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Research Article

GEOLOGICAL OBSERVATIONS OF ROCKS OF MEWANAGAR AREA AND ITS TECTONIC APPROACH - A PRELIMINARY REPORT, BARMER DISTRICT, WESTERN RAJASTHAN, INDIA.

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ABSTRACT
The rocks of Mewanagar area are a part of Malani Igneous Suite (MIS) which are characterized by widespread acid volcanic rocks besides minor amounts of basic rocks in Barmer district. Neoproterozoic MIS represents the largest felsic magmatism in India. MIS is the largest A-type, anorogenic acid magmatism in the Western Peninsular India and owes its origin to hot spot tectonism. Mewanagar consists of extrusive (rhyolite, trachyte, tuffs and basalts) and dyke phase (basalts and dolerite). Rhyolite shows various shades of colour viz. dark grey, light grey, purple, light brown, dark brown and brick red etc. Trachyte also exhibits these types of colouration. Mineralogically, bluish trachyte is similar to rhyolite and shows a sharp contact with rhyolite. Basalt is observed in form of flows as well as dyke which cut the different outcrops of the rhyolites. Basalt is fine grained and displays black/dark brown, light greyish brown and dark greyish brown colour. Basalt contains small size vesicles (up to 2 mm) and sometime vesicles are filled by calcite veins. Dolerite dykes (dark greyish, black colour and medium grained) are mainly cutting across rhyolite and trachyte. Petrographically, trachyte flows are showing similar petrographical features as shown by rhyolites and they consist of orthoclase, quartz, riebeckite, arfvedsonite, magnetite and hematite as a phenocrysts or groundmass. Porphyritic, glomero-porphyritic, perthitic and flow textures are observed in rhyolite. Basalt flows consist essentially of plagioclase feldspar (labradorite) and clinopyroxene (augite) in ophitic and sub-ophitic texture. Dolerite dyke contains plagioclase, pyroxene and iron oxides with hypidiomorphic texture. Malani volcanism was essentially under terrestrial conditions, although deposition by aqueous conditions is indicated. Luni River is flowing at outer margin of the studied area along Mewanagar village and taking sudden U turn from West to South direction. This indicates the relationship between tectonism and volcanism which can be explained and understand by petrological, petrographical and geochemical studies of the Mewanagar area.

Keywords: *Malani Igneous Suite, Mewanagar, Neoproterozoic, Volcanic rocks*

INTRODUCTION
The Mewanagar area (Survey of India topographic sheet no. 45C/1; Scale 1: 50,000; 25°47’- 25°48’ N, 72°08’-72°09’ E) which is a part of MIS is located 120 km SW of Jodhpur and 30 km NW of Siwana in Western Rajasthan. The late Proterozoic Malani volcanics spread thicklyin an area of approximately 55,000 sq. km in the Trans Aravalli Block (TAB) of Northern PeninsularIndia. In Rajasthan, the rocks of MIS are proliferated from South of Sirohi to North of Pokaran and from East of Jodhpur to the edge of the Thar Desert. The rocks of MIS are mainly of felsic volcanics besides minor amounts of mafic lithounits in Barmer district. They are well exposed in Tusham (Haryana), Jhunjhunu, Siwana, Jalor (Rajasthan) and also in Nagar Parkar (Sind-Pakistan), Kirana (Lahore-Pakistan) areas (Vallinayagam and Kochhar, 1998; Kochhar, 2000) (Figure 1). The MIS comprises voluminous phases of felsic and volumetrically insignificant mafic volcanism followed by granitic plutonism. Large (up to 5 m wide) felsic and mafic dikes represent the terminal phase of magmatism. These phases are characterized as A-type, peralkaline, peraluminous, anorogenic and owe its origin to hotspot tectonics (Kochhar, 1984, 2000, 2004; Pareek, 1981; Bhushan and Chandrasekaran, 2002; Vallinayagam, 2004).The initial basaltic magma was possibly generated at deeper depth by ‘hot spot’ activity. This magma while migrating upwards supplied additional heat for the partial melting of lower sialic crust resulting in the generation of felsic magma (Eby and Kochhar, 1990; Kochhar, 2000). The crustal extension has helped in the upward

advancement of the felsic magma. Igneous rock complexes in the study area generally preserve many primary and secondary structural features such as flows, vesicles and columnar cooling joints. The preponderance of rhyolitic rocks over other intermediate and basic rocks is a distinctive feature of Mewanagar hill.

