International Journal of Engineering Science Invention
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org Volume 2 Issue 2 ǁ February. 2013 ǁ PP.79-84

Crustal Deformation along the Manipur Hills Segment of Indo Myanmar Ranges of the Northeast India

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ABSTRACT: *Crustal deformation along the Indo Myanmar Ranges (IMR) is due to the subduction of Indian plate below the Myanmar micro plate. Shortening across the ranges calculated along the profiles perpendicular to the regional trend varies gradually with a maximum of 59% approximately. Shortening accommodate by the minor local scale folding is less than the regional shortening. The amount of excess shortening is accommodated by a series of imbricate thrust system in the lower horizon of the Disang sediments, and folding of the upper horizon of the Barails, develop due to the tectonic compression. A shear couple stress field produced by the relative plate motion is responsible for the crustal deformation around the Manipur Hills segment of the IMR.*

Keywords: *Barails, Disangs, imbricate, shortening, thrust.*

I. INTRODUCTION

The Indo-Myanmar ranges (IMR), evolves as an accretionary prism along the subduction margin of the Indian plate below Myanmar micro plate of Eurasian continent. The general trend of the hill ranges follows a curvature, NE-SW in the northern part to NW-SE in the southern part. Axes of the major folds are also following the same trend. Many regional scale thrust are found parallel to the regional trend as well as parallel to each other. The degree of compression is found to be more on the northern side, gradually reduce southward. This variation in the degree of compression is examined by calculating the amount of shortening, along different lines across the range perpendicular to the regional trend. Balance cross-section techniques are applied for calculating the shortening across the ranges perpendicular to the general trend.

Also it seems to be evident that crustal deformations and tectonics of this region is directly related to the motion of the Indian plate with respect to the Myanmar micro plate. As reveal by the data from various sources, Indian plate is moving towards north east direction. Myanmar plate is moving northward with transcurrent movement along Sagaing fault. Due to the configuration of the margin of the overriding Myanmar plate, and the motion direction of the Indian plate, a resultant compression along the direction, approximately in the east-west, is produced, as well as a dextral strike slip couple may be set up. This dextral couple can be used to explain the structural lineaments associated with the rocks and other topographic features in this region. Further, by calculating the shortening percentage across local scale minor structural features like folds, comparison can be made with that of the regional scale shortening.

Subduction of the Indian plate below the Myanmar plate has been observed by Fitch (1970 [1], 1972[2]). Motion of the Myanmar micro plate has been described by Curray *et al* (1978) [3]. Earliest regional geological accounts of Manipur Hills in brief were provided by Pascoe (1912) [4] and Evans (1964) [5]. Systematic geological maping of the region was carried out by Dayal (1963) [6], Dayal and Daura (1963) [7]. Accounts of regional geology and tectonics of northeast India are found in the works of Chattopadhyay *et al* (1983) [8], Ghosal (1983) [9], Mitra et al (1986) [10], Saxena (1987) [11] etc. Crustal deformation and tectonic shortening in the region have been estimated by using the principles of balance cross section given by Dahlstrom (1969) [12], adopted by Coward (1992) [13] and Soibam (1993) [14].

An attempt is made in the present work to provide a brief account of the structural and tectonic framework of the region, with an objective of understanding the evolution mechanism of the IMR basin.

II. REGIONAL GEOLOGY

Indo-Myanmar ranges extend in between 93^o E to 95^o E longitudes and in between 19^o N to 27^o 30' N latitudes. The margin of the eastern foothills is supposed to be aligned with the Myanmar plate boundary overriding above the Indian plate. The rocks are made up of Neogene molasses, tertiary and cretaceous Flysch sediments with minor igneous and metamorphic rocks of older age. The general stratigraphic sequence of the IMR is given in Table I. The whole ranges is longitudinally divided into Four major tectono-stratigraphic units, namely, Metamorphic Belt, Ophiolite Belt (Ophiolite Mélange Zone), Central Flysch Belt, and Molasses Belt.

