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Ministry of Petroleum & Natural Gas  
Government of India



**DIRECTORATE GENERAL OF HYDROCARBONS**  
(Ministry of Petroleum & Natural Gas, Government of India)

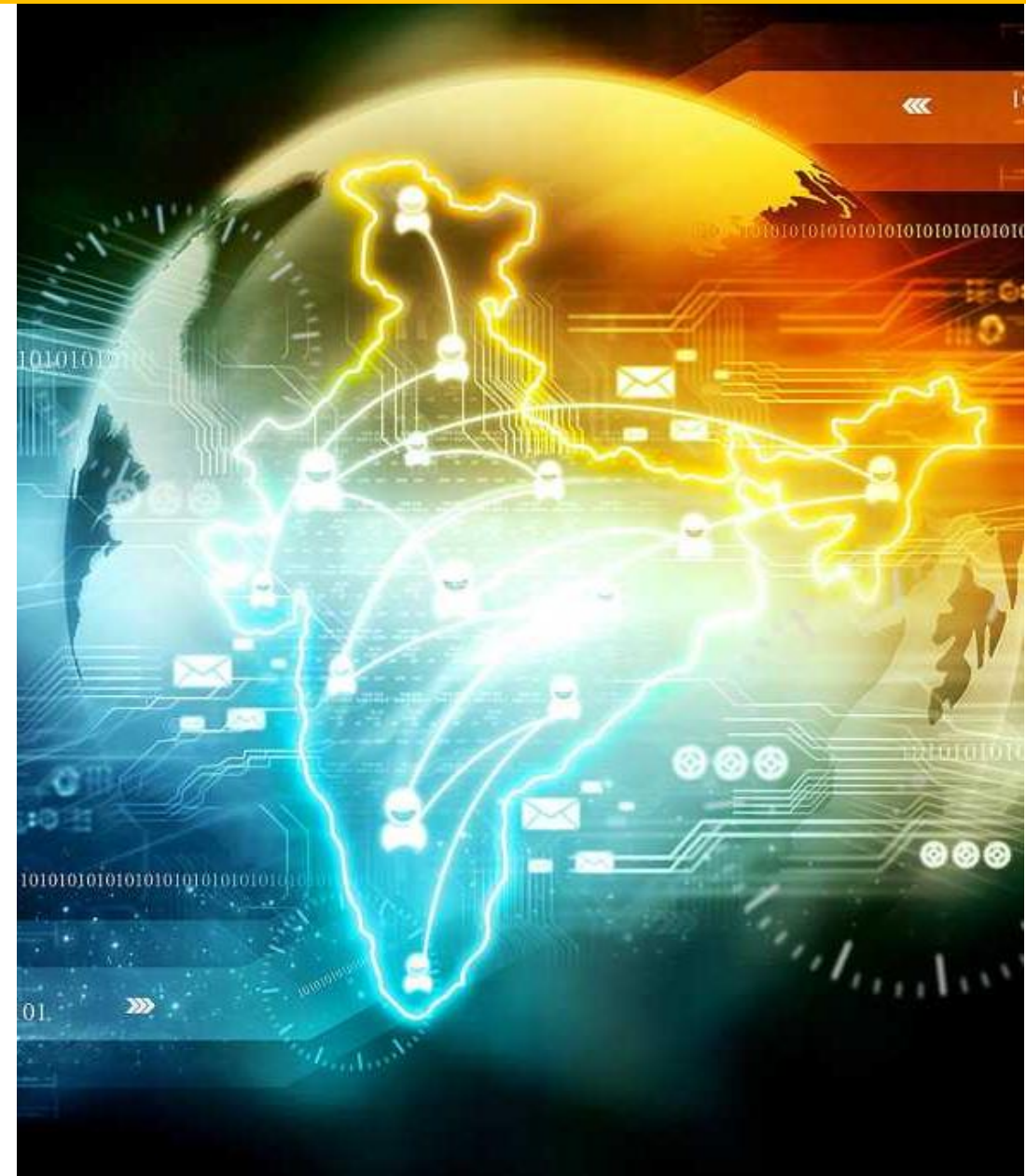
# Application of Geospatial technology in Hydrocarbon Exploration

**Dr. Kaustav Nag**  
**Additional Director General (Exploration), DGH India**

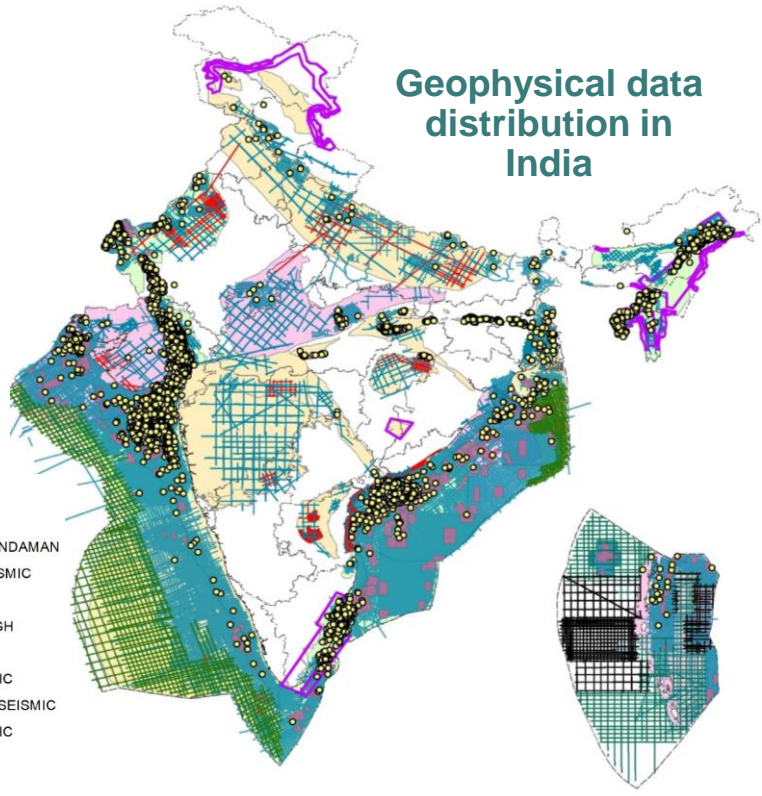
16.05.2024



- **Geospatial Technology**
- **Indian Geospatial Market**
- **Geospatial Technology Spectrum**
- **Applications of Geospatial Technology**
- **Geospatial Technology: Oil and Gas Exploration**
- **Case Studies**
- **Benefits of Geospatial Technology**



Geospatial Technology

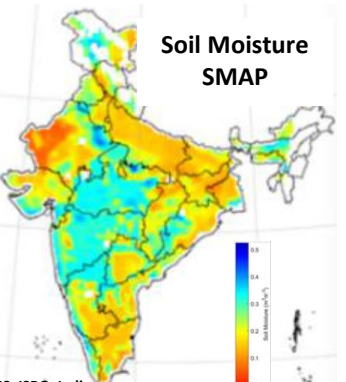
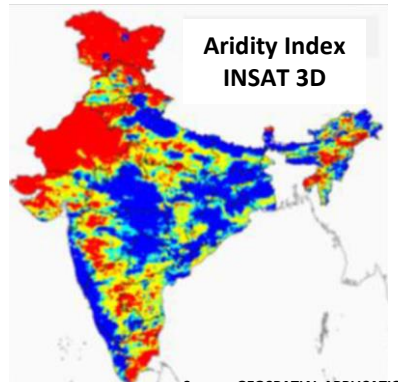
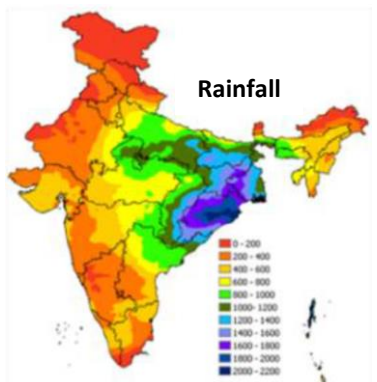


suite of advanced tools designed to collect, store, analyze, and present geographic and spatial data



enables the mapping of the Earth's features, analysis of spatial relationships, and visualization of data to enhance our decision-making

