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Deformational Structures in Ladakh Molasse and Their Significance in Interpreting the Collision Scenario

Unconformably resting over the Ladakh magmatic arc complex, the molassic sediments (Ladakh molasse) have been thrust over mainly by Dras and Indus formations within the Indus Suture Zone of Ladakh Himalaya. The convergence between the Indian plate and Tibetan microplate initially produced NW-SE trending cylindrical folds, but the continued NE-SW compression ultimately led to the collision between the two plates and resulted in northeast translated thrusting in molassic sequence. Indentation of Indian plate around the northwest corner during collision led to the accumulation of high compressive strain in the plate boundary i.e. along the Indus Suture Zone. This strain not only caused the intervening material to get escaped laterally eastwards in this zone but also activated the various NW-SE trending thrusts with simultaneous dextral strike slip movement. The latter movement produced many N-S oriented secondary fractures (faults) in the crystalline arc complex and subsequently forced them to undergo strike slip activation. In this manner the blocks formed by these two sets of faults were rotated dextrally together with overlying folded molassic sediments.

Introduction: Initiation of collision between the Indian plate and Tibetan microplate gradually uplifted the Ladakh magmatic arc complex along the Indus Suture Zone, which became the active source area for the Ladakh molasse deposits. These deposits are mainly comprised of interbanded sequence of coarse-grained, pebbly, reddish to grey coloured cross bedded gritty sandstone; conglomerates; purple, red, grey and green coloured mudstone; siltstone and marl beds. These sediments were deposited on the southern edge of the arc and on a part of Indus Formation in the intermontane valley. These sediments have been overridden by a thrust sheet comprising the Dras and Indus formations on to the south. These fresh water Oligo-Miocene sediments (Tewari, 1964; Nanda and Sahni, 1990) have been noticed around Kargil, Saspol-Basgo, Karu-Upshi and Nyoma areas (Frank *et al.* 1977; Thakur, 1981; Virdi, 1986) (Fig.1). It is learnt that the deposition of these sediments had been closely associated with the collision and post-collision processes and consequently it should be presumed that these sediments would be retaining all the deformational signatures in them. Studies made so far do not indicate any attempt in reconstructing the collision processes and, therefore to fill this lacuna, this note attempts to ascertain the collision scenario with the help of the tectonic structures preserved in these sediments along the Indus Suture Zone.

Deformational Features: The deformational structures in the Ladakh molasse have been represented by open folded structures and northeast directed thrust sheets. Overturned folds with southwest dipping axial planes have been noticed in the shale and mudstone sequence near Tharumsha village on the northern bank of Wakha Rong (Fig.2a). NW-SE trending axial traces of syncline and anticline near Basgo Monastery (Fig.2b) and NNW-SSE trending axial traces of similar structures opposite Basgo Monastery (Fig.2c) have been recorded. A broad open NW-SE trending synclinal structure is also seen near Igu, Karu (Fig.2d). Besides these, there are several smaller folds observed at other places. Generally, these folded structures are gently plunging in southeast direction, except for the folded structures exposed opposite

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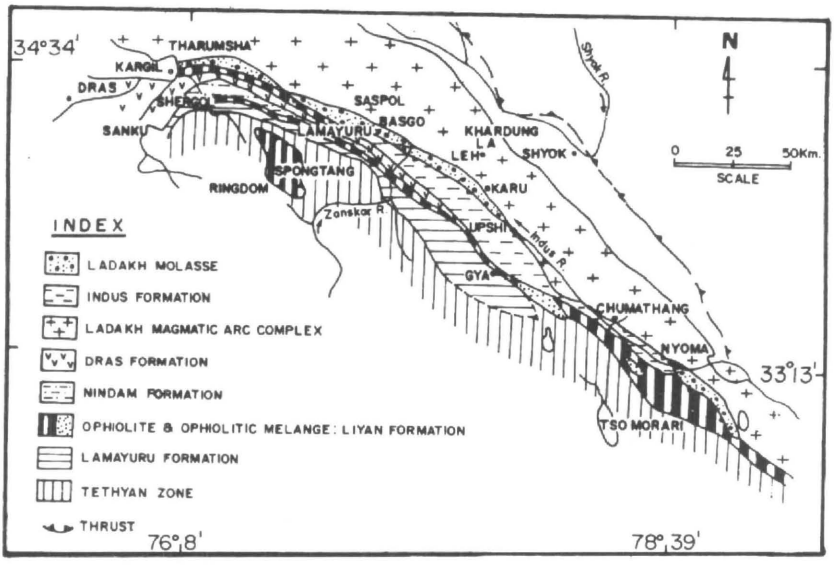

Fig.1. Generalised geological map of Indus Suture Zone showing distribution of Ladakh molasse deposits (modified after Thakur, 1981; Virdi, 1986).

Basgo Monastery, where the plunge of 50° to 55° in south-southeast direction has been recorded.

Northeast - directed thrust sheet with considerable translation can be distinguished easily near bridge on Wakha Rong at Tharumsha village (Fig.2a). In addition to these, a stack of thrust sheets near Basgo Monastery on the western slopes (Fig.2b), at Igu, Karu (Fig.2d) and near Nyoma Monastery can also be seen.