MATERIALS AND METHODS

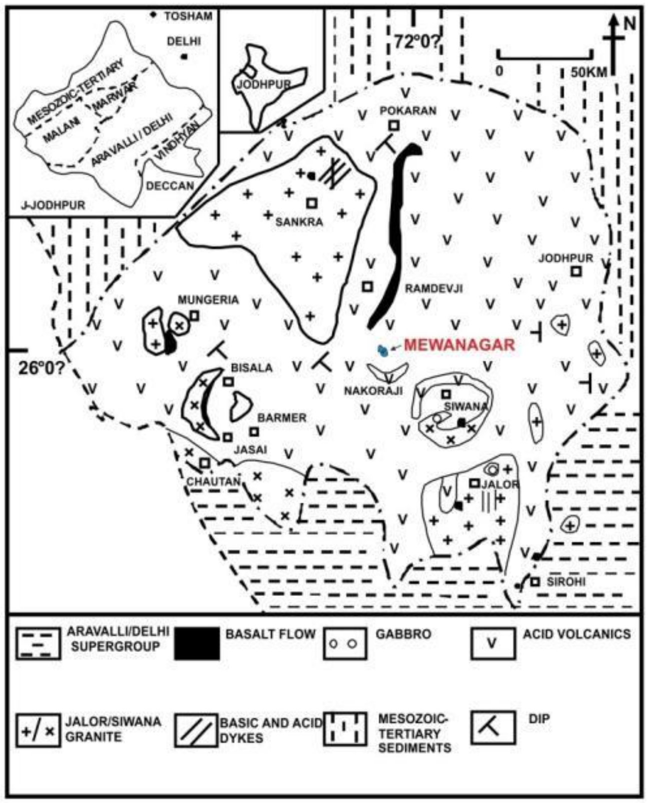

Figure-1. Geological map of Malani Igneous Suite in western peninsular India (modified after Vallinayagam, G. 2003).

Regional Geology and Stratigraphy

"Rajasthan Malani Beds" was the name given by WT Blanford (1877) for a series of volcanic rocks in western Rajputana (now Rajasthan) especially well developed in what was then the Malani district of Marwar (Jodhpur) State, India (Krishnan and Jacob, 1956). Subsequently, these rocks were described under the terms "Malani Volcanic Series" (La Touche, 1902), "Malani System" (Coulson, 1933), "Malani Granite and Volcanic suite" (Pascoe, 1959), and they are now being included under the name "Malani igneous suite," to group all of the lavas and the associated rocks. The Malani igneous suite had an initial volcanic phase, made up of extrusive felsic lava outpourings—Malani Tuff and Rhyolite, followed by plutonic intrusions—Siwana and Jalor Granites, which are comagmatic (Blanford, 1877). The gap between the effusives and intrusives was not much separated in time (La Touche, 1902; Coulson, 1933). The Mewanagar area is included in the Trans – Aravalli rocks sequence and situated at a distance of 30 km Northwest of Siwana ring complex in Western Rajasthan. Malani Igneous Suite consists three successive phases of volcanic, plutonic and dyke. The first phase comprises initially of basic flows in less quantity and latter outpoured the acid volcanic rocks which included the pyroclastic explosive rocks, acid lava flows (most voluminous) and pyroclastic ash fall. Granite intruded the acid flows as plutons, ring dykes and bosses and represents as second phase. The third phase consists of mafic and felsic dykes which cut the rocks of earlier phases (Pareek, 1981; Bhushan, 2000). The geology of the Northern western part of the Indian shield is shown in Figure1.

Malani volcanic rocks are underlain by the slates of Aravalli Supergroup at Miniari in Pali district of Rajasthan which represent the lower boundary of the Malani rocks (La Touche, 1902) and at Tusham and Bhiwani districts of Haryana, the Malani volcanic rocks are underlain by quartzite of Delhi Supergroup (McMohan, 1886). The Malani rhyolites also are overlying the metasediments of Delhi Supergroup at Kankari (30 Km SE of Jodhpur), East of Jalor and South of Bhinmal (Bhushan and Chandrasekaran, 2002). At 2 Km NW of Siyana, the Malani rhyolites overlain the Abu granites (Bhushan, 1985). But at Radar hill, near Jodhpur Fort, the Malani rhyolites are overlain by Jodhpur sandstone of Upper Vindhyan Supergroup (Hacket, 1981; Blanford, 1877; Oldham, 1886). Age of Malani rhyolites and granites are observed as 745±10 Ma (Rb/Sr method of Crawford and Compston, 1970; Kochhar *et al.*, 1985) and 723±6 Ma (Sr, Pb and Nd method of Dhar *et al.*, 1996). This age is corresponding with Mid-Upper Pan-African continents (ca. 500-1200 Ma) (Gass, 1981).

On the basis of detailed geological field work, the measurement of vesicles, lava flows, joints and petrographic nature of hill is marked. Rhyolite with the pyroclastic assemblages occurs in almost all the hills in Mewanagar and it is most predominant rock type in this region (Figure 2). The acid volcanics and the associated basic phases show volcano-plutonic inter-relationship. The author during the course of geological investigations found evidences which indicate that the area under study is characterised by tectonism and volcanism relationship. It is suggested that the hot spot tectonics were responsible for the interplate magmatism in the North western part of the Indian shield.

