An overview of uranium exploration strategy in India

By

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Outline

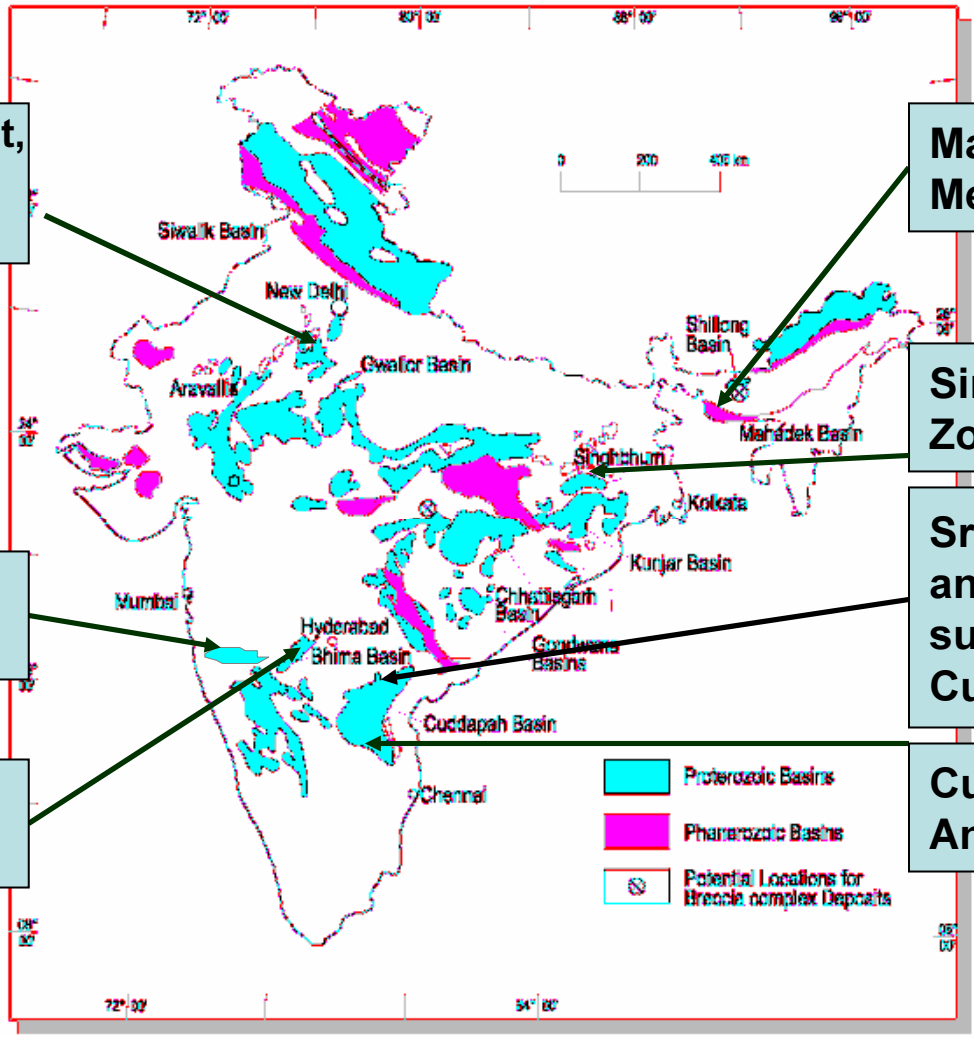
- Uranium provinces of India
- India's uranium exploration history
- Exploration strategy for Srisailam-Palnad-Kurnool sub-basins
- Exploration strategy for Southern Cuddapah basin
- Exploration strategy for North Delhi Fold Belt
- Exploration strategy for Cretaceous Mahadek basin
- Exploration strategy for Proterozoic Bhima basin
- Exploration strategy for Proterozoic Kaladgi basin
- Concluding remarks

Major Uranium Provinces of India

North Delhi Fold Belt, Rajasthan and Haryana

Kaladgi basin, Karnataka

Bhima basin, Karnataka



Mahadek basin, Meghalaya

Singhbhum Shear Zone, Jharkhand

Srisailam, Palnad and Kurnool sub-basins, Cuddapah basin

Cuddapah basin, Andhra Pradesh

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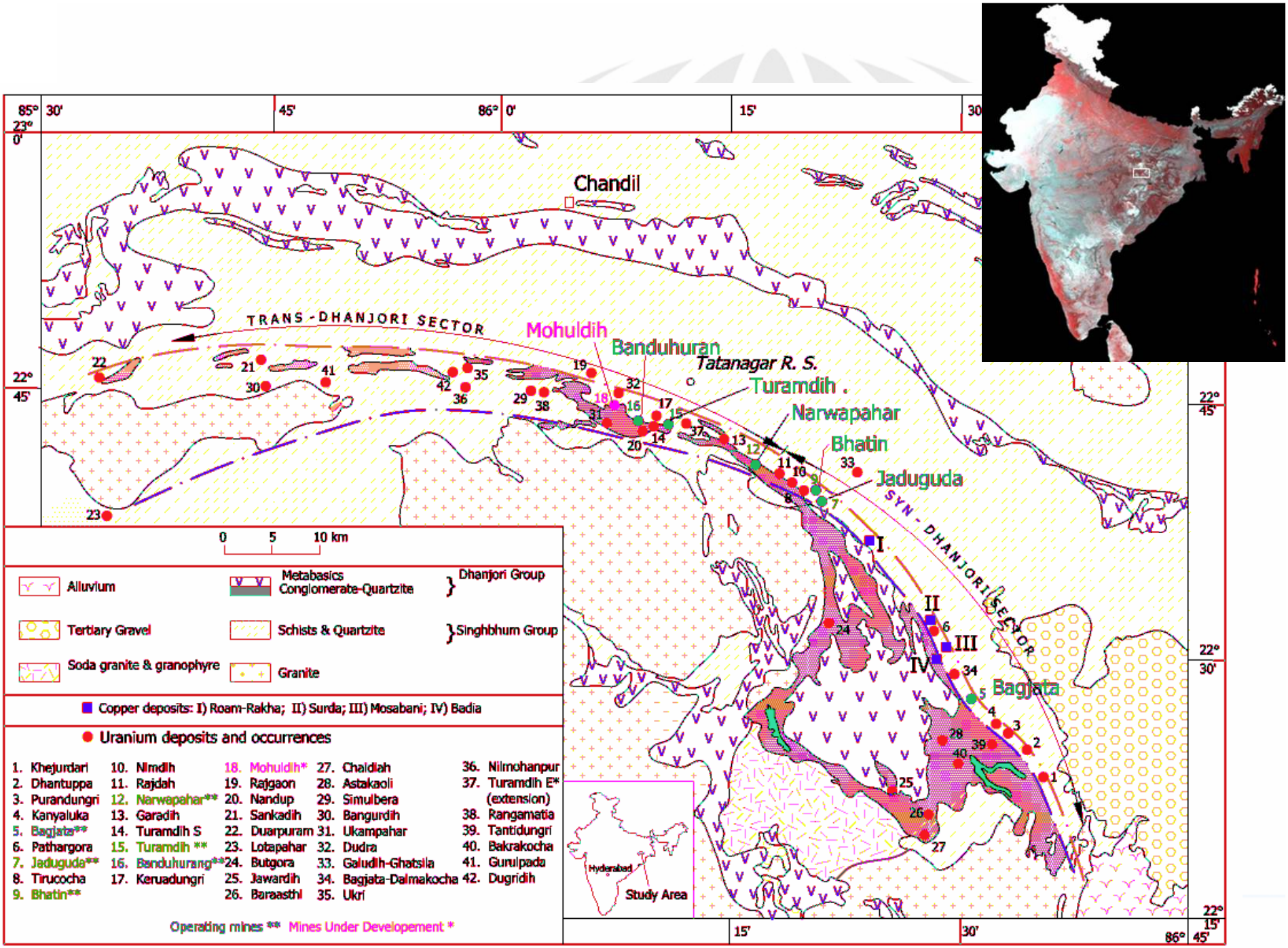


GEOLOGICAL MAP OF SINGHBHUM SHEAR ZONE SHOWING URANIUM & COPPER DEPOSITS/OCCURRENCES

History of uranium exploration in India

Exploration started in early 1950's

11 deposits (> 500 t U_3O_8 of grade: 0.02-0.06% U_3O_8) proved between 1951-1975

New discoveries from widely different geological settings in Rajasthan and Himalayas

New Uranium provinces viz. SSZ, Southern Cuddapah and Mahadeks established

Six Cretaceous sandstone type U-deposits in Meghalaya – Gomaghat (1974), Domiasiat (1983-92),Wakhyn (1995-2007) etc. established

Proterozoic Cuddapah Basin emerge as a major uranium province. Tummalapalle (1984 to present) in Dolostone hosted strata-bound, Lambapur-Peddagattu-Chitrial (1992-Present) in unconformity-related

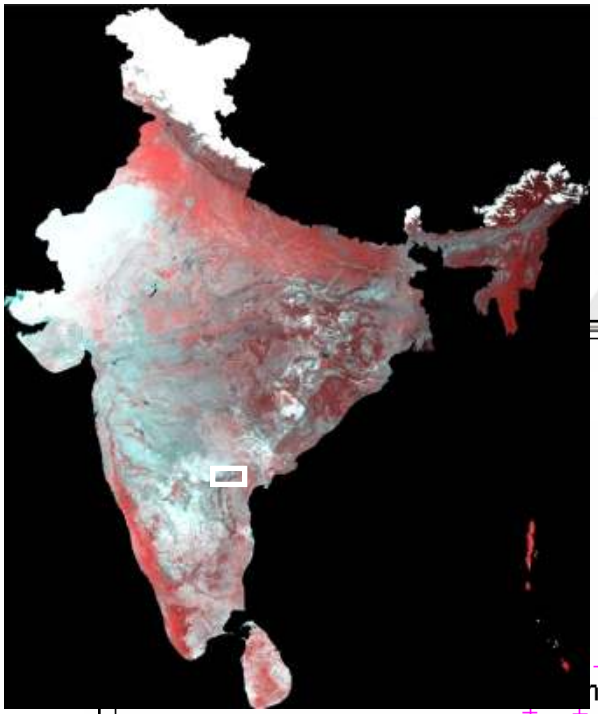
Proterozoic Bhima Basin – Gogi (1999-2002) – Vein type

