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Magnetic fabric variations along the fault related anticlines of Eastern Kachchh, Western India

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ABSTRACT

An investigation of the anisotropy of magnetic susceptibility (AMS) along the Kachchh Mainland Fault (KMF) and South Wagad Fault (SWF) in the eastern Kachchh has been carried out to determine the variation of magnetic fabric in different anticlines. 105 cores drilled from 35 Jurassic sandstone samples collected from both forelimbs and backlimbs of the anticlines are analyzed. The various types of fabrics from the three sites indicate essentially three stages of generation of magnetic fabric. The sedimentary fabric (type I) is affected a) initially by layer parallel shortening, resulting in the development of type-III fabric with oblique to parallel bedding and magnetic foliation, b) later by bedding parallel shear associated with the rotation of limbs resulting in the tectonic fabric type-IV and c) finally by bedding parallel thrusting, dominantly in the backlimbs resulting in the imprint of higher tectonic fabric type-V/VI. About 14% of the sampled sites belong to the sedimentary type-I fabric, 54% to the type-III and 32% show tectonic fabric (type-IV and V/VI). The different stages of fabric evolution are not accompanied by linear increase in the degree of anisotropy, but show construction and destruction of magnetic fabric during the layer parallel shortening to late stage bedding parallel thrusting. The tectonic magnetic lineation orientations are mostly not consistent with the bedding strikes or fold axes. The intermediate fabric lineation direction of NNE–SSW is superimposed by later tectonic lineation with varying orientations of NW–SE in the western end to NNE–SSW to NNW–SSE along the eastern end of KMF. We attribute the variations in shortening direction essentially to the transpressional deformation of the basin in general, and individual anticlines in particular. The variation in slip/propagation ratio along individual segmented faults has resulted in the rotation of fold limbs.

1. Introduction

In fold and thrust belts, fault related folds are common. The weakly deformed rocks, however, do not show strong evidences for internal deformation. The studies by Borradaile and Tarling, (1981), Averbuch et al. (1992), Parés et al. (1999), Saint-Bezar et al. (2002) and Luo et al. (2009) have demonstrated that some weak internal deformation does occur in such rocks. Generally three components of deformation, rigid body translation, folding and internal strain (Ramsey and Huber, 1983) occur when thrust sheets move. However, the deformational interrelationship between the three components is complex and not always straightforward, since they usually occur in combination. The evolutionary kinematics of thrust related structures can be determined based on finite strain analysis and balanced cross section. The creation of thrust related fold structures generates two different types of strain (Saint-Bezar et al., 2002); a) strain related to the development of pre-folding layer parallel shortening (LPS) and b) strain related to type of folding, fault bend folding (Suppe, 1983), fault propagation folding (Suppe, 1985; Suppe and Medwedeff, 1990; Mercier et al., 1997) or trishear fault propagation folding (Hardy and Ford, 1997; Allmendinger, 1998). If folds develop oblique to the main tectonic transport direction, then analysis of LPS should provide information about the shortening direction.

The anisotropy of low field magnetic susceptibility (AMS) provides a powerful and rapid technique to examine the preferred orientations of mineral fabrics to study the kinematics of fault related folds. This method helps to ascertain the distribution of strain in regions that are devoid of mesoscopic and microscopic strain markers. It allows studying the pattern of strain in rocks both during their formation and their subsequent deformation (Hrouda, 1991; Hrouda, 1993; Tarling and Hrouda, 1993; Borradaile and Henry, 1997; Aubourg et al., 1997, 1999; Borradaile and Jackson, 2004) and therefore, provides a rich source of information on tectonic evolution.

The Kachchh basin in western India is an example where the fault related fold growth commenced due to the structural inversion in Tertiary time, and continues till today (Mathew et al., 2006; Karanth and Gadhavi, 2007). The active growth of several E–W trending faults controls the basin architecture and strain enhancement. The

