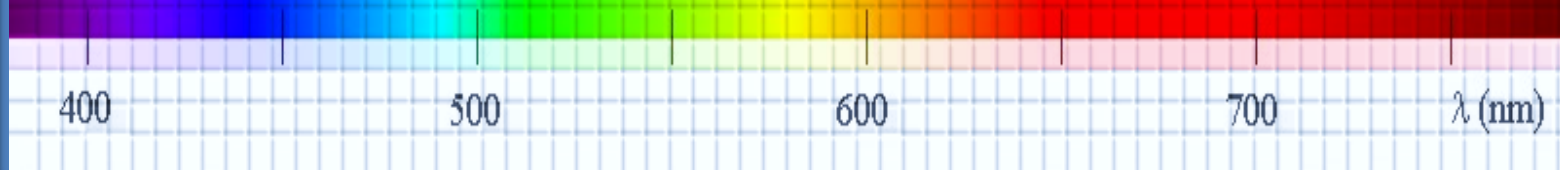


Spectral and Hyperspectral Image Analysis Consultancy by **SATELLITE & UAV**

March 2020



CONSULTANCY

MinEx Associates offer **image analysis** consultancy
to **mining and exploration** companies

Spectral and hyperspectral data may be fused with other remote sensing, geological and geophysical data such as LIDAR, air-mag, seismic, sampling, core logging and ultimately integrated into a Geospatial database to provide a highly characterized visualization of the surface and subsurface area of interest.

Although large Corporations have been involved this kind of work,

MinEx is one of just a few
consultancy companies able to fully exploit Satellite images
...and a forerunner, able to offer UAV (drone) data collection and analysis
in geological exploration.



WHY?WHAT'S THE NEED?

- Governments need to **attract investors with logical information** to encourage them to explore for, select and develop mineral resources. Image analysis provides an initial, clear, low cost, valuable information resource that is straightforward to interpret (unlike other forms of Geophysics).
- Exploration companies need a fast route to define targets for ground investigation and geological understanding.
- When **metal and commodity prices fall**, as has been seen over the past 7 years, mining **companies cut back on exploration** budgets and exploration diminishes.
- This leads to **mineral licences** being **abandoned or revoked** when insufficient work is done, because:
 - **Traditional methods** of exploration are **tedious, expensive** and have to be applied over the entire exploration area.
 - **Remote** (not on the ground) **methods** are very **inexpensive** in comparison. Clear **targets are identified** allowing Geologists to understand the geology better and investigate ONLY areas of interest. **Areas not of interest may be eliminated and licence cover relinquished.**
 - In practice, this **vastly reduces the** exploration **expenditure** and **time** by a factor of 5 – 10.

This is the motivation for utilisation of this technology and is a major improvement in exploration – no matter the economic climate in future.

THIS IS THE FUTURE OF MINERALS EXPLORATION.

A MINERAL EXPLORATION TECHNOLOGY

READY FOR CONSULTANCY OFFERING AND *RIPE FOR DEVELOPMENT*

- The probability of Making an Exploration Discovery is LOW.
 - (only 1 in 10,000 prospects becomes an economically viable mine)
- Large Discoveries are declining year by year.
- Discoveries are increasingly in remote areas, with high exploration costs.
- Technology so date has not lowered costs or increased success rates.
- Exploration Drilling is Expensive (>£150/meter).
- Junior Mining Companies are Dependent on Capital Markets which often finance projects at the wrong time and at the wrong price.
- **Of \$40 Billion spent in minerals exploration in the last 15 Years – 90% WAS LOST.**
- **Mineral Exploration is extremely high risk for Companies and Investors.**
- **This technology is an underutilised breakthrough.**
- **This technology is available but underused.**



EXISTING TECHNOLOGY

The technology is dependent upon:

1. **Image acquisition**

- Using UAV and/or SATELLITE acquired images.

2. **Image analysis**

- With PROVEN G.I.S. SOFTWARE (ERDAS, ENVI and OPTICKS).

3. **Practical application**

- COMPARE WITH GEOLOGICAL & TOPOGRAPHICAL MAPS & DATA.
G.I.S. Experts WORK WITH *THE CLIENT'S* EXPERIENCED GEOLOGISTS
USING GOOD COMPUTER HARDWARE TO EXPLORE THOROUGHLY.

