Review of Literature on Sedimentological study of Khalsi Formation Cretaceous Age, Ladakh

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Abstract: The "Himalaya" Hima-snow and Alaya-abode (Sanskrit word:) is the highest, youngest, and the most active and conspicuous mountain range on the earth that fashioned as a result of crash amid the Eurasian and Indian Plates in the Cenozoic Period (Gansser, 1974; Aitchison 2007; Lave and Avouac, 2000). The mountain is still unfinished and actively changing its topography with time and lead to the surfacing of Himalayan and Tibetan plateau to current latitude-longitude position as well as elevation that manifest the geo-dynamic behavior of Indian and Asian plates (Patriat and Achache, 1984; Yoshida et al. 2008). The eastern and western end of Himalaya is revealed by striking "syntaxial bends" known as western syntaxis and eastern syntaxis in the extreme west and east respectively (Wadia, 1931; Valdiya, 1980). These bends almost run parallel to the continental scale right-lateral Sagaing fault in the east and deep left-lateral Chaman fault in the west (Quittmeyer et al., 1979; Molnar & Dayem, 2010). The bends are fashioned due to crustal scale folding with highest compression parallel to the mountain range, oroclinal meandering of major thrusts, growth of duplex, northward trending pop-up configuration and juncture of arcuate thrust belt, (Bossart et al., 1988; Burg et al., 1998; Schneider et al., 1999a). The northern and southern closing stages of Himalaya are restricted by Indo-Tsangpo- Suture Zone (ITSZ) and Indo-gigantic plain correspondingly.

Keywords: Review of Literature, Sedimentological, Khalsi Formation, Cretaceous Age, Ladakh

INTRODUCTION

The Breaking up of Rodinia i.e. Supercontinent, and later assembly of Gondwanaland, that includes Australia, Antarctica, Greater India, Madagascar, Africa, and South America is the evidence of a long term process occurred on the planet earth in geological past between Neoproterozoic to Cambrian period (Powell et al., 1994; Dalziel, 1992, 1997; Dalziel 1997). It has been suggested that by 1050 Ma, the Rodinia was not fragmented, having Laurentia as its core (Bond et al, 1984, Hoffman 1999). The broken continental blocks of Rodinia moved from Laurentia towards African Congo and Kalahari cratons from in a fan-like rotation covering both eastern and western sides that merged by 820 Ma to form Gondwanaland (Hanson et al 1994; Hoffman 1999). Antarctica, Australia, Africa, India, South Africa and Madagascar were together around 500 Ma in the southern Hemisphere which is known by Gondwanaland (Hanson et al., 1993). The long processes of convergence, shortening, underthrusting and volcanism manifests the geo-dynamics of Indian and Asian plate (Patriat and Achache, 1984; Klootwijk et al., 1992). It is suggested that the Indian continent was separated from Asian continent by a widespread ocean called Tethys some 225 Millions year ago (Hoffman 1999). The continent began to move northward about 200 million year ago during the breakdown of Pangaea. The Indian plate started moving northward 80 million years ago at a rate of about 9 m a century covering roughly distance of about 6400 km (Hoffman 1999). Around 40 to 50 million years ago, due to ramming of Indian plate into the Asian counterpart resulted into closure of great Tethys and formation of Himalayan mountain system (Gansser, 1974). The Indian plate drifted at the rate of 15-20 cm/year during Cretaceous and Paleocene times and virtually slows down to about 5 cm/year by 45 Ma in the Eocene time. This is evidenced by the paleomagnetic studies on the rocks of Indian ocean floor and trans-Himalayan region. The youngest granites of trans-Himalaya reflect the episode of cessation of Subduction of Neo-Tethys around 40Ma (Gansser, 1964, 1974; Dewey and Bird, 1970). The Indo-Tsangpo Suture Zone (ITSZ) and deep marine sediments of Triassic to Eocene represent the abducted trace of Neo-Tethyan oceanic crust. The presence of Kohistan-Ladakh Arc (KLA), an intra-oceanic Cretaceous island arc is the typical confirmation of continent-continent collision (Molnar & Tapponnier 1975; Bard 1983; Pudsey et al. 1985; Khan et al. 1998; Khan et al. 2009). The mountain is made up of collage of northwest-southeast trending rocks of the Asian and Indian Plates for about 2400 km long and with 200-300 km wide (Fig.1). The northwestern region of Indian Plate shows the evidence of early collision around Cretaceous Tertiary (K-T) followed by collision with the eastern Himalaya later (Patriat and Achache 1984; Treloar and Coward 1991). The further movement rate decreased thereafter and virtually decreased to half due to collision (Molnar and Tapponnier 1975; Klootwijk et al., 1992). Further the dynamic forces involved in the formation of Himalayan mountain range also include rifting which is evidenced by presence of Panjal traps erupted due to continental rifting between Indian and Tibetan block. Due to continuous movement along the plates the depositional environment also started to shift from previously marine environment to the fluvial system. During Paleocene to Eocene, the foreland deposition was typically in marine setting that later during Miocene-Pliocene shifted to the continental setting. The depression or trough formed in the frontal part of Himalayan orogen i.e. Himalayan foreland basin, received thick cover of sediments from highlands of Indian craton. The shortening in the Himalaya is represented by the Main Central thrust (MCT), Main Boundary Thrust (MBT), Himalayan Frontal thrust (HFT) systems (Valdiya 1973; Thakur 1993; Narula et al., 2000). These thrust structures represent compressional tectonics with transfer of motion and distribution of strain represented by the tear faults, strike-slip faults and normal faults (Khattri et al., 1978; Kumar and Mahajan, 2001). The young generation faults particularly showing strike slip motion in the MBT and MCT zones indicate reactivation of existing faults (Patriat and Achache 1984). Among the early workers the geology of northwest Himalaya had been established by significant contribution of Medlicot (1864); Oldham (1883) and Middlemiss (1885, 1887, 1890) in nineteenth century and Pilgrim and West (1928); Wadia 1931; Auden (1934), Heim and Gansser (1939) and Gansser (1964) during the twenty century and are still taken as a basemap for any further study in the northwest Himalaya. The most prominent recent workers who made significant contribution in the Geology and tectonics of northwest Himalayan are Valdiya (1964, 1978, 1980); Saklani (1970); Pande (1974); Powar (1980); Thakur (1992).

