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Short Communication

Appraisal of Paleotectonic Setup of Mizoram Based on Geochemical & Petrological Signature

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The complexities of mother earth become deeper when it comes to the mysteries of the past. The nature on one hand gives us challenges of revealing the past and on the other hand provides us with the wisdom of cracking the puzzle through different tools. Geology is one such effective tool that is capable of establishing the Palaeotectonic and Palaeoslope of a region. The geological investigation conducted in the area around Aizawl, Mizoram of (Latitude 23° 43' N- 23° 73'N and longitudes 92° 43' E- 92° 71' E), is a classic example of generating valuable information and evidences on the Palaeotectonic and Palaeoslope of Tripura-Mizoram Mio-Geosynclinal basin, through the application of structures, lithology, petrology, and geochemistry.

The state of Mizoram is located in the south-eastern corner of the northeastern India, and it has an area of 21,087 sq. km. The state is bordered to the east by Myanmar and to the south by Bangladesh. It lies between latitudes 21°56´N. and 24°31´N latitudes and longitudes 92°16´E and 93°26´E (Fig.1). Aizawl, the capital of Mizoram, is located in the northern part of the state. It lies approximately in between 92°60' E longitude and 23°58' N Latitude. The city elevation varies from 800 m to 1188 m above mean sea level. (MSL). Aizawl is connected by road to Silchar, Shillong, Churachandpur and Agartala. Beside road link, Aizawl is linked by air service from Lengpui Airport to Kolkata, Guwahati and Imphal.

Detailed fieldwork was carried out in and around Aizawl city. Further, macroscopic, and microscopic studies. Finally, bulk chemical analyses of sandstone and shales for major, minor oxide percentages and trace elements were conducted on X-R-F.

Palaeotectonic History

Mizoram is a part of Tripura-Mizoram Mio-geosyncline which constitutes a part of the Assam-Arakan Geosynclinal basin (Nandy, 1972, 1980 & 1982). The Mizoram Hills (Lushai Hills) form an integral part of the ''Indo-Myanmar Mobile Belt'' constituted of very tight, elongated asymmetrical, N-S trending anticlines alternating or en-echelon with broad saucer shaped synclines, showing a slightly arcuate and convex westward sub-meridional trends (Shrivastava et.al., 1979). The hill ranges mainly comprise of compact and resistant older units exposed in the synclinal troughs. The region is exposed mainly by Geosynclinal molasses sediments of Neogene age, comprising of poorly fossiliferous successions of alternating shale and sandstones in varying proportions.

The area is evolved after the regional uplift of Barail Group of sediments as the result of plate collision in the subduction zone west of Arakan-Yoma, followed by the spreading of Indian Ocean. It is apparent that the deposition of sediments of the study area took place, after the uplift of Barail geosyncline, in a great tectonic trough of Mio-Geosynclinal character having a 'Bell-shaped' pattern. The thick bedded turbidite greywackes were deposited in the channel areas as proximal deposits whereas the silt/shale interlamination was deposited in inter channel distal areas. A shallow sea might have prevailed during the time of deposition of these rocks, as is evidenced by the presence of large scale planer crossbedding, trough cross-bedding and coarse grained sandstone with less clay in the top of the syncline.

Geology, Lithology & Depositional Environment

The rocks of the study area belong to Middle Bhuban formation of Surma Group, represented by sandstone-shale intercalation. It was noticed that within sandstone-shale intercalation the shale composition dominates, which is characteristic of ''flysch facies''. Noticeably, the flysch facies represent a sequence of sedimentary rock layers that progress from deep-water and turbidity flow deposits to shallow-water shales and sandstones. It is deposited when a deep basin forms rapidly on the continental side of an orogenic episode, as the second phase of a shallowing geosyncline, which is preceded by the "preflysch" facies." that is dominantly consisting of darker and lighter shale rocks of relatively deeper marine origin. The sandstones of the area exhibit more than 15 % of rock fragments along with quartz, orthoclase, microcline, and albite. Thus, the sandstones of the area are classified as greywacke.

Petrography

The area comprises of different rock beds such as Shale, Siltstone and Sandstone. The Shales are thickly bedded relatively more compact, smooth and of gray colour. Thin bands of crumpled grey Shale have also been observed at places. In some rocks, the sandstone beds are very thick while in others they are thinly bedded. The Sandstones are brown coloured, medium to coarse grained and some of them are grey. Bivalve fossils are also observed throughout the study area.

The representative samples are observed under the Microscope. In most of the thin sections it is found to be difficult to study the mineralogy and texture of sandstones simply because of the fact that presence of shale and other fine grained rocks are overshadowing the sandstones. Further, shale and other fine grained rocks are too fine to be studied under a Petrological microscope. Moreover, sandstones themselves are also fine grained, and have an argillaceous matrix. Sometimes, siliceous, ferruginous, and calcareous (due to presence of fossils) sandstones are also present.

Geochemical Results

The Chemical analysis of major and minor element have been performed on X-R-F in oxide percentages. The Trace elements in parts per million were also determined.