ALL THESE TECHNOLOGIES EXIST

ALL ARE AT AN ADVANCED STAGE OF DEVELOPMENT

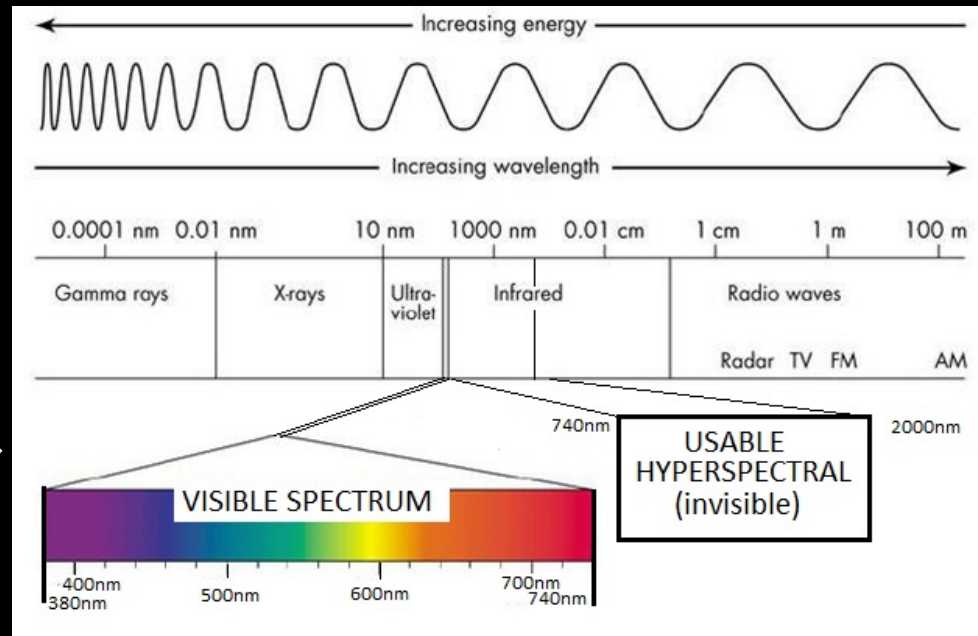
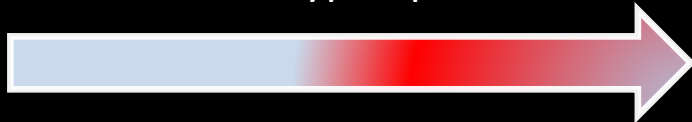
.....BUT HAVE NEVER BEEN PROPERLY BROUGHT TOGETHER

WHAT IS 'SPECTRAL' AND 'HYPER-SPECTRAL' IMAGE ANALYSIS?

'Spectral' *photographic images* (in the visible light spectrum) are used to analyse satellite and UAV images.

Hyper-spectral images capture 'colours' (infrared) *outside* of the visible light spectrum, in the 'infrared band'. Different rock types have a different 'invisible' or infrared 'colour'. This cannot be detected by the eye, but photo sensors can easily detect these 'invisible' colours. Using dedicated software (already available and commonly used), 'non-visible, infrared colours' can be represented with a recognisable, visible colour.

