GEOLOGICAL SURVEY OF INDIA

Mineral Exploration

Finding Concealed Deposits

MEGECON 2022

20TH December 2022
Hosapete

PRELUDE

- **GSI with Pan India presence, is the prime agency involved in carrying out Geological studies across the country**

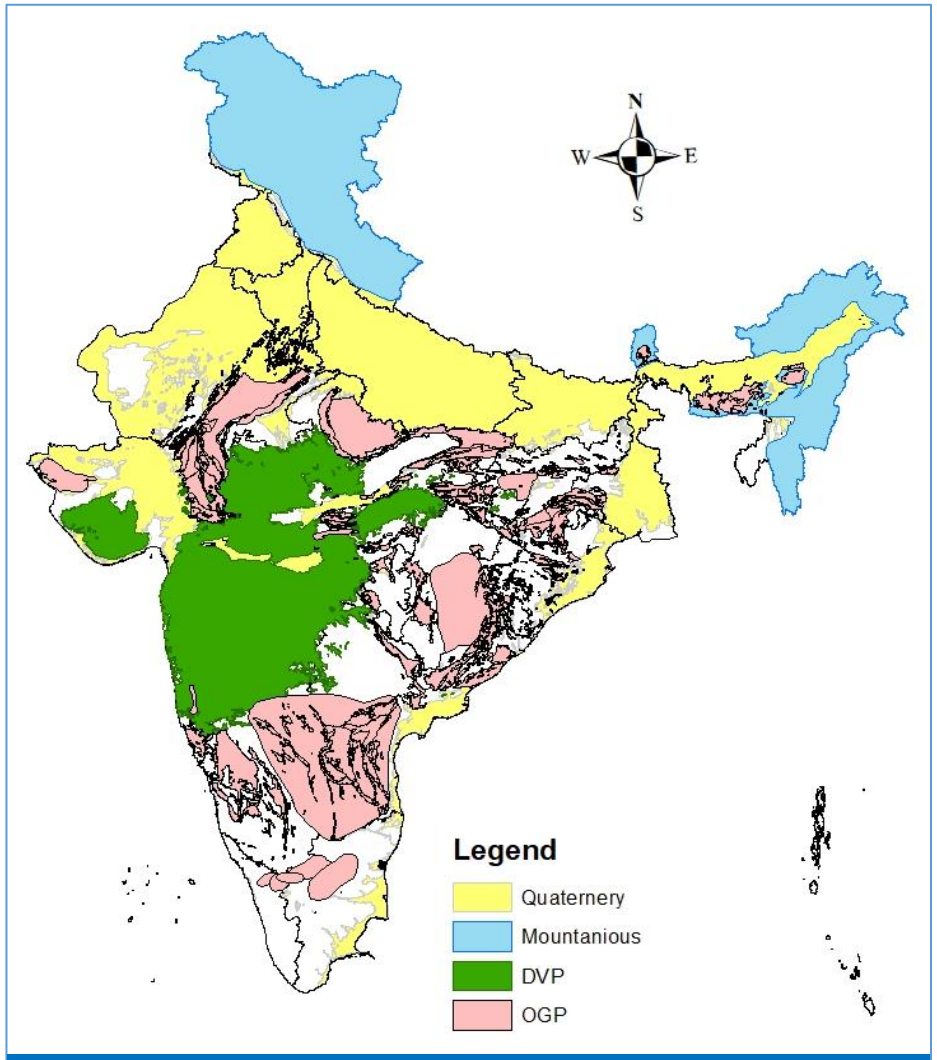
  - ❑ **Multi-disciplinary capabilities**
  - ❑ **Baseline data generation (Mapping)**
  - ❑ **Exploration in Greenfield areas**

- **Strategy**
  - ❑ **Balance wider Coverage with detailed R&D**
  - ❑ **Adopting new techniques into operational procedure**

Geological Potential Area vis-à-vis Cover & Other Areas







Total Area is about 32.87 Lakh Sq.km.

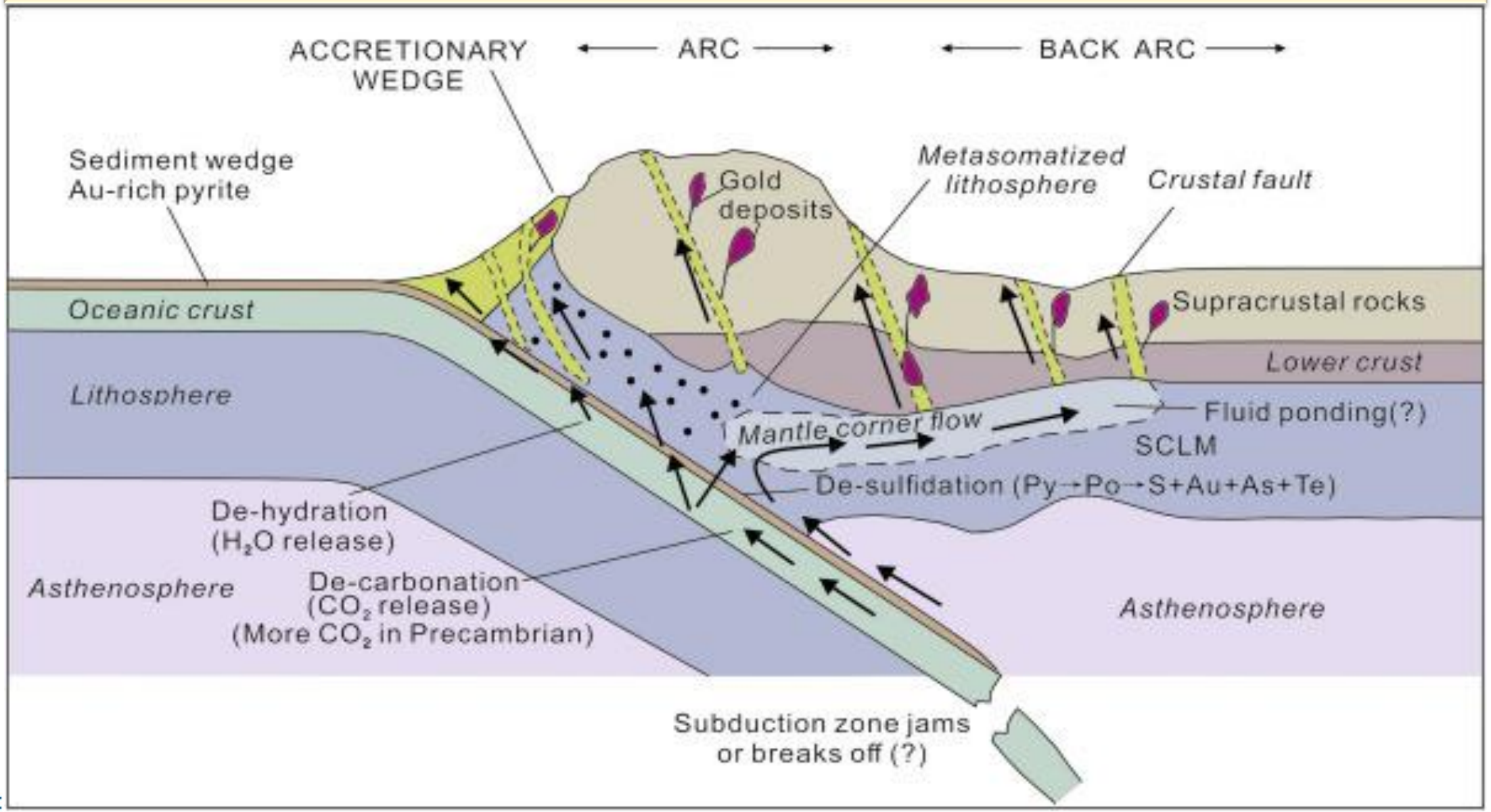
Terrain	Area
Himalaya Terrain	5 lakh sq. km
Quaternary & Cover Plains	10 lakh sq. km
Deccan Volcanic Province	5 lakh sq. km
Geological Potential Area	**6.88 lakh sq. km**
Remaining Area (Granulite Terrain, Cover Sequences etc)	5.9 lakh sq. km

Mapping and Exploration In GSI – Present & Future

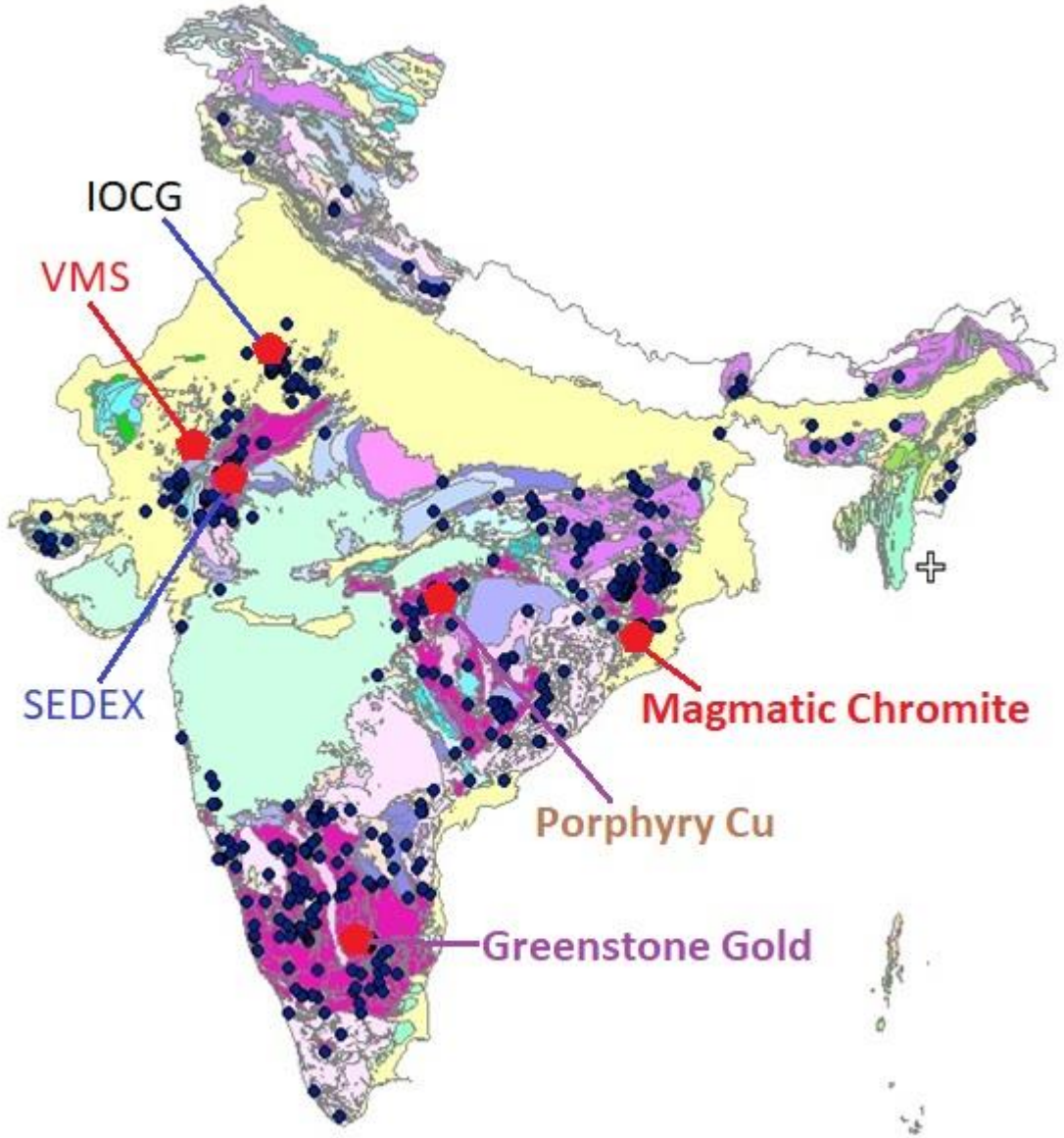
- Geological –Mineral Systems Approach
- Geophysical – Aero-geophysics, Ground geophysics
- Geochemical - NGCM
- Remote Sensing – Hyperspectral
- Integration Geoscience – RMT, Uncover, Data Integration

- Heliborne Electromagnetic Survey
- IndMap – Magnetotelluric survey across country
- Deep Seismic Reflection Survey
- National Geoscience Data Repository and Digital Core Library

Dynamic Earth and Ore Deposit Formation



Approach

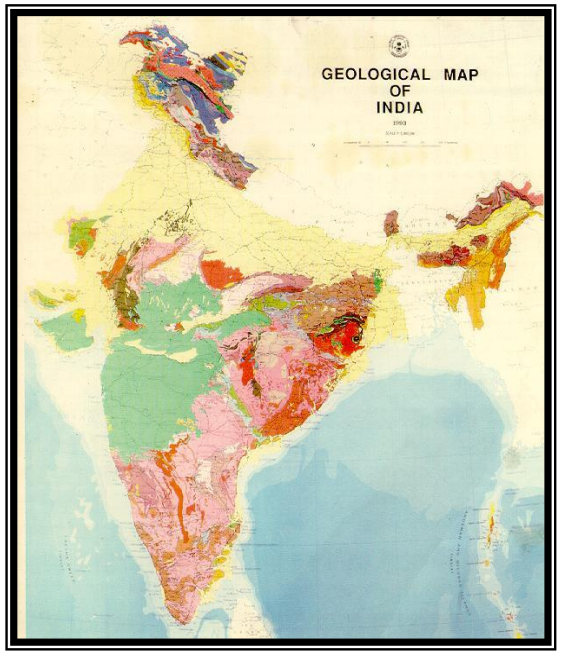


- Find which part of earth's crust now we see
- Locate deep faults, sutures
- Geological understanding leads us to find areas of interest
- It requires modern techniques, integration geoscience approach with conceptual modelling

Baseline Geoscience Data

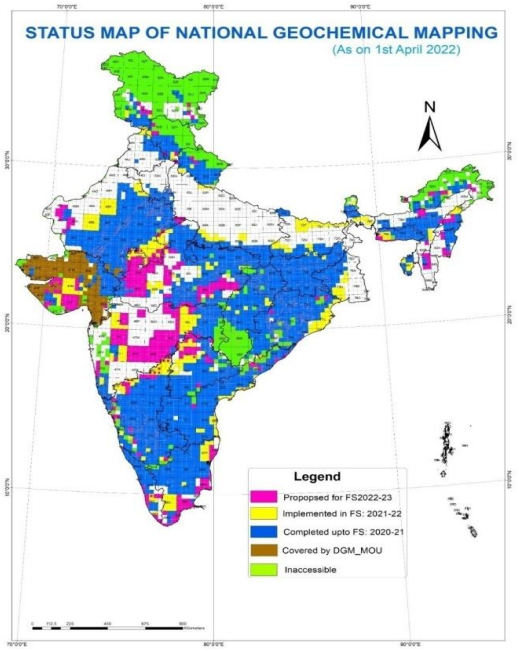




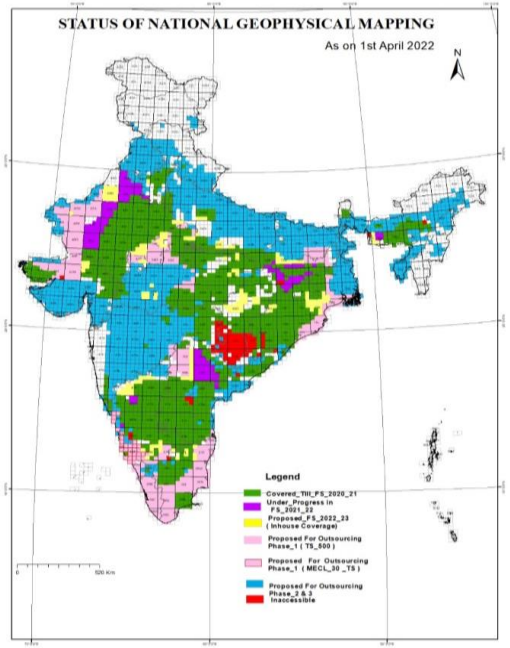


Systematic Geological Mapping at 1:50K for whole country.

