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Neotectonic Behavior Of Transverse Faults In Central Mainland Kachchh, Western India: Case Studies Of Kodki, Ratiya And University Faults

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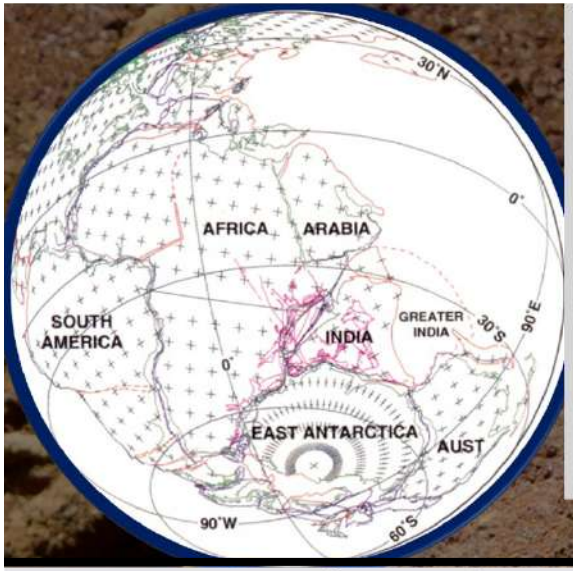
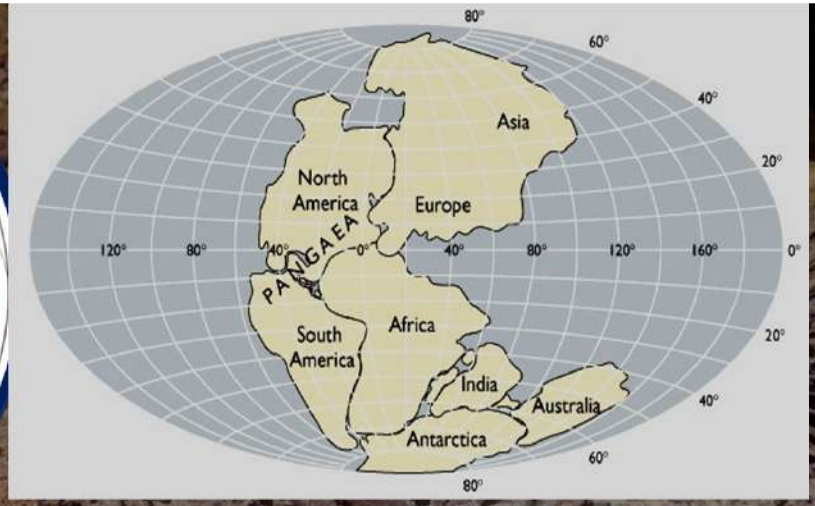
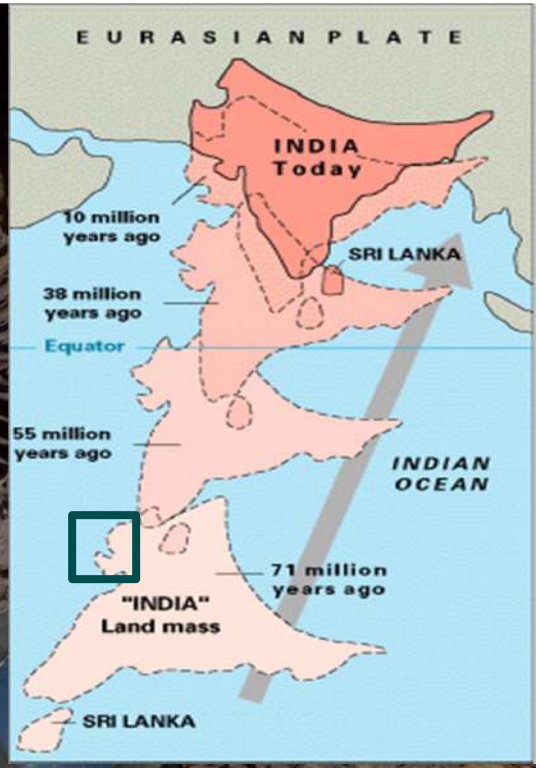
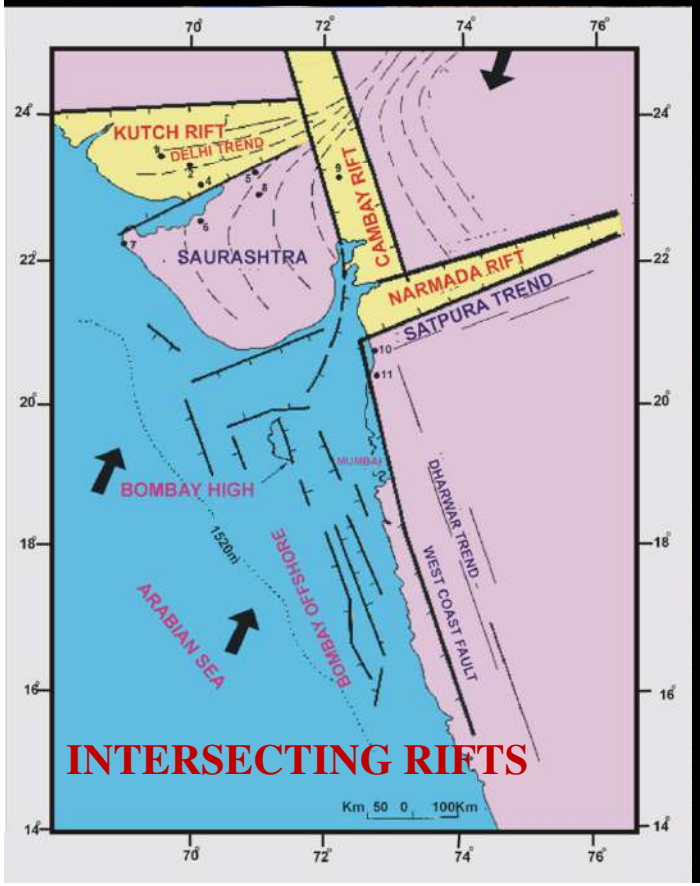




CONTINENTAL DRIFTING:

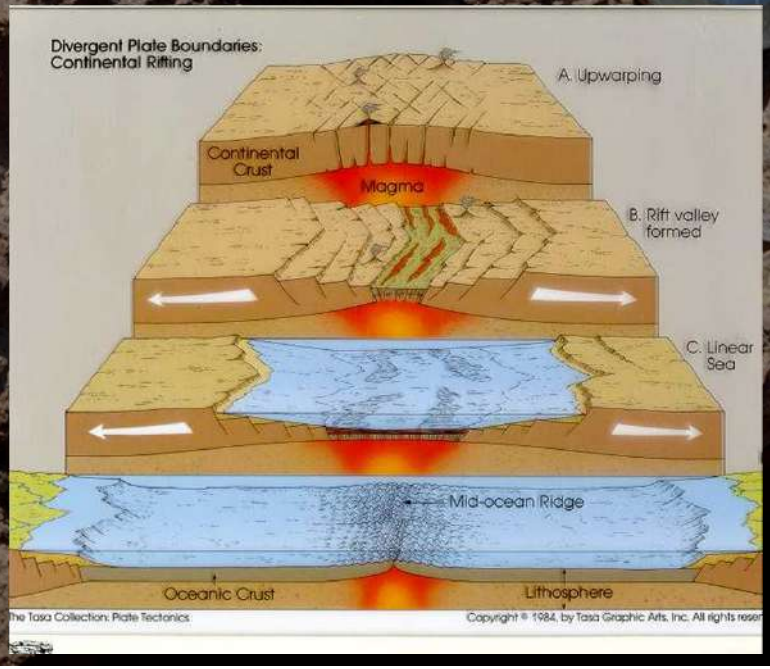
PRE-JURASSIC POSITION OF THE CONTINENTS





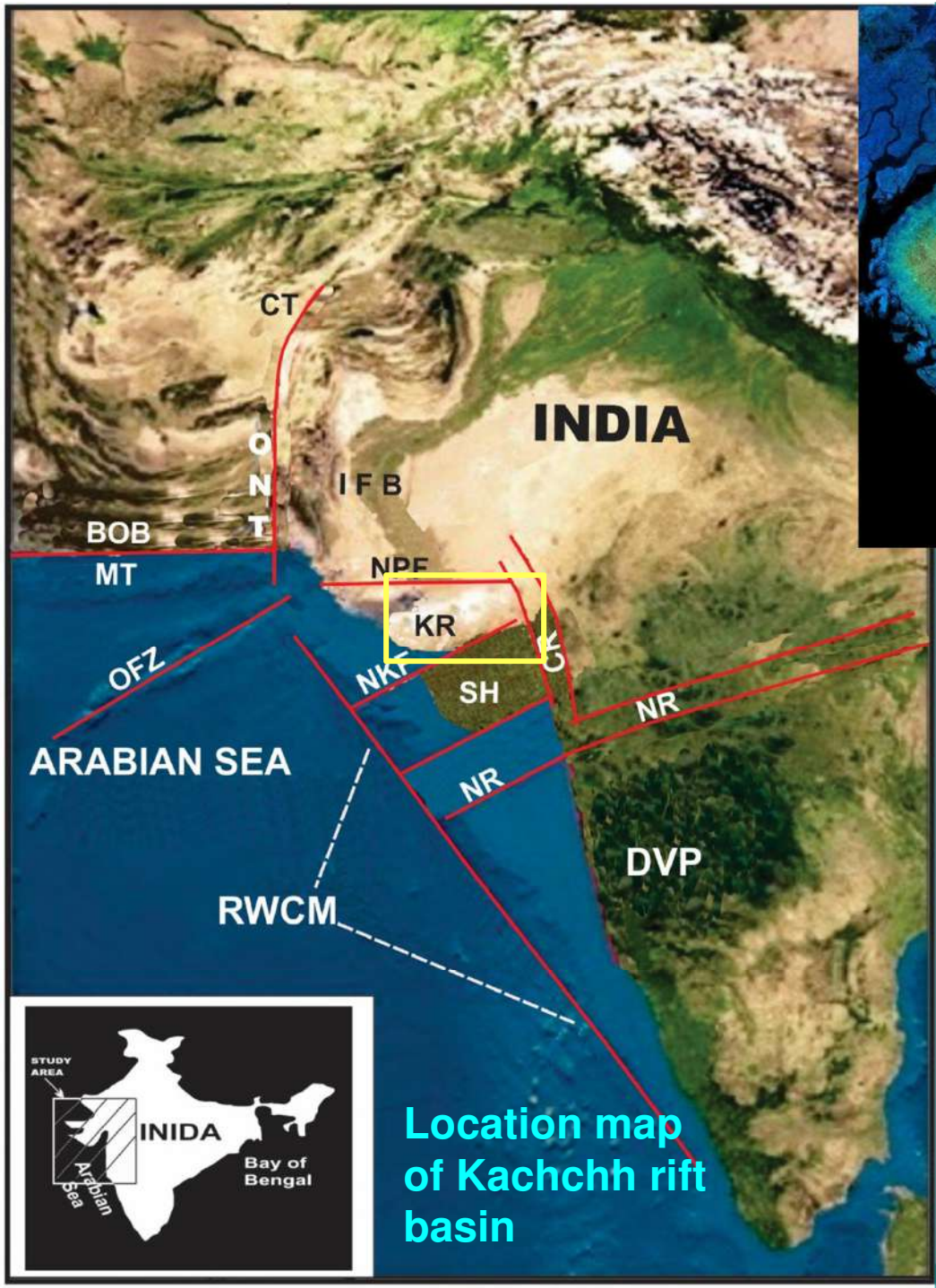
INTERSECTING RIFTS

Kachchh rift model

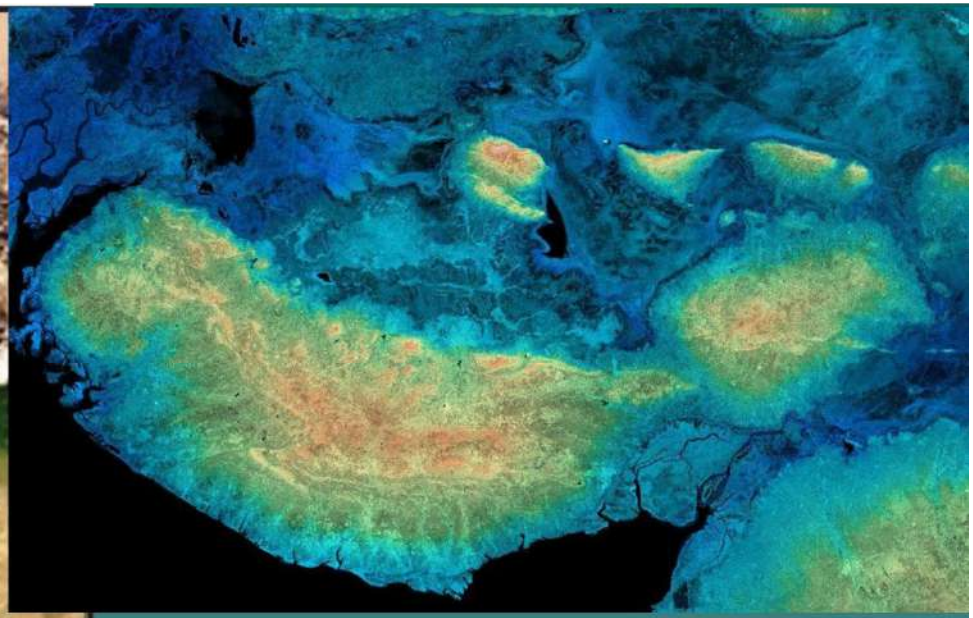


Rifting generated the normal tectonics and open embayment – half graben system in the western margin of Indian plate

On this basement the Jurassic rocks laid down



Location map of Kachchh rift basin



Location of Kachchh Rift basin in Indian plate context.

See the Kachchh Rift is situated to the south of Indian foreland basin, north of Kathiyawar horst and west of the Cambay Rift.

