Geological & Structural Setup of Khalsi Formation Cretaceous Age, Ladakh

***Saleem Ahmed,** Research Scholar, Department of Geology, SunRise University, Alwar, Rajasthan (India)
****Dr. Rajni,** Associate Professor, Department of Geology, SunRise University, Alwar, Rajasthan (India)

Abstract: Sedimentary basins of the Himalayan region have been largely developed by a collisional mountain building processes. At multiple stratigraphic stages, petroleum systems, conventional as well as unconventional, have been formed due to continuous deformation from Precambrian to Neogene. Himalayan basins are prospective for hydrocarbon exploration because of suitable tectono-sedimentary geometry, oil/gas seepages/leakages. The occurrence of commercial oil and gas discoveries in adequately identical structural niches in eastern and western regions hint us the possibility of similar basins in northwestern region (e.g. Middlemiss, 1919). The ascertaining of the hydrocarbon potential has been challenging for prospective exploration in Northwestern Himalayas (Meissner et al., 1974; Khan et al., 1986; Jaswal et al., 1997). However, the geology and structural aspect of Himalayas has been established to a considerable degree of certainty by the acquisition of geological data, surface mapping, and the study of bore wells. Since major part of marginal Tethyan sedimentary record of Indian plate has yielded and been lost to under-thrusting, the only available pre-Himalayan successions towards the south of central axis becomes become all the more important. Major part of Himalayan sedimentary successions representing all periods from Cambrian to Eocene, with a remarkable degree of perfection is present towards north of the central crystalline axis (Wadia, 1944).

Keywords: GEOLOGICAL & STRUCTURAL SETUP, KHALSI FORMATION CRETACEOUS AGE, LADAKH

Introduction

The northwestern Himalaya is the vital section of Himalayan range to deduce the collision tectonics because of the presence of plate boundaries, collision related magmatism, i.e. island arc and batholiths as well as the rocks representing marine and continental environment. The road map to study the geology of northwest Himalaya was laid down by Godwin-Austin and R Lydekker during mid and late nineteenth century followed by Middlemiss during early twentieth century. The area was further explored and mapped by D.N. Wadia who identified the huge thrust sheet in Kashmir Himalaya and named it as Kashmir Nappe (Wadia, 1934). The Kashmir nappe moved southward along the thrust plane named as Panjal Thrust (PT) that extend further westward upto south of Nanga Parbat syntaxis and Hazara syntaxis (Thakur and Rawat, 1992; DiPietro and Pogue, 2004). The northwest Himalaya and neighboring part comprises of the chief tectonic belts which extends throughout Jammu and Kashmir upto the Pakistan. The tectonic belts of northwest Himalaya from north to south are: (a) Karakoram belt (b) Shyok Suture belt (c) Main central thrust zone (d) Main boundary thrust zone (e) Himalayan frontal thrust zone (Fig.2.2).

Karakoram Belt

In northwest Himalaya, the Karakoram belt constitute northernmost lithotectonic belt that include the part of Eurasian plate (Thakur and Mishra, 1984). The belt was originated as a result of folding as a part of origin of Himalaya with post collision related strike slip movement typical of right lateral strike slip fault nature (Coward et al., 1986). The rock types of Karakoram belt are mainly granites, granitoid and low to high grade metamorphic rocks.

Indus Shyok Belt

The Indus Shyok Belt is bordered by Main Himalayan belt particularly Zanskar thrust zone from south and Karakoram belt from the north. This belt comprises of sediments of Cretaceous to Tertiary age along with the magmatic rocks of ultramafic to acidic nature (Shanker et al., 1976). This belt host the sediments as older as late cretaceous slightly earlier than the Main Himalayan belt (Shanker et al., 1976). The emplacement of ophiolites in this belt represent the oceanic floor and complex interaction of sub-duction related processes (Gansser, 1974). The Indus shyok belt comprises of Nindam Formation, Lamayuru Formation, and marine Indus Formation as major lithostratigraphic units. The emplacement events are represented by Ladakh plutonics, Drass volcanics, and Kurdungla Formation (Frank et al., 1977; Pal et al., 1978; Honegger et al., 1982). Shyok group and Nubra group constitute two major group of Indus Shyok belt that comprises of serpentinite and peridotites interbeded with the slate, basic to intermediate volcanics with gabbro, phyllite, quartzite and limestone. (Thakur and Mishra., 1984).