(99.35% completed)

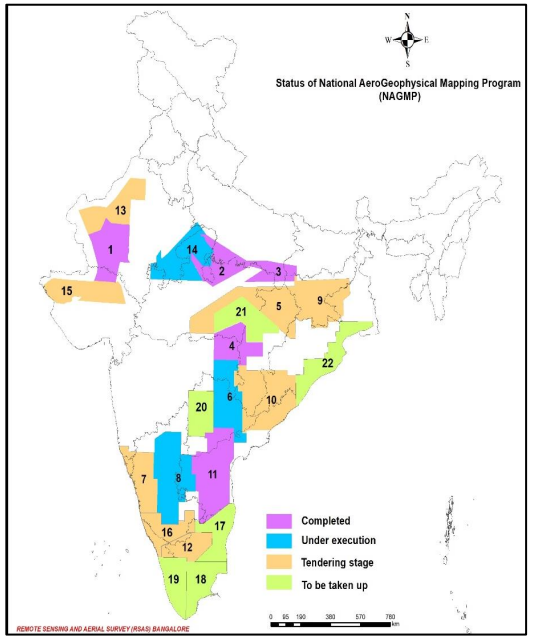


Regional Geochemical data (16.21 lakh sq. km completed (remaining area by 2025)



Regional ground geophysical data

10.63 lakh sq. km completed remaining area by 2025)

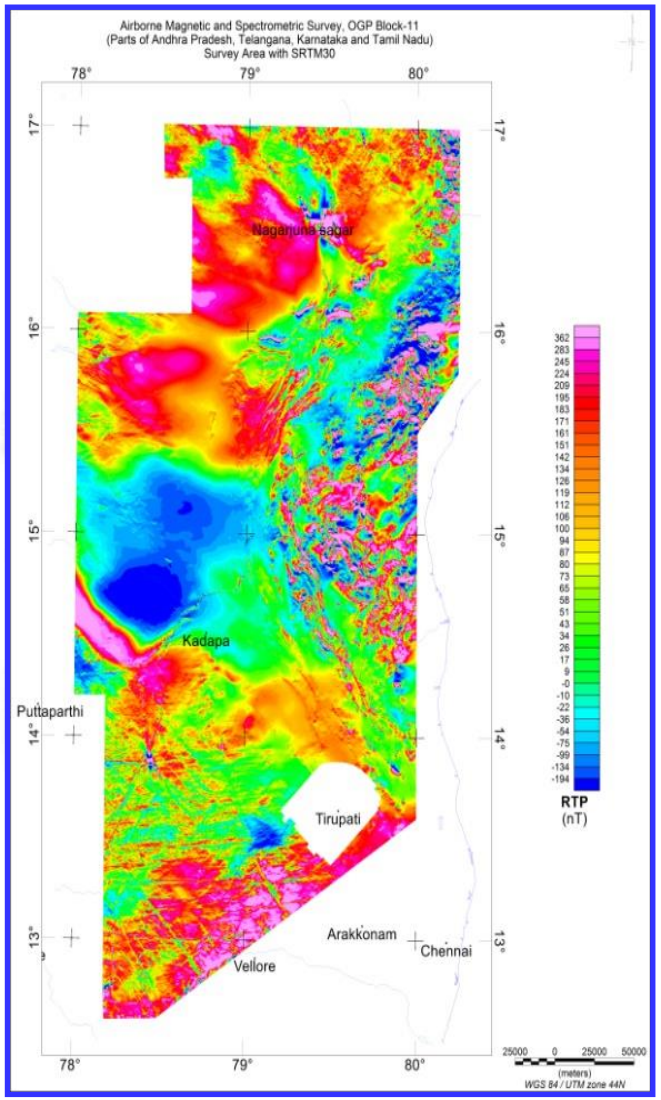


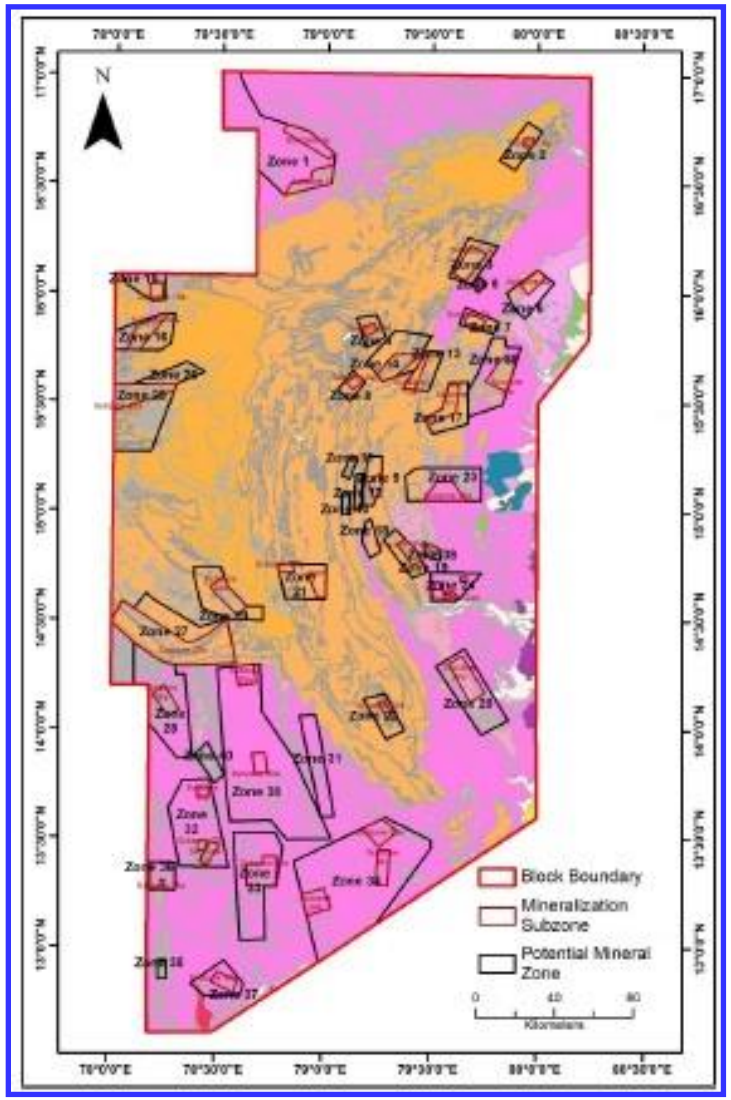
Aero-geophysical Mapping

(2.69 lakh sq. km area covered, remaining area by 2026)

Baseline data are used to identify mineral exploration target areas

National Aero-Geophysical Mapping





Data acquired:

Airborne magnetic gradiometric and radiometric data

Survey Parameters:

Survey Line spacing: 300 m

Control Line spacing: 3000 m

Height: 80 m AGL

Coverage:

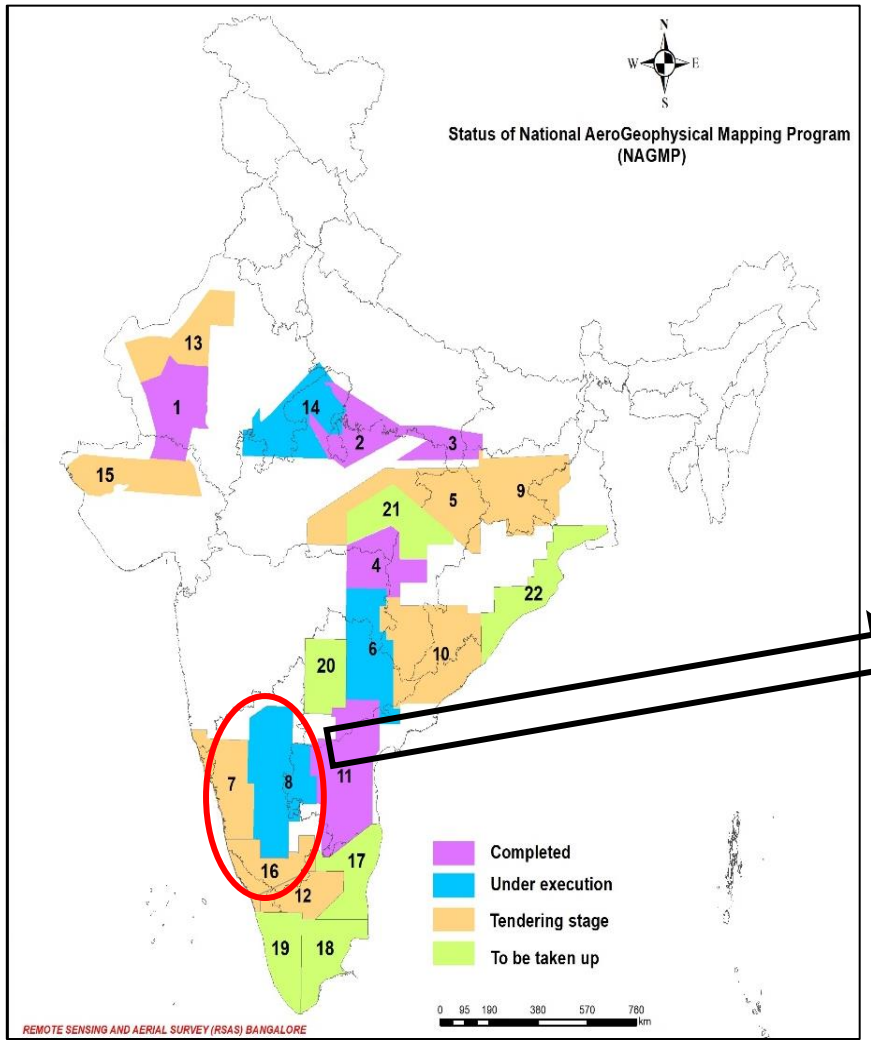
Total area: 12.64 L Sq. Km

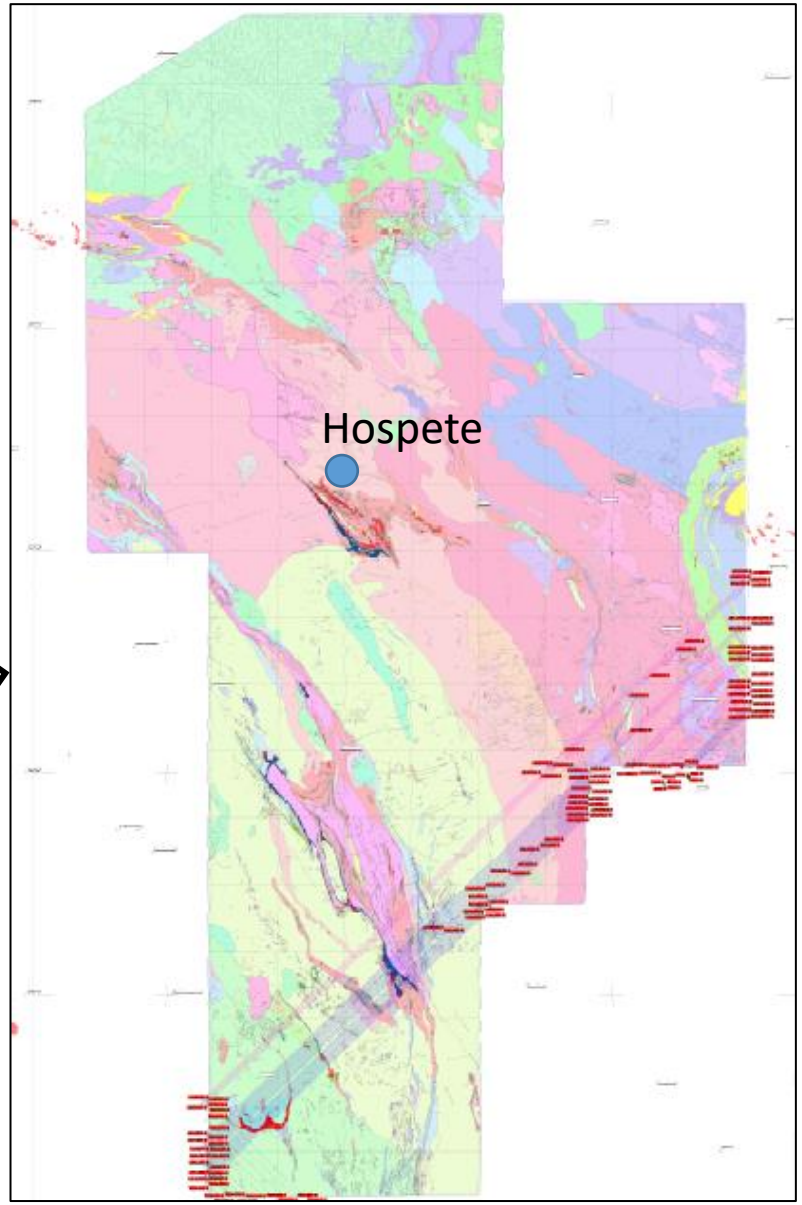
Total Line Km: 46.37 L

Outcome so far in 5 Blocks:

150 potential targets identified

Ongoing Aero-Geophysical Survey in Karnataka



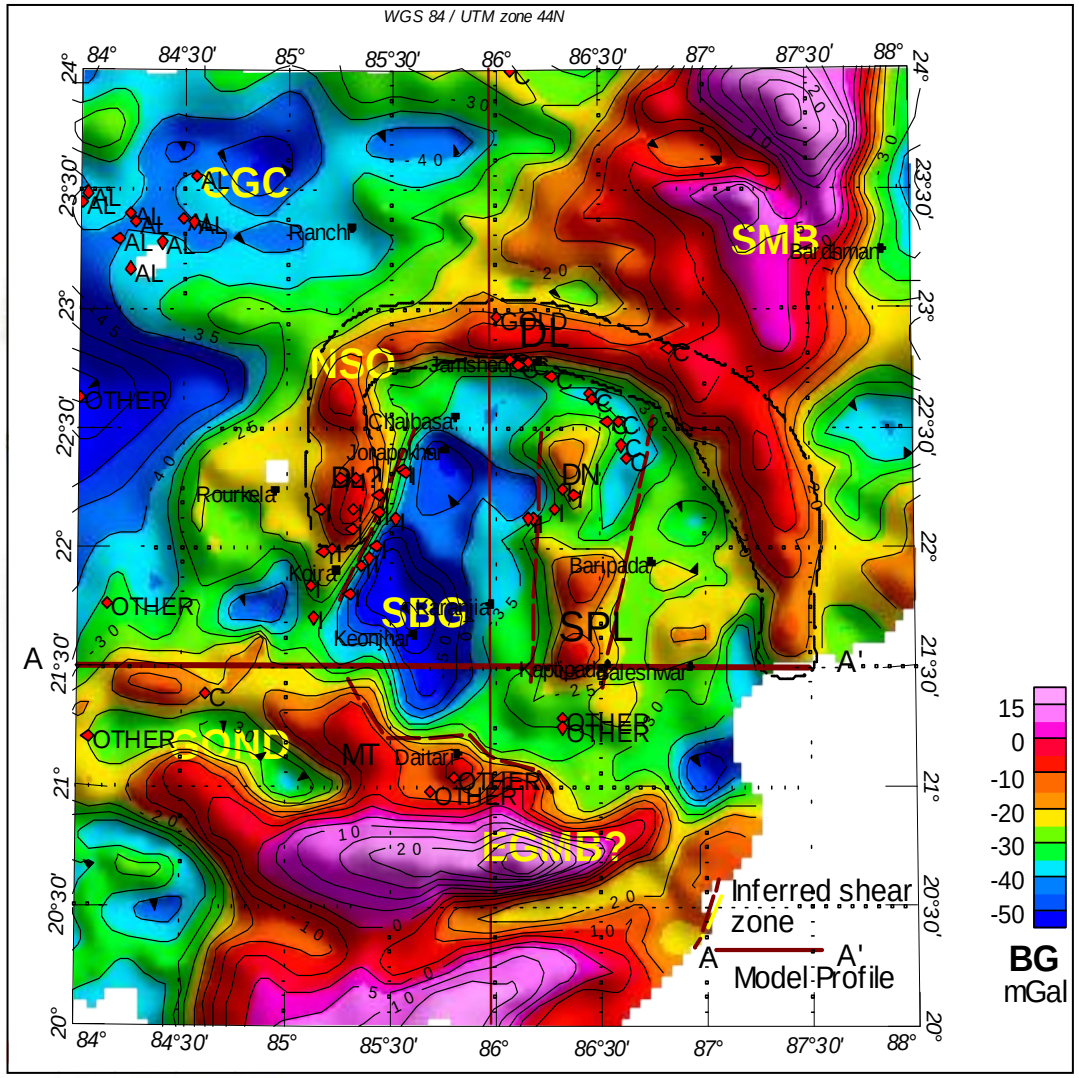


NAGMP Block 8

- ✓87,914 Sq Km
- ✓3.22 Lakh Line Km
- ✓80 m AGL300 m line spacing

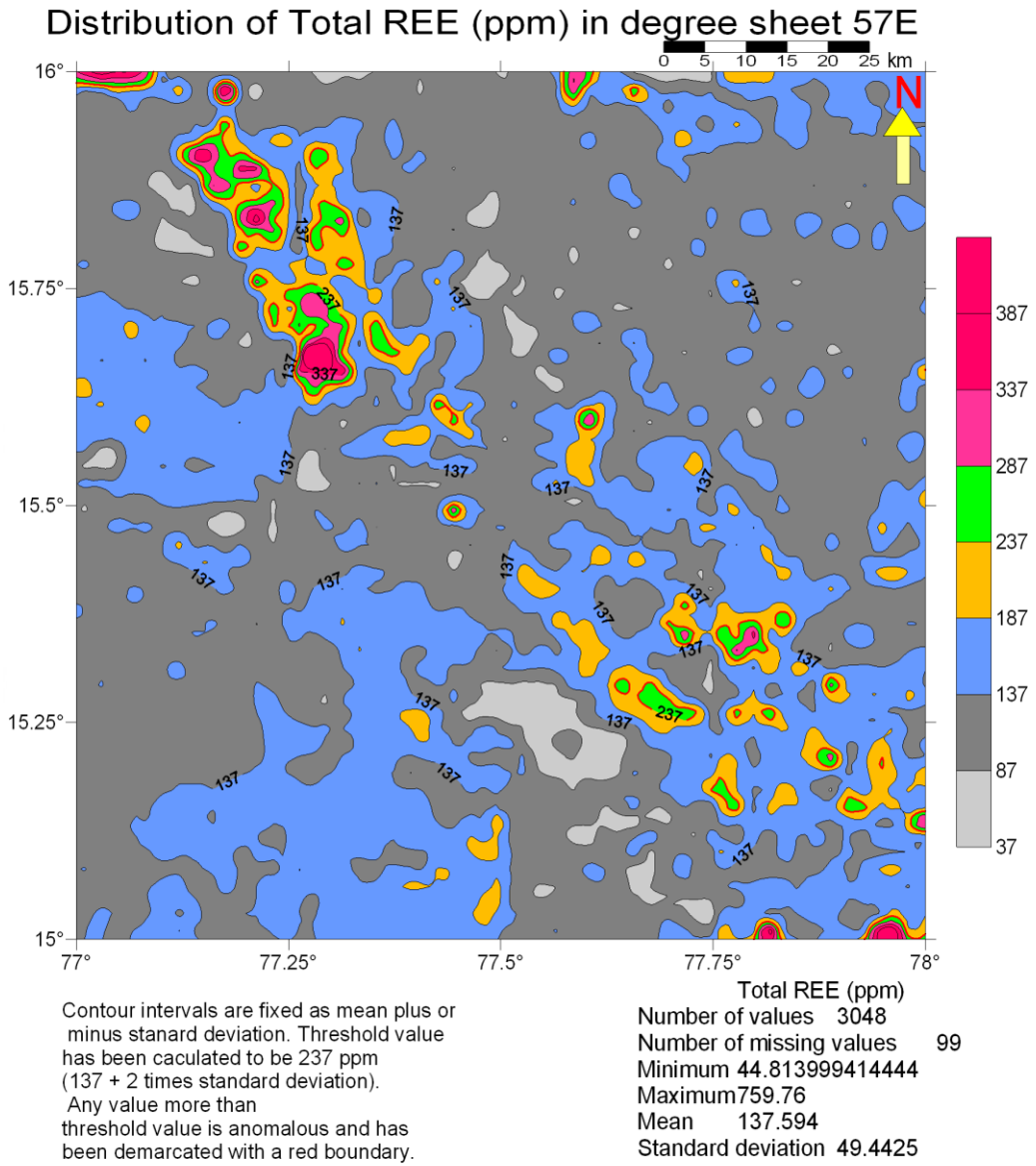
National Geo-Physical Mapping

Gravity Anomaly Map (Singhbhum Crustal Province)



- **Ground gravity and magnetic data with 1 reading per 2.5 sq.km**
- **26.73 L Sq.km coverage**
- **Outcome: 32 new areas of exploration** [Base metal, Fe, Ni-Cr, REE, Potash, gold, graphite, PGE]

National Geo-Chemical Mapping



- **Geochemical Database using multi-elemental analysis for preparation of distribution pattern of 64 elements**

- **170 spin off items generated in last 5 years**
  - ✓ **Very high REE (9804 ppm) over Gondwana rocks at Kothagudem dt, Telengana. G3 exploration is taken up**
  - ✓ **3119 ppm REE over lateritic soil at West Khashi Hill dt, Meghalaya**
  - ✓ **Pegmatite with REE 2301 ppm, along with Nb (356 ppm), Ta (17.46 ppm) at Salem and Dharampuri dt of Tamil Nadu**

Mineral System

Ore body is part of a much larger entity, called ***mineral system.***

- Mineral System encompasses entire lithospheric pathways of mineralizing fluids in space and time. (Wyborn, 1994)

  Sources, Fluid-flow drivers, Fluid-flow pathways and architecture, Depositional sites and mechanisms, Critical elements

- Ore deposits (particularly large deposits) represent the **foci of large-scale systems** of mass and energy flux.

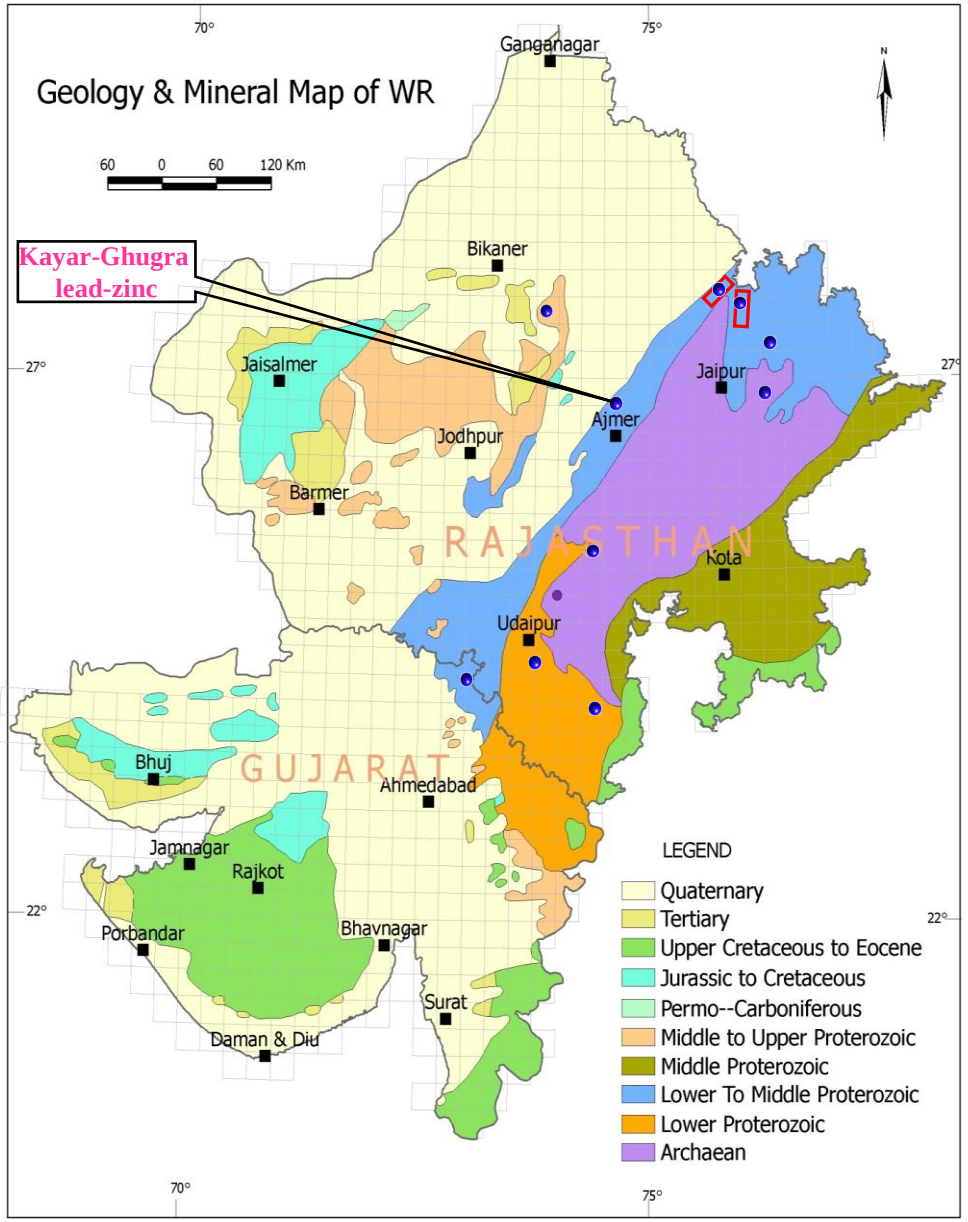
- Allows assessment of mineral potential in greenfield regions.

- Gives opportunity to discover deposits below cover. Buried terrains require use of extensive geophysical data sets for mineral targeting.

Finding Concealed Deposit - Greenfield



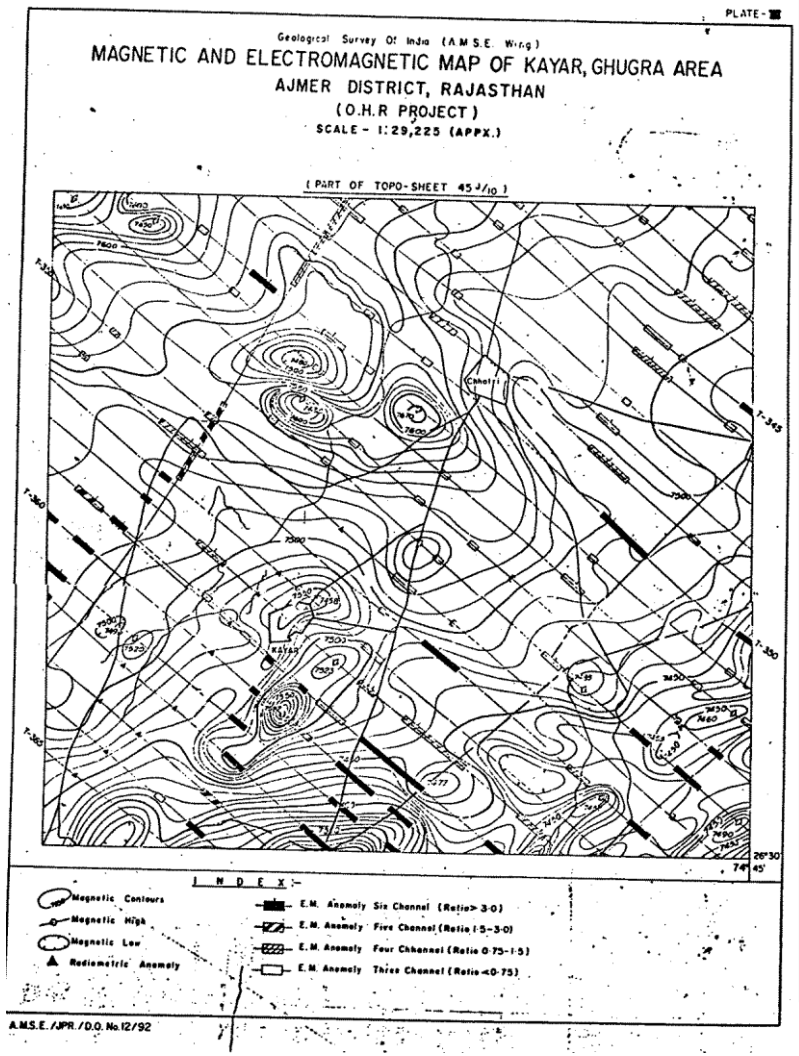


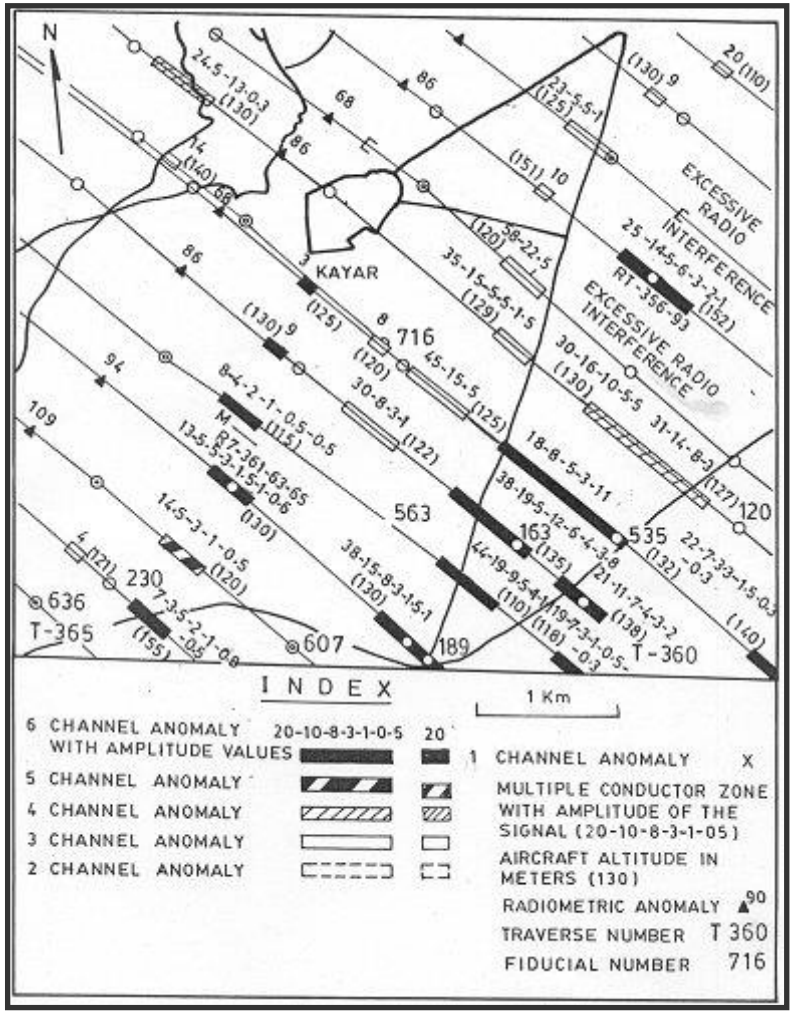


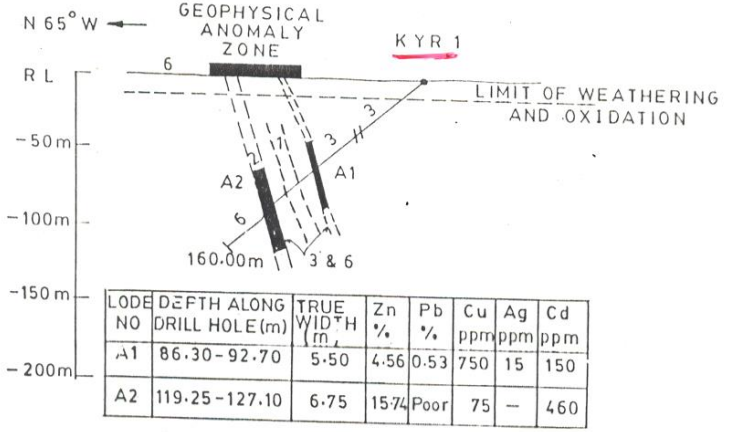
Story of Kayad, Rajasthan

- ✓ It is soil covered
- ✓ GSI acquired Aero-GP data in 1967-68 through OHR project. Mag and EM anomaly were picked up
- ✓ Follow up geochemistry, geophysical survey and drilling intersected mineralization over 1140 m long Ore zone upto a depth of 270 m with 9.18 MT of Pb-Zn ore
- ✓ Kayar mine was commissioned in 2014 with production of 1.2 million tonnes of ore per annum.

