BALDOTA

WE ARE LIFE

Recent Advancements in Exploration Techniques and Associated Technologies

By
O.P.Somani
Vice President –Exploration
MSPL Ltd.
Baldota Group
www.baldota.co.in

Introduction to Mineral Exploration

Mineral exploration is the process of discovering new deposits of valuable minerals, metals, and resources hidden beneath the Earth's surface.

It uses geological , geophysical , geochemical data to locate mineral deposits.

Presently, it involves a range of advanced techniques and technologies to identify and assess potential mining sites.

Traditional Exploration Methods

Geological Mapping

Detailed on-site surveys to understand the underlying rock formations and structures.

Geochemical Sampling

Collecting and analyzing soil, stream sediment, rock, and water samples for mineral signatures.

Drilling and Coring

Extracting core samples to directly assess the composition and quality of the deposit.

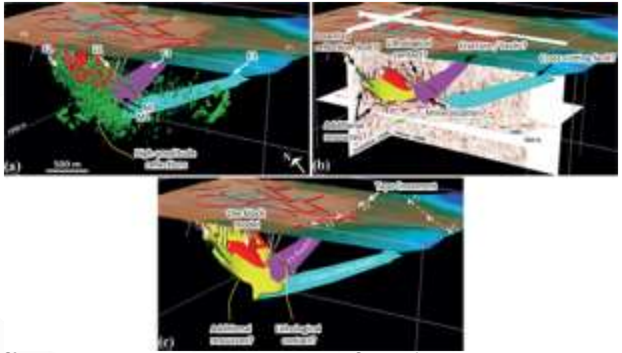
Advancements in Geophysical Techniques

Airborne Surveys

Using planes or drones to map the Earth's magnetic, gravitational, and electromagnetic fields from above.

Seismic Imaging

Generating and analyzing seismic waves to create 3D models of subsurface structures.



Sparse 3D reflection seismic survey for deep-targeting iron oxide deposits and their host rocks, Ludvika Mines, Sweden

Major Drilling Types:

Diamond Drilling

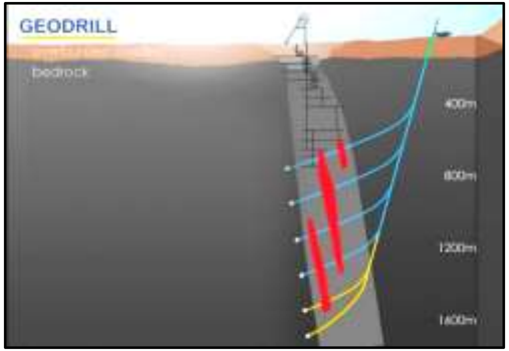
Extracting a cylindrical core of rock from the ground to analyze subsurface geology and structure

Reverse Circulation Drilling

Uses a dual-walled drill pipe to collect rock samples and drilling fluids for analysis.

Directional Drilling

Allow multiple target intersections by drilling branch holes off the mother hole and also controls deviation.



Innovative Geochemical Approaches

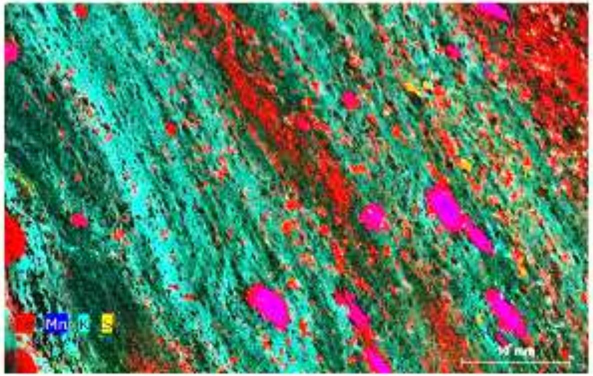
Portable XRF and LIBS

Hand-held X-ray fluorescence analyzers for on-site, real-time identification of mineral compositions.

Portable XRF is good for preliminary grade analysis on the spot.