Main Himalayan belt

The main Himalayan belt is sandwiched between the frontal fold belt (FFB) in the south and Indus Shyok belt (ISB) in the north. The main Himalayan belt contain thick package of rocks ranging in age from Proterozoic to Quaternary Period with merely few unconformities. Towards east it abuts adjacent to the Lohit complex while in the direction of west it continue upto Pakistan (Acharyya, 1982). Main central thrust, one of the most significant tectonic structure passes through this zone. The MCT demarcate low-grade metasediments, high grade metamorphic rocks, the central crystallines and the low-grade metasediments (Heim and Gansser, 1939).

Frontal Fold belt

The frontal fold belt is the southernmost tectonic belt of Himalaya, comprises of Tertiary - Quarternary to recent sediments. These lithotectonic units are Murrees, Subathu, Siwaliks and recent alluvium which rest on the Proterozoic basement. The frontal fold belt in this

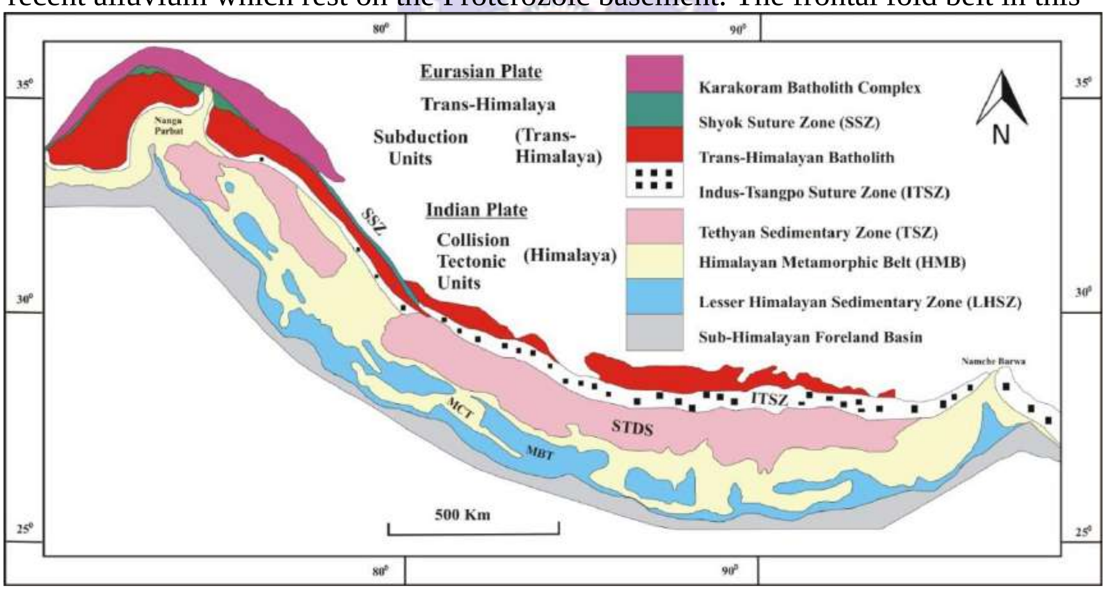

Fig.1 Regional geological map showing different litho-tectonic units after Singh et al., 2015.

region is bordered by north plunging Murree thrust in the north and Himalayan Frontal Thrust (HFT) in the South ((Wadia, 1931; Valdiya, 1988). Another northerly dipping significant tectonic structure lie between MT and HFT which is locally recognized as Reasi thrust (RT) (Medlicott, 1864 and Wadia, 1937). Both RT and HFT shows impact of neotectonic activity where the Quaternary and recent sediments show prominent deformation (Thakur et al., 2010; Thakur, 2013). In addition, the frontal fold belt include parallel to sub-parallel reverse faults, inliers, low plunging folds, and fault propagated fold (Suran Mastgarh Anticline).