*Geospatial Data : time-based data related to a specific location*



Source: GEOSPATIAL APPLICATIONS, ISRO, India

*one of the biggest moments in geospatial history (2005)*

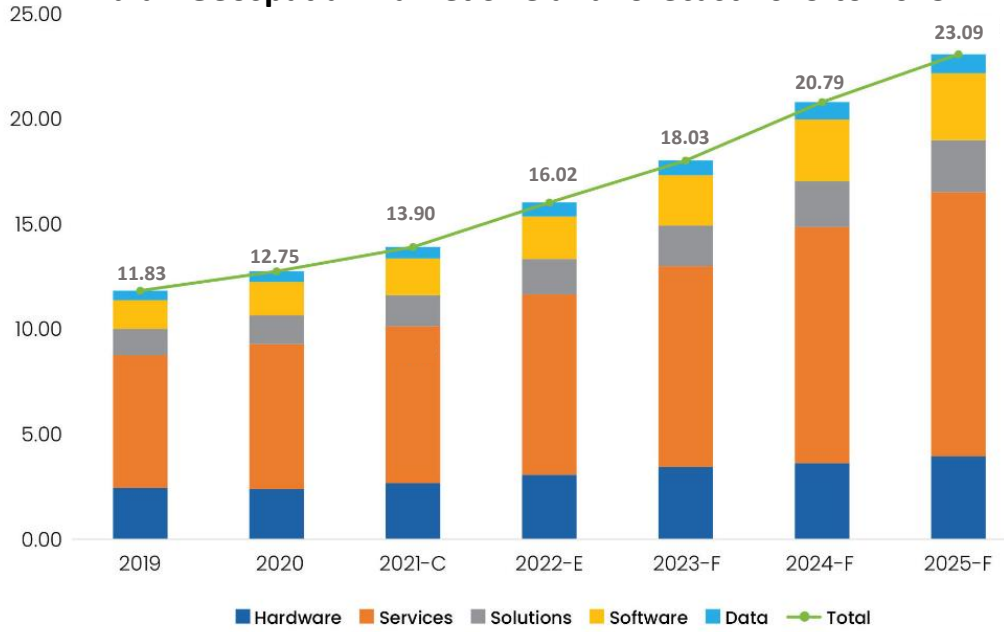




# Indian Geospatial Market



### Indian Geospatial Market Size and forecast 2019 to 2025

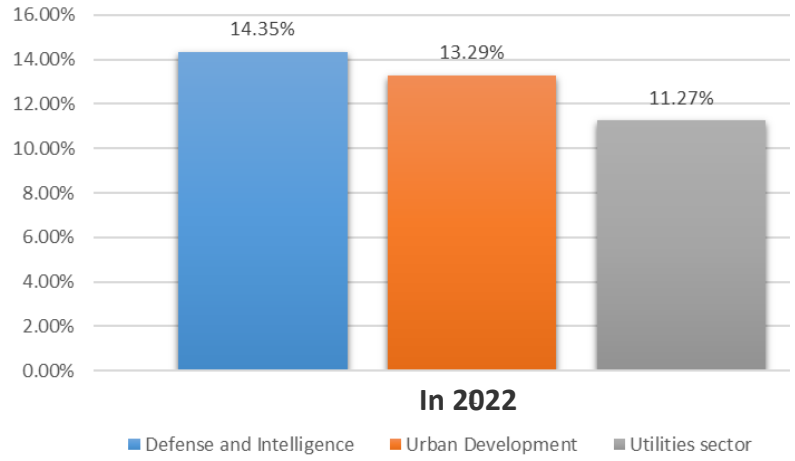


**India's Geospatial market**

- to grow at ~13.5% CAGR between 2021 and 2025
- forecasted to rise from ₹13.90 thousand crores in 2021 to app. ₹23.09 thousand crores in 2025
- dominated by Defense and Intelligence, Urban Development, and Utilities sector in 2022
- GoI issued 'Geospatial Data Guidelines 2021' and the "National Geospatial Policy 2022" to accelerate the use of Geospatial data and technologies
- national missions like SVAMITVA, PM Gati Shakti, Smart Cities Mission, and Namami Gange

C-Corrected  
E-Estimated  
F-Forecasted

Source: GW Consulting Analysis **\*Geospatial World**



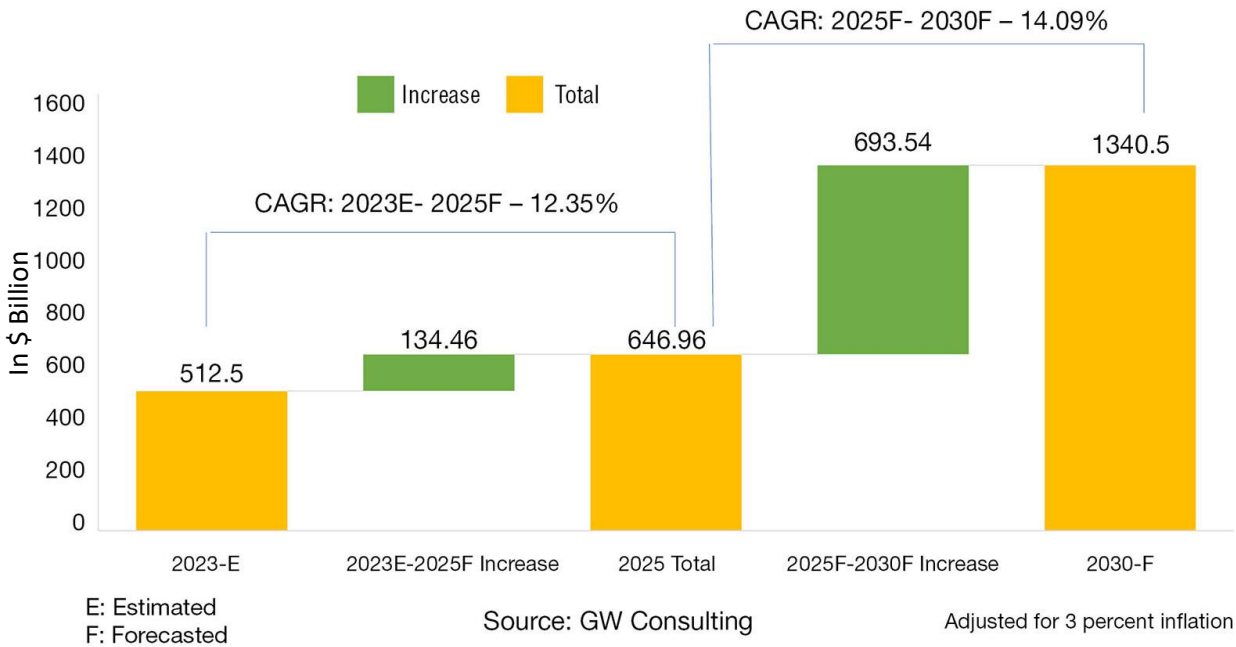
\*SVAMITVA: Survey of Villages Abadi and Mapping with Improved Technology in Village Areas