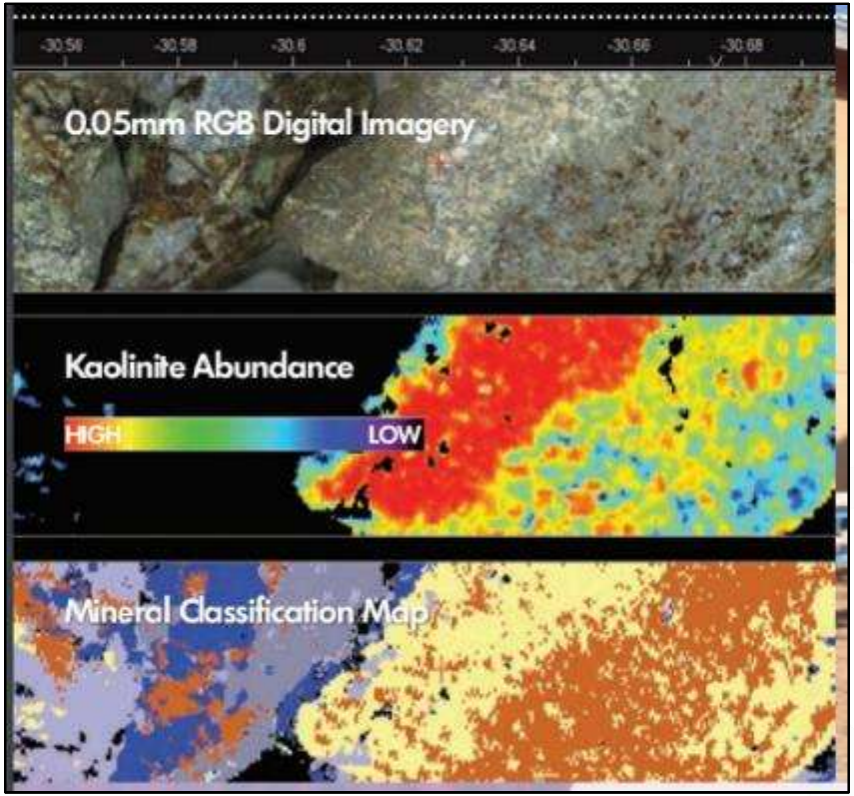
Portable LIBS (Laser Induced Breakdown Spectrometer) is suitable for lighter elements also in the periodic table including Be and Li.

Drill Core Analysis with In-Line XRF



XRF analysis allows for the determination of rock cores elemental composition. The ability to carry out XRF-based rock core analysis at sites of interest enables mineral exploration assays to be performed without having to transport heavy samples to a different analysis site. As the analysis can be done automatically a quick and thorough assay of all samples is possible with reduced personnel workload and analysis time.

Spectral Imaging of Drill Cores



Core Scanner

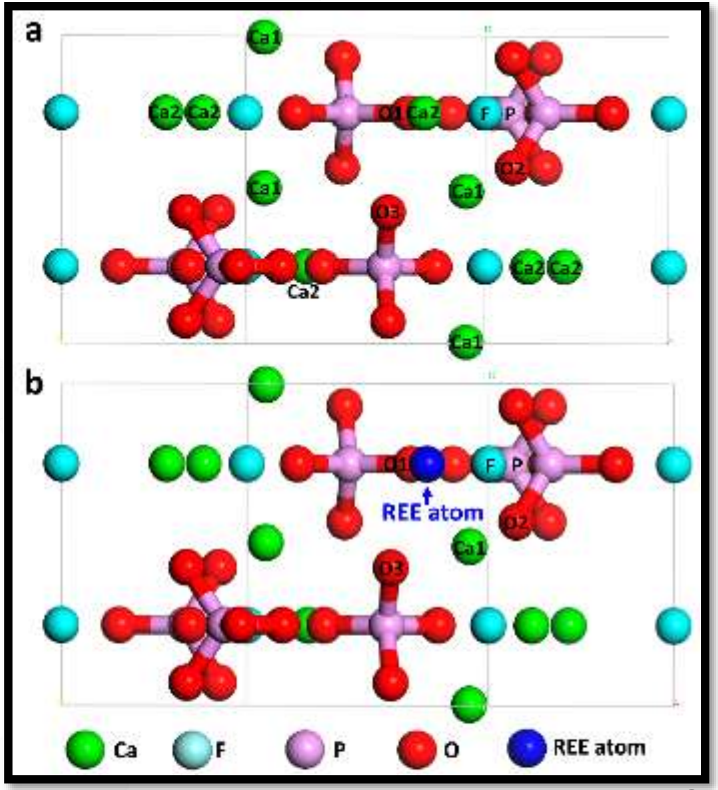
Hyperspectral Core Imager (HCI) integrates high resolution VNIR-SWIR imaging spectroscopy, core photography and 3D laser profiling to deliver the most advanced automated core logging system.