RESULTS AND DISCUSSION

Field Observations

Igneous rock complexes generally preserve many primary and secondary structures and features. The primary features are formed immediately after the magma is exposed on the surface and provide information about the physical condition of the volcanic activities. Secondary features such as vertical columnar joints are useful in analysing the "Tectonic history of an area". Various structures of rock unit's viz. vesicular, spheroidal, rapakivi, sphelurite, orbicular, perthitic, ophitic, sub-ophitic are realized. They are interpreted as evidence of difference in physical and chemical conditions of the magma at various stages of cooling crystallization processes. Volcano-plutonic associations of the MIS belongs to three different phase. First phase is initiated by flow of minor basic volcanic rocks followed by major felsic flows; second phase is represented by intrusive phase. The dyke rock represents the third phase and they have intruded in the earlier phases. The preponderance of acid volcanic rocks relative to intermediate and basic rocks is a distinctive feature of MIS.

The rocks exposed in this tectonic area are dominated by Rhyolite with different texture and structures. Rhyolite is mainly dark brown in colour with various hues of light brown, brick red, grey and purple etc. They are observed as porphyritic and non-porphyritic in nature and have sharp contact to each other (Plate – 1; P1; P2; P3; P4). Different types of cooling joint patterns viz. regular, irregular and mixed are exposed in the jointed rhyolites (Plate-1; P5). The rhyolitic rocks are generally siliceous and are interstratified with tuffs, representing the explosive phases of eruption. The trachyte flow is observed at the outer margin of hill and it is second dominant rock type after the rhyolite. The trachyte flows are dark / light bluish colour with porphyritic as well as non-porphyritic nature. The sharp contact between trachyte and rhyolite is observed. Xenoliths of basalts in trachyte indicate that the trachyte flow is younger than basalt. Basalt is fine grained and shows black colour. Basalt occurs in small thickness and underlies the rhyolite and trachyte flows. The rhyolite and basalt flows show sharp contact between each other. Basalt contains small size (2 mm) vesicles and sometimes vesicles are filled by calcite. The vesicular, amygdaloidal and spheroidal structures are observed in basalt. Xenoliths of basalt are observed in the rhyolite and trachyte which indicate that basalt is older than rhyolite and trachyte. Basalt–trachyte–rhyolite association suggests that the large amount of heat is supplied to the crust from the Magma chamber before the eruption. Dolerite dykes are predominated in the inner circle of the study area. The radial pattern of dykes can easily be observed in the study area. Mainly they are cutting across rhyolite and trachytes. The

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dolerite dyke is black in colour and medium grained (Plate-1;P6). Calcite veins are observed along the dykes (plate-1; P7). The width of dolerite dykes varies from 1m to a maximum of 50 m. Gully erosion and thick vegetation are observed along the dyke. Volcanic caves and columnar joints are observed at different levels of the rhyolites (plate-1; P8; P9).