- It is a marginal cratonic basin bounded by NPF – Nagar Parkar Fault and NKF – North Kathiyawar Fault

(Top) DEM of Kachchh basin

Basin Evolution

1. Gondwana Fracturing
2. Rifting
3. Rift basin formation
4. Rift sedimentation (continental to shallow marine and carbonates)
5. Drifting and continental deposition
6. Sagging
7. Sag basin formation
8. Half graben open embayment basin
9. Marine transgressive and regressive sediments
10. Rift inversion
11. Half graben formation
12. Formation of Banni, Rann and various uplifts

TRIASSIC to EARLY JURASSIC

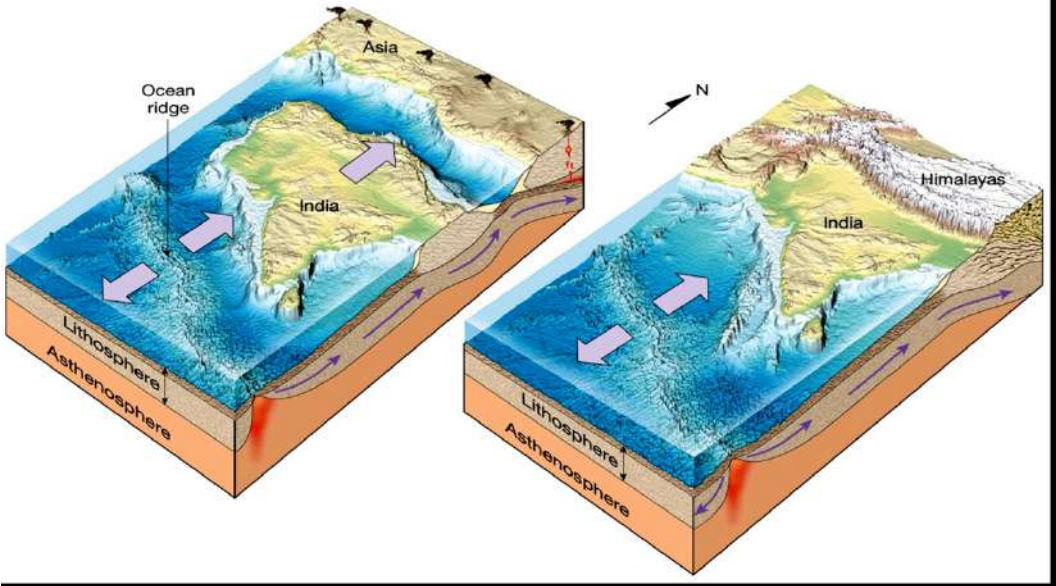
MID – LATE JURASSIC

CRETACEOUS

CRETACEOUS TO EARLY TERTIARY

EARLY TO LATE TERTIARY

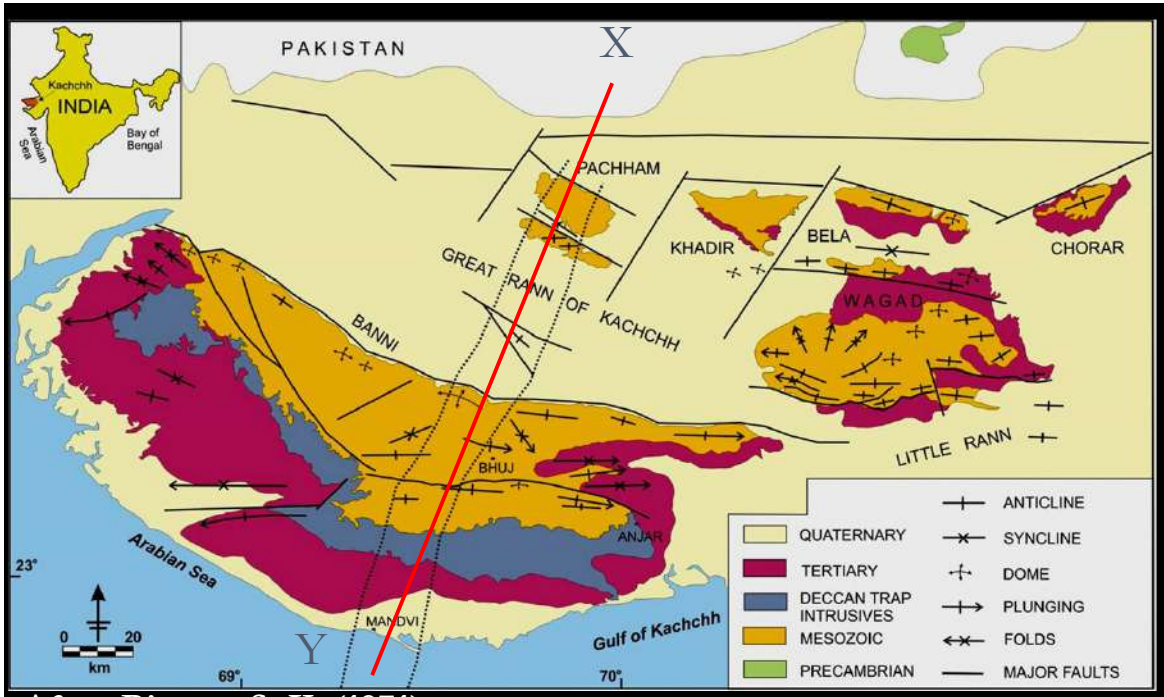
QUATERNARY



Collision of India and Asia produced the Himalaya and uplifted the Kachchh basin

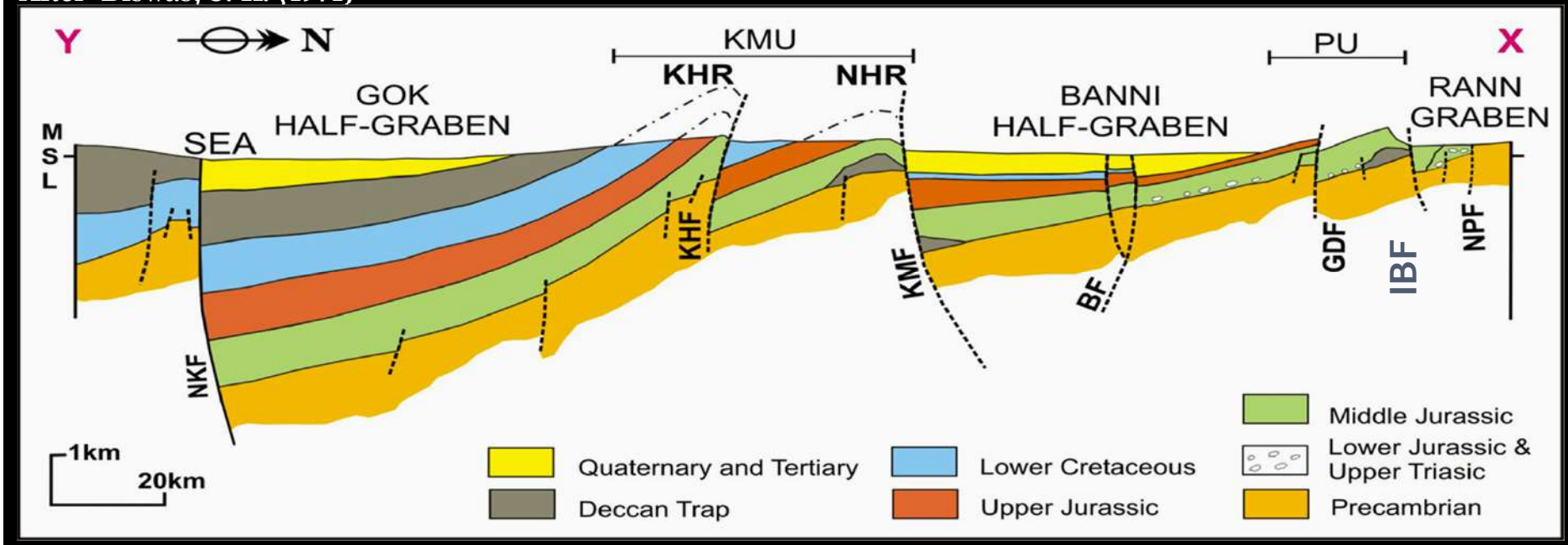
QUATERNARY

- Reactivation of Old faults
- Generation of new faults – blind faults
- Landscape evolution : Generation of geomorphic features like Gorges, Gullies, Straight mountain fronts, Young Fault Scarps, Triangular facets etc.



After Biswas, S. K. (1971)

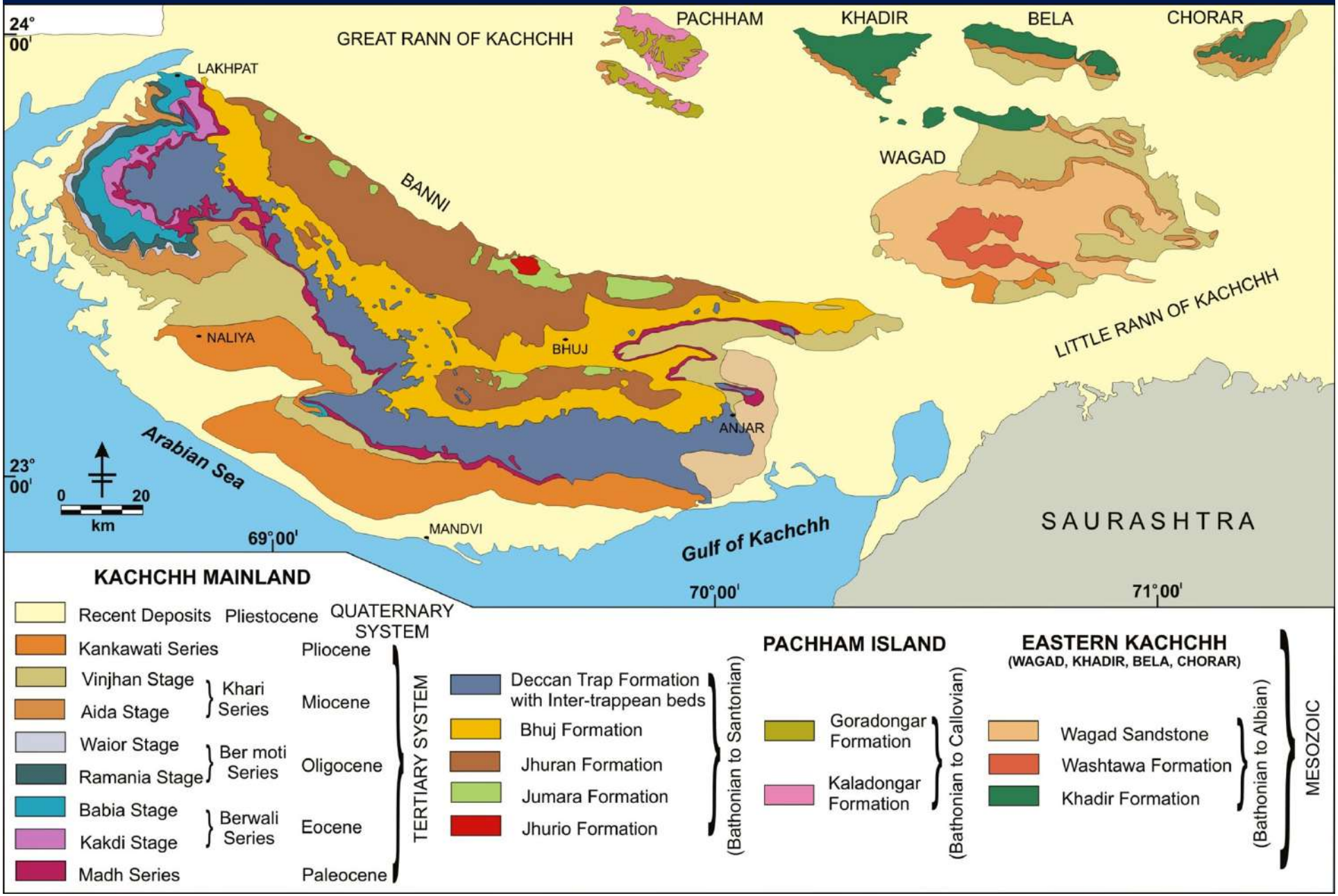
NKF : North Kathiyawar Fault
KHF : Katrol Hill Fault
KMF : Kachchh Mainland Fault
BF : Banni Fault
GDF : Goradungar Fault
IBF : Island Belt Fault
NPF : Nagar Parkar Fault



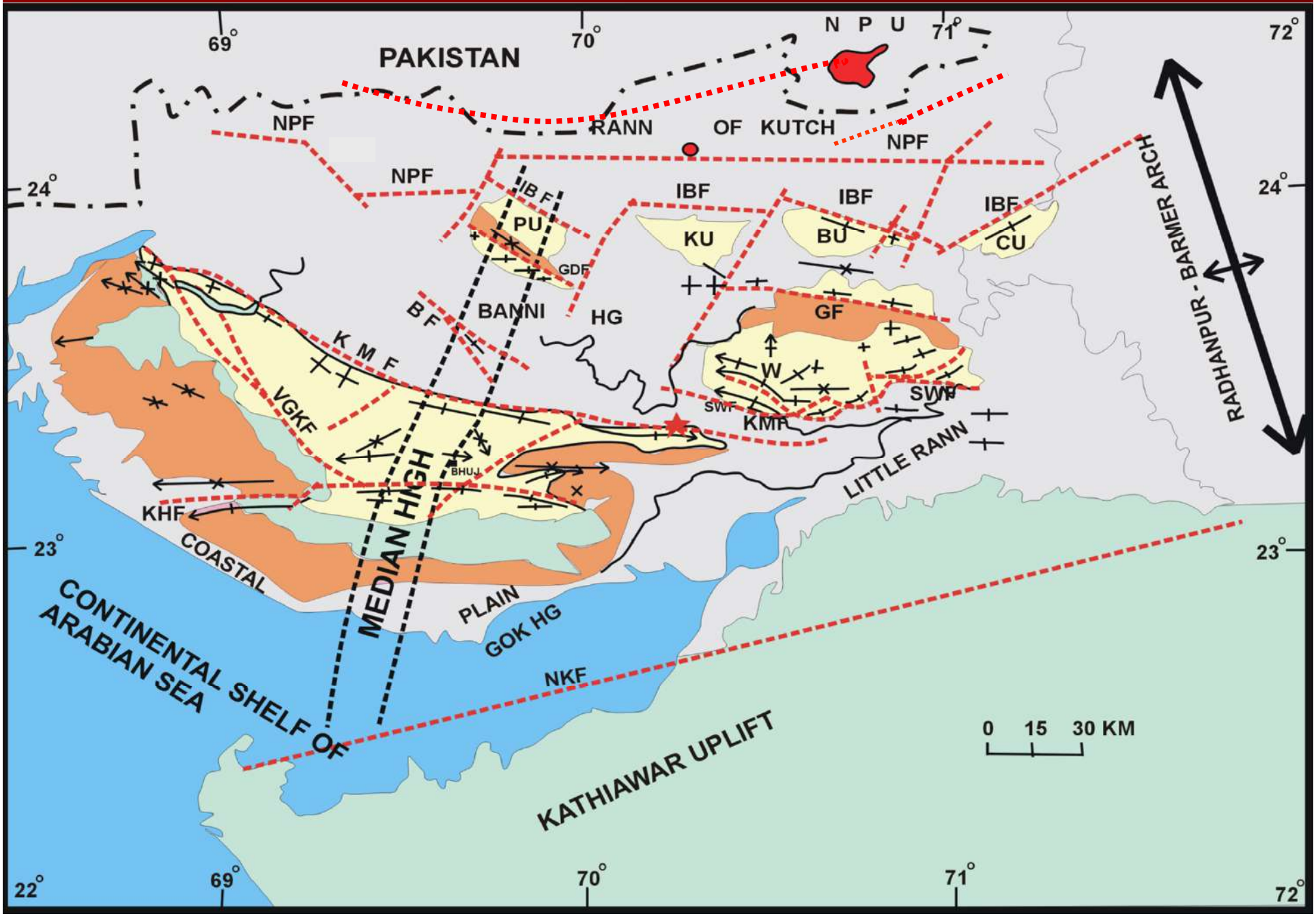
Geological Cross section across Kachchh basin, (cross section line is marked by red colour)