The metamorphic complex on the extreme eastern part is composed of low to medium grade phyllitic schist, quartzite, marble, granite-gneiss etc and is the oldest in the stratigraphic sequence, but over thrust the younger sequences westward. The eastern ranges contains the Ophiolite mélange zone, approximately 200 km long Ophiolite suit, chiefly made up of basic and ultra basic intrusive and extrusive, associated with conglomerates, volcanic pillows, coarse grained exotic sandstones, pelagic sediments like shales, chert, and limestones. This ophiolite belt in the western side of the metamorphic belt is thrusting over the central flysch belt of Disangs and Barail sediments. Surma sediments lie in the westernmost part of this region in contact with the Barail, and further extend with younger Tipam sediments. General lithological and structural lineaments are trending NNE-SSW. The Metamorphic unit is exposed only in a small part in the Ukhrul District of Manipur, but exposed well in Saramati and Nimi formations in Nagaland, and Somra Tract of Myanmar (Brunschwieller, 1966 [15]; Acharya *et al*, 1986 [16]; Bhattacharya & Sanyal 1985 [17];). Ophiolite rocks, mainly peridotite ultramafic, with serpentinites and associated pelagic sediments like limestones, chert, shales, and exotic blocks of coarse grained sandstones, together constituted the Mélange zone. Within the Flysch Belt, The older Disang formation overlies the younger Barail sediments along the Churachandpur-Mao thrust; however, synclinal remains of the same Barail beds are seen frequently on top of the ranges. Surma sequences of the Molasses sediments are found in the western part of the ranges, overthrusted by Barails. Beyond, the younger sequences of Surmas and Tipam extend towards west as usual. The median line of the IMR is a major water divide in between the catchments of Chindwin-Irrawady system in the eastern side and catchments of Brahmaputra-Ganga system in the western side. This median range runs along the Arunachal-Myanmar boundary, in its northern end, trending NE, crosses the Indo-Myanmar international boundary through Tuensang district of Nagaland, passing Zunheboto and Phek districts entered Manipur on the eastern side of Senapati district and runs along the Kenedy peak of Chin Hills segment in Myanmar.

III. CRUSTAL DEFORMATIONS ACROSS THE MANIPUR HILLS SEGMENT

Structural and tectonic features in the Manipur Hills segment of the IMR infer an east-west tectonic compression with shortening of the region. The degree of shortening is expressed as the percentage ratio of the amount of shortening upon the original length. Method used by Coward (1992) [13], subsequently adopted by Soibam (1996) [18], has been applied. During the deformation of the rock beds, due to lateral pressure, we assume three conditions that, rocks are incompressible, change in the width (the other horizontal perpendicular) is negligible and the amount of shortening is compensated by vertical thickening only. Two commonly used techniques are i) Line balancing (Gibbs, 1990 [19]; Hossack, 1979 [20]; Woodward et al, 1989 [21]), and ii) Area balancing (Chamberlain, 1910 [22], 1919 [23]; Bucher, 1933 [24]; Goguel 1962 [25]; Dahlstrom, 1969 [12]; Laubscher, 1976 [26]; Hossack, 1979 [27]; Coward, 1992 [13]; Soibam, 1996 [18]),.

In the first case, a visible stratigraphic section profile is used to stretch out one of the bedding to its original position and original length is calculated. The second case uses only a topographic profile. Area beneath the curve and a selected datum line is calculated, which is further used for calculation of the original width of the whole region before compression.

Topographic profiles are drawn across selected sections, which are almost parallel to the direction of the resultant compression. Endpoints or pin lines are chosen in such a manner that both end of the profiles fall in between the same tectonic segment. The foreland on the western front of the range system has an altitude below 50 m of the MSL. Therefore, mean sea level is taken as datum line for calculating the area. The thickness of the crust below the IMR varies from 52 to 55 km. And the thickness of the crust outside the mountain belt is that of the oceanic crust under the Bay of Bengal, which is taken approximately, 20 km (Rajsekhar & Mishra, 2008 [28]; Mukhopadhyay & Dasgupta, 1988 [29]; Mukhopadhyay and Krishna, 1991 [30]). Hence the approximated excess thickness is taken as 33 km. By using these values, shortening across the sections are calculated along some chosen profile lines. The eastern ends of the profiles are taken along the eastern foothills of the range system and the western margin is chosen along the line of Barak-Makru Rivers. (A tectonic break is inferred along this line). Table II shows the amount of shortening across different section along the IMR. A mount of shortening is found as maximum along the sections through the Mount Iso Tolloi peak and Siroih peak.

