# Uranium and thorium resources in India: UNFC system

**P.S.Parihar**

**Atomic Minerals Directorate for Exploration and Research**
**Department of Atomic Energy**
**Government of India**

# Government of India's Policy on Atomic Minerals

The federal status of the DAE and the powers invested in it under the Indian Atomic Energy Act (1948 and 1962) as amended from time to time, bestow upon it several rights to facilitate atomic mineral exploration. The more significant ones are-

- Exclusive rights to conduct exploration for uranium, thorium and other prescribed minerals such as beryllium, lithium, niobium, tantalum and rare-earth elements all over the country .
- Exclusive rights to buy prescribed minerals from private mine owners produced incidental to mining of other economic minerals.
- Rights to access to surface and sub-surface data on areas under exploration or mining/recovery for oil, coal, minerals and ground water by Government or Public Sector Organisations. The facility includes carrying out of gamma-ray logging of boreholes and checking of mine workings and collection of samples etc.

# Government of India's Policy on Atomic Minerals

**Uranium exploration, production and utilisation are under the control of Central Government.**

**Only public sector companies under Government of India are allowed to explore and mine atomic minerals viz. U, Th, etc.**

**Present system of reporting of uranium reserves in India is as per the IAEA system of uranium resource classification**

- Indicated – [Reasonable assured resources (RAR)]
- Inferred – [Inferred resources (IR)]
- Prognosticated resources (PR)
- Speculative resources

# NEA-IAEA classification of uranium resources

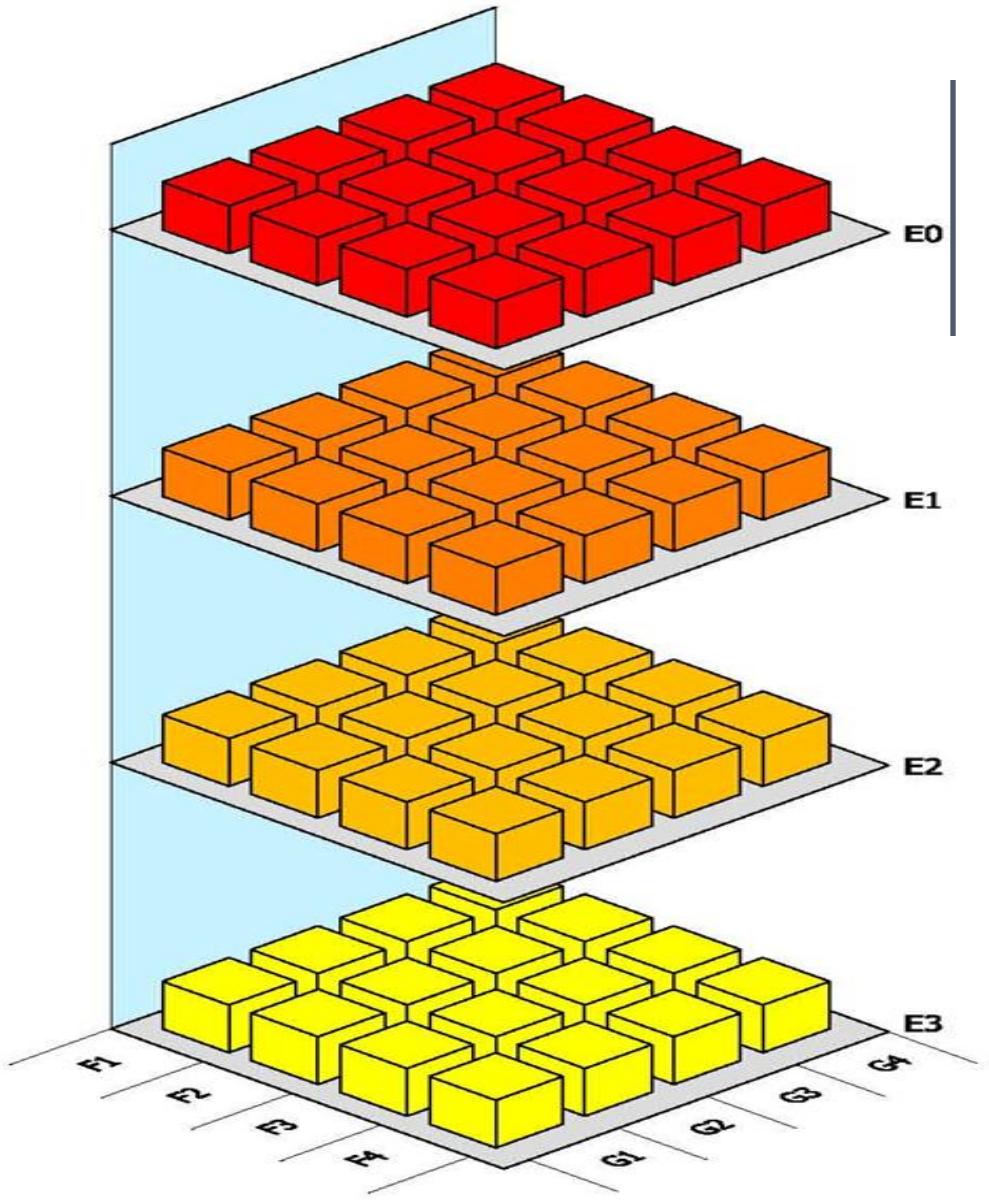
| | | Identified Resources | | Undiscovered Resources | |
|---|---|---|---|---|---|
| Cost of recovery | USD <40/kgU | Reasonably Assured Resources | Inferred Resources | Prognostigated Resources | Speculative resources |
| | USD 40–80/kgU | Reasonably Assured Resources | Inferred Resources | Prognostigated Resources | |
| | USD 80-160/kgU | Reasonably Assured Resources | Inferred Resources | Prognostigated Resources | |
| | USD 130–260/kgU | Reasonably Assured Resources | Inferred Resources | Prognostigated Resources | |

Decreasing economic viability

Decreasing confidence in estimates

- Two agencies, viz., Atomic Minerals Directorate for Exploration and Research (AMD) and Uranium Corporation of India Limited (UCIL) under the Department of Atomic Energy are engaged in the exploration and mining of uranium, respectively for its exclusive use as fuel in the nuclear power stations owned by Government of India.
- As per UNFC, reporting of resources are to be done by numerical coding on three axes (E,F&G).
- The geological details (G) and feasibility status (F) of almost all the Indian uranium and thorium deposits have been widely reported, but the details related to the economics (E) is not reported.
- As a result, the classification with reference to E axis may be difficult for Indian deposits.

# UNFC system for uranium resource classification- suggested system for indian uranium resources




A new plane $E_0$ is suggested for those countries who want to keep the uranium production cost confidential.

# Thorium resources

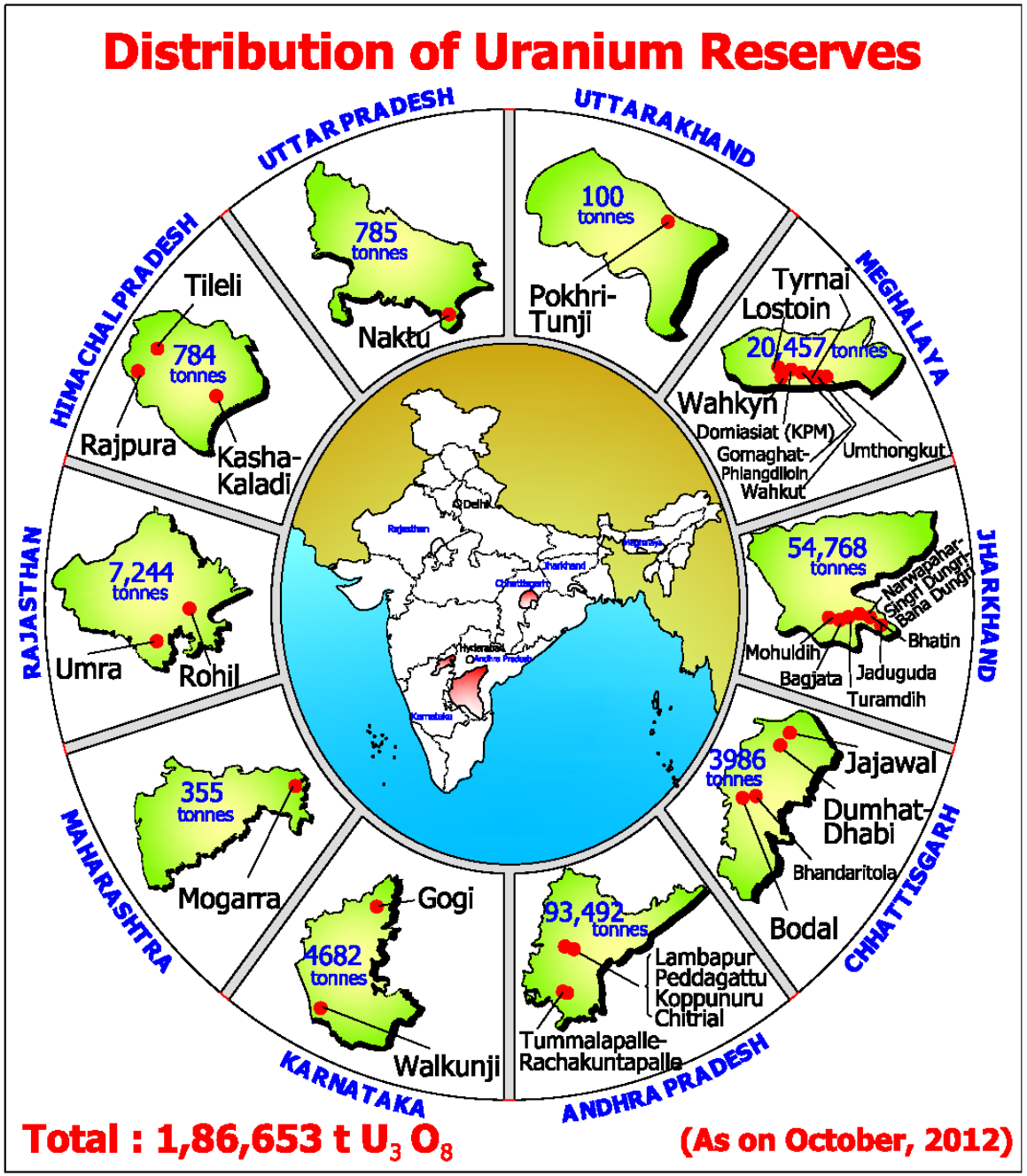
- All the evaluated thorium resources in India is confined to the mineral monazite occurring in the beach sand heavy mineral suite of East and West coasts.

- Indian resources fall under the category "VI. Placer and residual deposits of hill and valley wash" of UNFC system and the deposits have been classified in the geological and Feasibility axes .

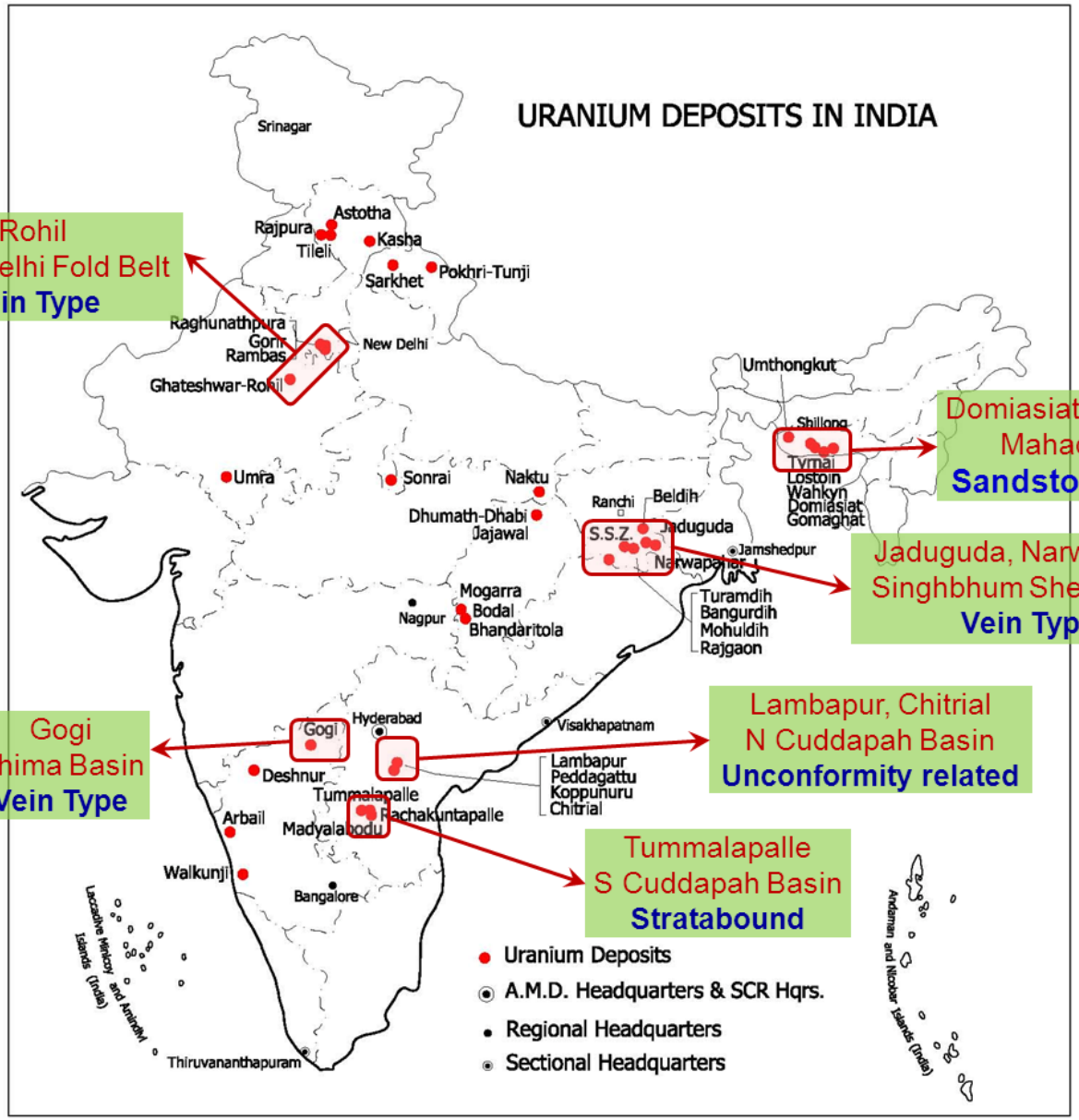
- Economic axis depends on the associated heavy minerals and needs to be addressed separately. Numerical codes for E axis has not been worked out for Indian thorium deposits.

