SWiR
Spectral Analysis

geoimage

Everything you need to know about SWIR

ABOUT

GEOIMAGE

Geoimage has been a leading independent specialist in satellite imagery and geospatial solutions for more than 30 years.

With decades of local, national and international experience working within the mining, engineering, oil and gas, agricultural, government and environmental industries, we have built trusted relationships with our clients and our partners based on insightful service, shared knowledge and aligned goals.

Our success is achieved from the expert advice and innovative problem solving of our team. We are committed to translating our innovation and new spatial technologies into solutions that deliver greater efficiencies, lower costs and improved outcomes for our clients.

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ABOUT

SWIR

For many, using satellite imagery has been a game changer for their business. The great news is that SWIR just got better.

For over 30 years, Geoimage has been a world leader in spectral analysis of SWIR using ASTER & Landsat Data. Geoimage has broad expertise of providing objective, temporal and multispectral analysis of many of the world's leading commercial satellites imagery, across all vertical markets.

Using SWIR technology, we are assisting many businesses to collect, understand and leverage competitive advantage and operational efficiency within their business.

In this eBook we share our knowledge and insights on SWIR and how it's set to revolutionise the remote sensing industry by differentiating ground materials through automated information extraction. Our highly specialised team have highlighted the key benefits and applications and demonstrate its applications with current samples and case studies.

This eBook is essential reading for those wanting to stay one step ahead of their competitors.

SWiR
Spectral Analysis

THE SPECIALISTS

Greg Madden /
Geospatial Processing Specialist

Greg Madden is a Geospatial Processing Specialist with over 15 years experience within the commercial geospatial industry.
Prior to joining Geoimage, Greg served 22 years in the Royal Australian Air Force, the last 13 of which were as a Geospatial Imagery Intelligence Analyst. During this period he was involved in the planning, tasking, collection, analysis and delivery of Defence imagery and imagery-derived products.

Simon Greig /
Sales Manager

Simon has over eight years experience within the commercial geospatial industry and has been involved with database design and management, software sales, remote sensing, analysis and the delivery of imagery-derived products. With experience in the field of remote sensing for the major vertical markets including mineral exploration, agriculture and the natural and urban environments, Simon provides invaluable support to our clients when looking for the right solution.

Mark Covington /
Enterprise Solutions Manager

Mark has extensive technical and managerial experience spanning 25 years developing intelligent mapping solutions for clients across the mining & exploration, transport, utilities and government sectors. Marks' experience managing projects and technical skills ensure high returns on investment and outstanding outcomes for clients.
Mark is passionate about problem solving and using technology as an enabler of business. His experience covers the full gamut of product and service development from idea through design, implementation, testing, deployment and ongoing support.

ABOUT

MAXAR

Maxar is a leading provider of commercial high-resolution earth observation and advanced geospatial solutions that help decision makers better understand our changing planet in order to save lives, resources and time. Sourced from the world's leading constellation, their imagery solutions deliver unmatched coverage and capacity to meet our customers' most demanding mission requirements. Each day customers from a wide range of industries depend on Maxar data, information, technology and expertise to gain actionable insight.

Maxar owns and operates the most agile and sophisticated constellation of high-resolution commercial earth imaging satellites, including WorldView-3 which can capture images in shortwave infrared (SWIR).

MAXAR

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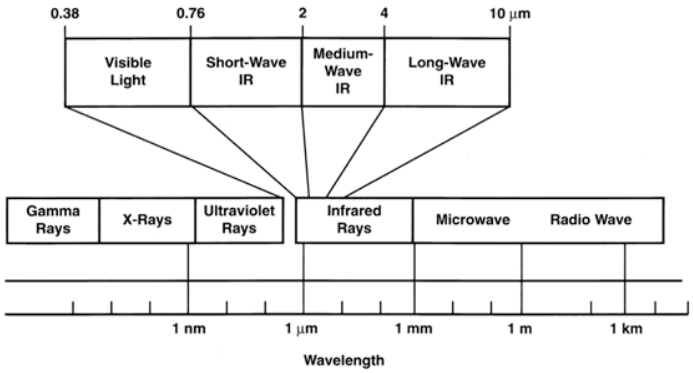
01 / WHAT IS SWIR?

Capturing images with Shortwave Infrared (SWIR) isn't anything new in itself, however capturing very high resolution SWIR in eight bands has opened up a new world of potential that Geoimage is using to tip established business models on their head.

Transforming the remote sensing industry from a pixel-based industry into a product-based industry, DigitalGlobe's WorldView-3 commercial satellite expands deeper into the infrared spectrum with SWIR providing rich data for precisely identifying and characterising man-made and natural materials.

SWIR data allows you to see what the human eye cannot. A typical human eye will respond to wavelengths from about 390 to 700 nanometres (nm). The visible light spectrum is not limited to all the colours that the human eyes and brain can distinguish and as we move away from visible light towards longer wavelengths of light, we enter the near infrared region which is followed by the SWIR region. Shortwave infrared light is typically defined as nonvisible light which falls within the 1400 and 3000 nanometres (nm) in wavelength.

Figure 1 - Electromagnetic Spectrum



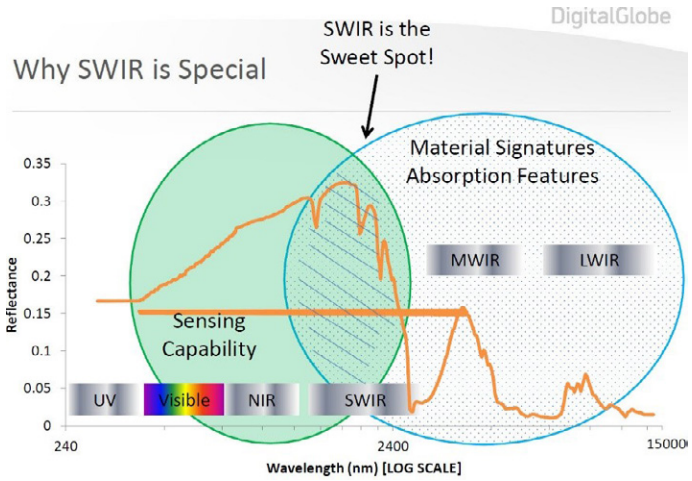
SWIR light is reflective; it bounces off of objects much like visible light, however SWIR wavelengths make objects easily recognisable and yield one of the tactical advantages of this imagery, namely, object or individual identification.

How can I use it?

Due to minimal atmospheric influence or noise in this part of the Electromagnetic Spectrum, as well as an enhanced ability to differentiate among ground materials, the SWIR bands open the door for automated information extraction that allow it to be interpreted in some incredible ways.

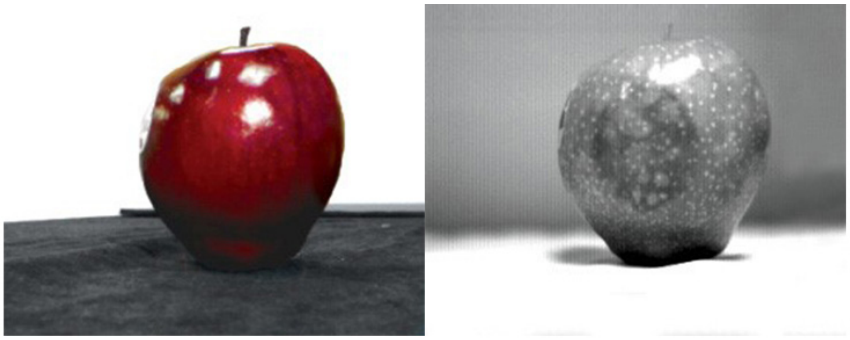
The benefits of collecting reflective data in these wavelengths are vast as the measurements can help reveal the mineral content of rocks, the moisture of soil, the health and species of vegetation, the physical composition of building and thousands of other invisible details. This spectral information is visible to the digital sensor because of the energy reflectance it measures.