3.1. *Regional compression and shear couple*

Motion of the Indian plate with respect to Eurasian plate is described by its pole of rotation at 24.4 N, 17.7 E, with an angular velocity (ω) 5.3×10^{-7} deg yr $^{-1}$ moving along NNE direction (around N18°), subducting below the Eurasian plate (De Mets, *et al,* 1990 [31]; Soibam, 2006 [32]). For Myanmar plate, it is 23.86^{o}N, 125.12^{o} E, with ω 6.4×10^{-7}, moving towards N 350^{o} (Curray, et al, 1978 [3]; De Mets, *et al*, 1990 [31]; Soibam, 2006 [32]). The direction of relative plate motion is therefore, along the NE-SW, and the compression direction is EW. Relationship between the motion direction and compression direction is explained by the shear coupled stress, with the help of strain ellipse deformation mechanism (Soibam, 1996 [18], 2001 [33]). The compression features like thrust and folds are aligned along the direction 45^{o} from the shear couple orientation; extension features like normal faulting, extension joints are perpendicular to compression direction. Synthetic and antithetic strike slip features are along directions making 60^{o} with the extension directions. The shear couple is produced by the combination of relative motion direction, configuration of the overriding margin of the Myanmar plate and variable rate of motion of the plate pairs. The tectonic features observed in the Manipur Hills segment are aligned according to this mechanism.

3.2. *Deformation structures*

In Manipur Hills segment of the IMR, regional thrust and folds are well aligned with the compression direction of the region. Amount of shortening in this segment of the IMR seems to be accommodated well along the thrust planes. Shortening accommodated by folding is comparatively less. Shortening calculated from minor folds observed in the field (Table III) and inferred folds from the section profile constructed from field data (Table IV) are compared with the regional shortening to examine the amount of shortening shared by the structural features.

These minor folds are produced by the east-west tectonic compression and mostly on the upper layers (Barails and Upper Disangs). The amount of shortening accommodated by them is less than the degree of regional shortening of the profiles where they exposed (5, 6, and 7 of Table II). The remaining amount of regional shortening may be accommodated in the thrust zones, parallel to the regional trend. When the regional shortening ranges from 40 to 60 percent (averaged to 50 %), shortening contributed by the folding ranges from 31 to 35 percent (averaged to 33%). These folds are in the Central Flysch belt, in between two major thrust zones, the Ophiolite thrust, and Churachandpur Mao thrust. Inferred folds from the section profiles constructed from bedding data are all from the Barail beds. They are synclinal remains on top of the hill ranges and occurred in between major thrust planes. Shortening accommodated by them is also very less compared to the regional one.

3.3. *Depth to detachment*

The degree of shortening shared by the local folds as well as inferred fold bands in between major thrust planes are always less than the degree of regional shortening along the profile section nearby it. Depth to detachment of the deformed segments is calculated from the section profiles assuming a plain strain condition (Woodward et al., 1989 [21]). Around Manipur Hills segment, the depth to detachment is increasing towards the zone of maximum shortening, indicating concentration of stress (Table V).

3.4. *Joints and fractures*

Plot of 564 joints data, mostly from the flysch belt, shows that the general elongation direction is almost NS. Conjugate pairs of joints are also well represented in the rosette. Rose diagram drawn with the Georient Software is given in the Fig. 1.