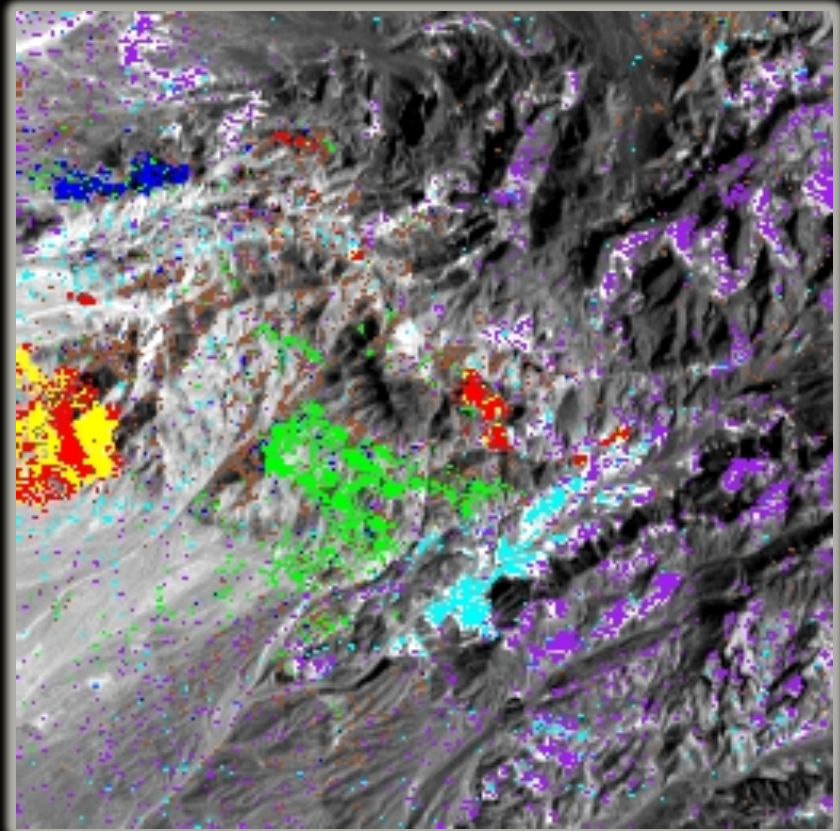
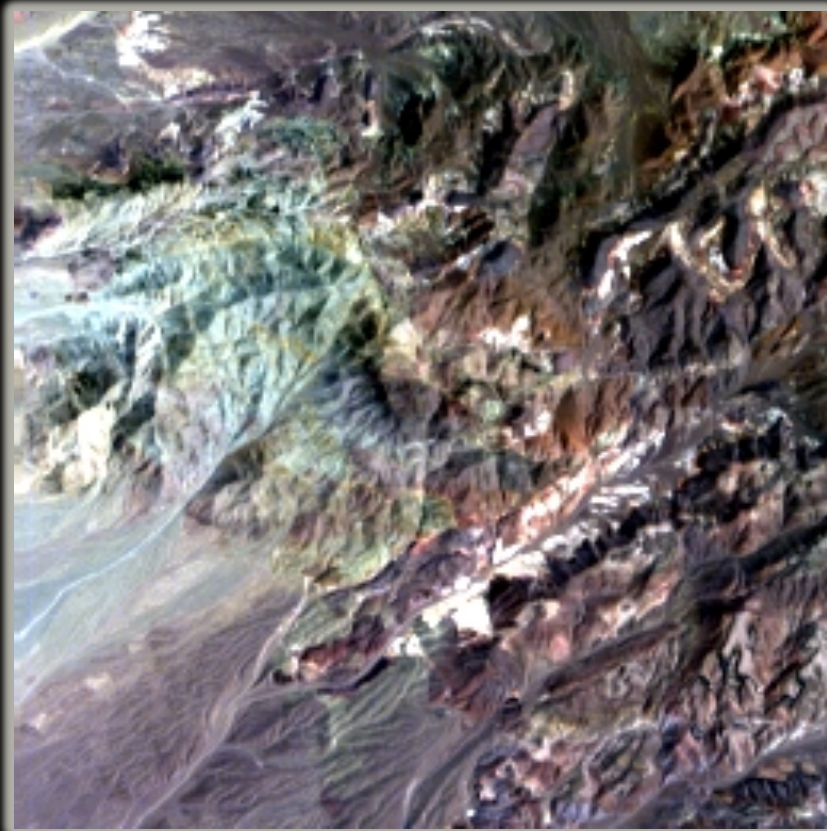
This chart shows the **small range of visible colours** compared with the **enormous range of 'invisible colours'** in the useful 'hyperspectral band'



WHY USE SPECTRAL & HYPERSPECTRAL IMAGE ANALYSIS?

- Commercial **mineral deposits are usually small in surface area** and are easily overlooked by conventional exploration methods. It's usually like 'looking for a needle in a haystack'. Image analysis is able to identify very small targets.
- Even if there is soil cover, the **underlying rock types** exist in the surface soil, in the same way as geochemical soil samples contain metals and minerals from deep below surface. These minerals **can be identified** by the 'colours' they reflect. On the ground, these mineral types may be completely invisible.
- **Over a large area** (of an exploration lease) it is **impossible to walk everywhere** and take representative samples of the soil over the entire area. An image covers the entire area.
- Even when there is thick **vegetation cover**, if the images are captured at the right time of year, they can be very useful. Vegetation mirrors soil/mineral types.

