

EMPLACEMENT OF THE BIBAI AND GOGAI NAPPES, NORTHEAST OF QUETTA

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ABSTRACT

Emplacement of the nappe structures has been studied in an area ENE of Quetta. The area is underlain by sedimentary rocks of Mesozoic and Cainozoic era with minor volcanic intercalations. Two large thrust sheets, i.e. the Bibai and Gogai nappes, were emplaced between Middle Eocene and Early Oligocene epochs. The Gogai nappe is a hinterland dipping duplex in which thrusting was in piggyback fashion while a blind imbricate zone is present along the Bibai thrust.

INTRODUCTION

This paper describes a thrust sequence in an area around Gogai village, about 70 km ENE of Quetta and accessible by Quetta-Ziarat road (Fig. 1). Tectonically it is situated on the inner side of the Sulaiman fold belt. The area was first studied by the Hunting Survey Corporation (1964).

The thrusting in the area is somewhat similar to those of classic thin skinned tectonics studied by other workers in various parts of the world (McClay and Coward, 1981; Charlsworth and Kilby, 1981; Boyer and Elliott, 1982). The thrust sheets cut-off stratigraphic sequence on frontal ramps and then slide on incompetent unit composed of shale which provide good horizon for a flat (Hubbert and Rubey, 1959; Gretener, 1981). Complex folding is associated with the thrusting.

TECTONIC SETTING

The structures of interest in this area are two large nappes of which the lower one is the Bibai nappe and the upper one the Gogai nappe (Fig. 1). The nappe structures were previously observed by the Hunting Survey Corporation (1964) and Kazmi (1979).

The Bibai nappe includes rocks ranging in age from Late Cretaceous to Early Eocene, i.e. part of Parh group to Ghazij shale. The Gogai nappe sheet includes rocks of Triassic, Jurassic and Cretaceous periods. Ghazij shale is present underneath the thrust sheets. The Bibai nappe is nearly of uniform thickness in east-west direction in this area while the Gogai nappe is thicker westward and pinches out eastwards. The Bibai nappe, however, also pinches out about 5 km east of the study area.

STRATIGRAPHY

The following stratigraphic succession (Shah, 1977) occurs in the area:

Dhok Pathan Fm.	Pliocene	Clays with subordinate sandstone.
Nagri Fm.	Miocene	Sandstone with subordinate shale and conglomerate.
<hr style="border: 0.5px solid black; margin: 5px 0;"/> Unconformity <hr style="border: 0.5px solid black; margin: 5px 0;"/>		
Ghazij Fm.	Early Eocene	Shale with subordinate sandstone.
Dungan Fm.	Paleocene	Limestone with shale interbedding.
Bela Volcanic Group	Late Cretaceous	Shale, sandstone, conglomerate and volcanics.
Parh Limestone	Late Cretaceous	Limestone with chert nodules.
Goru Fm.	Early to Late Cretaceous	Shale with some marl and limestone.
Scmber Fm.	Early Cretaceous	Shale with subordinate limestone.
Loralai Limestone	Jurassic	Autoclastic and oolitic limestone with some shale.
Alozai Group	Triassic	Shale with subordinate limestone.