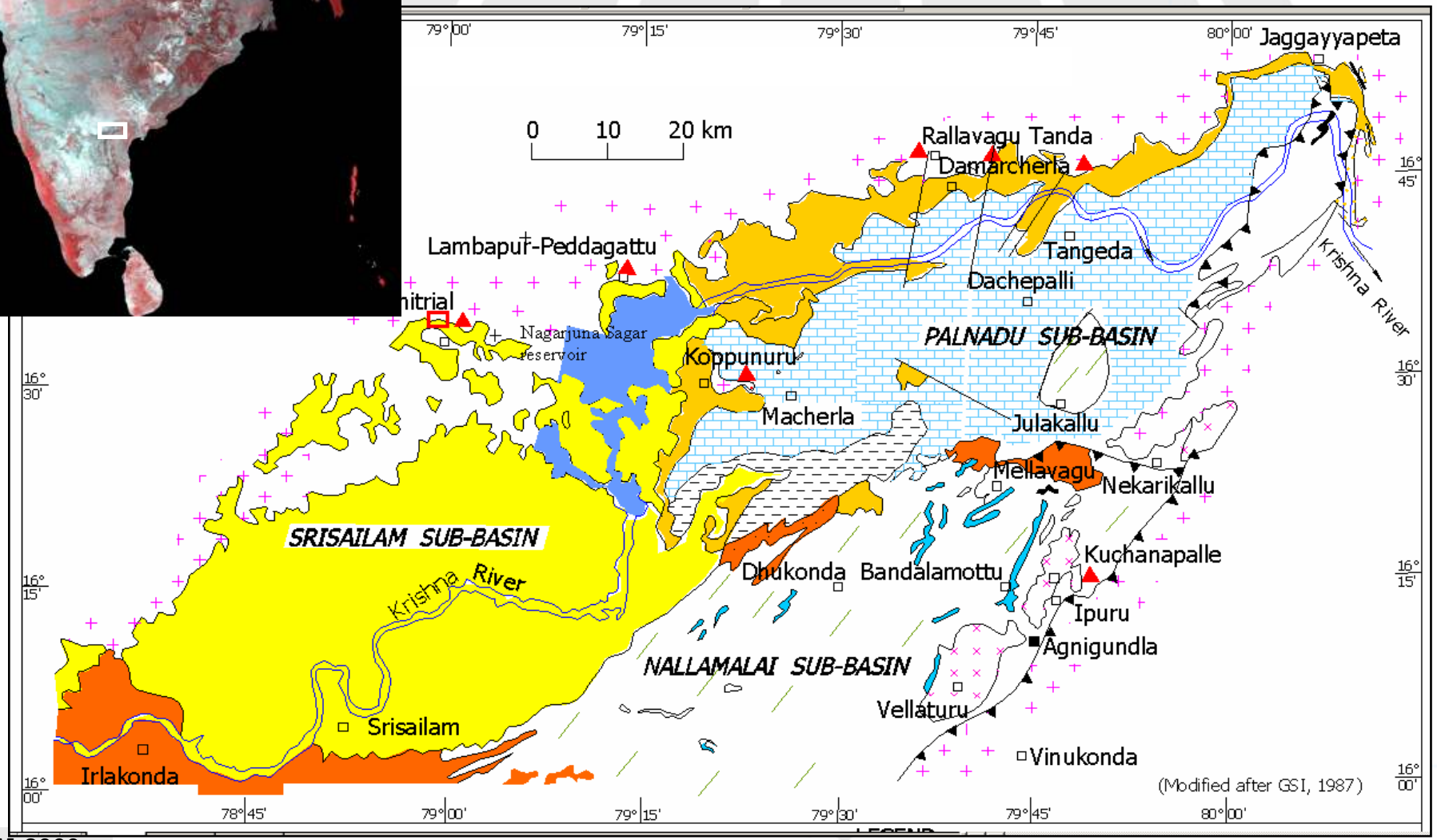
Proterozoic vein type U deposit in Rajasthan – Rohil – Ghateshwar (2000-Present)

Proterozoic Kaladgi basin – Emerging

Srisailam-Palnad-Kurnool sub-basins

Srisailam-Palnad sub-basins, Cuddapah basin





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Uranium mineralisation in northwestern parts of Cuddapah basin

Northern and north-western part of Cuddapah basin is the host for unconformity related uranium mineralisation

The formations are of Middle to Upper Proterozoic age

Unmetamorphosed sediments of orthoquartzite, limestone and shale

Three low grade – low tonnage deposits have been established in Lambapur - Peddagattu, Koppunuru and Chitrial in the northwestern periphery of Cuddapah basin

Nearly 60 sq.km area unexplored in Chitrial and Peddagattu deposits

3000 sq.km inside the basin under sanctuary holds high potential is yet to be explored

Prognostic reserves of Chitrial deposit is about 30,000 tonnes of U_3O_8

Uranium mineralisation in northwestern parts of Cuddapah basin

Lower Proterozoic granite unconformably overlain by Middle Proterozoic Srisaialam formation

Uranium mineralisation follows the unconformity contact between the Srisailam Formation and granite

Major part of the mineralisation is confined to basement granites

Pitchblende, Uraninite, Coffinite and Uranophane are uranium minerals

Exploration strategy for unconformity related deposits in Cuddapah basin

Radiometric and Geological mapping

Radiometric logging of groundwater tubewells

Airborne and ground based geophysical surveys (TDEM, Magnetic and Radiometrics)

Geochemical, petro-minerological and isotopic characterisation of ore body and host rocks

Hyper-spectral Remote Sensing for alteration mapping

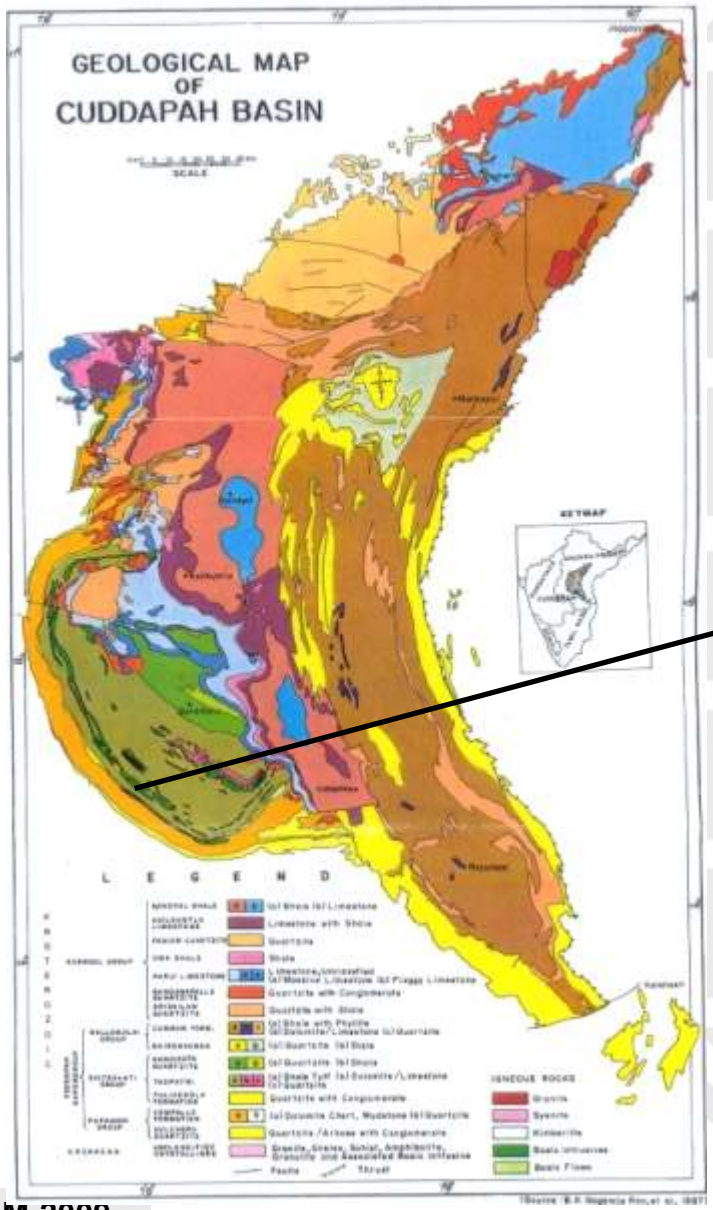
Drill cores- mineral alteration studies

Groundwater hydrology

Genetic modeling of uranium mineralisation

Southern Cuddapah basin

Southern Cuddapah uranium province



Chitravati group

---------- **disconformity** ----------

Papagni group - **<u>Vempalle Formation</u>**
Limestone, dolostone
shale, chert

Gulcheru quartzite

---------- **non-conformity** ----------

Granites, gneissic rocks, Dharwar schists

Characteristics of uranium mineralisation in Vempalle dolostone

Nature of host rock	**Impure, siliceous, phosphatic, dolomitic stromatolitic limestone**
Uranium Minerals	**Pitchblende , Coffinite, U-Ti complex, Collophane**
Associated minerals	**Pyrite, Chalcopyrite, Molybdenite bornite, digenite, covellite**
Gangue Minerals	**Dolomite, Quartz, Microcline**
Average Grade	**0.040 to 0.046% eU_3O_8**
Trace Elements	**Molybdenum - 230 ppm** **Nickel - 30 ppm** **Copper - 90 ppm** **Cobalt - 25 ppm** **Barium - 215 ppm** **P_2O_5 - 2.46%**
Controls of mineralisation	**Phosphate, silica and organic matter in the impure dolomitic limestone are the main controlling factors for uranium mineralisation**

Petrography of Vempalle Dolostone

Thin alternating light and medium to dark gray color bands.

Light gray bands are fine grained and rich in carbonates (micritic and sparritic) mostly dolomites.

Medium to dark grey bands are ultrafine and rich in phosphates mostly collophane

These bands contain floating grains of detrital quartz, felspars and opaques (pyrites).

Uranium mineral - `pitchblende' which occurs as ultrafine granular aggregate, in intimate association with both biogenic and diagenetic pyrite

Other primary uranium minerals in minor amounts are coffinite and U-Ti complex.

Coffinite is later to pitchblende, as it replaces the boundaries and fracture plane. U-Ti complex is present as stringers and inclusion in clastic quartz.