Kachchh Basin
Great Rann of Kachchh
Island belt
Wagad
Kachchh mainland

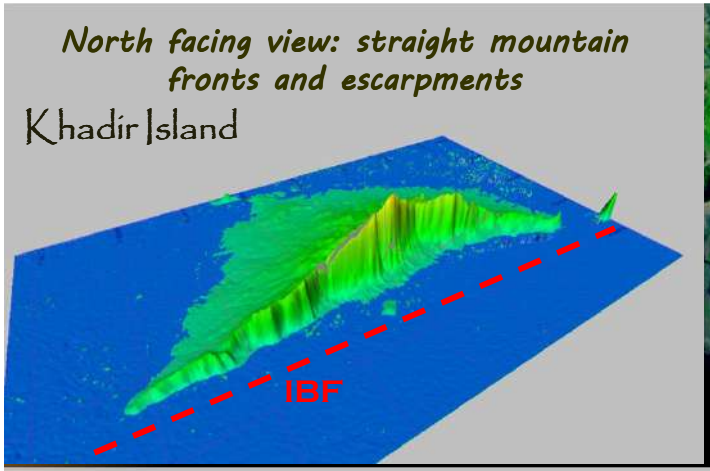
Geological map of Kachchh (After Biswas, 1987)

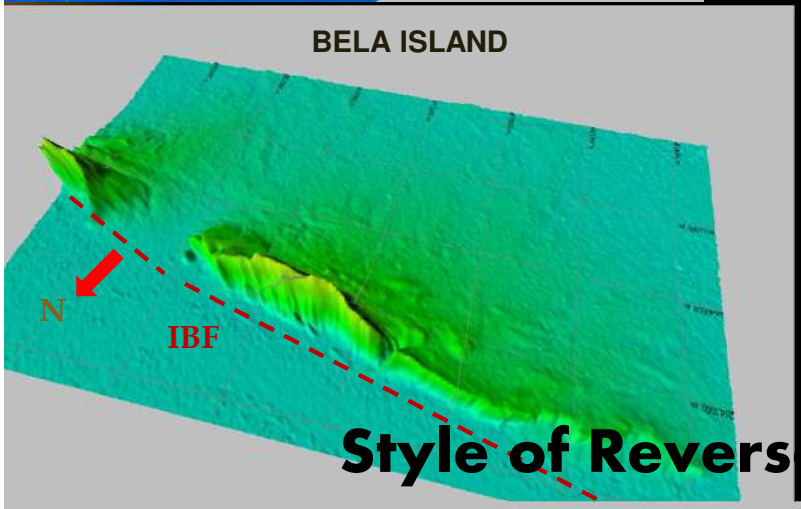


TECTONIC MAP OF KACHCHH

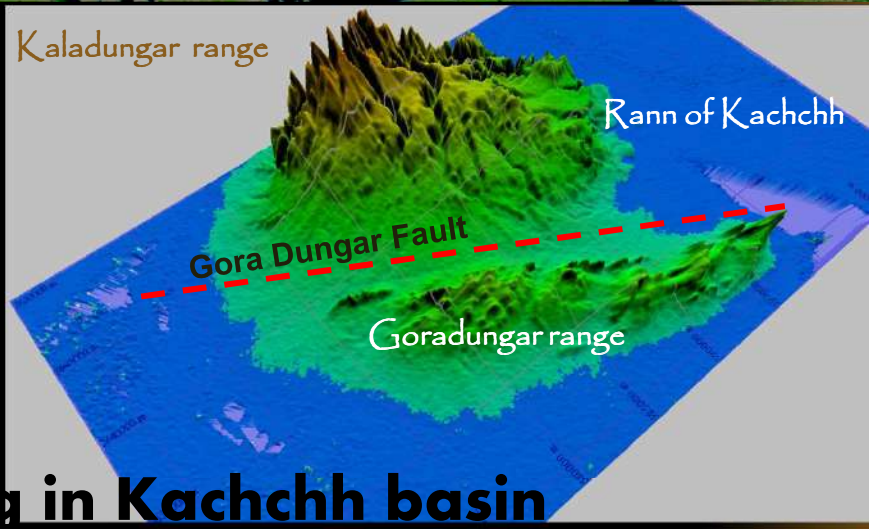


North facing view: straight mountain fronts and escarpments

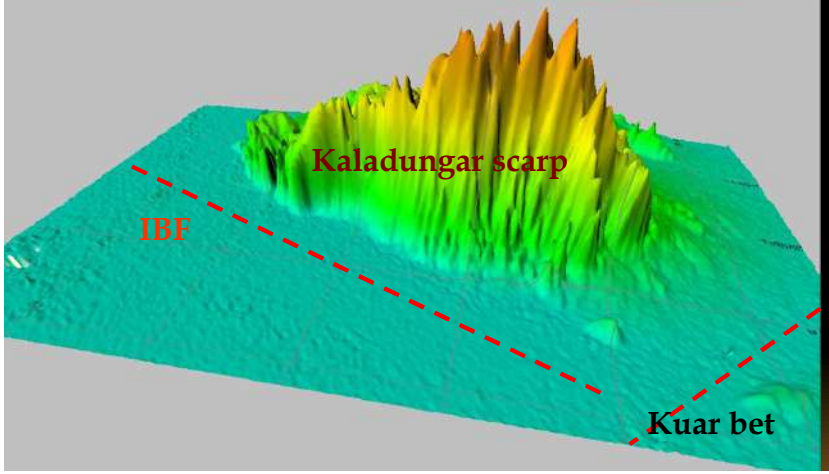




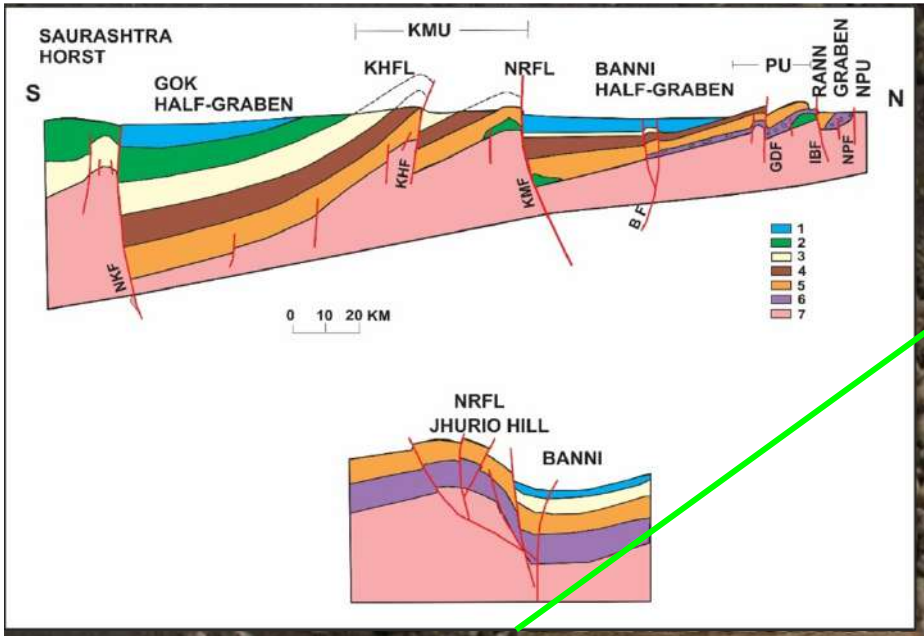
Fault (IBF) expression on landscape



Style of Reversing in Kachchh basin



Receding scarp of IBF at Kaladongar range

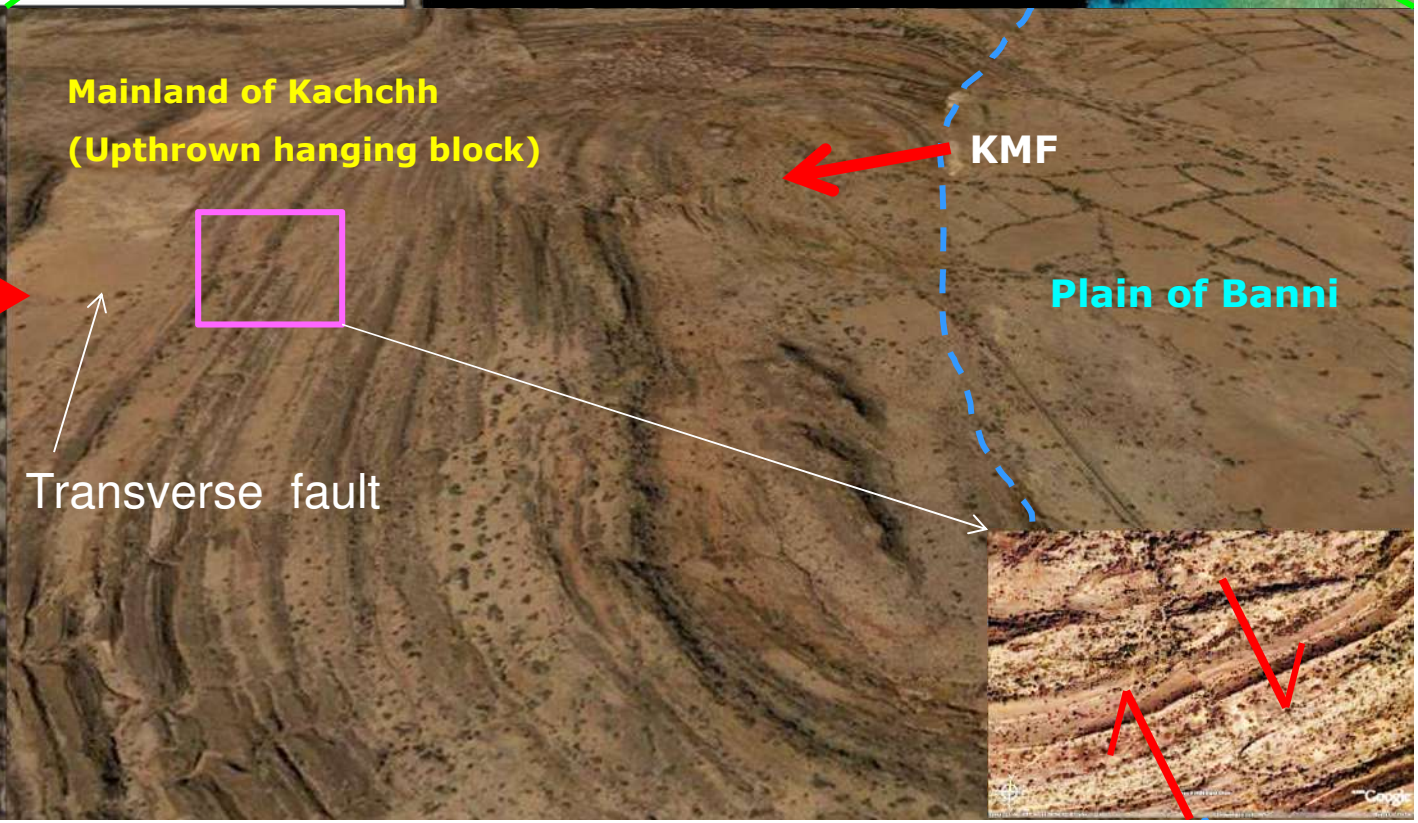


Topography of Structural Domes in Kachchh

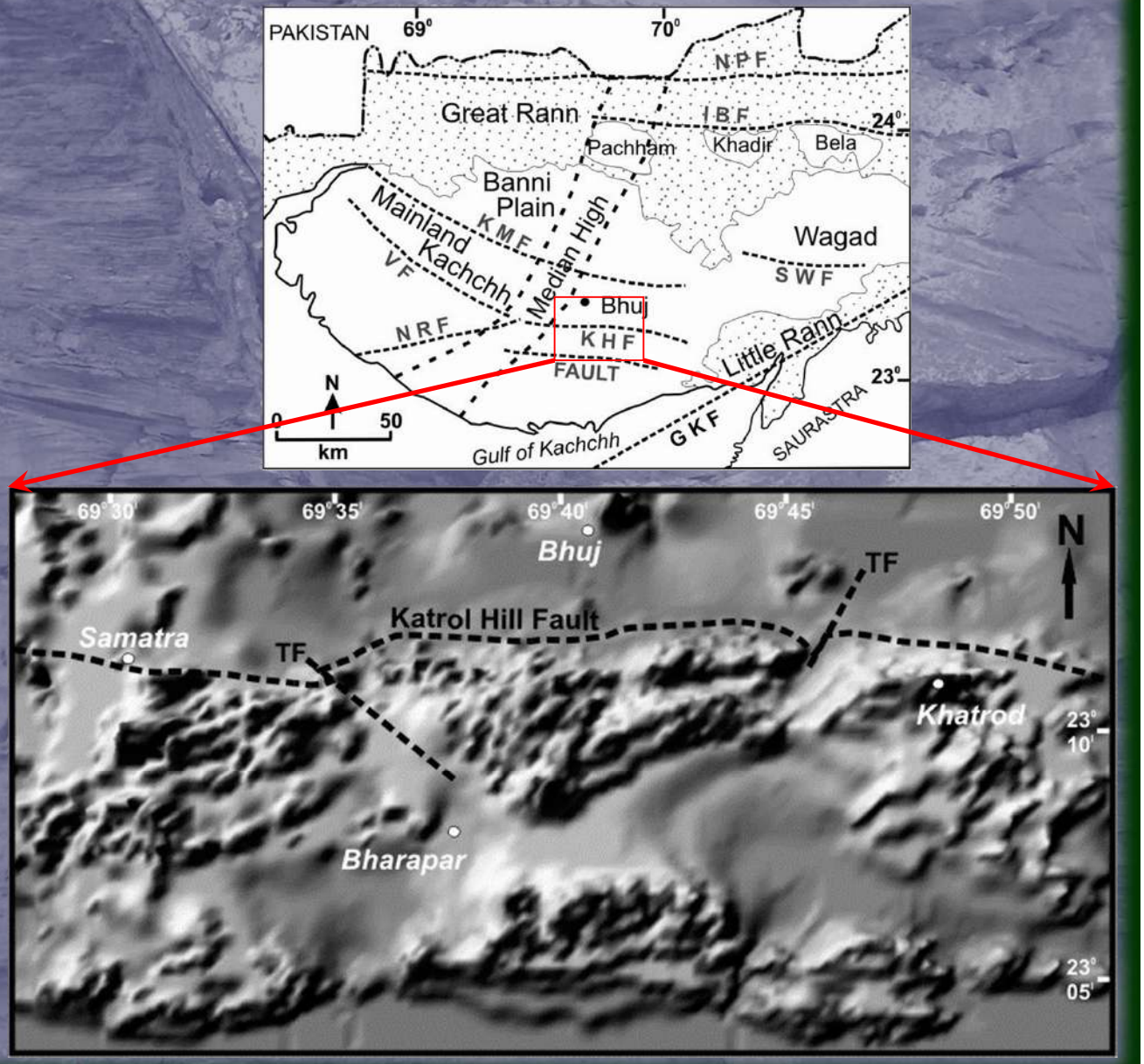
Domes developed along the E-W master faults while uplift

