AN OVERVIEW OF
URANIUM-RARE METAL-REE MINERALISATION,
SONBHADRA DISTRICT, UTTAR PRADESH, INDIA

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Cratons of India

1. Schist belts within nuclei
2. Tonalitic Gneiss
3. Granodiorite, gneisses and granulites of EPMB
4. K-granites in EPMB
5. Granulites and gneisses of MPMB
6. Middle Proterozoic Sedimentary Basins
7. Gondwana Sediments (Godavari Rift Valley)
8. Anorthosites along EPMB-MPMB contact
9. Eastern Ghat-Sukinda-Singhbhum Thrust
10. Deccan Trap Cover

KN: Karnataka Nucleus
JBN: Jeypore-Bastar Nucleus
SN: Singhbhum Nucleus
EPMB: Early Proterozoic Mobile Belt
MPMB: Middle Proterozoic Mobile Belt
Geological Map of Central India
Geological Map of Chotanagpur Gneissic Complex (CGGC)
Migmatite Terrain, Son Valley

- Northwestern extensions of Chotanagpur Granite Gneiss Complex (CGGC)
  - Banded gneisses and metasedimentary enclaves, overlain by Mahakoshal supracrustals and Vindhyan Supergroup in the North and Gondwana Supergroup in the south
  - E-W, NE-SW and NW-SE faults and fractures
    - Youngest is E-W and is sympathetic to the Son-Narmada rift
  - Intense fracturing, brecciation and mylonitisation resulting in the development of dilated cataclastic breccia
- U-Nb-REE Mineralisation hosted by migmatites and younger intrusives over 350 sq km
Son valley

INDEX
- GONDWANA
- QUARTZ REEF, QUARTZPROPHRY
- TECTONIC BRECIA, SILICIFIED ROCK
- ULTRABASICS, GABBRO, ANDESITES
- ALKALI GRANITE, SYENITE
- MIRGARANI GRANITE
- MISNITITE COMPLEX
- MAHAKOSHALS
- BASMENT COMPLEX AUGEN GNEISSES, PORPHYRITIC GRANITE, GRAPHITE, SCHIST, CLEIOLITE, SILICATE ROCK
- FAULT
- URANIUM ANOMALY
## Stratigraphy

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<th></th>
<th>Recent</th>
<th>Upper Vindhyan</th>
<th>L. Vindhyan</th>
<th>Upper Bijawar</th>
<th>Middle Bijawar</th>
<th>Lower Bijawar</th>
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<tr>
<td></td>
<td>Alluvium</td>
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<td>Turbidite Group</td>
<td>Chemogenic Group</td>
<td>Greenstone Group</td>
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<td><strong>Gondwana Cover Sediments</strong></td>
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<td><strong>Post Jungel Extrusives (919±21Ma)</strong></td>
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<td><strong>Syenite, Alkali Feldspar Granite (Kundabhati-Sonwani)</strong></td>
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<td><strong>Post Bijawar Acid Intrusive Phase II (1200-1100Ma)</strong></td>
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<td><strong>Granite</strong></td>
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<td><strong>Migmatite Complex</strong></td>
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<td><strong>Metamorphites</strong></td>
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<td>Jungel Molasse</td>
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<td>Transition sediments with QPC</td>
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<td><strong>Archaean Complex</strong></td>
<td>Augen gneiss, porphyritic granite, granite gneiss, amphibolite, BHQ, Hornblende schist, dolomite, graphite schist, pyroxene granulite, leptynite &amp; Calc-silicate rocks</td>
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Uranium Mineralisation

• First reported in 1977-78
  – Asnahar in granite-gneiss,
  – Kushmahar in brecciated granite gneiss
  – Bammani-Bari in granite-syenite.