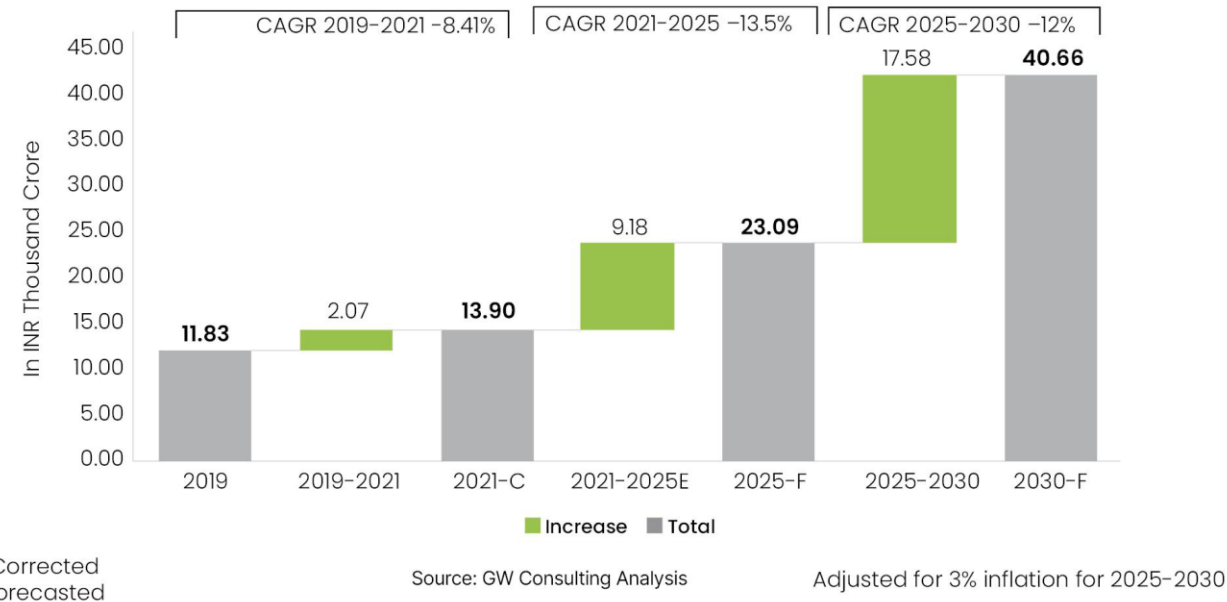
# Global vs. Indian Geospatial Market Size and Forecast 2023-2030



## Global Geospatial Market Size and Forecast for 2023-2030



## Indian Geospatial Market Size and Forecast for 2019-2030

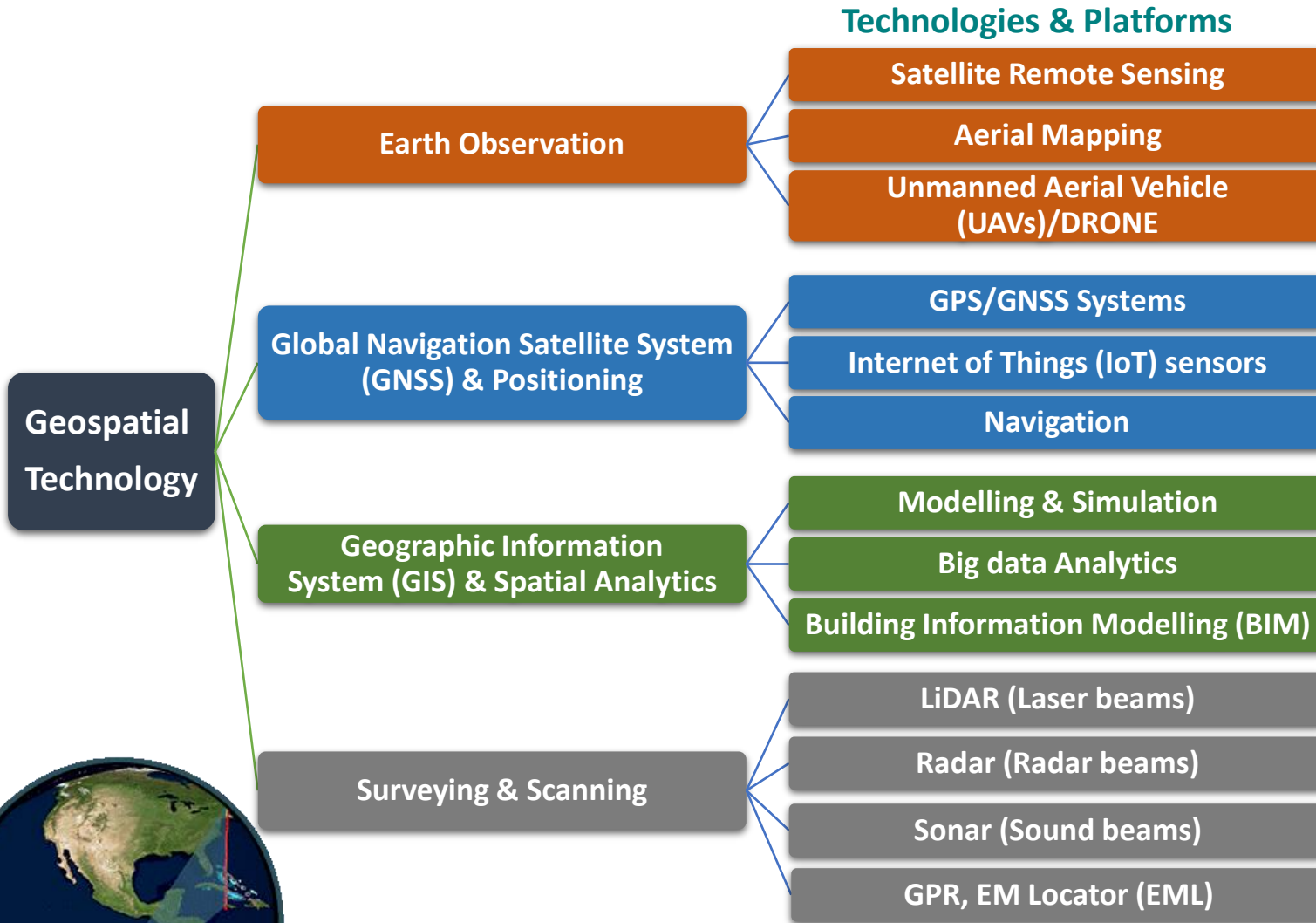


- The Global geospatial market forecast for 2030 is \$1.34 Trillion

- CAGR: 2025-2030: 14.09 %

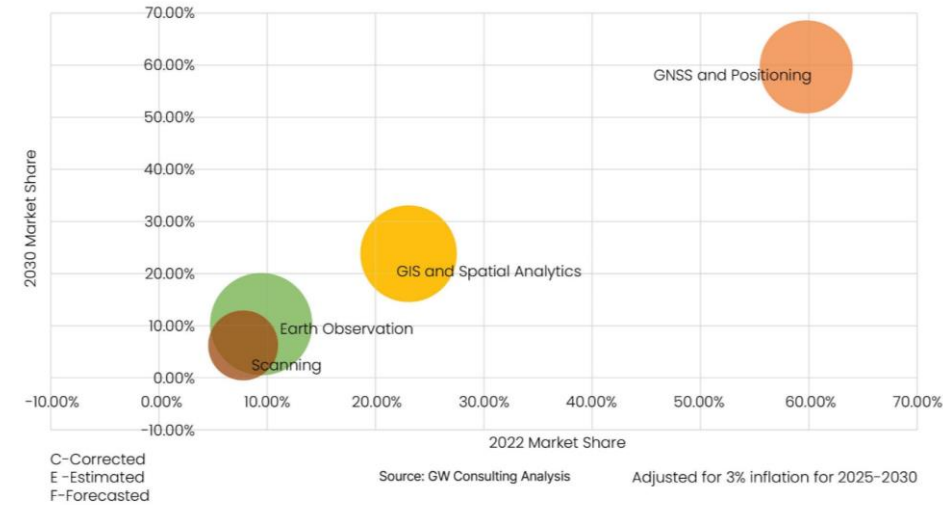
- The Indian geospatial market forecast for 2030 is ~\$5.0 Billion

- CAGR: 2025-2030: 12.00 %



*IoT Sensors examples: Accelerometers, Air quality sensors, Chemical sensors, Gyroscopes, Motion sensors, Proximity sensors, Temperature sensors*

**Indian Geospatial Industry Technology-wise Market Share 2022 & 2030F**



**Market Share in 2022**

GNSS and Positioning ~59%

GIS and Spatial Analytics ~23%



Logistics



Transportation



Meteorology



Forestry



Agriculture



Healthcare



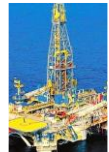
Ecology



Marketing



Real Estate



Minerals, Oil &  
Gas Exploration

## Future of Geospatial Technology



Geospatial AI



Autonomous  
Vehicles



Drones



Carbon Source  
Capture

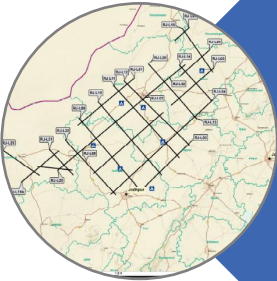


Nanosatellite  
monitoring




Gas Leakage  
Detection




### Exploration

- Lineaments/Structures
- Surface geology
- Faults
- Oilfield infrastructure, roads
- Surveying using GPS
- 2D/3D Seismic data acquisition
- Utilities: forests, River
- Other G&G data planning



