

# SERVIÇO GEOLÓGICO DO BRASIL – CPRM

## GEOLOGICAL SURVEY OF BRAZIL

**APLICAÇÃO DE DADOS DE SENSORIAMENTO REMOTO E  
ESPECTROSCOPIA DE REFLECTÂNCIA EM PROJETOS DE MAPEAMENTO E  
INVESTIGAÇÃO MINERAL NA CPRM - SERVIÇO GEOLÓGICO DO BRASIL.**

*APPLICATION OF REMOTE SENSING AND REFLECTANCE SPECTROSCOPY  
DATA IN MAPPING PROJECTS AND MINERAL RESEARCH IN CPRM -  
GEOLOGICAL SURVEY OF BRAZIL*

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Geologist – Geological Remote Sensing Coordinator  
Member of the committee for gender and race equality

## SUMMARY

- Main remote sensing data used in the CPRM geological projects
- Spectroscopy Laboratory - Spectral Library of Geological Survey of Brazil
- Airborne hyperspectral surveys



## Main remote sensing data used in the CPRM geological projects

Because of the work scale (mainly 1:100.000 and 1:250.000), nature of investigations and availability of data, the most used optical sensors in CPRM geological projects are the multispectral LANDSAT TM/ETM+/OLI and TERRA-ASTER, mainly their bands in visible, near infrared and short wave infrared wavelengths of electromagnetic spectrum, with spatial resolution varying from 15 m to 30m.

In terms of radar sensors, the data most used is SRTM, ALOS-Palsar and, SAR-SIPAM (Amazon Protection System).



## Main optical sensors used in the CPRM geological projects

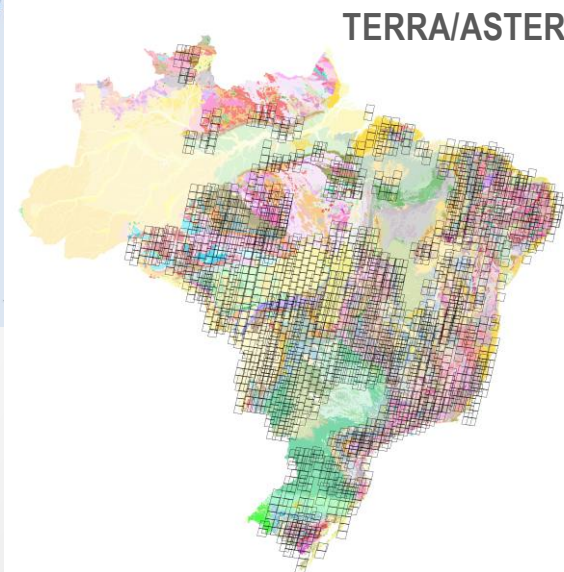
LANDSAT- 5/TM (Thematic Mapper)

LANDSAT-7/ETM+ (Enhanced Thematic Mapper)

LANDSAT-8/OLI (Operational Land Imager)



