(A)** Panoramic view of Lonar crater within the Deccan volcanic province. This nearly circular structure is found to be located along a NW-SE trending subsurface rift. **(B)** Amber lake north of Lonar crater is one of the several nearly circular structures found in its vicinity. **(C)** Remnant of lava channel / tube characterized by induration and thus standing out in relief, found emanating from the nearby areas of these craters. **(D)** Volcanic debris material comprising huge blocks of basaltic rocks represent vulcanian and ultravulcanian phase of eruption.

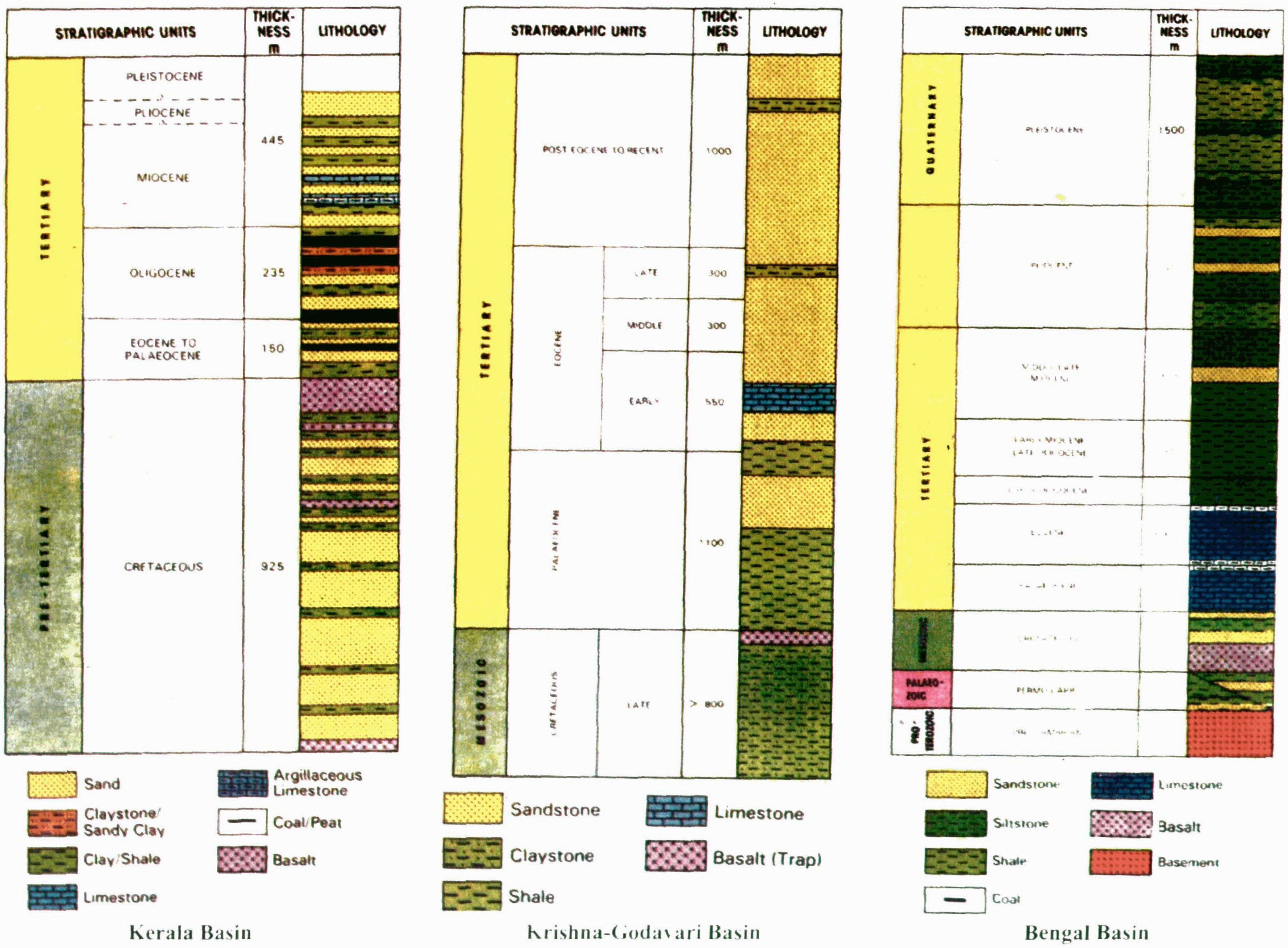

Fig.3. Generalised lithologs from Kerala, Krishna – Godavari and Bengal basins. It can be seen that volcanics occupy unique stratigraphic position and are interlayered with the Cretaceous sedimentary rocks. In Kerala basin four units of volcanics can be seen, the thickest one represents the terminal phase of activity during the upper Cretaceous. In Krishna – Godavari basin only one unit is logged shortly before the end of Cretaceous. On the contrary in the Bengal basin a thick unit of volcanics representing lower Cretaceous is recorded. Adopted and modified after Berger et al. (1983).