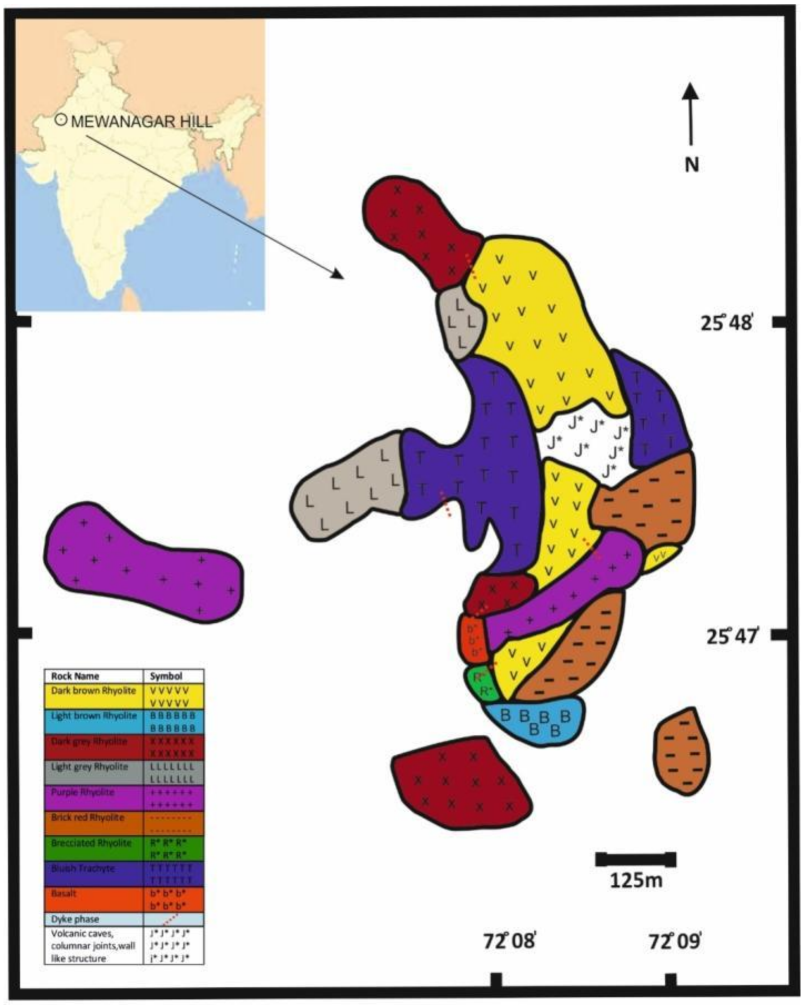

Figure-2 Lithological Map of Mewanagar Hill, Barmer District, Rajasthan, India

Petrography

Distinct mineralogical and textural features are observed in each lava flow. Rhyolite shows flow bands, porphyritic, aphyritic, spherulitic and perlitic textures when viewed under a microscope. Dolerite dykes exhibits ophitic and subophitic texture (Plate-2; T1). The rhyolite consists of Phenocrysts of orthoclase, quartz, and arfvedsonite as essential minerals in the quartzo-feldspathic groundmass and shows porphyritic textute (Plate-2; T2). Arfvedsonite occurs as large prismatic crystals (length 2 mm and width 0.5 mm), dark green colour (X= dark bluish green, Y=bluish green, Z=yellowish green; extinction angle X^C 13^0 -15^0). High temperature alkali feldspar i.e. euhedral sanidine crystals are also observed in few samples. The groundmass is devitrified to a microcrystalline aggregates of quartz, alkali feldspar, blue colour amphibole (riebeckite), pyroxene (light green aegirine), blood red aenigmatite, magnetite and hematite. The fine quartzo-feldspathic groundmass represents the flow directions of the lava flow. Black colour haematite and brown colour magnetite are scattered in fine-grained groundmass. Quartz Phenocrysts occur in various forms viz. drop like, embayed (Plate-2; T3) and fractured pattern with fine grained groundmass (Plate-2; T4). Trachyte shows porphyritic texture. Sometimes directive flow and parallelism of elongated crystals represent trachytic texture (Plate-2; T5). The petrographical features of trachyte are very similar to rhyolite with relatively less amount of quartz and more ferromagnesian minerals viz. riebeckite, arfvedsonite, magnetite and hematite. It consists of Phenocrysts of quartz, orthoclase and riebeckite as essential minerals in quartzo-feldspathic groundmass (Plate-2; T6). It shows Carlsbad twinning and kaolin alteration. Basalt shows ophitic and sub-ophitic textures. The basalt flows consist essentially of plagioclase feldspar (labradorite) and clinopyroxene (augite). Fine grained quartz, hematite and magnetite occur in the groundmass as accessories. Dolerite shows ophitic and sub-ophitic textures. The dominant felsic mineral found in the dolerite dyke is plagioclase feldspar (labradorite). The other dominant mafic component is clinopyroxene (augite). The accessory minerals are hematite and magnetite as opaques. Subhedral plagioclase laths are embedded in the several augite crystals and occur as twinned and untwined mineral. The above petromineralogical observations suggest comagmatic nature of the source in their genesis.