Genesis of uranium mineralisation

Shallow inter tidal flat / mud flat sediments -- Mud cracks, ripple marks, intraforamtional conglomerate layers

Organic activity /deposition of algal debris -- Secondary structures like secretion nodules, oolites and stromatolites

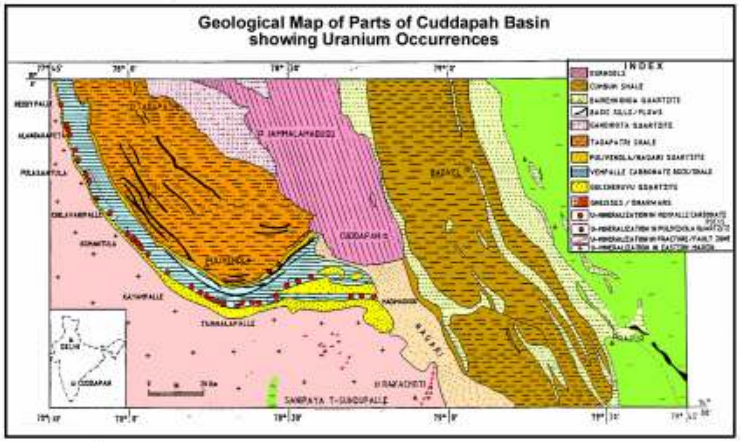
Source of uranium -- Fertile basement granite in the SW

3 stages of uranium concentration

Syngenetic stage : Adsorbed U in phosphate - Algal debris created reducing environment leading to the formation of pyrite and precipitation of uranium

Diagenetic stage : Dolomitisation/ formation of microstylolites and uranium mineralisation

Epigenetic stage : Pitchblende, coffinite in grain boundaries, micro fractures, bedding planes


Geological Map of Parts of Cuddapah Basin
showing Uranium Occurrences
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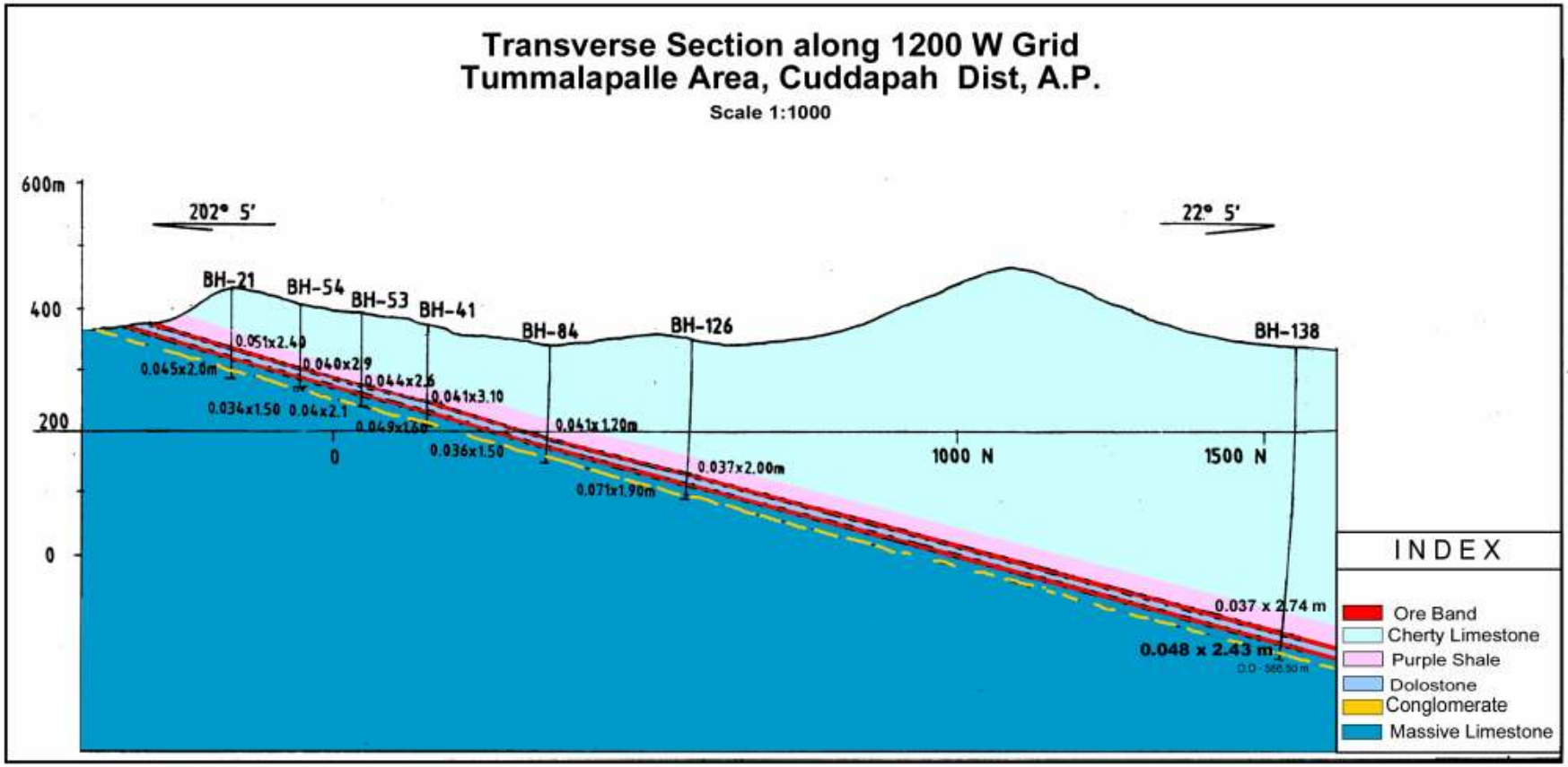

Transverse Section along 1200 W Grid
Tummalapalle Area, Cuddapah Dist, A.P.
Scale 1:1000
600m
400
200
0
202° 5'
22° 5'
BH-21
BH-54
BH-53
BH-41
BH-84
BH-126
BH-138
0.051x2.40
0.045x2.0m
0.040x2.9
0.044x2.6
0.041x3.10
0.034x1.50
0.04x2.1
0.049x1.60
0.041x1.20m
0.036x1.50
0.037x2.00m
0.071x1.90m
0
1000 N
1500 N
0.037 x 2.74 m
0.048 x 2.43 m
INDEX
Ore Band
Cherty Limestone
Purple Shale
Dolostone
Conglomerate
Massive Limestone

Tabular, stratabound, non-transgressive ore zones, homogenous

Mineralisation extends for 160 km along the strike

Limited variation in grade and thickness along strike as well as in dip directions

Two ore lodes – separated by 3m (average) lean zone

Basic dyke which lies in the centre of the deposit has not disturbed the continuity of the mineralization

Exploration strategy

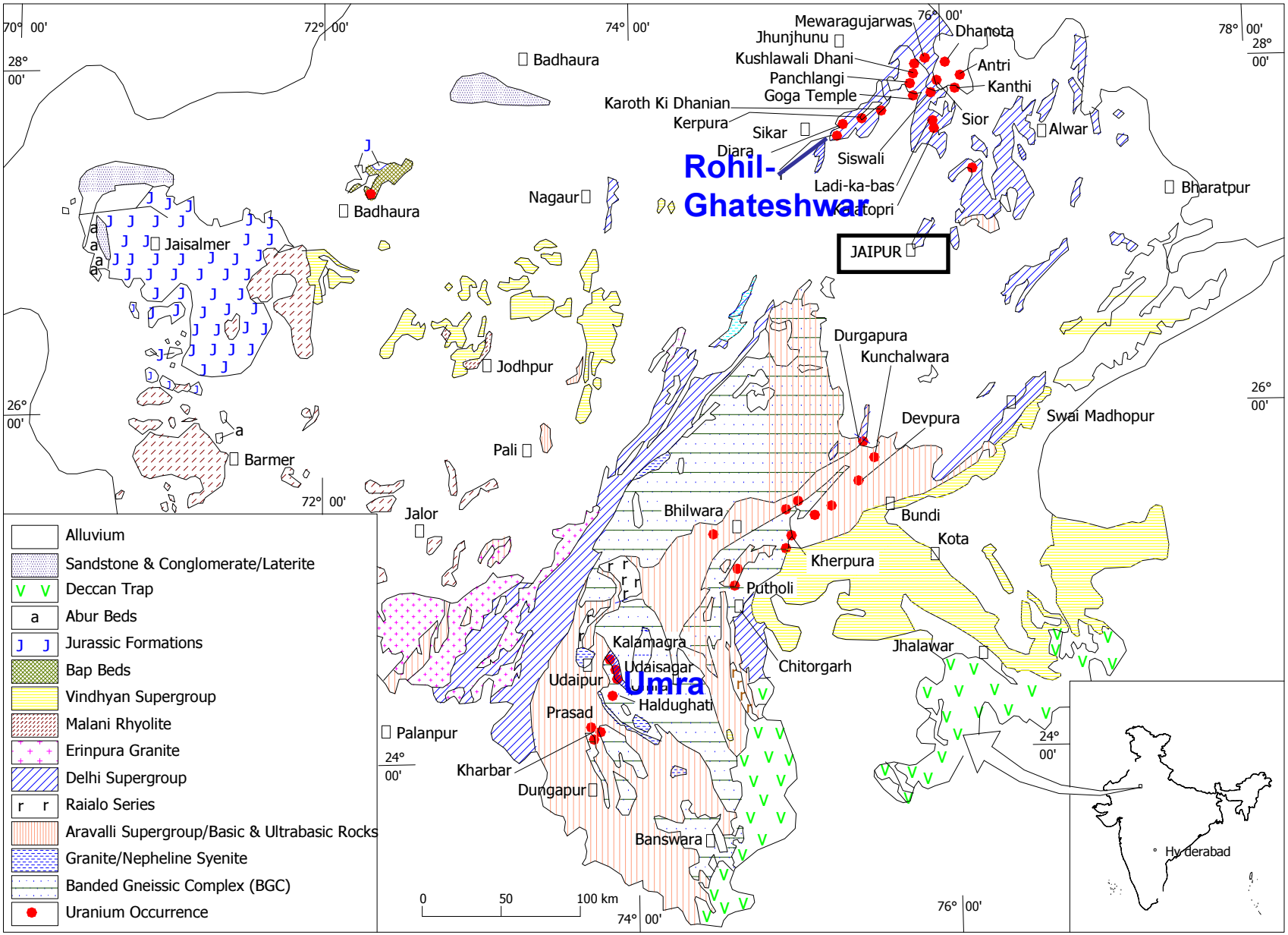
Extensive Drilling -- 160 km long belt of near-isotropic(?) uranium mineralisation along the strike

Sedimentary facies mapping of massive / cherty limestones of Vempalle Formation to identify pockets of higher grade mineralisation

Geochemical characterisation and genetic modeling for U, Mo and other elements in the orebody and provenance rocks

Construction of mine and mill in progress

North Delhi Fold Belt



GEOLOGICAL MAP OF PART OF RAJASTHAN SHOWING URANIUM OCCURRENCES

Uranium potential of North Delhi Fold Belt

Uranium mineralisation intermittently along 320 km long east west trending Kaliguman lineament