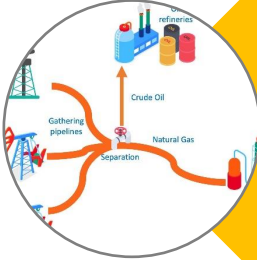
### Production

- Ongoing field analysis
- Lease management
- Pipeline inspection
- Encroachment management
- Track of platforms, Rigs & pipelines
- Monitoring & repair




### Transportation

- Routing
- Least cost paths
- Scheduling
- Directions
- Tracking & Planning
- Location of vehicles
- Geofencing and restricted areas
- Safety and accident planning



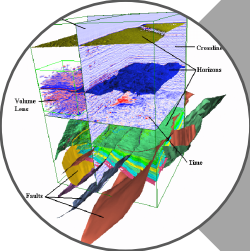
### Pipeline distribution & modelling

- Pipeline inspection & routing
- Load forecasting
- Pipeline monitoring
- leak detection
- Facility modelling



### Environmental

- Environmental monitoring and reporting
- Identify reserved and Protected areas
- Risk prediction and management
- Oil Spill monitoring



### Data Management

- Assets management
- Previous work information
- Acreage wise data
- Data Integration across the industry



## Exploration

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## Production

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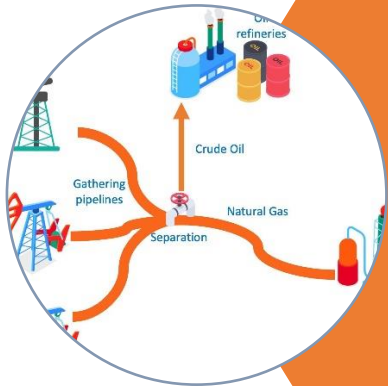
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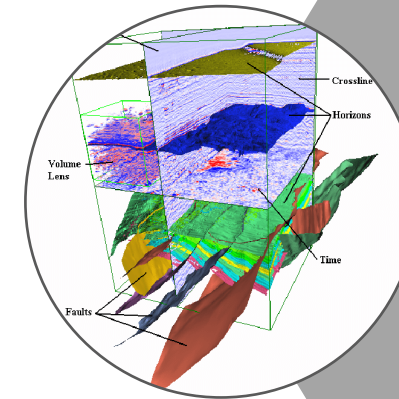
## Environmental

- Environmental monitoring and reporting
- Identify reserved and Protected areas
  - Risk prediction and management
- **Oil Spill monitoring**



## Data management

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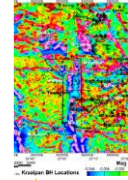




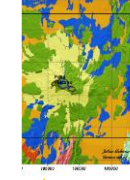
Identification of Oil and Gas micro-seepage