# India’s uranium resources and UNFC coding

# India's uranium resources



# Major uranium deposits




**Major Uranium Deposits**

Rohil
North Delhi Fold Belt
**Vein Type**

Domiasiat,Wahkyn
Mahadeks
**Sandstone type**

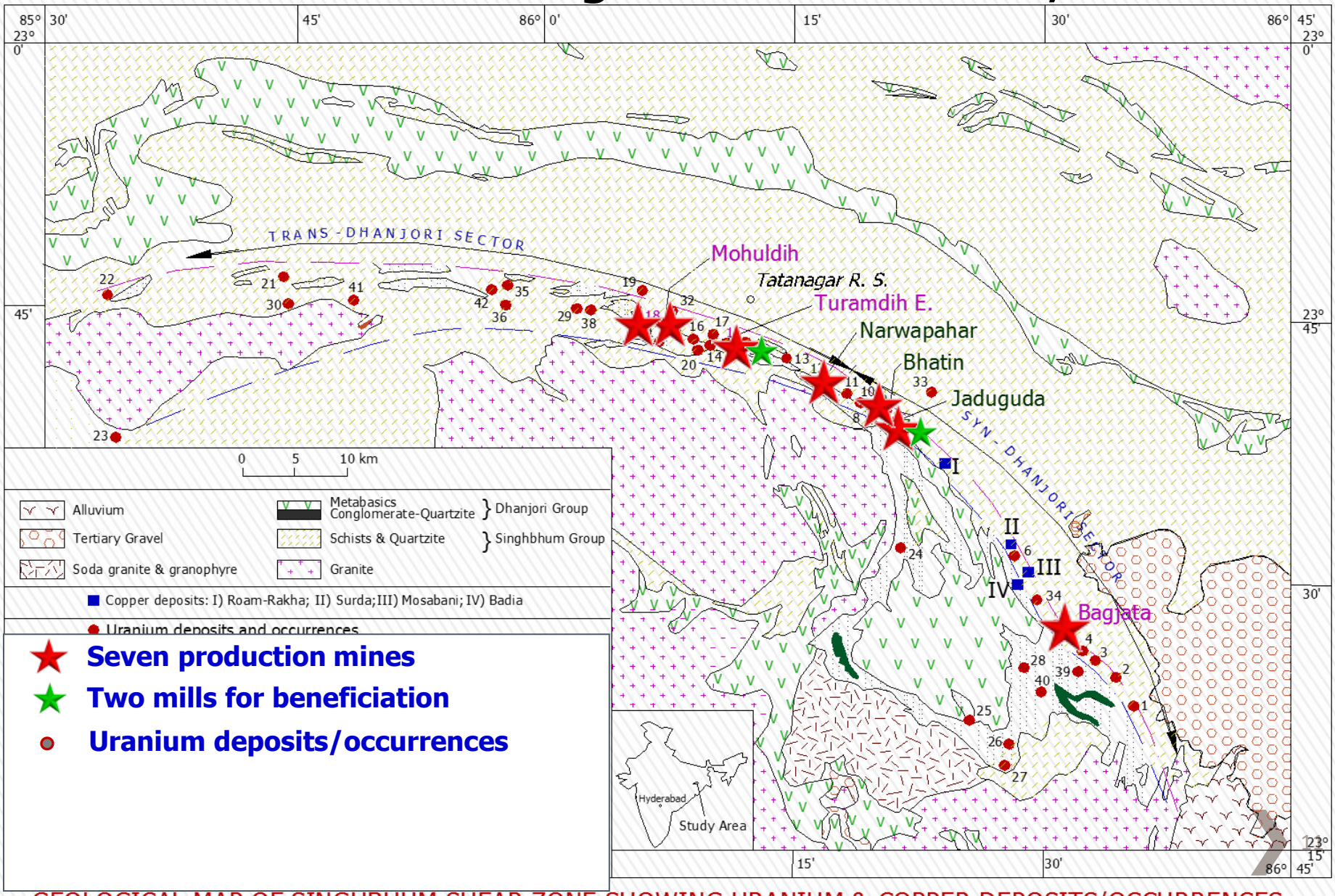
Jaduguda, Narwapahar
Singhbhum Shear Zone
**Vein Type**

Gogi
Bhima Basin
**Vein Type**

Lambapur, Chitrial
N Cuddapah Basin
**Unconformity related**

Tummalapalle
S Cuddapah Basin
**Stratabound**

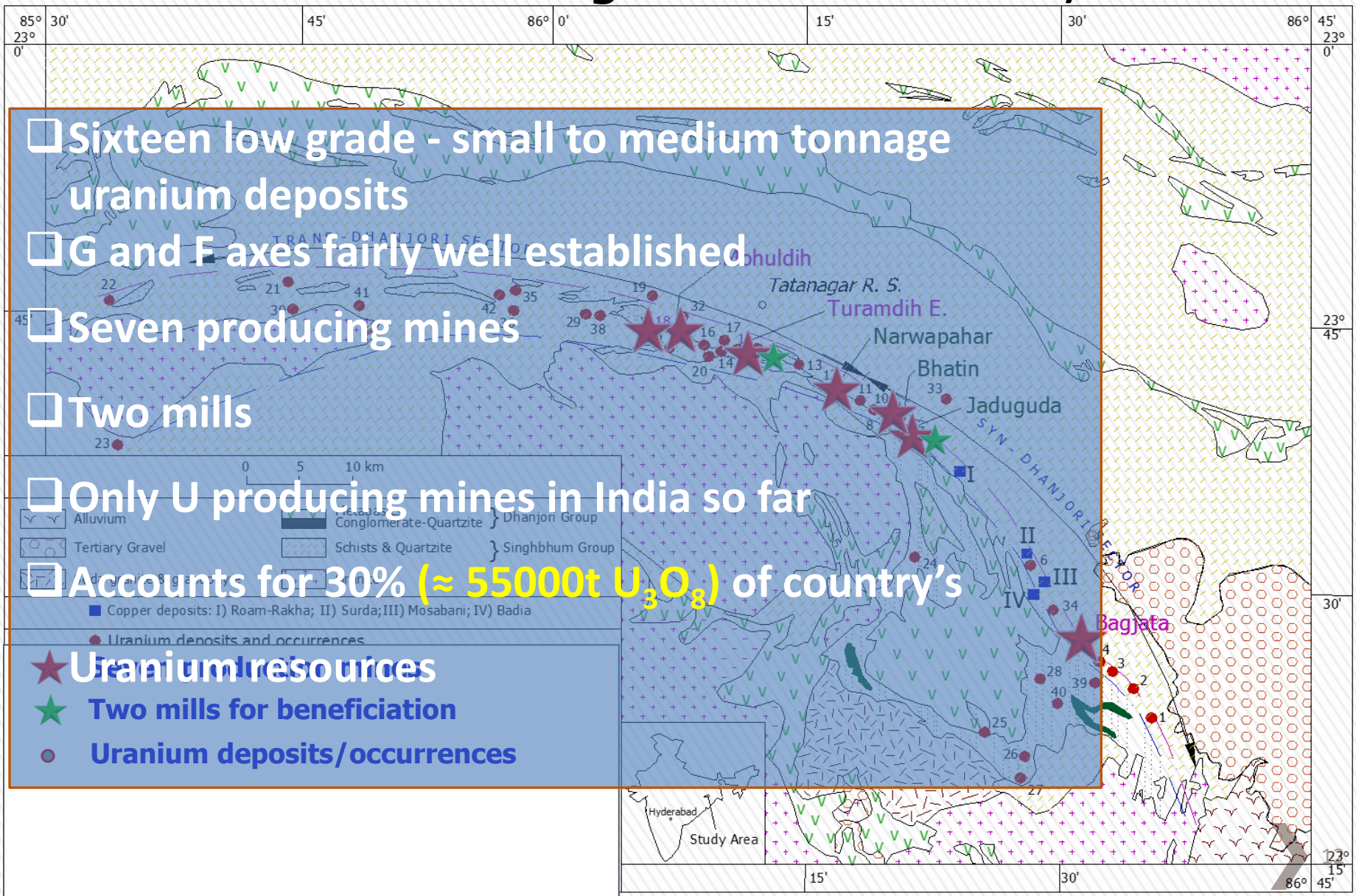
# Singhbhum Shear Zone, Jharkhand




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

# Singhbhum Shear Zone, Jharkhand

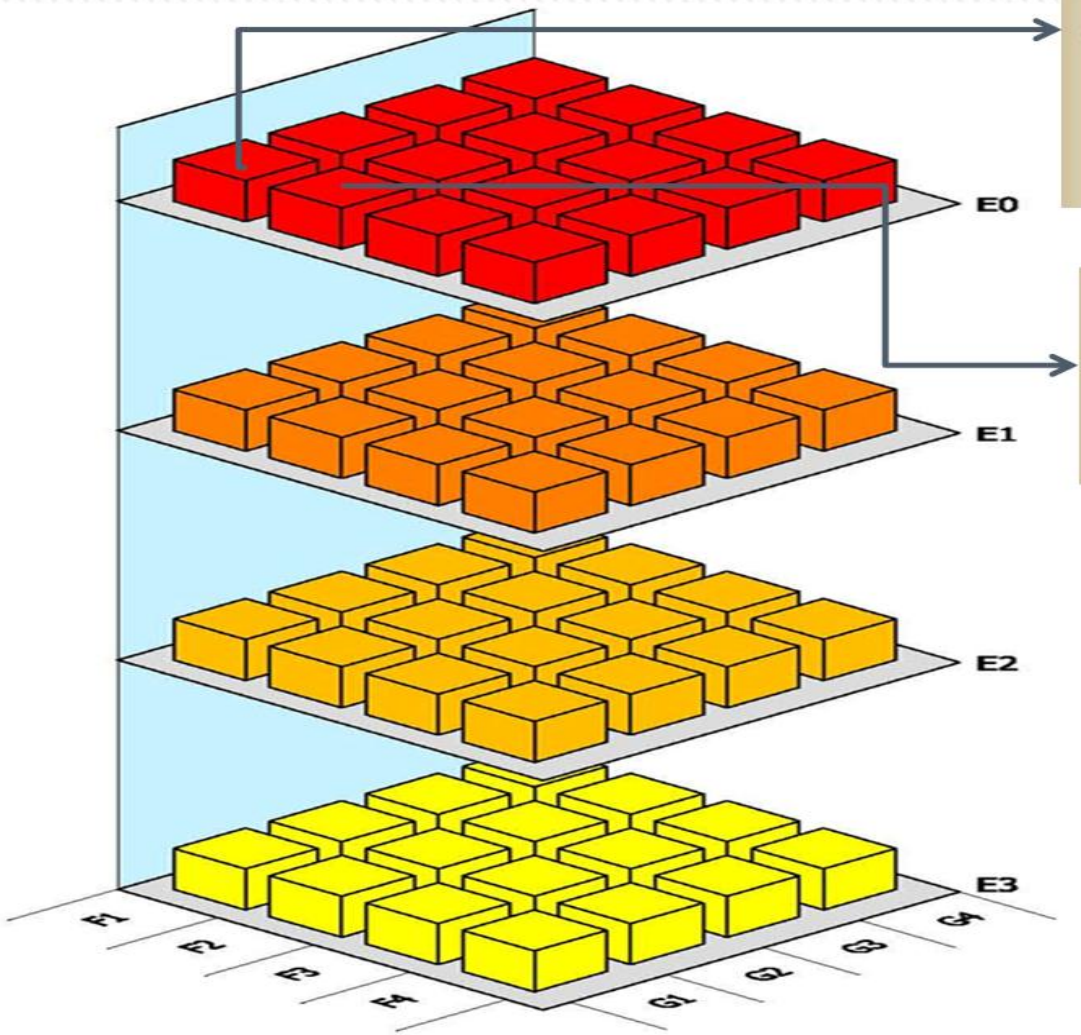
- Sixteen low grade - small to medium tonnage uranium deposits
- G and F axes fairly well established
- Seven producing mines
- Two mills
- Only U producing mines in India so far
- Accounts for 30% (≈ 55000t $U_3O_8$) of country's Uranium resources