North Delhi fold belt lies in the northern part of the lineament

Comprise Khetri, Alwar and Lalsot-Bayana sub-basins

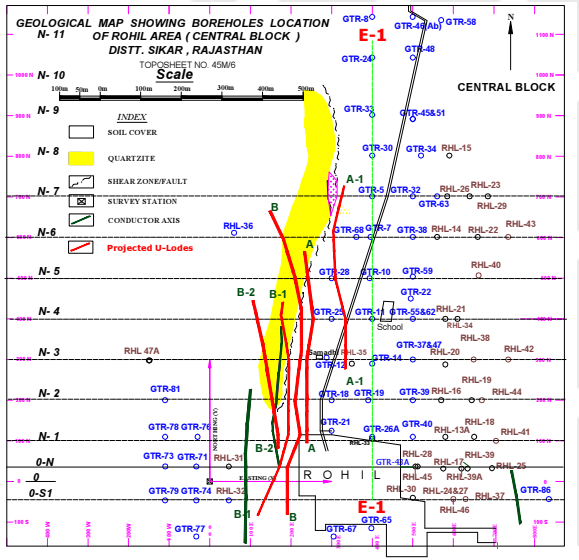
Middle Proterozoic Metasedimentary rocks with acidic intrusives

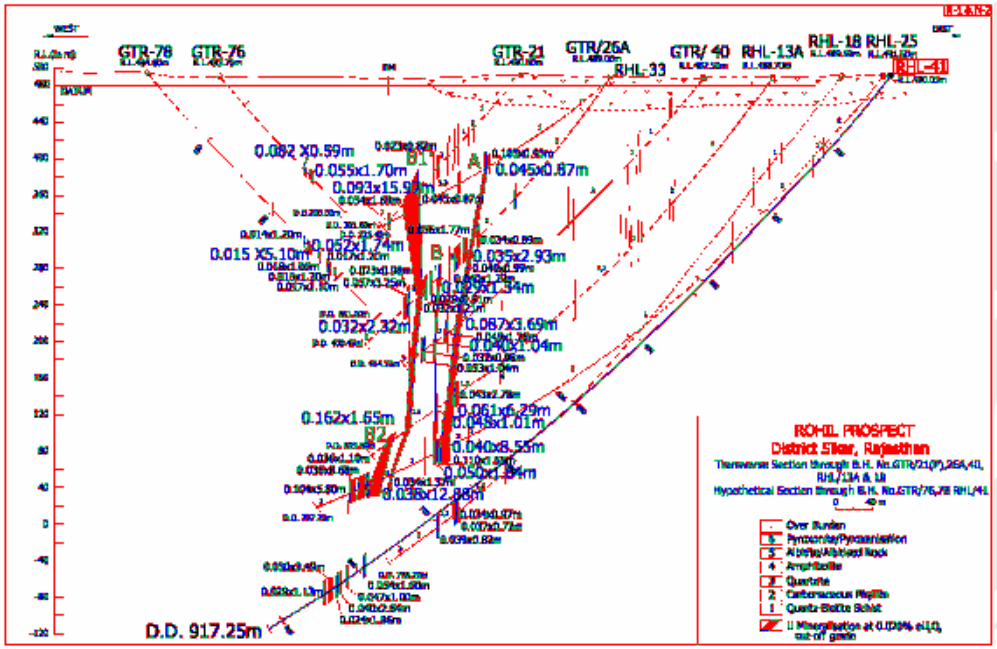
Extensive albitisation

Established a low grade – low tonnage uranium deposit in Rohil village

Scope for similar mineralisation along the 320 km long lineament in other sectors.

Disposition of orebody and surface projection - Rohil





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Characteristics of uranium mineralisation - Rohil

Mineralisation along shear zones and fractures

Confined to albitised meta-pelitic rocks and neighborhood

Mineralisation is associated with massive sulphide minerals

Sulphide minerals are manifested as good conductors in the ground and airborne electromagnetic data/images

Areas of hydrothermal activity represented by a low magnetic zone as a result of alteration of minerals of high magnetic susceptibility

Axial planes are the zones of intense shearing

Exploration strategy for NDFB

Area is mostly covered by quaternary alluvium

Geological and radiometric study of scanty outcrops

Hydro-geochemical surveys

Radiometric logging of pre-existing groundwater tube wells

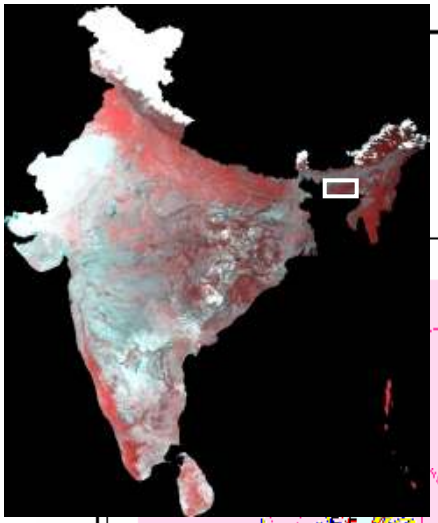
Areas along the Kaliguman lineament with
- **area of albitisation**
- **linear low magnetic zones**
- **association of high conductors**
- **association of shear/fracture zone and axial planes of folds**

are the signatures for possible uranium mineralisation in NDFB

Mathematical modeling of geological and geophysical datasets

Exploration programme stresses on extensive airborne geophysical surveys and a matching drilling campaign

Mahadek basin

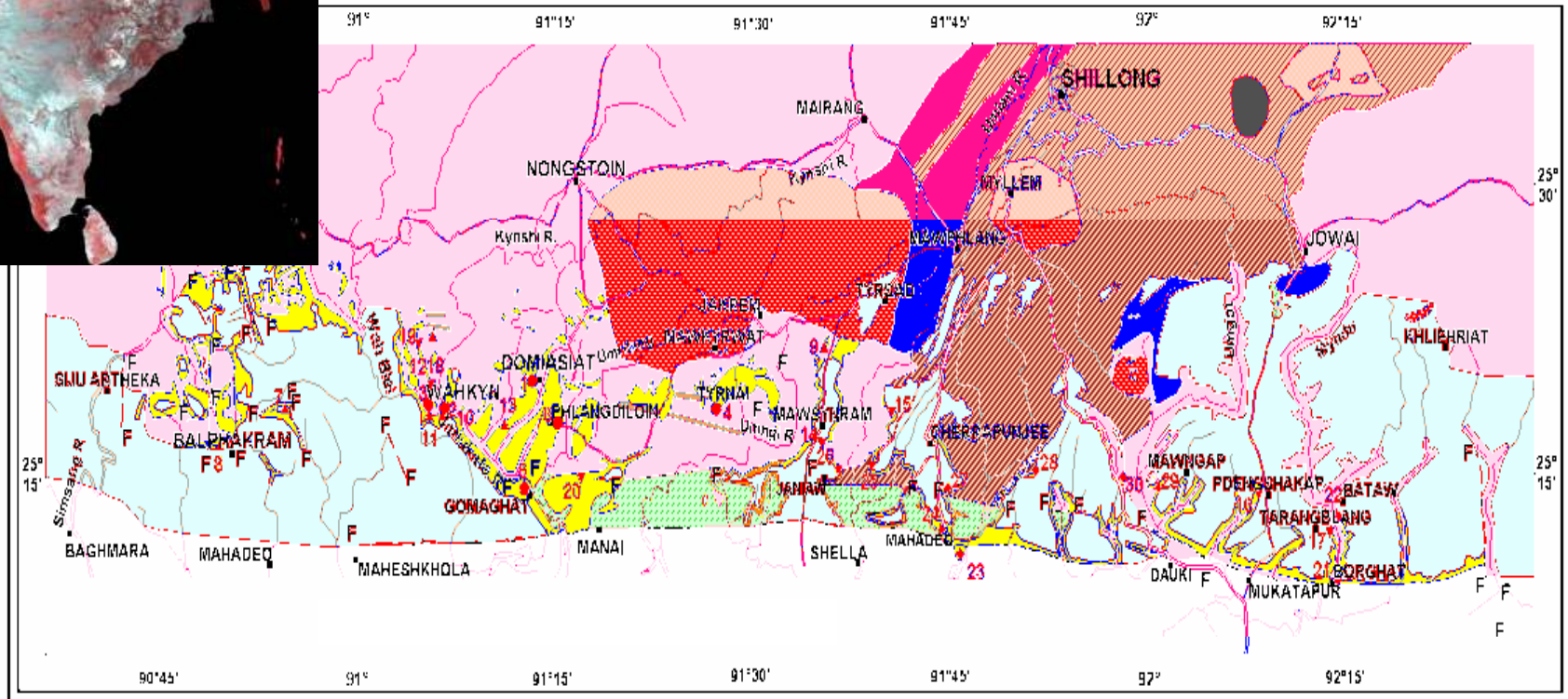


MAHADEK BASIN OF JAINTIA, KHASI & GARO HILLS, MEGHALAYA

TOPOSHEET NO. 78O, 78K & 83C

N

0 50 km



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- LANGPAR/SHELLA/TURA/SIJU FORMATION: TERTIARY
- MAHADEK FORMATION: CRETACEOUS
- JADUKATA FORMATION: CRETACEOUS
- CARBONATITE COMPLEX: CRETACEOUS
- SYLHET TRAP: JURASSIC
- YOUNGER GRANITE: PROTEROZOIC
- INTRUSVE QUARTZ: PROTEROZOIC
- BARAPANI FORMATION: PROTEROZOIC
- TYRSAD FORMATION: PROTEROZOIC
- BASEMENT GNEISSIC COMPLEX: ARCHAEAN

ORE DEPOSIT

1. DOMIASIAT
2. WAHKYN
3. LOSTOIN
4. TYRNAI
5. GOMAGHAT
6. PHILANGDILOIN

THRUST AREAS

7. UMTHONGKUT
8. BALPHAKRAM
9. RANGSOHKHAM
10. WAHKUT
11. PLU NALA
12. WAITING UMLANG
13. MAWTHAWPDAH

INVESTIGATED AREAS

14. PHLANG SYNNEI
15. LAITDUH
16. PDENGSHAKAP
17. TRANGBLANG
18. UMTHALENE
19. UMTINIANG
20. NONGNAH

URANIUM OCCURRENCE

21. BORGHAT
22. BATAW
23. THERRIA
24. MAHADEO
25. MAWSAHEW
26. KENSHLUID
27. LAITIAM
28. MAWBEH
29. KHONGLAH
30. PONGTUNG