Oil Spill detection and monitoring



Geological Mapping



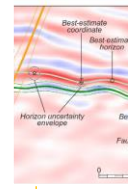
Lithology mapping



Geomorphology mapping



Evaluating Geological Structure



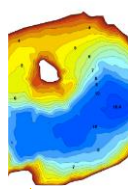
Assist seismic data Interpretation



Vegetation Analysis



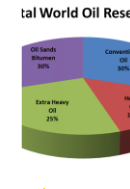
Soil Analysis



Satellite-derived bathymetry



Thermal Anomaly Detection



Reserve Estimation



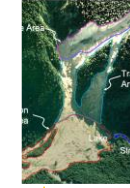
Pipeline Monitoring and Maintenance



Offshore Platform Siting



Safety and Security



Seismic & Geological Hazard Assessment



Climate & Environmental Impact Assessment



Greenhouse gas monitoring



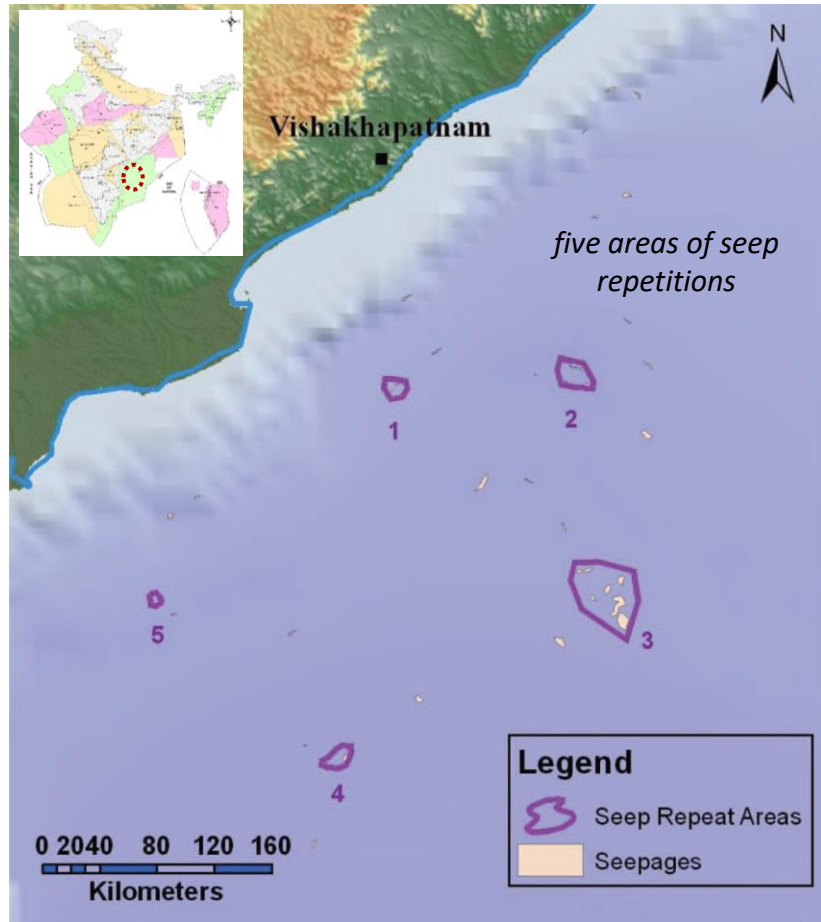
Gas Flaring Monitoring



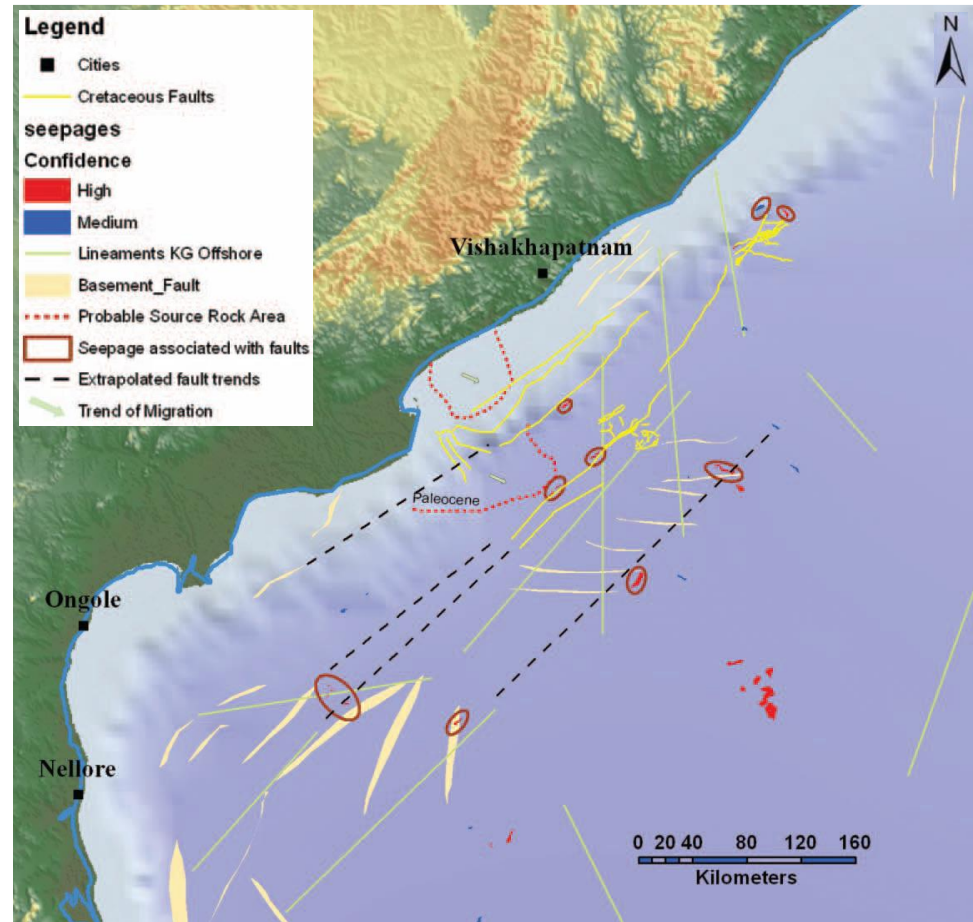
Asset Management

Oil Seep: Oil on the sea surface dampens the wave signature in the microwave ranges and is detected as a dark area on a bright surface in the SAR image

Seepage repetition: The repetitiveness of the identified seepages are more likely to be of natural origin than others



Areas of seepage repetition



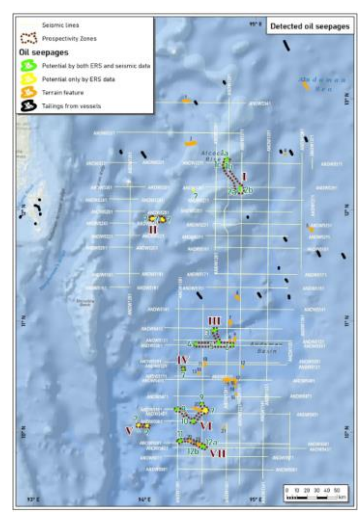
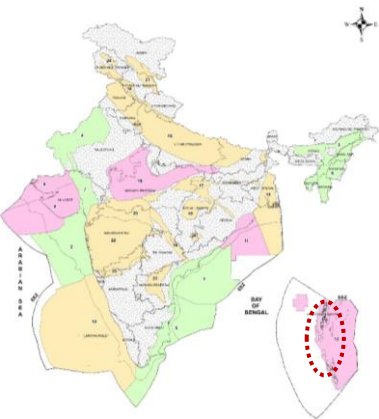
Overlay of detected seepages on probable source rock area, faults from available seismic data, basement faults and lineaments

Oil seeps were detected & monitored using ERS/ENVISAT/SAR/ASAR data and seismic studies in Krishna–Godavari offshore basin, India

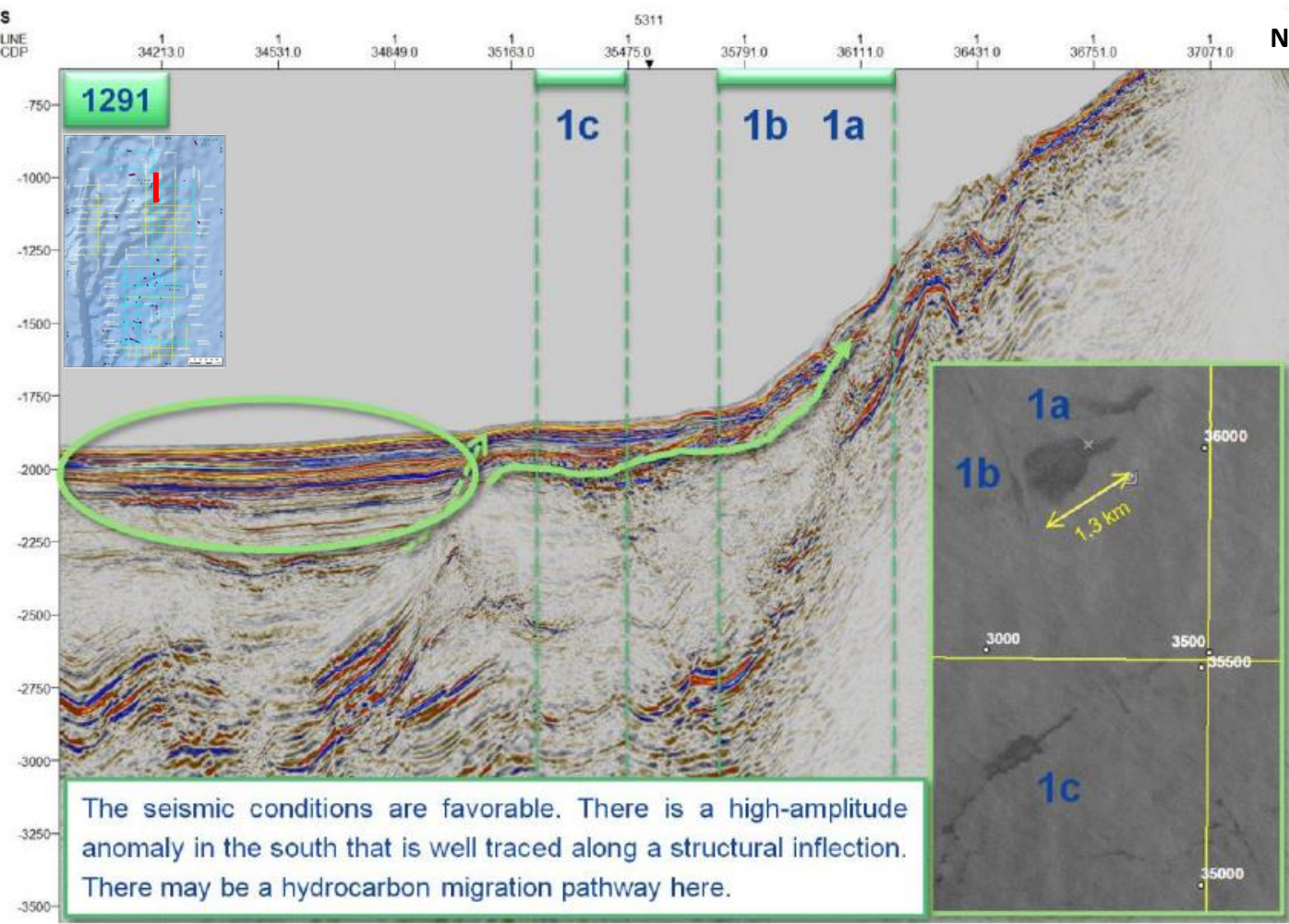
Studies have shown the presence of excellent source rock within the Cretaceous sequence and fair to good source rock within the Paleocene sequence in the area

Interpreted seismic data & free-air gravity suggest the presence of faults that connect the oldest Cretaceous sections to the seabed

Characterization of the dark features on ERS data and its representation in seismic section with highlighted migration pathways and potential hydrocarbon reservoir



Detected oil seepages distribution



The seismic conditions are favorable. There is a high-amplitude anomaly in the south that is well traced along a structural inflection. There may be a hydrocarbon migration pathway here.