The density, water content, chemical make-up and other unseen conditions and characteristics of a particular surface feature all influence how energy in various wavelengths (or spectra) interact with that feature and reflect off it. In effect, the digital sensor measures this spectral interaction, which in turn provides insight to those invisible conditions and characteristics.



The invisible becomes visible

A person viewing a natural colour image, can easily identify basic features we come to see every day with the naked eye. However, at times the absorption features which define a material will only be apparent in the shortwave infrared region of the electromagnetic spectrum. As is the case below, the apple appears to be normal and healthy, yet when you introduce the SWIR lens, you can clearly see the difference. Blemishes and imperfections are now readily identifiable, which may indicate disease or other concerns.



Natural Colour Image | Same image view through SWIR lens

The same principle is applied when using satellite imagery. Viewing a scene in multispectral mode can only show you what is apparent to the naked eye yet there is often more to the story.

Decisions are limited by the amount of information available, so the ability to augment your results by having data covering more of the electromagnetic spectrum will only help you to see and understand more about your area of interest.

Who can use it?

There are a number of industries that would benefit from using SWIR data, particularly those businesses that would benefit from object identification or objective analysis. For example;

- Farmers looking to increase yields whilst decreasing costs and minimising the environmental impact with precision agriculture and farming practices.
- Insurance companies and loss adjusters who need to identify, detect or verify the existence or condition of assets.
- Mining companies could save millions of dollars with much improved ability to identify ore body indicators during their exploration phase.
- Local governments can utilise SWIR in identifying different land cover types, emergency management planning practices and new land tax strategies.

These are but a few industries that would value the insight and impact that SWIR can have on your company's bottom line.

02 / APPLICATIONS AND BENEFITS

Using SWIR technology to extract real world information, Geoimage has the ability to differentiate ground materials through automated information extraction.

Imagine a product that could indicate potential ore bodies anywhere in the world; detect the amount of crop residue left behind after a harvest without even leaving your office; classify tree species over vast areas or being able to confirm and auto-detect the change of any roofing material on any building across a whole city; or an image that can penetrate smoke haze and cloud cover better than ever before.

Moving from pixel-based images into providing solutions-focussed services, Geoimage delivers business intelligence like never before.

Infrastructure and Planning Management

KEY BENEFITS:

- Strategic planning
- Improved mineral identification

Utilising SWIR data, you can manage downstream operations around your key assets i.e. processing plant and infrastructure, access and haulage, route planning and alike.

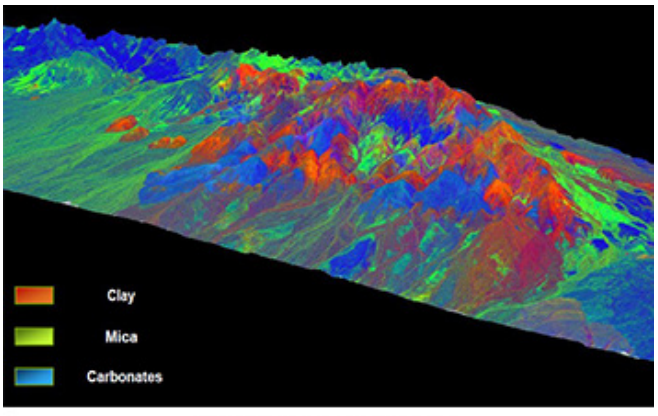
While the geology and mining industries spend millions of dollars to identify potential mining sites during their exploration phase, SWIR data can cut costs and increase efficiency by narrowing the potential area before field verification is planned. Spectral bands allow for unique mineral identification and chemical measurements. Energy from light is either transferred to molecules of matter or reflected away from them. Based on the mineral content, different materials absorb specific wavelengths of light and reflect others.

Fires have a devastating impact on communities and natural resources. They can cover extensive areas, move at incredible speeds and change direction without notice.

The unique SWIR band not only penetrates smoke, it allows for a clear view of the ground and can also pinpoint sites of active burning.

This type of imagery can be a tremendous asset in discovering burn extent information and analysing the impact of the fire and is useful to power and water utilities, communications companies, insurance providers and state and federal Government agencies involved in disaster mitigation and relief.

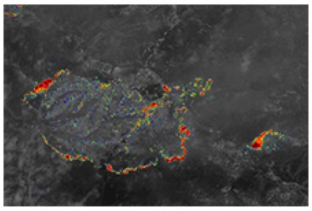
WorldView-3's increased spectral resolution of
16 bands spanning the VNIR to SWIR, allows for
an extension of visual interpretation to machine interpretation and analyses using material spectral signatures. Non-visual imagery will become a new standard for imagery information extraction and insight derivation.



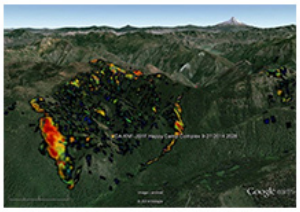
Mineral Indices WorldView-3
Image courtesy of DigitalGlobe

Wildfire smoke in colour image

Wildfire smoke penetration in SWIR



Wildfire smoke penetration & heat map in SWIR



Heat map as overlay in GoogleEarth

Yield Management

KEY BENEFITS:

- Improve efficiency
- Observe and map phenomena

SWIR data provides your business with the ability to improve efficiencies and adopt new lean process management functions to ensure highest yield.

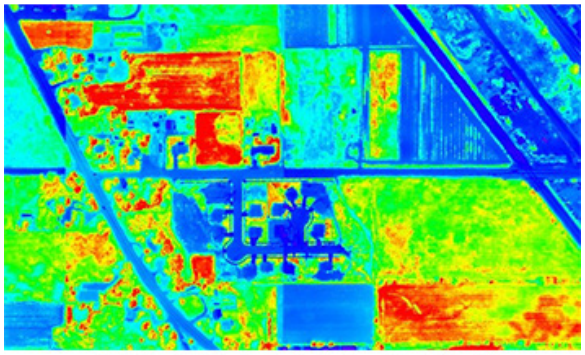
The SWIR band at 2.2 micrometres makes it possible to detect the amount of crop residue left behind after a crop is harvested and provides farmers with key information to make decisions about whether and how to till the soil. There are best-management practices that tell you the percentage of crop residue to leave on the field. The SWIR bands at 1.6 micrometres or 1600 nanometers will make it possible to see whether an agricultural field contains sufficient moisture.

The visible and NIR bands give great information but also contain a lot of atmospheric noise because they are affected by aerosols and water vapour, which are constantly changing. SWIR, however, minimises this noise. We can actually start differentiating between different types of crops using the SWIR bands as well as the visible and NIR bands

It is critical to improve farm productivity and yield while decreasing costs, minimising the environmental impact with precision agriculture practices and better managing agriculture production and associated inventory. It is important to take corrective action early in the growing season by understanding crop conditions such as crop health and stress due to problems such as nutrient deficiency, moisture stress and pests.