EXAMPLES - HYPERSPECTRAL IMAGE ANALYSIS - 1



The left image is the basic visible light range spectral image.

When software (spectral signature filters) are applied - the right image, is hyper-spectral
(I.e. Green=muscovite #1, Blue=muscovite #2, Red=calcite, Yellow=dolomite, Purple=silica, Cyan=zeolites.)

With hyper spectral filters, specific mineral types and soil types light up clearly, like beacons!

EXAMPLES - HYPERSPECTRAL IMAGE ANALYSIS - 2

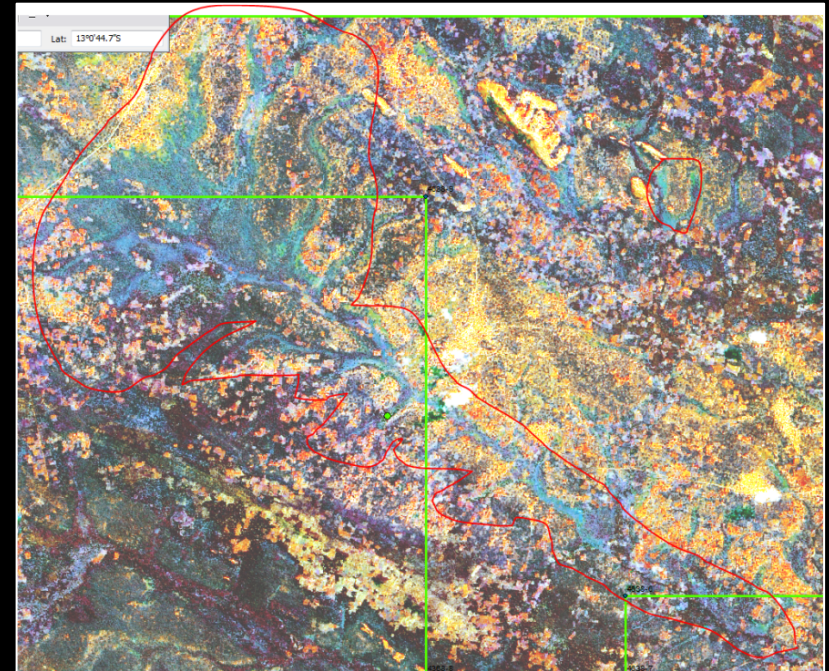
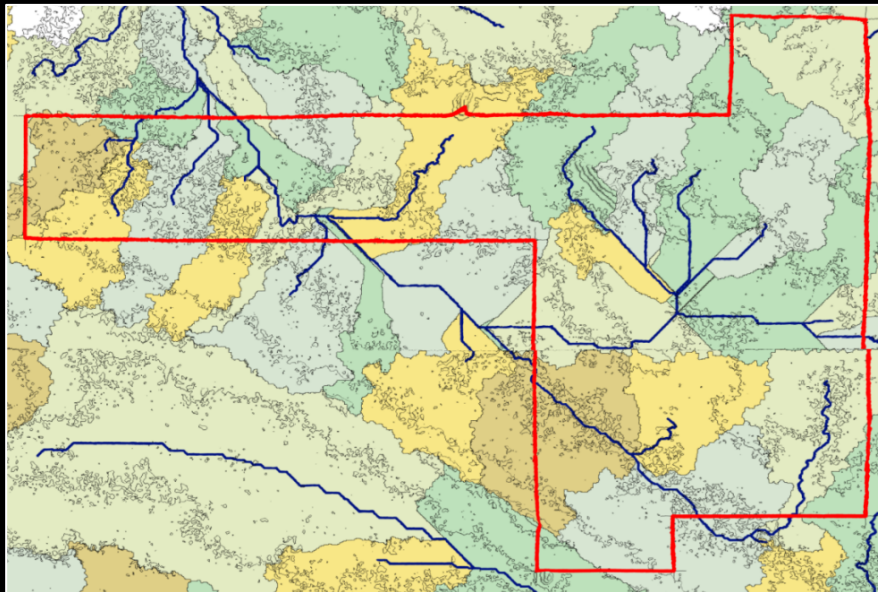
This satellite images analysis shows an area that is very unique and is a 'variable directional drainage basin'.