IV. DISCUSSION

It is observed that folding accommodate comparatively more amount of shortening in the sections southward. Probably, Barail beds are folded on top of the imbricate thrust slices propagated through the underlying Disang beds. Lower horizon of the Disangs, as observed in the riverbed exposures in the Manipur Hills segment, has approximately NS trending strike dipping easterly at high angles, 70^{o} to 85^{o}. Again width of around 40 km of the Central Flysch belt has continuous exposure of Disangs sequences. It is not possible for Disangs, having this much thickness. Average thickness of Flysch sediments are given only 5 to 6 km (Muang, 1987 [34]; Acharya, 1991 [35]; Nandy, 1980 [36]). The wide exposures of the Disangs might be probably due to repeated overlapping of the imbricate slices. Sediments in the lower horizon are subject to vertical pressure exerted by the overloading sediments and horizontal compression is accommodated by thrust systems, following ramp-flat geometry model given by Twiss and Moores, (1992) [37]; Woodward, et al., (1989) [21]; Suppe (1983) [38]; Boyer & Elliote (1982) [49]. Upper layers are folded with sharp anticlines along the thrust planes, which were prone to erosion and occupied by streams and major rivers. New thrust planes are propagated westward (Fig. 2).

V. CONCLUSION

Crustal deformation along the IMR is due to tectonic compression produced by the relative motion of Indian and Myanmar plates. Relative motion direction, configuration of the Myanmar plate margin, and variable rate of motion generate a shear couple, to produce the compression stress along approximately EW direction with NS extension. Most of the compression stress is accommodated by imbricate thrust system in the lower horizon of Disangs and by folding in the upper horizon of Disangs and Barails.

REFERENCES

[1]. Fitch T. J., Earthquake mechanism in the Himalayan, Burmese, and Andaman regions and continental tectonics in central Asia. *J. Geophy. Research, 75*, 1970, 2999-2709.

[2]. Fitch T. J., Plate convergence, transcurrent faults, and internal deformation adjacent to Southeast Asia and Western Pacific. *J. Geophy. Research, 77*, 1972, 4432-4460.

[3]. Curray, J. R., Moore, D. G., Lawver, L. A., Emmel, F. J., Raitt, R. W., Henery, M., & Keickhefer, R., Tectonics of the Andaman Sea and Burma. *Am. Assoc. Petro. Geol. Memoir, 29*, (1978), 189-198.

[4]. Pascoe, E.H., Coal in the Namchik Valley, Upper Assam. *Rec. Geol. Surv. Ind. Vol. 41 Pt. 3* 1912, pp. 214 - 216.

[5]. Evans, P., the tectonic framework of Assam. *Journ. Geol. Soc. Ind. Vol. 5*, 1964, pp. 80 - 96.

[6]. Dayal, B., (1963), Report on recconanisance mapping of parts of Tengnoupal subdivision in Manipur. *Geol. Surv.of India Progress Report for F.S.*1961-62. (Unpublished).

[7]. Dayal, B., & Duara, B.K., (1963), Report on geological mapping and mineral survey in parts of Manipur state. *Geol. Surv. of India. Progress Report F.S.* 1962-63. (Unpublished).

[8]. Chattopadhyay, B., Ranjit, K. R., & Srivastava, S. N. P., 1983. Structure and Stratigraphy of the ophiolites and associated rocks around Chingai, Manipur East district, Manipur, India. *Geol. Sur. India, Mics Publ. 43*, 167-175

[9]. Ghosal A.K.,A note on stratigraphy and tectonics of the Ukhrul beds, Manipur.*Geol. Surv. of India. Misc.publ.43*, 1983, 164-166.

[10]. Mitra N. D. et al, Geology of Nagaland ophiolite. *Geol. Sur. of India Memoir*, 1986,119, 113

[11]. Saxena, S. P., Some observation on the lithostratigraphy of Barail group in Nagaland, Manipur and Upper Assam and suggestion for regrouping. *Geol Sur. India, Rec, 115 (3&4)*, (1987), 75-84.

[12]. Dahlstrom, C. D. A., Balanced cross section: *Canadian Journal of Earth Sciences, v. 6*, 1969, p 743-757.