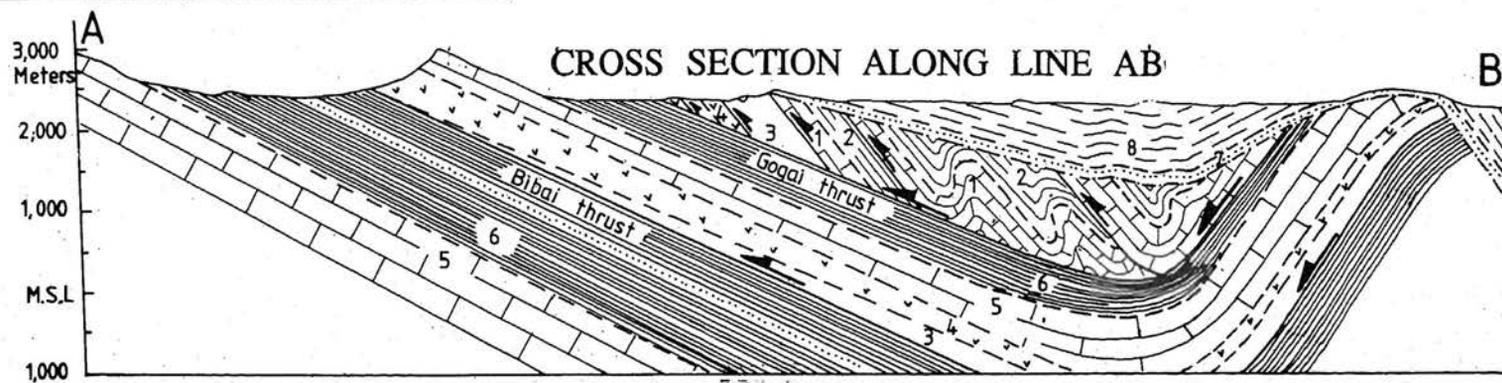
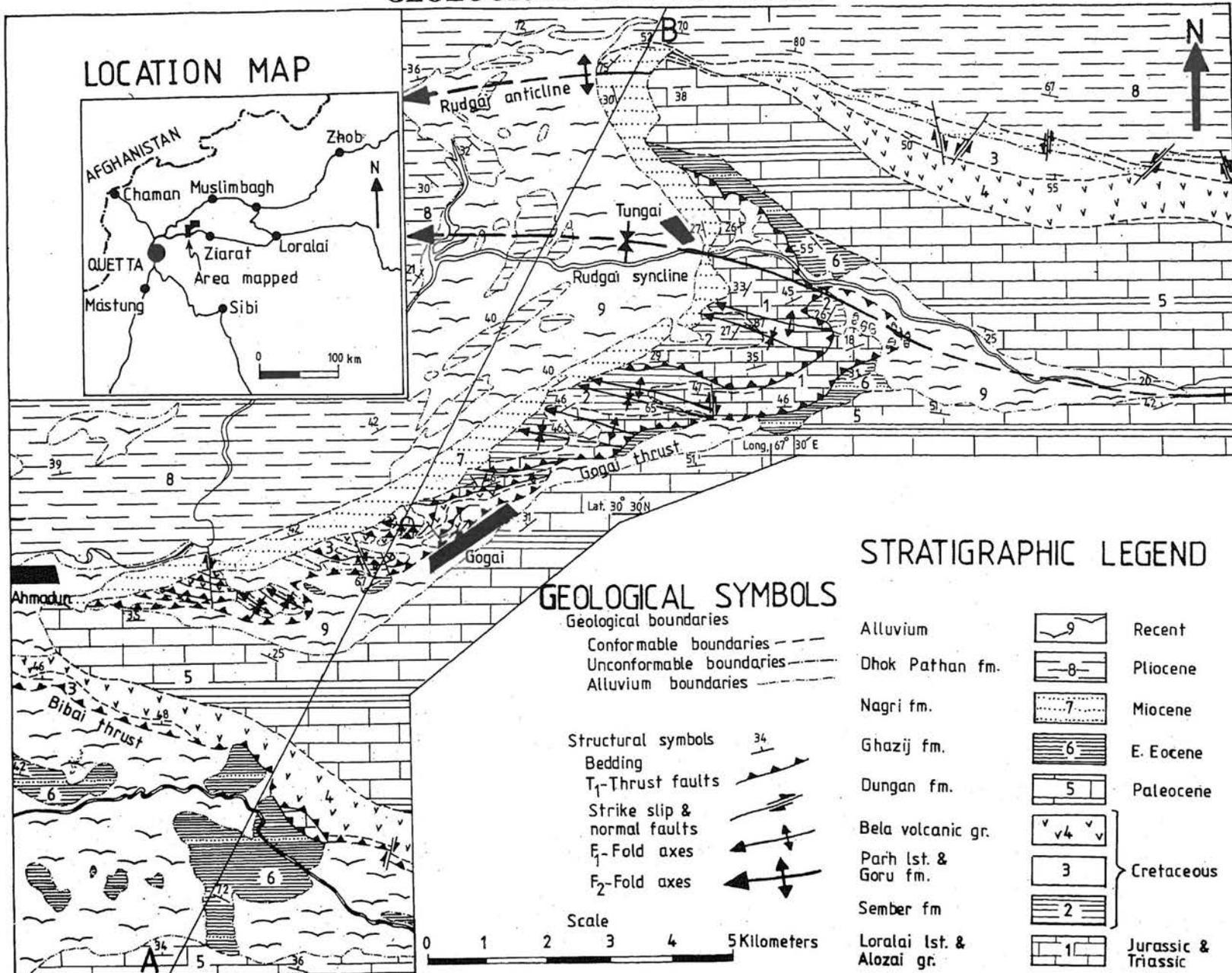
The rocks are not much tectonized in the Bibai thrust sheet. Some drag folding and thrusting can be seen at the base of the Bibai nappe. On the other hand, rocks comprising the Gogai nappe are strongly deformed and at some places occur as a package of thrust slices forming an imbricate zone verging southwards.