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

# Singhbhum Shear Zone, Jharkhand

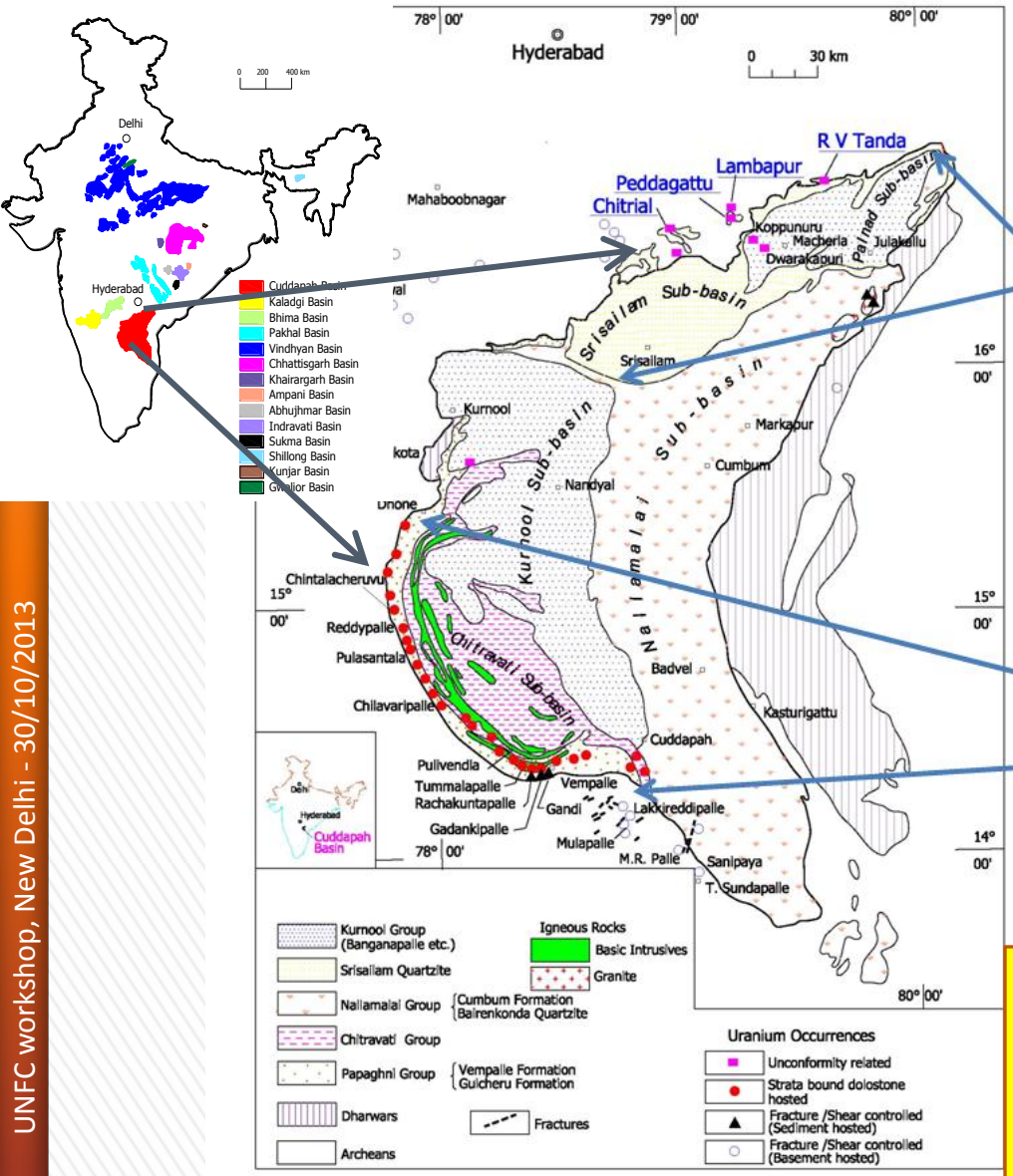
- Sixteen low grade - small to medium tonnage




SSZ group
Deposits (011)
(65% of the resources)

SSZ group
Deposits- (021)
(35% of the resources)

# Uranium resources in Cuddapah basin, Andhra Pradesh




**Unconformity related uranium mineralisation:**

**Deposits**

- Chitrial
- Lambapur
- Peddagattu
- Koppunuru

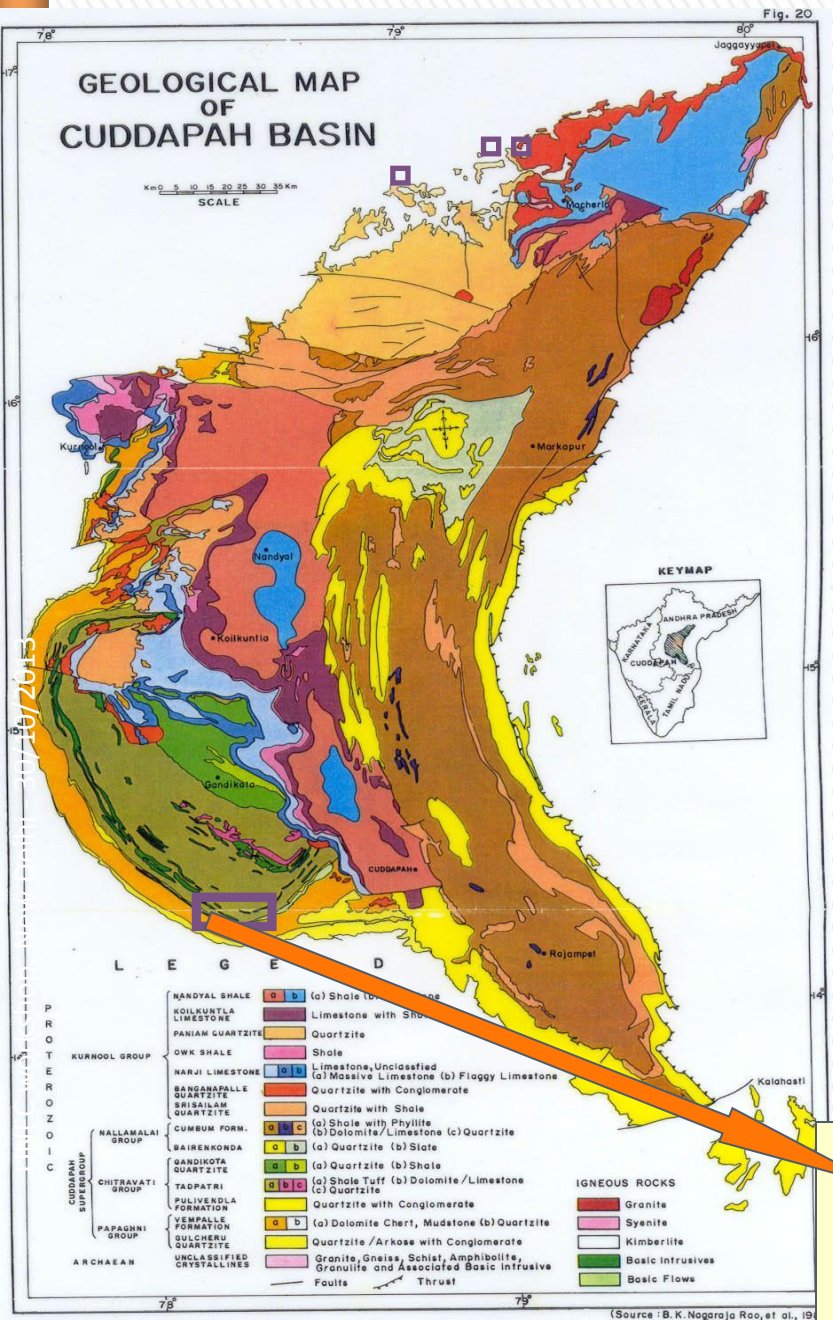
**Dolostone hosted stratabound uranium mineralisation:**

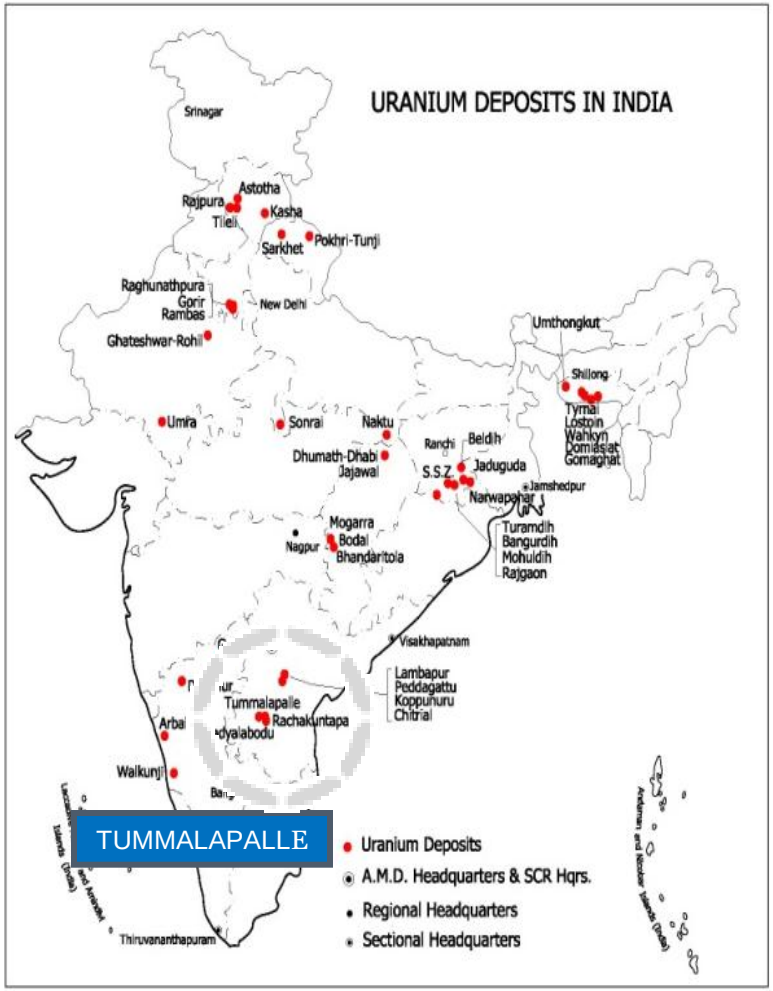
**Deposits**

- Tummalapalle
- Rachakuntapalle
- Kanampalle

- **Cuddapah basin accounts for ≈ 50% of country's uranium reserves**
- **Hold potential for immense additional resources**

# Uranium resources in Cuddapah basin, Andhra Pradesh

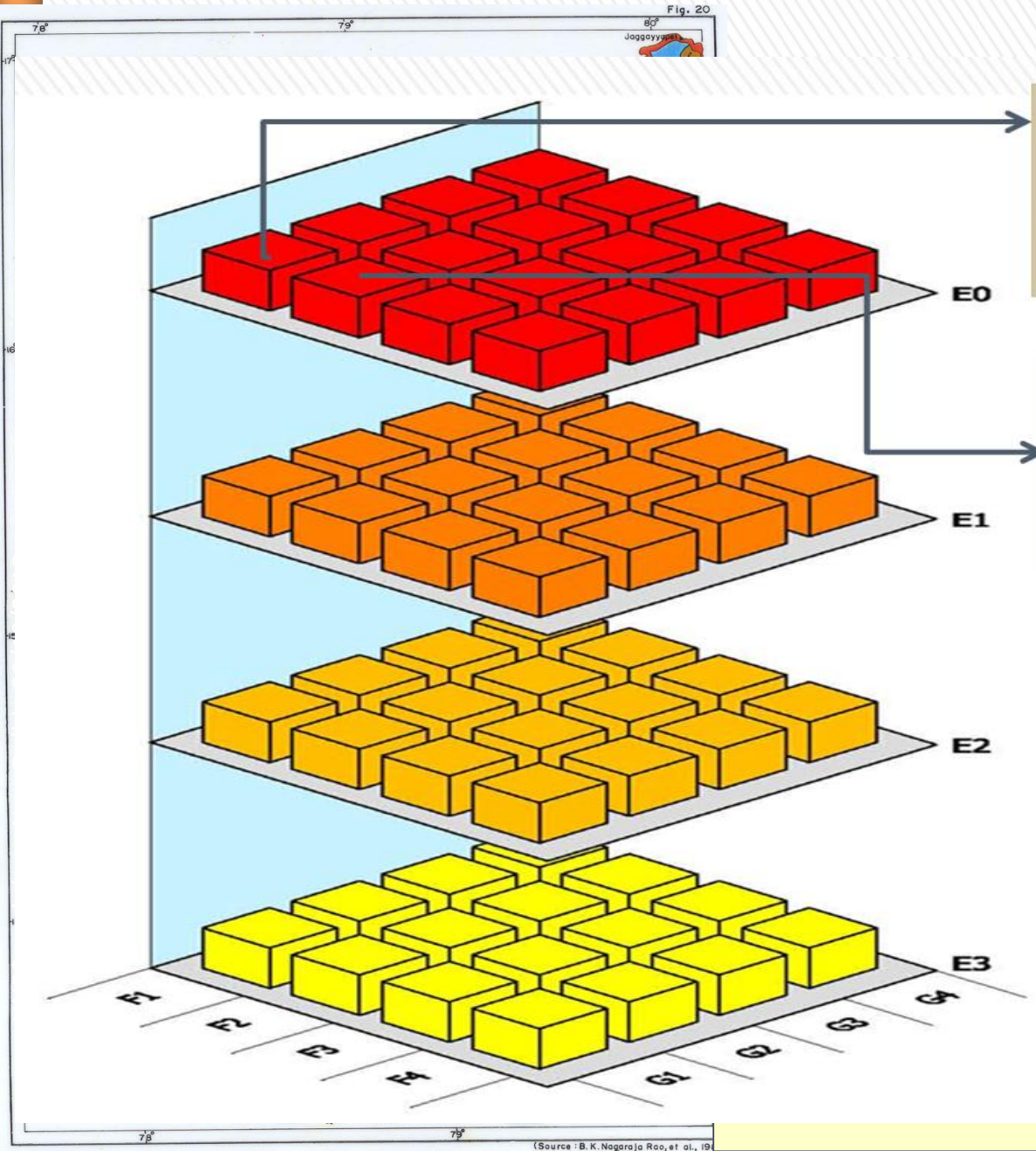



**STRATABOUND CARBONATE HOSTED**

**Tummalapalle uranium deposit ≈ 70,000t $U_3O_8$**

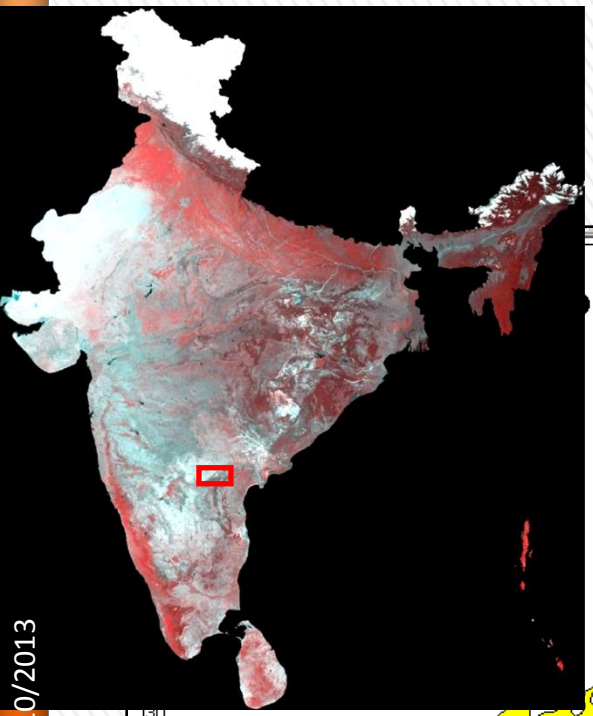
# Uranium resources in Cuddapah basin, Andhra Pradesh