[13]. Coward, M.P., (1992), Lecture notes on course for M. Sc. Applied Structural Geology and rock mechanics (1992-93), Imperial College, University of London.

[14]. Soibam, I., Geology Structure and tectonics of Manipur, India, *unpublished M. S./DIC thesis*, 1993, University of London, London, 131.

[15]. Brunschweiler, R. O., On the geology of the Indo-Burman ranges (Arakan cost and Yoma, Chin Hills, Naga Hills); *J. geol. Soc. Aust., 13(1)* 1966,: pp, 137-194, pls 3-4, 1966.

[16]. Acharyya, S. K., Mitra, N. D. & Nandy, D. R., Regional geology and tectonic setting of northeast India and adjoining region. *Geol.Sur. India Memoirs, 119*, 1986**,** 6-12.

[17]. Bhattacharya & Sanyal, R., Systematic geological mapping around Nimi and Khongka villages, district Tuensang, Nagaland. Large scale geological mapping along reference section between Luthur and Salumi villages, district Tuensang, Nagaland. *Geol. Surv. of India. Progress Report. F.S. 1983-84.* (Unpublished). 36p.

[18]. Soibam, I. Kinematic implication of structural and tectonic lineaments analysis of Manipur, India (Ab). *Proc. Indian Geol. Congress*, ISM, Dhanbad, 1996, 4

[19]. Gibbs, A.D. (eds) *Tectonic Evolution of the North Sea Rifts*, Clarendon Press, Oxford, 1990, pp 145-157.

[20]. Hossack, J. R., The use of balanced cross section in the calculation of orogenic contraction: a review: *Journal of Geological Soc. of London, 136*, 1979, p 705-711,

[21]. Woodward N.B., Boyer S.E. & Suppe J., Balanced geological cross-sections: an essential technique in geological research and exploration. *American Geophysical Union*., Washington, 1989, 132 p

[22]. Chamberlain R. T., The Applachian folds of the central Pennsylvania: *Journal of Geology, V 18*, 191), p 228-251.

[23]. Chamberlain, R. T., The building of Colorado Rockies: *Journal of Geology, V 27*, 1919, p 225-251.

[24]. Bucher, W. H., *The deformation of the Earth's crust*, Princeton Univ. Press, 1933, 518p.

[25]. Goguel, J., *Tectonics*, Freeman, San Francisco, 1962, 348p.

[26]. Laubscher, H. P., Fold development in Jura: *Tectonophysics, v. 37*, 1976, p 337-362

[27]. Hossack, J. R., The use of balanced cross section in the calculation of orogenic contraction: a review: *Journal of Geological Soc. of London, 136*, 1979, p 705-711,

[28]. Rajasekhar, R. P., Mishra, D.C., Crustal structure of Bengal Basin and Shillong Plateau: Extension of Eastern Ghat and Satpura Mobile Belts to Himalayan fronts and seismotectonics. *Gondwana Research, Vol 14, Issue 3*, 2008, P 523–534.

[29]. Mukhopadhyay, M. & Dasgupta, S., Deep structures and tectonics of Burmese arc: constraints from earthquakes and gravity data. *Tectonophysics, 149*, 1988, 299-322.

[30]. Mukhopadhyay, M. & Krishna, M. R., Gravity field and deep structure of the Bengal fan and its surrounding margins, northeast Indian Ocean, *Tectonophysics, 186*, 1991, 365-386.

[31]. De Mets, C., Gordon, R. G., Argus, D. F., & Stein, S., Current plate motions. *Geophysical Journal International, 101*, 1990, 425-478.

[32]. Soibam, I., Relative plate motions in and around Manipur and its implication on the tectonics of Indo-Myanmar Ranges. *Himalayan Geology. vol. 27 (2)* 2006, pp. 111-122.

[33]. Soibam, I., *Imphal Valley A Transtensional Basin*, DST, Project Completion report , 2001.