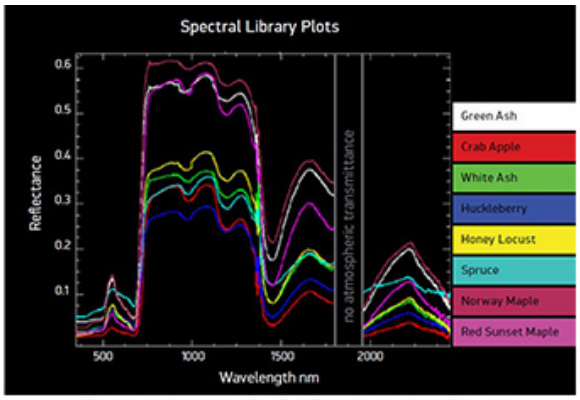
WorldView-3 data is uniquely designed to observe and map these phenomena.

Crop stresses change the green chlorophyll content of the leaves and replace them with carotenoids that have yellow and red colours, identifiable in the Electromagnetic Spectrum. Yellow, red edge and the two near-infrared bands are sensitive to changes in the green chlorophyll and expose the carotenoids during stress. In addition, SWIR bands are used to assess crop moisture, as another health indicator. Observing soil types and conditions before, during and after a crop season is important for managing crop health. WorldView-3 offers a window into underlying soil conditions and how such conditions might affect vegetation. Soil organic composition and moisture levels are assessable through the VNIR and SWIR bands. When properly monitored, such information can help users understand current and future crop potential.



Soil Adjusted Vegetation Index from WorldView-3

Image courtesy of Excelisvis



Spectral signatures for 8 different species of trees

Our systems can be programmed and trained to identify and report pertinent information periodically to better inform your business. SWIR bands make it possible to differentiate between an oak tree, an aspen tree, and a pine tree. It also makes it possible to detect very early when trees are affected by infestations, such as the pine beetle. WorldView-3's spectral bands, including VNIR and SWIR, allow for tree class and species identification. Tree species have unique spectral signatures, like fingerprints, that can be extracted automatically. Stressed trees will exhibit similar symptoms as stressed crops, as green chlorophyll in the leaves is replaced by yellow and red carotenoids.

Asset Management

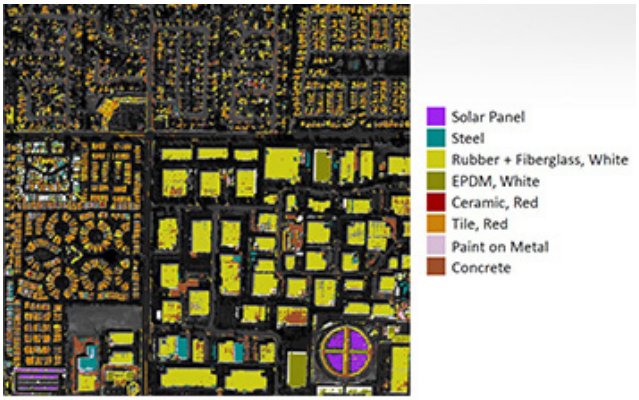
KEY BENEFITS:

- Materials identification
- Auto-detect and report change

To insurance companies and loss adjusters, the roof is the most important part of your house or building. The roof is the first layer that wind, hail, wildfire and other hazards really begin to impact. In more than 90 percent of hail or high-wind claims, there is a payout relative to the roof cover.

Not all roof types are treated equally when it comes to insurance. There are roofs that are insured with no questions asked, while others require additional inspections for underwriting purposes, and then there are roofs that some companies simply won't insure. With this in mind, the insurance industry are keen to understand what materials roofs are made of and the use of SWIR data can help them classify this. The example below shows a classification utilising WorldView-3's SWIR data.

Geoimage can use data derived from SWIR to not only identify roof types, but can write an algorithm that auto-detects and reports change in roof materials.



Roof material identification for insurance company

03 / RESOLUTION

We all know that when it comes to pixels, small rules. However, WorldView-3 offers spatial, spectral, temporal and radiometric enhancements that when combined provide significant opportunity to perform a range of value added analysis. For many companies, institutions and organisations this offers a significant advantage and competitive edge.

The WorldView-3 SWIR bands are the focus of the Spatial Intelligence Series and in our mind offer greatest potential for a variety of applications. Geoimage can use the above-mentioned resolution enhancements offered by WorldView-3 as building blocks to run analysis and to extract information to support your business.

Spatial Resolution: Area & Detail

The spatial resolution specifies the pixel size of a satellite image. The higher the spatial resolution, the more detail it will contain. Fine details can be seen in the very high and high resolution images, whilst a low resolution image will only show coarse features.

At Geoimage, we break down the spatial resolution into 3 ranges:

- Very High resolution (sub metre): 30cm – 1m
- High resolution: 1.5m – 10m
- Medium resolution: 15m – 30m

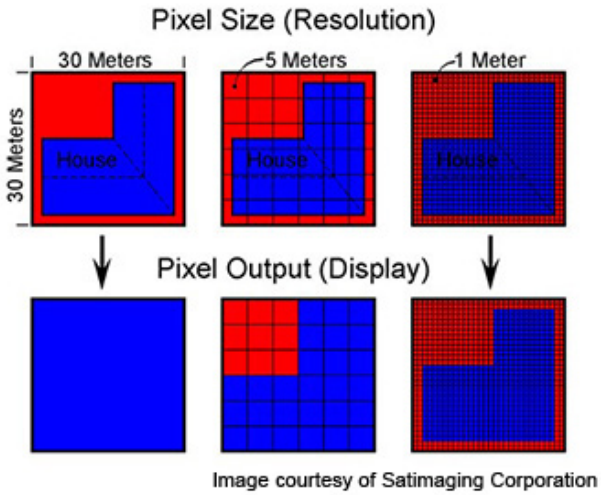
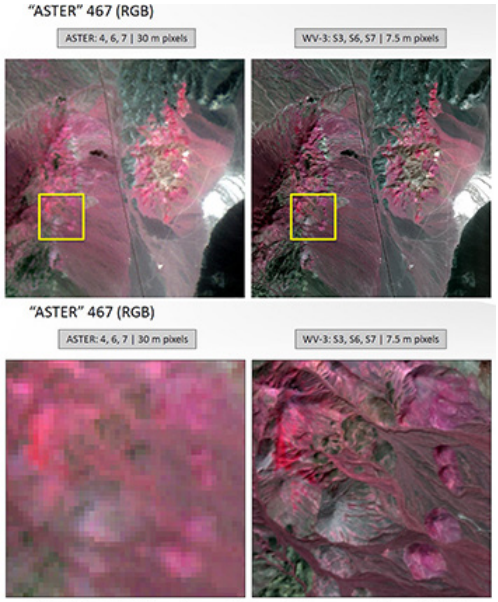


Image courtesy of Satimaging Corporation



ASTER & WorldView-3 - spatial resolution comparison. ASTER captured at 30m resolution compared to World-View-3 - delivered at 7.5m resolution

Image courtesy of DigitalGlobe

The spatial resolution you choose depends on the smallest object that you would like to see. An important factor to consider is the trade-off between scene size and spatial resolution.

Images of our changing planet are important for decision makers managing Earth's natural resources. With WorldView-3, you can automatically distinguish different colour textures and measure change over time which is important for the energy sector, conservationists and governments. The shortwave infrared (SWIR) sensor will multiply the value of WorldView-3 imagery by enabling the detection of specific mineral content and species of vegetation through signatures not identifiable with the naked eye.

WorldView-3 can also more accurately monitor the rate of development and investment at a regional or global scale. This includes the rate of construction as well as finer details like building materials, rooftop reflectance, road networks and population density, which is valuable to governments, industry and location based service customers.

Did you know?

Maxar's WorldView-3 actually captures SWIR data at 3.7m resolution.