REGIONAL DIVISION "NORTH TO SOUTH VIEW"

The Himalayan orogen have been sub-divided into six major longitudinal tectono-stratigraphic belts based on the Geology, Structure and Tectonic setting. These belts run almost parallel to each other and display different characteristics. These subdivisions can be described better under different sub-headings like, (i) Trans Himalaya (ii) Indus-Tsangpo Suture Zone (ITSZ) (iii) Tethys Himalaya (TH) (iv) Greater Himalaya (v) Lesser Himalaya and (vi) Outer-Himalaya. (Gansser, 1964, 1974; Valdiya, 1984; Verma et al., 2012; Thakur 1981, 1992) (Fig.2.3and 2.4). These subdivisions from north to south show a younging age and shallow depth. Additionally, these tectonic belts are bounded by the east-west extending regional thrust/faults named by different names locally but a common name regionally. These are Main Central Thrust (MCT), Main Boundary Thrust (MBT) and, Himalayan Frontal Thrust (HFF) (Thakur 1981, 1992). The Himalaya is separated into six lithostratigraphic units on the basis of stratigraphic positions of the rocks of the basins showing prior during and post-collision processes. These include Trans-Himalaya, Indo-Tsangpo Suture zone, Tethyan Himalaya, Higher Himalaya, Lesser Himalaya and Sub-Himalaya/Outer Himalaya from north to south (Gansser, 1964).

TRANS-HIMALAYA

The 'Trans-Himalaya' refers to the mountain range to the north of the Indus and Yarlung-Tsangpo rivers which was first used by Alexander Cunningham in his book Ladak (1854) and was significantly popularized by S. Hedin in his book Trans-Himalaya (1909-1912) during exploration to this region. From north to south, Trans-Himalaya is characterized by four tectonic units. These are Shyok suture zone (SSZ); Ladakh batholith (LB); Indus Tsangpo suture zone (ITSZ) and Tethys Himalaya (TH) (Searle et al., 1987). Trans-Himalaya is geologically, made up of rocks of felsic plutonic nature i.e. granitic and volcanic assemblages emplace around 110-40 million years ago (Ma). These rocks represent a linear plutonic complex zone also known as Trans-Himalayan Batholith. The batholith body is later intruded by the metamorphic and sedimentary rocks. This igneous complex represents typical I-type granite and diorites (Honneger et al., 1982; Schafer et al., 1984; Allègre et al., 1984). The rocks in this region are composed of norite, granites, and leucogranite and show at some places quite a complex relationship (Ahmad et al., 1982, Honegger et al., 1998). The felsic magma in trans-Himalaya is a result of partial melting of the subducting Neo-Tethyan slab beneath the Eurasian plate (Sorkhabi 1999; Weinberg and Dunlop, 2000). The magmatic activity in Ladakh batholiths ranges between those during and very close to actual collision to that of post-collosion anatexis (Honegger et al., 1982; Beck et al. 1995; Scharer et al., 1984a; Weinberg and Dunlop, 2000). The Kohistan-Ladakh region which is a trans-Himlayan region shows an island arc environment whereas eastern counterparts towards Namcha Barwa represent an Andean-type environment (Windley 1995). Geographical extent of trans Himalaya can be described as Kohistan (west of Nanga Parbat), Ladakh (between Karakoram strike-slip fault and Nanga Parbat and the), Lhasa, Kailash, Gangdese, (southern Tibet) and Mishimi (east of Namcha Barwa).