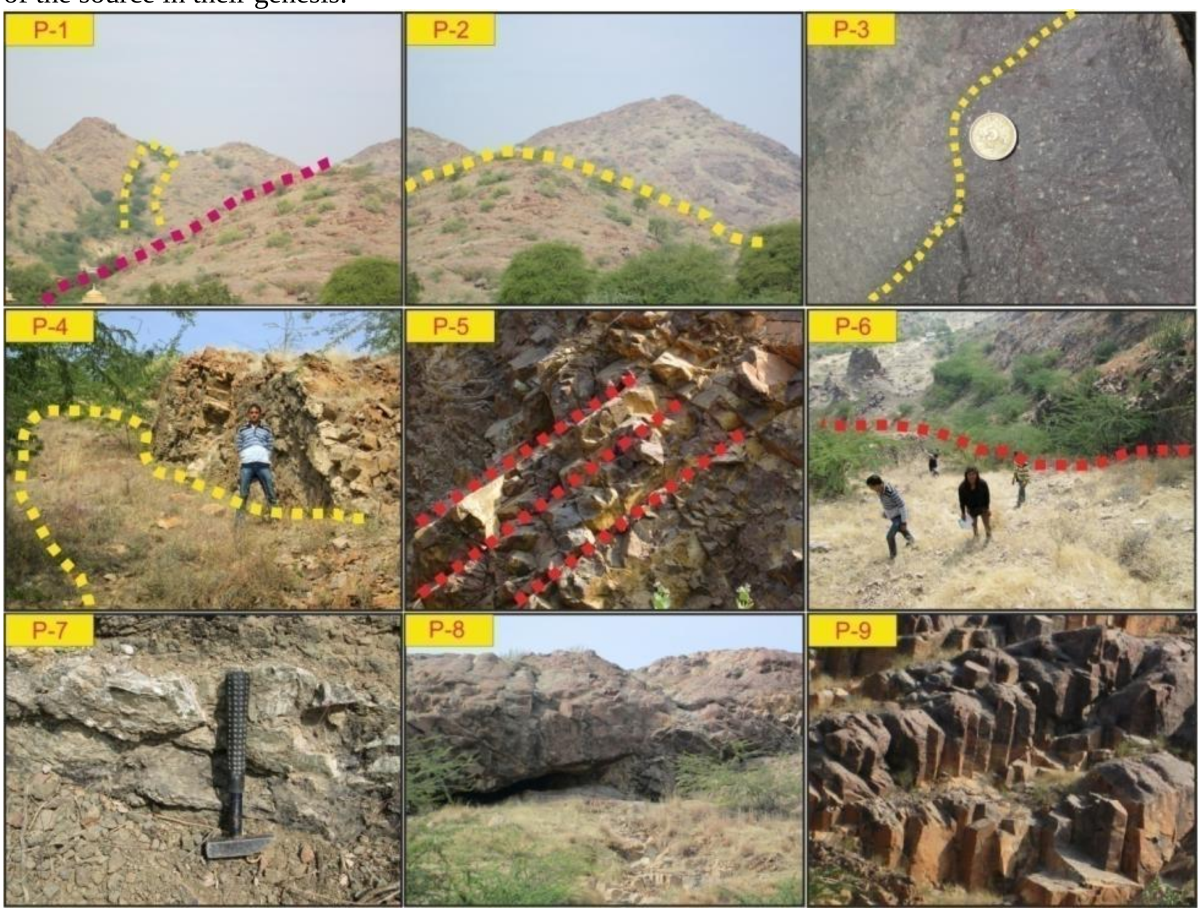

Plate-1

P-1. Shows dark brown rhyolite with basic dyke and vegetation.

P-2. Shows a sharp contact between light brown rhyolite and dark brown rhyolite.

P-3. Shows a contact between light grey rhyolite and dark grey rhyolite and dark grey rhyolite with Phenocrysts of feldspar with small size of vesicles.

P-4. Shows wall-like structures observed at contact of dyke and light brown rhyolite, highly fractured and jointed rocks.

P-5. Shows fractured and dipping joints in light brown rhyolite.

P-6. Students are standing in the middle of dolerite dyke having 9.2 m thickness.

P-7. Calcite grains observed along the dyke.

P-8. Caves and joints are observed in dark brown rhyolite.

P-9. Well-developed columnar joints in dark brown rhyolite with more than 1m vertical height