## Imagery Collection

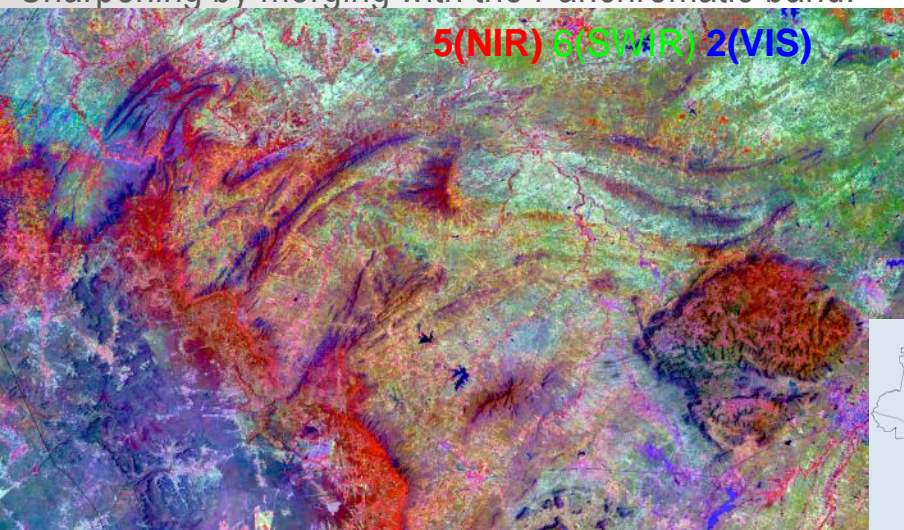


**TERRA/ASTER** (Advanced Spaceborne Thermal  
Emission and Reflection Radiometer)

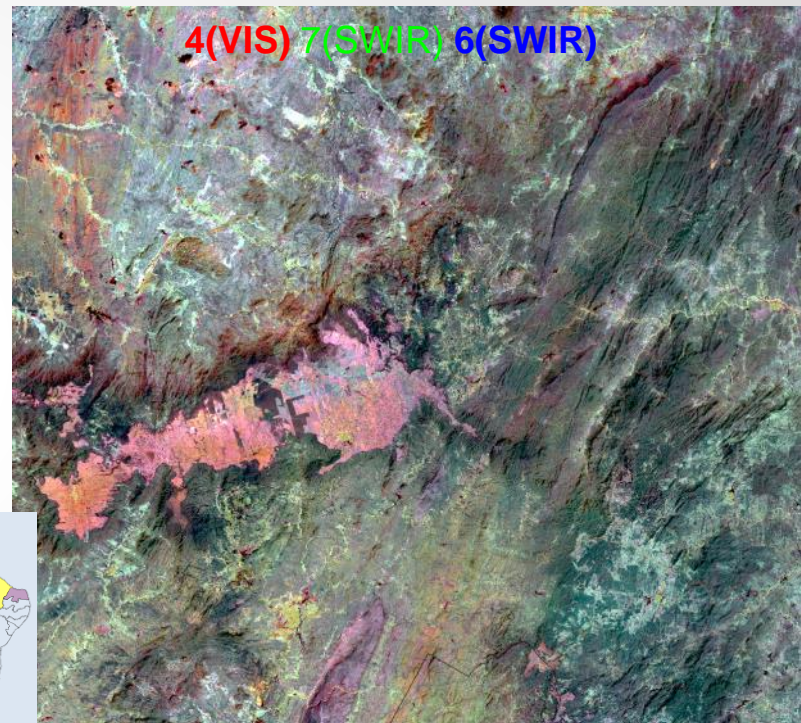
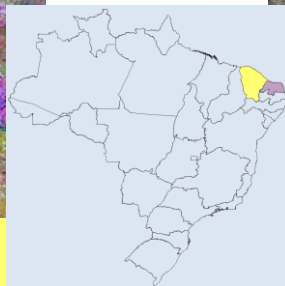


## Sensors usage examples in the CPRM projects - LANDSAT-8 / OLI

Recognition of lithologic variation using enhancement based on:  
Gaussian contrast stretch applied to a RGB color composite  
followed by Color Saturation Stretch, Laplacian Filter and, Image  
Sharpening by merging with the Panchromatic band.