Dark Features on ERS data at objects 1a, 1b, 1c

High-amplitude anomaly in the south that is well traced along a structural inflection in Seismic data

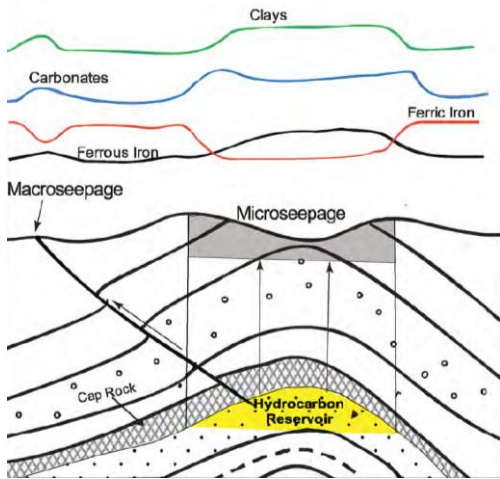
There may be a hydrocarbon migration pathway here, which on two cross-section lines

Fault pattern, tectonic maps and seismic data suggest the presence of HC system which are reflected in the ERS image

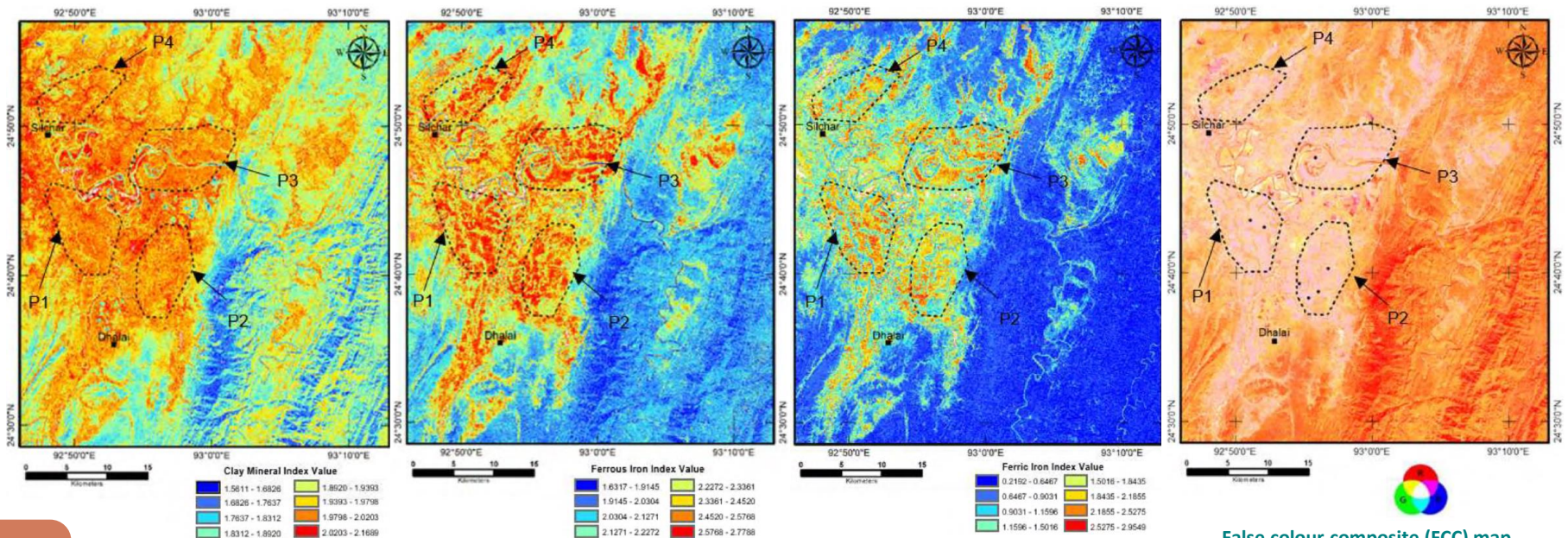
Long-term migration of hydrocarbons in microseepage areas alters the mineralogy and geochemistry of the overlying soils and sediments

This alteration areas can be mapped by remote sensing studies. SAM on ASTER images classifies the hydrocarbon-induced mineral alteration areas effectively

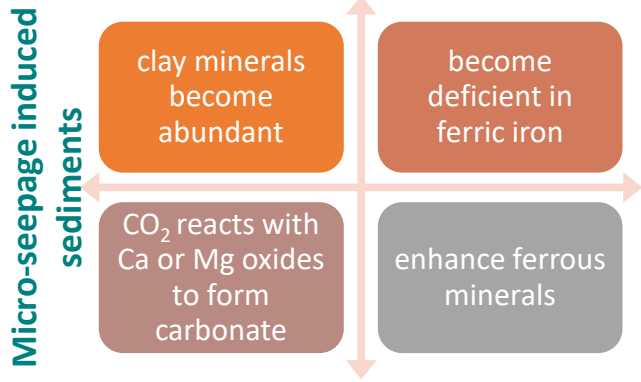
A generalized model for hydrocarbon micro-seepage



Advanced Spaceborne Thermal Emission and Reflection (ASTER) radiometer Images



P1, P2, P3 & P4  
four  
prospective  
microseepage  
areas



Clay mineral distribution  
ASTER band ratio (5 + 7)/6 image

Ferrous Iron distribution  
ASTER band ratio (1 + 4) / (2 + 3)

Ferric iron index map  
ASTER compound band ratio (2/1) × (0.5 × (2 + 4)/3)

False colour composite (FCC) map  
indicating ferric iron (R), clay (G) and ferrous iron (B) as RGB combination

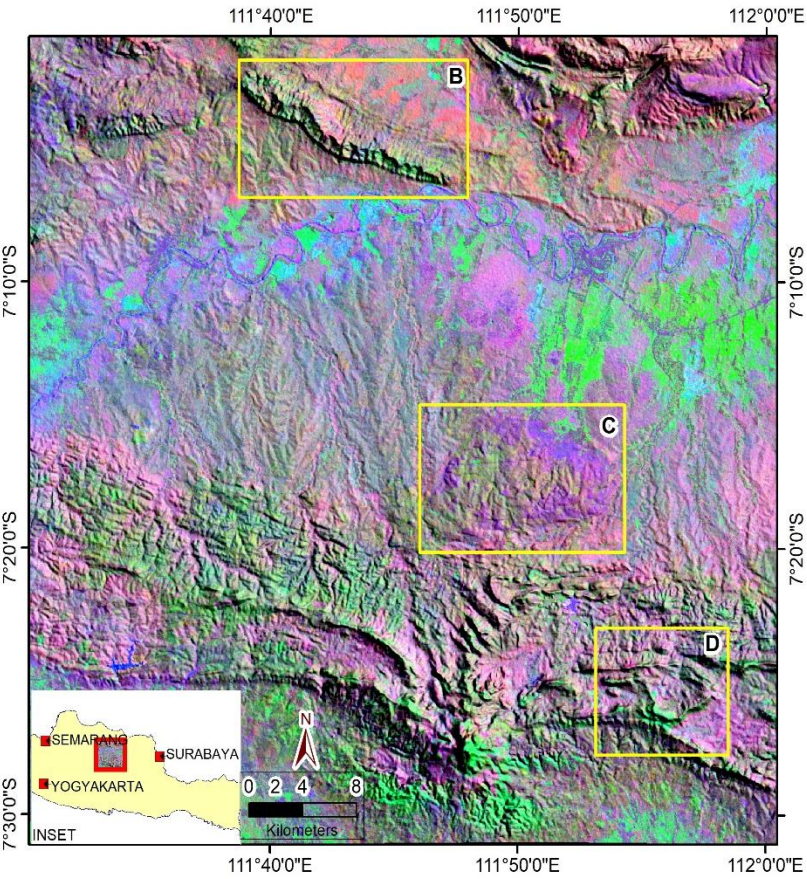
**Assam-Arakan  
Fold Belt  
India**

Integration of remote sensing (ASTER), geochemistry, gravity and magnetic anomaly data successfully delineates microseepage prospect areas in the basin

