Paleogeological Evolution of The Kutch Rift Basin, Western India: Stratigraphic, Structural and Paleoenvironmental Reconstruction

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***Abstract*—The Kutch Basin of western India represents a pericratonic rift basin formed during the Late Triassic breakup of Gondwanaland. It preserves a thick Mesozoic–Cenozoic sedimentary succession overlain by Deccan Trap volcanics, offering a significant archive for paleogeological reconstruction. This study integrates stratigraphic succession, lithological characteristics, fossil assemblages, structural framework, and tectonic evolution to reconstruct the paleoenvironmental history of the basin. Jurassic formations indicate shallow marine to sub-littoral conditions marked by politic limestones, fossiliferous sandstones, corals, and ammonites. A shift to fluvio-deltaic and marginal marine environments during the Cretaceous reflects regression and basin reorganization prior to Deccan volcanism. Major E–W trending faults such as the Kutch Mainland Fault controlled sedimentation patterns, basin subsidence, and later inversion tectonics. The basin evolved through rifting, inversion, strike-slip reactivation, and magmatic intrusion phases. The integrated analysis suggests that the Kutch Basin records the transition from a marine rift setting to an inverted tectonic basin influenced by Indian plate dynamics. The study highlights its importance in understanding Tethyan paleogeography and intraplate tectonics of western India.**

***Index Terms*—Kutch Basin, Paleogeology, Rift Basin, Jurassic Stratigraphy, Tethyan Sea, Basin Inversion, Deccan Trap, Marine Transgression.**

I. INTRODUCTION

The Kutch Basin, located in Gujarat, western India, is one of the most significant Mesozoic sedimentary basins of the Indian subcontinent. It represents a pericratonic rift basin formed during the fragmentation of Gondwanaland in the Late Triassic. Due to its well-exposed stratigraphic sections and fossil record, it serves as an important site for paleogeological and paleoenvironmental studies.

The basin preserves approximately 2000–3000 m of Mesozoic sediments overlain by nearly 1000 m of Cenozoic deposits and Deccan Trap volcanics. The objective of this study is to reconstruct the paleogeological evolution of the basin using stratigraphy, paleontology, structural geology, and petrography

II. GEOLOGICAL SETTING

The Kutch Basin is bounded by major E–W trending faults including: Kutch Mainland Fault (KMF), Island Belt Fault (IBF) Nagar Parkar Fault (NPF), North Kathiawar Fault (NKF).

The basin formed as an extensional rift during the Late Triassic and evolved through multiple tectonic phases including rifting, inversion, and strike-slip reactivation. It slopes south- westward and consists of uplifted blocks and residual depressions forming the present physiography of mainland Kutch, Banni plains, and the Rann.

III. STRATIGRAPHIC FRAMEWORK

3.1. Mesozoic Succession

The Mesozoic succession comprises four major formations:

Jhurio Formation (Middle Jurassic)

Dominated by limestone, shale, and golden oolites deposited in sub-littoral marine environments.

Jumara Formation (Middle–Upper Jurassic)

Argillaceous shales and oolitic limestones reflecting shallow marine conditions.

Jhuran Formation (Upper Jurassic)
Alternating sandstone and shale units representing transitional marine settings.

Bhuj Formation (Lower–Upper Cretaceous)
Non-marine sandstones and fluvio-deltaic deposits indicating regression and continental influence.
These formations record repeated marine transgressions and regressions linked to Tethyan sea-level fluctuations.

IV. PALEONTOLOGICAL EVIDENCE

The fossil record provides strong evidence of marine paleoenvironments. Corals (Scleractinian corals) indicate reefal or shallow marine conditions. Ammonites confirm Jurassic marine transgressions.
Oolitic limestones reflect high-energy shallow marine shoals. Fossiliferous sandstones show marine fauna adaptation.
The fossil assemblage suggests warm, shallow Tethyan marine conditions during the Jurassic, followed by regression and marginal marine conditions in the Cretaceous.

V. PETROGRAPHY AND LITHOLOGY

Petrographic analysis reveals:
Oolitic limestone indicating shallow marine carbonate platform deposition. Fossiliferous sandstone with quartz overgrowth cementation.
Ferruginous sandstones reflecting diagenetic processes.
Basaltic flows and intrusive bodies associated with Deccan volcanism.
Microscopic textures such as porphyritic basalt, intersertal texture, and bioclastic limestone support both marine sedimentation and magmatic phases.

VI. STRUCTURAL EVOLUTION AND TECTONICS

The structural framework is controlled by E–W trending master faults. The tectonic evolution occurred in three major phases:
Rift Phase (Late Triassic–Early Cretaceous), Normal faulting and sediment accumulation in half-grabens. Inversion Phase (Late Cretaceous)
Compressional stress caused uplift and reactivation of faults. Strike-Slip Phase (Post-Cretaceous to Recent)
Right-lateral movement along KMF and related faults. The 2001 Bhuj earthquake highlights ongoing tectonic activity, confirming that the basin remains structurally active.

VII. PALEOGEOGRAPHIC RECONSTRUCTION

During the Middle–Upper Jurassic, Kutch was part of a shallow Tethyan sea characterized by carbonate platforms and reefal environments. Progressive regression during the Cretaceous led to deltaic and fluvial sedimentation. Late Cretaceous Deccan volcanism dramatically altered the paleogeography.

Thus, the basin records transition from:
Marine Rift Basin → Marginal Marine Setting → Continental Fluvio-Deltaic System → Volcanic Plateau → Inverted Tectonic Basin

VIII. DISCUSSION

The Kutch Basin provides critical insights into:
Gondwana breakup dynamics Tethyan marine paleoenvironments Basin inversion tectonics Interaction between sedimentation and volcanism Intraplate seismicity
Its stratigraphic continuity and fossil diversity make it one of the most important paleogeological archives in India.

IX. CONCLUSION

The Kutch Basin evolved as a pericratonic rift basin during the breakup of Gondwanaland and experienced marine transgressions during the Jurassic, regression and fluvio-deltaic sedimentation during the Cretaceous, followed by Deccan volcanism and tectonic inversion. Structural reactivation continues to influence the basin today. The integrated stratigraphic, paleontological, and structural analysis confirms its importance for understanding Mesozoic paleogeography and Indian plate tectonics.

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