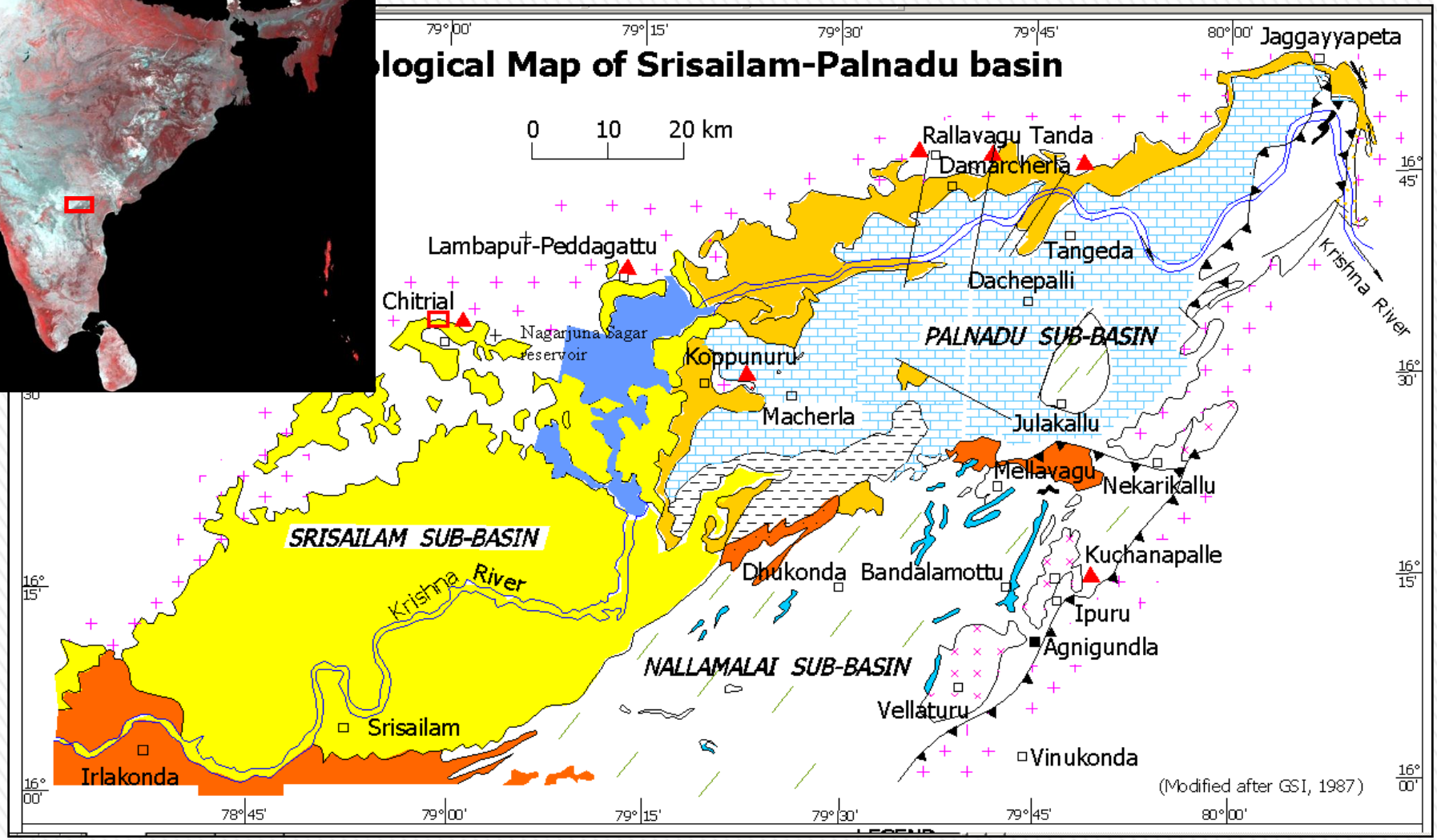



**Tummalapalle group – (011)**
**(77% of the resources)**

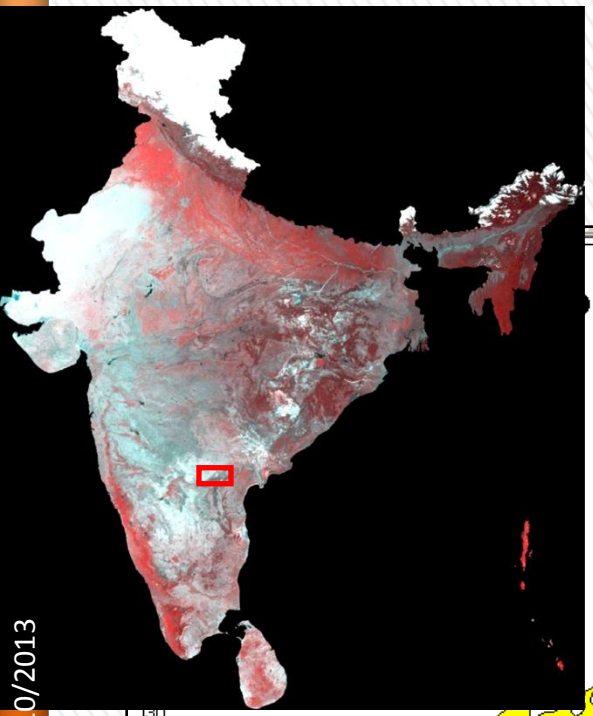
**Tummalapalle group – (021)**
**(23% of the resources)**

# Srisailam-Palnad sub-basins, Cuddapah basin

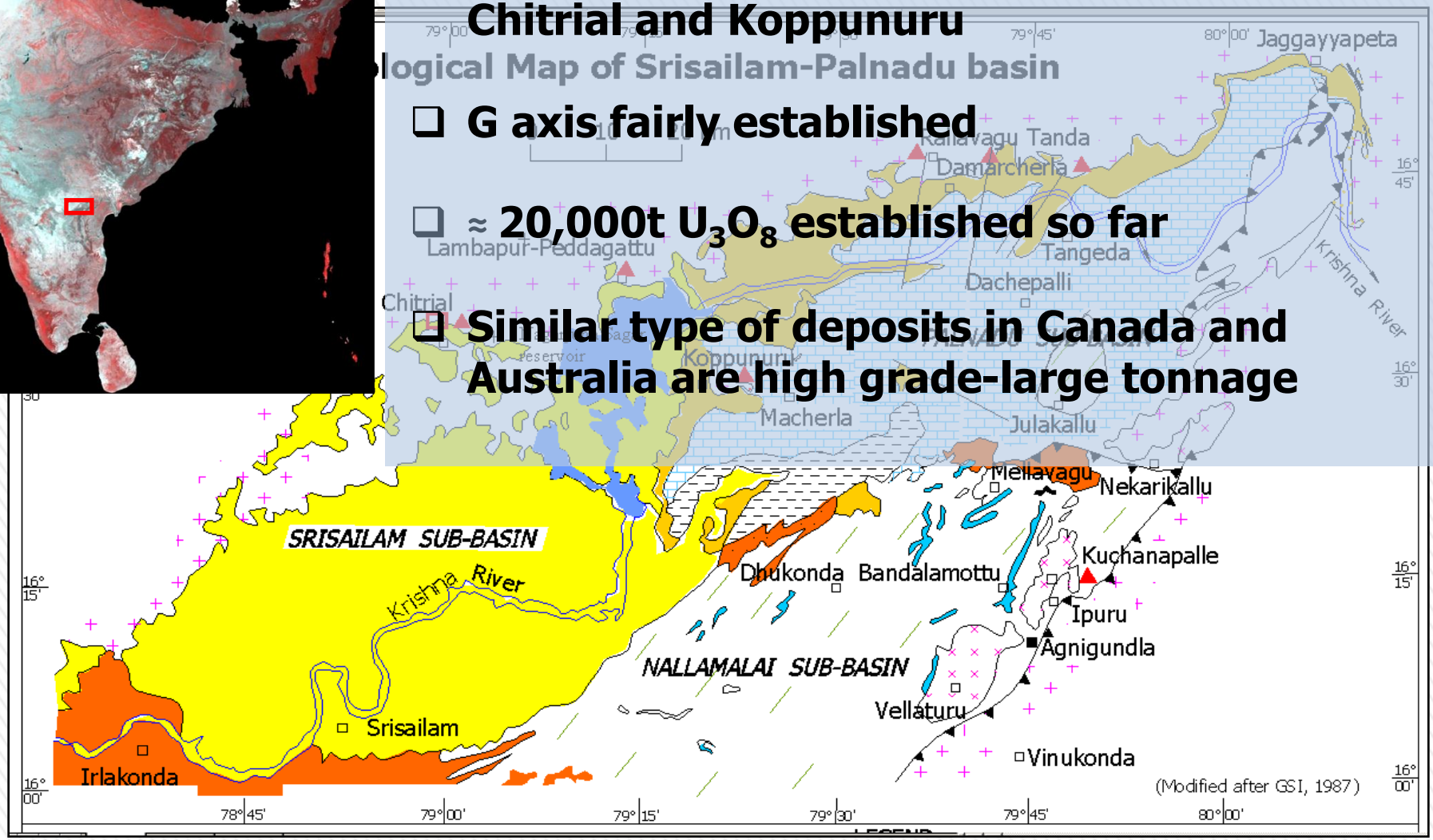




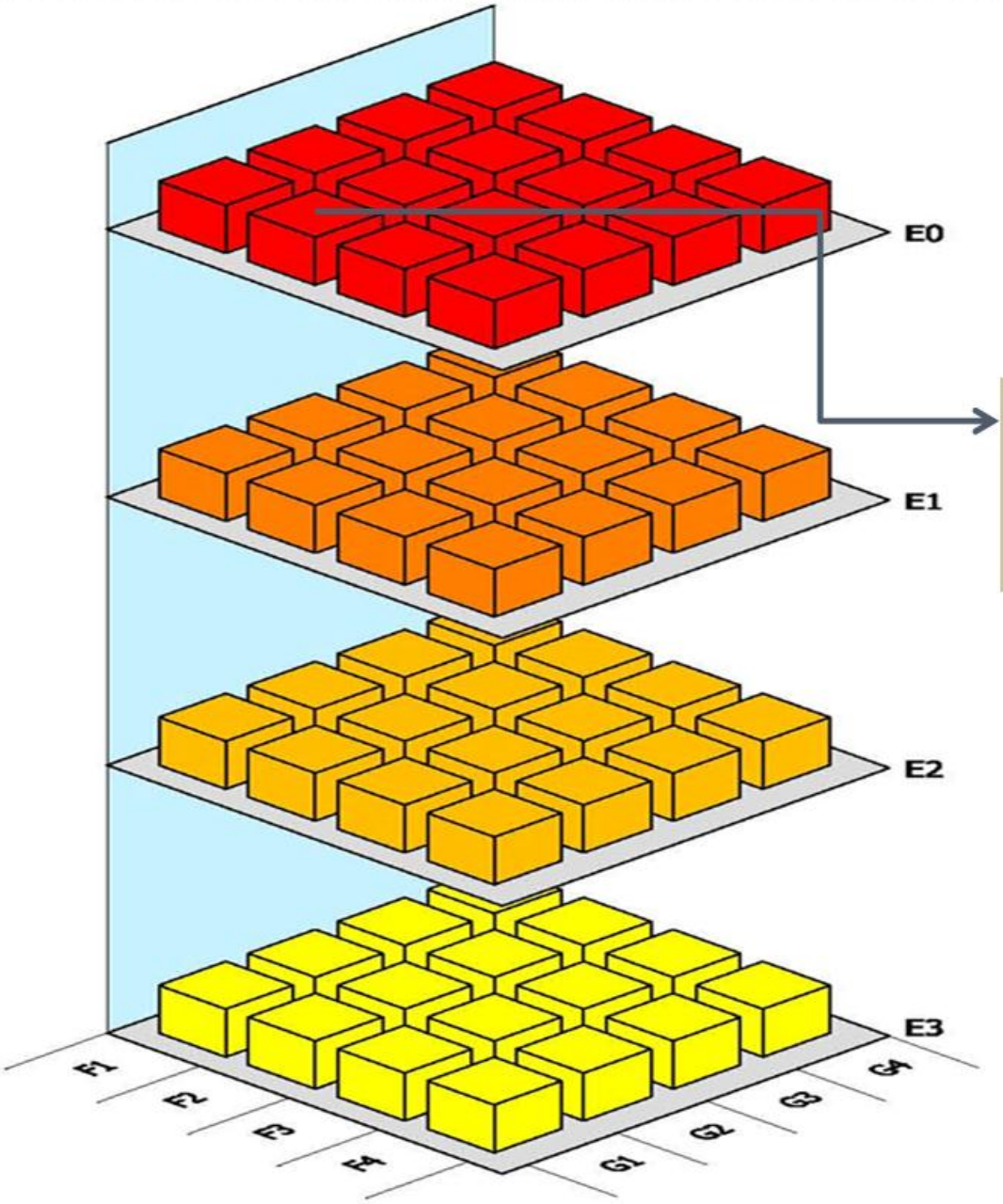
# Srisailam-Palnad sub-basins, Cuddapah basin



- Unconformity type deposits
- Four deposits viz. Lambapur, Peddagattu, Chitrial and Koppunuru
- G axis fairly established
- ≈ 20,000t $U_3O_8$ established so far
- Similar type of deposits in Canada and Australia are high grade-large tonnage