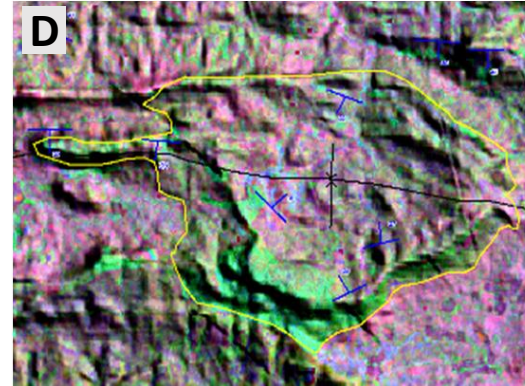
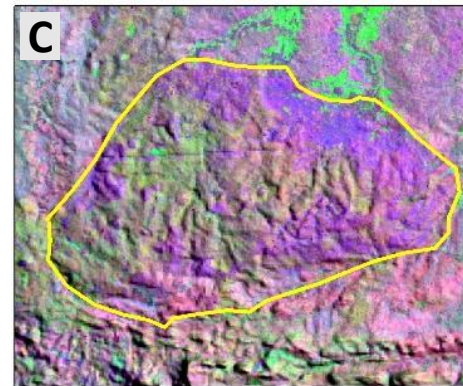
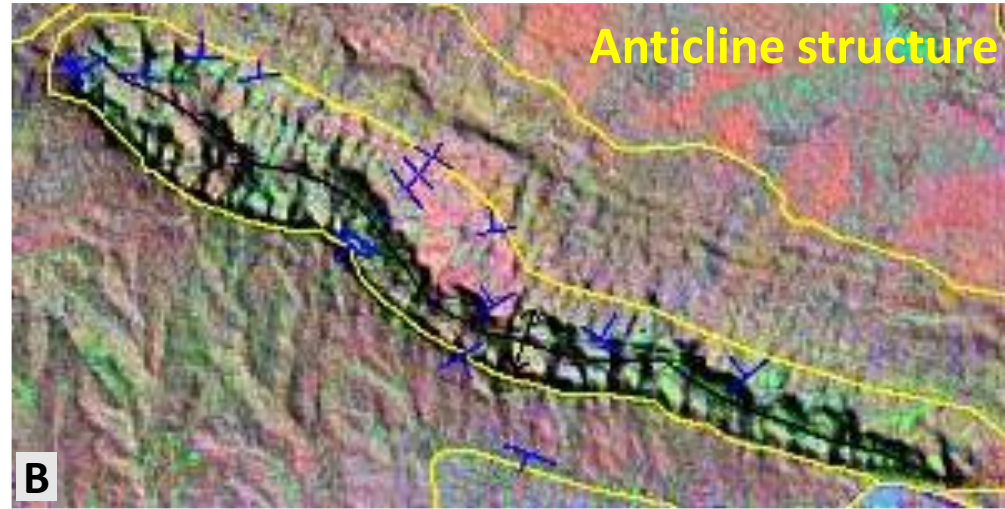
Lithology and structural mapping using Landsat (7ETM+) and ASTER through the Optimum Index Factor (OIF), Principal Component Analysis (PCA) & Band Ratio

## Landsat 7ETM+ and SRTM Processed Images

Susantoro et al., (2009)



Landsat 7ETM+ image band ratio 3/1, 5/7, 3/5 (RGB) with SRTM



Relief in remote sensing data reflects the resistance to the rocks to the energy acting in the area.

Limestone, intrusive & metamorphic rocks: more resistant rocks - high relief

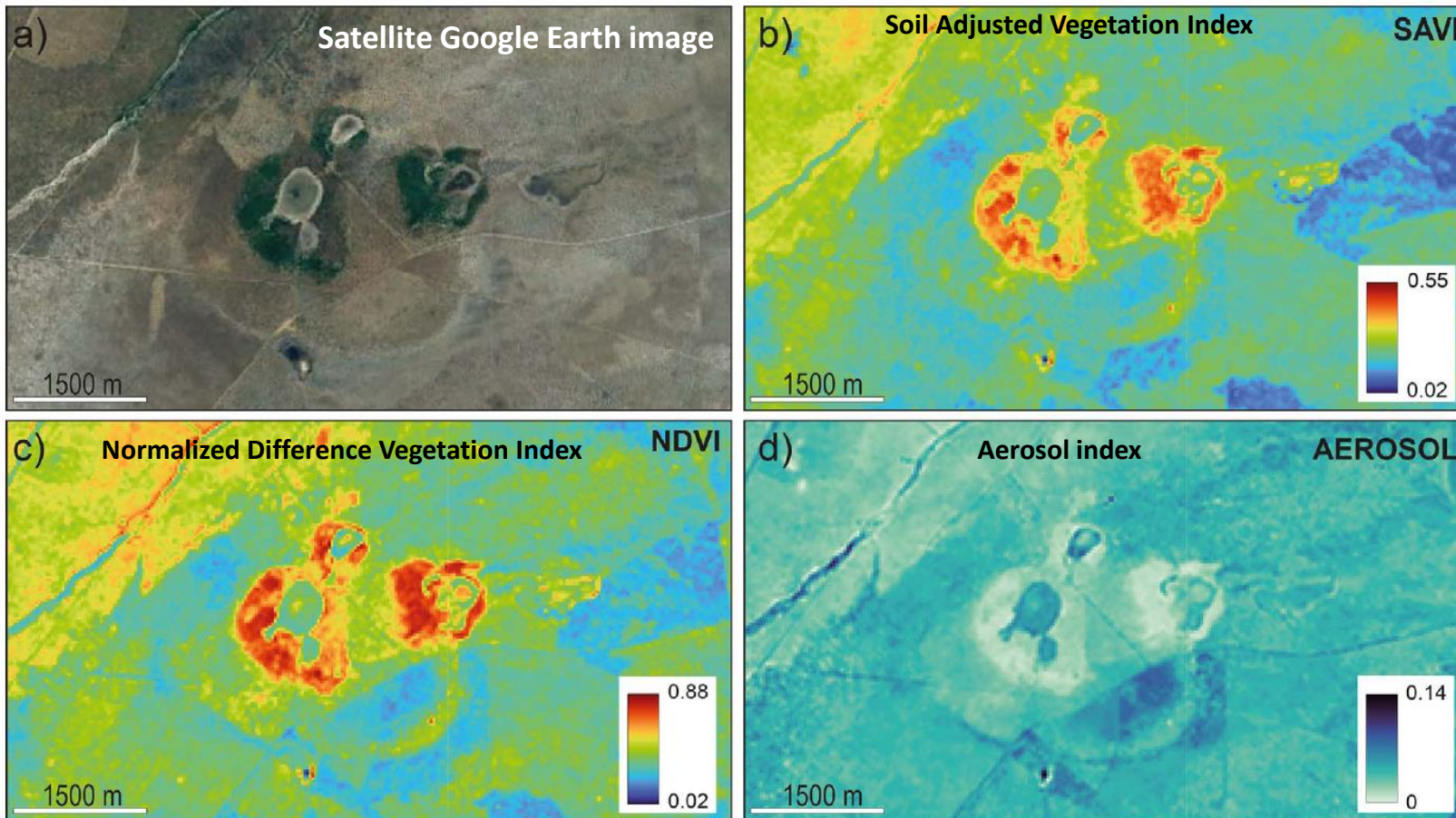
mudstone, shale, siltstone, tuff and marl: low relief rocks



Landsat Multispectral Images through Normalized Difference Vegetation Index (NDVI) and Soil Adjusted Vegetation Index (SAVI) combined with the coastal Aerosol band is used to better characterize the H<sub>2</sub> related SCDs (Moretti et al. (2022))

In the case of H<sub>2</sub> seepage, the vegetation evolves within the circular structure ranging from scarce in the center to healthy vegetation toward the edges