Review of Literature

The Review of Literature Himalaya is one of the most spectacular orogenic attributes created by the continent-continent collision between Indian and Eurasian plates (Dewey and Burke, 1973) and is the largest dynamic orogenic expression in existence similar to the older mountain systems (Aitchison et al 2007). It is characterized by a continue convergence rate of 5cm/year which is still ongoing (Klootwijk et al., 1992). The collision time period between the Indian and the Asian plate constrained from~65 to 34 Ma, while most commonly accepted of collision lies between 55 and 50 Ma. The collision has caused intense crustal shortening and deformation along southerly verging thrusts viz. the Main Central Thrust (MCT), the Main Boundary Thrust (MBT) and the Main Frontal Thrust (MFT), as well as large-scale strike-slip faults in Ladakh and Tibet region e.g. Karakoram strike slip fault. The resulting collision uplifts the Himalaya and Tibetan Plateau, define the geodynamic activity of Indian and Asian plate (Patriat and Achache, 1984). Onset of India-Asia collision, even though not well constrained dates back as early as 55Ma in the westernmost part of the orogen (Beck *et al.*, 1995; (Yin, 2006). Additionally, sedimentological investigations have suggested that, the Northwestern tip of India first contacted with the southern side of the Eurasian plate at 55 Ma (Le Fort 1996). By 40 Ma, the two continents apparently met along the full length (~2500 km) of the suture zone (Dewey 1988).