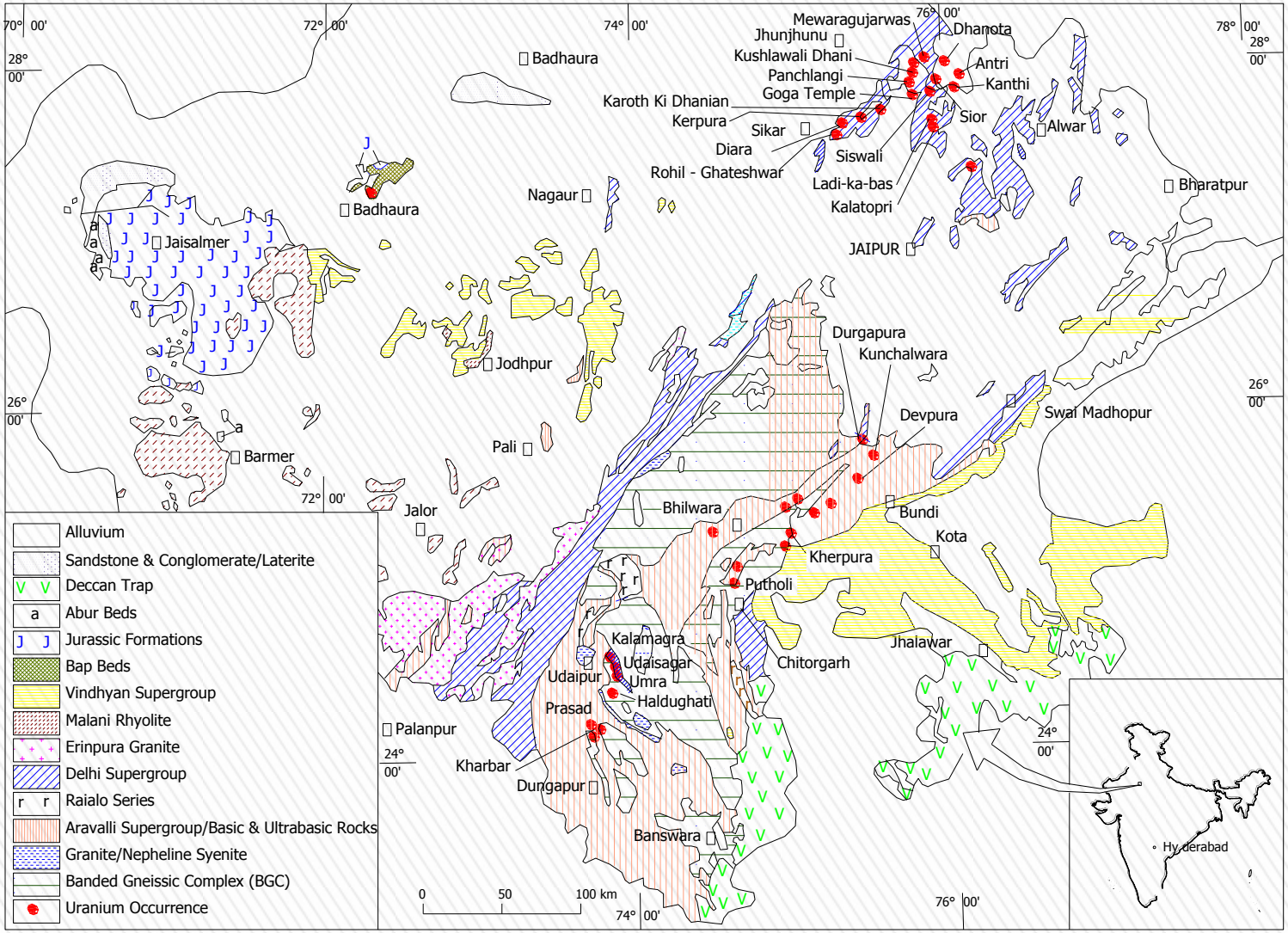


# Srisailam-Palnad sub-basins, Cuddapah basin




Lambapur-Chitrial -Koppunuru group. (021) ≈ 20,000t $U_3O_8$

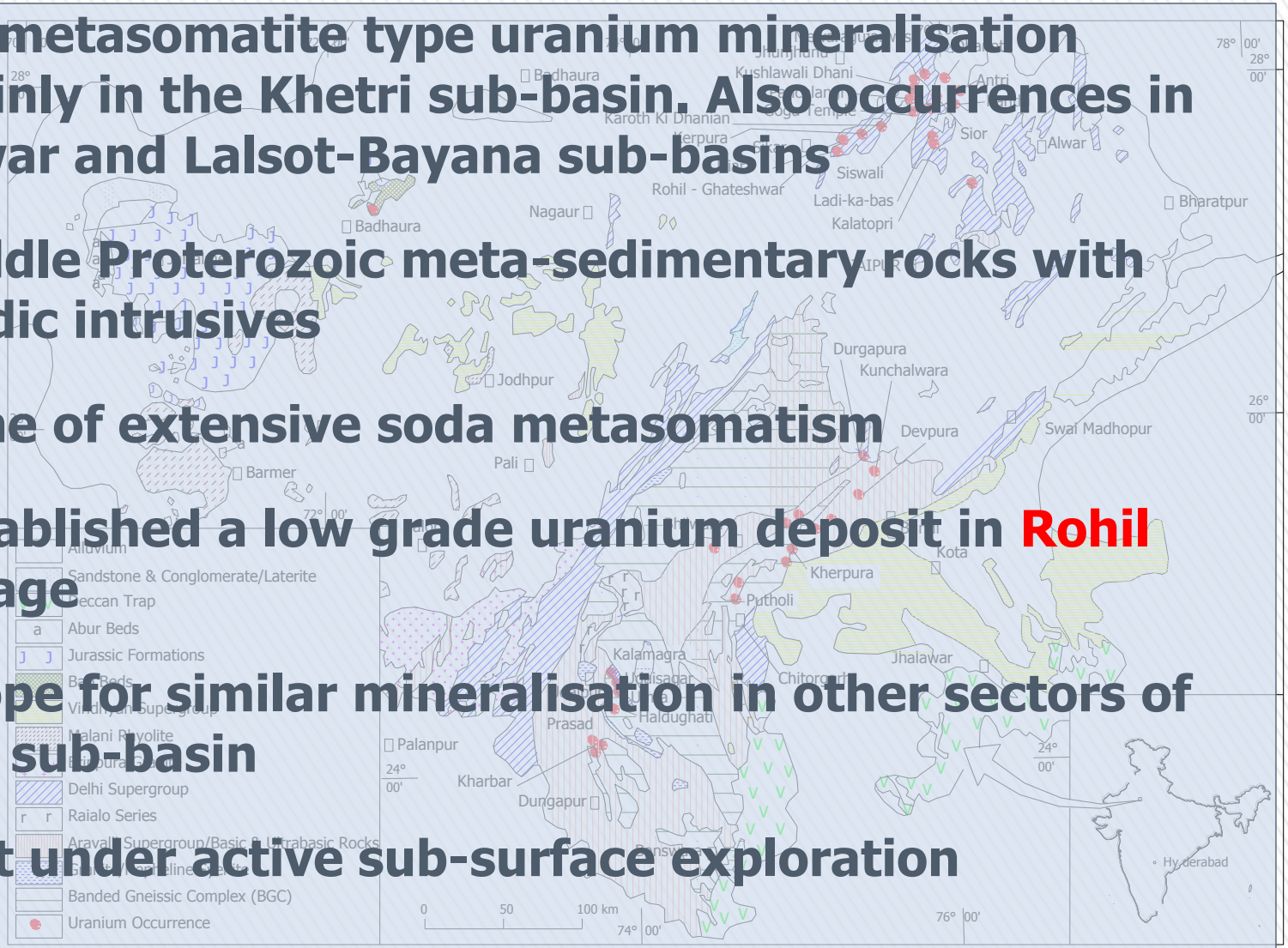
# Uranium resources in NDFB




GEOLOGICAL MAP OF PART OF RAJASTHAN SHOWING URANIUM OCCURRENCES

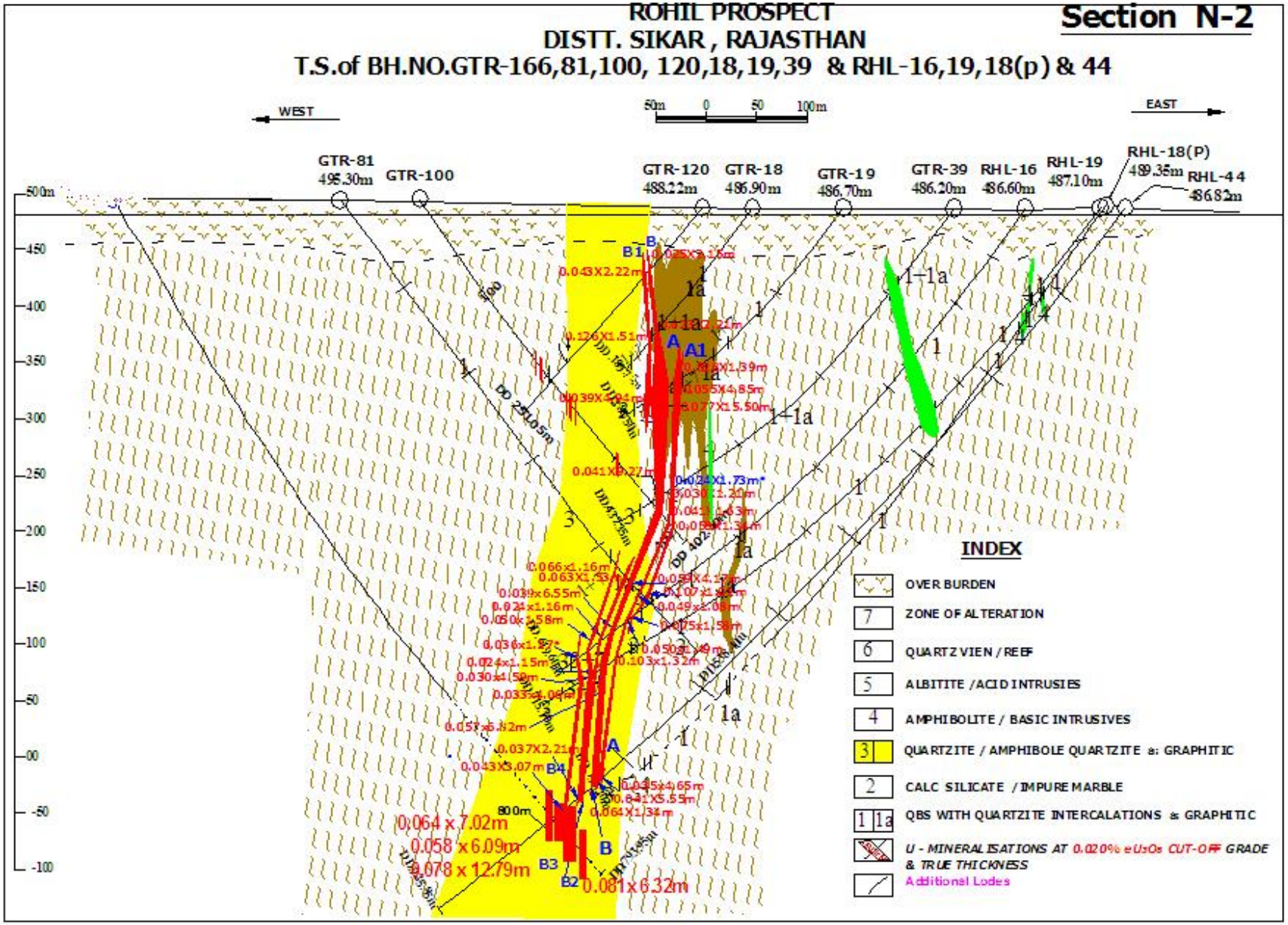
# Uranium resources in NDFB

- Na metasomatite type uranium mineralisation mainly in the Khetri sub-basin. Also occurrences in Alwar and Lalsot-Bayana sub-basins
- Middle Proterozoic meta-sedimentary rocks with acidic intrusives
- Zone of extensive soda metasomatism
- Established a low grade uranium deposit in **Rohil** village
- Scope for similar mineralisation in other sectors of the sub-basin
- Belt under active sub-surface exploration
- ≈ 7000t $U_3O_8$ established