Innovate Geochemical Approaches

Apatite Trace Element Composition by Laser Ablation ICP-MS

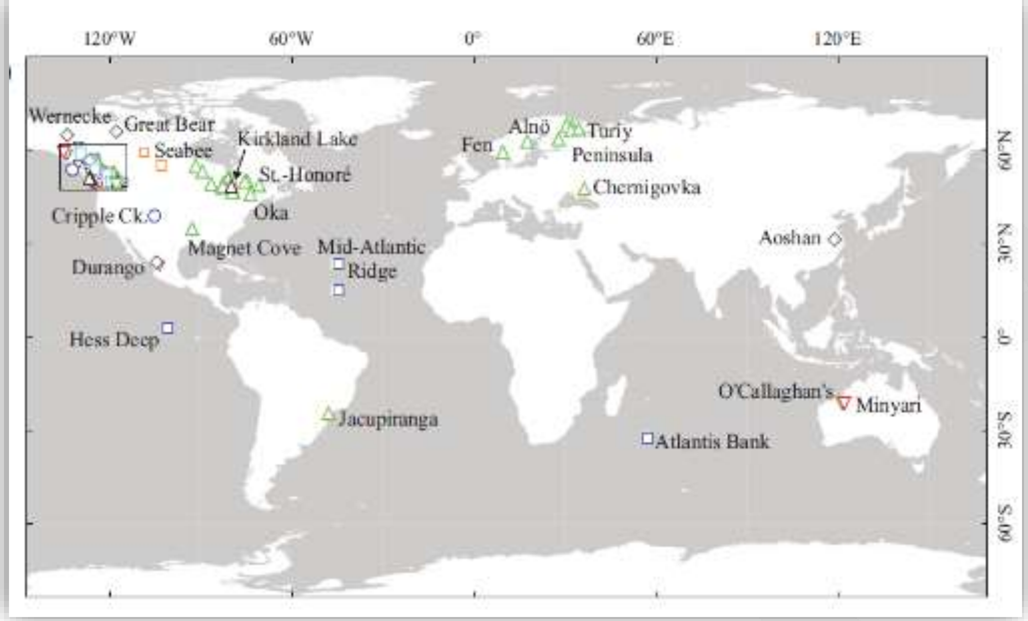
A robust new tool for mineral exploration.

Apatite structure can accommodate as much 50 trace elements



Apatite Trace Element Compositions: A Robust New Tool for Mineral Exploration

Apatites from the major types of mainly magmatic-hydrothermal mineral deposits (30 localities, mostly in British Columbia, Canada) together with apatites from carbonatites (29 intrusive complexes) and unmineralized rocks (11 localities) laser ablation-inductively coupled plasma mass spectrometry.



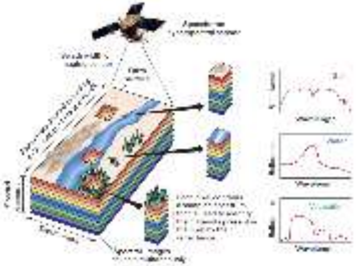
Apatites from the different deposit types also have distinct trace element compositions that are readily discriminated by the discriminant functions.

Ref: Mao Mao, Alexei S. Rukhlov, Stephen M. Rowins, Jody Spence, and Laurence A. Coogan, Economic Geology, v. 111, pp. 1187–1222

Remote Sensing and Satellite Imagery

Recent advances in remote sensing have significantly enhanced its applications in geology, offering more precise, efficient, and comprehensive tools for geological studies. These advancements encompass improvements in sensor technology, data processing techniques, and integration with other geospatial technologies. Here are some notable recent advances:

1. High-Resolution Satellite Imagery
2. Improved Hyperspectral Sensors:
3. LiDAR (Light Detection and Ranging)
4. Unmanned Aerial Vehicles (UAVs):



Advancements in Remote Sensing

BALDOTA
WE ARE LIFE

1. **High-Resolution Satellite Imagery**

Very High-Resolution (VHR) Satellites:

New satellites, such as WorldView-3 and Pléiades provide imagery with spatial resolutions of less than one meter. This enables detailed geological mapping and the identification of small-scale geological features. Enhanced spectral resolution allows for better discrimination of minerals and rock types.

3. **Improved Hyperspectral Sensors:**

Sensors like the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) and the Hyperspectral Imager Suite (HISUI) offer hundreds of contiguous spectral bands, allowing for precise identification of mineral compositions and subtle variations in rock types including alteration features which are characteristics of many hydrothermal deposits.