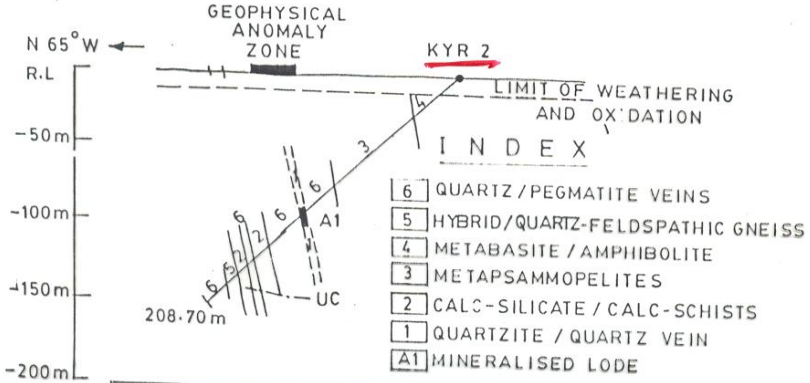
Finding Concealed Deposit - Greenfield







LODE NO	DEPTH ALONG DRILL HOLE (m)	TRUE WIDTH (m)	Zn %	Pb %	Cu ppm	Ag ppm	Cd ppm
A1	86.30–92.70	5·50	4·56	0·53	750	15	150
A2	119.25–127.10	6·75	15·74	Poor	75	—	460



LODE NO	DEPTH ALONG DRILL HOLE (m)	TRUE WIDTH (m)	Zn %	Pb %	Cu %	Ag ppm	Cd ppm
A1	127.70–132.35	3·9	15·82	2·77	0·11	30	500
UC	175.90–184.60	7·48	1·11	0·09	0·03	—	350

UC – UNCLASSIFIED

Kayad Deposit

1. ***Geology***: Mica schist and calc-silicate rocks of the Ajmer Formation of Mid-Proterozoic Delhi SuperGroup.

2. ***Host rock***: Quartz – mica – schists and calc – silicate rocks

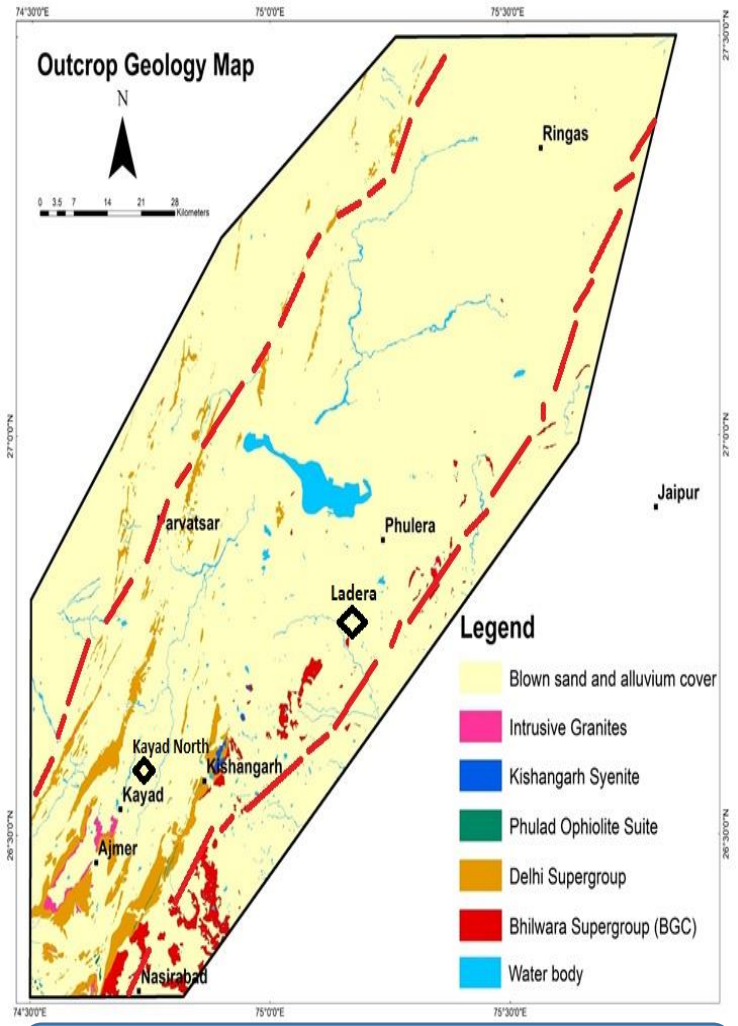
3. ***Ore Mineralogy***: The major ore minerals are sphalerite (~20%) and galena (~2%) while pyrrhotite and pyrite constitute the subordinate sulphides (~5-6%).

4. ***Occurrence***: Sulphides occur as discontinuous veins, massive bands, fracture fillings, and occasionally as disseminations.

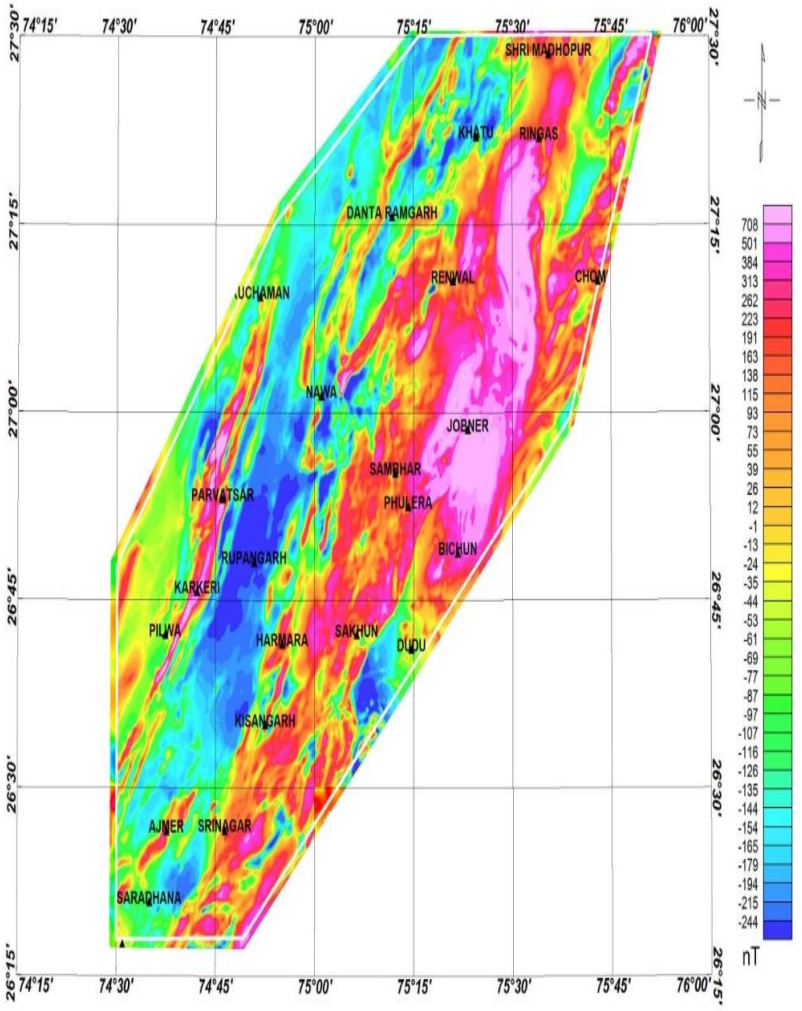
5. ***Structure***: Laminations of sphalerite in gangue are at times co-folded - evidence of syngenetic sedimentary character of ore minerals

6. ***Deposit Type***: The Kayar Pb-Zn deposit is considered as SEDEX type. Later recrystallization due to regional metamorphism affected the host rock. As such, the deposit can be considered as remobilized SEDEX type deposit.