[34]. Muang Hla., Transcurrent movement in the Burma Andaman sea region, *Geology, 15*, 1987, 911-912

[35]. Acharya, S. K., Late Mesozoic Early Tertiary basin evolution along the Indo-Burmese range and Andaman island arc. In Tandon, S. K. Pant, C. C. & Casshyap, S. M. (eds), *Sedimentary basins of India, Tectonic context.* Gyanodaya Prakashan, Nainital, India, (1991), 104-130.

[36]. Nandy, D. R., Tectonic pattern in north eastern India; *Indian J. Earth Sci. 7*, 1980, 103–107

[37]. Twiss R.J.& Moores E.M., *Structural geology*. W.H. Freeman & Company, New York, 1992, 532 p.

[38]. Suppe, J. (1983), Geometry and kinematics of fault-bend folding. *Am. j. sci., vol. 283*, p. 684-721.

[39]. Boyer S.E.& Elliott D., Thrust systems. *Bulletin of the American Association of Petroleum Geologists 66 (9)*, 1982, 1196-1230.

TABLES

Table I: ***Stratigraphic Successions of IMR along Naga Hills***

<table>
<tr><th colspan="4">GEOLOGICAL TIME SCALE / CHRONOSTRATIGRAPHY</th><th>NAGA HILLS</th></tr>
<tr><td rowspan="23">CENOZOIC</td><td rowspan="5">QUART</td><td colspan="2">HOLOCENE</td><td>Alluvium</td></tr>
<tr><td rowspan="4">PLISTOCENE</td><td>Milazzian</td><td rowspan="7">Tipams</td></tr>
<tr><td>Sicillian</td></tr>
<tr><td>Emilian</td></tr>
<tr><td>Calabrian</td></tr>
<tr><td rowspan="9">NEOGENE</td><td rowspan="3">PLIOCENE</td><td>Gelasian</td></tr>
<tr><td>Placenzian</td></tr>
<tr><td>Zanclean</td></tr>
<tr><td rowspan="6">MIOCENE</td><td>Messinian</td><td rowspan="6">Surmas</td></tr>
<tr><td>Tortonian</td></tr>
<tr><td>Serravalian</td></tr>
<tr><td>Langhian</td></tr>
<tr><td>Burdigalian</td></tr>
<tr><td>Aquitanian</td></tr>
<tr><td rowspan="9">PALEOGENE</td><td rowspan="2">OLIGOCENE</td><td>Chattian</td><td rowspan="2">(gap)</td></tr>
<tr><td>Rupellian</td></tr>
<tr><td rowspan="4">EOCENE</td><td>Priabonian</td><td rowspan="3">Barails</td></tr>
<tr><td>Bartonian</td></tr>
<tr><td>Lutetian</td></tr>
<tr><td>Ypresian</td><td rowspan="8">Disangs</td></tr>
<tr><td rowspan="3">PALEOCENE</td><td>Thanetian</td></tr>
<tr><td>Selandian</td></tr>
<tr><td>Danian</td></tr>
<tr><td rowspan="13">MESOZOIC</td><td rowspan="12">CRETACEOUS</td><td rowspan="6">UPPER</td><td>Maastrichtian</td></tr>
<tr><td>Campanian</td></tr>
<tr><td>Santonian</td></tr>
<tr><td>Coniacian</td></tr>
<tr><td>Turonian</td><td rowspan="8">Ophiolites
Naga Metamorphics (?)</td></tr>
<tr><td>Cenomanian</td></tr>
<tr><td rowspan="6">LOWER</td><td>Albian</td></tr>
<tr><td>Aptian</td></tr>
<tr><td>Barremian</td></tr>
<tr><td>Hauterivian</td></tr>
<tr><td>Valanginian</td></tr>
<tr><td>Berriasian</td></tr>
<tr><td colspan="4">J U R R A S S I C</td></tr>
</table>