NW Ceará State



Seridó - Rio Grande do Norte State



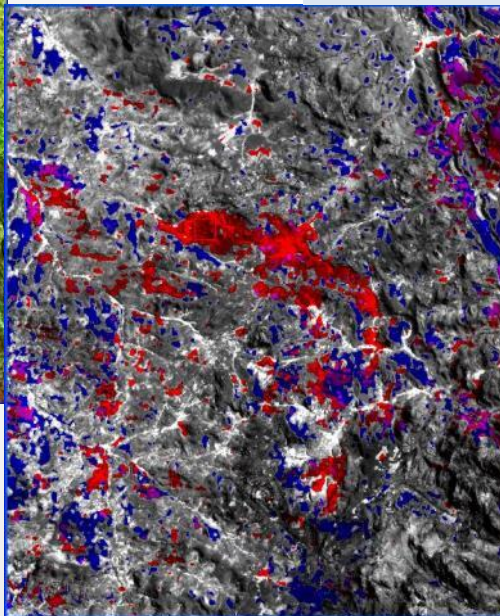
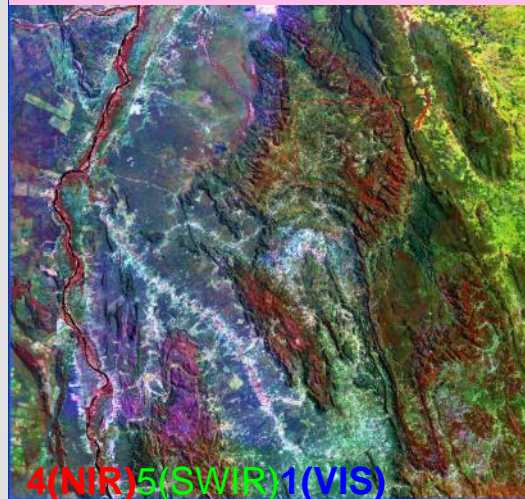


## Sensors usage examples in the CPRM projects - LANDSAT-5 / TM and LANDSAT-7 / ETM+

Recognition of lithologic variation

Gentio do Ouro – Bahia State

Gold  
prospection



Alteration Mapping using  
Selective Principal  
Component Analysis –  
Crôsta Method

**Iron Oxide**  
**Hydroxyl**  
**Iron Oxide +**  
**Hydroxyl**



Research of marine  
mineral resources:  
enhancement of  
arenous reefs by an  
HSV transform to  
merge a linearly  
stretched true color  
composition with the  
first principal  
component of bands  
1, 2 and 3 subjected  
to directional filter

Paraíba  
State Coast

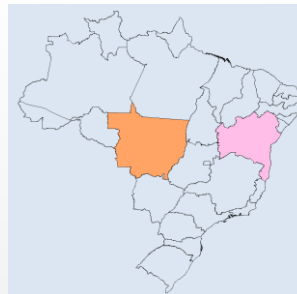


# Sensors usage examples in the CPRM projects – TERRA/ASTER

Serra da Borda – Mato Grosso State

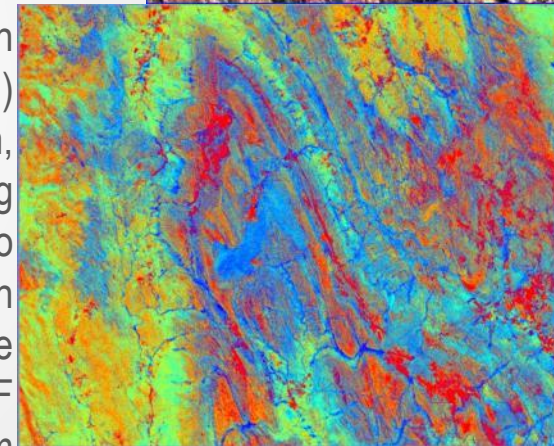
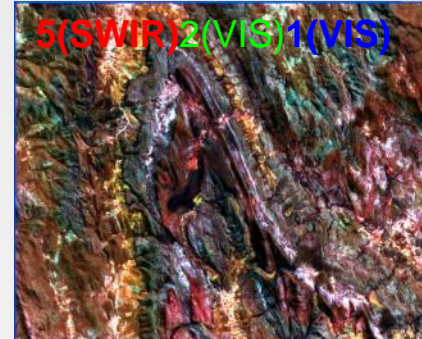
5(SWIR)2(VIS)1(VIS)

Recognition of lithologic variation using gaussian contrast stretch applied to a Region of Interest



Recognition of lithologic variation using enhancement based on Minimum

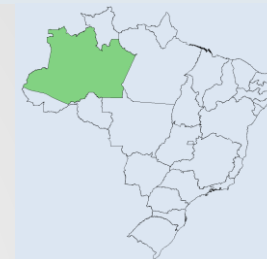
Noise Fraction (MNF) transform, considering albedo elimination in the inverse MNF transform