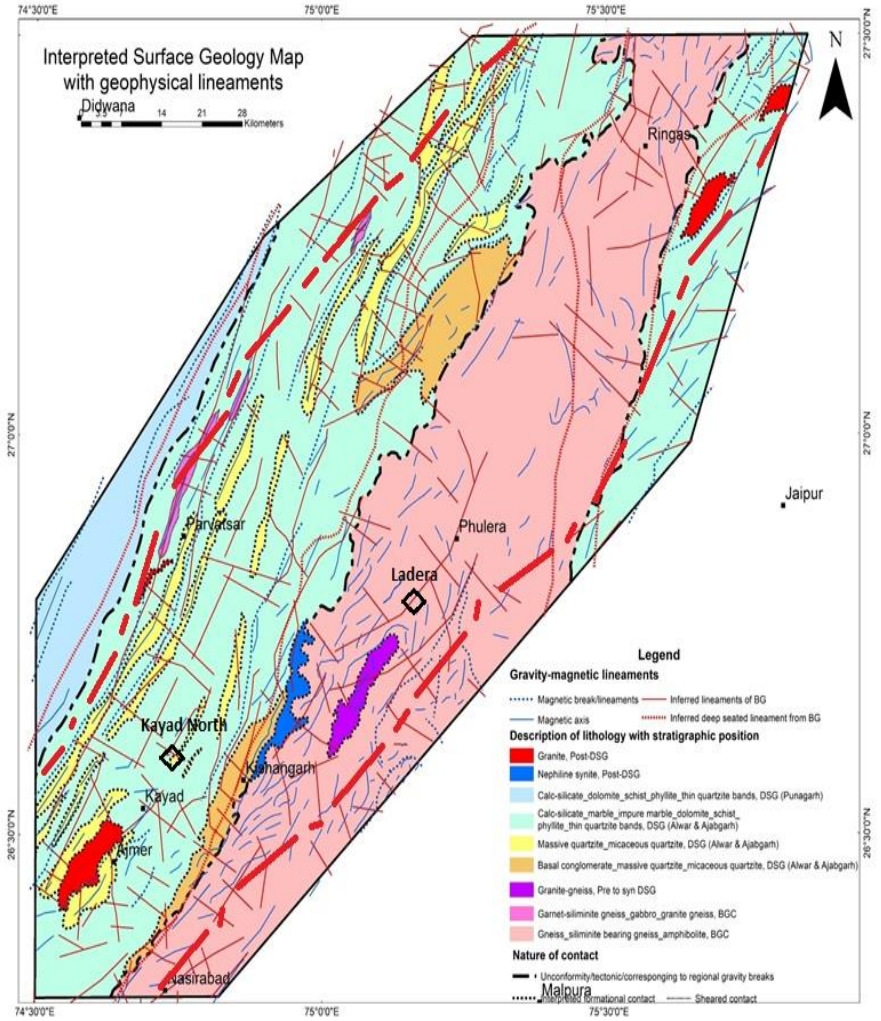
Finding Concealed Deposit - Brownfield



Geological Map

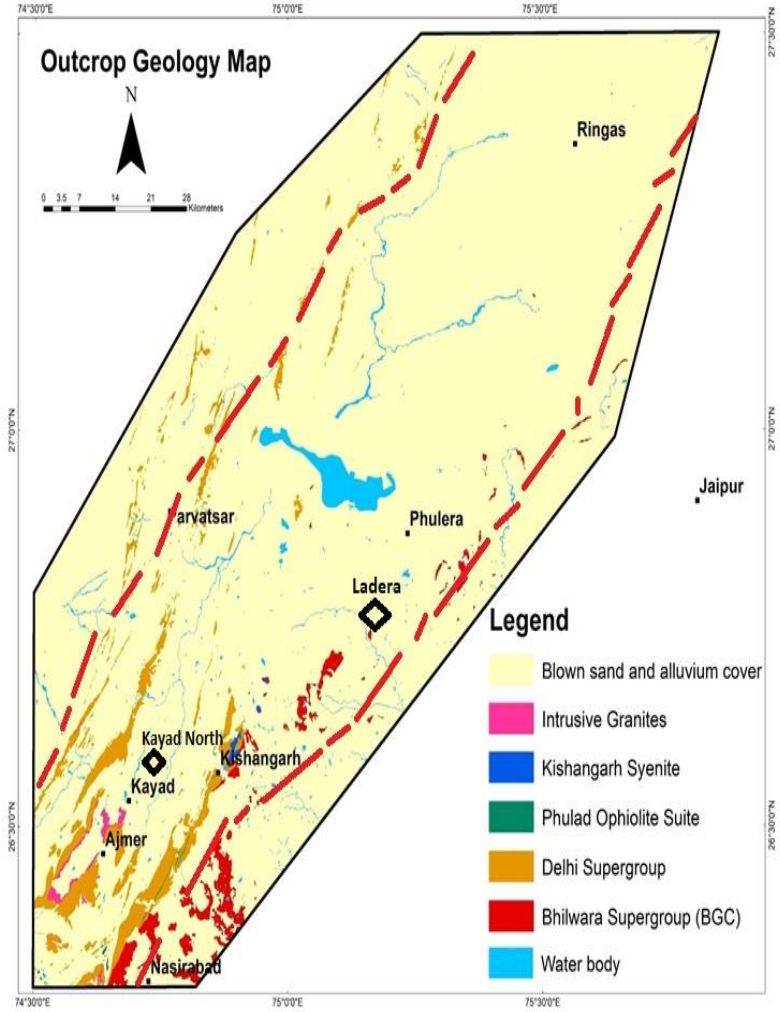


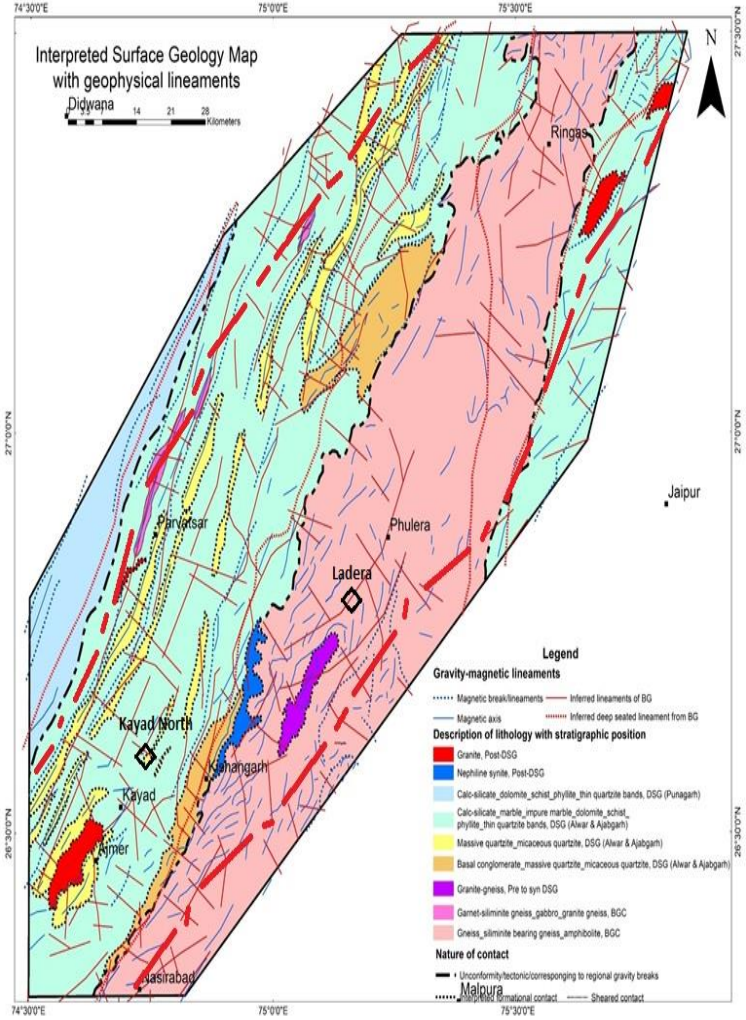
Aero-Mag Map

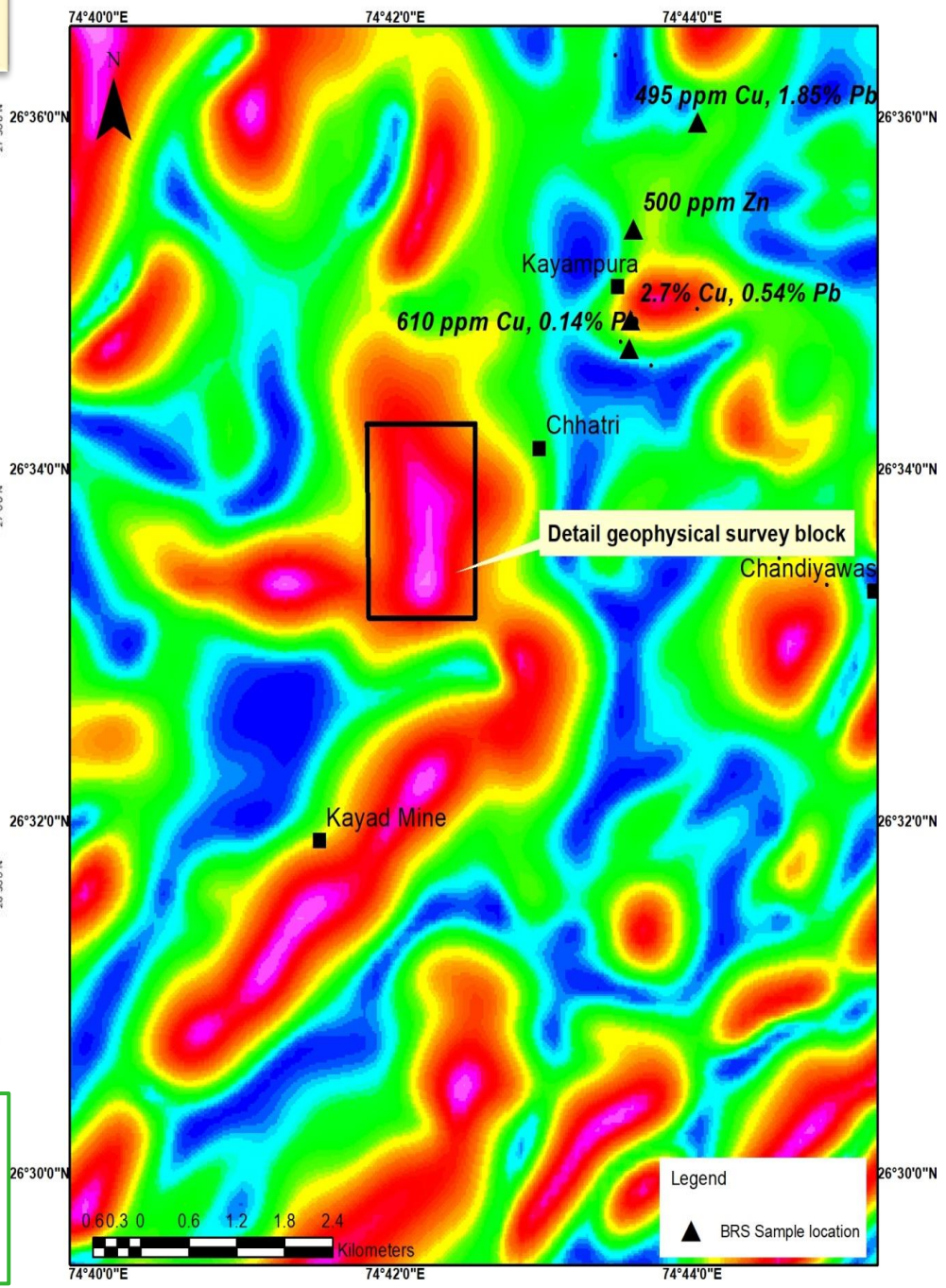


Interpreted Map Combining Geology & Geophysics

Kayad North Block



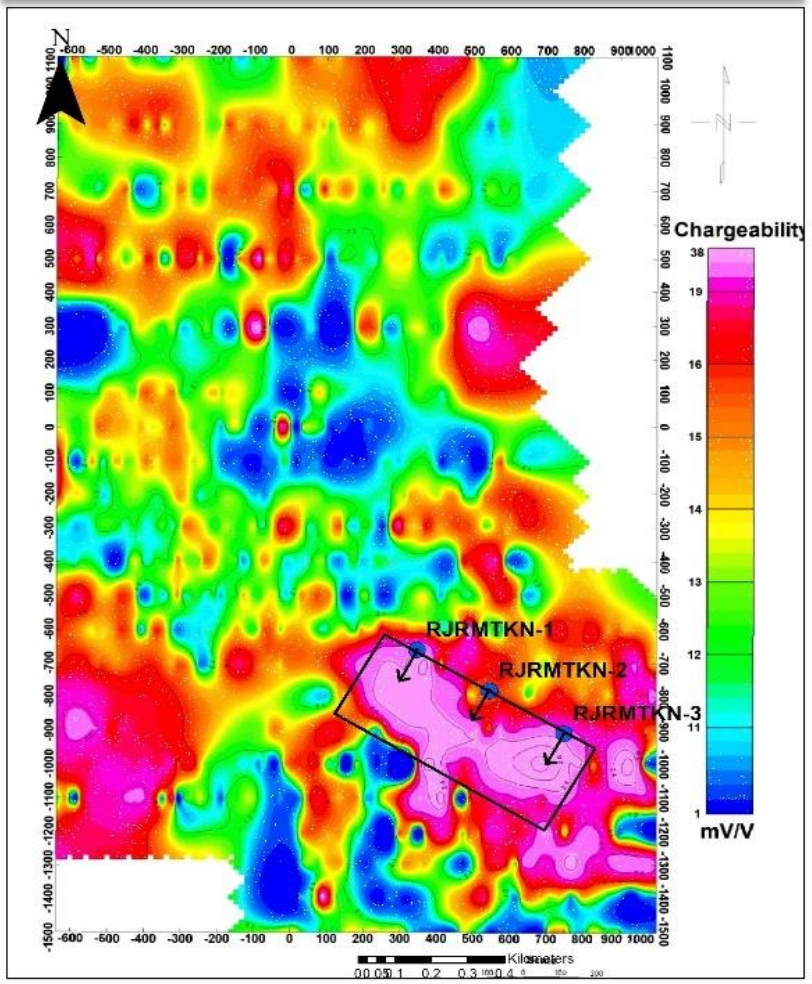




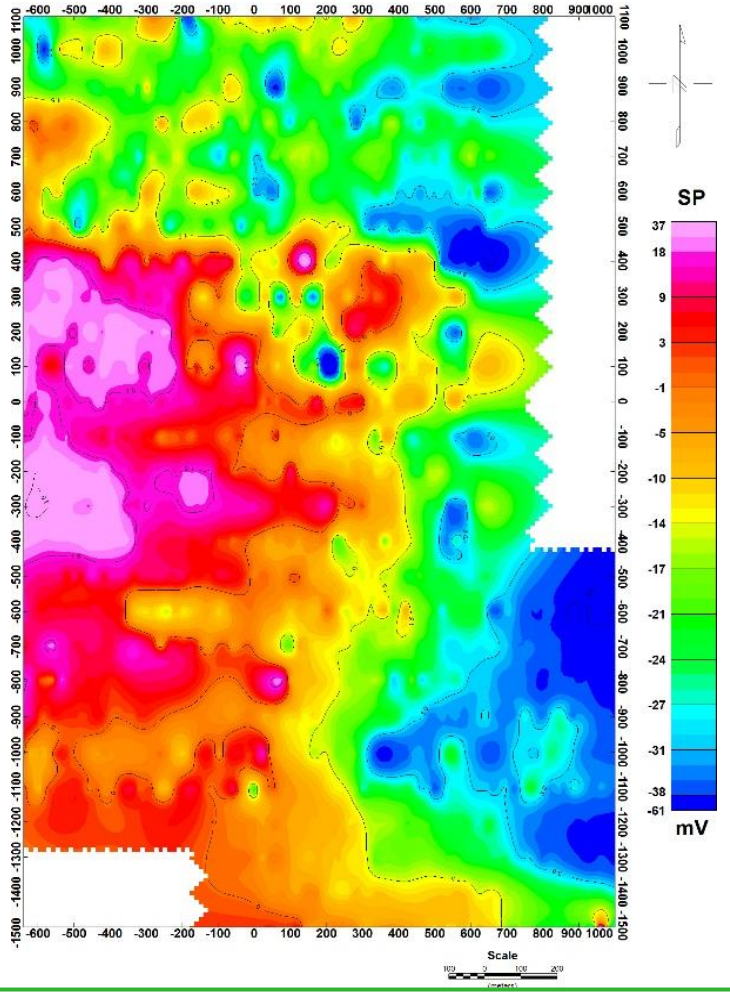
This area is located north of the SEDEX type Pb-Zn deposit of Kayad.

The area exhibit lithounits of the DSG [metamorphosed argillites, arenites and carbonates]

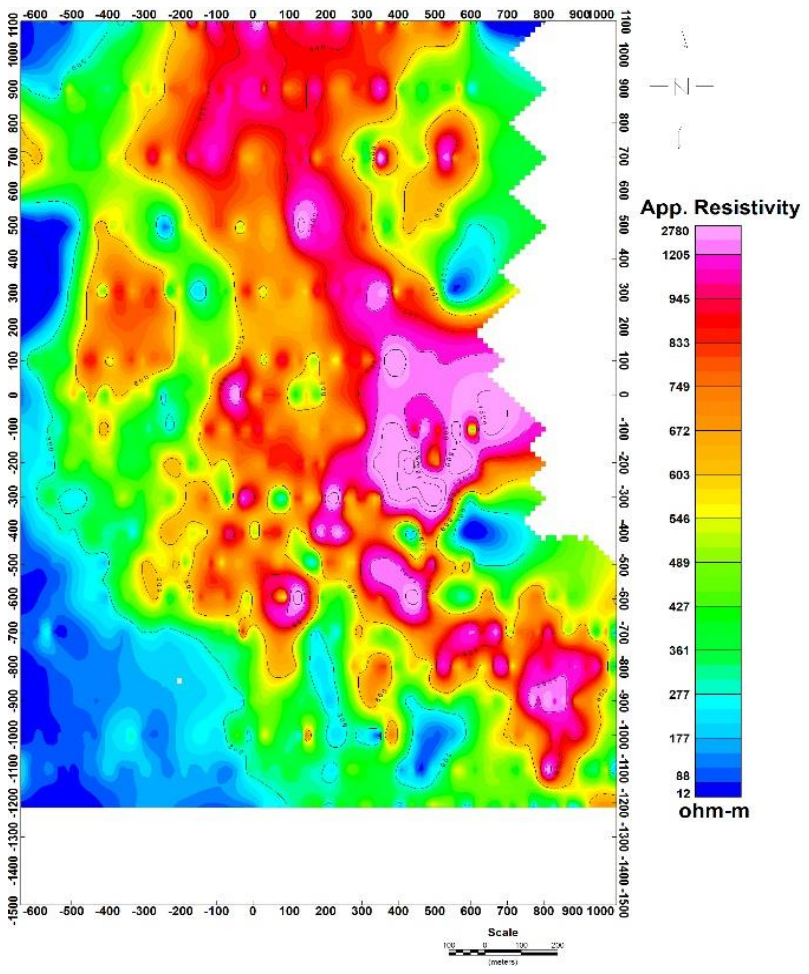
IP(Chargeability) map



SP map

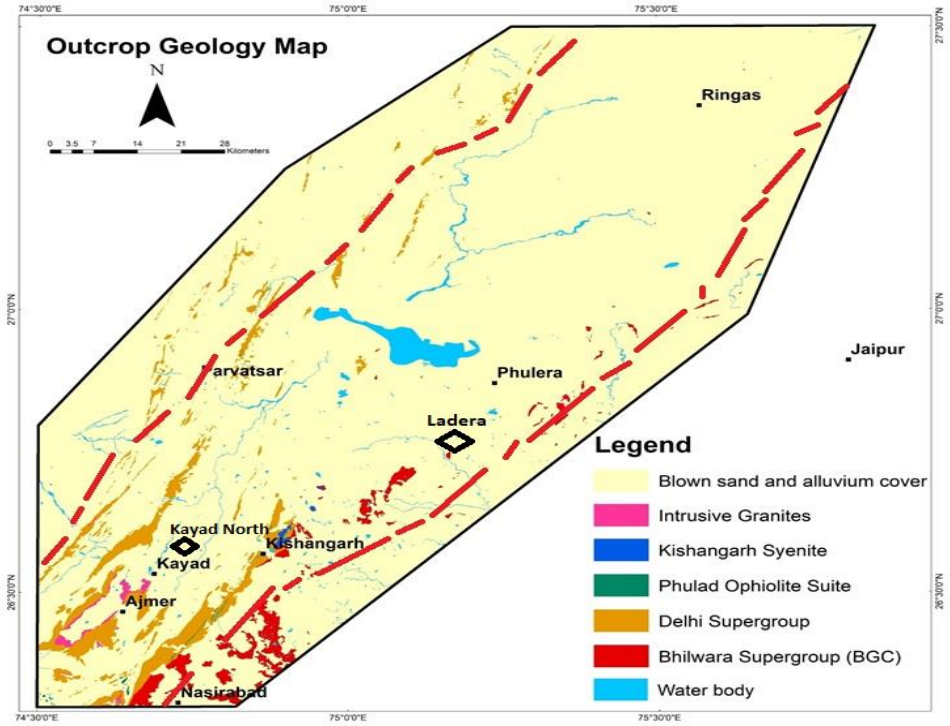


IP (Resistivity) map

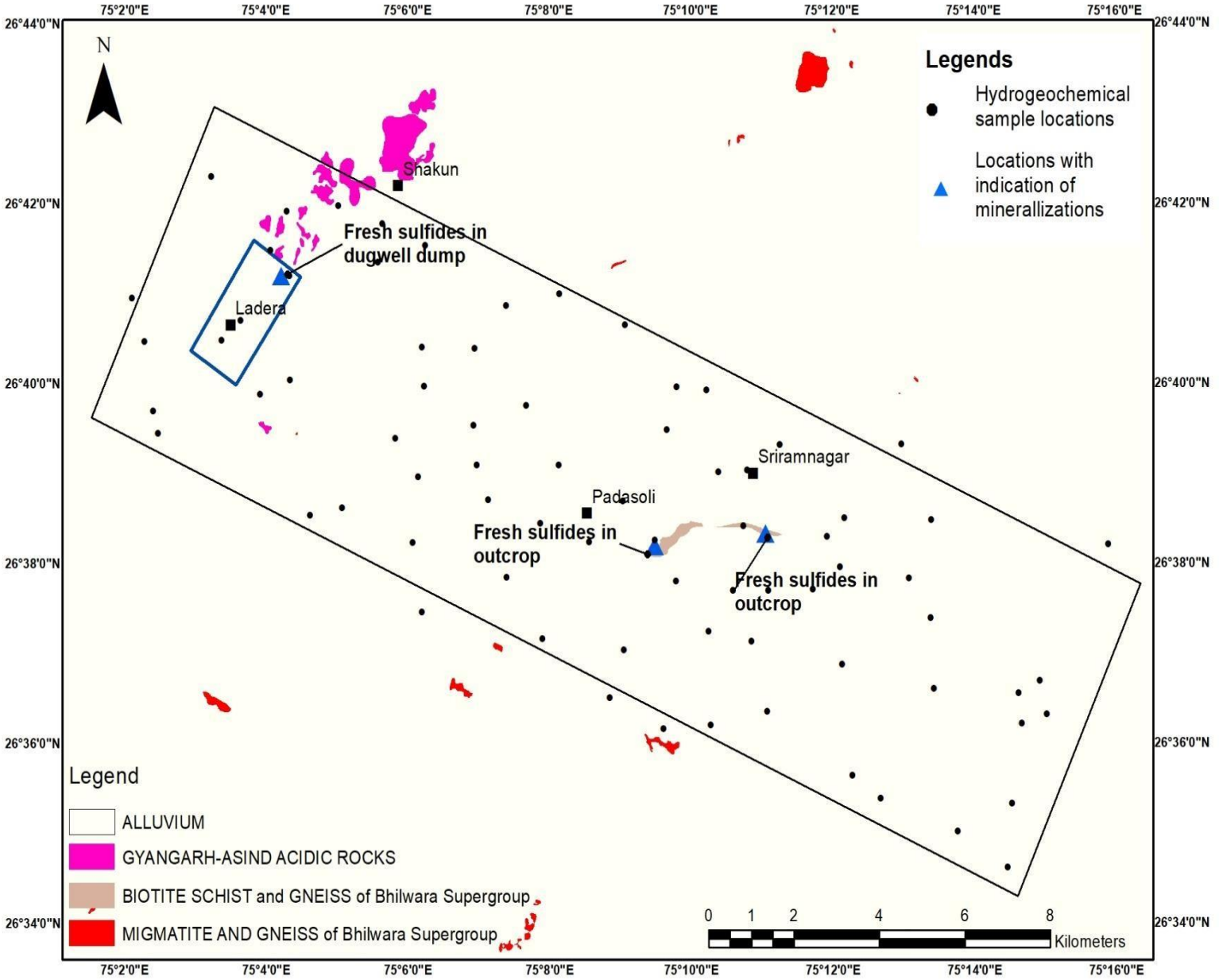


- ✓ **Shallow magnetic body identified from Aero-MAG data is corroborated with ground magnetic data**
- ✓ **This chargeability zone is also associated with negative SP and low resistivity values.**
- ✓ **This zone [~700m × 250m] trending 125º-305º has been targeted by three boreholes.**