GUNERI DOME

(small dome along KMF)

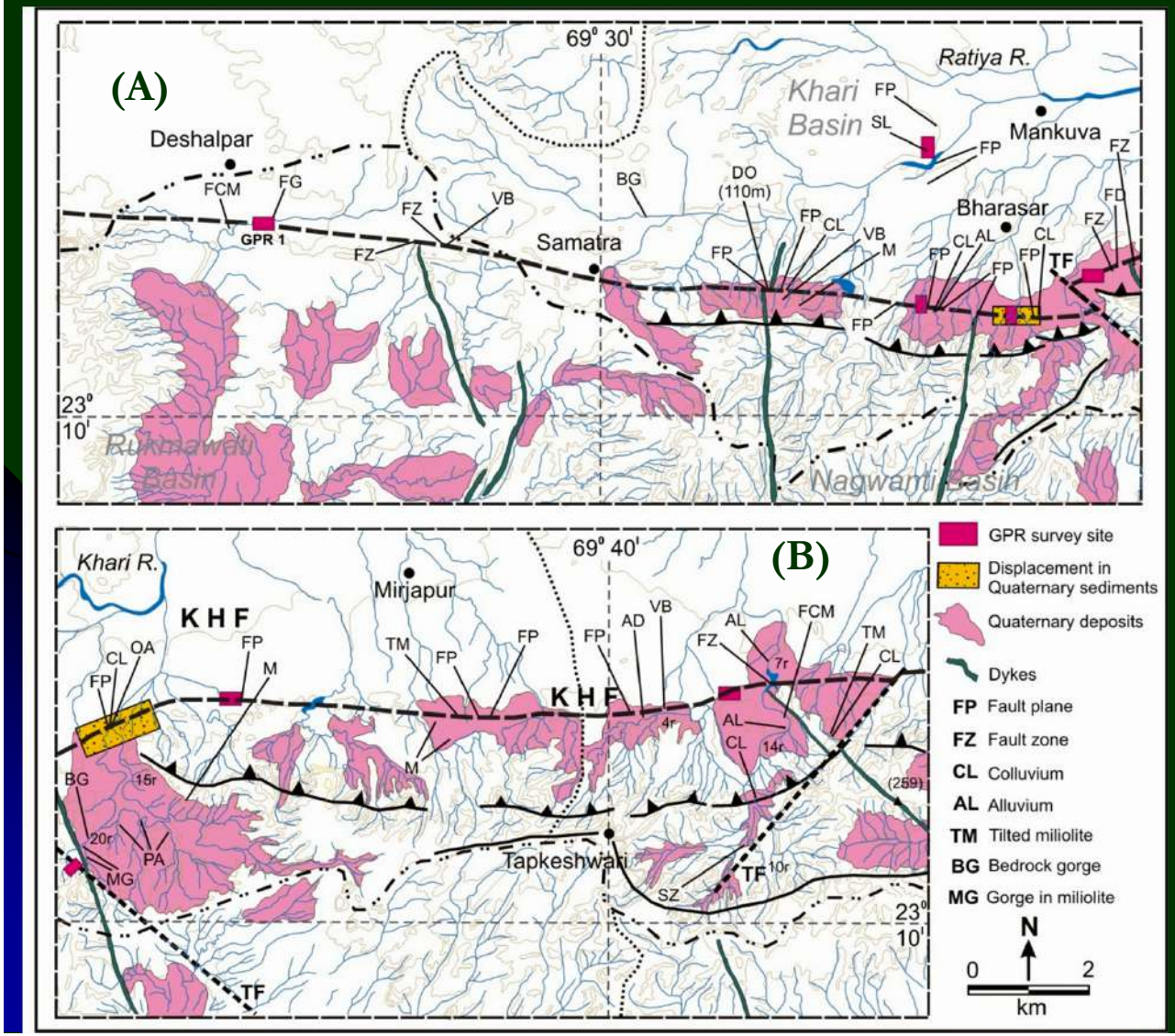


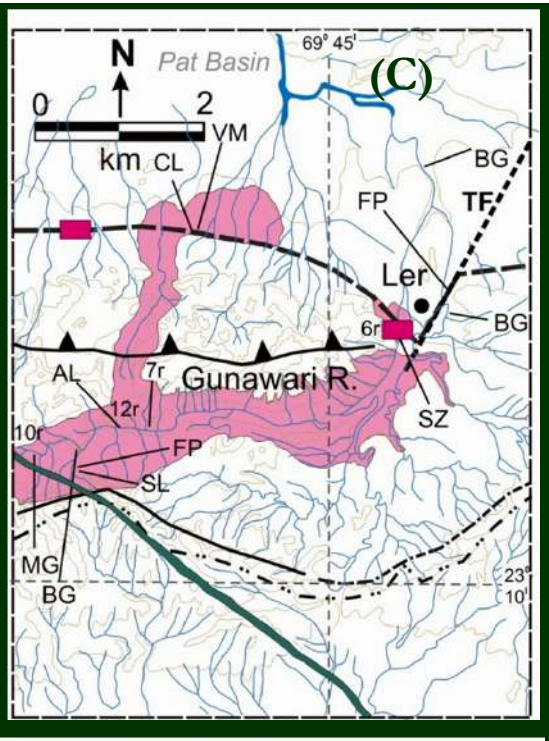
Transverse Faults

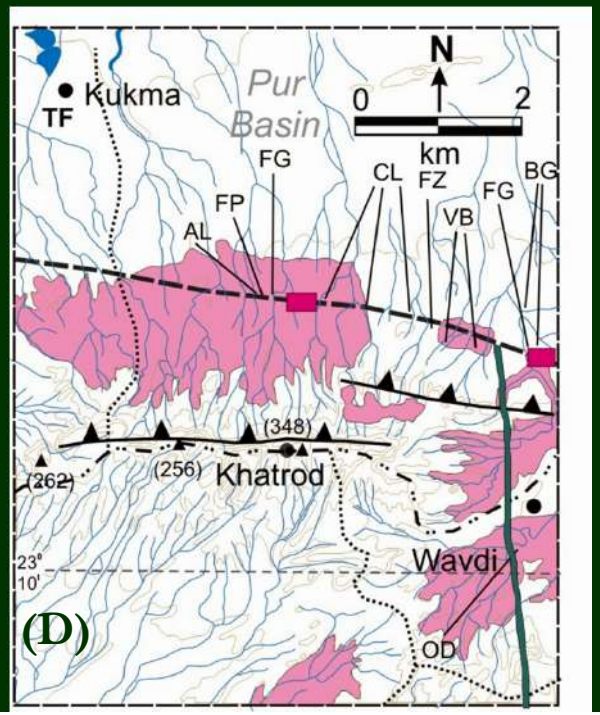


Segmentation of Katrol Hill Fault by many transverse faults

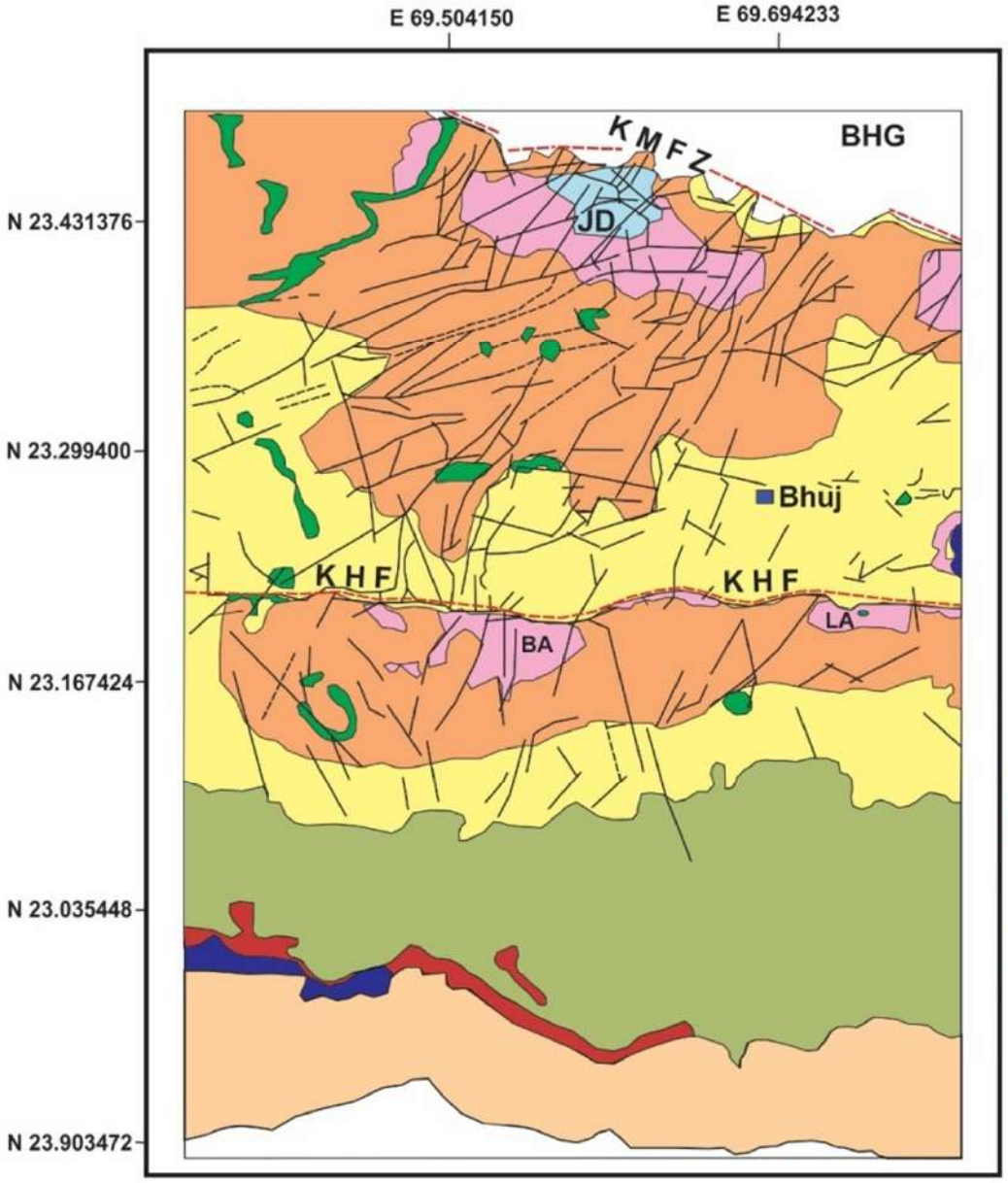
Distribution of Quaternary deposits in the hinterland are mostly on the hinge zone of median high