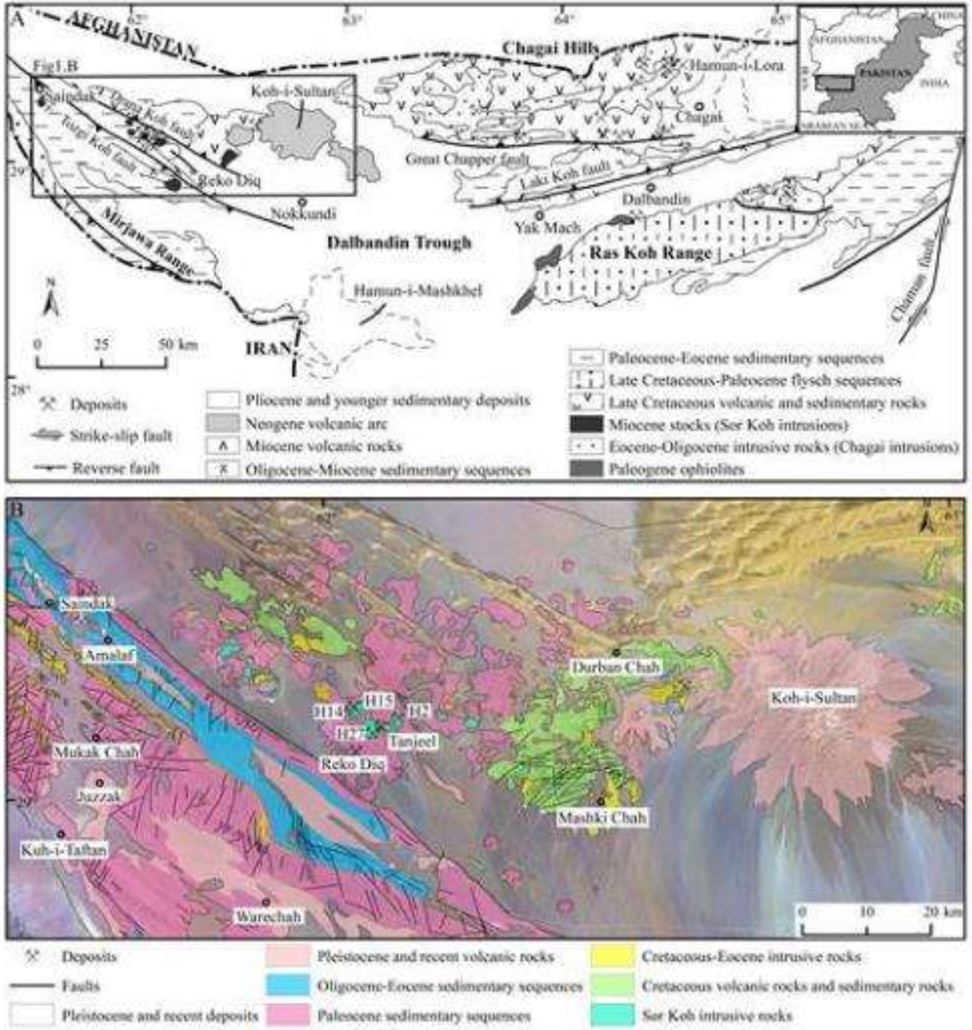
2. **LiDAR (Light Detection and Ranging)**

High-Density LiDAR:

LiDAR technology has advanced to provide higher point densities, which improves the accuracy of topographic models and enables detailed mapping of geological structures, fault lines, and landslide-prone areas.Integration with other data types, such as multispectral and hyperspectral imagery, enhances the interpretation of surface and subsurface geological features.

4. **Unmanned Aerial Vehicles (UAVs):**

UAVs equipped with high-resolution cameras, multispectral, hyperspectral, and LiDAR sensors offer flexible, cost-effective, and high-resolution data acquisition. This is particularly useful for detailed mapping of small or remote areas. UAVs facilitate rapid deployment and data collection in challenging terrains.