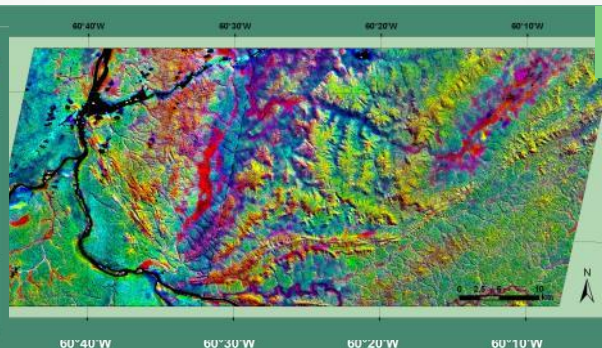
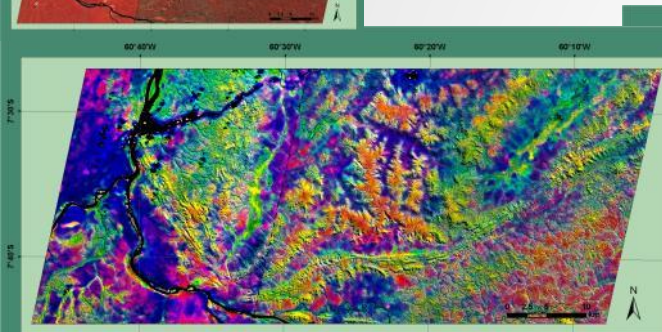
Rio de Contas – Bahia State



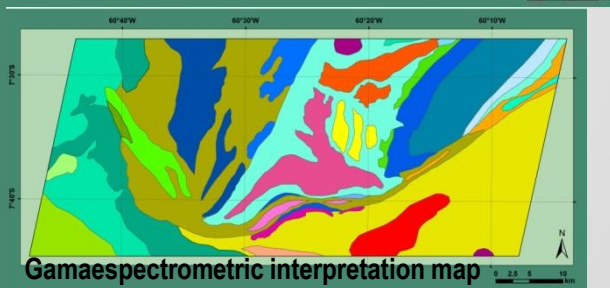
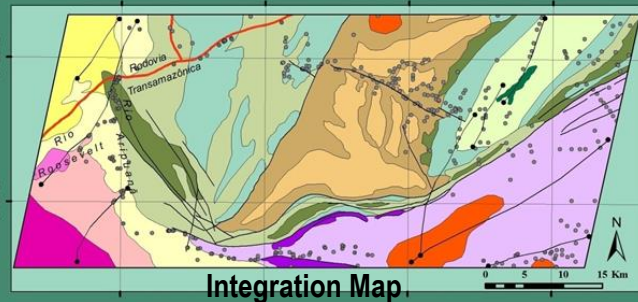
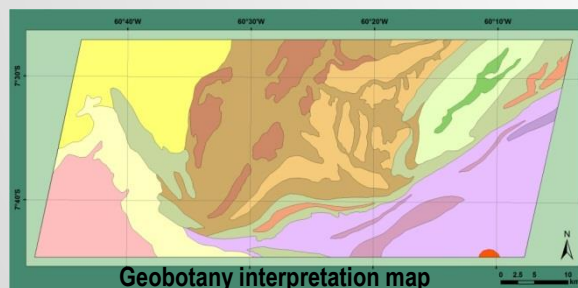
# Sensors usage examples in the CPRM projects – TERRA/ASTER



Enhancement of lithological variation using Geobotany technique (vegetation spectral enhancement based on variation of the vegetation characteristics in response to the geologic variation). Comparison with airborne geophysical data.