Hyperspectral analysis shows river sands in blue. ***This is not water!***

In the past, drainage was from NW to SE. Currently drainage is from SE to NW. This is a rare scenario and highly favourable for alluvial heavy mineral concentration.

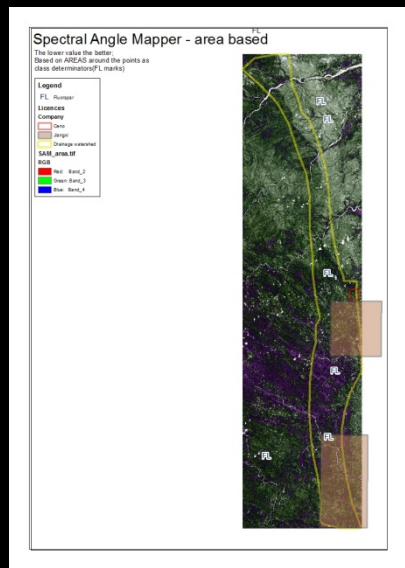
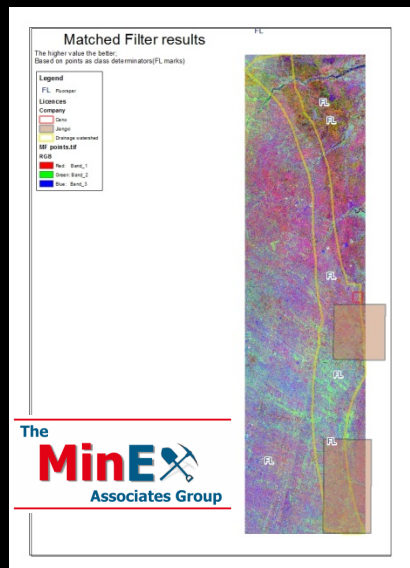
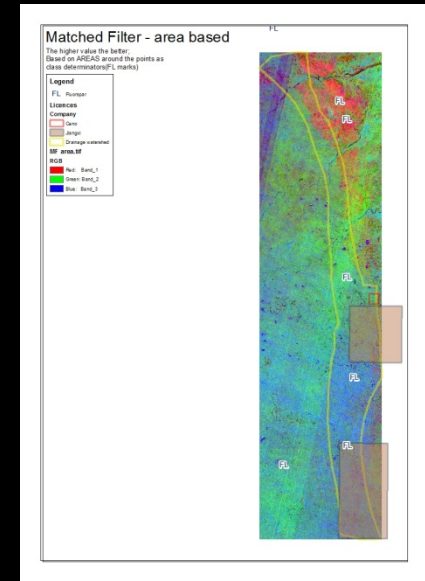
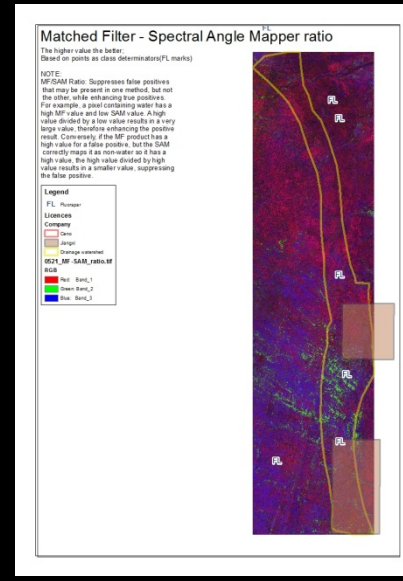
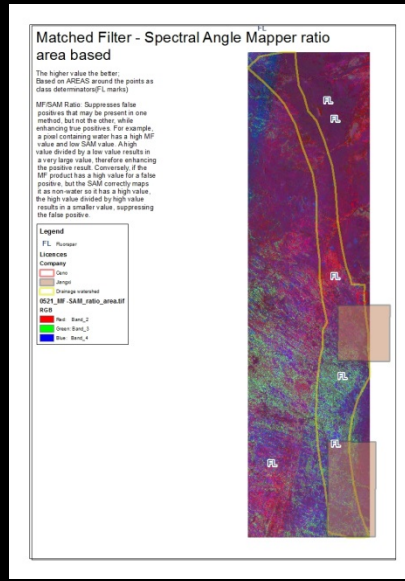
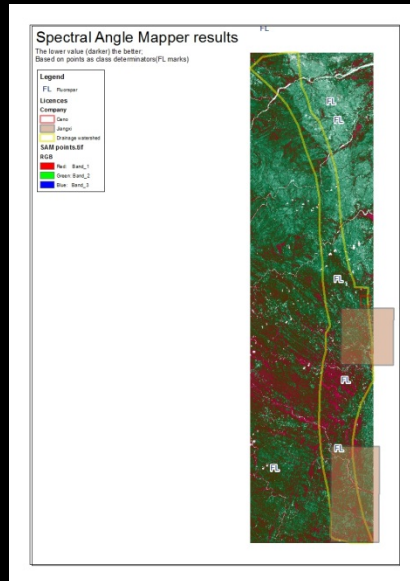
Without hyper-spectral satellite image analysis, this would be a totally invisible feature.