• Concerted exploration during 1988-1998
  – Naktu, Kudar, Nawatola, Lakhar, Sirsoti, Kudri, Kundabhati, Jaurahi, Anjangira
Categories of Mineralisation

A. Mineralisation within CGGC
   - Pegmatoid Leucosome Mobilizate (PLM) within migmatite complex. e.g. Naktu, Kudar, Kudri etc.
   - U-Nb-Ta-REE mineralisation associated with pegmatite injections within granitoids, e.g. Jaurahi
   - Associated with surface breccia over migmatites, e.g. Kudar

B. Mineralisation within Mahakoshals
   - Associated with anorogenic high potassic granites and episyenites, e.g. Kundabhati, Sonwani
Types of Mineralisation

• Based on host-rock Characteristics

1. Pegmatoid Leucosome Mobilizate (PLM) and Biotite Melanosome Mobilizate (BM) hosted
   - Soda-metasomatism is ubiquitous
   - U-Rare metal-Mineralisation

2. Potassic Granite and Syenite hosted
   - Rift-related anorogenic granites with episyenitisation
   - Extreme K-metasomatism

3. Brecciated Rock Hosted

4. Pegmatite Hosted
   - Rare-Metal and REE bearing
1. PLM and BMM Hosted Mineralisation

• Naktu, Kudar and Kudri

• Ore Minerals
  – Uraninite, Uranophane, Coffinite, Uranothorite, Samarskite, Fergusonite
  – Trace xenotime
    • Two types of uraninite: (a) rounded and euhedral crystals along biotite-albite interface and (b) as inclusions within albite and quartz.

• Imprints of Soda metasomatism
  – Replacement of alkali feldspar by albite

• Metallogeny
  – By the remobilization and concentration of the intrinsic U of the antecedent sediments, during migmatisation through anatectic processes
Migmatite

- Banded rocks of composite nature, constituted by paleosome, neosome, and melanosome
- Leucosome:
  - Hypidiomorphic texture, myrmekitic
    - Quartz, microcline, albite (minor biotite)
    - Accessories: zircon, apatite, sphene, hornblende, garnet
- PLM:
  - Medium grained to very coarse grained (pegmatoid) quartz-rich leucocratic suite
    - Quartz, sodic plagioclase, microcline, perthite and biotite
    - Zoned zircon, muscovite, apatite, purple fluorite, garnet and pyrite as accessories
    - Hypidiomorphic and myrmekitic texture
- Melanosome
  - Mainly biotite
  - Occasional quartz, microcline, plagioclase and graphite.
### Naktu

<table>
<thead>
<tr>
<th>Host Rock</th>
<th>Mode of Occurrence</th>
<th>Mineralisation</th>
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<tbody>
<tr>
<td>Pegmatoid Leucosome mobilzates (PLM)</td>
<td>a. Radioactive zone of 2200m x 0.50-8.0m (upto 0.14%U₃O₈)</td>
<td>0.020-0.050% U₃O₈ x 1.20-1.50m</td>
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<td>b. Lenticular bands, disposed in en-echelon pattern with frequent pinching and swelling</td>
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**A. Northern Block**

Only the main lode over 400m strike at a vertical depth of 5-70m (0.032% x 4.58m)

**B. Southern Block**

Main lode + lodes on FW and HW side.

Main lode between 5-150m vertical impact.
Naktu

Radioactive core, Naktu
Naktu

Euhedral uraninite

TRANVERSE SECTION THROUGH NN/106,92,93,99,78,11 & NS/7, NAKTU AREA, SONBHADRA, U.P.

INDEX

- Alluvium
- Pegmatoid Leucosome
- Migmatite Mobilize Complex
- Meta-Arkose
- Basement Gneisses Complex
- Mineralised Band

N75°W

D.D. 215.00m
D.D. 164.05m
D.D. 206.00m
D.D. 140.05m
D.D. 100.30m
D.D. 52.00m
D.D. 55.00m
D.D. 120.00m

0 20 40 60 80 100m
Nature of Occurrence

- As sheet-like mass with shallow to moderate rolling dips
- Lensoidal, in en-echelon manner
- Upto 1800m along the strike and 80-120m along the dip.
- Grade 0.010-1.00% U$_3$O$_8$

- **Naktu-Kudar**
  - Large thickness of Migmatite, with development of thick pegmatoid leucosome bands

- **Kirwil-Kudri-Anjangira**
  - Thin veneer of migmatites over basement, with thin PLM bands
Anjangira

- Extends intermittently over 5km strike with 0.5-8.25m width
- 0.022-0.027%U₃O₈ x 1.60-7.90m at a depth of 7-100m
- Uranophane, phosphuranilite
2. Potassic Granite and Syenite Hosted