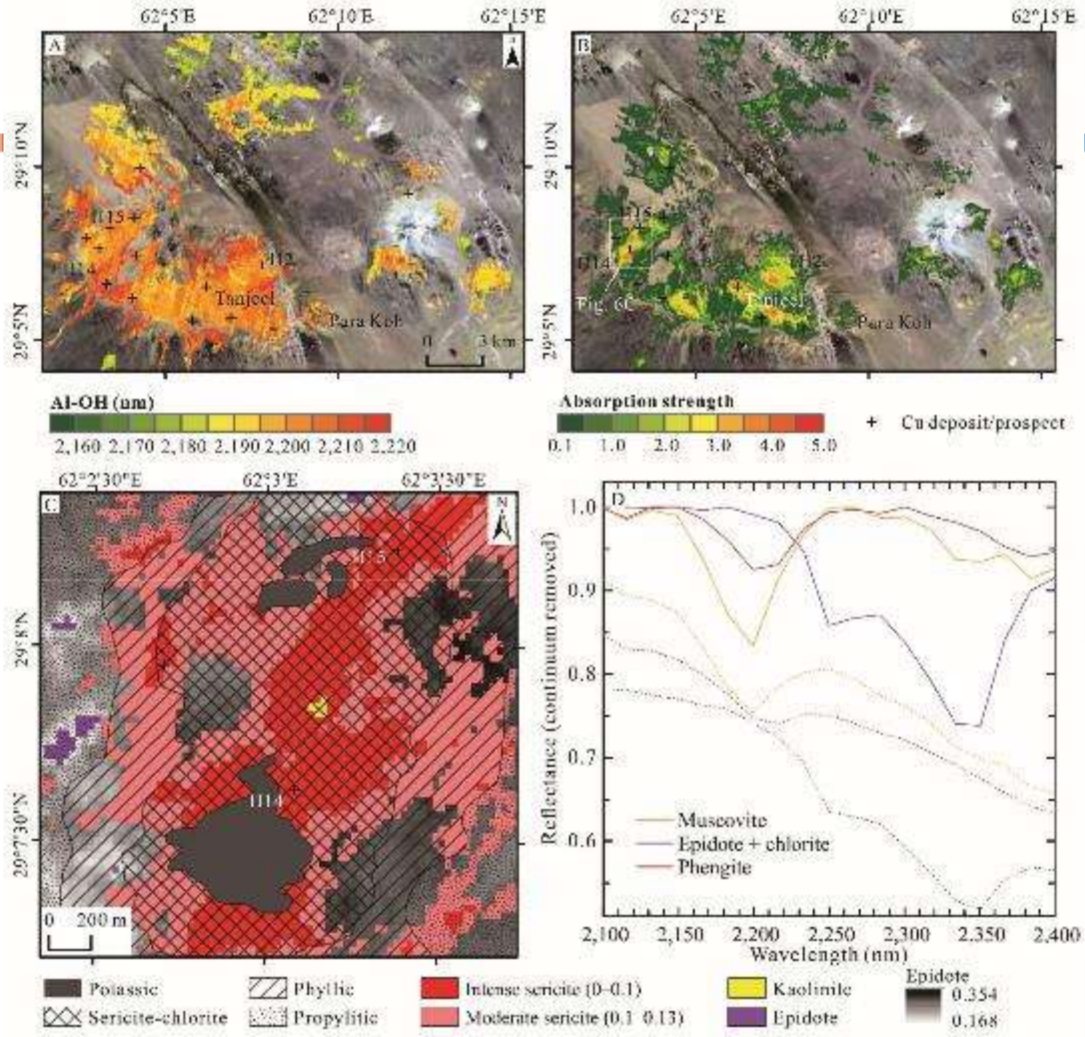
Case history of Hyper Spectral Data interpretation

BALDOTA
WE ARE LIFE

(A) Regional geology and structures of the Chagai belt, Baluchistan province, Pakistan (modified after Perelló et al., 2008).

(B) Geologic map of the western Chagai belt (adapted from the reconnaissance geology maps at scale of 1:250,000).

Economic Geology MARCH 01, 2024
Alteration Mapping for Porphyry Cu Targeting in the Western Chagai Belt, Pakistan, Using ZY1-02D Spaceborne Hyperspectral Data
Lei Liu; Chuntao Yin; Yasir Shaheen Khalil; Jun Hong; Jilu Feng; Huishan Zhang



Mineral variation maps of Reko Diq area.