The mountain similar to Himalaya are always characterized by structural complexities in term of to folds and faults particularly reverse faults or thrusts where imbrications of rock strata give significant accommodating space. The study of plate tectonics has provided significant opportunities to address the mechanisms by which lithospheric plate margins behave to convergent movements and resultant collisional orogenesis (Tapponnier et al., 1981, 1986; Molnar and Tapponnier, 1975, 1977, 1978, 1985; Hodges, 2000). The geodynamic development of Himalaya has been inferred from different chronological stages: (a) Late Mesozoic subduction and accretion (b) Cenozoic Collision (c) Late Collision extensional tectonics (d) Post-Collision sedimentation in fore-deeps and (e) Present-day geodynamics (Jain et al., 2002). This geodynamic evolution has been modeled into a global frame of under-thrusting Indian plate beneath the Eurasian plate along two major suture zones i.e., the Indus-Tsangpo Suture Zone (ITSZ) and the Shyok Suture Zone (SSZ). The over thrusted Eurasian plate represents its character in a Late Mesozoic Andean-type Kohistan-Ladakh Batholith Complex, which is separated from the Karakoram metamorphic and its batholithic complexes by the Shyok Suture Zone (SSZ). The two prominent suture zones i.e. Indus-Tsangpo and Shyok both are characterized by island-arc setting, presence of back-arc and fore-arc sediments and ophiolite emplacement. Physiographically, Himalayan mountain belt extends in the East-West direction for about 2400 km. The western end of mountain belt takes a sharp arcuate turn which is called as "the syntaxial bend" (Wadia 1931; Valdiya 1980). Similar bend is also present at the eastern end of the Himalaya thereby changing NE-SW trend to NNE-SSW. The southern boundary of Himalaya is marked by the distribution of extensive alluvial plains of Ganga (Ganges), Indus, and Brahmaputra or Yarlung Tsangpo (or Zangbo = river in Tibetan). The major peaks of the Himalaya include Nanga Parbat, Mount Everest, Kanchenjunga, K2, Dhaulagiri, Gasherbrum and Gosainthan rising to an elevations of about 24,000 feet (7,300m) or more above sea level (Wadia, 1944). The geographical distinction of the Himalayan orogen along the strike (west to east) includes the Western Himalaya (66^0-81^0), the Central Himalaya (81^0-89^0) and the Eastern Himalaya (89^0-98^0). The western Himalayan orogenic division extends from Salt Range and Kashmir Himalaya in the west to Kumaon Himalaya in the east, the central Himalaya covers Nepal and Sikkim in the west and south-central Tibet in the east, the eastern Himalaya extends from Bhutan in the west to Arunachal Pradesh in the east (Fig.2.1).

The tectonic belts of the Himalaya have been disturbed greatly by the complex folding, faulting and over thrusting. The distinct physiographic features in the Himalaya have been documented by a number of geo-scientists for the last over a century. The significant growth of Himalaya has been witnessed by India's great antecedent rivers Indus, Ganga, and Brahmaputra (Patriat and Achache 1984). Deep seismic reflection profilingin the western Himalaya has indicated limited thickness of Indian crust subducted beneath southern Tibet (Zhao et al., 1993; Guo et al., 2017). At the same time the study of quaternary basins suggest a general gradient towards SE during the Quaternary period (Singh et al., 2019). The orogen is bounded in the north by the Indus-Tsangpo suture zone, towards west by left-lateral Chaman fault, to the east the right-lateral Sagaing fault, and to the south by the Main Frontal Thrust (MFT) (LeFort, 1975).

The main contribution were made by Strachy (1851); Medlicot (1864); Oldham (1883) and Middlemiss (1885, 1887, 1890) to establish the roadmap for systematic studies. Some other noteworthy contributors were made by Pilgrim and West (1928); Wadia 1931; Auden (1934) and Heim and Gansser (1939). Gansser (1964) has given a classical description of the regional geology of Himalaya, to systematically work on and to make it simple for the geoscientists of different sub-branches. The recent workers whose contribution is of immense importance in the Himalayan studies are Valdiya (1964, 1975); Saklani (1970, 1971); Pande (1974); Powar (1980); Jain (1987); Thakur (1992).

The northern tectonic boundary between the Tibetan Plateau (Lhasa terrane) and Himalaya (Indian plate) is marked by Indus–Tsangpo or Yarlung Zangpbo suture zone. The emplacement of andesitic magma along plate boundary represents escape of oceanic lithosphere from subduction at the onset or prior to the collision (Hennig, 1915). The presence of obducted ophiolite suite shows the evidence of pre-convergence boundary between under thrusting Indian plate and over-riding Eurasian Plate (Gansser, 1966; Dewey and Bird, 1970; Powell and Conaghan, 1973).

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