Past, drainage to the NW



Present, drainage to the SE

EXAMPLES - HYPERSPECTRAL IMAGE ANALYSIS - 3



Here are a range of hyperspectral images produced over the Fluorite region in Mozambique.

Fluorite and its depositional features show up well on spectral image analysis. Various different analyses are applied to obtain the most accurate results.

The images used were Landsat 8 (free) images, identifying new targets when compared to known features.

Better quality images and/or UAVs would subsequently give more detail and accuracy on target areas.

BUT SURELY, IF IT'S SO GOOD ...IT'S BEING DONE ALREADY?NO! – not as well as it could be!

There *are* satellite image companies that sell images and can analyse images, **but** results are not brilliant because:

- They do not work with Government or Project Geologists directly.
- They do not explain, investigate and discuss the options properly.
- They produce a few 'generic' hard copy & digital images to sell to the Geologists, who are not qualified or experienced with the specialist software required to further analyse the digital images.

The result is invariably disappointment and confusion.

The power of spectral analysis methods is not appreciated.

Project Geologists feel left out, even threatened, because they are not trained in the techniques.

**Presently, there are no image analysis companies
exploiting UAVs.**

EXISTING COMPANIES & PRODUCTS

There are only a handful of companies that offer specialist geo-spectral and hyperspectral image analysis for mineral exploration.

All use **satellite images** few go as far as to collect and use other collectable data.

Probably the **best known companies** are:

USA (spectir.com)



galileo-gp.com



Australia (geoimage.com.au)



South Africa (geoscientific.net)



- These **companies supply** images to exploration companies *without field knowledge*.
- They provide '**standard images**', usually in hard copies (on paper or digital but '**non-manipulatable**' images) for the Project Geologists to study.
- The **vast majority of the data collected and paid for by the client, is not used**.
- They are **given special discounts with satellite companies to RE-SELL images**. Thus they have bias (or are usually confined) to the images they acquire at from specific image sources.
- **American companies** are not *mineral exploration specialists*.

UAV COST COMPARISON

(versus traditional prospecting)

UAV Exploration:

- From £500 per day
- 6 flights per day (1.5 hrs)
- 10.8 square miles per day
- Mapping done at same time as mineral exploration.
- Consistent data
- Complete Coverage
- **Cost per square mile = £50**

Boots on the Ground Exploration:

- £1,000 per day (1 Geologist)
- 2 square miles per day
- Mapping done separately from mineral exploration.
- Inconsistent Data
- Low Coverage
- **Cost per square mile = £500**



WHY UAVs?



As with any form of photography

The quality of image is dependant upon the pixel size.

Typically, pixel size on a satellite image is between 30m and 5m square. A few go to half metre squares.

UAVS can acquire a pixel size smaller than 20mm square, this is *at least 100 times more 'accurate'* than satellite images at their very best.

WORK METHOD STRATEGY

- **Collaborate** with local project members and partners to ensure all available information about the project geology is known. This allows for excellent interpretation of the images.
- **Commence with satellite image analysis**, but with a **different strategy from competitors**. Collaboration and project study through various analyses scenarios **with** Project Geologists. Not just sending them 'print outs' and digital images which they are unable to develop any further.
- **Define the most suitable UAV and appropriate cameras** to enable the collection of the raw images.
- It is essential that **MinEx are flexible** because UAV and camera technology is developing rapidly. The market is dynamic, depending on the clients' needs and geological scenarios encountered. Flexibility in application of the technology means that it is **applicable to every type of mineral**.
- **MinEx have a UAV exploration option**, using the same processing techniques as satellite image analysis. A UAV image capture and analysis will provide more detail after the initial satellite analysis, if needed.