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Upper Cretaceous Lower Mahadek sediments are the host for Sandstone type uranium mineralisation in Meghalaya, India

Meghalaya plateau in northeast India is a horst block uplifted during Eocene along with Himalayan orogeny

Southern part of Meghalaya plateau is exposed with 1800 sq.km of Cretaceous and Tertiary sediments

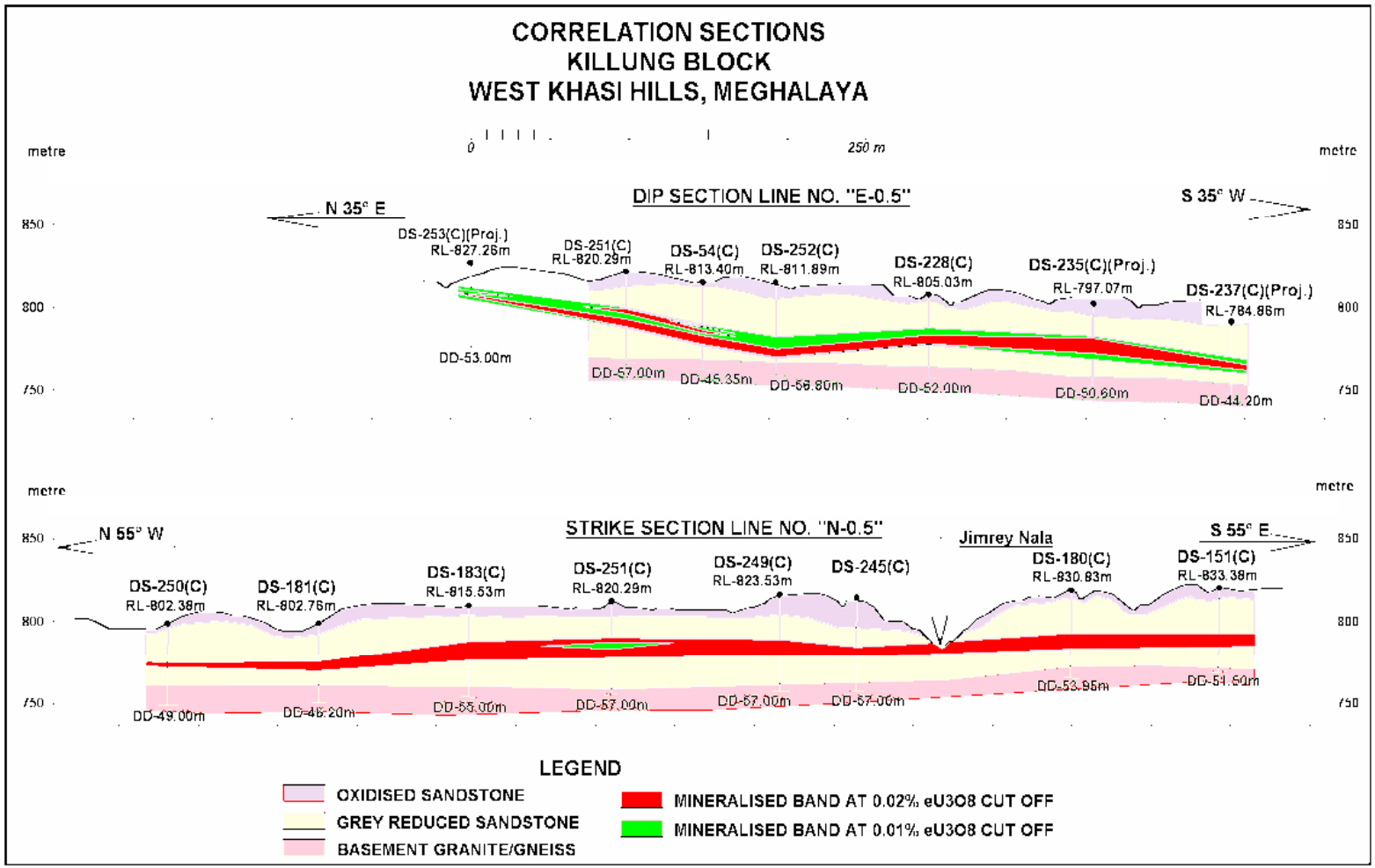
Two medium grade low tonnage deposits and four satellite deposits have been established in this province

Lower Mahadek sediments (thickness-30-40m) are of fluvial nature and characterised by Channel filled and flood plain sediments

Lower Mahadek sediments are exposed over 500 sq.km area, while in the remaining 1300 sq.km, they are overlained by younger Tertiary sediments

The channel filled sediments of the lower Mahadeks are the target horizon for sandstone type of Uranium mineralisation

Correlation sections of Domiasiat uranium deposit



Domiasiat-Wahkyn uranium deposits

Deposited as tabular/peneconcordant body along palaeo channels of basement topographic lows in a proximal braided channel system

Average vertical impact is 30m

Pitchblende, uraninite, coffinite, U+Si+C complex & secondary uranyl complexes are the uranium minerals

73 - 92% laechability by pug Cure, hot agitation & conventional leaching

Associated elements are V, As, Co, Se, Mo, Organic matter : 0.5 to 1%

Uranium exploration strategy

Mahadek sediments -- 500 sq.km exposed : Radiometric surveys done; rest 1300 sq.km covered by upto 300m thick pile of Tertiary sediments

Most of the area under thick forest cover and wild life sanctuary

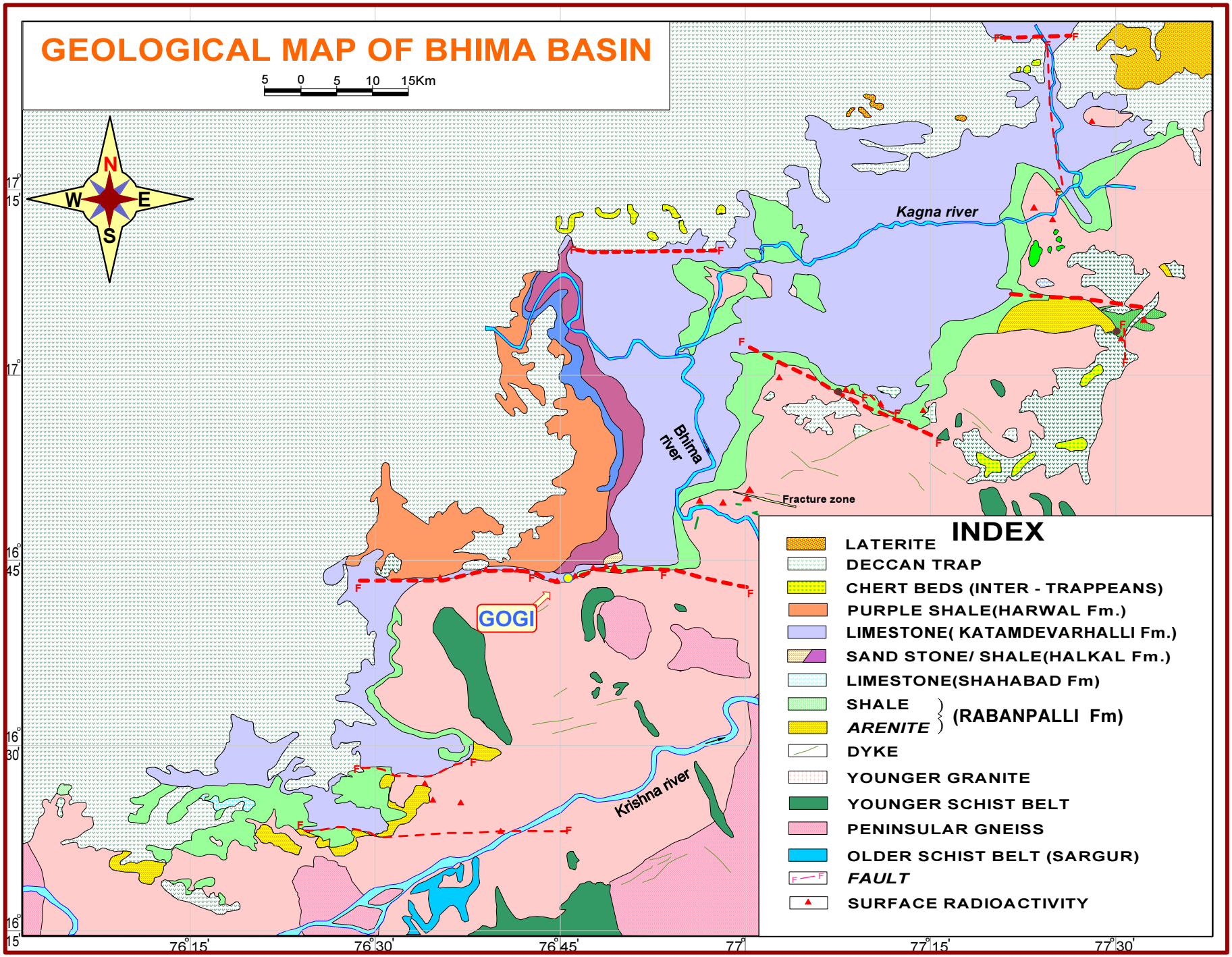
Micro-geomorphological studies using aerial photos and high resolution satellite images for the delineation of Channel sediments and Flood plain sediments among the exposed parts of Lower Mahadeks

Ground magnetic and resistivity surveys for the delineation of palaeo-channels and basement lows

Other geophysical inputs

* TDEM for delineation of palaeo channels where the target is covered by a thick pile of Tertiary sediments
* Gamma-ray spectrometer survey
* Magnetics and Resistivity surveys for basement topography
* Drilling with geophysical logging

Bhima basin


GEOLOGICAL MAP OF BHIMA BASIN
5 0 5 10 15Km
N
W
E
S
Kagna river
Bhima river
Krishna river
Fracture zone
GOGI
INDEX
LATERITE
DECCAN TRAP
CHERT BEDS (INTER - TRAPPEANS)
PURPLE SHALE(HARWAL Fm.)
LIMESTONE(KATAMDEVARHALLI Fm.)
SAND STONE/ SHALE(HALKAL Fm.)
LIMESTONE(SHAHABAD Fm)
SHALE
ARENITE
(RABANPALLI Fm)
DYKE
YOUNGER GRANITE
YOUNGER SCHIST BELT
PENINSULAR GNEISS
OLDER SCHIST BELT (SARGUR)
FAULT
SURFACE RADIOACTIVITY
17° 15'
17°
16° 45'
16° 30'
16° 15'
76° 15'
76° 30'
76° 45'
77°
77° 15'
77° 30'

