TECTONO-STRUCTURAL ATTRIBUTES OF CENTRAL KACHCHH MAINLAND WITH SPECIAL EMPHASIS ON ACTIVE TECTONICS AND PALAEOSEISMICITY*

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EXTENDED ABSTRACT

Introduction

The Kachchh peninsula, an intra-cratonic basin forms a part of the western continental margin. Numerous E-W and WNW-ESE trending parallel sets of faults in the region have played a vital role in the evolution of the present day landscape of Kachchh represented by uplifts and depressions (Biswas, 1987). Except for Biswas (1980, 1987), the structural, tectono-geomorphic and seismotectonic aspects of Kachchh region have not received adequate attention in the past. This study involving central part of Mainland Kachchh provides information, which enables a better understanding of tectonic aspects of *Katrol Hill Fault Zone* (KHFZ). The results of the investigations carried out have provided vital information, which is of considerable relevance towards unraveling the tectonic and seismic set-up of the region as a whole. An attempt has been made to describe the spatial distribution and geometry of various faults. Also, the folding and doming in *Central Kachchh Mainland* (CKM) are described and a model suggesting the genetic mechanism responsible for the folding in Katrol Hill Fault Zone (KHFZ) has been proposed.

Structure

The region provides an avenue to study spatio-temporal distribution of a variety of structures. Although the study emphasizes on general structural pattern of the area, due to the conspicuous occurrence of variety of faults, the faulting attributes of CKM have received greater attention. The *normal faults* in CKM occur throughout the exposed Mesozoic succession but most of these are encountered in the Late Cretaceous Bhuj formation. Sedimentary succession of the studied region is characterised by several zones of detached normal faults (faults that do not penetrate basement) and show differential morphologic geometry. The exposed faulted sections, which appear simple at the exposure scale, often contain more complex patterns of interaction and linked segments. Such a variation is on account of changing mechanism and superposed tectonic events. Field observations indicate that *reverse faults* are present within the deformed Katrol Hill Zone only (i.e. the zone to the south of KHF). Almost all the faults observed are oriented roughly in the E-W direction and the associated beds show conspicuous drag effect, indicative of N-S horizontal shortening. Various small and large *strike-slip faults*, exposed throughout the study area at most places show a distinct segmentation, a phenomena typical of strike-slip fault zones. All the major strike-slip faults encountered in the area trend dominantly in N-S, NNW-SSE and NNE-SSW directions. These faults can be seen transecting as well as cutting the KHF and are related to the stress pattern that caused reversal along KHF, and thus are coeval and genetically part and parcel of the same stress field.

Apart from faulting, conspicuous folding is other phenomenon observed in CKM. According to Biswas (1987) the folding seen along the major faults is on account of gravitational necking of sediment along the fault planes. Several evidences such as the exposure scale detachment folds and fault propagation folds exposed along the Katrol Hill Fault (KHF), Kachchh Mainland Fault (KMF) and Island Belt Fault (IBF) point to the influence of compressional shortening. Such evidences therefore, lead to the difficulty to explain both i.e. the vertical uplift along the major faults and the compressional horizontal shortening with similar mechanism. The present study indicates that all the major faults have slips from south and point to the fact that all of these dip due south in the direction of displacement. The present day structure of the region is a case of structural inversion with all the major faults showing inversion, related to horizontal shortening on account of compressive stresses. The initial dip of all the major normal faults may have been modified making them gentle in nature due to horizontal shortening.

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Jointing is one of the other group of meso-scale structures seen widely developed on CKM. Extensive jointing is seen in the rocks of practically all the age groups. However, the Lower Cretaceous Bhuj sandstone shows the most intensive jointing. The interesting part as can be seen from various field exposures is that all the three Mesozoic Formations (i.e. Bhuj, Katrol and Chari) show the development of orthogonal joint sets, where one set is roughly perpendicular to the fold axis and the other near orthogonal to it. The presence of such joint sets in CKM and essentially in Katrol Hill Range indicate that these must have formed in relation to the major structural inversion resulting in the development of the fault propagation folds.