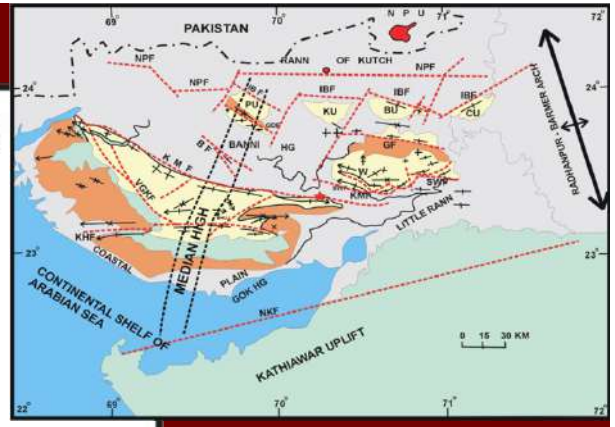






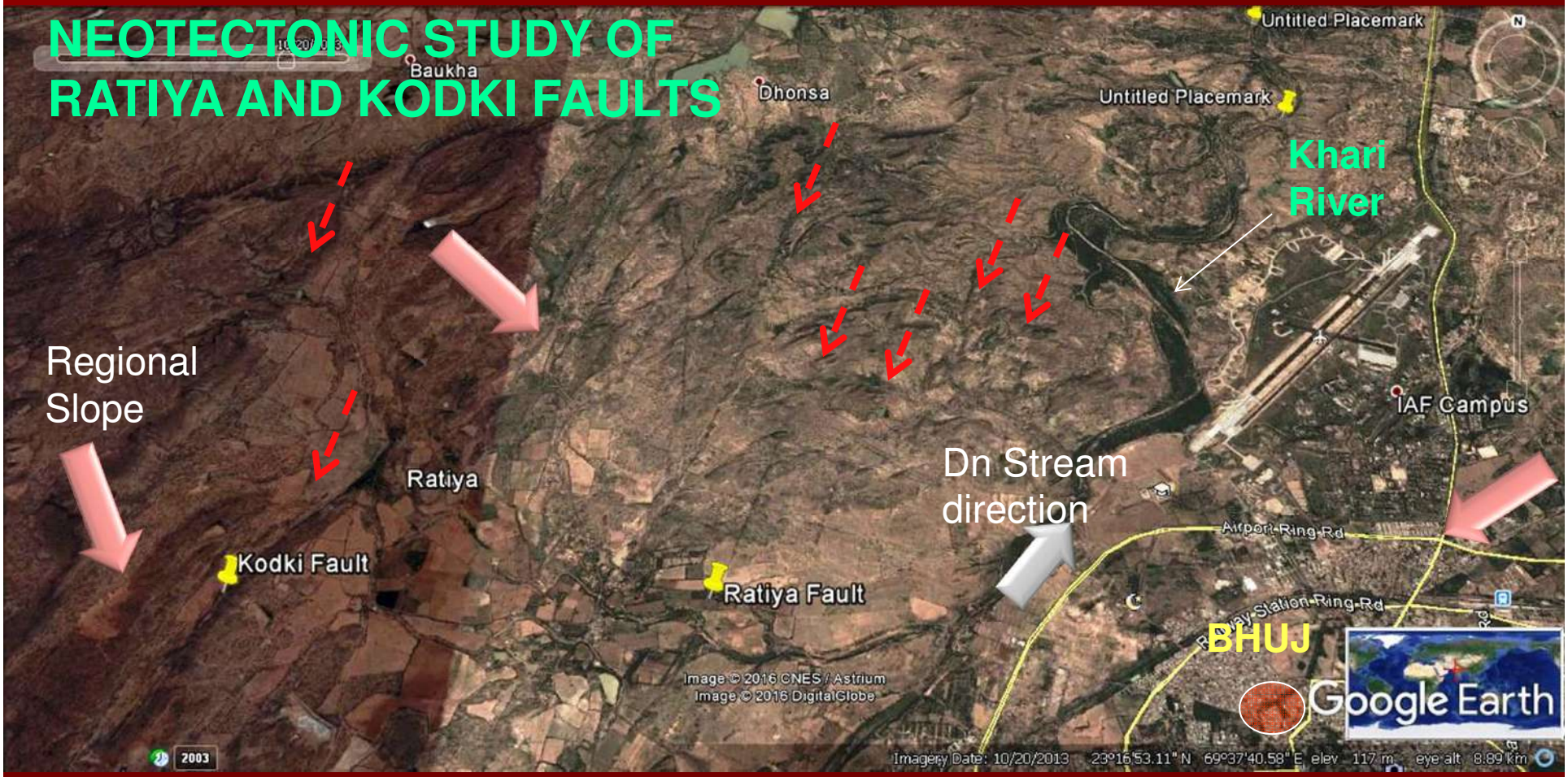
GEOLOGICAL MAP OF CENTRAL KUTCH MAINLAND



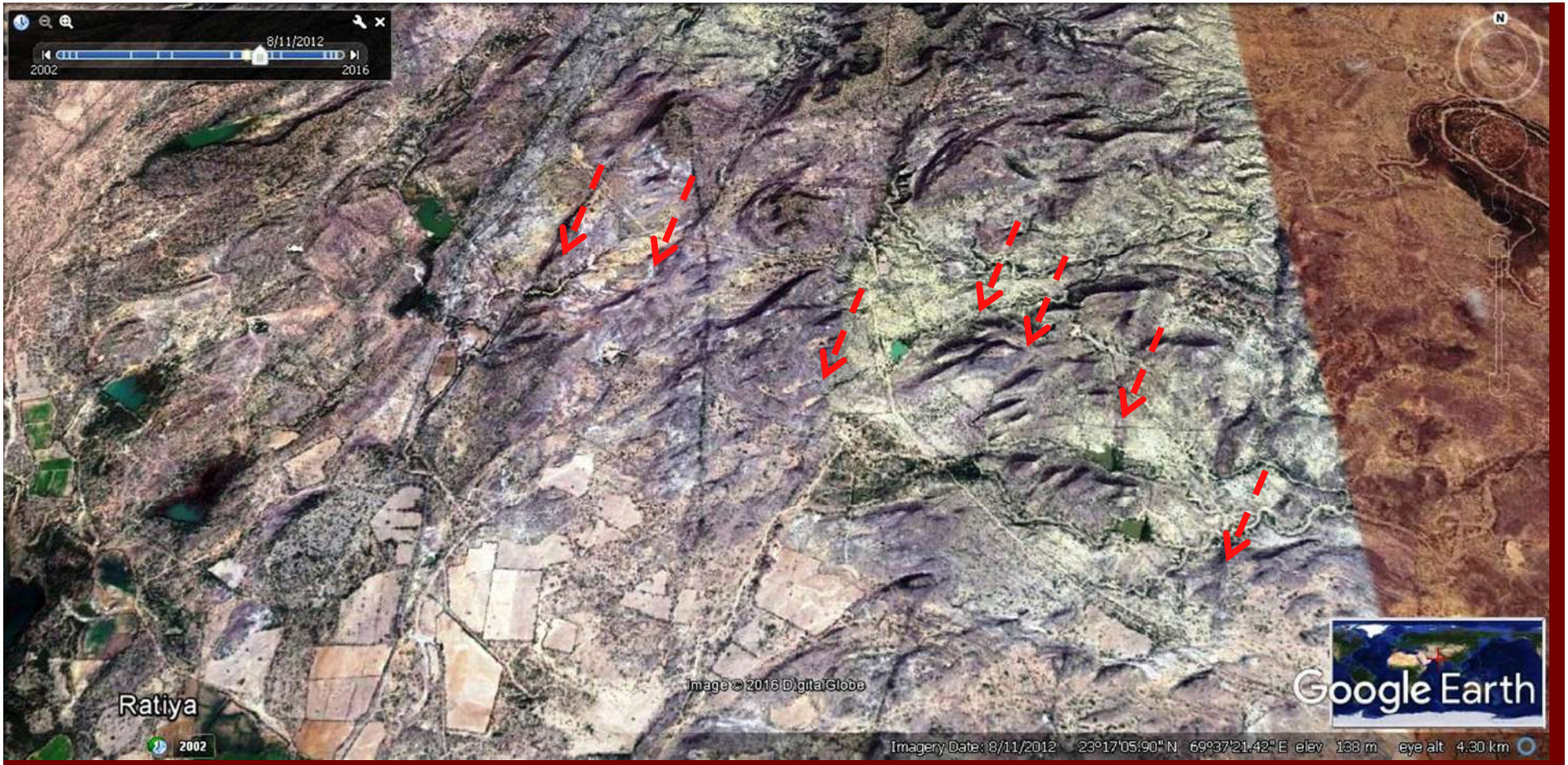


Clustering of the transverse faults (N-S, NW-SE, NE-SW, NNE-SSW) in the central part of the Kachchh mainland indicates fracturing along the Median High bulging axes (See the above tectonic map for median high region in the basin)

NEOTECTONIC STUDY OF RATIYA AND KODKI FAULTS



- Locations of Ratiya and Kodki transverse faults in the middle part of the Median High.
- Red arrows indicate Parallel faults in the central mainland Kachchh; while close field observation unfolds the facts that the downthrow of these hinge faults are very small and Normal in nature.
- Regional slope of terrain is SW, SE or East, but downstream direction is to the North.



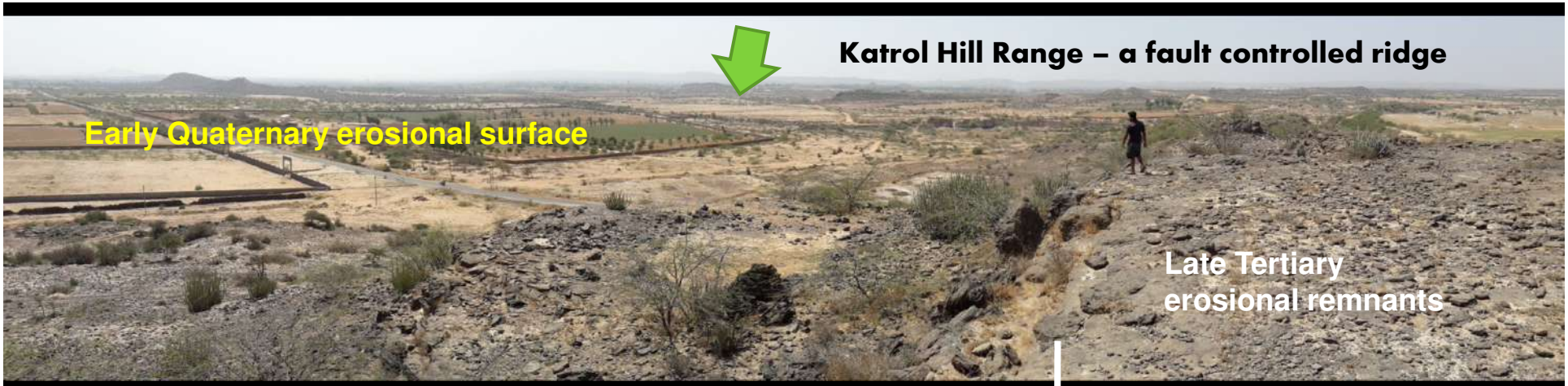
N-S and NNE-SSW trending Transverse faults are very distinct features in Central Kachchh Mainland.

Several transverse faults do have dykes along the faults, which indicates that the TF are not young, but initiated during the basin inversion in early Tertiary

Reactivation of median high axes also triggers less throw, extensive faults

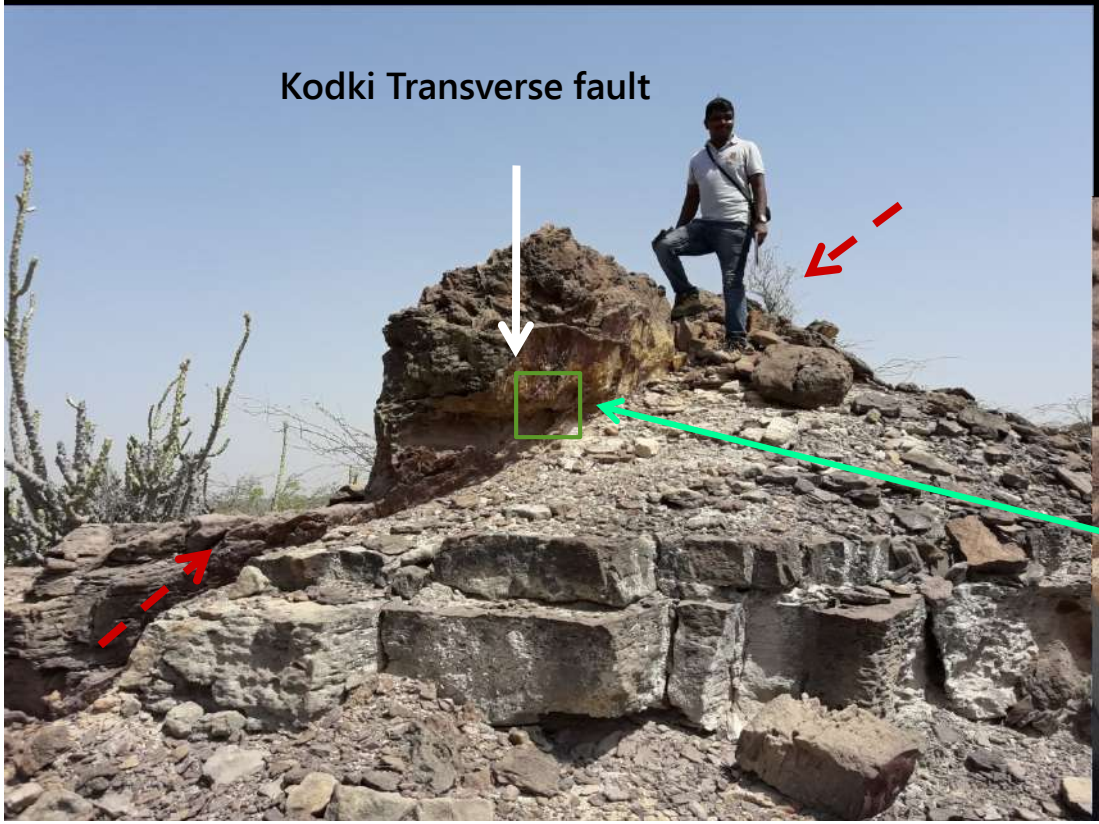
Kodki Fault FIELD OBSERVATION

- Deltaic sandstone of Cretaceous age is traversed by the N-S trending faults and igneous dykes.
- The dykes are post-Cretaceous – trappean age
- Faults are reactivated in Quaternary modifying the landscape
- These transverse faults with normal nature are high angle, small throw hinge fractures