Characteristics of uranium mineralisation in Gogi area

Small – medium grade deposit

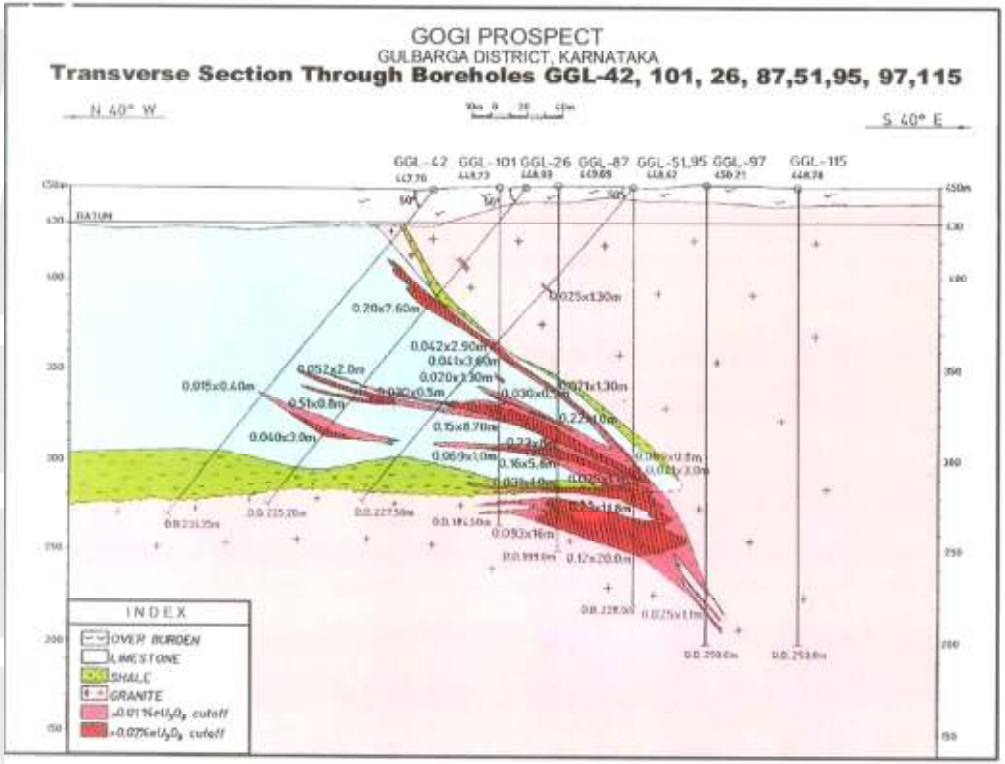
Uranium mineralisation associated with tectonised limestone and sheared basement granites

Mineralisation in the environs of thrust plane and unconformity

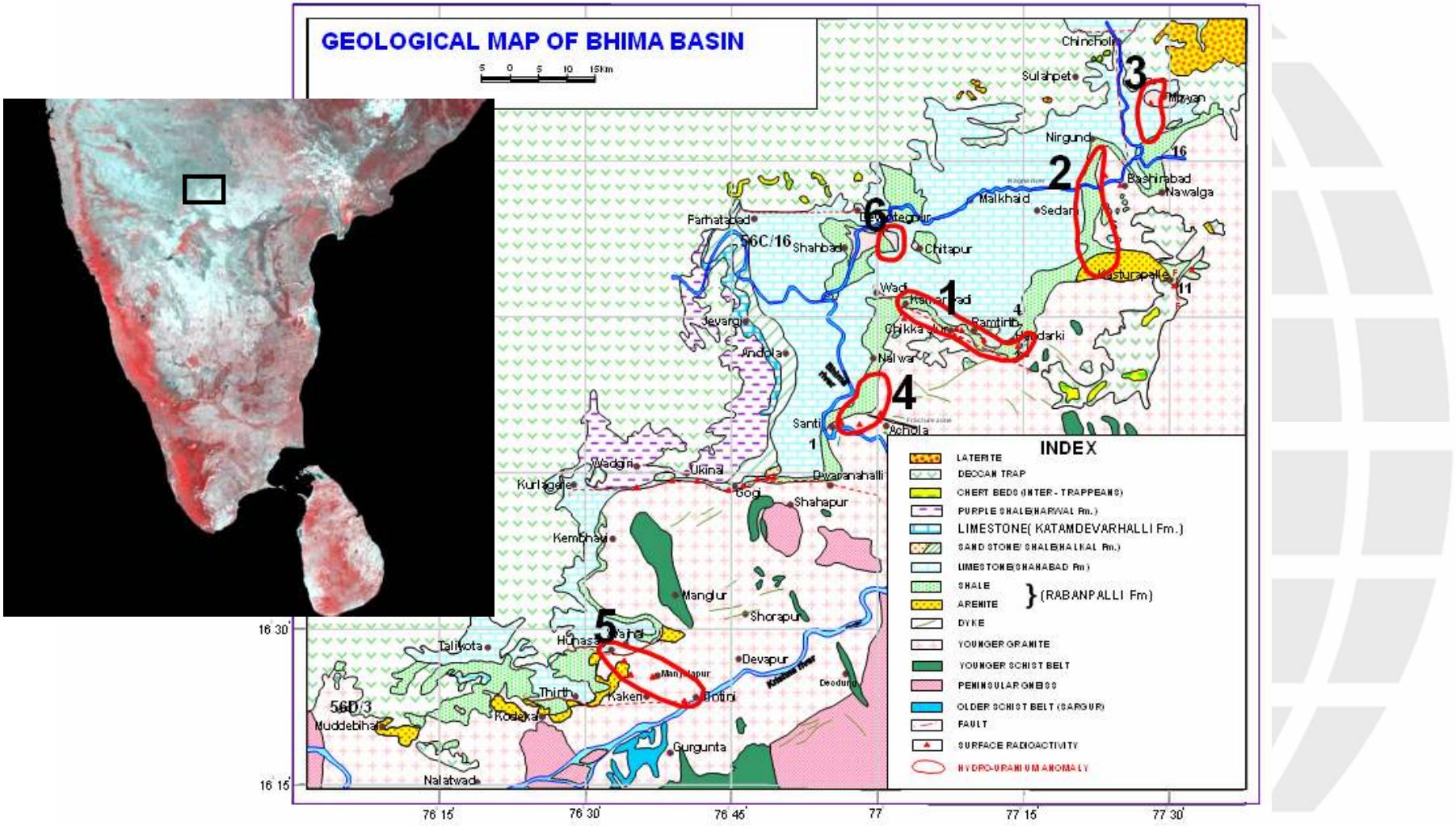
Coffinite and pitchblende are major uranium minerals

Mineralisation is intimately associated with carbonaceous matter

Alteration in basement are chloritisation and sericitisation



Hydro uranium anomaly zones



1. Wadi fault zone
2. Karankot – Kallur
3. Wajhal – Tintini
4. Sedam – Ekmai
5. Santi – Achola:
6. Shahabad – Bankur

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Exploration strategy

Radiometric and Geological mapping

Geochemical, petro-minerological characterisation of ore body and host rocks

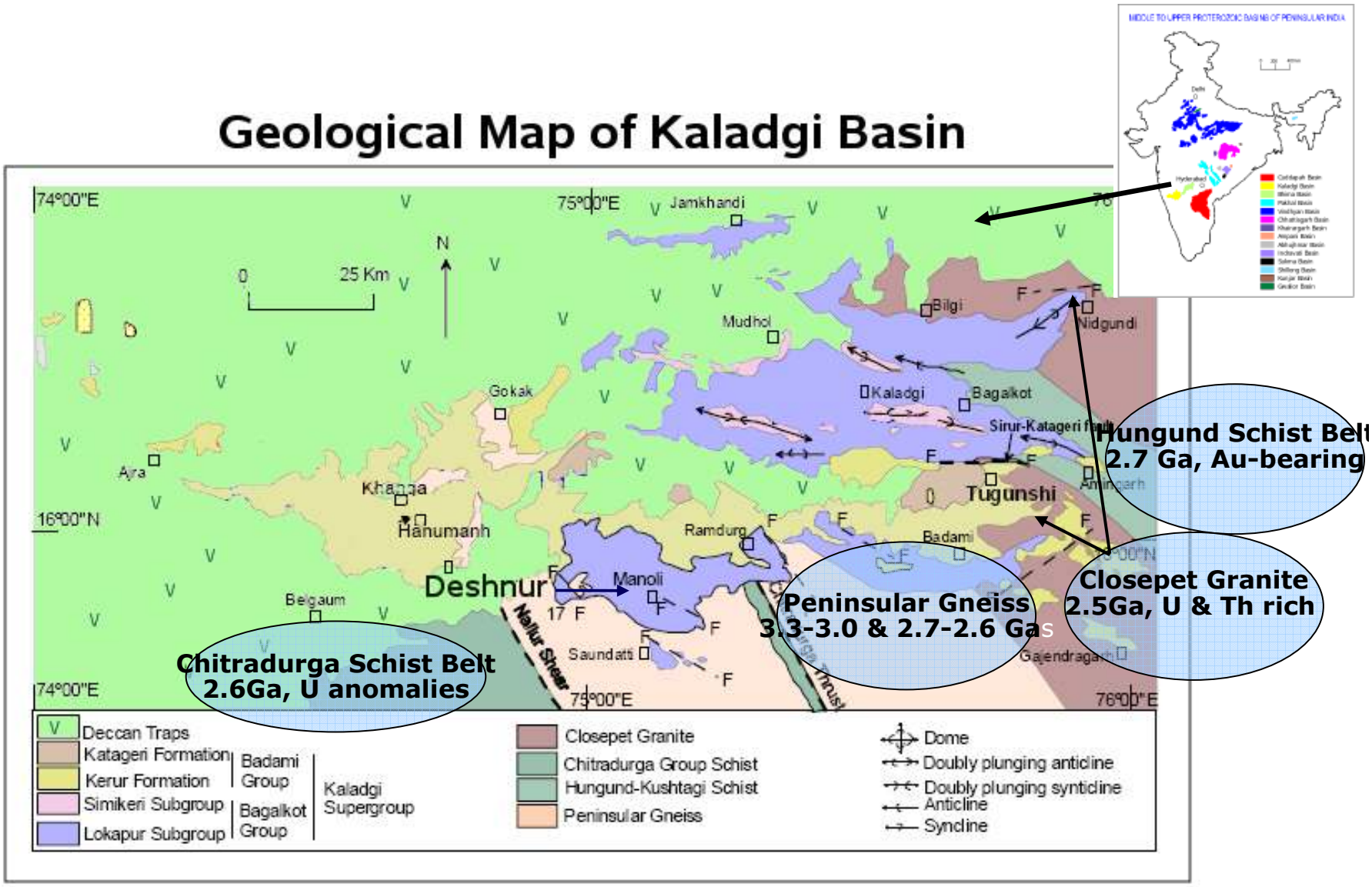
Airborne and ground based geophysical surveys (TDEM, Magnetic and Radiometrics)

Radiometric logging of groundwater tubewells

Genetic modeling of uranium mineralisation

Kaladgi basin

Geological Map of Kaladgi Basin



After Geological Society of India, 1999

- Total aerial extent ~ 8500 sq km

Uranium mineralisation in Kaladgi sediments

Reduced nature of the radioactive core

Presence of rich sulphides in the mineralized portions in dispersed form as well as fracture fillings

Replacement of sulphide (pyrite) by the uranium phase.