3. Whether these zones and centres continued outpouring of lava from the beginning to the end of volcanism and did lavas travel to long distances such as Rajahmundry, Mandla and Rajmahal areas?

Two such zones which seem to have continued outpouring of lava from almost beginning to the end of volcanism coincide with the major geological structures and they are Narmada – Tapti tectonic zone and Cambay structure. Along these structures a great variety of volcanic rocks, explosive volcanism, emplacement of plugs, volcanic cones, and domes are recorded.

There are no field evidences to suggest that lavas traveled to very long distances such as Rajahmundry, Mandla and Rajmahal regions. Incorporation of bore hole data from Bengal basin, off-shore Mahanadi, on-shore and off-shore Krishna-Godavari basin, Mannar basin, Kerala-Lakshadweep basin and Sindh basin has brought out consanguineous quartz normative tholeiites in far off regions. These regions of outpouring of lavas are located in the intersectional areas of major geological structures (Misra, 2004). Drilling data reveals that the Deccan and all other associated volcanics occupy unique stratigraphic position confined within the Cretaceous period (Fig 3). Since these volcanics are interlayered with fossiliferous horizons their ages could be established unambiguously (Misra, 2004). Further, the association suggests that there were several pulses of volcanism from the beginning to the end of Cretaceous. The important fact thus emerges out is that, the volcanism continued for fairly long duration of nearly 80 million years.

4. If the volcanism is of multicentral nature is it worthwhile to work on unified lava stratigraphy for the entire Deccan volcanic province ?

It was because of the nonrecognition of effusive centres and zones within the Deccan volcanics, it was assumed earlier that eruption of volcanics has taken place from a single volcanoe which was believed to have existed somewhere in the west and now submerged in the Arabian sea. A chemical approach for establishing a unified stratigraphy was adopted by several groups. This approach has very serious drawbacks which are absence of distinguishing chemical signatures in the general quartz normative tholeiites which could help to map them in field. Reproduction of the reported ratios of trace elements even after very elaborate and sophisticated analysis has also not been achieved. Furthermore, most of the work is done only along a few traverses and also in the middle and supper sequences only. Lower felsic sequence was not taken into consideration because of older radiometric ages. Attempts have been made to explain the outcrops of associated volcanics differently by invoking a number of mantle plumes. Apart from these, all the attempts to establish unified stratigraphy did not take into account innumerable regional faults along which vertical tectonics is quite pronounced. Deposition of thick sediments (<400m) along many structures during Quaternary alone indicates large elevation differences and any stratigraphy established across them will certainly be erroneous.

References

Avinash Chandra, (2004) Emerging trend in oil and gas exploration in India - A bright future ahead, Jour Geophys., v XXV, nos 2&3, pp 3 11

Berger, P, Cerny, P, Hook J C, Jaffex, Kabir, C S, Kumar, R, Minne, J C, Pinningtou, D J, Serra, O, Shukla, S N, Sibbit and Visvanath, S N (1983), Petroleum Geology of India in Schlumberger, Well Evaluation Conference, pp 1-36

Biswas S K (1987) Regional tectonic framework, structure and evolution of the western marginal basins of India Tectonophysics, v 135, pp 307-327

Guha, S K and Basu, PC (1993) Catalogue of Earthquake (>M 3 0) in Peninsular India AERB Technical Document No TD/CSE-1, pp 1-70

Karanth, R V and Sant, D A (1995) Lineaments and Dyke Swarms of Lower Narmada Valley and Southern Saurashtra, Western India Mem Geol Soc India, No 33, pp 425-434

Mishra, D C, Bijendra Singh, Gupta, S B, Prabhakar Rao, M R K, Singh, A P, Chandrasekhar, D V, Hodlur, G K, Rao, M B S V, Tiwari, V M, Laxman, G, Venkata Raju, D Ch, Vijay Kumar, V, Rajesh, R S, Babu Rao, V and Chetty, T R K (2001) Major Lineaments and Gravity - Magnetic trends in Saurashtra, India Curr Sci, v 80, pp 1059 1067

Misra, K S (2004) Deccan and associated volcanics and their relationship with the development of Hydrocarbon pools around peninsular India Souvenir volume 20th Annual Convention and Seminar on Exploration Geophysics 2-5 November, 2004 Guwahati

Misra, K S (2002) Arterial System of Lava Tubes and Channels within Deccan Volcanics of Western India Jour Geol Soc India, v 59, pp 115 124

Misra, K S (2001a) Lineament Fabric and its relation to the Eruption of Deccan Volcanics and Seismicity of West-Central India Geol Surv India Publ No 64, 2001, pp 209-221

Misra, K S (2001b) The "Panvel Flexure" Part of a Large

Structure ın Western Indıa Mem Geol Soc Indıa, No 47, pp 225-232

MISRA, K S (1999) Deccan volcanıcs ın Saurashtra and Kutch, Gujarat, Indıa Mem Geol Soc Indıa No 43, pp 325-335