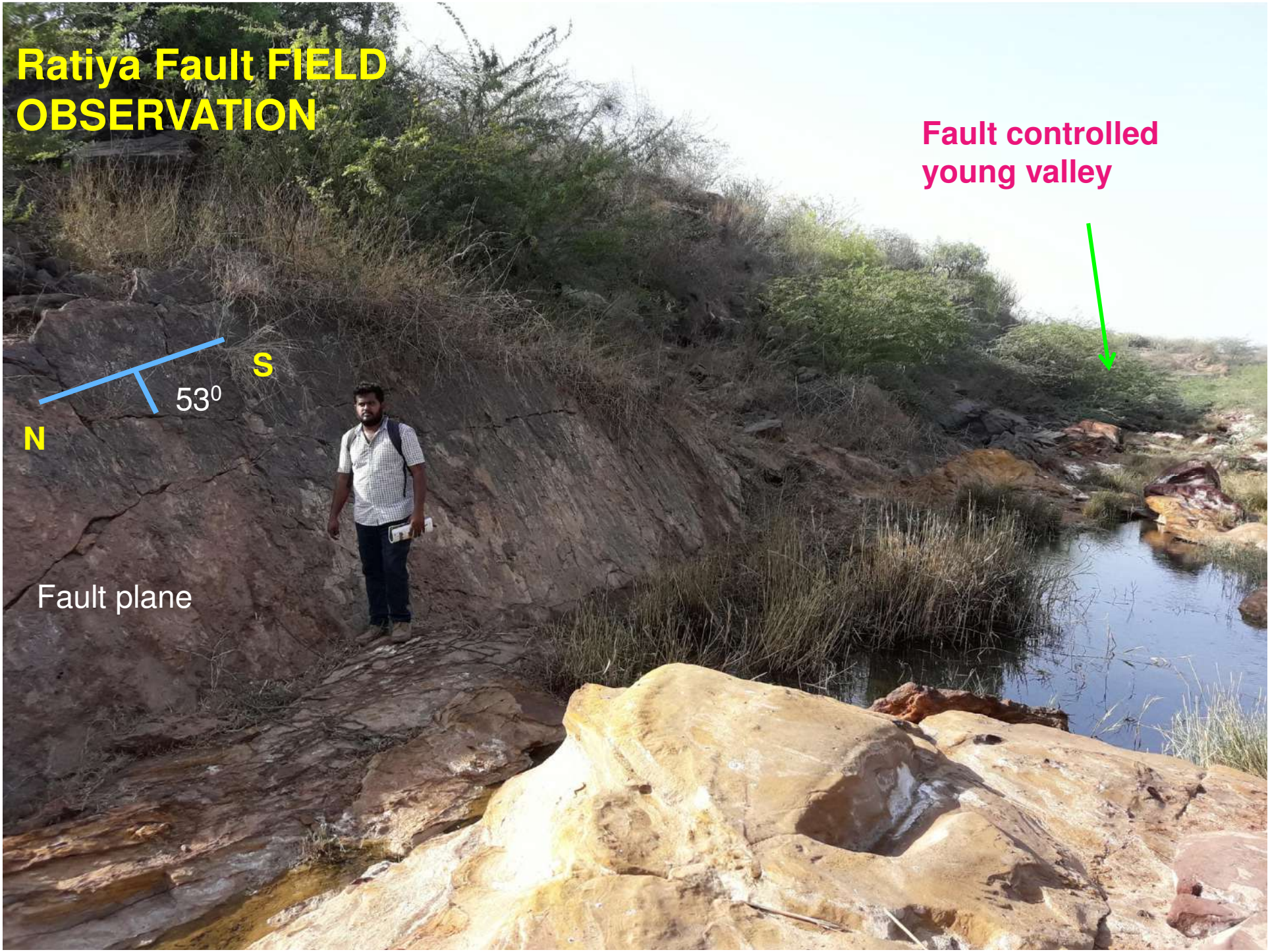


Fault controlled morphology (Transverse fault controlled ridge is perpendicular to the Katrol Hill Fault)

Transverse fault controlled ridge II to N-S dykes



Sliken slides on this fault indicates Normal Fault with dip slip motion


Ratiya Fault FIELD OBSERVATION
Fault controlled young valley
S
N
53⁰
Fault plane

Fault controlled young bedrock river and responsible Ratiya Fault

E

Downstream

Upthrown block

S

S1

53^0

Downthrown block

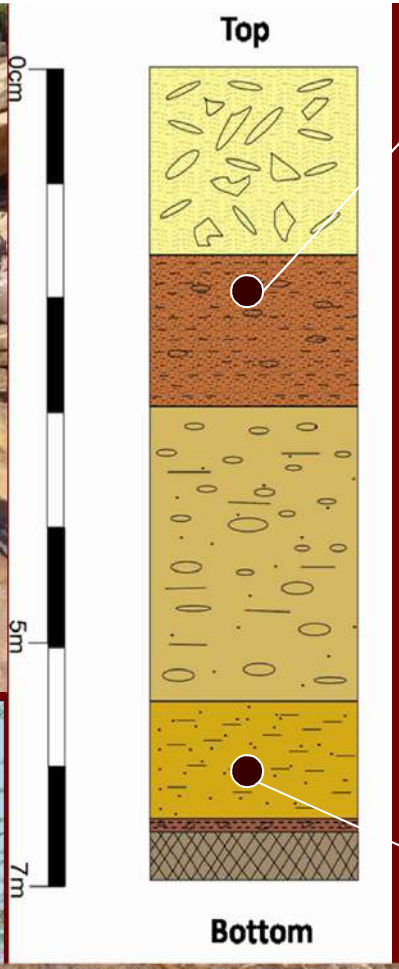
Fault plane

N

S2

Fault controlled young bedrock river – Ratiya Nala

- The downthrown block in the foreground is standing at higher position while the upthrown block is more incised to the base level
- Wider bedrock channel of Ratiya Nala indicates prolonged erosion
- The Ratiya channel is fed by two younger streams S_1 and S_2 that post dates the fault



R1= 33.18 ± 2.1 ka

Angular to sub-angular platy lthoclasts (Debris deposits)

Sand dominated clast supported gravels

Clast supported gravels with fine yellow sand and clay

Clayey and silty sand

Fluvial coarse sand
Bedrock sandstone

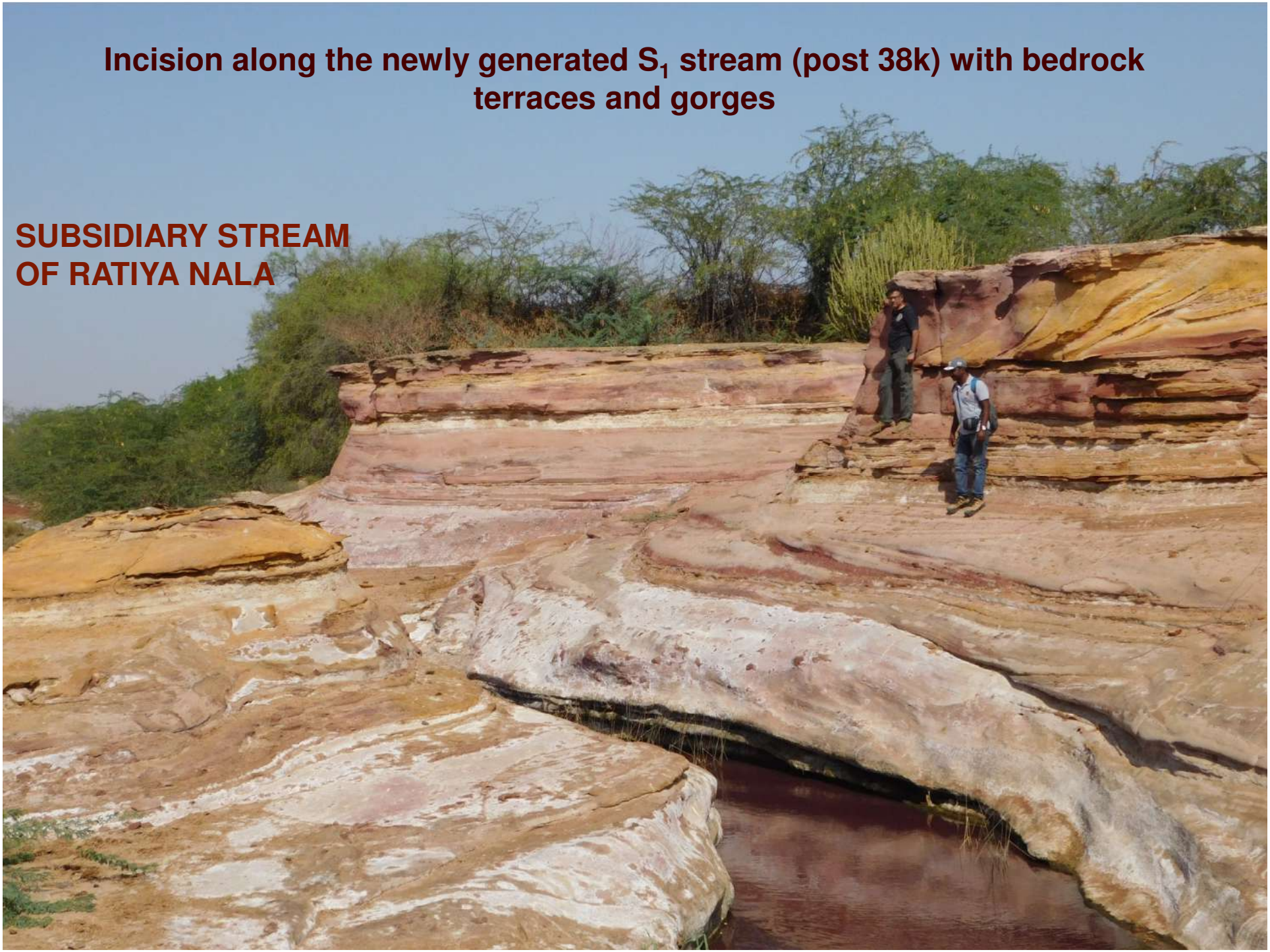
R1= 38.8 ± 2.8 ka

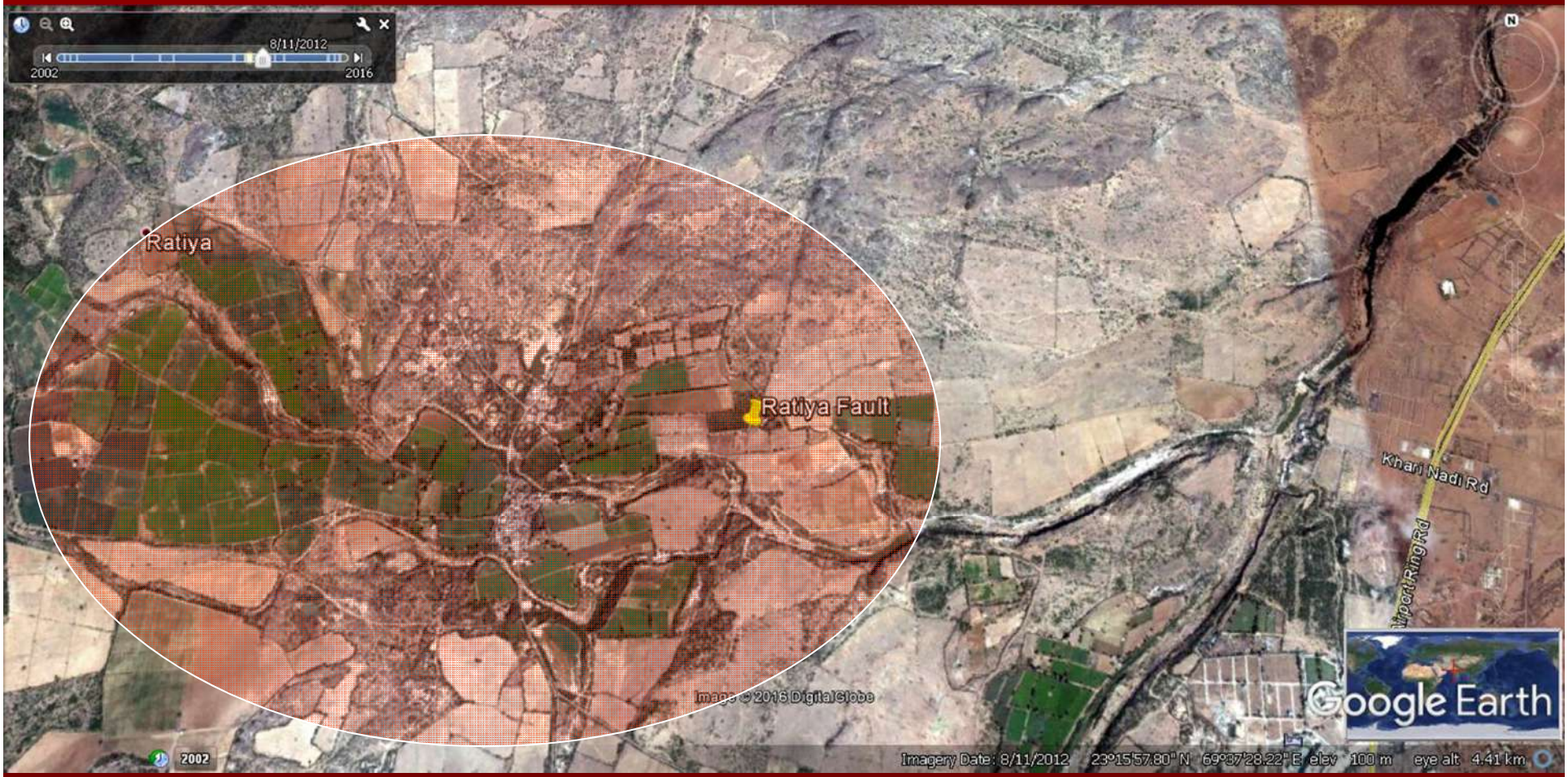
1. Youthful incision developed on the downthron block

2. N- S flowing fault controlled valley (S1)

3. A new stream – S2 developed – during lateral erosion

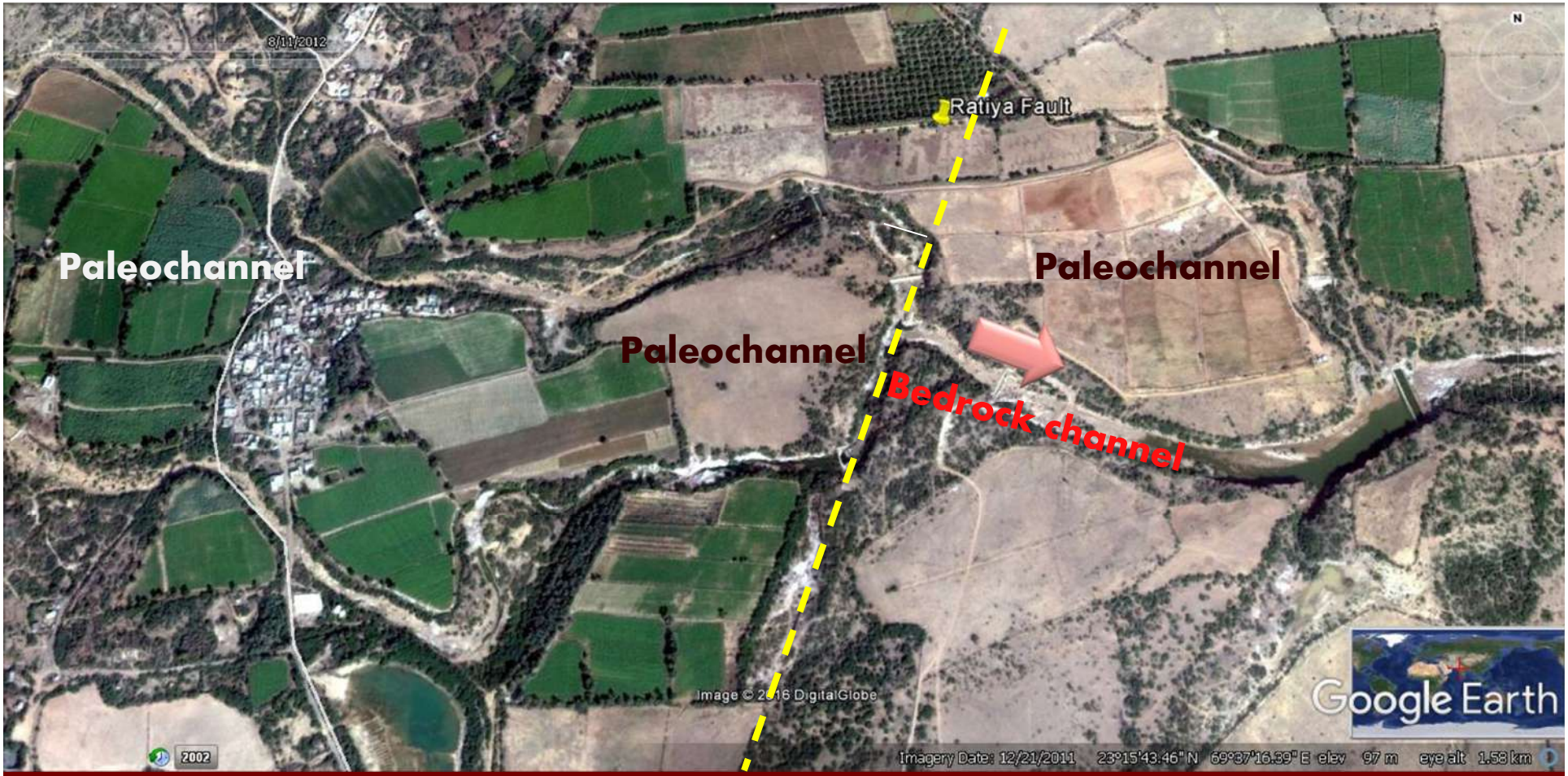
Incision along the newly generated S_1 stream (post 38k) with bedrock terraces and gorges