Presence of secondary uranium mineral

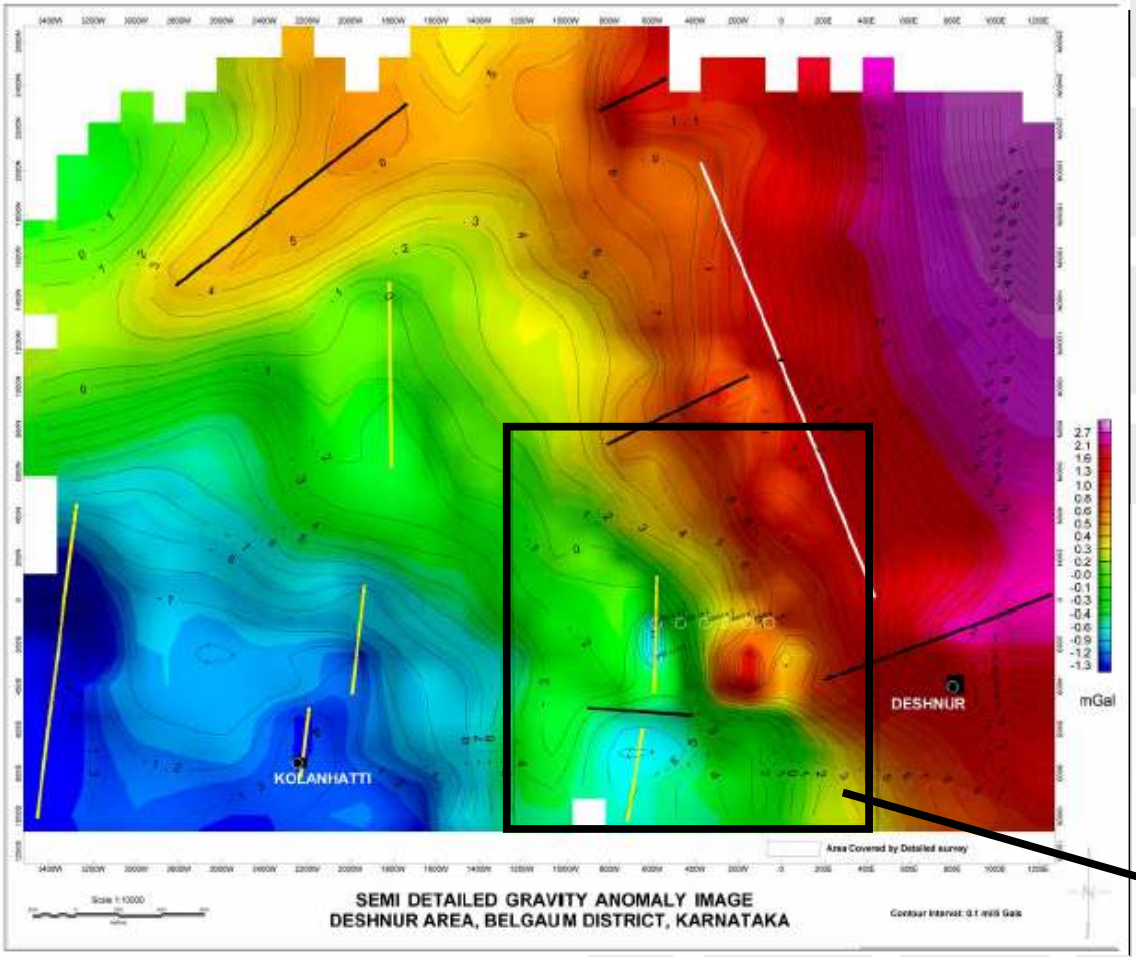
Absence of oxidized basement schist below the unconformity

Higher concentration of uranium mineralization and the associated sulphides in structurally weak zones and in paleo-lows.

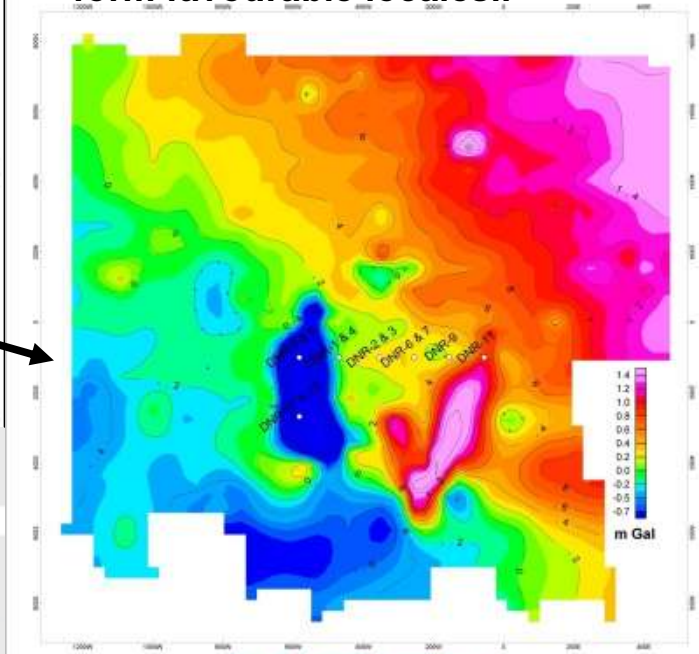
Uranium mineralisation in Kaladgi sediments

Nature of host rock	**Quartz arenite**
Uranium Minerals	**Pitchblende, Uraninite, Brannerite and secondary uranium**
Associated minerals	**Pyrite, hematite and limonite**
Alteration	**Secondary silica overgrowth, replacement of pitchblende along borders and fractures of pyrites**
Controls of mineralisation	**Hydrothermal epigenetic along fractures and weak planes**

Gravity Survey, Deshnur area

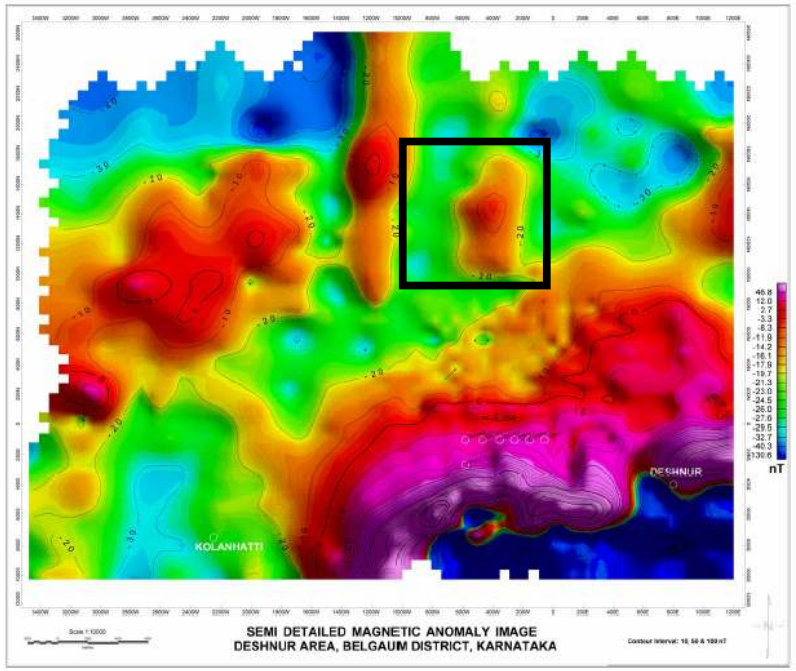


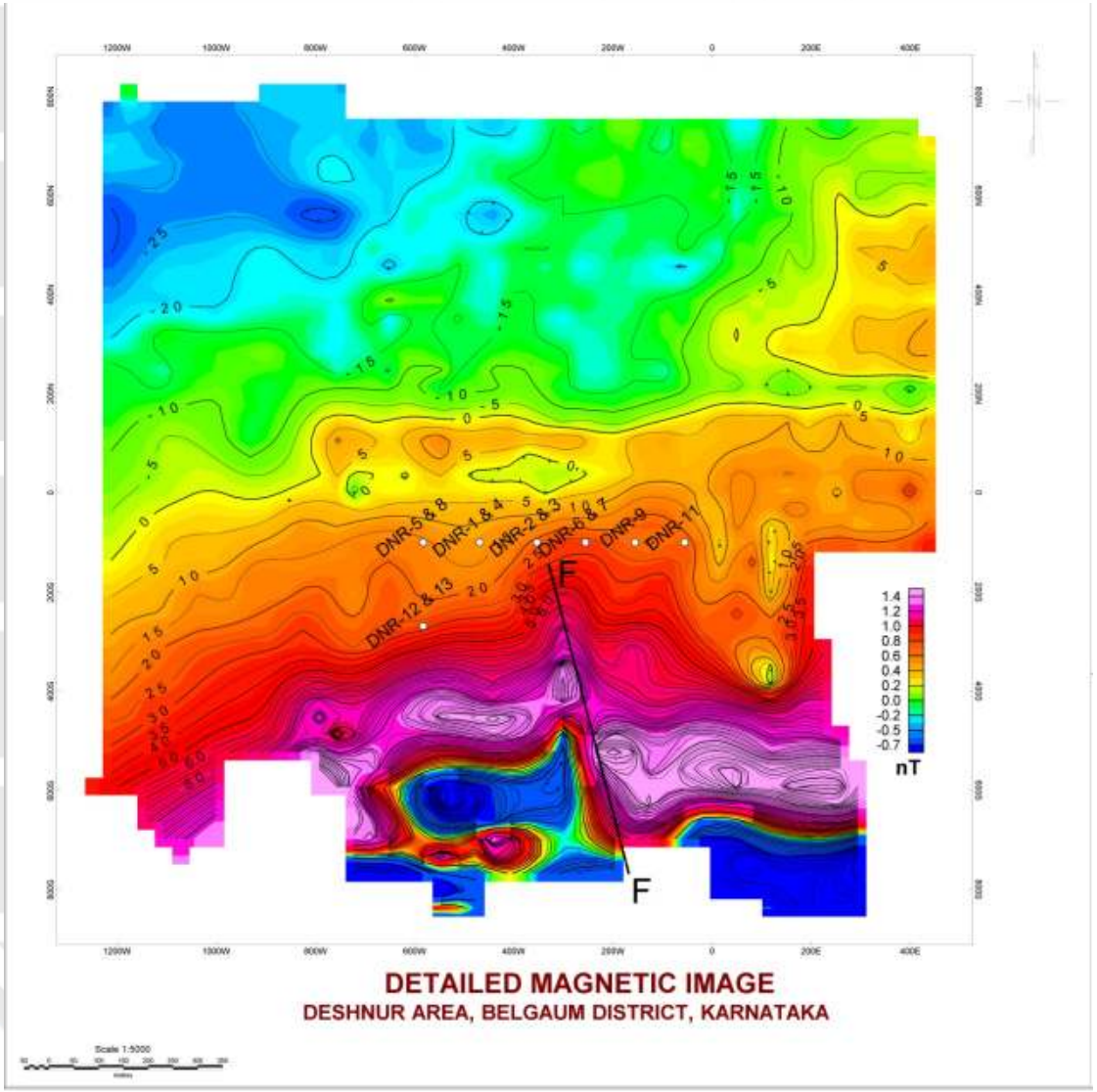
- The anomaly amplitudes decreases towards SW indicating the increase in the sediment thickness
- The high gradient in NE may be due to NW-SE trending structural dislocation
- Localized N-S trending gravity low in the vicinity of boreholes DNR-13 and DNR-17 is proved to be mineralized. Hence such lows may form favourable locales..