Spectral Resolution: Colours & Bands

A sensor's spectral resolution specifies the number of spectral bands in which the sensor can collect reflected radiance. The choice or number of spectral bands required will depend upon the application of use. The spectral reflectance curves, or spectral signatures of different types of ground targets provide the knowledge base for information extraction. Reflectance measurements can help reveal a multitude of invisible details such as mineral content of rocks, the health of vegetation, the moisture of the soil and the physical composition of buildings to name but a few.

Things to consider with regards to spectral resolution:

- Number or choice of spectral bands (red, green, blue, NIR, SWIR, thermal etc.)
- Width of each band
- Certain spectral bands (or combinations) are good for identifying specific ground features

At Geoimage we classify the spectral resolution into 5 ranges:

- Panchromatic – 1 wide Band (B&W imagery)
- Colour – 3 bands (Red, Green, Blue)
- Multispectral – 4-8 bands (RGBN)
- Super spectral – 16 bands or more
- Hyperspectral – hundreds of bands

Besides offering 30 cm resolution panchromatic and 1.2m eight band visible and near-infrared (VNIR) imagery, WorldView-3 is able to collect shortwave infrared (SWIR) imagery in eight bands. This allows the satellite to sense the VNIR spectrum as well as expand deeper into the infrared spectrum, than any other commercial imaging satellite, providing rich data for precisely identifying and characterising man-made and natural materials. Worldview-3's eight SWIR bands span the spectrum's three atmospheric transmittance imaging windows to capture unique information for agriculture, forestry, mining/geology and other applications. The SWIR bands open the door for automated information extraction to save time, money and lives.

SWIR Band	Wavelength	Application of Use
SWIR 1	1195 - 1225 nm	
SWIR 2	1550 - 1590 nm	Between 1550 and 1750 nm, Man-made materials and chemicals present multiple absorption features in this range, examples include plastics, fiberglass, petroleum and snow and ice can be differentiated from clouds.
SWIR 3	1640 - 1680 nm	
SWIR 4	1710 - 1750 nm	
SWIR 5	2145 - 2185 nm	
SWIR 6	2185 - 2225 nm	Between 2000 and 2400 nm offers unique opportunities because of its mineral absorption features. With sufficient sensor radiometric resolution observers can make mineral identifications and chemical measurements in these windows.
SWIR 7	2235 - 2285 nm	
SWIR 8	2295 - 2365 nm	

Temporal Resolution: Time/Season/Year

The temporal resolution specifies the revisiting frequency of a satellite sensor for a specific location and the availability of archive data over a specific location.

To acquire SWIR data previously, you generally relied on ASTER, SPOT or one of the Landsat satellites capturing over your area of interest and then you had to hope that your area of interest was not affected by cloud cover when the satellites passed. With ASTER and Landsat, you were unable to place a new capture request to acquire your area, and had to rely on what was in archive. The revisit timeframe was/is 16 days (if acquired at all).

With WorldView-3, not only is the spatial resolution better, you are able to place new capture requests to acquire your specific area of need and the agility of this satellite means that it has a revisit capability of 1-3 days with regards to SWIR captures. For standard captures (8 bands or less) the revisit capability is less than a day.

Important factors to consider with regards to temporal resolution and multispectral imagery:

- Leaf on/leaf off
- Tidal stage
- Seasonal differences
- Shadows
- Relationship to field sampling
- Phenological differences such as flowering, breeding and migration differences in relation to climatic conditions
- Revisit times for satellites and how often can you acquire the same area

Radiometric Resolution: Colour or Bit Depth

Radiometric resolution refers to how much information is in a pixel and is expressed in units of bits. A single bit of information represents a binary decision of yes or no, with a mathematical value of 1 or 0. Typical Black & White images from a source such as a digital camera are 8 bits, meaning the information is represented with a value of 0-255 or 256 in total. In contrast, a colour image is represented using 3 channels, Red, Green, Blue and each channel is 8 bits, equalling 24 bits of information. Humans visualise colours as a combination of the three primary colours, red, green and blue. Every colour and corresponding shade is represented using a combination of these 3 primary colours and the intensity of each colour. A value of 0 in the blue channel means that pixel is black. If the value of a pixel in blue channel is 255, it means that the pixel is bright blue. So if a blue channel pixel has a radiometric resolution of 8 bits, there will be 256 shades of blue. A radiometric resolution of 11 means the pixel has 2,048 possible intensities of blue, 12 bit resolution represents 4,096 shades of blue and 14 bits represents 16,384 shades of blue.

DigitalGlobe's WorldView-3 satellite provides shortwave infrared (SWIR) imagery in 14 bit resolution to ensure users have the ability to leverage the power of SWIR bands for more robust information extraction.

The finer the radiometric resolution of a sensor, the more sensitive it is to detecting small differences in reflected or emitted energy and therefore small differences in ground cover.

Diagram showing the different shades of blue with 11 bit data (left) & the difference between 14 bit & 11 bit radiometric resolution – displayed as 8 bit data (right).

Resolution Trade-Offs

In the past there was always some type of trade-off when it came to resolution. Either the spatial resolution was high, but the spectral resolution was low or vice versa.

Now with the new offerings from WorldView-3, a new benchmark has been set.

Not only does the satellite offer the highest commercially available resolution at 30cm, it also offers 16 bands of spectral data, with a radiometric resolution of 14 bits for SWIR data and 11 bits for VNIR & multi or pan, and a revisit capability of less than 1-3 days. All bases are covered!

04 / CORRECTIONS AND COMPARISONS

Atmospheric conditions can impede image capture. WorldView-3 is capable of detecting the presence of clouds, aerosols and water vapour to provide you with a clearer image. SWIR technology is invaluable for companies and organisations to better identify objects, track changes and harness the power of big data analysis.

Geoimage provides custom solutions utilising SWIR technology, empowering organisations to make better decisions with enhanced outcomes.

Atmospheric Corrections

KEY BENEFITS:

- Identify features and perform analysis that have not been possible before
- Detect the presence of clouds, aerosols and water vapour
- Measure the exact atmospheric conditions

Remote sensing satellites view Earth from above the atmosphere i.e. they collect top-of-the-atmosphere (TOA) measurements of the Earth's features.

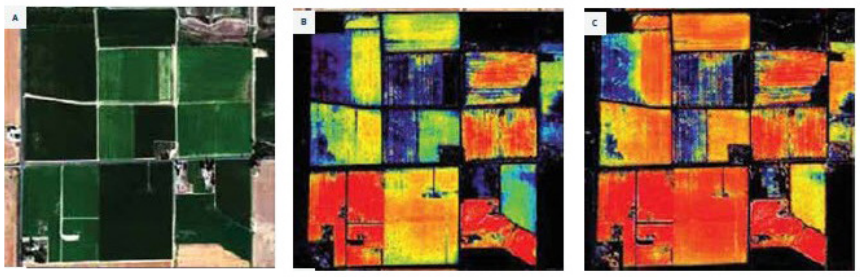
Changes in the atmosphere, sun illumination and viewing geometries during image capture result in inconsistent image data, hindering automated information extraction and change detection. Atmospheric conditions typically change during and between different imagery collections due to varying moisture levels (water vapour) and particulates (aerosols) in the atmosphere. Much research has been done trying to accurately convert the TOA measurements to surface-reflectance measurements.

The challenge has been the availability of accurate atmospheric measurements at appropriate scale, ensuring imagery can be normalised. WorldView-3 addresses this problem by being the first commercial imaging satellite with an atmospheric sensor as part of its payload.