Two episodes of tectonic deformation can be observed in the area. The structures developed in the first deformation, i.e. thrusts (including Bibai and Gogai thrusts) and folds, behaved passively in the second deformation. The second deformation has rotated the earlier structures. The fold axes of the two deformation have the same orientation, i.e. WNW-ESE (Fig. 1) and they plunge towards WNW. Structures of both deformations, i.e. folds and thrusts, verge southwards.

TECTONIC HISTORY

The first deformation which was responsible for the emplacement of nappe structures took place after the deposition of Ghazij shale but prior to deposition of rock of the Siwalik group. Southward vergence of F_1 folds and T_1 thrusts indicates that the tectonic transport was from north. It is suggested that the Gogai nappe was emplaced first. In the north the thrust sheet probably slid on Lower Cretaceous and Triassic rocks while in the south, after climbing through frontal ramps, the sheet slid on Ghazij shale which provided a good flat for its emplacement (see Hubbert and Ruby, 1959; Gretener, 1981). The emplacement history of the Gogai nappe is

GEOLOGICAL MAP OF GOGAI



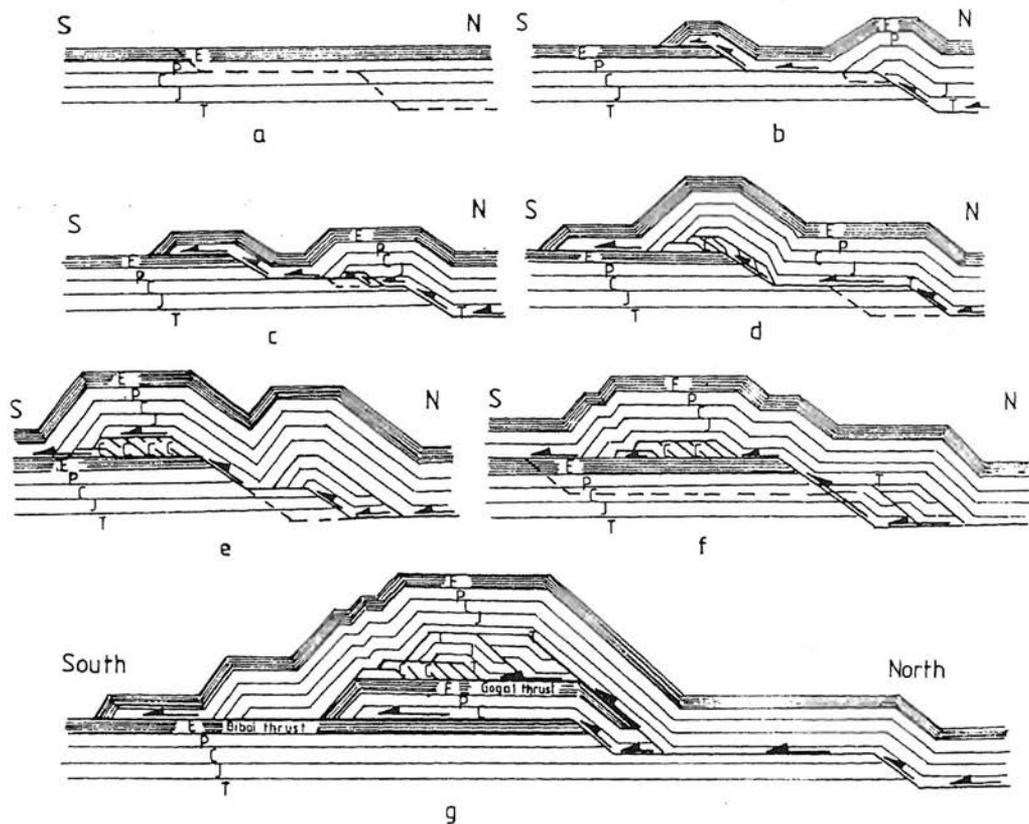


Fig. 2. A model to illustrate the emplacement history of Gogai nappe in various stages (a to f) and emplacement of Bibai nappe (g). Symbols are; T= Triassic, Aozai group; J= Jruassic, Loralai limestone; C= Cretaceous, Parh group; P= Paleocene, Dungan formation; and E= Eocene, Ghazij formation. All sketches are looking westward, drawn neither according to scale nor balanced. Thick lines are faults.

quite complex (Fig. 2a-F). It is a hinterland dipping duplex (c.f. Boyer and Elliott, 1982; Ramsay and Huber, 1987, p. 527) in which the Gogai thrust served as a floor thrust. An excellent imbricate zone of Parh group and Bela Volcanic group is present west of Gogai village (Fig. 1), where horses and splay faults all are dipping towards north. The emplacement of the duplex was in a piggyback fashion (Butler, 1983).

After the formation of the Gogai nappe, the Bibai nappe was emplaced southwards with former thrust sheet on its back (Fig. 2g). Contrary to the structures present in the lower part of the Gogai nappe, a blind imbricate fan is present in the lower part of the Bibai nappe where splay faults are dipping northwards (Fig. 3), branched off from the Bibai thrust.

The allochthonous blocks may have travelled tens of kilometers. It is difficult to give a rough estimate of displacement because the thrust sequence is overlain by post-deformation rocks in the north. However, the displacement looks to be of a greater magnitude along the Gogai thrust as compared with that of Bibai thrust, because (1) the rocks are more strongly