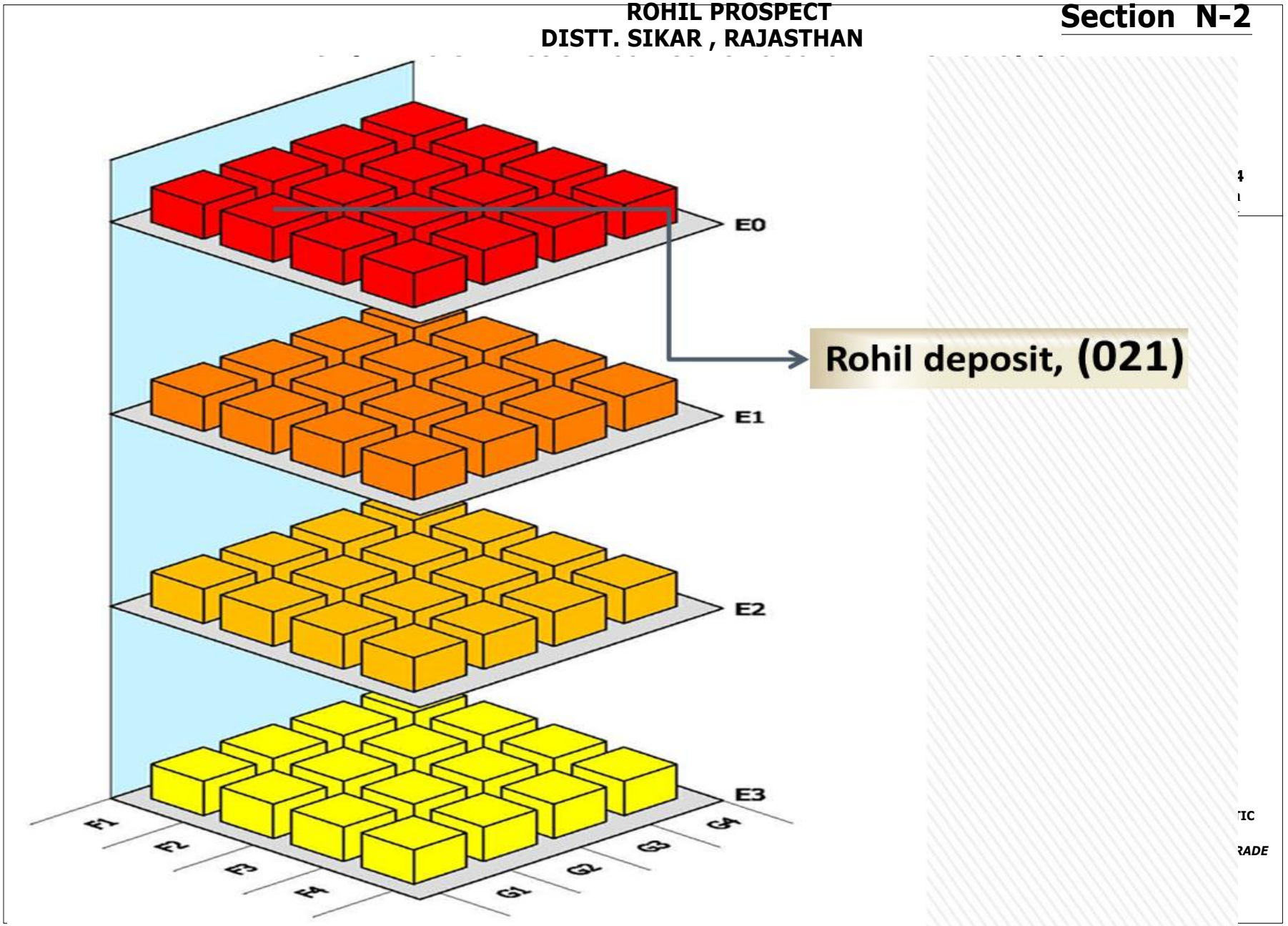



GEOLOGICAL MAP OF PART OF RAJASTHAN SHOWING URANIUM OCCURRENCES

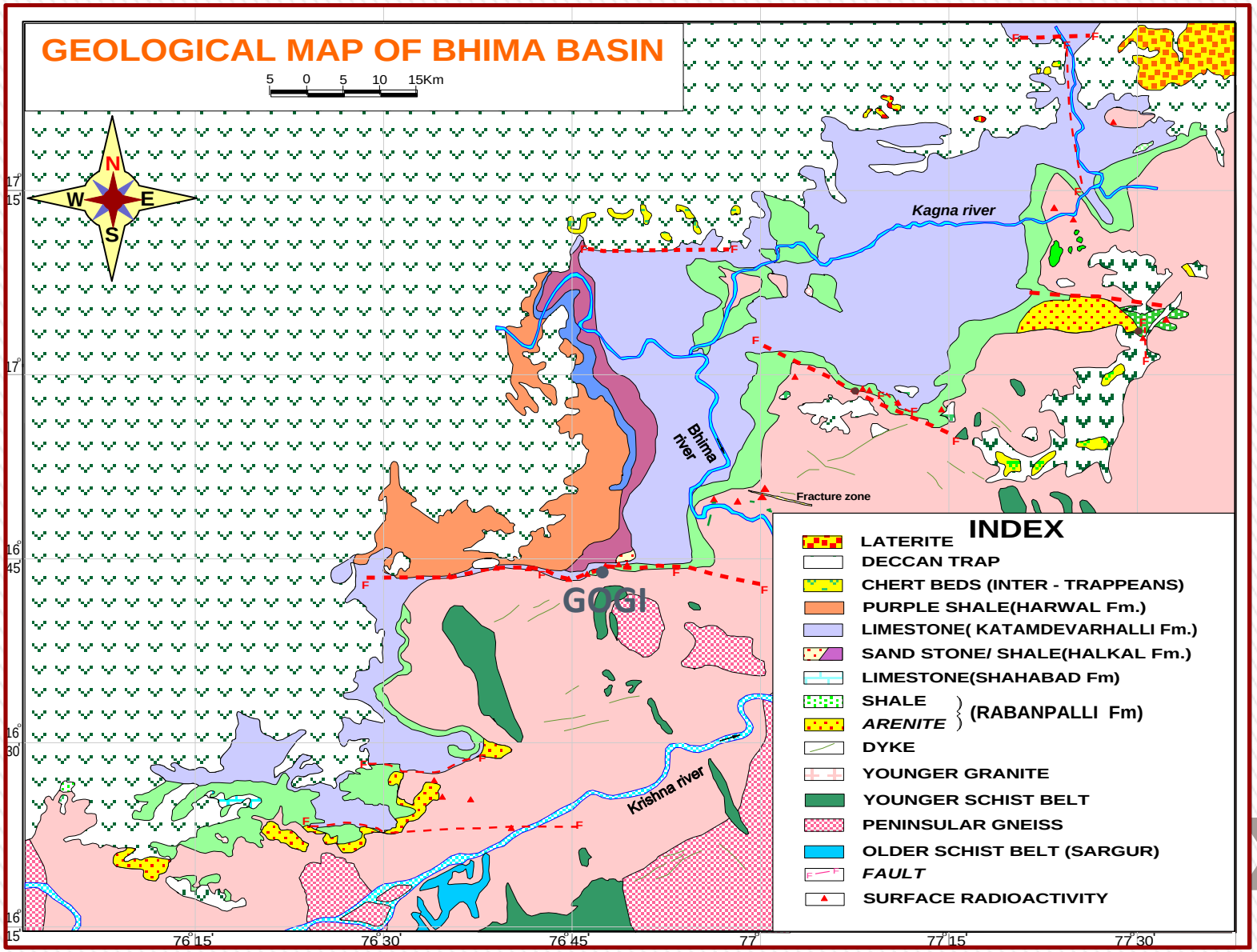
# Uranium resources in NDFB



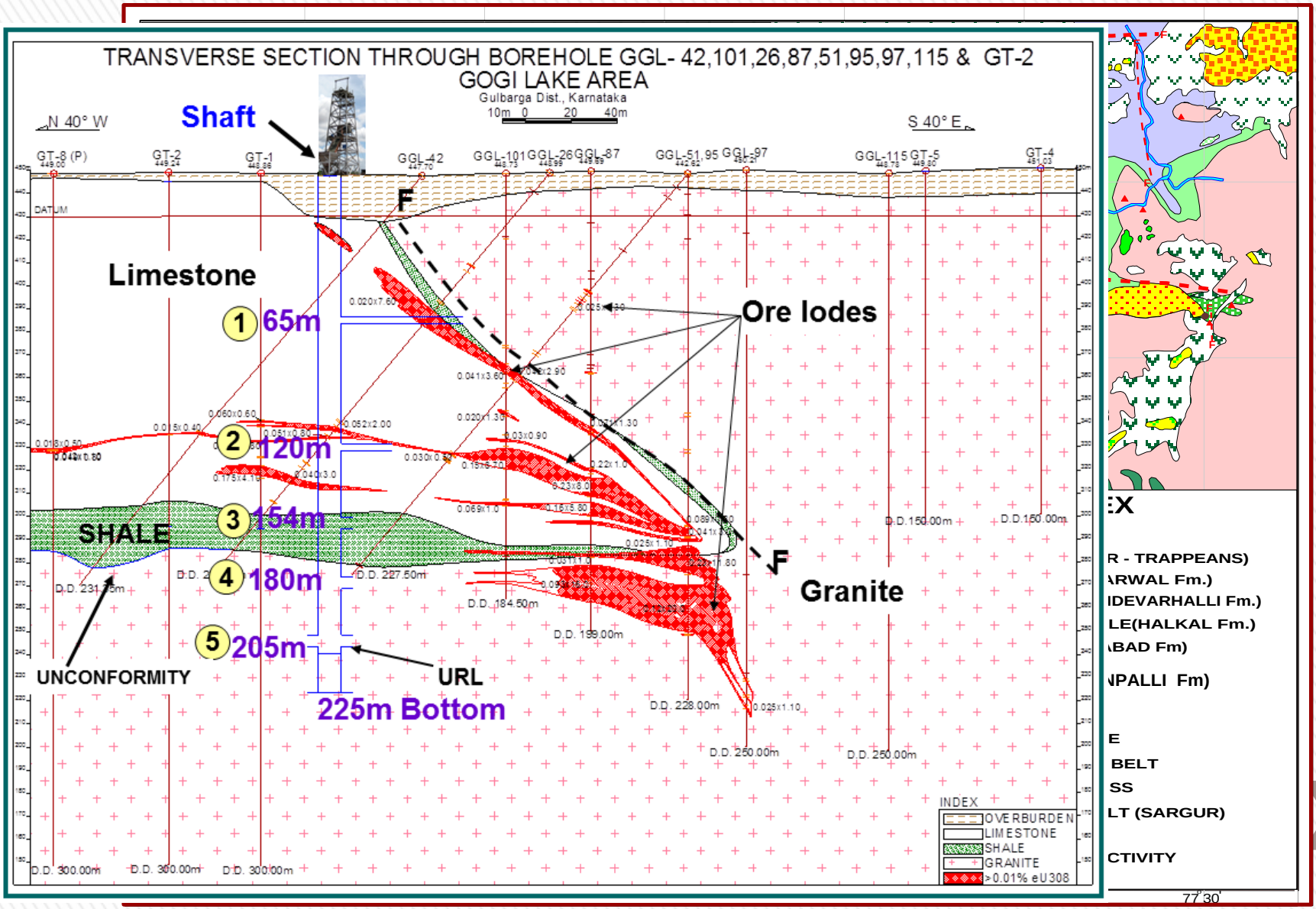
# Uranium resources in NDFB



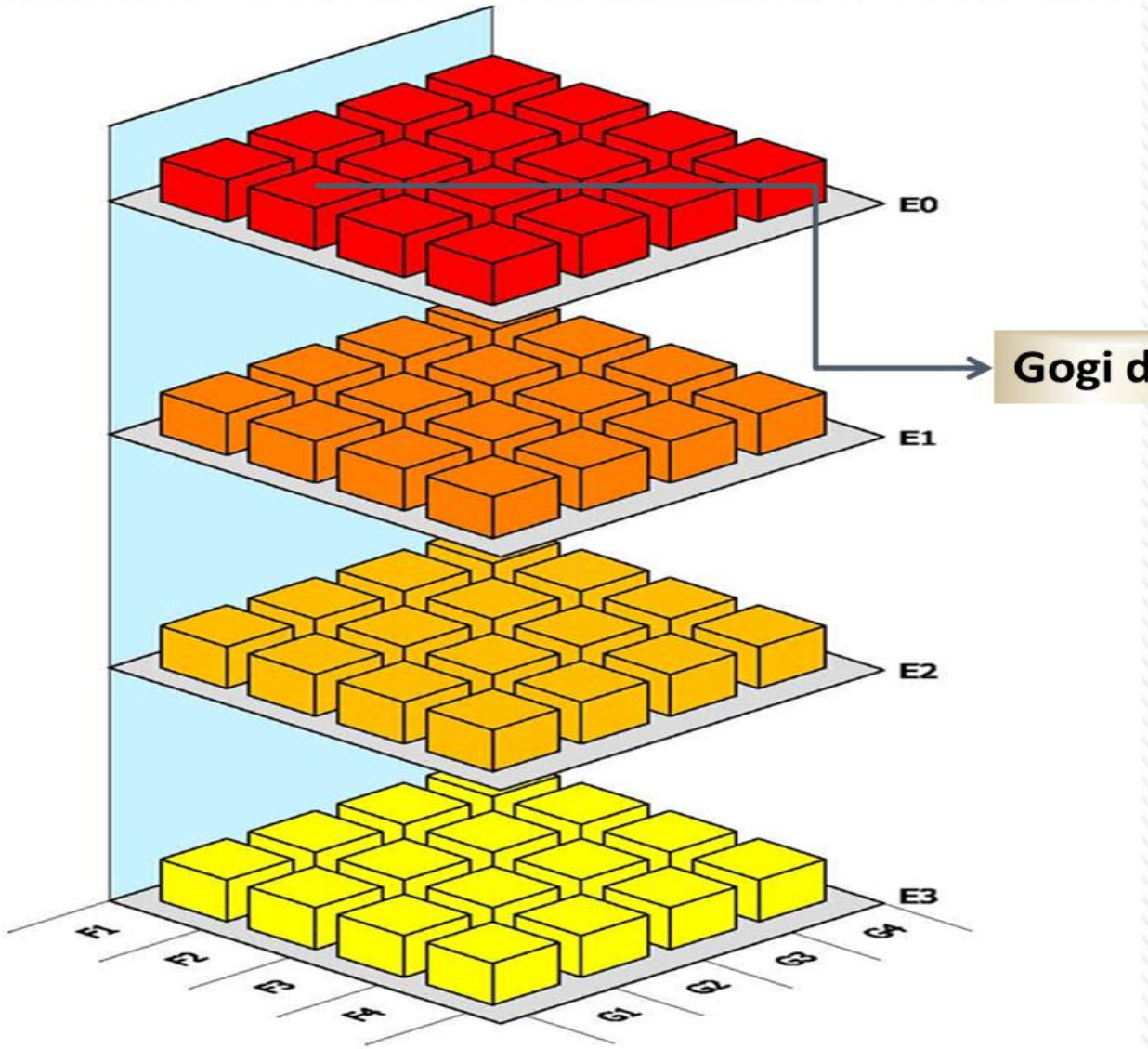
# Uranium resources in Bhima basin, Karnataka



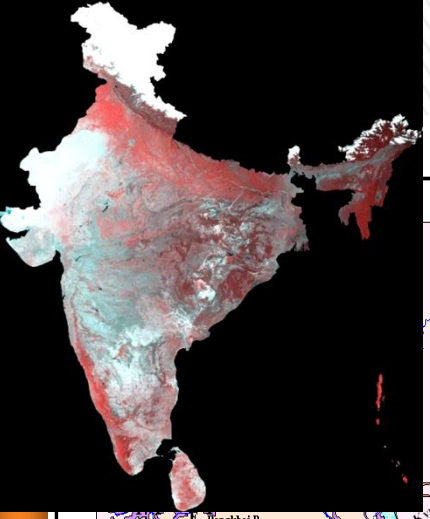
# Uranium resources in Bhima basin, Karnataka