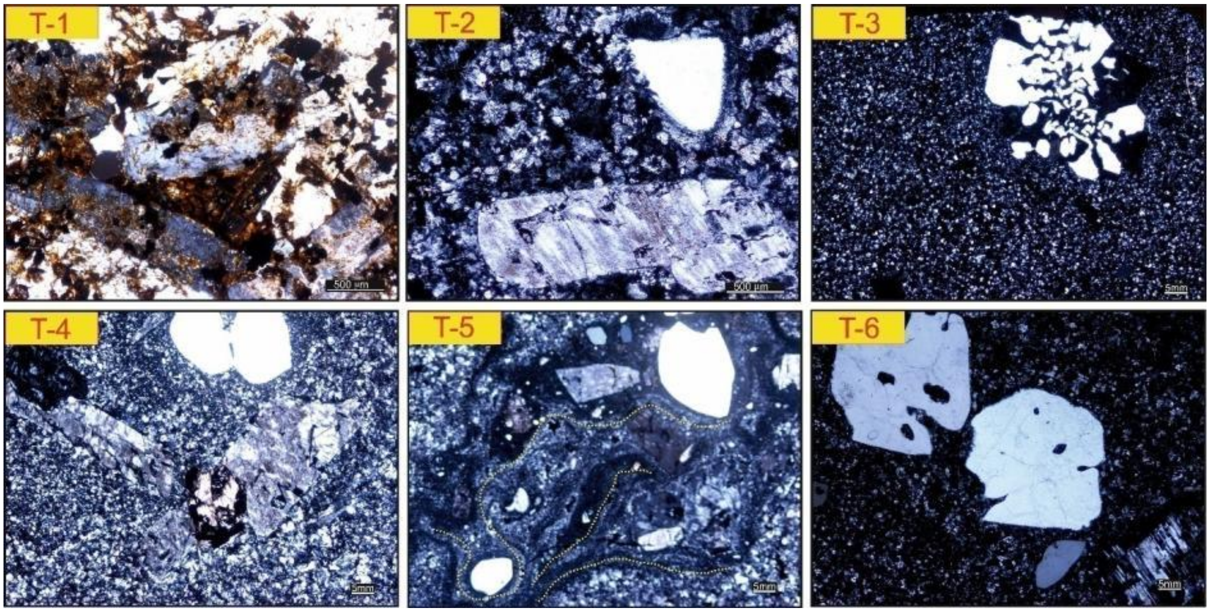

Plate-2
T-I. Shows ophitic and sub ophitic texture in dolerite dyke.
T-2. Shows porphyritic texture in rhyolite.
T-3. Shows embayed quartz in fine grained rhyolite.
T-4. Shows porphyritic texture and the groundmass of the rock are very fine grained and uniform.
T-5. Shows flow-texture in trachyte.
T-6. Showsembayed quartz with feldspar in trachyte.

Tectonic Environment

The magmatism of the MIS represents the lineament which acted as channel for lava emplacement. The Sirohi and Jhunjhunu lineaments are located at Eastern boundary of the MIS and Ganganagar lineament is located at Western boundary of MIS (Roy, 1977; Pareek, 1981) (Figure 3). The MIS field relationships explain the sub-volcanic setting, ring structures and radial dykes which are indicatives of extensional tectonic environment. Ring complex structures can be developed during the emplacement of almost any high level volcano-plutonic rocks type. The Mewanagar area is situated at a distance of 30 km Northwest of Siwana ring complex and close to Nakora Ring Complex (NRC). These geological structures and rock types indicate that MIS have formed in extensional tectonic environment.

Luni rift (Narayan Das *et al*., 1978) in the TAB is an important tectonic lineament which is related to major crustal dislocation of the continental rift type (Bailey, 1974). In Rajasthan, the Luni River takes sudden 'U' turn from West to South direction along the Luni rift. It is likely that the major fractures acted as channels for the magma extrusions and intrusions. This suggests that Luni rift served as channel for magma rising to the surface at Nakora which indicates that the Nakora volcanic vent is perhaps related to the rift dynamics and advocates a relationship between tectonism and volcanism.

Conclusion

The 'Malani Igneous Complex' consists of a variety of igneous rocks comprising acid, intermediate, basic, ultra basic and alkaline intrusive rocks. It spread over an area of about 55,000 sq. km in the Thar Desert with voluminous initial phase of felsic and mafic followed by granitic plutonism. MIS constitutes the largest anorogenic acid volcanism in India and the third large in the world. MIS displays distinctive ring structures and radial dykes. It owes its origin to hot spot tectonics and controlled by NE - SW trending lineaments in the TAB.