## Sub-Circular Depressions (SCDs) in Brazil

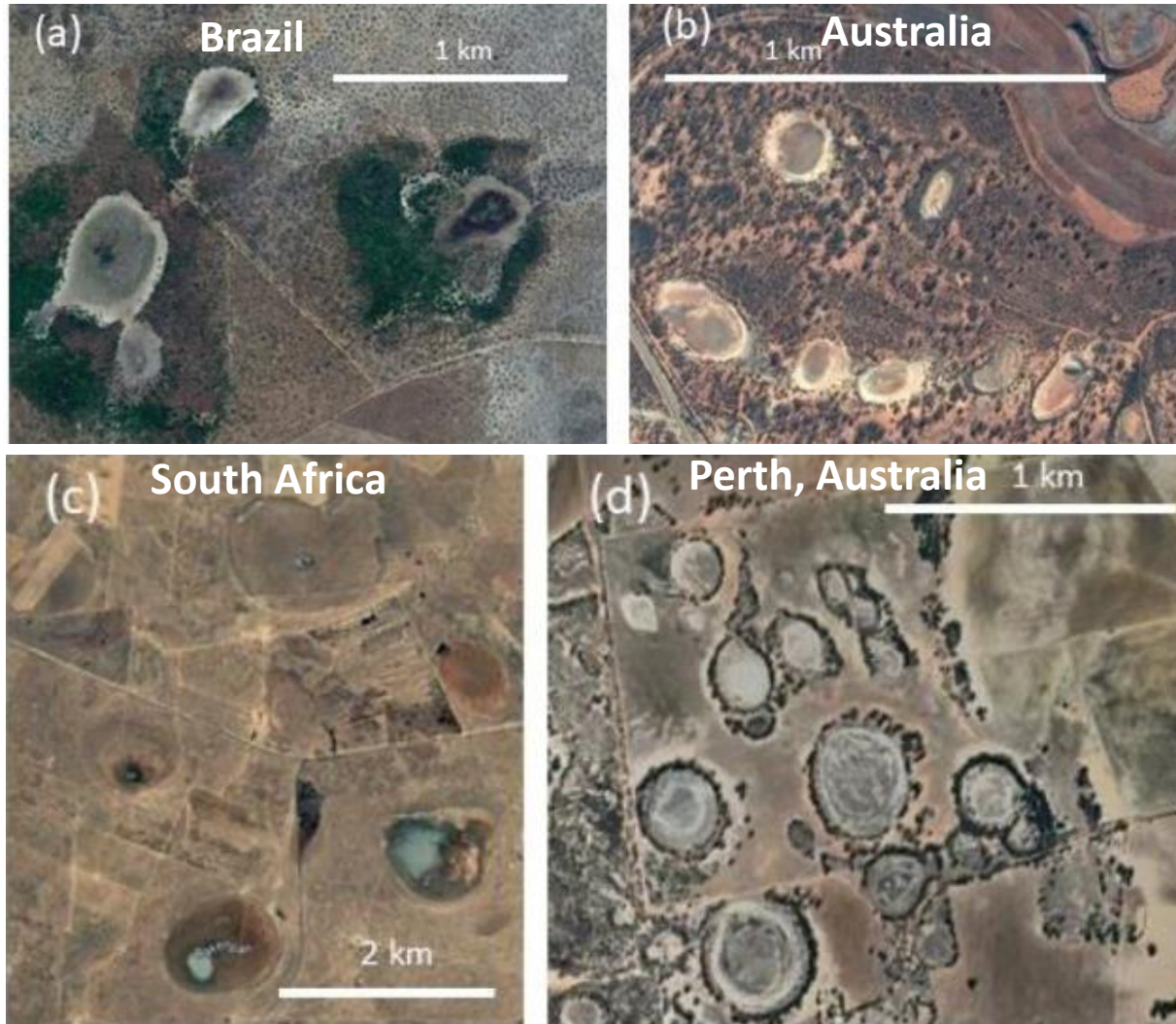


Three H<sub>2</sub> emitting structures are highlighted

Fig. (b) & (c) Vegetation Indexes showing healthy vegetation in red around SCDs

Fig (d) Aerosol index showing low concentrations in light blue around SCDs

H<sub>2</sub> contents have been published from Sub-Circular Depression (SCDs) observed from aerial photographs

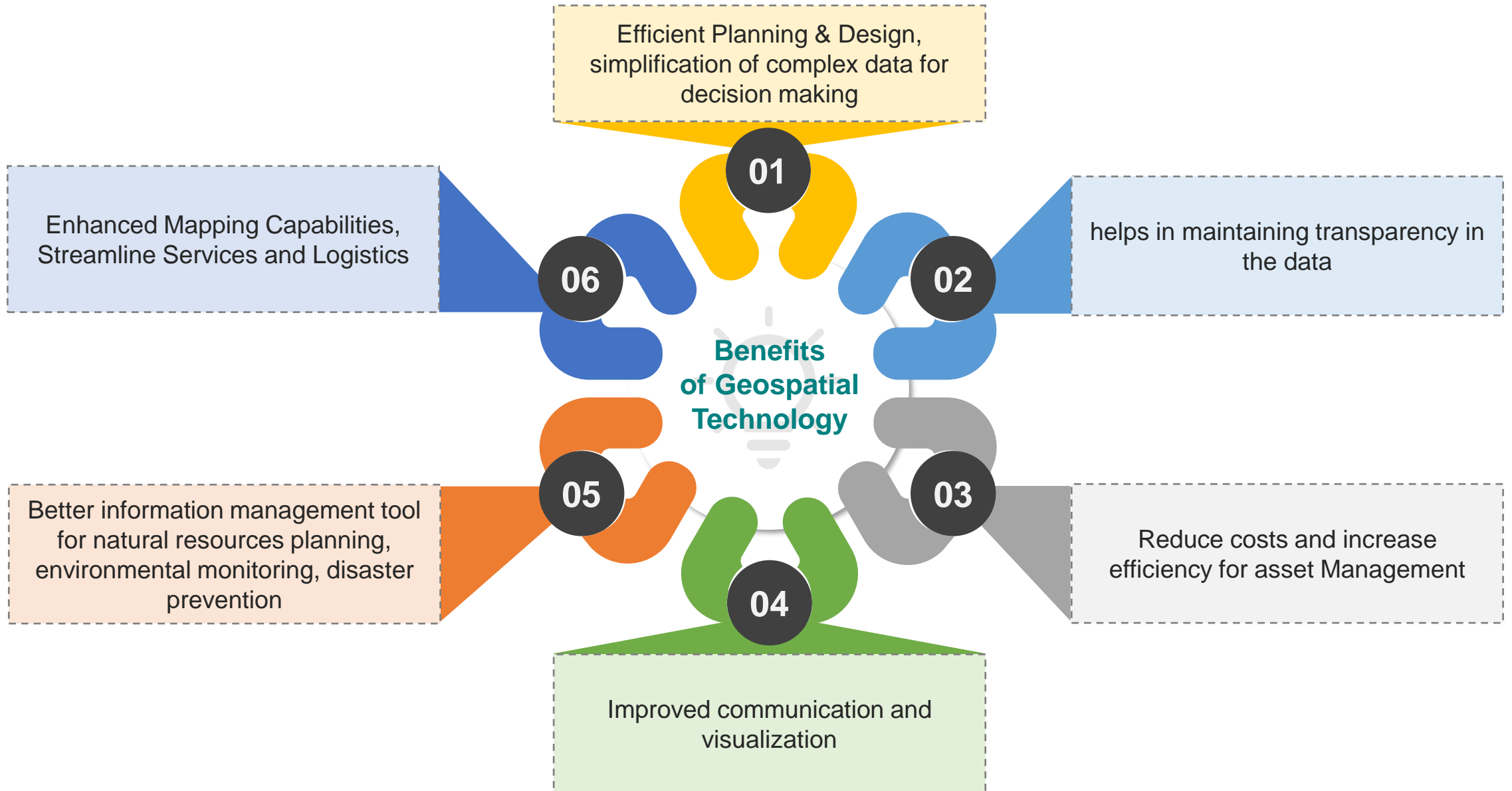


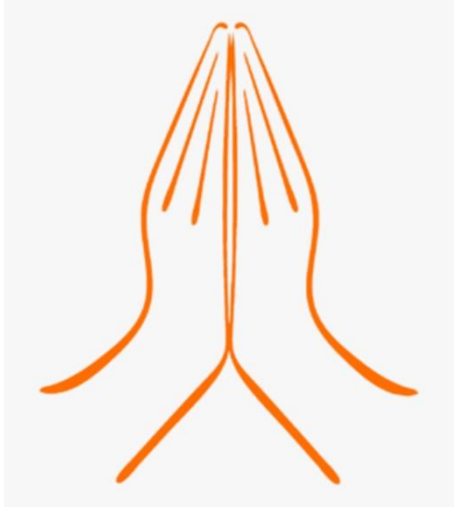
SCDs are recognized as a good proxy for natural H<sub>2</sub> exploration

In Australia, South Africa and Brazil, the presence of H<sub>2</sub> in SCDs is proven and has been measured by gas detectors

These SCDs are in the vicinity of the BIF-hosted iron mines

Satellite imaging revealed the presence of these structures worldwide





**Thank You**



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