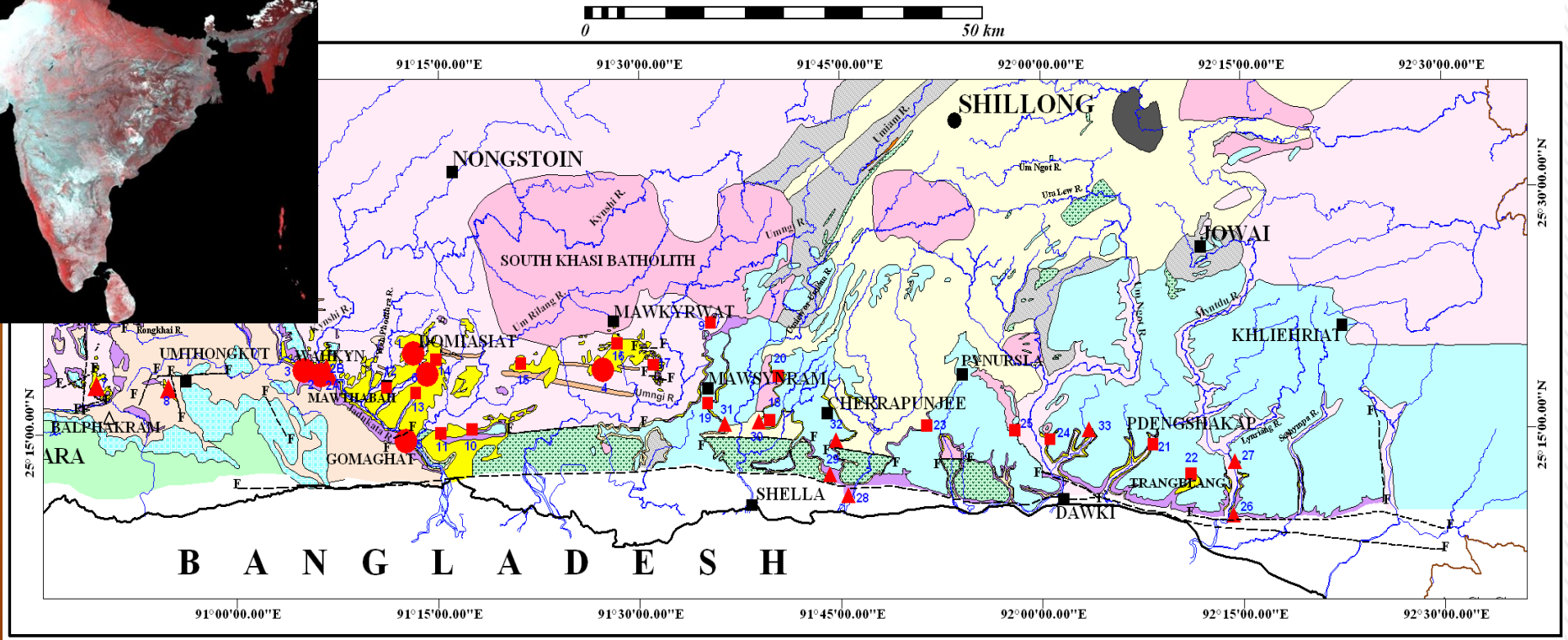


# Uranium resources in Bhima basin, Karnataka



# Mahadek basin, Meghalaya






## L E G E N D

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

URANIUM DEPOSIT

- 1: DOMIASIAT
- 2: WAHKYN
- 3: LOSTOIN
- 4: TYRNAI

PROMISING AREA

- 7: BALPHAKRAM
- 8: UMTHONGKUT
- 2A: WAHKUT
- 2B: WAITING UMLANG

MINOR URANIUM DEPOSIT

- 5: GOMAGHAT
- 6: PHILANGDILOIN
- **7. Umthongkut**

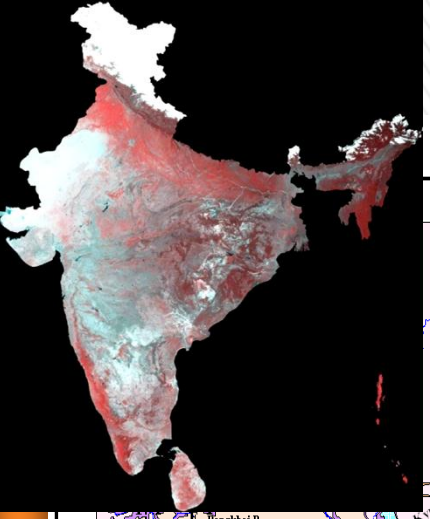
AREA EXPLORED

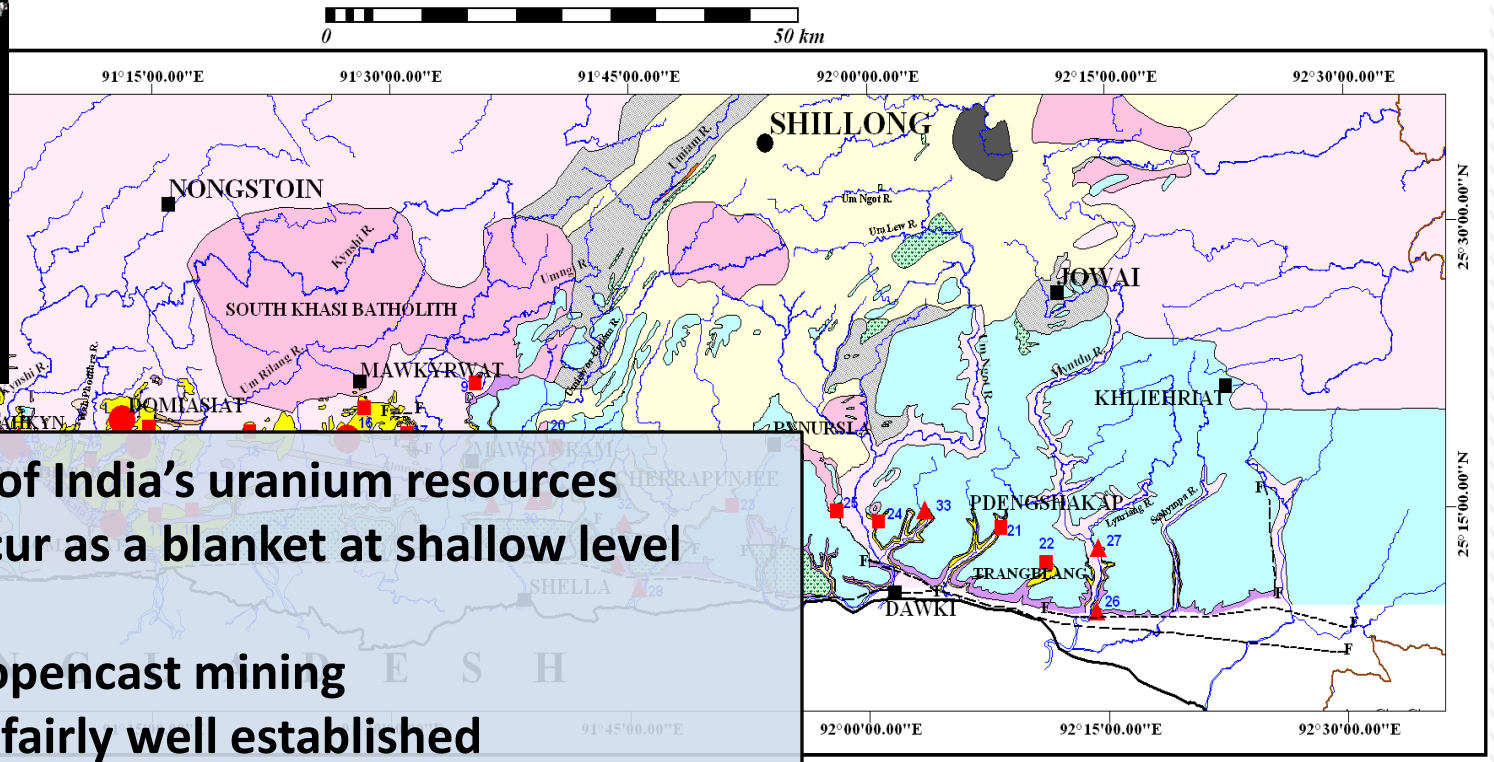
- 9: RANGSOHKHAM
- 10: NONGWAH
- 11: DIRANG
- 12: TYRKHANG
- 14: SINDUMDUM-SNGET
- 13: LUIYANG
- 15: RANGJADONG
- 16: NONGLANG-PHUDJAUD
- 17: RANGMAW
- 18: WAHKALIAR
- 19: PHLANG SYNNEI
- 20: LAITDUH
- 21: PDENGSHAKAP
- 22: TRANGBLANG
- 23: MAWBEH
- 24: KHONGLAH
- 25: PONGTUNG.

URANIUM OCCURRENCE

- 26: BORGHAT
- 27: BATAW
- 28: THERRIA
- 29: MAHADEO
- 30: MAWSAHEW
- 31: KENSHLUID
- 32: LAITIAM
- 33: MAWNGAP

# Mahadek basin, Meghalaya






- Holds ≈ 10% of India's uranium resources
- Ore body occur as a blanket at shallow level (<50m)
- Suitable for opencast mining
- G and F axes fairly well established
- Prospect for more resources in the basin

≈ 20,000t $U_3O_8$

KOPILI FORMATION: TERTIARY
SIJU FORMATION: TERTIARY
TURA/SHELLA FORMATION: TERTIARY
LANGPAR/SHELLA FORMATION: TERTIARY
UPPER MAHADEK SEDIMENTS: CRETACEOUS
LOWER MAHADEK SEDIMENTS: CRETACEOUS
JADUKATA FORMATION: CRETACEOUS
CARBONATITE COMPLEX: CRETACEOUS
SYLHET TRAP: JURASSIC
YOUNGER GRANITE: PROTEROZOIC
INTRUSIVE QUARTZ: PROTEROZOIC
TYRSAD FORMATION: PROTEROZOIC
BARAPANI FORMATION: PROTEROZOIC
BASEMENT GNEISSIC COMPLEX: ARCHAEAN

URANIUM DEPOSIT
1: DOMIASIAT
2: WAHKYN
3: LOSTOIN
4: TYRNAI
7: BALPHAKRAM
8: UMTHONGKUT
2A: WAHKUT
2B: WAITING UMLANG

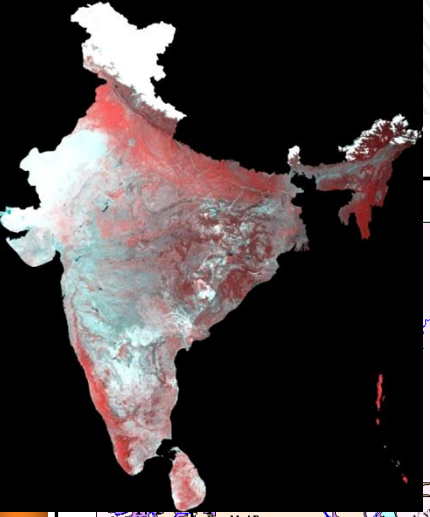
MINOR URANIUM DEPOSIT
5: GOMAGHAT
6: PHILANGDILOIN
7. Umthongkut