During image capture, the WorldView-3 atmospheric sensor is designed to detect the presence of clouds, aerosols and water vapour at 31m resolution, thereby measuring the exact atmospheric conditions corresponding to every recorded image.

Maxar has developed algorithms that use these atmospheric measurements to normalise WorldView-3 imagery for consistency. This normalisation is called atmospheric compensation, which is especially important for information extraction, such as change detection and vegetation analysis because changes due to the atmosphere have been removed. Atmospheric compensation results in surface-reflectance image data.

Below is a comparison of top-of-atmosphere reflectance and surface reflectance.



A true colour surface reflectance image after atmospheric compensation

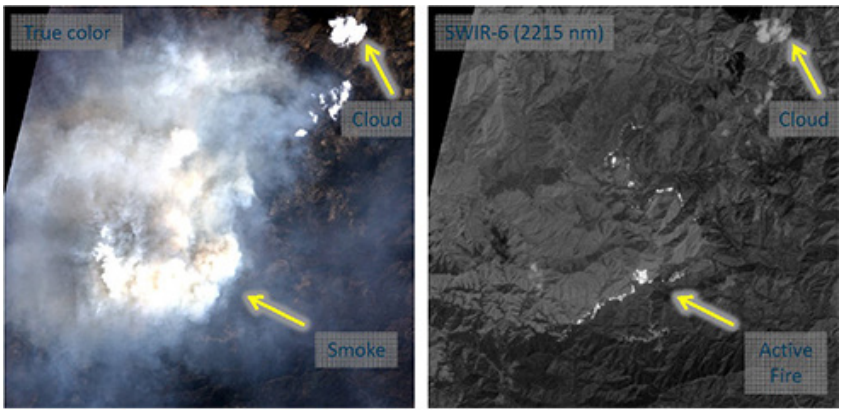
Normalisation Difference Vegetation Index (NDVI using top-of-atmosphere data

Normalisation Difference Vegetation Index (NDVI using surface reflectance

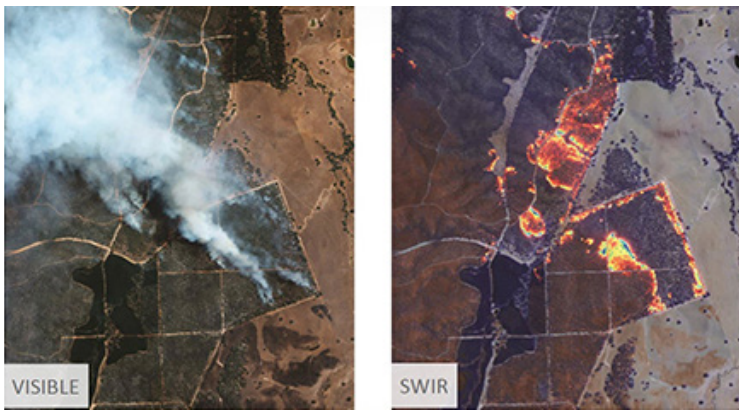
The NDVI from TOA data underestimates the relative amount of vegetation by about 10-13%

Another issue impairing automated information extraction is accurately mapping cloud cover. The sensors on WorldView-3 have spectral bands that range from the VNIR into the SWIR part of the Electromagnetic Spectrum to accurately distinguish clouds from other bright features such as snow and ice.

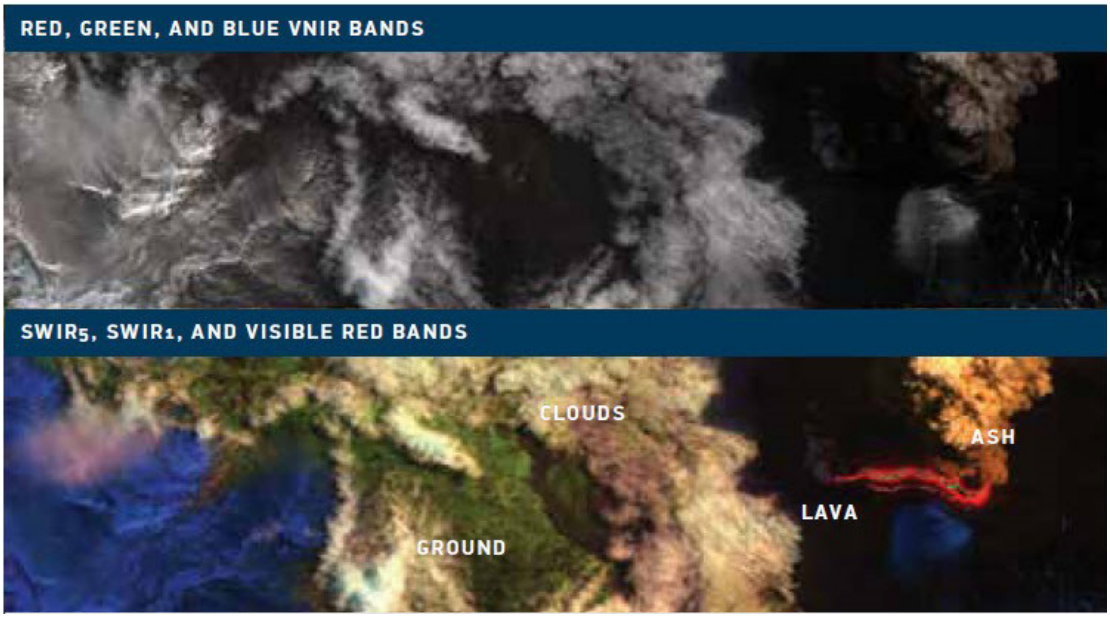
The longer wavelengths in the SWIR range of the atmospheric sensor are able to penetrate fire smoke and haze.



The above and below images of fires show how SWIR can penetrate through smoke. In each case the image on the left is a true colour (RGB) composite and the image on the right is a SWIR image. Note that in the above right image water vapour clouds remain opaque.



The below example shows an example of a 2010 volcano in Iceland using WorldView-3 simulated data using the Hyperion sensor to differentiate between ash, ice and snow.



WorldView-3 is the first super-spectral satellite to simultaneously map atmospheric conditions during image collection, allowing unprecedented access to normalised images across the globe. Such standardisation has introduced a new age in automated information extraction and change detection.

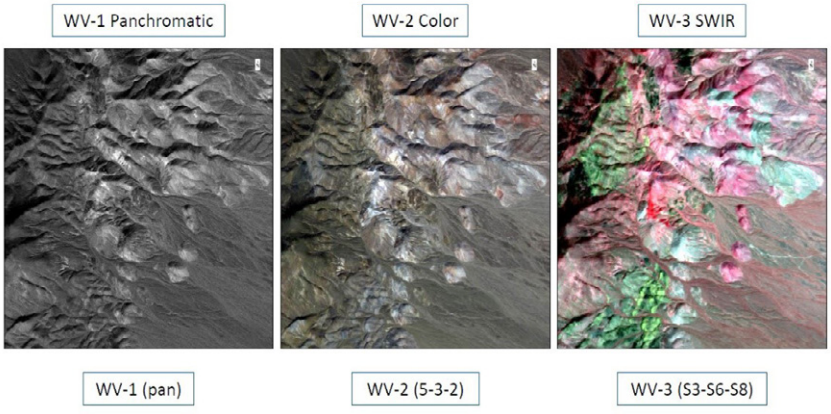
Comparisons: Band Combinations

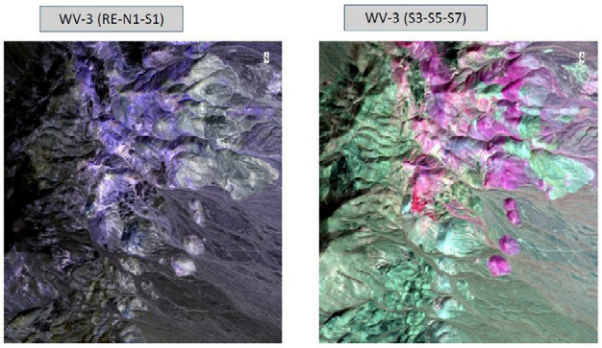
KEY BENEFITS:

- Image + Analysis = Insight
- Empower better decision making
- Geoimage can provide custom solutions

Exposed outcrops are manifestations of potential mineral ores or sub-surface deposits. The geology and mining industries spend millions of dollars to identify potential mining sites during their exploration phase. Utilising SWIR data from WorldView-3, mining operations can cut costs and increase efficiency by narrowing the potential area before field verification is planned.