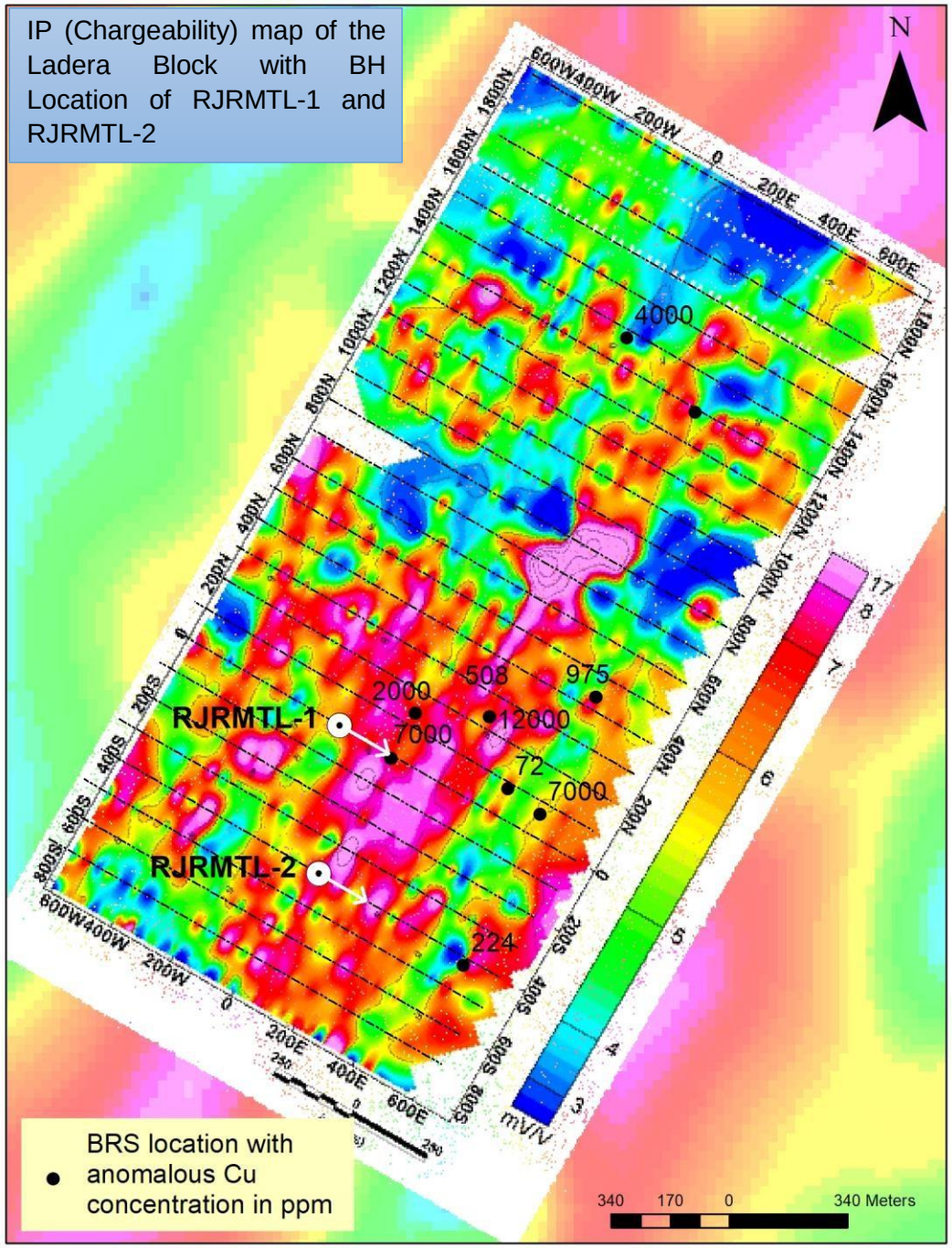
Case Study : Ladera Block

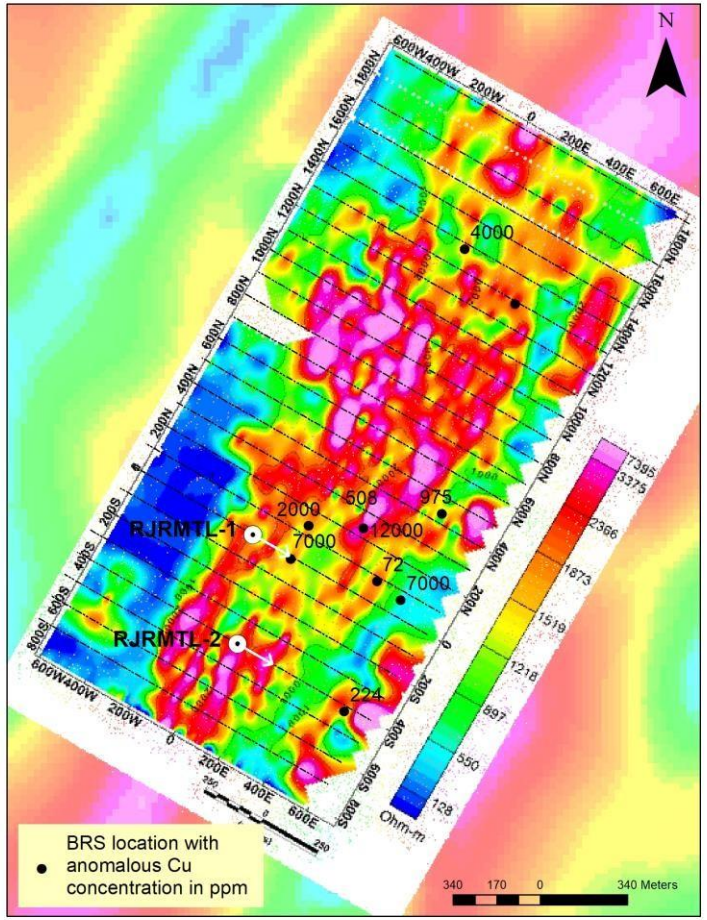


- ✓ **Ladera is situated to NE of Kayad and falls within BGC [Gneiss, migmatites, schsits]**
- ✓ **Fresh sulphide chunks were found in the dug well dumps which sits on the shallow magnetic anomaly zone.**
- ✓ **Intense albitization and shearing observed in the outcrops.**

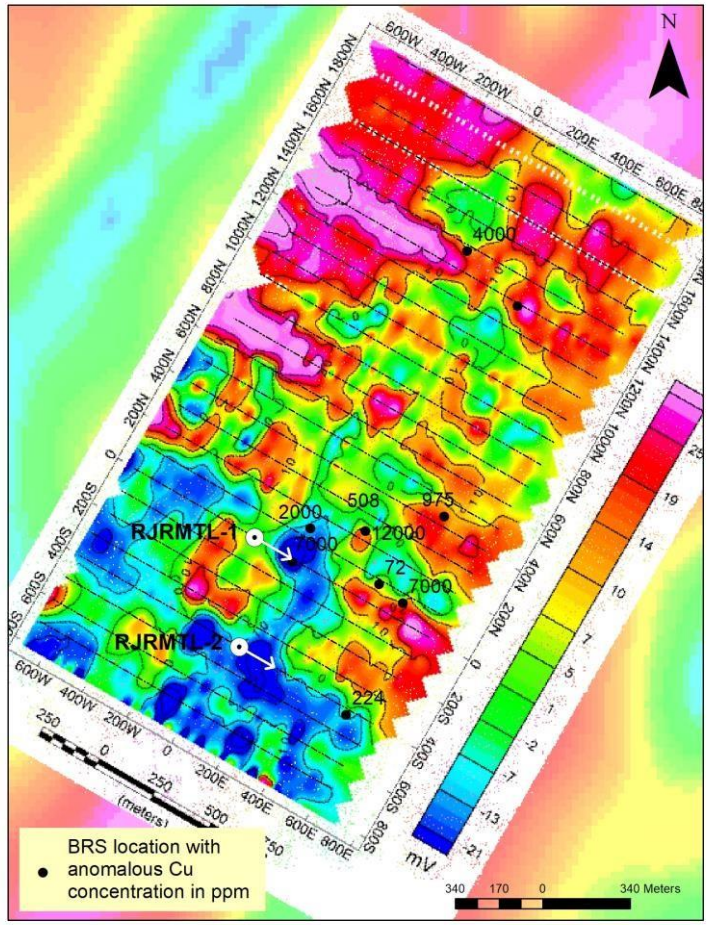


Detail Geophysical Survey: Ladera Block



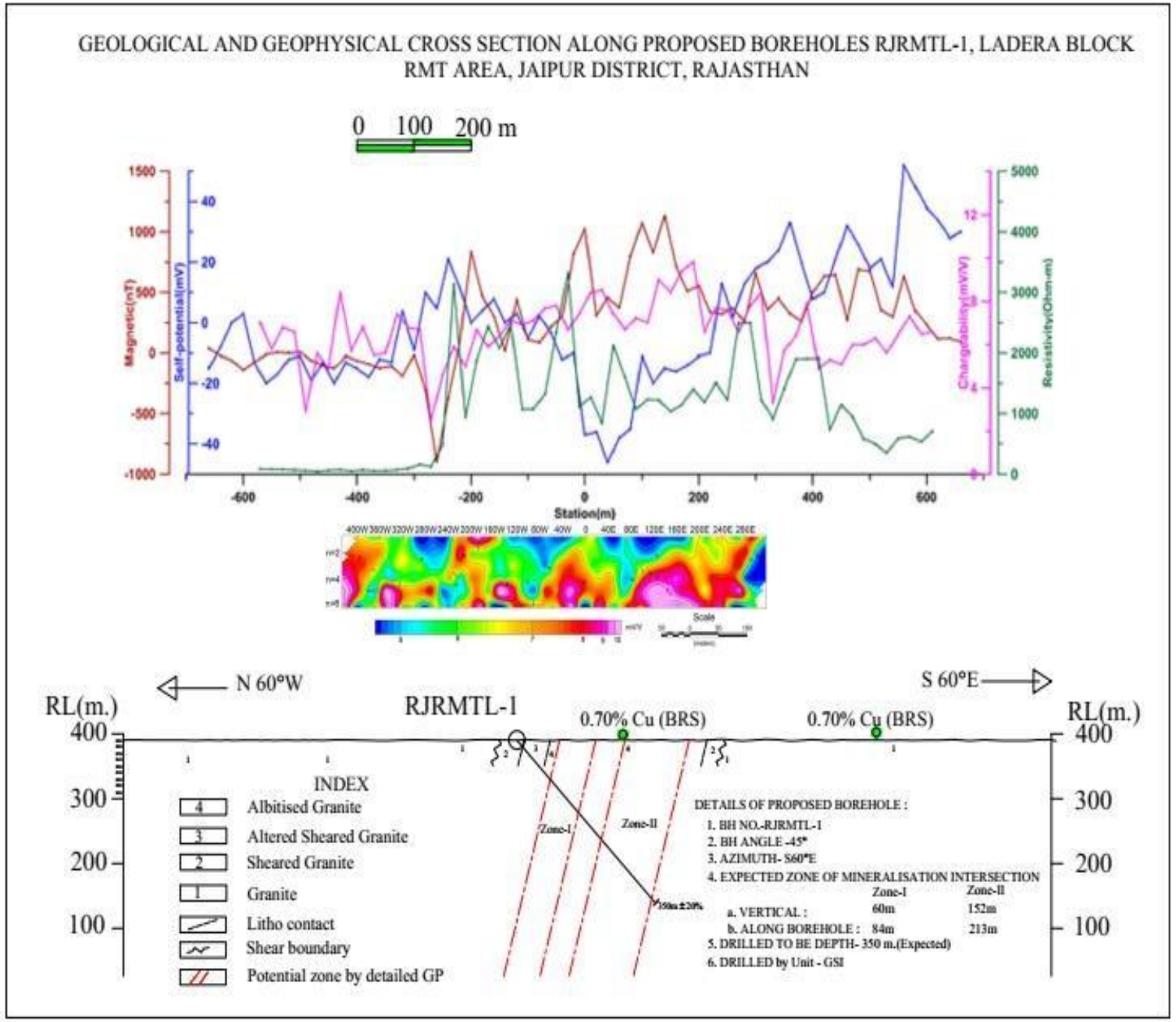


IP (Resistivity) map of the Ladera Block



SP map of the Ladera Block

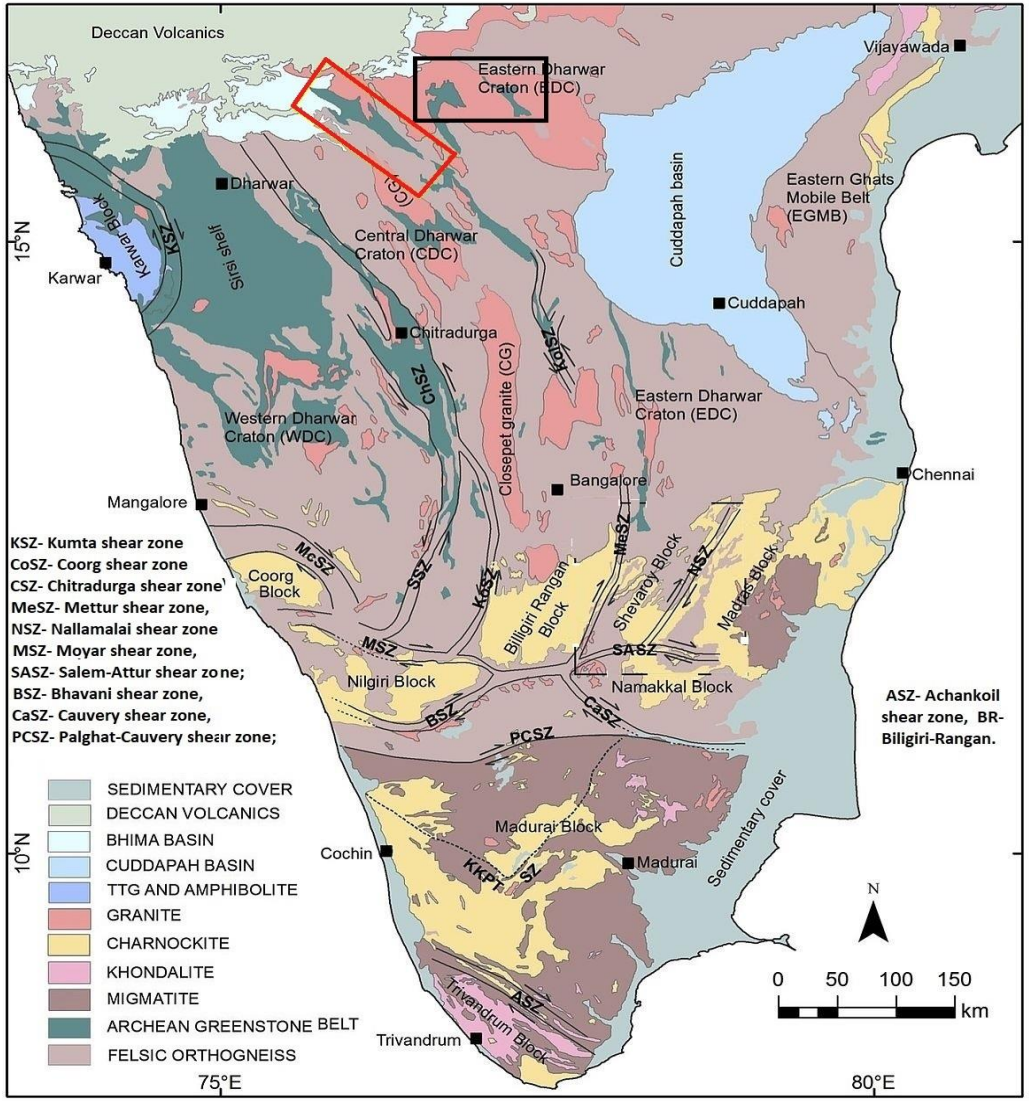
The results indicate presence of a high chargeability zone coinciding with the high magnetic zone following the local trend of the shear zone and general structures in the south-central part of the block. This chargeability zone is also associated with negative SP and low-moderate resistivity values.