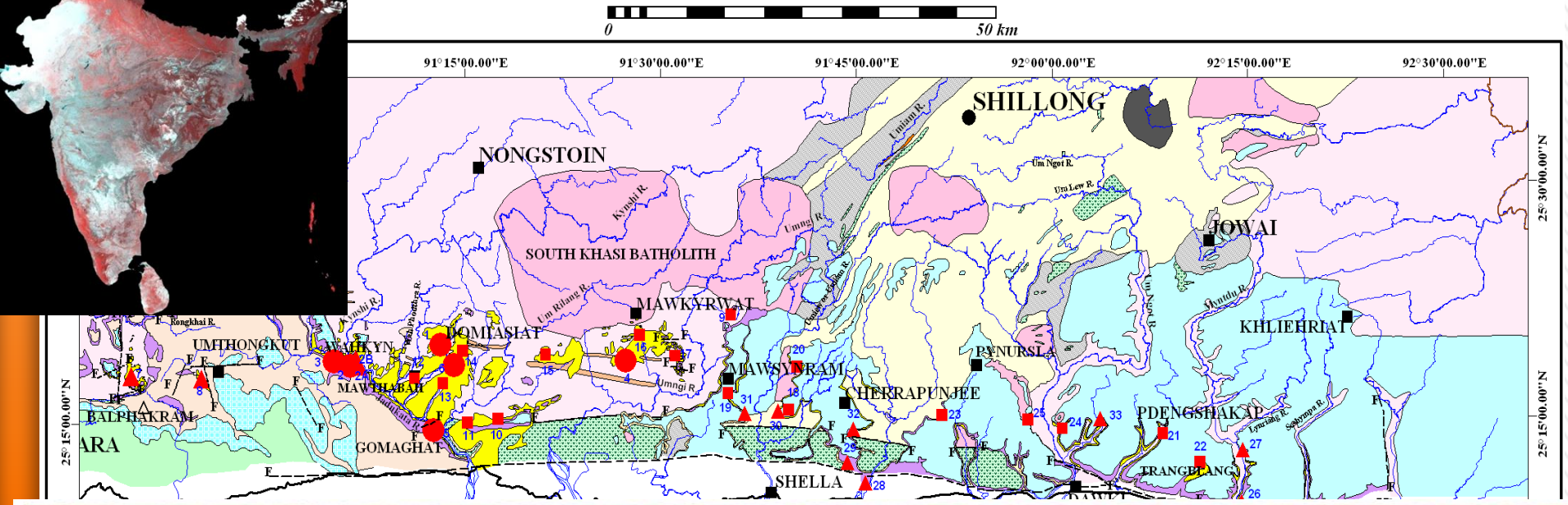
PROMISING AREA

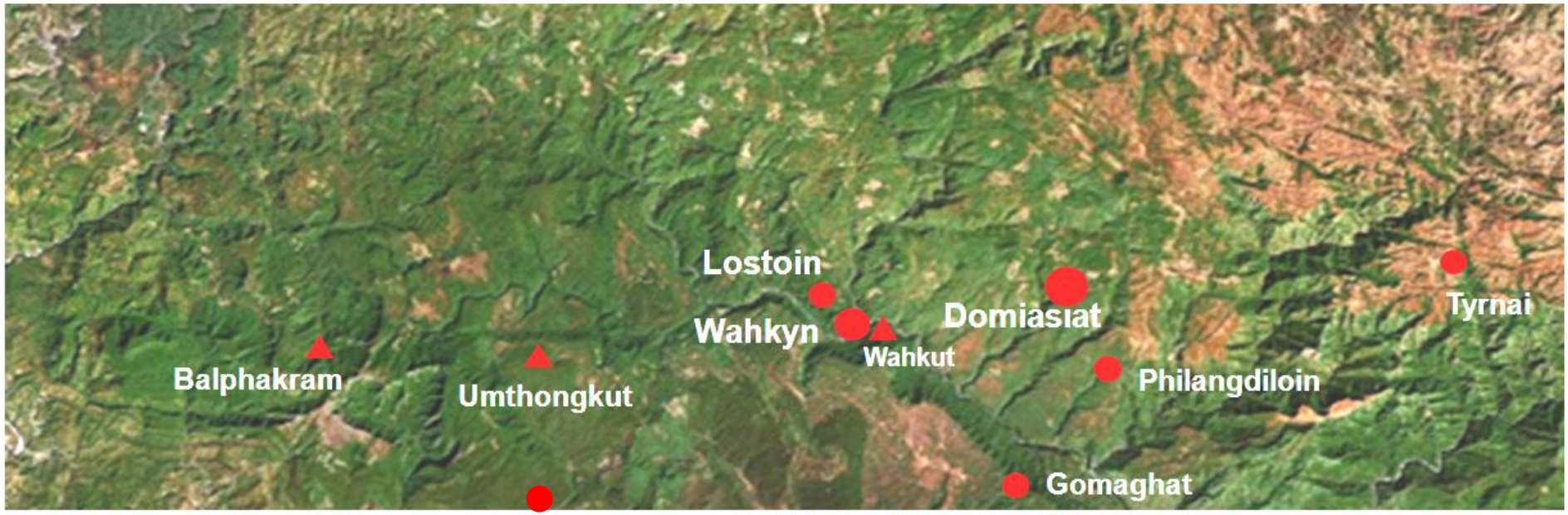
AREA EXPLORED
9: RANGSOHKHAM
10: NONGWAH
11: DIRANG
12: TYRKHANG
14: SINDUMDUM-SNGET
13: LUIYANG
15: RANGJADONG
16: NONGLANG-PHUDJAUD
17: RANGMAW
18: WAHKALIAR
19: PHLANG SYNNEI
20: LAITDUH
21: PDENGSHAKAP
22: TRANGBLANG
23: MAWBEH
24: KHONGLAH
25: PONGTUNG.

URANIUM OCCURRENCE
26: BORGHAT
27: BATAW
28: THERRIA
29: MAHADEO
30: MAWSAHEW
31: KENSHLUID
32: LAITIAM
33: MAWNGAP

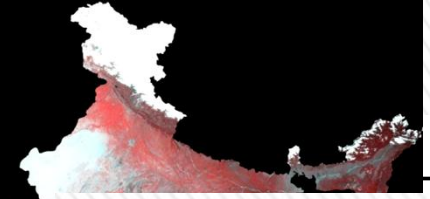
# Mahadek basin, Meghalaya



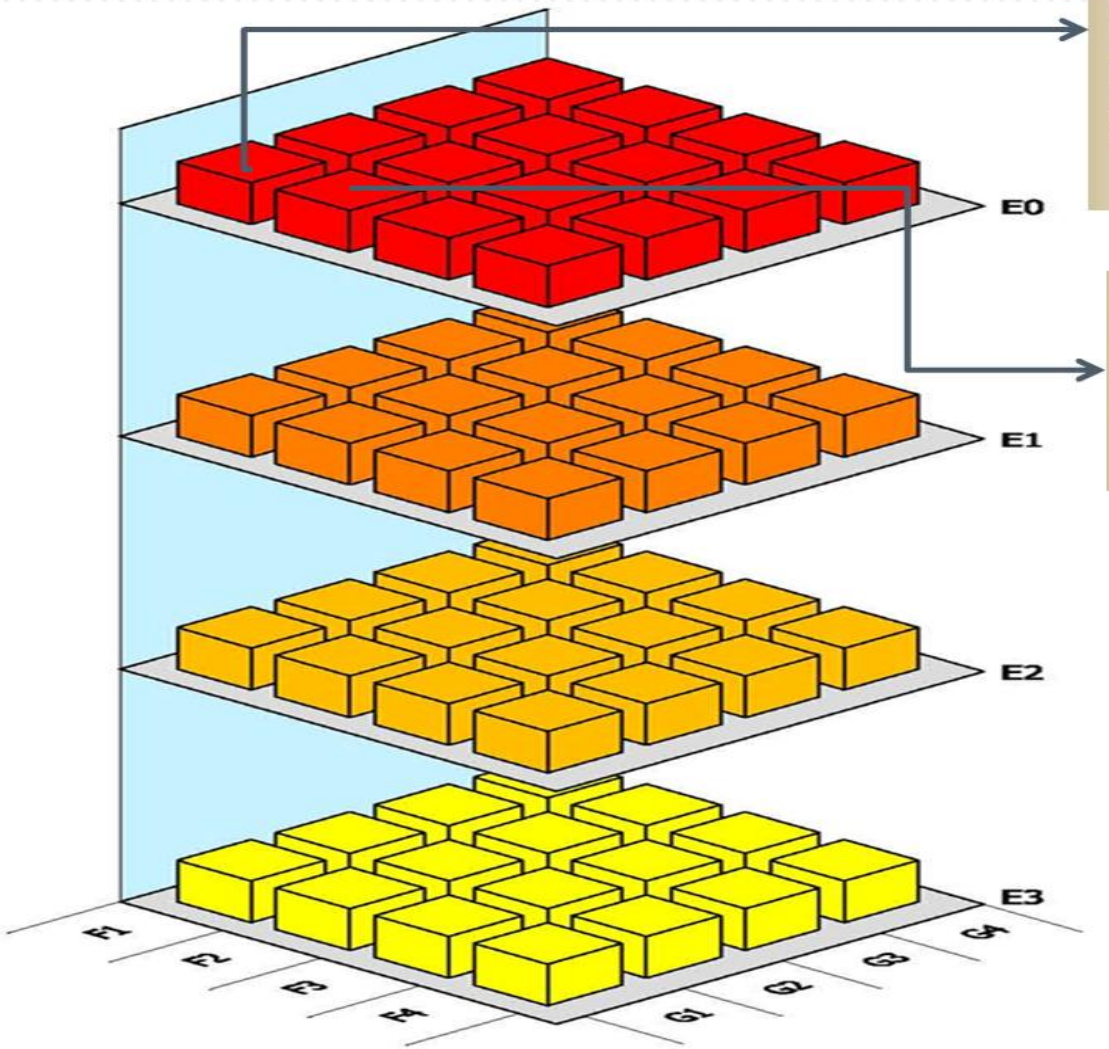


# Mahadek basin, Meghalaya



0 50 km




**Mahadeks group Deposits (011) (85% of the resources)**

**Mahadeks group Deposits- (021) (15% of the resources)**

Gomaghat

● Uranium Deposits

▲ Major Uranium Occurrences

# Thorium exploration

# Thorium mineralisation

- Heavy Mineral Placer Sand deposits
  - Shoreline Placer
  - Alluvial Placer
  - Inland aeolian Placer
- Late-stage Igneous rocks
  - Alkaline Complexes
  - Carbonatite
  - Alkali granite/Pegmatite
- Pegmatite
- Hydrothermal veins
- Quaternary sediments
- High grade Metamorphic rocks

# Thorium mineralisation - Monazite

- Source for Th and REE
- Discovery – in the year 1909 from beach sands from Manavalakurichi, Tamil Nadu.
- Occurs in placer sands along with ilmenite, rutile, leucoxene, garnet, zircon & sillimanite.
- Monazite-bearing placer sands found along the coast-line and also inland in aeolian and riverine environments.
- Recovered as by-product at:
  - **Chavara, Kerala**
  - **Manavalakurichi, Tamil Nadu**
  - **Chattarpur, Odisha**

# Monazite

- **Grade in different environments**
  - > **Beach sands : upto 1%**
    **(up to 5% in some places in Kerala, Tamil Nadu)**
  - > **Teri Sands Tamil Nadu :Upto 0.10%**
  - > **Siri River, Chhattisgarh: Upto 0.8% (Riverine Placer)**

- **$ThO_2$ : upto 9-10% (av.)**
- **$U_3O_8$ : 0.3%**
- **REO : 60%**
- **$P_2O_5$ : 27%**

# Beach and inland placer deposits

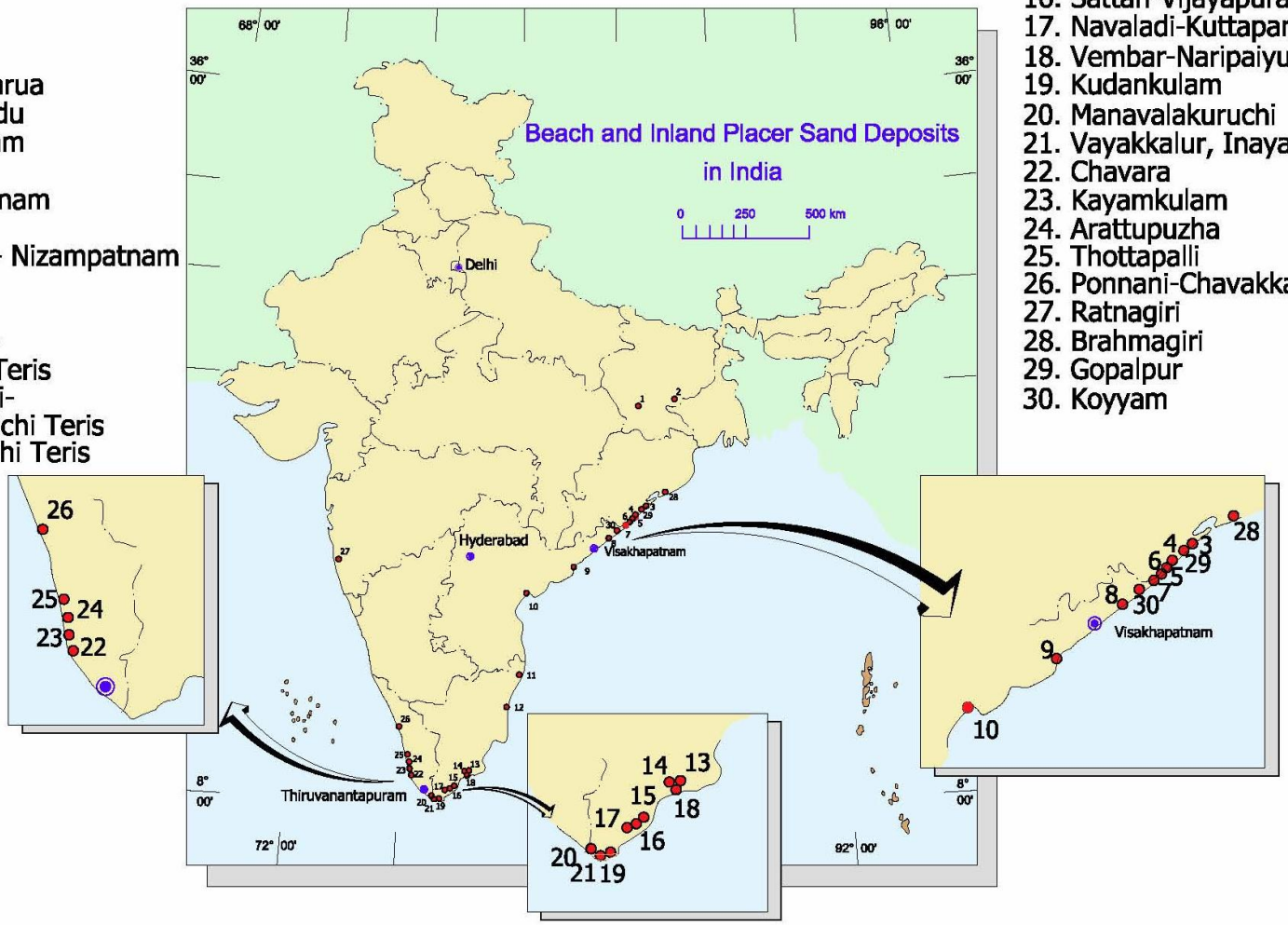
## Beach and Inland Placer Sand Deposits in India

### Index to Localities

1. Ranchi
2. Purulia
3. Chatrapur
4. Donkuru-Barua
5. Bhavanapadu
6. Kaligapatnam
7. Srikurmam
8. Bhimunipatnam
9. Kakinada
10. Suryalanka- Nizampatnam
11. Kalpakkam
12. Karaikal
13. Surangudi-Sevalpatti Teris
14. Kuttampulli-Naduvakurichi Teris
15. Kudirai Mozhi Teris

### Index to Localities

16. Sattan-Vijayapuram Teris
17. Navaladi-Kuttapanai-Periathalai
18. Vembar-Naripaiyur
19. Kudankulam
20. Manavalakuruchi
21. Vayakkalur, Inayam-Midalam
22. Chavara
23. Kayamkulam
24. Arattupuzha
25. Thottapalli
26. Ponnani-Chavakkad
27. Ratnagiri
28. Brahmagiri
29. Gopalpur
30. Koyyam



# Beach placer resources in India

| Minerals | Reserves as on August 2009 (million tonnes) |
|---|---|
| Ilmenite+Leucoxene | 520.38 |
| Rutile | 29.11 |
| Monazite | 10.70 |
| Zircon | 32.28 |
| Garnet | 154.26 |
| Sillimanite | 195.85 |
| Total | 942.58 |

# Conclusion

- The main constraint in adopting the UNFC system for uranium and thorium resources in India is that the production cost of uranium is not in public domain.
- It may not be possible to assign numerical codes for the Indian uranium and thorium deposits in the E axis.
- UNFC system therefore may incorporate a numerical code in the E axis for those deposits where economics is not considered.
- This may help countries like India to adopt UNFC within their policy framework.

# Thanks