The potential record of far-field effects of the India-Asia collision: Barmer Basin, Rajasthan, India

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The timing of the collision of the Indian plate with the Asian plate to create the Himalayas is broadly dated at ca 55-50 Ma. However, the extent and duration of deformation caused by the collision remote from the Himalayan mountain belt remains poorly understood. In particular, the nature and extent of foreland uplift and the initial Himalayan fore-bulge is poorly defined (Bera and Mandal, 2013), as is the extent of Himalayan compression. The Barmer Basin, Rajasthan, situated 800 km from the Himalayan front and 400 km from the Kirthar Mountains / Central Bruhui Range of Pakistan, is one basin where it has been proposed that far-field effects of India-Asia collision are evident (Compton, 2009). It is a major oil and gas producing region, with hydrocarbon generation and migration potentially influenced by Himalayan tectonic events. Until recently, the scale, structure and geology of the Barmer Basin were poorly constrained and only since subsurface and well data became available over the last decade has an appreciation of the significance of the basin been achieved (Bladon et al., in review; Dolson et al., in review); a rift-related setting but with regional tilting and reactivation of basement structures on the Indian craton potentially due to the India-Asia collision.

The Barmer Basin is a long (200 km), narrow (<40 km) and deep (<6 km), north-northwest trending, failed continental rift covering ~6800 km^2 principally situated in Rajasthan, northwest India (Figure 1a). The basin forms the northward extension of the Kutch and Cambay basins via the Sanchor and Tharad sub-basins within the West-Indian Rift System (Bladon et al., in review).

The main phase of extension within the Barmer Basin *sensu stricto* occurred between the late Cretaceous (Maastrichtian) and mid-Eocene (Lutetian) (Bladon et al., in review). The basin fill incorporates Lower Jurassic (Lathi Fm.) and Lower Cretaceous (Ghaggar-Hakra Fm.) pre-rift continental clastic successions. Syn-rift sedimentary successions are predominantly Paleocene to Eocene in age, and indicate a relative increase in water depth, with a progression from fluvial, through lacustrine, to shallow marine deposition (Dolson et al., in review). Latest Cretaceous (Maastrichtian) to Lower Palaeocene (Selandian) fluvial sandstones and lacustrine deposits (Fatehgarh Fm.) are deposited following a ~30 Ma hiatus. The Barmer Hill Formation overlies this succession, recording a complex array of different sedimentary styles filling the basin including: gravity flow deposits, lake margin deltaic sediments, diatomites, and pelagic mudstones. Deposition of these units is followed by the predominantly claystones of the Dharvi Dungar Formation (upper Thanetian-Ypresian) and the Thumbli, Akli and Nagarka Formations (Ypresian-Lutetian). Finally Miocene to Recent sediments unconformably overlie this succession (Jagadia and Uttarlai Formations). A major unconformity separates Lutetian and Miocene sediments, the Oligo-Miocene Unconformity (Compton, 1999).

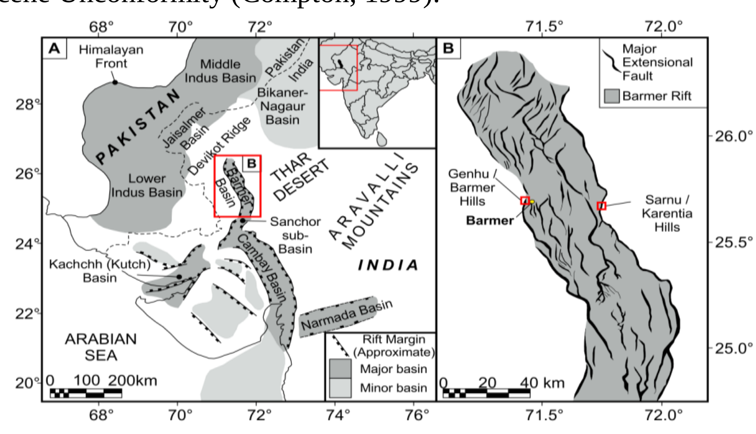

Figure 1: a) Onshore rift basins of northwest India, the West Indian Rift System (WIRS), incorporating the Kachchh (Kutch), Cambay, Barmer, and Narmada basins (location within India inset). b) Current basin-wide structural interpretation based on subsurface data alone [location highlighted in (a)] (Adapted after Bladon et al., in review)

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Previous workers have proposed effects of the Himalayan Orogeny to explain a number of features present in the Barmer Basin, including the small angular unconformity at the Paleocene-Eocene transition, the influx of sediment in the Early Eocene which is ascribed to uplift of the northern margin of the basin, and the Oligo-Miocene unconformity (Compton 2009; Dolson et al., in review), evidence of N-S and NNE-SSW compressive stress directions (Compton 2009), and >1km of uplift in the north of the Basin (Dolson et al., in review). This work documents and investigates the regional compression and Oligo-Miocene uplift, and considers it in light of the possible far-field effects of the India-Asia collision. To achieve this, the work:

1. Documents and dates compressional structures providing evidence of inversion using public and company seismic data to record the amount of inversion along reactivated structures and determine which successions are affected, thus dating compressional events. Previous work has not identified any evidence of inversion or reactivation at outcrop scale within the eastern basin margin (e.g., Sarnoo (Sarnu) Hills; Figure 1b; Bladon et al., in review). However, non-coaxial extension structures have been identified leading to differential fault networks within the Barmer Basin (Bladon et al., in review). Within the western basin margin, potential small-scale reactivations of Malani basement-derived faults and steepening of pre-existing extensional faults have been suggested to indicate inversion (e.g. Barmer Hills; Figure 1b). Structural inheritance combined with potential reactivation of pre-existing non-coaxial fault networks during the India-Asia collision has major implications for basin compartmentalisation.
2. Documents, dates and considers the extent of the Base Miocene (Oligocene) Unconformity (BMU) within the Barmer Basin using public and company seismic data. Previous work has identified a major Oligocene unconformity along the entire length of the Himalayan peripheral foreland basin (e.g., Kohat Plateau; Hazara Syntaxes; Sabathu / Jammu / Kangra sub-basins e.g., DeCelles et al., 1998; Najman et al., 2004; Bera & Mandel, 2013). Development of this unconformity has previously been suggested as a result of tectonic processes associated with collision and / or a passage of a flexural forebulge (Najman et al., 2004; DeCelles et al., 1998; 2004; Irfan et al., 2005; Bhatia and Bhargava, 2006; Bera et al., 2010). This has been contradicted by Bera and Mandal (2013). A similar-aged unconformity is identified within the Barmer Basin (Compton, 1999) but is not present in all surrounding basins. Documentation of this unconformity beyond the extent of the foreland basin and Himalayan fore-bulge could require a revision of previous suggestions regarding the cause of the foreland basin unconformity and opens up the possibility of different interpretations to explain the hiatus (e.g. perturbations in the mantle such as those potentially caused by slab break off).

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