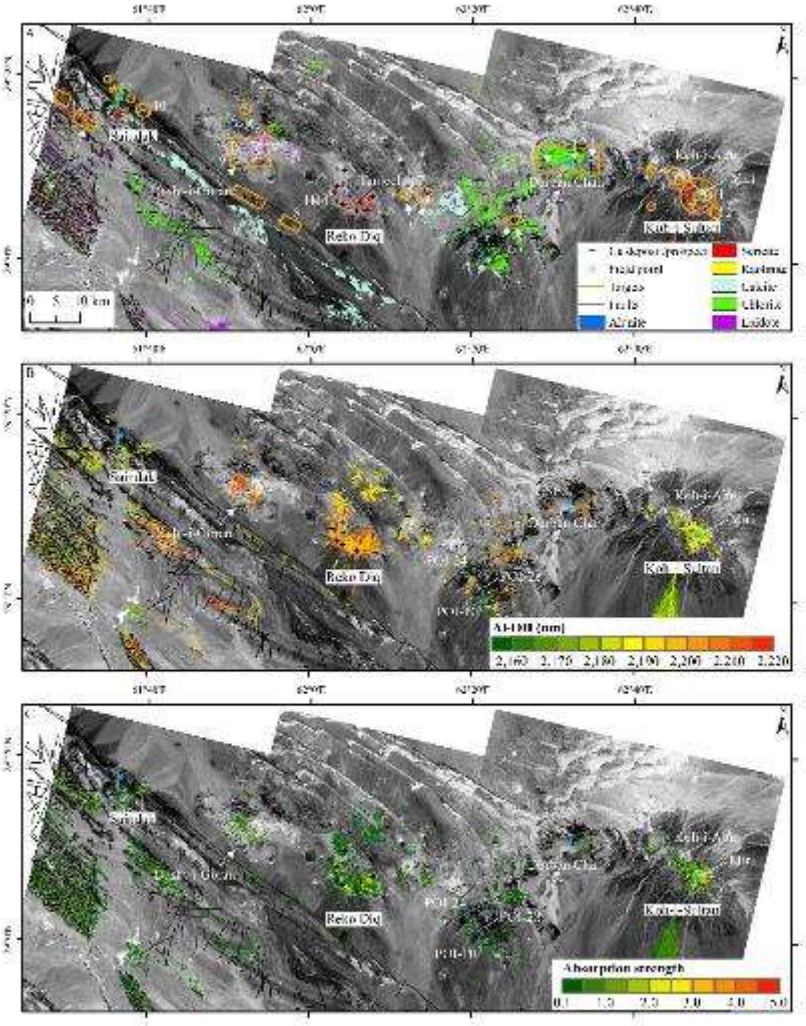
(A) Map of Al-OH absorption wavelength.

(B) Map of Al-OH absorption strength.

(C) Surface alteration map (shade patterns) of H14 and H15 porphyry deposits based on field work (after Razique, 2013) and spectral angle mapper (SAM) maps of sericite, kaolinite, and epidote.

(D) Raw (dot lines) and continuum removed (solid lines) ZY1-02D image spectra of pixels containing muscovite (sericite), phengite, and epidote.

Reko Diq is copper deposit with 5.9 billion tons of resiyrce at 0.41% Cu and 0. 22 g.t Au



(A)Spectral angle mapper (SAM) mineral maps derived from the use of reference Jet Propulsion Laboratory (JPL) mineral spectra applied to ZY1-02D (Chinese-Brazilian Earth Resources Satellite) data.

(B) Map of Al-OH absorption wavelength.

(C) Map of Al-OH absorption strength.

Automation and Robotics in Exploration

Aerial Drones

Mapping terrain and identifying targets for further investigation.

Robotic Rovers

Navigating rugged landscapes to collect samples and survey subsurface features.