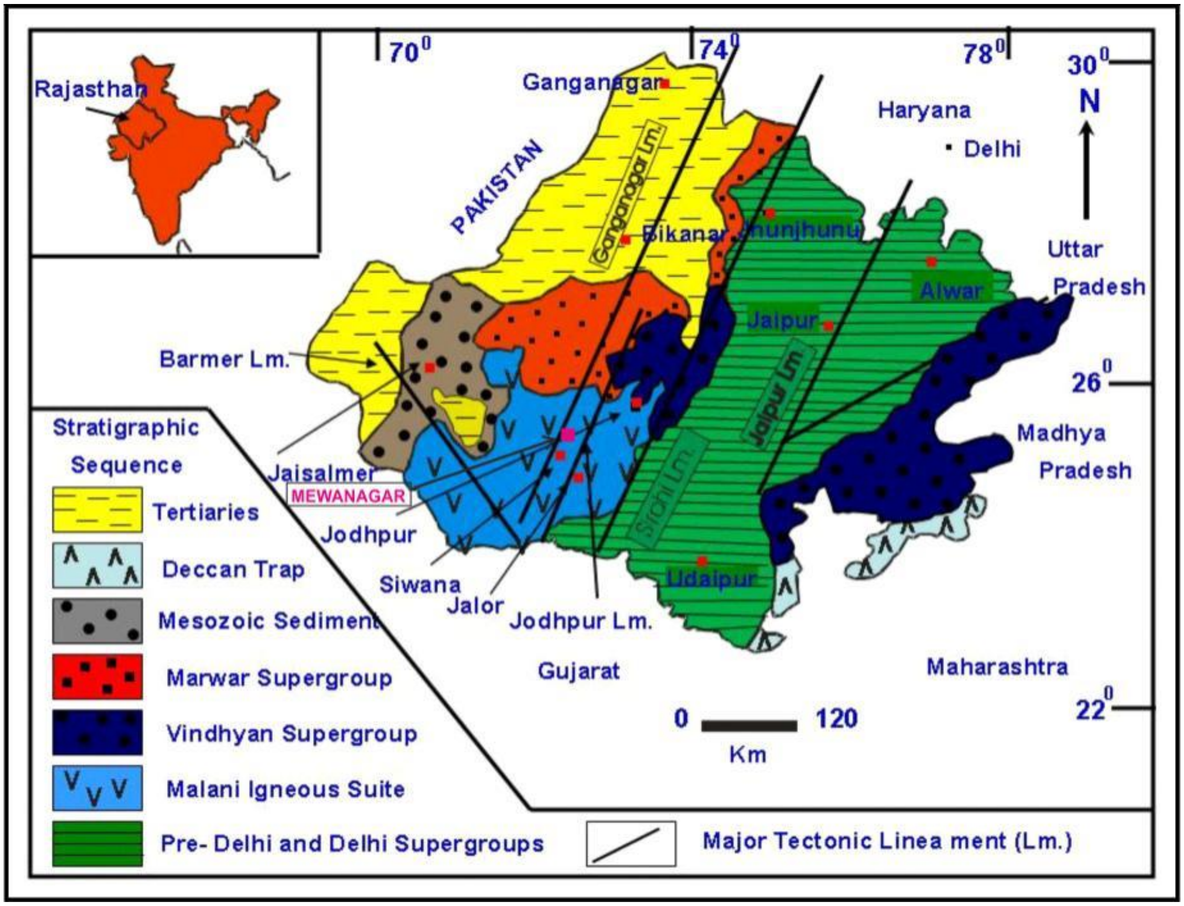

Figure-3 Geotectonic Map of Rajasthan (Modified After Pareek, 1981)

The 'Malani Rhyolites' (rhyolites of dominantly felsic composition) spread over an area of about 31,000 sq. km in western Rajasthan form the major rock type of the Malani Igneous Complex. Magmatism at Mewanagar initiated with minor amount of (basic) basalt flows and followed by the extensive/voluminous acid (rhyolites– trachytes) flows. The observed ripple marks is the surrounding area in tuffaceous rhyolite flow suggested the aqueous condition of flows deposition. The emplacement of the magma appears to have been controlled by a well defined NE–SW tectonic lineament and cut by radial pattern of dykes. Luni river is taking sudden U-turn along the Mewanagar area at Nakora. Luni rift is an important tectonic lineament in TAB. This lineament is related to major crustal dislocations of continental rift type for the extrusions and intrusions of the magma. Hence, Luni rift served the way for magma rising through various major fractures; it is accompanied by anorogenic volcanism which may precede/follow the emplacement of ring complexes. The emplacement of the magma appears to have been controlled by a well defined NE–SW tectonic lineament and cut by radial pattern of dykes. These NE–SW tectonic lineaments are the linear zones of crustal weakness and high heat flow. Volcanic caves, lava flows, vertical columnar joints, vesicles, fracture zones and contact zone are the manifestation of magmatism in tectonic framework. The spheroidal and rapakivi structures in the Nakora acid volcanics indicate the relationship between genetic link and magma mixing (Vallinayagam and Kumar, 2010). Basalt–trachyte–rhyolite association suggests that the large amount of heat is supplied to the crust from the magma chamber before the eruption. Hot spot or mantle plumes are the best media for underplating and availability of heat for generation of such types of rocks. The field (elliptical/ring structures), mineralogical and petrographical characteristics of Mewanagar attest an alkaline character in their evolution and consistent with within plate tectonic setting. The emplacement of these acid-volcanics and associated lithounits is controlled by ring structures, a manifestation of plume activity and cauldron subsidence, and an evidence of extensional tectonic environment. Tectonic environment explains the relationship between magmatism and tectonism.

The main purpose of this paper to represent the petrological, physical observations and tectonic lineaments of rocks of Mewanagar area which is a part of Malani Igneous Suite. Rhyolite shows various shades of colour viz. dark grey, light grey, purple, light brown, dark brown and brick red etc. Mineralogically, bluish trachyte is similar to rhyolite and shows a sharp contact with rhyolite. Petrographically, trachyte flows are showing similar petrographical features as shown by rhyolites. These observations are indicating the source of similar characteristics of two phases. Further, a detailed geochemical analysis will provide a suitable petrogenetic modelling of rocks of Mewanagar area.

REFERENCES

Bailey DK (1974). Continental drifting and alkaline magmatis. In: Sorensan *TS* (edition), *Alkaline rocks*, (John Wiley and Sons, New York) 148-159.

