Uranium and thorium resources in India: UNFC system

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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.
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

<table>
<thead>
<tr>
<th>Cost of recovery</th>
<th>Identified Resources</th>
<th>Undiscovered Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>USD &lt;40/kgU</strong></td>
<td>Reasonably Assured Resources</td>
<td>Inferred Resources</td>
</tr>
<tr>
<td><strong>USD 40–80/kgU</strong></td>
<td>Reasonably Assured Resources</td>
<td>Inferred Resources</td>
</tr>
<tr>
<td><strong>USD 80–160/kgU</strong></td>
<td>Reasonably Assured Resources</td>
<td>Inferred Resources</td>
</tr>
<tr>
<td><strong>USD 130–260/kgU</strong></td>
<td>Reasonably Assured Resources</td>
<td>Inferred Resources</td>
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</table>

- **Decreasing economic viability**
- **Decreasing confidence in estimates**

**UNFC workshop, New Delhi - 30/10/2013**
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.
A new plane $E_0$ is suggested for those countries who want to keep the uranium production cost confidential.
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
Major uranium deposits

- Rohil, North Delhi Fold Belt, Vein Type
- Domiasiat, Wahkyn Mahadeks, Sandstone type
- Jaduguda, Narwapahar, Singhbhum Shear Zone, Vein Type
- Lambapur, Chitrial, N Cuddapah Basin, Unconformity related
- Tummalapalle, S Cuddapah Basin, Stratabound

Major Uranium Deposits
Seven production mines
Two mills for beneficiation
Uranium deposits/occurrences

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 U₃O₈) 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

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

Unconformity related uranium mineralisation:
- Deposits
  - Chitrial
  - Lambapur
  - Peddagattu
  - Koppunuru

Dolostone hosted stratabound uranium mineralisation:
- Deposits
  - Tummalapalle
  - Rachakuntapalle
  - Kanampalle

UNFC workshop, New Delhi - 30/10/2013
Uranium resources in Cuddapah basin, Andhra Pradesh

Tummalapalle uranium deposit \( \approx 70,000 \text{t } \text{U}_3\text{O}_8 \)
Uranium resources in Cuddapah basin, Andhra Pradesh

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

Tummalapalle group – (021)
(23% of the resources)
Unconformity type deposits

Four deposits viz. Lambapur, Peddagattu, Chitrial and Koppunuru

G axis fairly established

≈ 20,000 t $\text{U}_3\text{O}_8$ established so far

Similar type of deposits in Canada and Australia are high grade-large tonnage
Unconformity type deposits

- Four deposits viz. Lambapur, Peddagattu, and Koppunuru
- G axis fairly established
- More than 20,000t U₃O₈ established so far
- Similar type of deposits in Canada and Australia are high grade-
  large tonnage
- Super high-grade deposits are associated with this type of deposits

Srisailam-Palnad sub-basins, Cuddapah basin

Lambapur-Chitrial-Koppunuru group. (021) \approx 20,000t \text{ U}_3\text{O}_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.
- \( \approx 7000t \, U_3O_8 \) established.
Uranium resources in NDFB

The ROHIL PROSPECT in DISTT. SIKAR, RAJASTHAN includes T.S. of BH.NO.GTR-166, 81, 100, 120, 18, 19, 39 & RHL-16, 19, 18(p) & 44.

The geological map of part of Rajasthan showing uranium occurrences includes:

- Alluvium
- Sandstone & Conglomerate/Laterite
- Deccan Trap
- Abur Beds
- Jurassic Formations
- Bap Beds
- Vindhyan Supergroup
- Malani Rhyolite
- Erinpura Granite
- Delhi Supergroup
- Raialo Series
- Aravalli Supergroup/Basic & Ultrabasic Rocks
- Granite/Nepheline Syenite
- Banded Gneissic Complex (BGC)
- Uranium Occurrence

Main types of uranium mineralization include:

1. Na metasomatite type uranium mineralization mainly in the Khetri sub-basin. Also occurrences in Alwar and Lalsot-Bayana sub-basins.
2. Middle Proterozoic meta-sedimentary rocks with acidic intrusives.
3. Zone of extensive soda metasomatism.
4. Established a low-grade uranium deposit in Rohil village.
5. Scope for similar mineralization in other sectors of the sub-basin.
6. Belt under active sub-surface exploration.
7. More than 7000t U3O8 established.

A UNFC workshop was held in New Delhi on 30/10/2013...
Uranium resources in NDFB

ROHIL PROSPECT
DISTT. SIKAR, RAJASTHAN

Section N-2

Rohil deposit, (021)
Uranium resources in Bhima basin, Karnataka

GEOLOGICAL MAP OF BHIMA BASIN

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

GOGI

Karna river

Fracture zone

N
E
S
W

GEOLOGICAL MAP OF BHIMA BASIN

5 0 5 10 15Km

UNFC workshop, New Delhi - 30/10/2013
Uranium resources in Bhima basin, Karnataka

Transverse section through borehole GGL-42,101,26,87,51,95,97,115 & GT-2

Gogi Lake area

Shaft

Limestone

Ore lodes

Granite

Shaft

Index

Laterite

Deccan trap

Chert beds (inter-trappeans)

Purple shale (Harwal Fm.)

Limestone (Katamdevarhalli Fm.)

Sandstone/shale (Halkal Fm.)

Limestone (Shahabad Fm)

Shale

Dyke

Younger granite

Younger schist belt

Peninsular gneiss

Older schist belt (Sargur)

Arenite

Fault

Index

Surface radioactivity

Kagna river

Fracture zone

UNFC workshop, New Delhi - 30/10/2013
Uranium resources in Bhima basin, Karnataka

Gogi deposit - 021
Mahadek basin, Meghalaya

UNFC workshop, New Delhi - 30/10/2013
• 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 $U_3O_8$
Umthongkut
• Holds 11% of India’s uranium resources
• Ore body occurs 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

Mahadek basin, Meghalaya

UNFC workshop, New Delhi - 30/10/2013
Mahadek basin, Meghalaya

- Holds 11% 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

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

Mahadeks group Deposits- (021) (15% of the resources)
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$_3$O$_8$**: 0.3%
- **REO**: 60%
- **P$_2$O$_5$**: 27%
Beach and inland placer deposits

Index to Localities

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

<table>
<thead>
<tr>
<th>Minerals</th>
<th>Reserves as on August 2009 (million tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ilmenite+Leucoxene</td>
<td>520.38</td>
</tr>
<tr>
<td>Rutile</td>
<td>29.11</td>
</tr>
<tr>
<td>Monazite</td>
<td>10.70</td>
</tr>
<tr>
<td>Zircon</td>
<td>32.28</td>
</tr>
<tr>
<td>Garnet</td>
<td>154.26</td>
</tr>
<tr>
<td>Sillimanite</td>
<td>195.85</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>942.58</strong></td>
</tr>
</tbody>
</table>
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