Data Analytics and Machine Learning

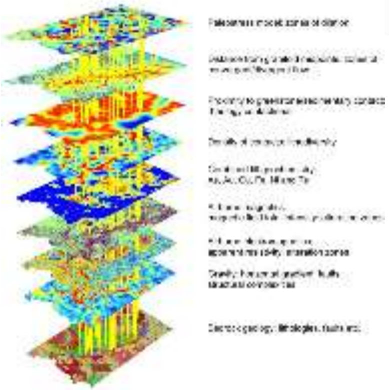
Data Integration

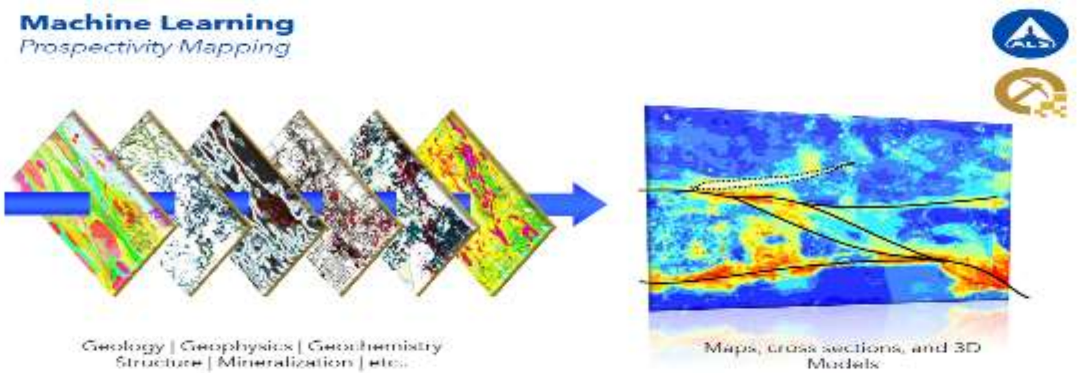
Combining diverse datasets from multiple sources for a comprehensive view.

Predictive Modeling

Using machine learning to identify patterns and make predictions about mineral deposits.
Targeted Exploration

Optimizing exploration efforts by focusing on the most promising areas.