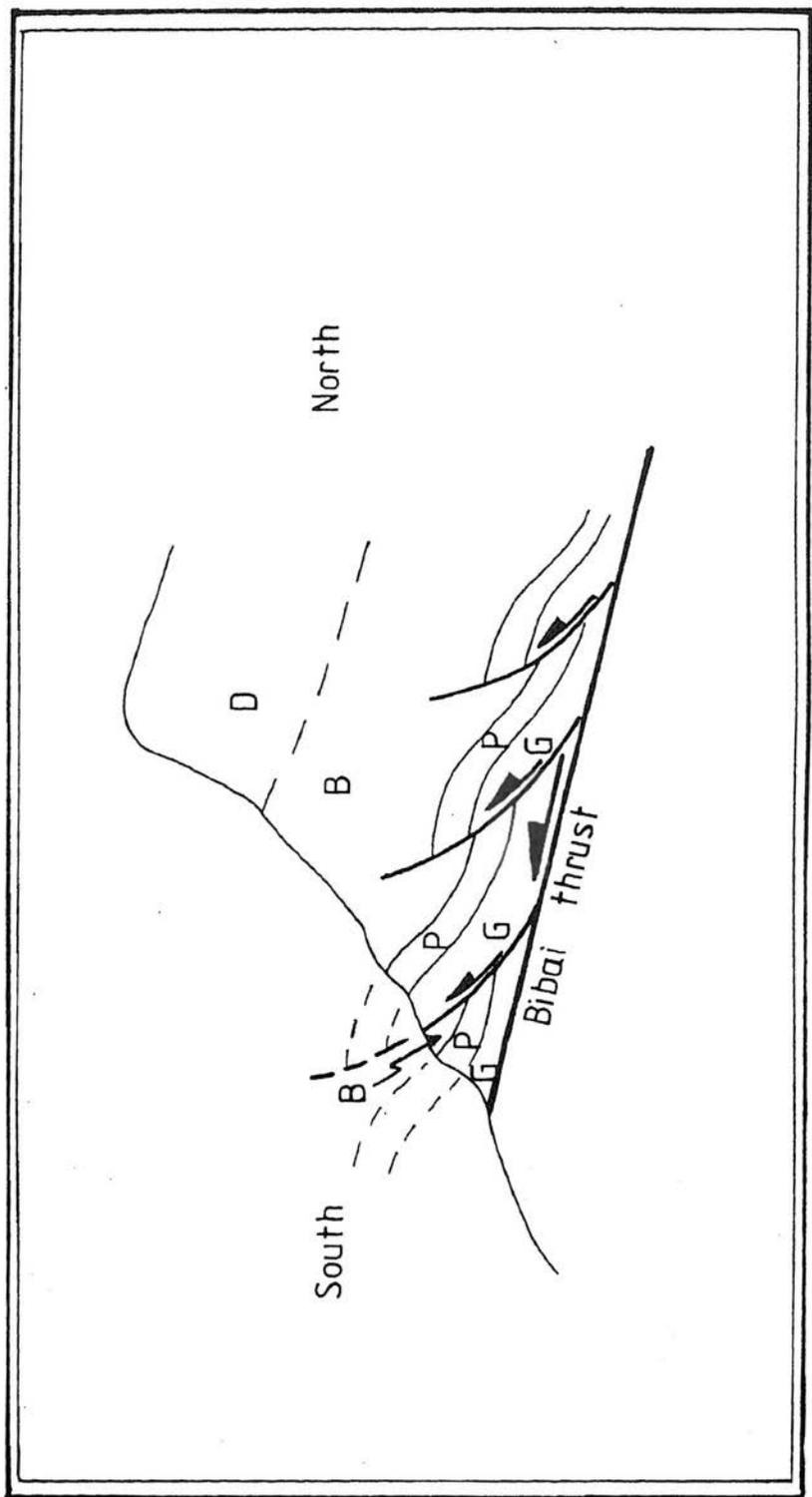


Fig. 3. Blind imbricate zone associated with Bibai thrust. Tip lines of splay faults are not reaching at the erosion surface except close to Bibai thrust which is due to later erosion. Sketch is looking westward and is not according to scale. Symbols are: Gh= Ghazij formation, G= Goru formation, P= Parh limestone, B= Bela volcanic group, and D= Dungan formation.

deformed at the base of Gogai thrust than those at the base of Bibai thrust, (2) The Parh limestone, present in Gogai nappe is quite different in lithology than that present in the Bibai nappe (Kazmi, 1979), while there is not much difference in lithology of Parh limestone present on the two sides of Bibai thrust, and (3) excellent slump structures in the Parh group of Gogai nappe suggest that these rocks were deposited on the continental slope while the same formation is well bedded at the base of Bibai nappe indicating deposition on continental shelf. All these observations indicate that a considerable tectonic transport was involved in the emplacement of Gogai nappe which brought together rocks which were diversely deposited.