MISRA, K S (1980) Tectonıc Settıng of Deccan Volcanıcs ın Southern Saurashtra and Northern Gujarat Memoır Geol Soc India 3 pp 81-86

MISRA, K S, BHUTANI R and SONP, R (2004) Seısmogeology of the Kutch and Adjoınıng Regıon, wıth specıal reference to 26th January 2001 Earthquake ın vıcınıty of Bachau, Gujarat Jour Geol Soc Indıa, v 64, pp 153-164

MISRA, K S, SABLE, A B and BHUTANI, R (2001c) Lava Channel/Tube network ın western Maharashtra Study of theır Morphology, Formatıon and Transportatıon of Deccan Lava Geol Surv Indıa Spl Publ No 64, pp 503-510

RADHAKRISHNA, B P (2004) Extra-Terrestrıal ımpacts ın the geologıcal past Some reflectıons Jour Geol Soc Indıa, v 64, pp 127-132

RAVI SHANKER and PANDE, P (2001) Geoseısmologıcal Studıes of Kutch (Bhuj) Earthquake of 26 January 2001 Jour Geol Soc Indıa, v 58, pp 203-208

SREEDHAR MURTHY, Y (1999) Images of the gravıty field of Indıa and theır salıent features Jour Geol Soc Indıa, v 54, pp 221-225

SREEDHAR MURTHY, Y and RAVAL, U (2000) Bouguer gravıty Image of Indıa and the neıghbourıng ESCAP regıon a study of tectonıcs and natural resources, Jour Geophys, v XXI, n 2, pp 59-70

SREEDHAR MURTHY, Y (2002) On the correlatıon of seısmıcıty wıth geophysıcal lıneaments over the Indıan subcontınent, Curr Scı, v 83, no 6, pp 760-766

ANNOUNCEMENTS

TRAINING COURSE IN HYDROGEOCHEMISTRY

A short term traınıng course ın "Mathematıcal Models ın Hydrogeochemıstry Assessment of Groundwater Qualıty and Management" ıs scheduled durıng 19th September to 5th October, 2005 at the School of Envıronmental Scıences, Jawaharlal Nehru Unıversıty, New Delhı For further detaıls, please contact AL Ramanathan, School of Envıronmental Scıences, Jawaharlal Nehru Unıversıty, New Delhı - 110 067 **Phone:** 91-11-26194938, **Fax:** 91-11-26106501, **Email:** hydromodel_jnu@yahoo co ın

25th INTERNATIONAL CARTOGRAPHIC CONGRESS OF INDIAN CARTOGRAPHIC ASSOCIATION (INCA)

The above Congress wıth the focal theme of 'Brıdgıng the Dıgıtal Dıvıde and Takıng Cartography to Grass root Level' ıs beıng organısed by the Department of Applıed Geology, Dr H S Gour Unıversıty, Sagar, M P, durıng 28 Nov - 1 Dec, 2005 For further detaıls, please contact Dr R K Trıvedı, Secretary, 25th INCA, Department of Applıed Geology, Dr H S Gour Unıversıty, Sagar - 470 03, M P **Phone/Fax:** +91 7582-265300 (O), **Mobile:** 0098268 30045, **Email:** ınca25_sagar@redıffmıal com, ınca25_sagar@ yahoomaıl com Regıstratıon form and other ınformatıon can be downloaded from www sagarunıversıty nıc ın, www ıncaındıa com

SEDIMENTARY BASINS OF THE HIMALAYAS: CHALLENGES FOR THE FUTURE AND XXII CONVENTION OF INDIAN ASSOCIATION OF SEDIMENTOLOGISTS

The above conventıon ıs scheduled to take place at Dehra Dun durıng 21-23, December 2005 For further detaıls, please contact Dr Sumıt Ghosh, Wadıa Instıtute of Hımalayan Geology, 33 Gen Mahadeo Sıngh Road, Dehra Dun - 248 001 (UA) **Phone:** 0135-2624805 Ext 551 (O), 0135-2625773 (R), 9412381151 (M), **Email:** skghosh@wıhg res ın or skgesh@redıffmaıl com

NATIONAL SEMINAR ON HYDROLOGY WITH SPECIAL REFERENCE TO URBAN GROUNDWATER POLLUTION

The above semınar ıs beıng organısed to coıncıde wıth the XXIV Annual Conventıon of the Assocıatıon of Hydrologısts of Indı durıng 27-28 December, 2005 at the Department of Studıes ın Geology, Karnatak Unıversıty, Dharwad For further detaıls, please contact Prof S C Puranık, Department of Studıes ın Geology, Karnatak Unıversıty, Dharwad - 580 003 **Phone:** 0836-2215288 (O), 2743728 (R), **Fax:** 0836-2747884 / 2771275, **Email:** scpuranık@yahoo com