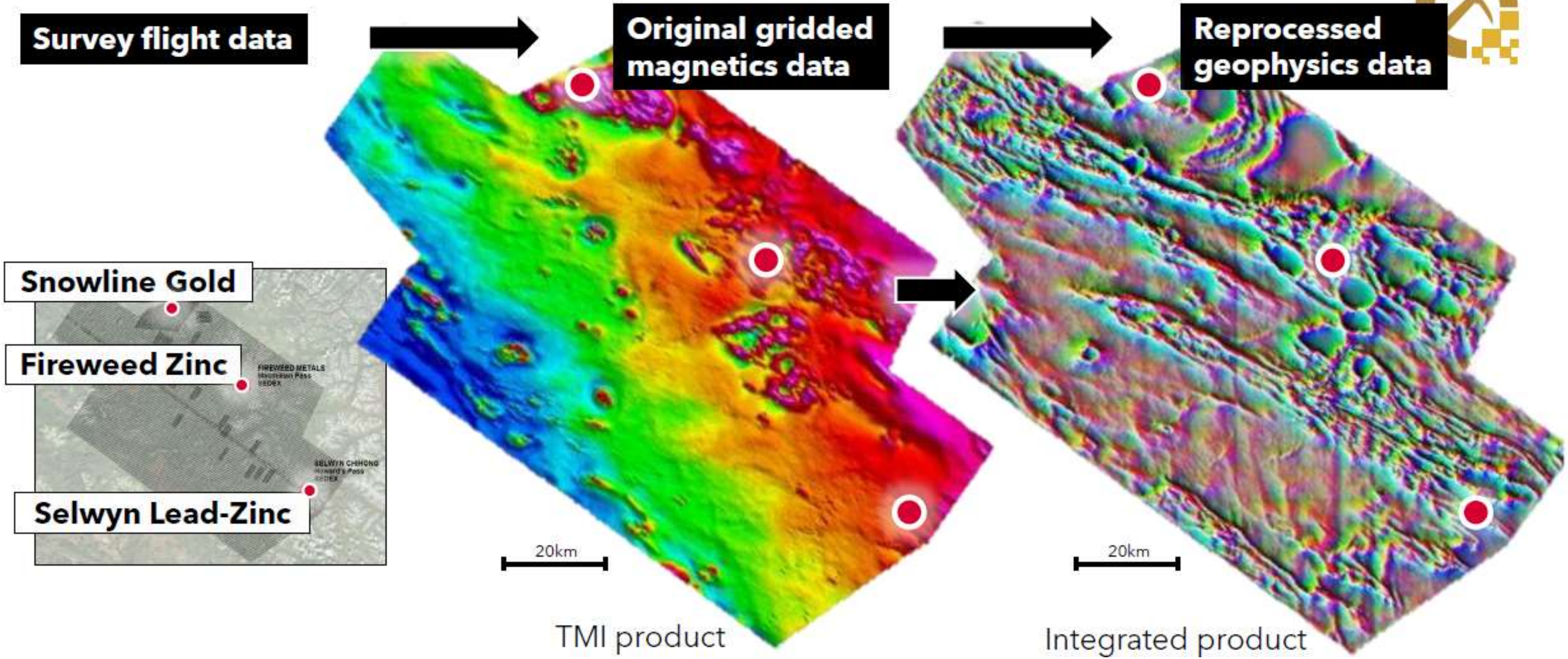




Conventional Geophysics

Re-analyse historic and new geophysics datasets

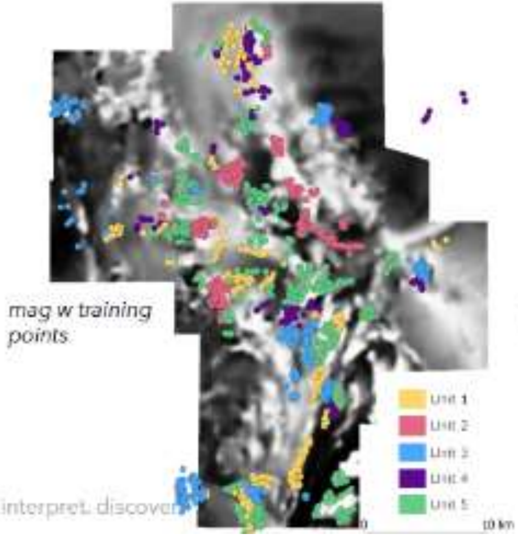
- Extract new detail from VTEM, ZTEM, Magnetics, Gravity, and more

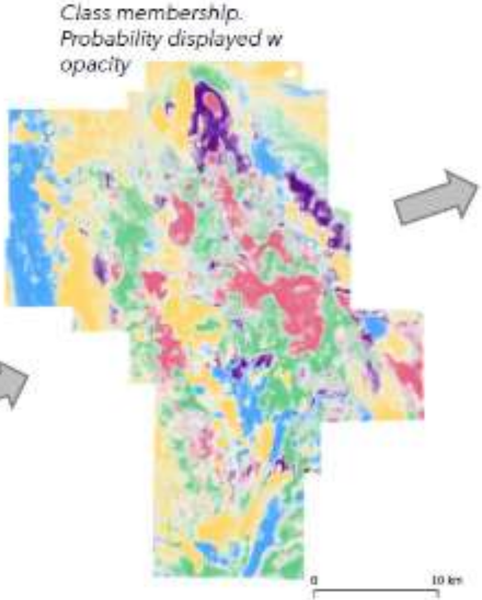


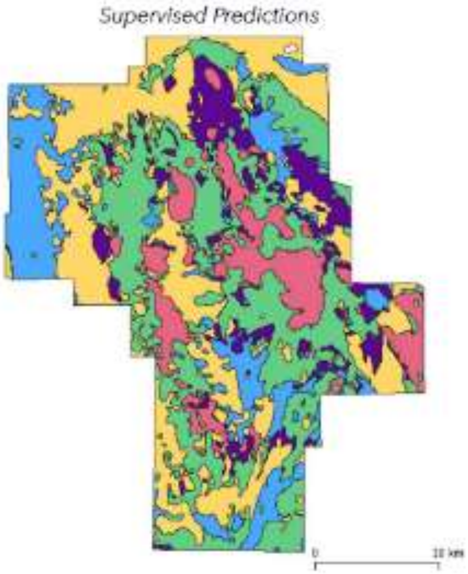
Machine Learning

Predictive Geological Mapping

- Unsupervised clustering & Supervised ML (machine assisted geological map)
- Geophysical data layers, remote sensing layers
  - Derived products
  - Feature engineering
- Classification and Probability







Conclusion and Future Outlook

Continuous Innovation

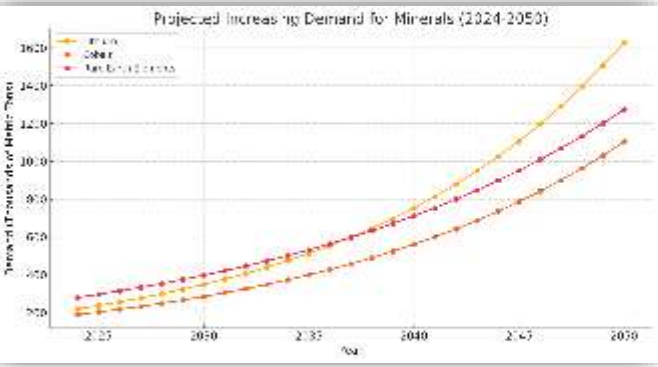
Advances in technology are transforming the mineral exploration industry, making it more efficient, accurate, and sustainable.

Sustainable Practices

Emerging techniques aim to minimize the environmental impact of exploration and mining activities.

Increasing Demand

Growing global demand for minerals and metals will drive continued investment and advancements in exploration.



Thank You !
For Your Attention