The image on the right shows the comparison between panchromatic band (B&W), WV-2 in (RGB) and WV-3 using SWIR bands (3, 6, 8). The SWIR image is highlighting alteration, clays, carbonates using this band combination.



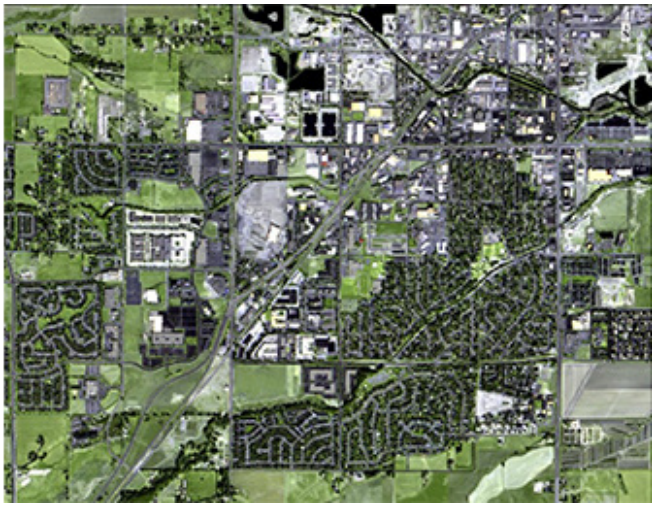


The images on the left highlight Iron bearing minerals and also alteration minerals and clays.

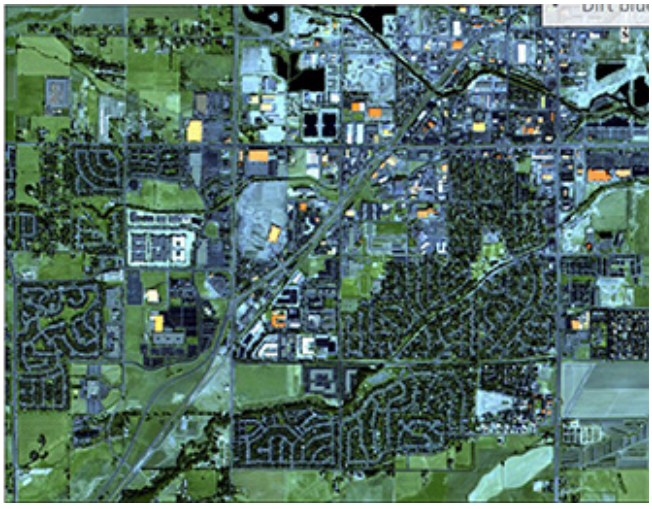
Rooftop detection from satellite images is important in a variety of applications. Some examples of which are change detection in urban monitoring, the production of digital maps, verification and updating of GIS databases, land use analysis and route planning.

Manual detection of building rooftops can be an expensive and tedious task but with the new SWIR bands, automatic identification and mapping of urban surface materials can reduce the time it takes, thus saving you time and money.

The image below identifies vegetation as green using the material SWIR Band combinations, S2, S3 and S5.



The following image depicts polymer/plastic as orange, vegetation as green and dirt as blue-grey using the material SWIR band combinations S2, S4 and S8.



Geoimage has extensive knowledge and can provide you with a suite of enhancements that extracts maximum benefit from SWIR data to better inform your business.

05 / CASE STUDY: MINERAL EXPLORATION

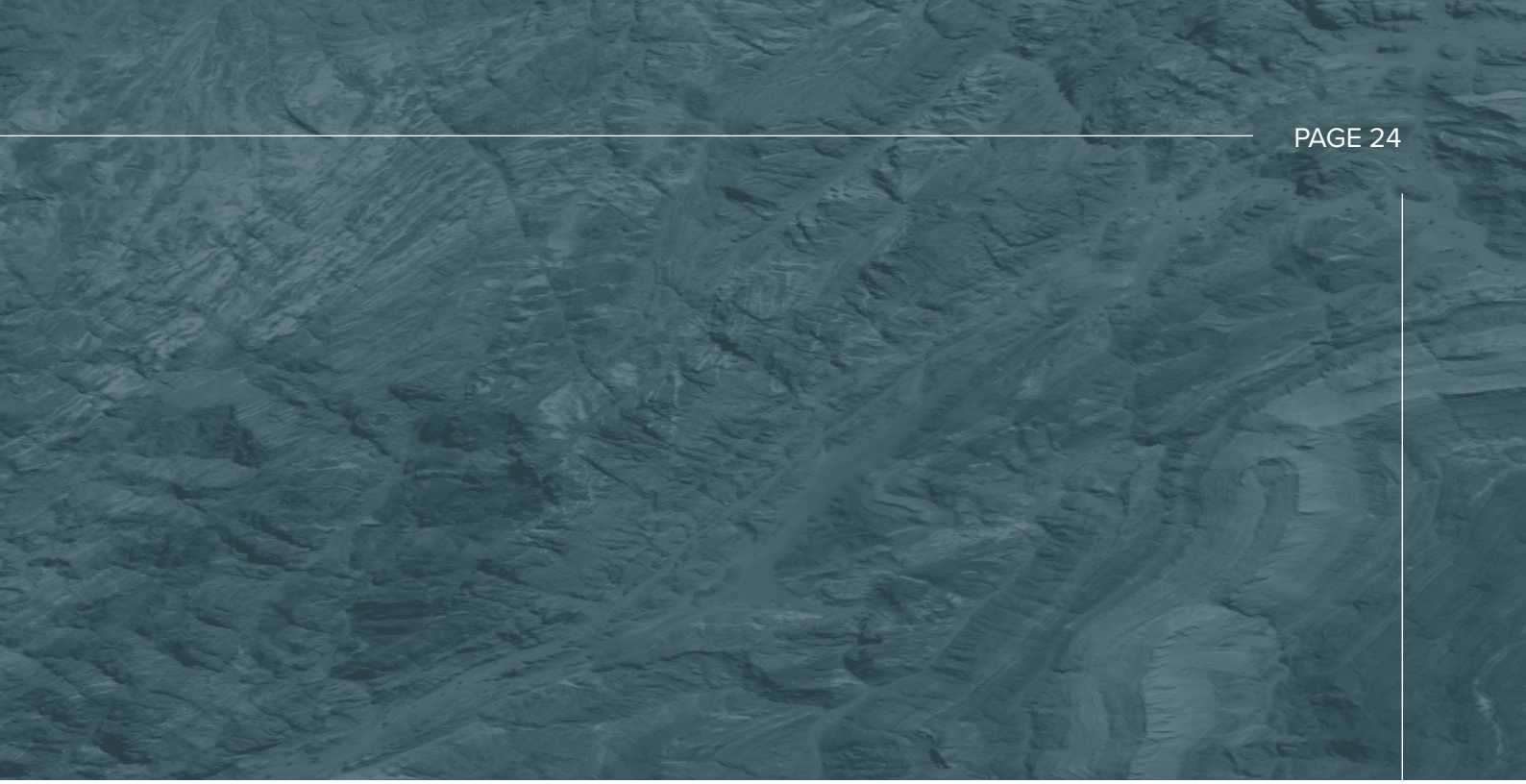
Delivering unprecedented geologic information and revolutionising the remote sensing mineral exploration market, WorldView-3 delivers detailed geological maps to clients in a rapid, cost-effective manner.