TEST DRILLING

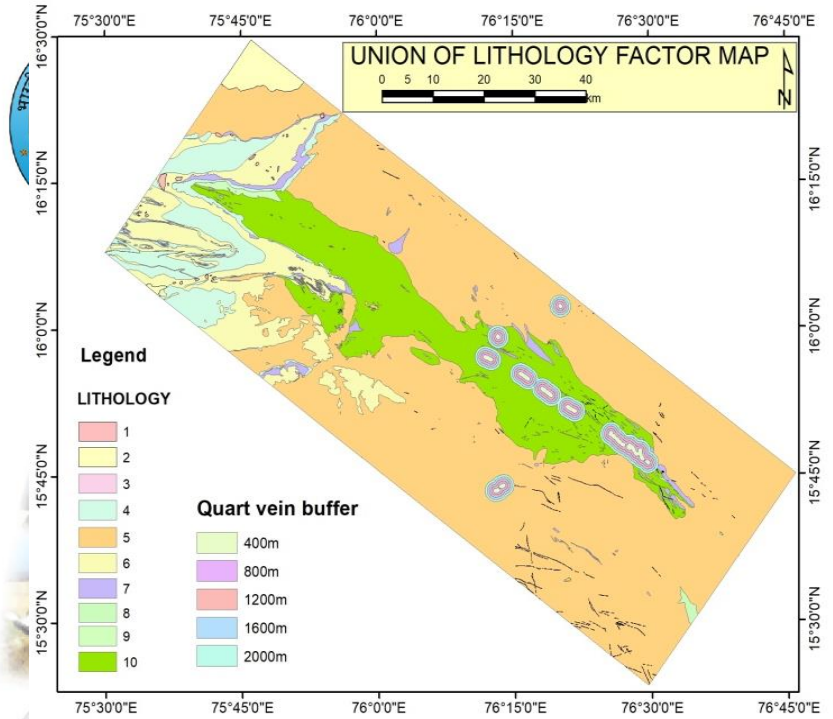
- 144 m of cumulative sulphide bearing zones observed along BH
- Granite and altered granite are the host rock
- Visible sulphides: Chalcopyrite, Pyrrhotite, Pyrite, Molybdenite
- Vein, chunks, specks, dissemination

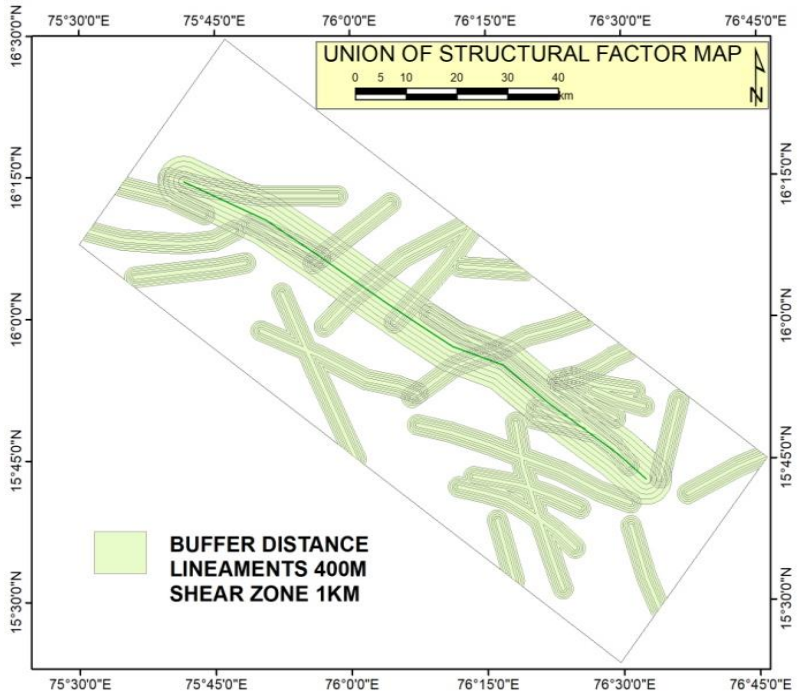
RMT Case Study- Hutti-Maski and Hungund-Kushtagi Schist Belts

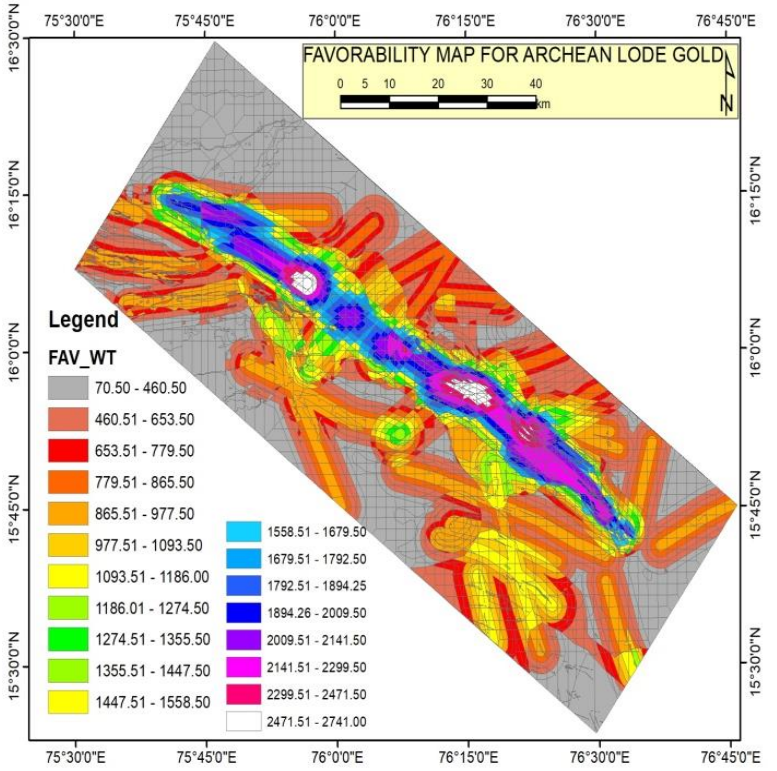


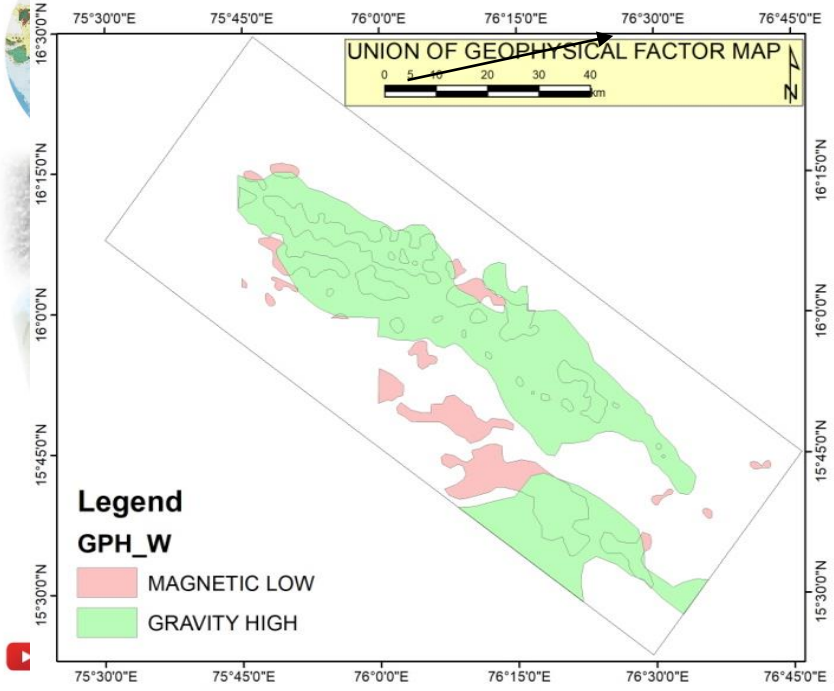
- Mineral System based integrated studies to target concealed Mineral Deposits
- Integration of Lithology, Structure, Geophysical and ASTER data, old workings, Geochem anomalies
- Outcome
  - **3** major Mineral Systems Identified: Lode Gold, Granite-Hosted Cu-Mo and Ni-PGE
  - **5** Blocks at Hutti-Maski and **7** blocks at Hungund-Kushtagi identified
  - G3 Block for Copper in western extension of abandoned Copper Mine at Tintani

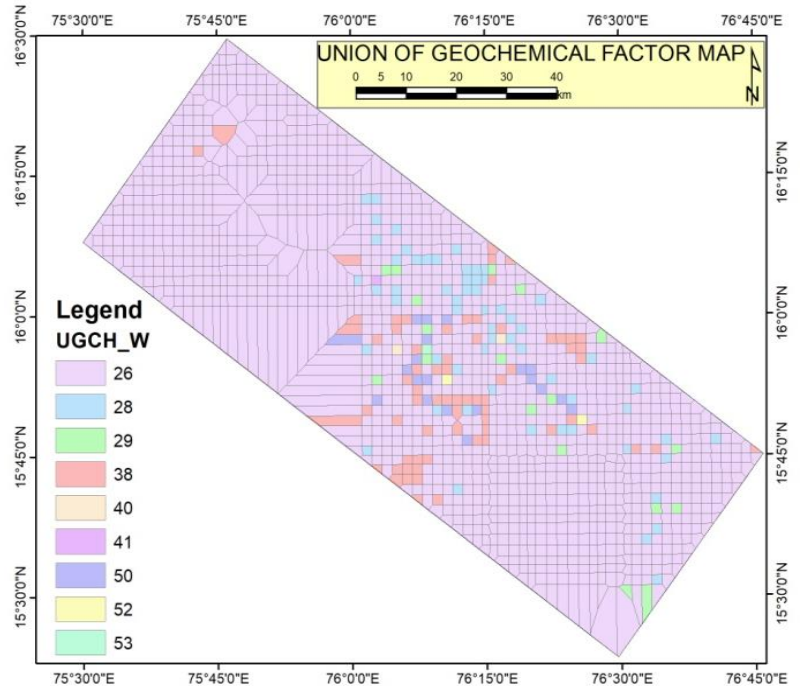
Hungund-Kushtagi
Mineral Prospectivity Map (Gold)





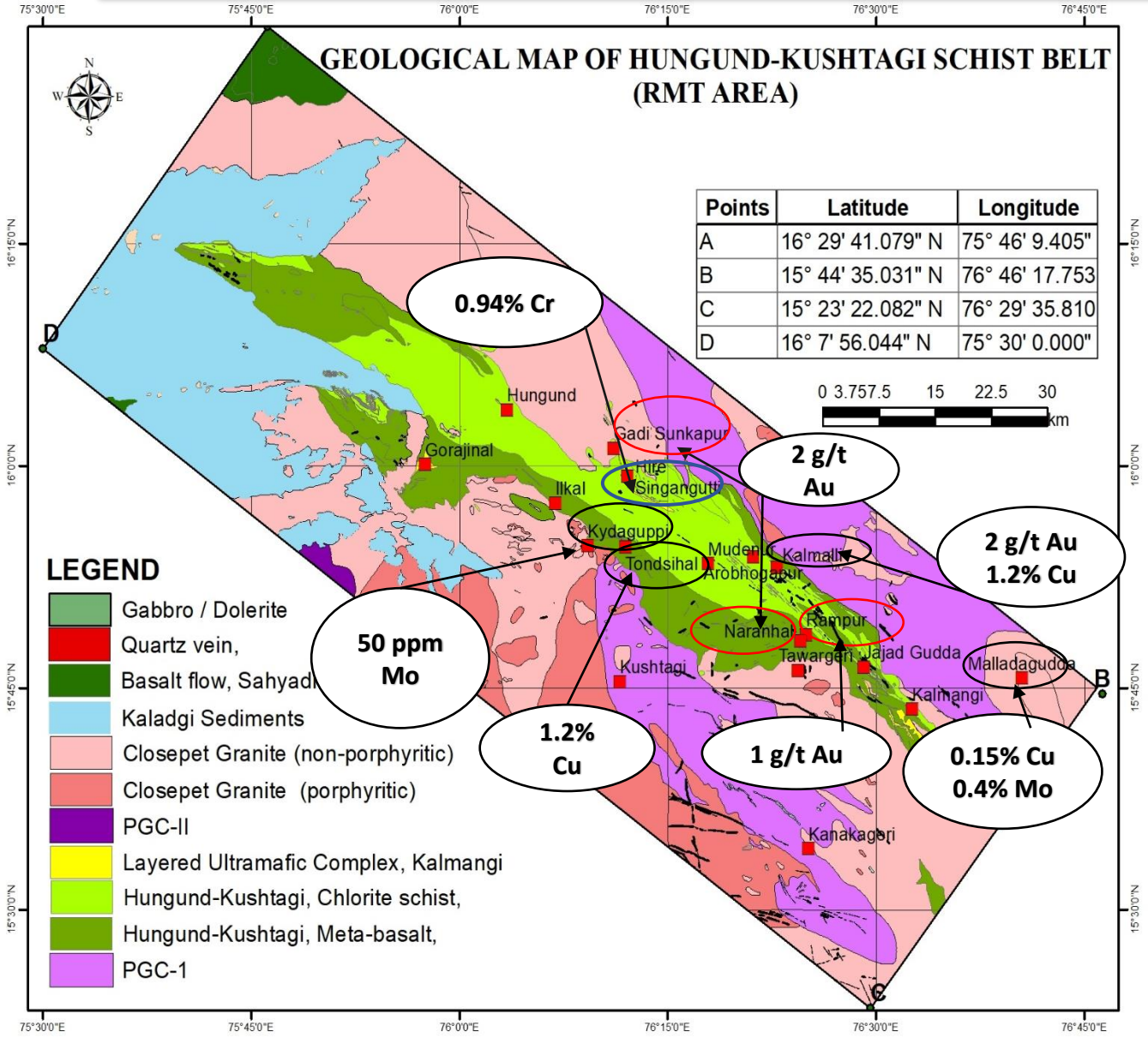






Factor	Weightage
Geology	8
Structure	9
Geophysical	4
Geochemical	6

RMT Case Study- Hungund-Kushtagi Schist Belts



Archean Lode ***Gold***	Shear Zones within greenstone sequence	***4 Areas***: 1. Rampur (1g/t Au), 2. Naranhal (2g/t Au), 3. Gadisunkapur T (2 g/t Au), 4. Kalmalli (Au 2g/t & 1.2 % Cu)
porphyry-type (***Cu-Mo***)	Granites / Granite-meta-volcanic contact	***3 Areas:*** 1. Malladagudda (0.4% Mo), 2. Tondsihal (1.2% of Cu), 3. Kyadiguppa (50ppm Mo)
Mafic-Ultramafic associated ***Ni-PGE***	Gorajinal mafic ultramafc complex	Dunite body with anomalous 0.94% Cr