CURRENT PROJECT ABILITY

- **Experts** who working on this project are among the brightest and most experienced spectral G.I.S. Technicians and Geologists in the world, with specific experience in minerals analysis.
- **MinEx have used hyperspectral satellite image analysis** as a Consultant to exploration clients over the past eight years.
- **MinEx have Associate 'pairs' who analyse satellite images** and are experienced in the various GIS programs needed to do this.
- **MinEx have Associates** who are highly experienced **Field Geologists**, able to work with the GIS personnel and client Geologists.
- **MinEx have access to many young Exploration Geologist** Associates who understand the principles of the project and are able to take the remote image results to the field, to study and prioritise targets.
- **MinEx have researched available UAVs** and have Associates who are licenced and highly experienced in operating UAVs.
- **MinEx have extensive contacts** in the exploration industry **to promote and market** the technology to.

PROJECT MANAGEMENT

A project, Contractors and Clients will be coordinated by an experienced solid minerals project professional. This may be done remotely, or may involve site visits. The Project Manager will manage contacts, oversee projects and accompany teams to locations to ensure fluidity in work flow. The applicability is world wide.

Presently the base for communication is in the UK where

- immigration entry visas are easily obtainable if the team need to come together to share ideas for projects and development and where it is possible to test and gain experience in UAV flights.
- internet data transfer rates are very fast for large data sets.
- There is a sizable potential client base in the exploration sector.

Personnel will initially mostly 'work from home', and on an 'as and when needed' contract basis, executing site visits and contract work as required.

Steve Canby, B.Sc. (Hons.) Eng. NADSAM (U.C. Cardiff, South Wales) Minerals Project Evaluation/Assessment expert.

Steve is able to administer the initiative and coordinate the work and head the marketing and project coordination. Presently based in the United Kingdom, consulting to the exploration and mining industry. Working mostly on exploration projects world wide with GIS experts in remote sensing applications, he has realised that remote data analysis is the future of minerals exploration.

Steve brings over 39 years' experience as a Minerals Exploitation Engineer initially with project experience at Anglo American and De Beers. He is a project assessor and developer and has been involved in many more than 100 mining and exploration projects. As Principal Associate of the MinEx Associates Group, he has access to more than 270 registered Associates. He is a specialist in diamond and other precious and semi-precious stones, COLTAN (tantalite), tin, gold, coal, copper, mineral sands, iron ore, dimension stone (including limestone, marble and granite), asbestos, etc. He has been a driver of cutting edge geophysics techniques among technical leaders, worldwide. Experience in Mozambique, South Africa, Uganda, Swaziland, Ethiopia, Cameroon, Sierra Leone, Guinea and the DRC, in all 20 countries in Africa, South and Central America, Russia & FSU and Europe.

Steve worked for and consulted to many junior and mid-tier Stock Exchange companies in the UK as well as senior Geo-Engineering Companies, Wardrop (now Tetratex) Atkins, DRA, Batemans. Responsible for budgets and project executions exceeding \$100m, involved in key positions with projects in excess of \$700m.

Zsolt Katona, Expert GIS Technician (20 years), IT systems analyst and trainer

Zsolt will be responsible for processing data and discussing with geologists to make accurate geological analysis to produce targets. Presently ZsK is a senior GIS engineer at Envirosense Hungary Ltd He is an accomplished trainer of (GIS and IT), GIS support to different research programmes, and is an excellent overall system administrator – windows, UNIX.

He is highly experienced practical engineer with desktop and server GIS software (both Open Source and commercial) and has completed various specific analyses in the minerals sector from satellite images. He has written handbooks in Hungarian language for training in ArcGIS and delivered that training to all levels of personnel in various disciplines.

He has performed many field surveys in Africa and Europe (with GPS and sonar systems), post-processing the results (including creating geodatabase to store the data from different sources, to perform high level analysis, datum conversions and 3D modelling) he produces cartographic maps for decision making support and presentation, including various LIDAR-related tasks, mainly DTM, DSM and nDSM creation.