Magnetic Surveys in Deshnur area

Magnetic Image suggest the **N – S feature** associated with mineralisation





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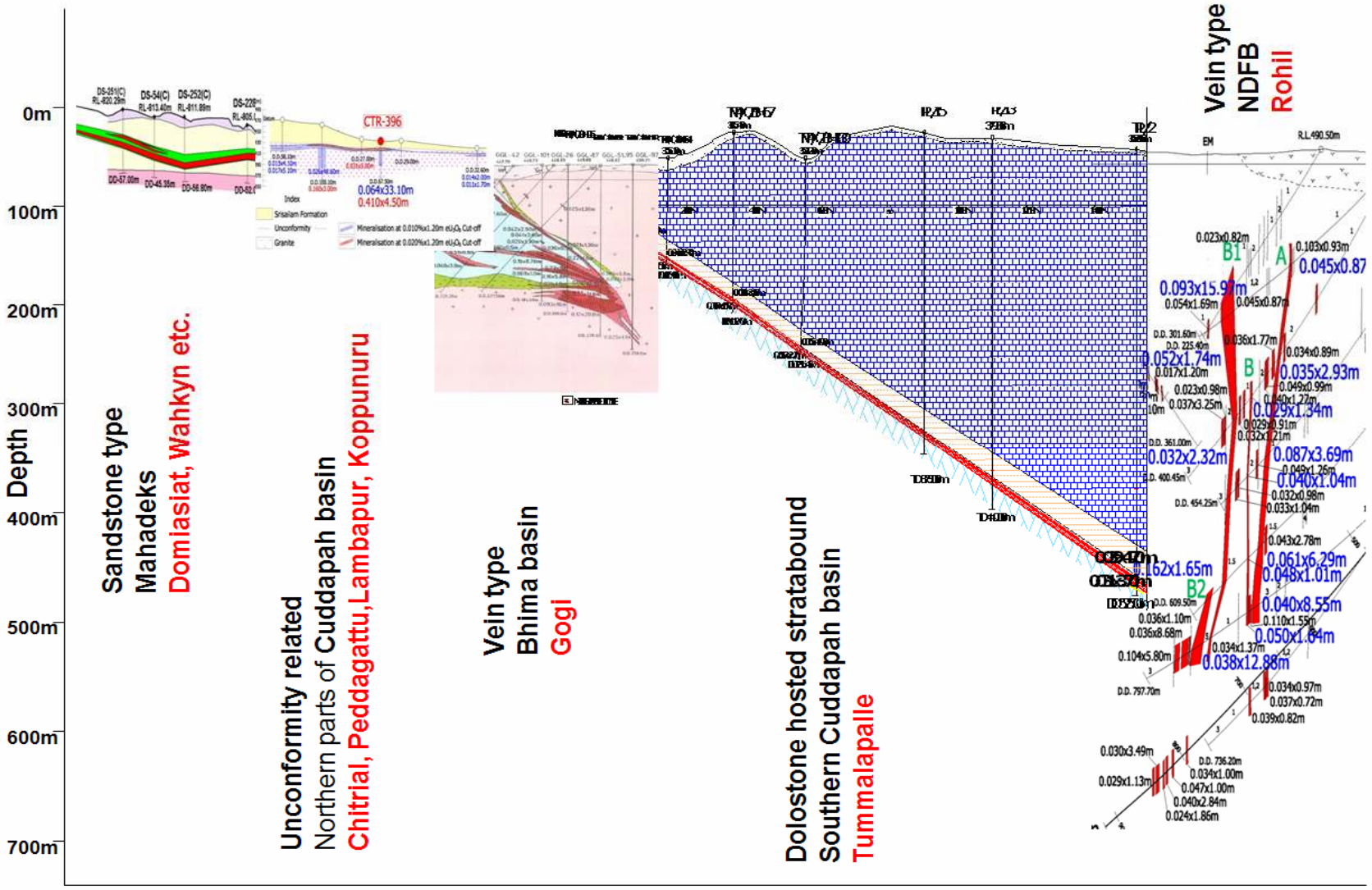
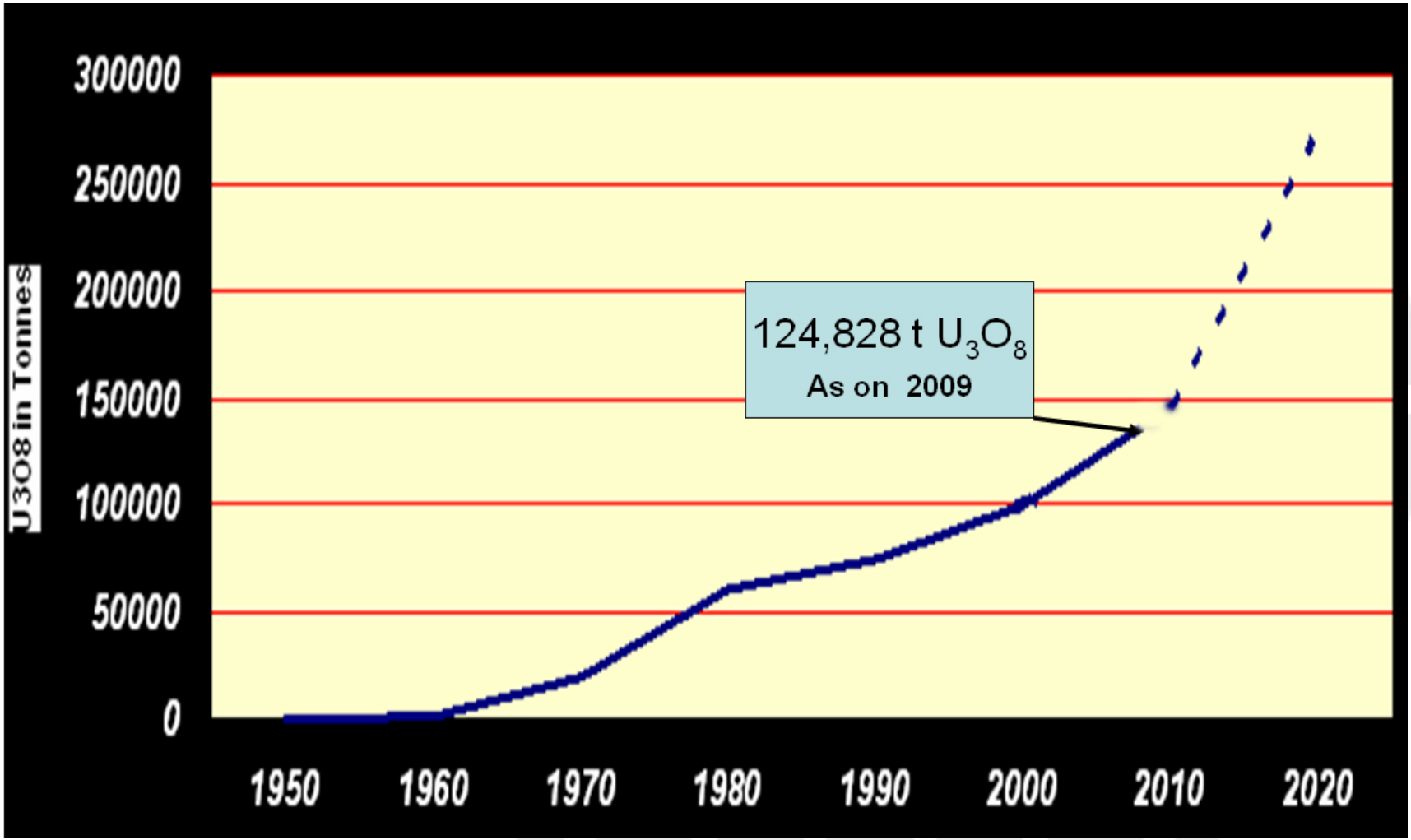
Indian uranium deposits – a comparison



India's Uranium Resources through the years



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Concluding remarks

- India has vast low grade uranium resources in Cuddapah basin
- Very high potential to host high grade unconformity related mineralisation in the Proterozoic basins
- India has 14 Proterozoic basins, of which three known to host unconformity related uranium deposits hosted and vein type mineralisation – Potential for huge uranium resources
- Areas in Rajasthan along Kaliguman lineament is open for exploration
- Uranium mineralisation has been established in all the other Proterozoic basins

Future strategy

- Uranium exploration in India is now geared up to face the challenges of the rapidly growing domestic nuclear power sector and has carefully laid down plans for the next five to ten years.

- Airborne Time Domain Electromagnetic surveys have been introduced in a big way in the uranium exploration programme of the country. More than 4,00,000 line km of airborne geophysical surveys, including TDEM, Gamma-ray spectrometric and magnetic surveys are proposed to be carried out over potential Proterozoic Basins of India.

- An ambitious drilling programme to drill about 7,00,000m in potential target areas of the country has already been formulated in order to augment the uranium resources.

Thanks