In many countries, mining can account for up to 90 percent of a country's gross domestic product and provide employment for a significant percentage of the population. Billions are invested yearly in mineral exploration, but traditional ground survey methods are expensive, potentially restricted by social, political or environmental issues, weather or access and are unable to thoroughly explore large areas in a timely manner.

WorldView-3's multispectral and SWIR data make it possible to generate spectral reflectance maps which show accurate and detailed geology for optimised field exploration at a high resolution, without being affected by adverse developments in the political climate or weather conditions allowing mining companies a scalable, cost-effective, qualitative and continuous way to explore for minerals.

The following case study is an example of the use of WorldView-3's multispectral and SWIR data to identify lithology with a high potential for uranium mineralisation, adjacent to the Rössing Uranium Mine in Namibia. The higher resolution WorldView-3 imagery is directly compared to lower resolution ASTER imagery over a test site south west of the mine.

Previous interpretation work by Anderson and Nash (Reference 1) using Landsat and aeromagnetic and airborne radiometric data is included in this case study and showcases the unprecedented detail available in the WorldView-3 imagery. Geoimage gratefully acknowledges the contributions by Dr Colin Nash to this paper.



Namibia: Southwest of Rössing Uranium Mine

Excerpts from www.rossing.com/history.htm:

“Uranium was discovered in the Namib Desert in 1928, but it was not until intensive exploration in the late 1950s that much interest was shown in the area. After discovering numerous uranium occurrences, Rio Tinto secured the rights to the low-grade Rössing Uranium deposit in 1966. Ten years later, Rössing Uranium, Namibia’s first commercial uranium mine, began operating.

Today, Namibia has two significant uranium mines, which together provide for 5.8 per cent of the world’s uranium oxide mining output. Rössing Uranium produces 2.3 per cent of the world’s uranium oxide production. The mine has a nameplate capacity of 4,500 tonnes of uranium per year and, by the end of 2014, had supplied a total of 127,405 tonnes of uranium oxide to the world.

The mine is located 12 km from the town of Arandis, which lies 70 km inland from the coastal town of Swakopmund in Namibia’s Erongo Region. Walvis Bay, Namibia’s only deep-water harbour, is located 30 km south of Swakopmund.

The mine site encompasses a mining licence and accessory works areas of about 180 km^2, of which 25 km^2 is used for mining, processing and waste disposal. Mining is done by blasting, loading and hauling from the open pit, referred to as the SJ Pit, before the uranium-bearing rock is processed to produce uranium oxide. The open pit currently measures 3 km by 1.5 km, and is 390 m deep.”

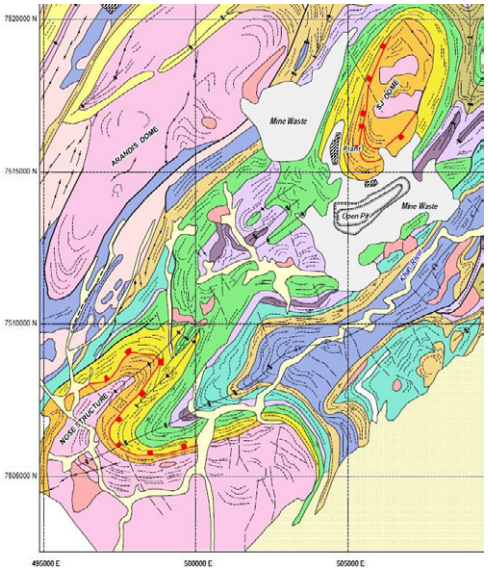
The alaskite type Rössing uranium deposit contains the largest uranium deposit in the world associated with an igneous rock and lies within the 400 to 500 km-wide Upper Proterozoic Damara orogenic belt, which extends from the Atlantic Ocean north-easterly across south western Africa before submerging beneath the post-Palaeozoic Kalahari Basin. Rössing is located on the south western flank of a regional oval NE-SW trending dome, about 2km from the contact of a gneissic Proterozoic basement and meta-sediments consisting of schist and graphite- and sulphate-rich marble (Reference 2).

Namibia: Southwest of Rössing Uranium Mine

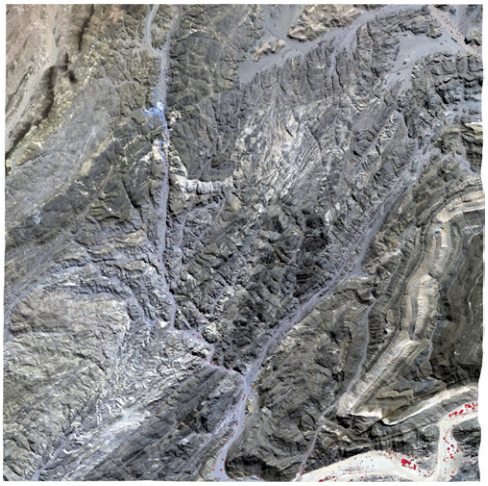
Location of test site outlined in red.

Rössing Uranium Mine lies to the north east of the test site.

Background image is a natural colour composite of Landsat-8 data acquired 30 August 2015.



Geological interpretation by Anderson and Nash (Reference 1), based on LANDSAT imagery, and aeromagnetic/airborne radiometric data.



WorldView-3 image.

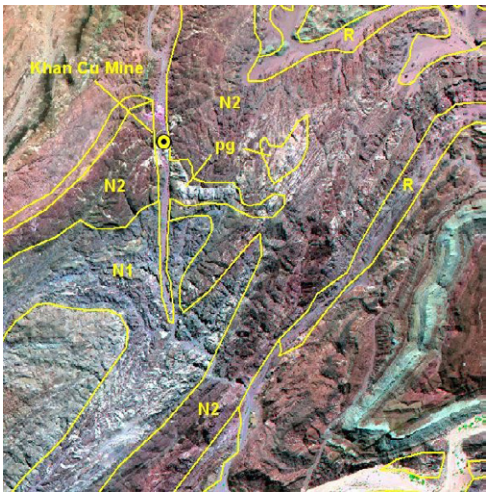
False colour composite over the test site - vegetation is shown in red.

Pixel resolution is 0.5 metres.

ASTER image.

False colour composite over the test site - vegetation is shown in red.

Pixel resolution is 15 metres.



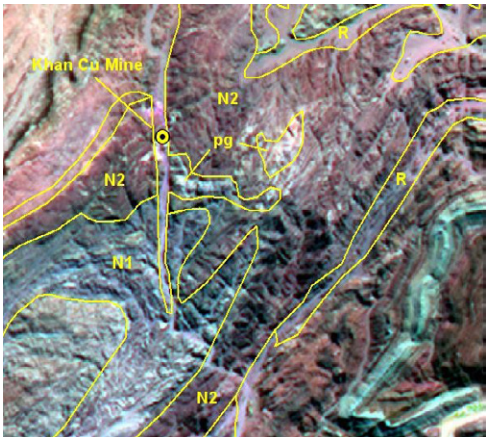
WorldView-3 SWIR image.