Many N-S fractures (dilational joints) have been filled up by secondary minerals, mainly gypsum and calcite and can be seen along Indus river at Nyoma and near Nimu and Basgo Monastery. The fabric generated by the gypsum fibres in the dilational fractures indicate that the blocks on the eastern side have moved down relative to the blocks in the west.

Tectonics: The NW-SE trending axial traces of the folded structures observed in these molassic sediments, suggest a consistent NE-SW compressional field, which is attributed to the convergence between the Indian plate and Tibetan microplate. This compression subsequently generated northeast-directed thrust sheets, which may be related to the collision of the two continental plates. Large-scale southwest-directed thrusting south of the Indus Suture Zone within the Indian plate and subsequent formation of the Siwalik foreland basin can be correlated with the northeast thrusting in the Ladakh molasse. Besides major thrusting, the collision has also generated cross-folds and simultaneous strike slip movement in the collision boundary (Sati and Rautela, 1993). The Ladakh magmatic arc complex, which is bounded by the Karakoram Fault/Shyok Suture on the north and various shears in the south within the Indus Suture Zone in the ensuing strike slip movement produced a number of N-S oriented fractures and thus a number of blocks were formed. Moreover due to extension

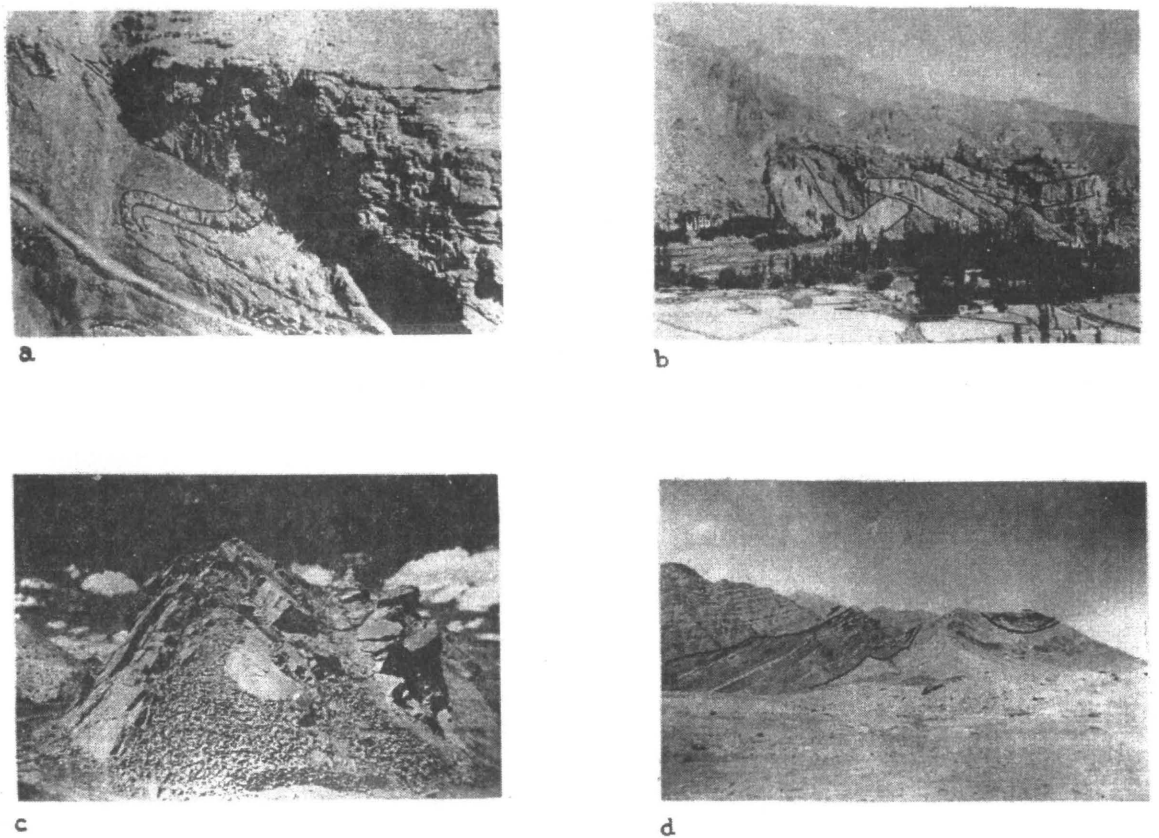

Fig.2a. NE-directed overthrusting near the bridge at village Tharumsha. The beds underlying the thrust plane have isoclinally overturned folds with SW-dipping axial planes. View towards SE. **b.** NW-SE trending axial traces of syncline and anticline near the Basgo Monastery. The anticlinal structure is later sheared along the constricted hinge in a manner that produced a stack of thrust slices. View towards SE. **c.** The molasse beds have been folded into an anticline and syncline opposite Basgo Monastery with 50° plunge towards SSE. Camera facing NW. **d.** Broad open SSE-plunging synclinal structure, thrust over by basal beds in the Ladakh molasse near Igu, Karu. The thrust translation is toward NE. View towards NW.

towards eastern side, these N-S fractures were later on transformed into east hading normal faults. This is evident from the shear sense indicated by the gypsum veins and also the steep plunging folds on the eastern slopes of a hillock opposite Basgo Monastery.

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