Table II: ***Amount of shortening across different sections***

SECTIONS	L_f (km)	A (km^2)	H (Km)	T (Km)	L_o (Km)	$L_o \sim L_f$	e (%)
1. Nagaland, 1643 peak	133	100	20	33	165	32	19.4%
2. Makokchung	154	160	20	33	264	110	41.7%
3. Saramati peak	176	190	20	33	313.5	137.5	43.9%
4. Mt Iso	132.5	200	20	33	330	197.5	59.8%
5. Tolloi peak	130	187.5	20	33	309.4	179.4	58 %
6. Siroih peak	166	210	20	33	346.5	180.5	52.1%
7. Koubru peak	120	135	20	33	222.8	102.8	46.1%
8. Through Imphal Valley							37 %*
9. Dingpi forest	110	105	20	33	173.3	63.3	36.5%
10. 2140 peak,	200	161.6	20	30	242.4	42.4	17.5%
11. latitude $23^0 18'$	172	137	20	30	205.5	33.5	16.3%
12. Blue mount.	182	133.8	20	30	200.7	18.7	9.31%
*data reproduced from Soibam (2001)							

Table III: ***Amount of shortening from minor folds***

Sl. No.	Locations	Structures	(e %)
1	Somtal Lamkhai, (around 24° 22 ′ 13 ′ ′ N, 94° 09 ′ 48 ′ ′ E)	Synform	30.00
2	Somtal Lamkhai, (around 24° 22 ′ 13 ′ ′ N, 94° 09 ′ 48 ′ ′ E)	Synform	33.60
3	Chakpikarong, (around 24° 12 ′ 22 ′ ′ N, 93° 54 ′ 06 ′ ′ E)	Synform	30.48
4	Awangkasom, (around 25° 18 ′ 33 ′ ′ N, 94° 28 ′ 50 ′ ′ E)	Synform	23.54
5	Ningchou, (around 24° 43 ′ 52 ′ ′ N, 94° 29 ′ 54 ′ ′ E)	Antiform	30.30

Table IV: ***Amount of shortening from inferred folds***

Sl No	Section	regional shortening	Local shortening
1	Jessami Section	59.8%	12.6%
2	Chingai-Poi Section	58%	10.8%
3	Gamnom-Phaimol Section	46.1%	15.8%
4	CCpur-Gelmol Section	36.5%	15.4%
5	Aizawl Section	30.69	29.7%

Table V: ***Depth to detachment at different sections***

Sections	L_o (km)	L_f (km)	$L_o - L_f$ (km)	A (km^2)	d (km)
Jessami	15.862	13.861	2.001	28.59	14.28
Chingai	14.775	13.183	1.592	18.719	11.76
Kamjong	11.4	9.6	1.8	20.0	11.11
Gelmol	1.529	1.294	0.295	1.214	5.17
Aizawl	34.5523	30.0005	4.5518	21.8485	4.8

FIGURES

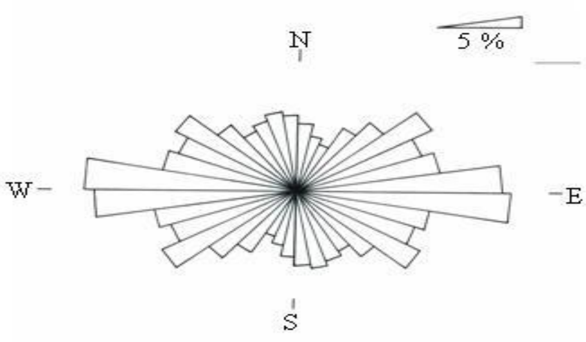

Fig.1: Rose diagram of 564 joints data

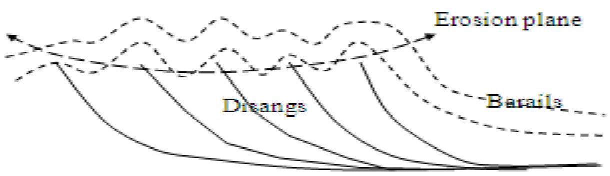

Fig.2: Schematic diagram for repetition of Disangs in imbricate slices with folding of upper layers on top