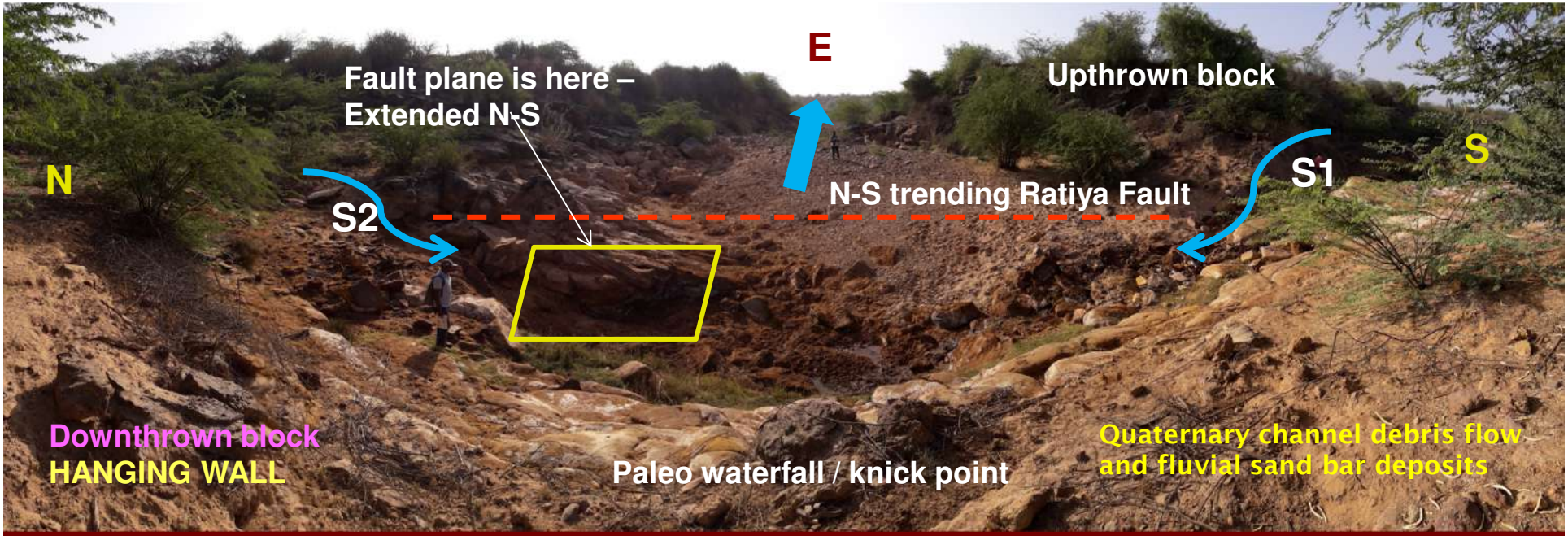
Ratiya Fault has arrested significant fluvial deposits for ~ 38 ka (OSL dates confirm it).

Based on the present study we could construct the



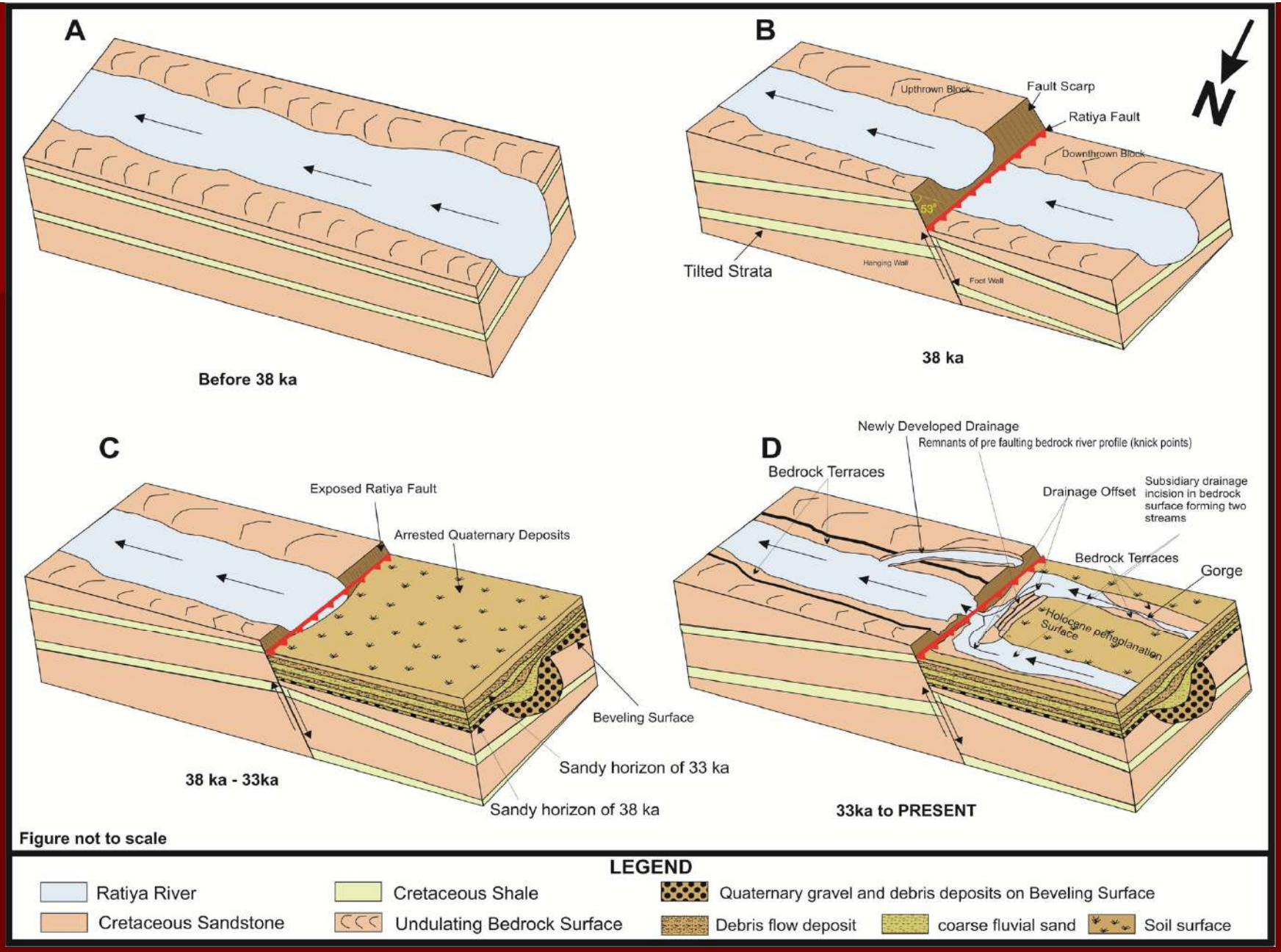
Satellite picture of Ratiya Nala (flowing to the east)

- **Note plough fields on the paleochannel deposits owing its fertility.**
- **Note River offset due to the Ratiya Fault, and Two young streams formed due to lateral incision**
- **They all meet at the fault sags and finally occupies the old bedrock channel**

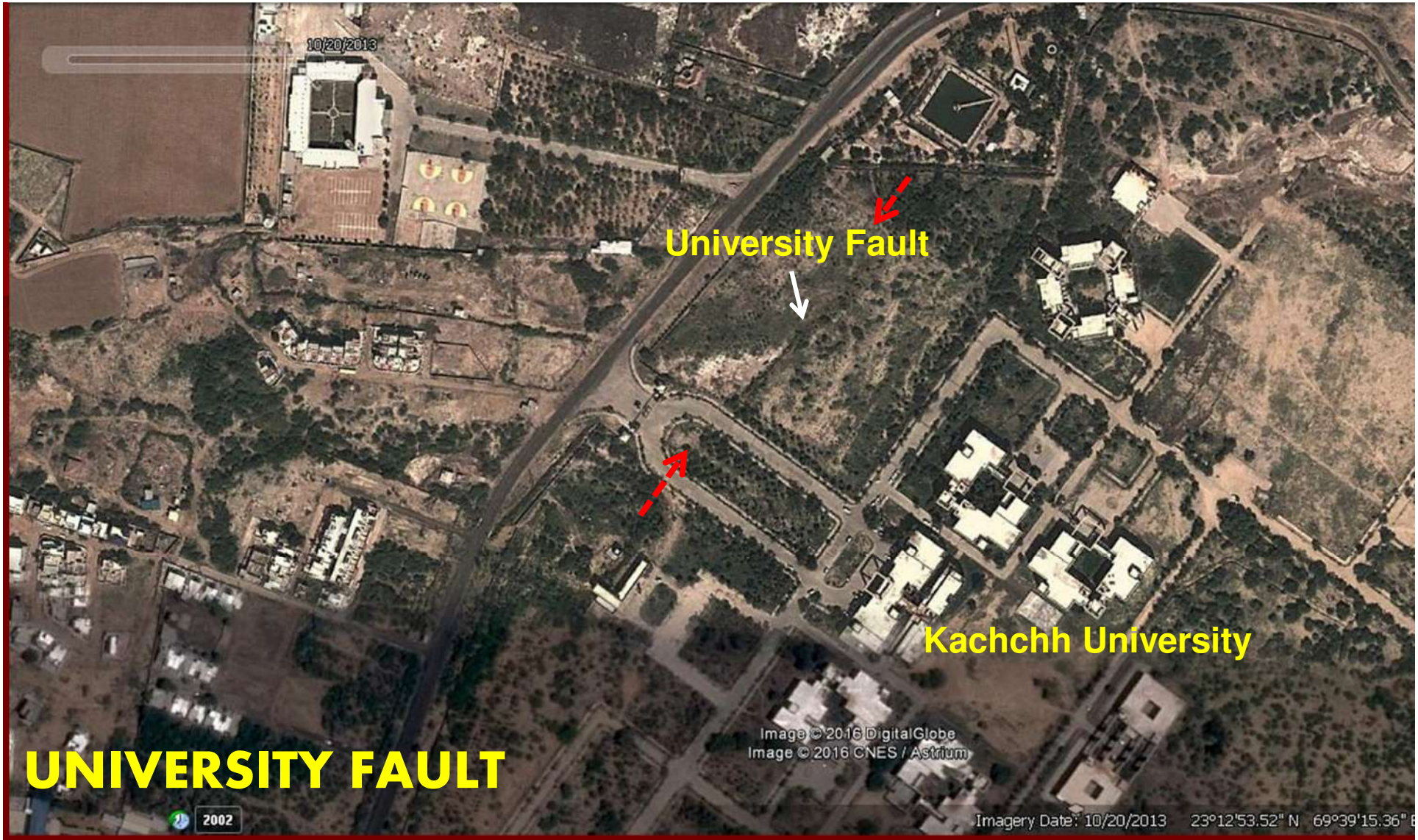


Chronology of Landscape Evolution along N-S Ratiya Nala (Conclusion)

1. Formation of East flowing master bedrock channel (Ratiya) earlier then 38 k
2. Formation of Ratiya fault (N-S) with > 2.0 m down throw towards west
3. East flowing master channel (from the foreground to background) blockage due to hanging wall subsidence
4. Deposition of Quaternary channel debris, fluvial sand bar deposits (6.5m deposits) until ~ 33k
5. Lateral incision – formation of two subsidiary channels flowing towards the fault sag
6. Footwall incision intensifies with lateral incision
7. Two lateral streams S1 and S2 with youthful valleys confluence at the middle and occupied the older/ East flowing bedrock channel