Rudi Romijn UAV Pilot. Maritime Management Graduate,

Rudi is a commodity inspector for a wide range of products in Rotterdam, Holland and has mining and exploration experience Solid fuels, Metals, Metal Ores, Non-metallic ores and minerals

He has considerable commodity expertise in western and central Africa with emphasis on Tantalite / Columbite / Wolframite and Cassiterite: mining / processing / sampling and analysis. The biggest of which was a barite mining project in which new deposits were sourced and exploited. Since 2004 he has been Director / owner of DutchInspect BV (www.dutchinspect.net);

Since the early 80's, Rudi has been flying everything with wings or propellers using remote control as a hobby has been integrated in today's inspection work by deploying UAV's; flown manually or autonomously and has been a licensed UAV pilot since 2015. This has involved volume calculations using dedicated software and autonomous UAV flights, Infrared recording using UAV's and damage assessment in areas which are difficult to reach (wind mills)

Tim Strong Consultant Geologist, BSc (Hons) Applied Geology CSM Exploration Geologist.

Tim is an exploration and resource professional with >10 years experience in the design, implementation and management of gold and base metal exploration projects in 11 countries on 3 continents. He holds a BSc (Hons) in Applied Geology from the Camborne School of Mines (UK) and is a current MBA candidate at the University of Dundee.

Tim has worked for companies such as Barrick, Antofagasta and Perseus Mining in locations such as Pakistan, Sudan, Eritrea, Spain and West Africa and is the Managing Director of Caribbean Minerals Ltd. focused on gold in Jamaica & Safi Minerals Ltd. focused on sedimentary copper in Mauritania, he has a wealth of exploration and resource geology experience positions Tim to partake in all levels of the exploration value chain, from project generation through to resource definition.

Tim is typically involved in technical due diligence for capital markets, project generation and technical review of projects and is a Qualified Person for NI43-101 reports and is an exploration and resource professional with >10 year's experience in the design, implementation and management of gold and base metal exploration projects in 11 countries on 3 continents.

In practice Tim will work with GIS experts to identify minerals and associations from spectral signature libraries to interpret and identify targets on images.

Terence Mothers MSc , IMBA Information Systems (GIS) at Portsmouth University in the UK.

Terry is a Geographical Information Systems and Remote Sensing Specialist

With 21 years of experience in the Sub Saharan Region Terence's other projects have focused on the use of Geographical Information Systems and Remote Sensing techniques, where he specialises in the definition of Geological and lithological units and identifies mineral compositions for specific exploration projects. An emphasis of Terence's work is focused on concessions with potential production of coal, iron ore, and gold. Terence has a wealth of experience originally originating from a commercial/amenity horticultural background in the UK he has developed a wide portfolio of work that includes the development of agricultural and horticultural high value crops in Africa, India and The Middle East.

In practice Terry will work remotely most of the time, but will travel to sites to work with Geologists, or Geologists will go to work with him to identify minerals and associations from spectral signature libraries to interpret and identify targets on images.

Mark Davis Consultant Geologist, B.Sc. (Hons) Geology; Research Masters Igneous Petrology FGS CGeol, EurGeol FSEG

Mark is an exploration and mine professional with over 25 years experience in mineral exploration and mining including the management of exploration projects for diamonds, base metals and gold. He holds a B.Sc. (Hons) from The university of Newcastle upon Tyne and a Research Masters from The University of KwaZulu-Natal focused on the Bushveld complex of south Africa.

Mark has been based in five countries and worked with companies such as Anglo American/De Beers, Anglo Platinum and consulting firms such as SRK and Fugro. Mark's work has included countries such as Russia, South Africa, the DRC, Saudi Arabia and the UAE. The majority of Mark's experience is in Africa.

Mark's involvement is typically based around either advising clients on how to develop early stage projects or advising clients on the investment potential of projects. Over the past 14+ years this work has included extensive field work for PFS and FS reports, data and report reviews on early stage projects for sale and evaluation, giving feedback on the results.

Field Geologists

MinEx Associates have many field geologists with various levels of practical experience, ready to jump aboard this interesting, cutting edge project anywhere throughout the world and to develop them to the next level

ENQUIRIES & COSTS

There are obviously many variables to consider.

Send us a formal RFQ (request for quotation)

*Even if you can provide some rough specifications of your project
(location, target/s and area)*

...we'll respond to you with options and proposals to suit your budget



Enquiries: **Steve Canby**
MinEx Associates
stevec@minex.org