After the formation of nappe sheets which were emplaced more or less on subhorizontal flats, the thrusting stopped and the thrusts and nappe structures were gently folded, followed by the deposition of the Siwalik group rocks. The employment of nappes can be correlated to collision of the Indian plate with Eurasia (Powell, 1979; Schwan, 1985) in Eocene-Oligocene epochs. It is important to note that these ages are post Ghazij, which served as flats for emplacement of these thrust sheets. The second deformation which started in Pliocene and accelerated in Pleistocene, folded older rocks, nappe structures and the Siwalik group rocks.

CONCLUSIONS

1. The structural data indicate a thin skinned tectonic model for the emplacement of nappe structures in which extensive folding, thrusting, imbrication and duplex formation took place in the area and Gogai village.
2. The vergence of F_1 folds and T_1 thrusts indicate that the nappes were emplaced from north.
3. Thrusting started from north, i.e. first the Gogai nappe was emplaced which was followed by emplacement of the Bibai nappe.
4. Duplex formation took place on the Gogai thrust. It is a hinterland dipping duplex disposed in piggyback fashion.
5. A blind imbricate fan developed along the Bibai thrust.
6. Greater tectonic transport was involved in the emplacement of the Gogai nappe as compared to Bibai nappe.
7. The nappes were emplaced between Middle Eocene and Early Oligocene.

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