True colour composite over the test site - equivalent to a Landsat 742 composite. Geological boundaries are from interpretation of LANDSAT, aeromagnetic and radiometric data by Anderson and Nash (Reference 1).

Uranium mineralisation occurs in the Rössing (R) and Khan (N2) Formations. Strongly foliated pelitic schists and gneisses of lower Nosib Gp (N1) contain abundant white concordant pegmatitic granites. The massive pyroxene/hornblende gneisses of the Khan Fm (N2) show up as red/brown. Abundant white pegmatitic granites east of Khan Mine appear to be both concordant to foliation and locally transgressive. Rössing Fm carbonate/schist unit (R) forms low outcrops.

Pixel resolution is 7.5 metres.

Namibia: Southwest of Rössing Uranium Mine



ASTER image.

True colour composite over the test site - equivalent to a Landsat 742 composite.

Geological boundaries are from interpretation of LANDSAT, aeromagnetic and radiometric data by Anderson and Nash (Reference 1).

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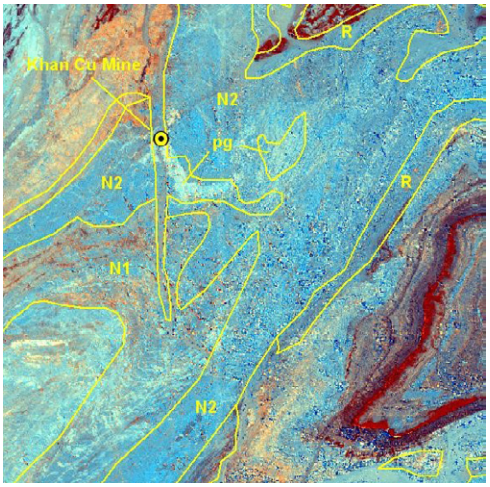
Pixel resolution is 30 metres.



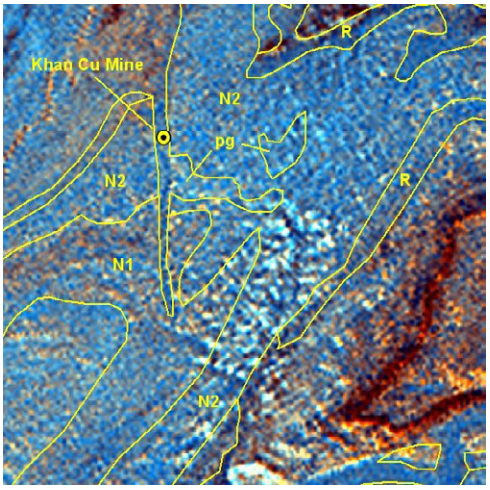
WorldView-3 SWIR image.

Al-OH Mineralogy composite over the test site.

Geological boundaries are from interpretation of LANDSAT, aeromagnetic and radiometric data by Anderson and Nash (Reference 1).

Uranium mineralisation occurs in the Rössing (R) and Khan (N2) Formations.

Pixel resolution is 7.5 metres.



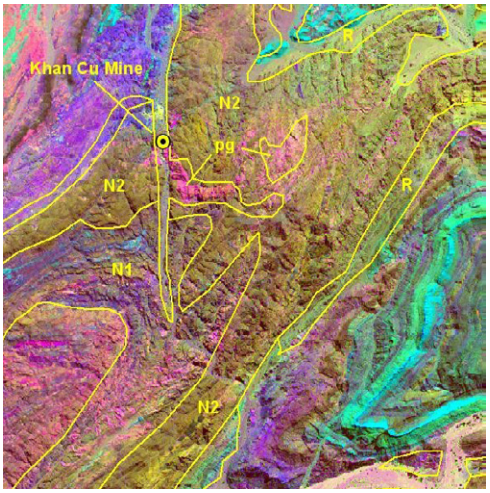
ASTER image.

Al-OH Mineralogy composite over the test site.

Geological boundaries are from interpretation of LANDSAT, aeromagnetic and radiometric data by Anderson and Nash (Reference 1).

Uranium mineralisation occurs in the Rössing (R) and Khan (N2) Formations.

Pixel resolution is 30 metres.



WorldView-3 SWIR image.

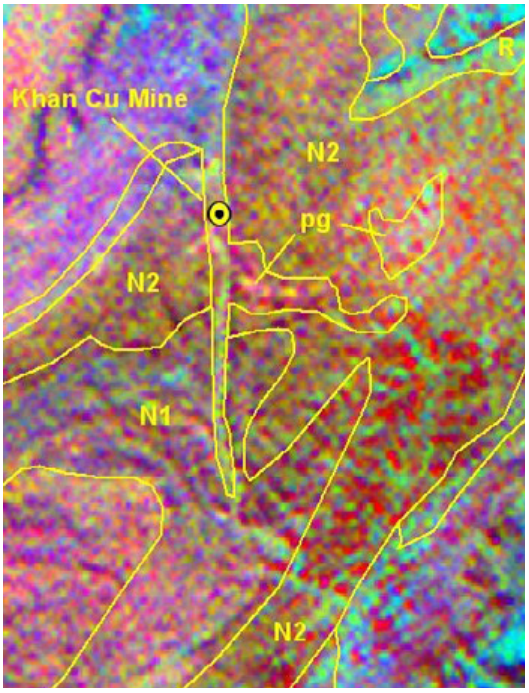
Decorrelation Stretch of SWIR bands 765 over the test site.

Geological boundaries are from interpretation of LANDSAT, aeromagnetic and radiometric data by Anderson and Nash (Reference 1).

Uranium mineralisation occurs in the Rössing (R) and Khan (N2) Formations. Strongly foliated pelitic schists and gneisses of lower Nosib Gp (N1) contain abundant pink concordant pegmatitic granites. The massive pyroxene/hornblende gneisses of the Khan Fm (N2) show up as brown. Abundant pink pegmatitic granites east of Khan Mine appear to be both concordant to foliation and locally transgressive. Rössing Fm carbonate/schist unit (R) forms low outcrops and display a greenish colour.

Pixel resolution is 7.5 metres.

Namibia: Southwest of Rössing Uranium Mine



ASTER image.

Decorrelation Stretch of SWIR bands 765 over the test site.

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Pixel resolution is 30 metres.

The Rössing case study illustrates how well WorldView-3 delivers improved definition of geological units and particularly the uranium bearing formations, which would help exploration efforts to locate additional uranium deposits near and around the mine site.

WorldView-3 multispectral and SWIR imagery provides vastly improved capabilities in support of geological and other surface mapping applications by delineating

- Clays
- Carbonates
- Iron-bearing rocks and iron oxide
- Alteration products
- Mica

at a higher resolution than previously available. The sharper images from WorldView-3 lead to improved analysis and interpretation, providing better discrimination of complex alteration systems.

Reference 1: Anderson and Nash, Explor.Geophys. Vol. 28
Reference 2: World Distribution of Uranium Deposits (UDEPO) with Uranium Deposit Classification 2009 Edition

THE LAST WORD

From all of us here at Geoimage, we hope you have found this eBook informative and helpful in your efforts to understanding SWIR and how Geoimage can help you to extract the most information from your data.

If you would like independent professional advice on any of our geospatial solutions, speak to one of our spatial specialists today.

Geoimage prides itself on offering unique insights to you and your business. We look forward to contributing to your future success.

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