## Apuí-Nova Aripuanã – Amazonas State





## Main radar sensors used in the CPRM geological projects

### SIPAM-SAR/R99B

Amazon Protection System - Airborne SAR sensor

Polarimetric quad L band and Xhh band

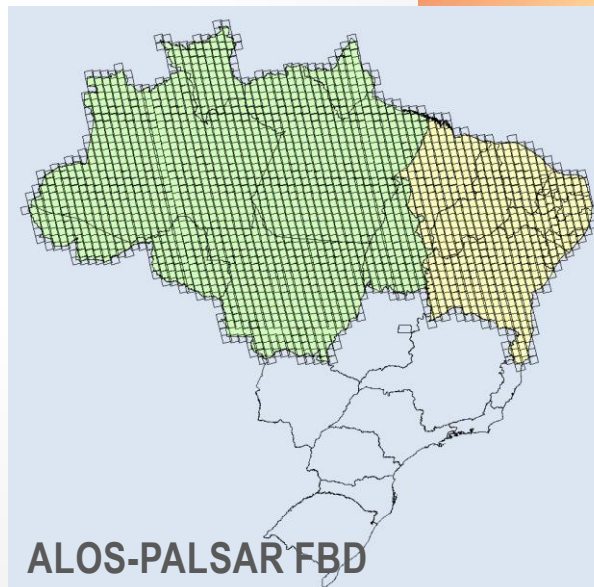
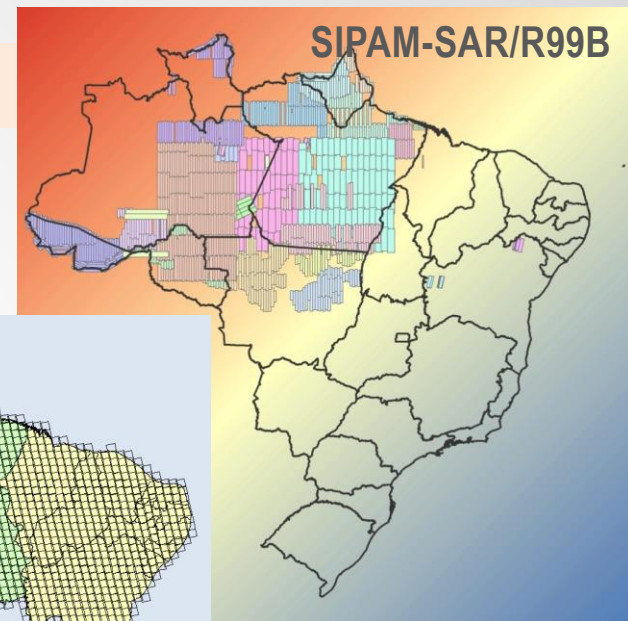
Spatial resolution from 3 m to 18 m

ALOS-PALSAR FBD (Fine Beam Dual)

Polarimetric dual (Lhh and Lhv) band

Spatial resolution of 12.5 m

(base de dados organizada pelo IBGE)

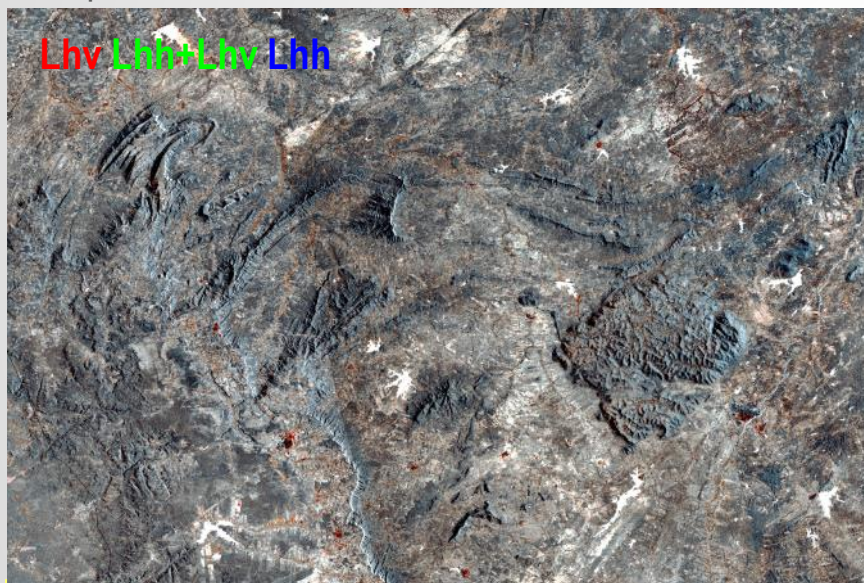
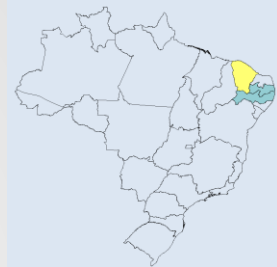