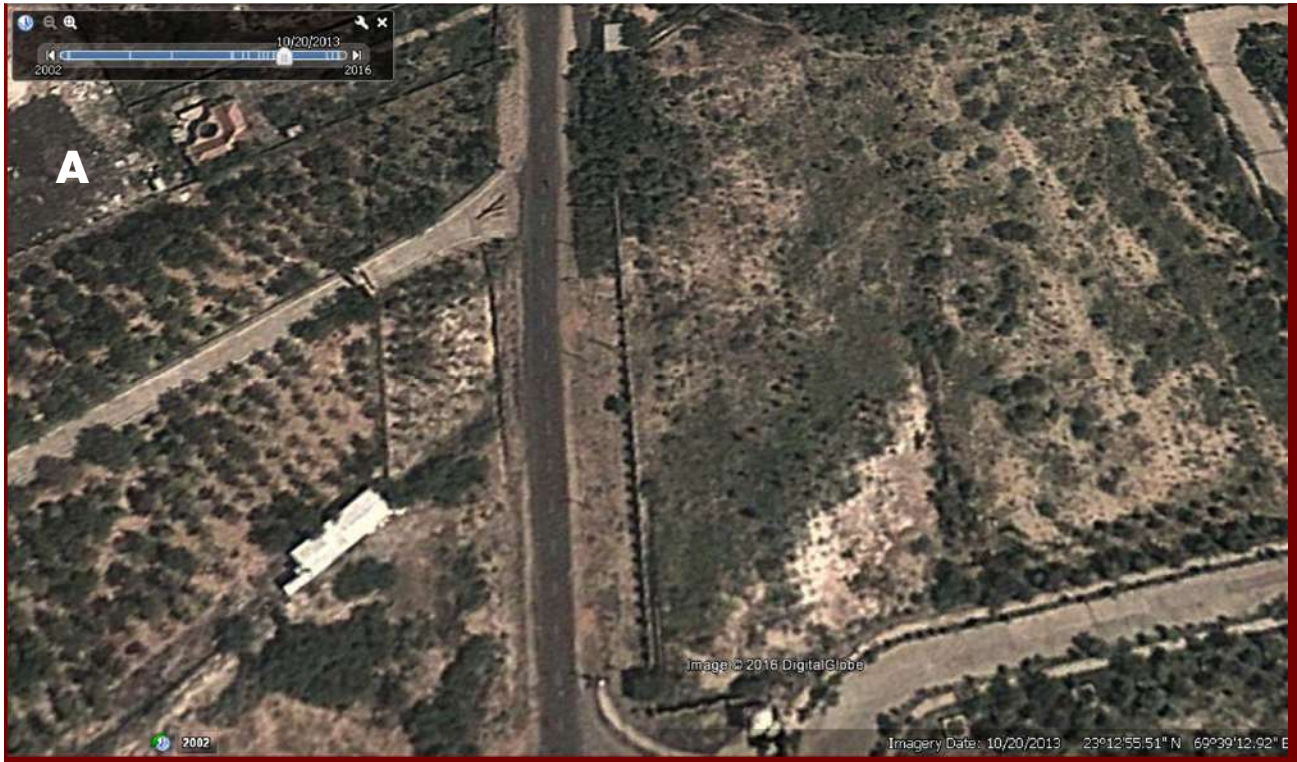


Block model of Ratiya fault – Median high hinge fault and subequent landscape evolution from 38.8 k to present day (based on OSL dates)



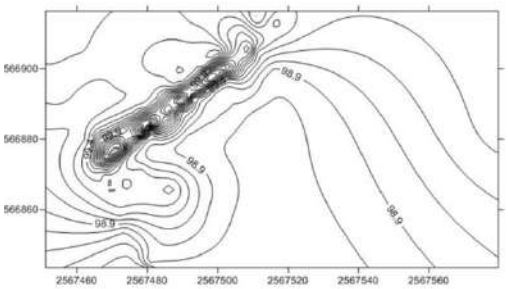
UNIVERSITY FAULT

Another NE-SW trending hinge fault passes through the Kachchh University campus having 2 m throw categorized as extensional fracture faults on bulging axes. Such faults are not much deep seated; however the deeper parts are showing compressional shear zones evidenced from large shear zone exposed within the city of Bhuj

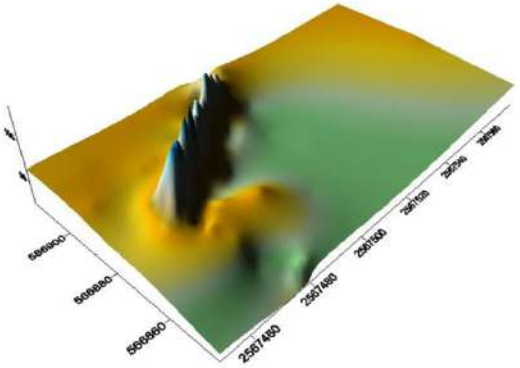


Closer look of University Fault: Note the ground to the east is uplifted and rocks are exposed as bright and brown colors. The DEM (below) prepared by the detail mapping using Total Station

A typical fracture fault where one block overrides other – as epigenetic brittle faulting

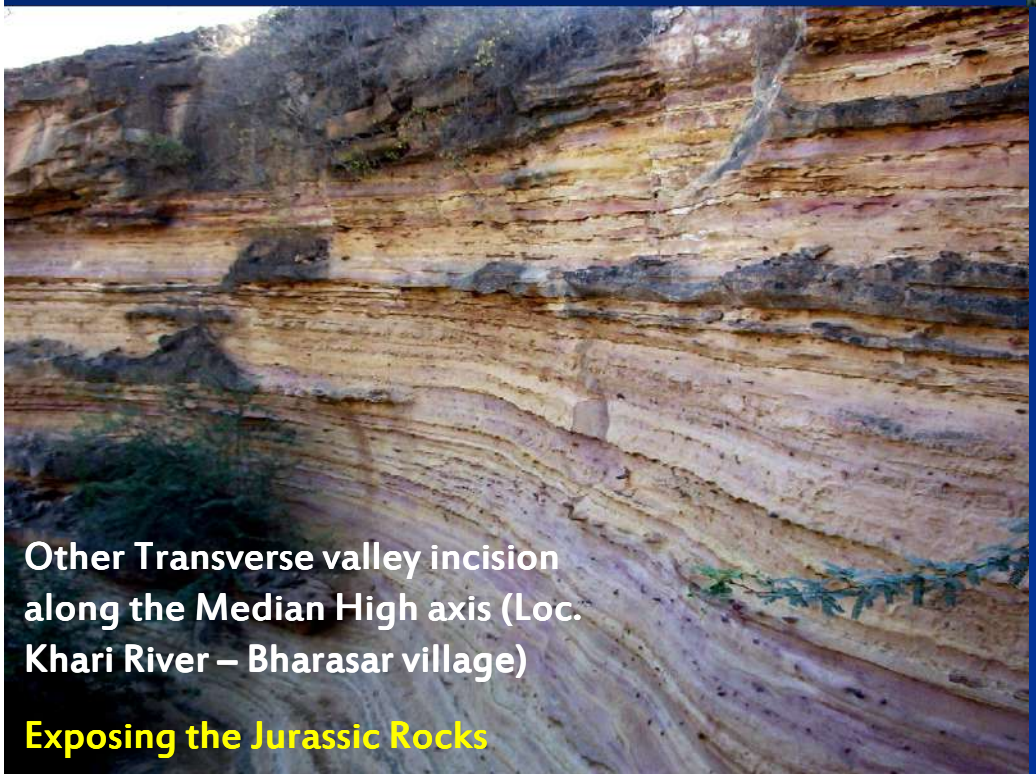


B



Neotectonic features developed along the median high region of Kachchh mainland

- Significant incision along the bedrock rivers
- Incision in the Quaternary fluvial deposits
- N-S trending Fault scarps preserved in hard rocks

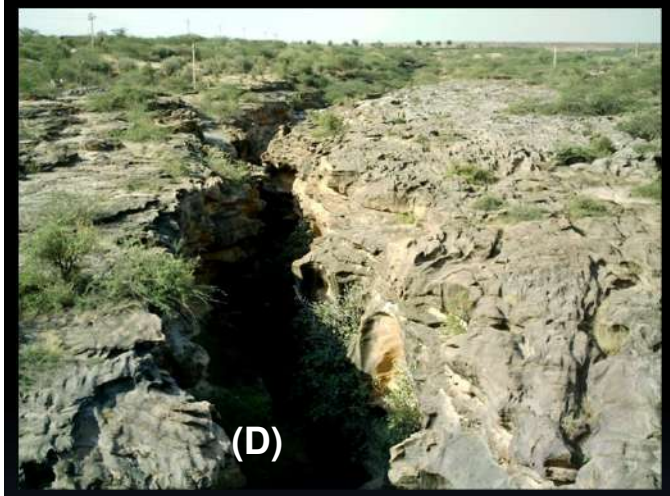


Other Transverse valley incision along the Median High axis (Loc. Khari River – Bharasar village)

Exposing the Jurassic Rocks

Incised valleys and intermittent gorges in the valley fill miliolites

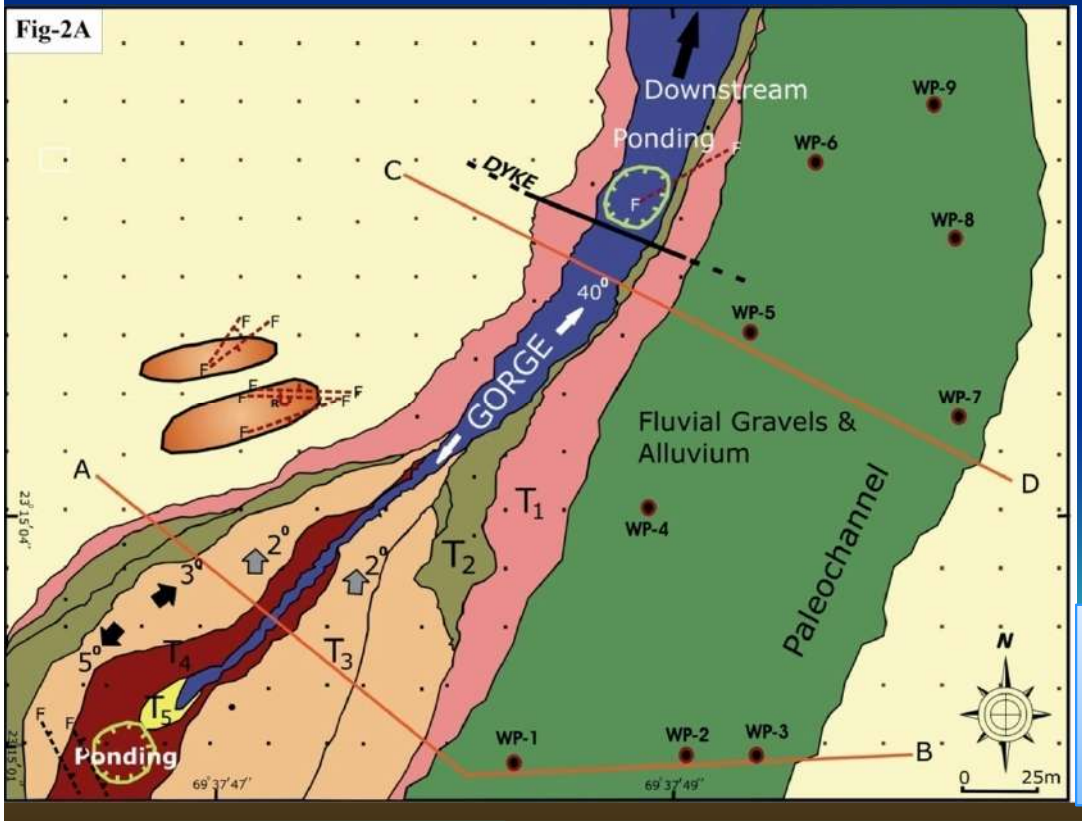
Landscape features developed along the transverse faults and lineaments



A - KHF Scarp at Katrod
B - Close view of the colluvial deposits incised by a small stream at the base of Khatrod scarp
C - Cliff section of Gunawari stream showing incision in the fluvial deposits. Note the incision in the Jurassic rocks exposed in the river bed
D - Upstream view of Khari gorge north of KHF
E - Close up of Khari gorge
F - Narrow gorge developed in Cretaceous sandstone near Bharapar village south of KHF

KACHCHH MAINLAND

Youthful – Neotectonic feature along the transverse faults / median high hinge fractures



Bedrock terraces with deep gorges developed in Bhuj sandstone. The paleo-channel passes NW of present day gorge indicates shifting of the bedrock river forming epigenetic gorge

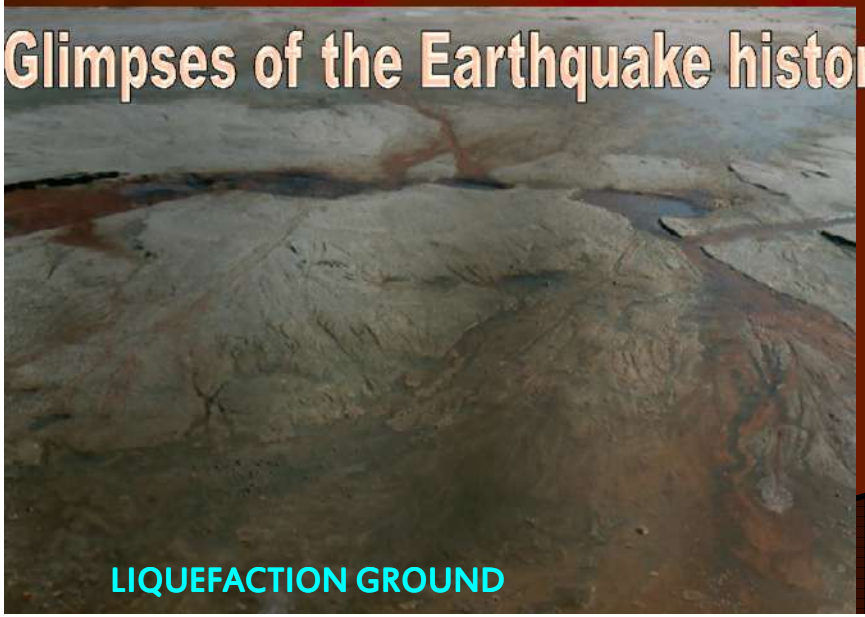
LANDSCAPE EVOLUTION : HILLY UPLANDS

QUATERNARY LANDSCAPE

Summery

- Kachchh Mainland Fault and Katrol Hill Fault are dissected by transverse faults of varying trends
- Most transverse faults are caused by the structural bending of Median high
- University fault, Ratiya Fault and Kodki faults are low amplitude faults developed as bending fractures on the crest of the Median High.
- These show geometry of normal, reserve and strike slip movement in the field
- N-S trending Kodki fault shows normal nature forming graben and half-Graben structures, while NNE-SSW trending University fault is reverse forming a small scarp.
- Ratiya fault is oblique slip in nature evidenced by drainage offsetting and alluvial fan and debris deposits on the hanging wall, above the fault plane
- Presently studied varied (normal, reverse and oblique slip) transverse faults are restricted to the Median High region between two major E-W trending reverse faults (KMF & KHF) suggesting N-S and E-W compressive stresses.
- The studies suggest that in neotectonic movement in median high of Kachchh mainland has generated varied transverse faults due to multiple stress regimes during inversion phase. It needs detailed geodetic and structural analysis to know the sources of these tectonic forces.

Transverse faults developed in 2001 Bhuj earthquake



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Salt encrustation in the Great Rann of Kachchh

“Banjaras” – Nomads in Kachchh

The youngest topography in Kachchh, western India: It is the axial region of 90 km long 16 km wide and 2.5m high co-seismic hump developed in the Great Rann-salt playa of Kachchh during AD 1819 Allahbund earthquake in western India


The invertebrates like Sepia – Belemnites in the narrow Jurassic sea of Kachchh flourished ~ 160 million years from today: The rock of Kachchh say it
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