The oxide weight percentages are plotted with silica percentage to observe the variation of oxides in all rocks of study area. From the plot vs. Silica, it is evident that CaO and MnO are not affected at all, while Na2O, K2O and MgO show maximum variation. These oxides are mainly incorporating during the weathering processes where clay minerals are forming at the expense of feldspars. Rb/Sr ratio plots show that Sandstones have lower Rb/Sr ratio than in Shales. Na2O vs. K2O plot exhibits a tendency of increasing K2O as compared to Na2O.This trend is again indicative of active weathering processes which are active throughout the study area. The formation of muscovite during the digenetic formation of Shale can also explain such trend. Same trend has also been observed when sandstones are shown separately.

The variation of Fe2O3 + MgO Vs Na2O + K2O in sandstone exhibits an overall increasing trend due to formation of clay minerals Illite and Montmorillonite. (Fe2O3 + MgO) Vs TiO2 show the overall increasing trends when plotted for sandstone. This trend can be explained by the presence of Sphene.

Further when behaviour of (Fe2O3 + MgO) is compared with Al2O3/SiO2. It is evident that rocks of Middle Bhuban as a whole and Sandstone as a separate unit behave in a similar pattern i.e., gradual increasing trend. The increasing trend signifies that alumina is increasing with respect to silica as total iron and magnesia increases. It is in agreement with the observed fact that silica minerals are converting into sheet structure represented by clay minerals and a small amount of muscovite during the digenetic processes.

The trace elements in parts per million (ppm) are also plotted to study their individual variation in Sandstone, Shale, and Siltstones of the study area. It is observed that Ni is showing maximum variation with highest peak of ~70 ppm in Shales. Cu follows similar trend and is maximum in Shales. Co and Sc are fluctuating but less prominently. They are higher in Shale and Grey Sandstone while low in Brown sandstone and Siltstone.

Prominent valuable information is a higher amount of (~4 ppm) uranium in the rocks of Middle Bhuban rocks in the Study Area (Solovov, 1987, Hoefs, 1997, Mook 2006). Further, it relatively lows in Shales as compared to Sandstones. Thorium also follows a similar trend, but values are more as compared to uranium. Again, Pb and Ga are also having higher values where uranium and thorium are higher.

Structural Features

The major structural trend in the area coincides with the regional tectonics' lineaments. The general strike of the bed is N-S to N5o E / N5oW to S5oW / S5oE, with dips varying from 40o to 50o either towards west or east. Structurally, the rock of the entire Mizoram (including the study area) lies on highly compressed asymmetrical anticlinal ridges and narrow valleys, with parallel to sub-parallel sub-anticlinal axial planes. The intensity of fold movements is lesser in the west and greater in the east due to the proximity of the plate boundary.

The tectonic setting and structural condition of Aizawl city is represented by repetitive cyclic succession of Neogene arenaceous and argillaceous sedimentary rocks which were thrown, folded, and faulted into series of N-S or NNW or SSE (approx.) plunging or trending anticlines and synclines. Aizawl and its surroundings are attributed that they seriously suffering from tectonic activities during Late Cretaceous to Tertiary. The phenomenon was evidenced due to the presence of series of faults and prominent relief. As studied from aerial photo, there are more than 17- fault lines within only 128.9 Sq. Km areas of Aizawl which control the geological structure and tectonic setting of the city. These fault lines are running in different directions such as NNE-SSW, NNW-SSE, nearly N-S and some are almost E – W.

Palaeoslope

Primary sedimentary structures recorded in the area are typical deep sea flysch-type structures, viz., graded bedding, flute casts, load casts, ridge structures, chevron marks, parting lineation, groove marks, ripple-drift-cross laminations of several types, flame structures, ripple-trough convolutions, and the complete sequence of turbidite structure, etc. (Pettijohn, 1969).

The palaeo-current directions shown by all primary features reveal a mean southerly transport direction indicating a southerly plunging basin. This infers a northward situation of parent rock source. Many of the established plate tectonic models clearly suggest that at the time of collision of Indian Plate and Burmese plate (Late Eocene to Early Oligocene) the present day Shan-Tensserim Block was lying to the north or Northwest of Mizoram basin. It is possible that Mogak Group consisting of Gneisses, schist, and Kalibag Granite of northern Myanmar could be the source area for the rocks of the Surma Group of the study area.

Summary and Conclusion

The overall petrologic, petrographic, and geochemical results indicate the formation of these rocks of the study area in a "Flysch Facies" as confirmed by the sandstone-Shale and Greywacke composition in the study area. Major & trace element geochemistry and heavy mineral assemblage in the Surma sediments suggests a mixed provenance of acid igneous and high grade metamorphic rocks.

The various primary sedimentary structures characterizing these sedimentary rocks are indicative of shallow marine to deltaic environment of deposition with a constant south worthy palaeoslope. Many of the plate tectonic models suggest that at the time of collision of Indian Plate and Burmese plate (Late Eocene to Early Oligocene) the present day Shan-Tensserim Block, which presently lies towards the east, was lying to the north or Northwest of Mizoram basin. Trace element geochemistry and heavy mineral assemblage too reveals that probably, the Mogak Group consisting of Gneisses, schist, and Kalibag Granite of northern Myanmar could be the source area. The northward palaeo-location of the present day Shan-Tensserim Block is also established by the mean southerly transport direction indicating a *southerly palaeoslope of the plunging basin*.

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