During subduction of Tethys under Asia, the northern region gave rise to an island arc magmatism trapped in between Asia and India forming a prominent geological feature of the Neo-Tethys that underwent two stages of deformation. At the onset the arc collided with Eurasian landmass and then another collision with India (Windley 1995). The area is dominated by tonalities, and granodiorites composed of quartz+K-spar+hornblende+sphene+biotite mineral assemblages. The pre-collision phases are represented by felsic intrusions, of 101±2 million years (dated by U-Pb in zircon techniques) (Searle 1991). The late stage dikes particularly leucogranite dikes and other magmatic pegmatite bodies had yielded n age of 60.±0.04 million years (dated by U-Pb in monazite) (Windley 1995). Towards the eastern region the Andean style tectonic environment have been suggested which include the metamorphosed assemblage of phyllites, slates, schists, amphibolites gneisses, and migmatites (Windley, 1995).

The Trans-Himalaya represent the northern most boundary of the Indian plate all along the Indo-Tsangpo Suture Zone (ITSZ) and account for the flysch deposits, basic and ultrabasic exotics, resting over the molasses deposits (Weinberg and Dunlop, 2000). The northern limit of Trans-

Himalaya is marked by Karakoram-Lhasa block and south Tibet showing the evidence of subduction of the southern margin of the Eurasian plate through Andean-type Ladakh batholith which is characteristic feature of the Trans-Himalaya (Allegre et al., 1984; Searle, 1991). The trans-Himalaya is divided into Indus Tsangpo suture and Lahsa-Karakoram block (Searle et al., 1987). The Indus Tsangpo suture zone comprises of oceanic crust of Tethys Ocean while Lhasa-Karakoram block represent south Tibet and Karakoram Mountain range comprising of magmatic arc comprising of granite, sedimentary rocks of oceanic trench (Thakur and Mishra 1984; Searle 1991).

References:

Avouac, J. P. (2003). Mountain building, erosion, and the seismic cycle in the Nepal Himalaya. Advances in geophysics, 46, 1-80.

Avouac, J. P., & Tapponnier, P. (1993). Kinematic model of active deformation in central Asia. Geophysical Research Letters, 20(10), 895-898.

Avouac, J. P., Ayoub, F., Leprince, S., Konca, O., & Helmberger, D. V. (2006). The 2005, Mw 7.6 Kashmir earthquake: Sub-pixel correlation of ASTER images and seismic waveforms analysis. Earth and Planetary Science Letters, 249(3-4), 514-528.

Bagati, T. N. (1990). Lithostratigraphy and facies variation in the Spiti basin (Tethys), Himachal Pradesh, India. Journal of Himalayan Geology, 1(1), 35-47

Banerjee, D. M. (1974). Stratigraphy and depositional characteristics of Tethyan sediments in Kuti-Kalapani area, Kumaun, India. Himalayan Geology, 4, 296-322.

Banerjee, P., & Bürgmann, R. (2002). Convergence across the northwest Himalaya from GPS measurements. Geophysical Research Letters, 29(13), 30-1.

Bard, J. P. (1983). Metamorphism of an obducted island arc: example of the Kohistan sequence (Pakistan) in the Himalayan collided range. Earth and Planetary Science Letters, 65(1), 133-144.

Barman, P., Sánchez-Beristain, F., Mishra, S. R., Ibrahim, M., Swami, N. K., Bamniya, M., & Singh, S. (2021). First report of Acanthochaetetes (Porifera: Demospongiae) from the Cretaceous Khalsi Formation, Ladakh Himalaya, India. Journal of Paleontology, 95(6), 1138-1146.

Baud, Aymon, Arn, R., Bugnon, P., Crisinel, A., Dolivo, E., Escher, A., ... & Tieche, JC (1982). The Gondwana-peri-Gondwana contact in eastern Zanskar (Ladakh, Himalayas). Bulletin of the Geological Society of France , 24 (2), 341-361.

Berthelsen, A. (1953). On the geology of the Rupshu District, NW Himalaya: a contribution to the problem of the Central Gneisses. F. Bagges kgl. hofbogtr.

Berthet, T., Ritz, J. F., Ferry, M., Pelgay, P., Cattin, R., Drukpa, D., Braucher, R & Hetényi, G. (2014). Active tectonics of the eastern Himalaya: New constraints from the first tectonic geomorphology study in southern Bhutan. Geology, 42(5), 427-430.