- **Kundabhati, Sonwani, Chitwar and Balsotha**
  - Associated with rift-related plutons of anorogenic alkali granite along the Son-Narmada Fault.
  - Emplaced within Mahakoshal supracrustals

- **Host:**
  - Alkali feldspar granite and episyenites
    - Consisting of microcline, microcline-perthite, sericitised albite and quartz
    - Episyenitisation and desilicification
    - K-Fe metasomatism

- **Ore Minerals**
  - Uranophane
Kundabhati

Staggered Longitudinal section along Mineralised Horizon
Kundabhati area, Sonbhadra district, Uttar Pradesh

Longitudinal section along Mineralised Horizon
(Second Series)
3. Brecciated Rock Hosted

- **Kudar**
  - Breccia zones within migmatites
  - Surface extension of 1300m with a thickness of 1-4m.
  - Breccia hosted mineralised band (E-W) cuts across the country rock (NNW-SSE)
  - Two mineralised lenses of 250m (0.029%U$_3$O$_8$ x 2.90m) and 435m (0.035%U$_3$O$_8$ x 1.72m)
  - **Ore Mineralogy:**
    - Uraninite, uranophane, adsorbed U
    - Molybdenite, pyrrhotite
    - Stilbite, secondary silica, chert, pyrite, chalcopyrite
    - Iron oxide coated
Kudar Proect
Longitudinal Correlation section through B.H. nos. KDR-15,17,18,20,22,24,26,30,32 (Projected on Vertical plane)
Dhanbadua

Dialated cataclastic breccia (N80W-S80E) cutting across NW-SE trending migmatite

Longitudinal section along Boreholes at Dhanbadua area, Sonbhadra district, Uttar Pradesh
4. Pegmatite Hosted

• Jaurahi
• Rare-Metal and Rare earth bearing pegmatitic injections
• Ore Minerals
  – Columbite, Samarskite, Aescheynite and Thorite
  – Xenotime
  – Associated fluorite, zircon, fluor-apatite
# General Characteristics of Mineralisation in Son Valley

<table>
<thead>
<tr>
<th>Age</th>
<th>~ Paleo-Mesoproterozoic Chhotanagpur Granite Gneiss Complex (CGGC).</th>
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<tr>
<td>Host rock</td>
<td>Pegmatoid Leucosome mobilizate, Melanosome mobilizate, Anorogenic alkali feldspar granite</td>
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<tr>
<td>Plutonic Activity and Associated Changes</td>
<td>Rift related anorogenic granite, episyenitisation, Desilicification K-Fe metasomatism</td>
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<tr>
<td>Structure</td>
<td>E-W, NE-SW and NW-SE faults and fractures. E-W fracture system sympathetic to Son-Narmada Rift.</td>
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<tr>
<td>Mineralogy</td>
<td>Uraninite, Samarskite, fergusonite, columbite, aescheynite, Pyrite, Pyrrhotite Thorite, Fluorite, fluorapatite,</td>
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</tbody>
</table>
Genetic Aspects

• Imprints of repeated thermal tectonic and metamorphic reactivation
  – Formation of migmatites as a result of ultra-metamorphism of arkosic to psammopelite sequence in extensional basins.

• Thermal regime in ultrametamorphism leading to anatexis led to:
  – the remobilization of intrinsic U in sediments
  – Subsequent concentration within the albite-rich pegmatoid leucosome and biotite rich melanosome

• Syn-tectonic plutonic activity also has contributed towards the mobilization and subsequent concentration of U
  – Mineralised episyenites are the product of shearing, brecciation and desilicification of anorogenic alkali granites.

• The multimetal mineralisation associated with magmatic pegmatites is a result of pneumatolytic/metasomatic activity at a later stage.
Concluding Remarks

• Low-grade, low-tonnage deposits at Naktu-Kundabhati sector
  – Anatectic and Associated Metasomatic events leading to concentration of uranium in pegmatoid leucosome
  – Presence of associated Rare metal minerals and rare earth minerals add to the potential of the area.

• The area has potential to host similar deposits.
Thank You