Conclusion





Modern mineral exploration is driven largely by S&T:

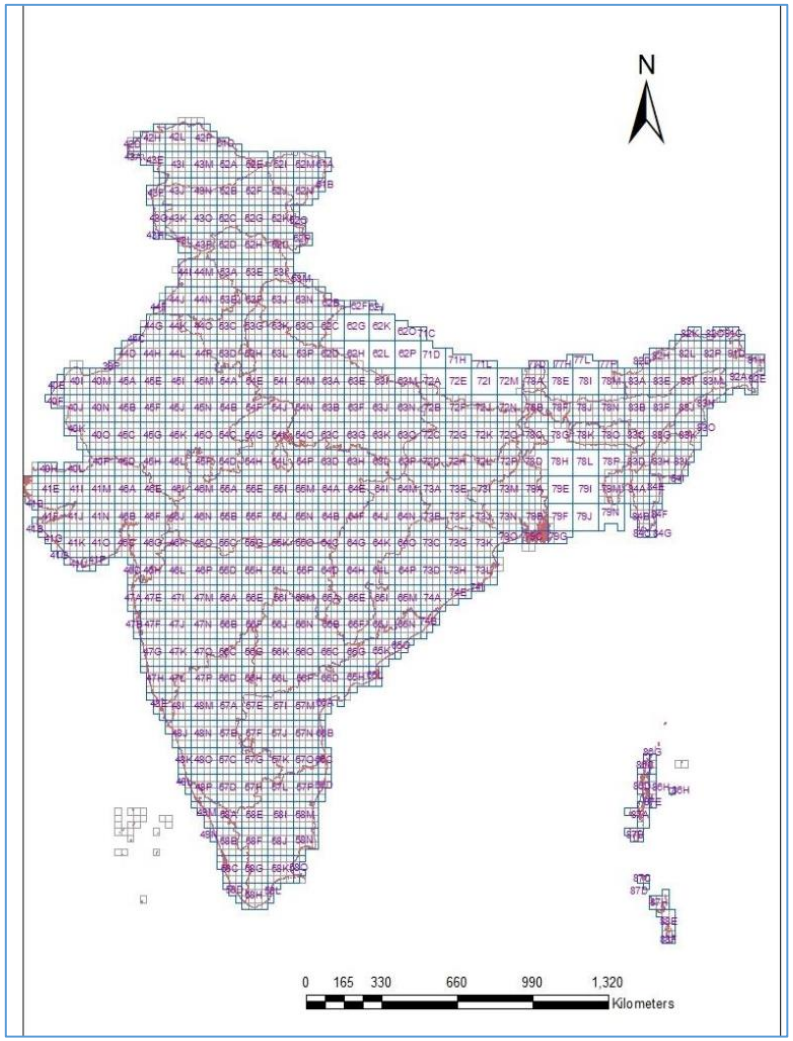
- Research in basic geological sciences, geophysical and geochemical methods, and drilling technologies could improve the effectiveness and productivity of mineral exploration

- Geological database would be beneficial along with a holistic Mineral System based exploration particularly in Greenfield areas

- We must gear up to look for concealed and deep seated mineralization by utilizing deep geophysical data sets along with geochemistry, geochronology & geology.

Thanks..

Magneto-Telluric Data Acquisition for the Country



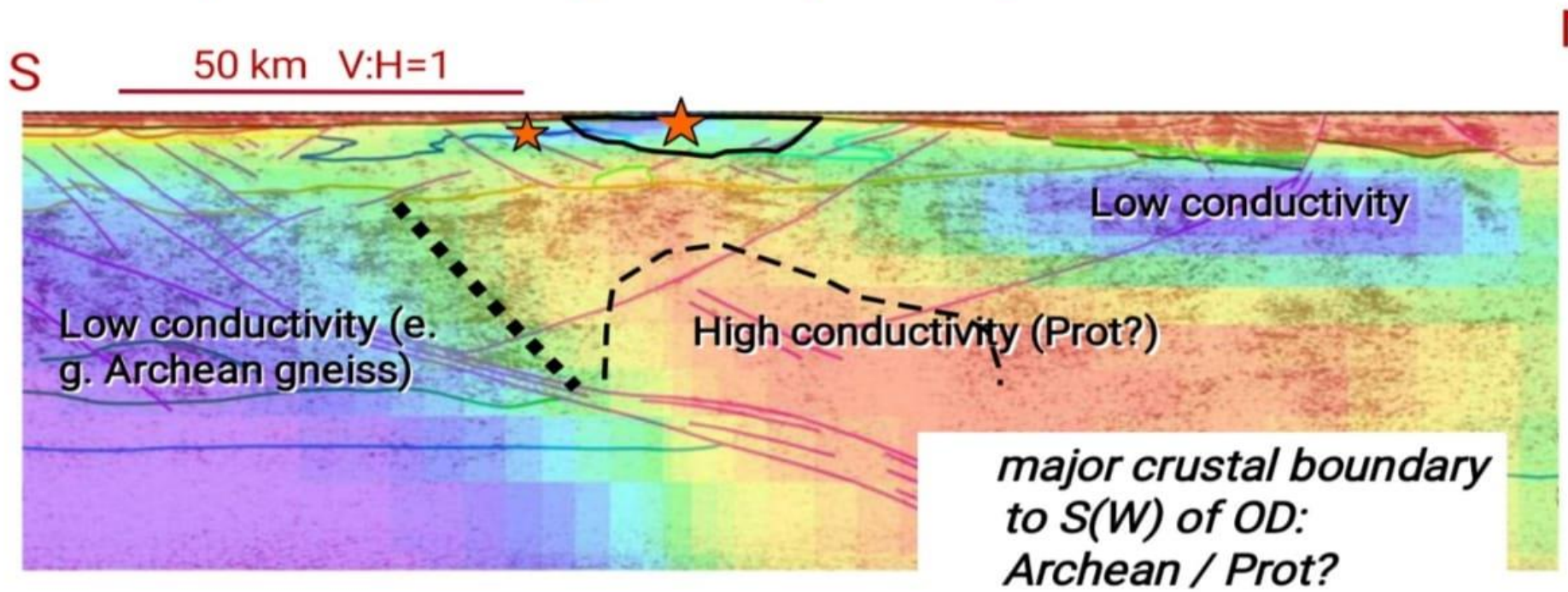
IndMAP: Proposed to collect in 27km grid (one from each TS)





- Complete coverage of India through MT survey in grid to image the electrical resistivity structure of the lithosphere
- Identify and characterize resistivity of the major structures (ex. Domain boundaries, faults, shear zones, sedimentary basins, fluids, thermal structure) in the crust and upper mantle
- These data sets are immensely useful in targeting concealed and deep-seated mineral deposits for various commodities like, Basemetals, Gold, Tin-Tungsten, Chromite, Nickel, REE, Diamond etc.

Olympic Dam region crustal architecture: major conductivity anomaly in magnetotelluric data

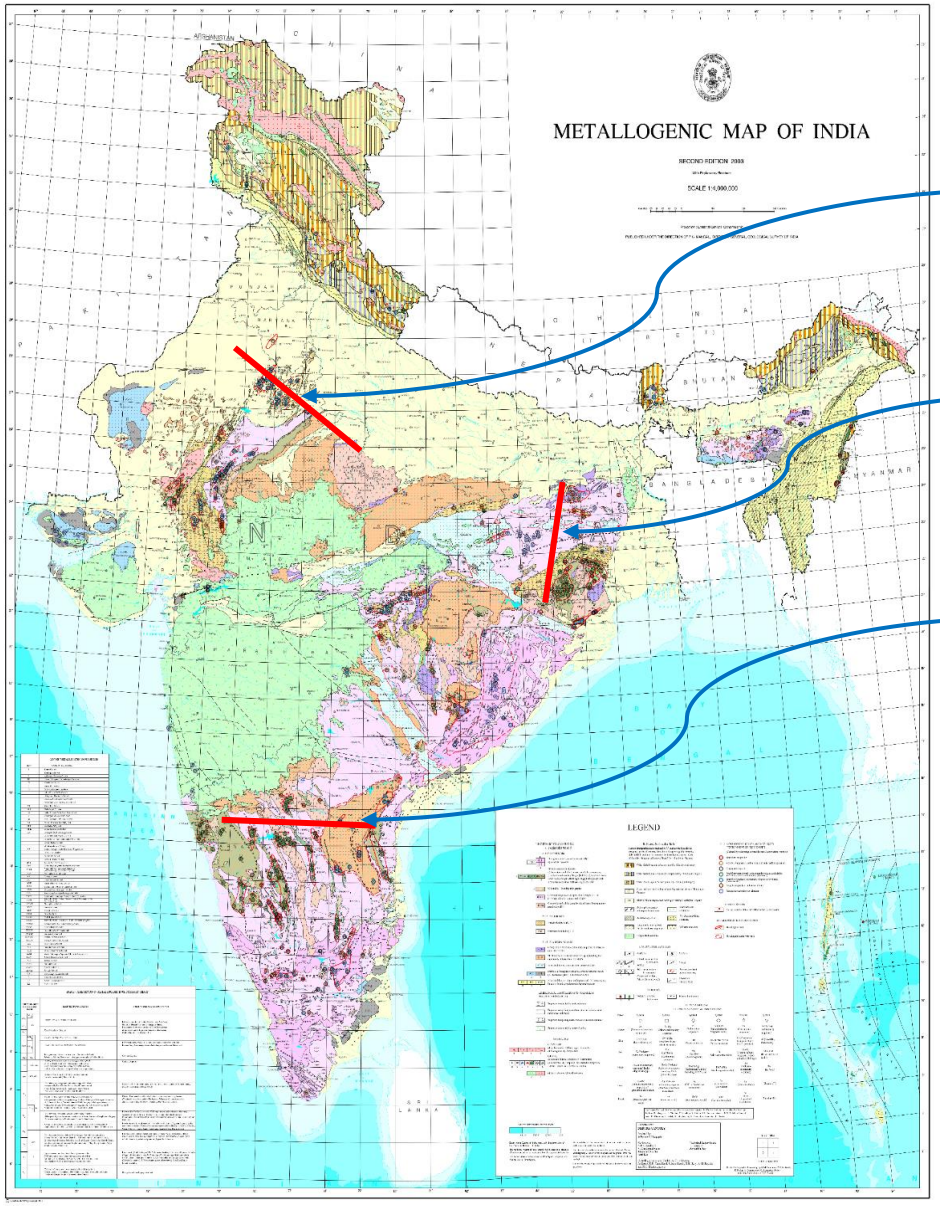


Coloured MT image courtesy R. Gill, G. Heinson, N. Direen at The University of Adelaide, and published in Thiel et al., (2004), Heinson et al. (2006).
MT image overlays GA-PIRSA seismic data with early interpretive linework by GA-PIRSA-UofA.





Deep Seismic Reflection Survey



Northern Transect: NDFB-Vindhyan-Bundelkhand Craton-620 km

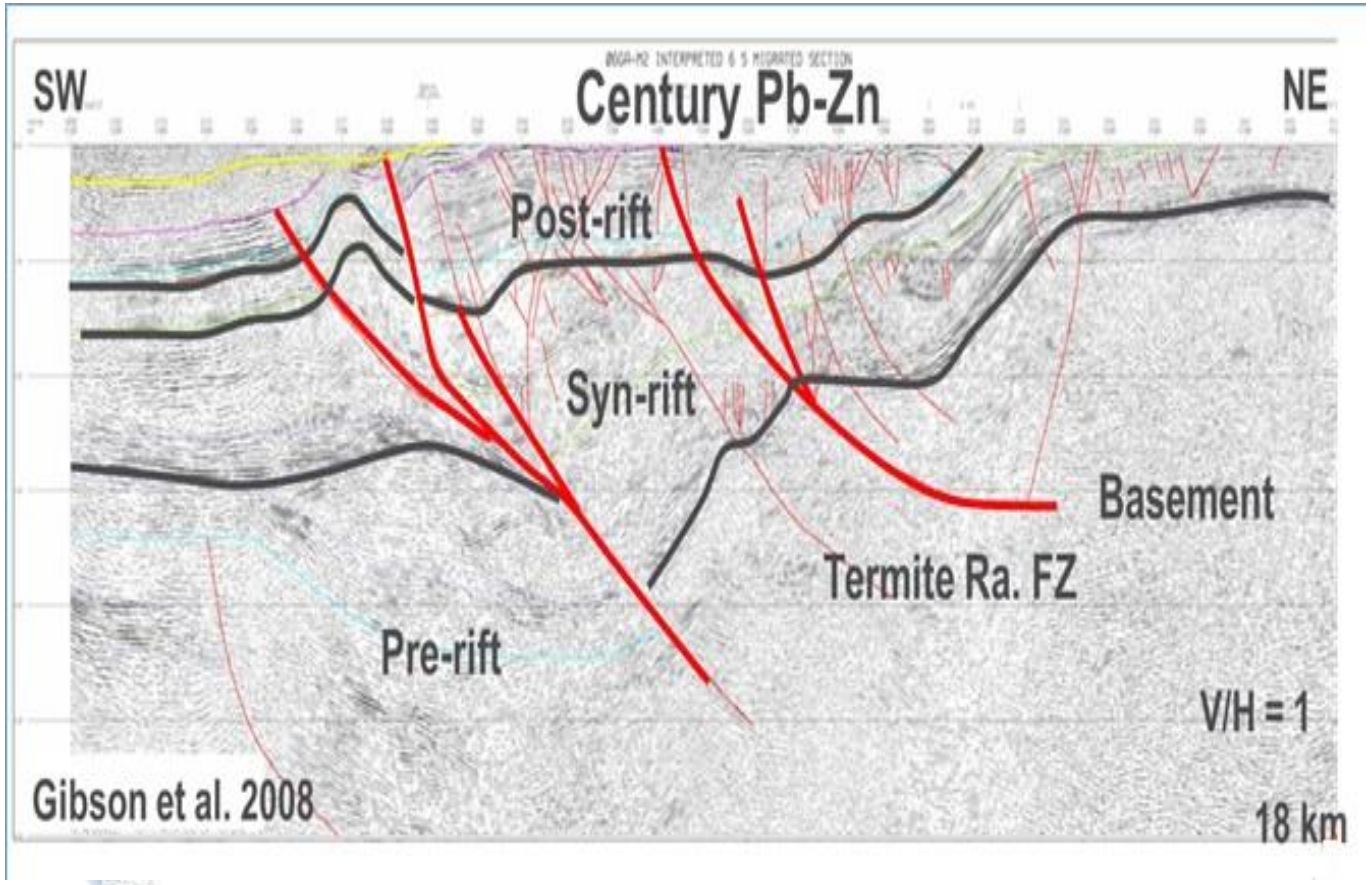
Eastern Transect: Singhbhum Craton-400 km

Southern Transect: Dharwar Craton-560 km

Deep Seismic Reflection Surveys when combined with Magneto-telluric surveys become powerful tool in Mineral exploration

- Three Transects for Crustal Studies by Acquisition of Deep Crustal seismic reflection Data and Applying Mineral System Concepts through Integration Geoscience
- Map the seismic reflection boundaries from shallow depth (few hundred meters) to Moho discontinuity and slightly below.
- Lithospheric architecture for mineral systems exploration.
- To map concealed and deep seated mineral deposits below cover for Regional drilling

DSRS for Targeting Concealed and Deep Seated Structures and Mineralization



Mount Isa is Australia's deepest mine which reaches 1900 m

Globally, the discovery of deposits having surface manifestations is rare

It has become a compulsion to look for concealed and deep seated mineralization by utilizing deep geophysical data sets along with Mineral System approach

Seismic-reflection imaging played a major role in mapping mineral trap as per Mineral System model