Bhushan SK (1985). Malani Volcanism in Western Rajasthan. *Indian Journal of Earth Sciences* **12** 58-71.

Bhushan SK (2000). Malani Rhyolite – A reviews. *Gondwana Research* **3** 65-77.

Bhushan SK and Chandrasekaran V (2002). Geology and Geochemistry of the Magmatic Rocks of the Malani Igneous Suite and Tertiary Alkaline Province of Western Rajasthan. *Memoirs of the Geological Survey of India* **126** 1-181.

Blanford WT (1877). Geological notes on the Great Indian Desert between Sind and Rajputana. *Geological Survey of India Record* **10** 10-21.

Coulson AI (1933). Geology of the Sirohi State, Rajputana. *Memoirs of Geology Survey of India* **63** 102-141.

Crawford AR and Compson W (1970). The age of Vindhyan System. *Journal of Geological Society of London* **125** 315-371.

Dhar S, Frie R, Kramers JD, Nagler TF and Kochhar N (1996). Sr, Pb and Nb isotope studies and their bearing on the petrogenesis of Jalor and Siwana complexes, Rajasthan, India. *Journal of Geological Society of* India **48** 151-160.

Eby GN and Kochhar N (1990). Geochemistry and Petrogenesis of the Malani Igneous Suite Northern Peninsular India. *Journal of Geological Society of* India **36** 109-130.

Gass IG (1981). Pan-african (Upper Proterozoic) plate tectonics of the Arabian shield. In: Kroner A (edition), *Precambrian Plate Tectonics*. (Elsevier Publication, Amsterdam) 387-405.

Hacket CA (1981). On the Geology of the Aravalli region, central and Eastern. *Record of Geological Survey of India* **14**.

Kochhar N (1984). Malani Igneous Suite: Hot-spot magmatism and cratonization of the Northern part of the Indian shiled. *Journal of Geological Society of India* **25** 155-161.

Kochhar N (2000). Attributes and Significance of the A-type Malani Magmatism, Northwestern Peninsular India. In: Deb M (edition) *Crustal Evolution and Metallogeny in the Northwestern Indian Shield*. (Narosa Publishing House New Delhi) **9** 158-188.

Kochhar N (2004). Geological evolution of the Trans-Aravalli Block (TAB) of the NW Indian Shield : *Constraints from the Malani Igneous Suite (MIS) and its Seychelles Connection During Late Proterozoic*. (Geological Survey of India Special Publication). **84** 247-264.

Kochhar N, Pande K and Gopalan K (1985). Rb/Sr age of the Tusham Ring Complex, Bhiwani, India. *Journal of Geological Society of India* **26** 216-218.

La Touche TD (1902). Geology of the Western Rajputana. *Memoirs of Geological Survey of India* **35** 1-116.

Mc Mohan CA (1886). The microscopic structure of Malani rocks of Aravalli region. *Record of Geological Survey of India* **19**(3).

Narayan Das GR, Begchi AK, Chaube DN, Sharma CV and Naveneetham KV (1978). Rare metal content, geology and tectonic setting of the alkaline complexes across the Trans-Aravalli region, Rajasthan, In: Verma PK, Verma VK (edition), *Recent Researches in Geology* (Hindustan Publishing Corporation) **7** 201-217.

Oldham RD (1886). Preliminary notes on the geology of the Northern Jaisalmer. *Record of Geological Survey of India* **19**(3) 17-21.

Pareek HS (1981). Petrochemistry and petrogenesis of the Malani Igneous Suite, India. *Bulletin of Geological Society of America* **92** 206-273.

Pascoe EH (1959). Manual of the Geology of India and Burma. *Geological Survey of India* **2** 533-549.

Roy DK (1977). *The Revised Tectonic Map of India and the Significance of Lineaments*. (Geological Survey of India, Miscellaneous Publications) **31** 3-4.

Vallinayagam G (2003). Basic Magmatism of Neoproterozoic Malani Igneous Suite, Western Indian Craton *: Pertological and Geochemical Modelling* **18** 1-18.

Vallinayagam G (2004) Peralkaline - peraluminous A-type rhyolite, Siwana ring complex, Northwestern India: Petrogenetic modeling and tectonic implication. *Journal of Geological Society of India* **64** 336-344.

Vallinayagam G and Kochhar N (1998). Geochemical characterization and petrogenesis of A-type granites and the associated acid volcanics of the Siwana ring complex, North Peninsular India. In: Paliwal BS (Edition), *The Indian Precambrian*, (Scientific Publication Jodhpur) 460-481.

Vallinayagam G and Kumar N (2010) First report of Spheroidal Rhyolite from Nakora area of Malani Igneous Suite, Northwestern Peninsular India. *Open Access E-Journal Earth Science India* **3**97-104.