Tectonic Geomorphology

Tectonic geomorphology has of late become an important tool to study recent crustal deformation and is even more relevant in areas such as the present one, where the information is lacking in terms of *in situ* stress measurements and other geophysical data by which some idea about the recent crustal instability could be obtained. In the present study different methods and approaches of modern tectonic geomorphology are used to study neotectonics aspects. The observations such as formation of terraces (Sohoni et al. 1999) and narrow and deep river gorges point to the strong influence of the tectonic activity on the CKM in the Quaternary times. The conclusions drawn from the field observations are well supported by the morphometric analysis of the various geomorphic parameters. The studies carried out on individual longitudinal profiles of number of streams draining north and south of KHF, essentially with a view to identify river response to active tectonism. Various morphometric parameters viz. Pseudo Hypsometric Integral (PHI), Sinuosity Fractal Dimension (*SFD*), Gradient Index (GI) and Gradient (slope) were studied to estimate the role of active tectonics on river channel morphology. Along with this, a relatively new approach to study the drainage behaviour on individual fault blocks has also been followed. The drainage related morphometric parameters indicate that there is strong influence of active tectonic activity on the rivers draining the CKM. However, it is seen that area to the south of KHF is comparatively tectonically more unstable than its northern counterpart. Our studies indicate that the KHFZ is one of the most active areas of the Kachchh region. The alluvial fan formation along the Kachchh Mainland Hill Range and subsequent incision of fans further add to the evidences suggesting an active tectonic control (Malik et al. 2001) on the general architecture of the CKM.

Palaeoseismicity and Seismotectonics

The Kachchh region has a long history of earthquakes of varying magnitudes. The Kachchh region including the Great Rann and Banni Plains fall in the seismically active region (Zone V) and has experienced several large magnitude earthquakes in recent and historic past. It is interesting to know that all the major towns of the region have a long history of recurrent earthquake shocks. The Rann and the Banni region have preserved with them a variety of deformational features related to seismic activity. The structures are widespread around Bhirandiala, Ludiya and Allah Band (Sohoni and Malik, 1998). Original flat topography and absence of overburden rules out the possibilities of the structures being influenced by burial related to non-seismic deformation or by slope failure. The lack of soil development at all the sites indicates that the event must have occurred sometime in recent past. The formation of the seismicity-related structures in the upper portion of the Banni-Rann sediments points to these being related to some of the more recent historical earthquakes of relatively high magnitude. Several deformational structures in Mesozoic and Tertiary strata were also recorded which are similar to seismites. Occurrence of small-scale folding and associated micro-faulting have been observed in the sandstone strata of Mesozoic age near Bhuj. Similar structures have been reported by Seth et al. (1990) from the Mesozic rocks. The structures in unconsolidated sediments provide a window towards understanding the numerous occurrences of comparable/identical structures in older consolidated sequences. It is thus possible not only to conclusively establish a seismic origin of such deformational structures, but also enable one to explain the origin of similar structures in older consolidated sequences whose origin could otherwise have remained ambiguous.

Conclusions

Some of the important conclusions may be summarised as follows:

1. The Kachchh region in general and study area in particular has undergone structural inversion resulting in the formation fault propagation folds. The doming and folding in the area are genetically unrelated, where the doming may have been on account of igneous activity and the folding on account of horizontal shortening
2. The reverse faults striking E-W in general are essentially found in the Katrol Hill Range and are the result of the compressional stresses responsible for bringing out selective reactivation of the existing

normal faults. Most of the strike-slip faults essentially strike N-S, NNW-SSE, NNE-SSW and are part of the NE directed compressional stresses.

3. The near orthogonal joint sets in Central Kachchh Mainland are related to the major folding on account of fault propagation and sudden change in least principal stress axes in the perpendicular directions.
4. The CKM in general and KHFZ in particular have experienced at least three events of uplift, one coinciding with the major inversion event, which resulted in the large-scale drainage reversal and the other two post-dating it. The chronology of the later events is inferred on the basis of individual terraces exposed within the CKM and KHFZ.

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