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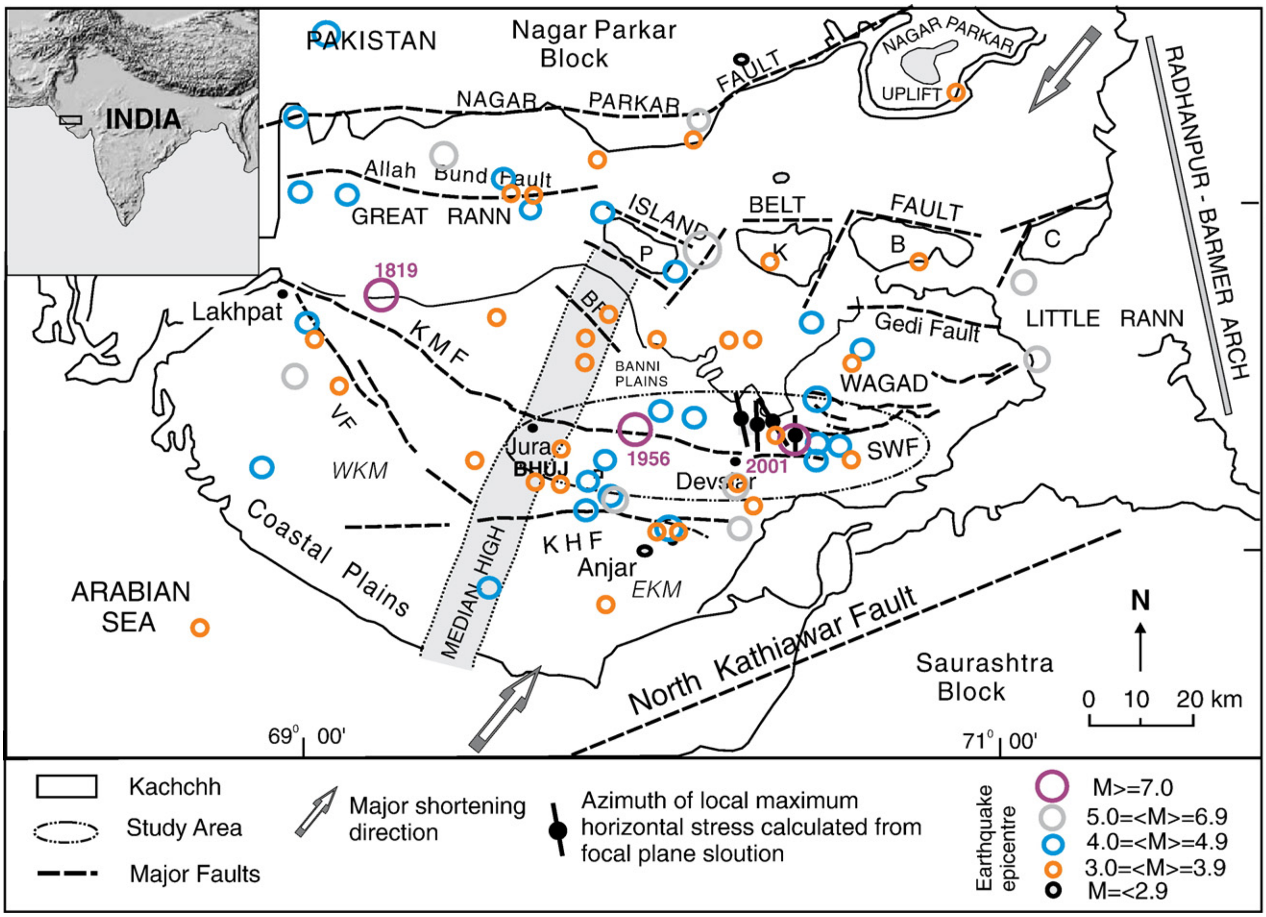

Fig. 1. Seismotectonic map of Kachchh showing epicenters of major and minor seismic events. KMF–Kachchh Mainland Fault, KHF–Katrol Hill Fault, VF–Vigodi Fault, BF–Banni Fault, SWF–South Wagad Fault, P–Pachham Island, K–Khadir Island, B–Bela Island C–Chorar Island, EKM–Eastern Kachchh Mainland and WKM–Western Kachchh Mainland (modified after Biswas and Khatri, 2002; Mathew et al., 2006).

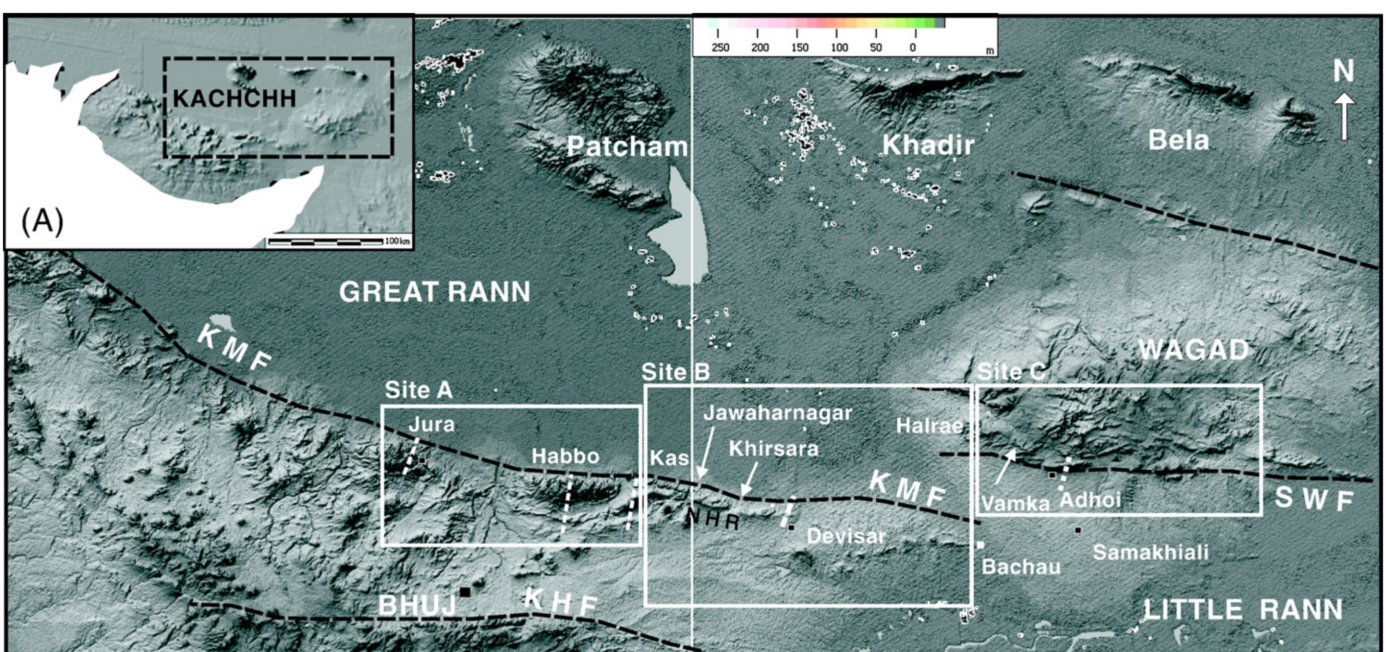

Fig. 2. SRTM digital elevation data of Kachchh (Level 1, 3 arc second). A) The Kachchh region. Black broken lines show the limits of fig. b. B) The study area and the three sites of sample locations. Black broken lines indicate the thrust faults and white broken lines indicate topographical profile across KMF and SWF.