Imagery Collection

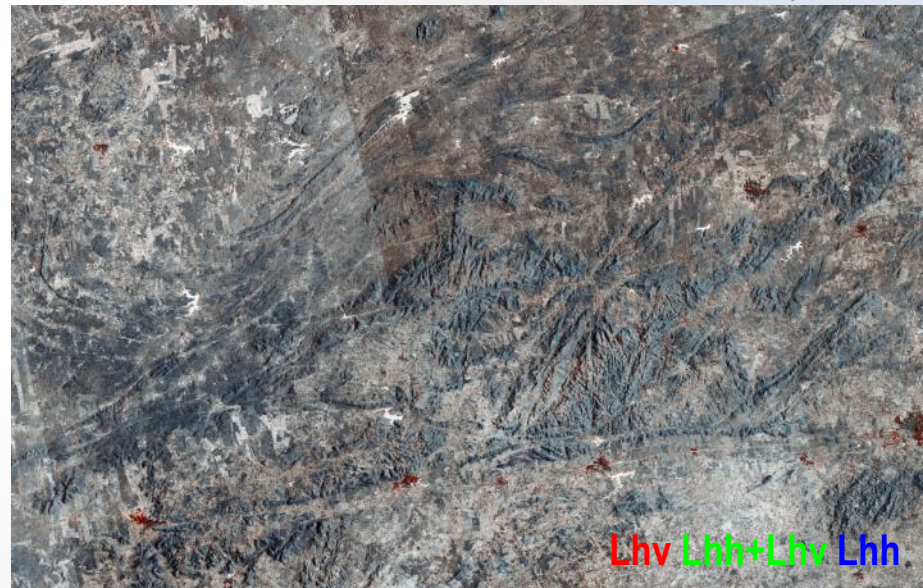


## Sensors usage examples in the CPRM projects – ALOS PALSAR FBD

Recognition of structural patterns using enhancement based on gaussian contrast stretch applied to negated original bands. Addition of the Lhh and Lhv bands was used to product a RGB color composite.



NW Ceará State

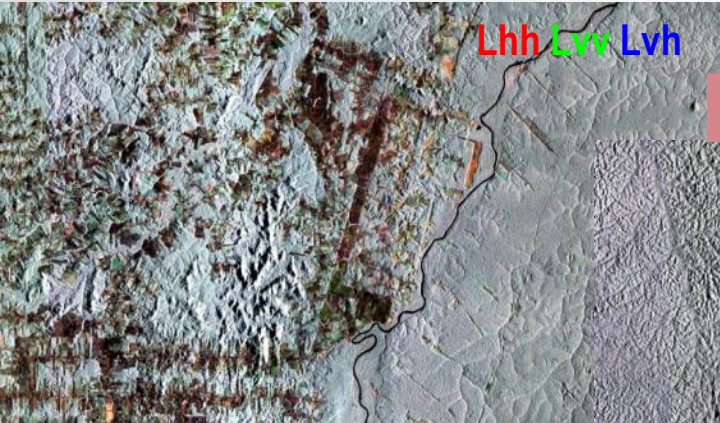


Alto Moxotó –Paraíba and Pernambuco States



# Sensors usage examples in the CPRM projects – SIPAM-SAR/R99B

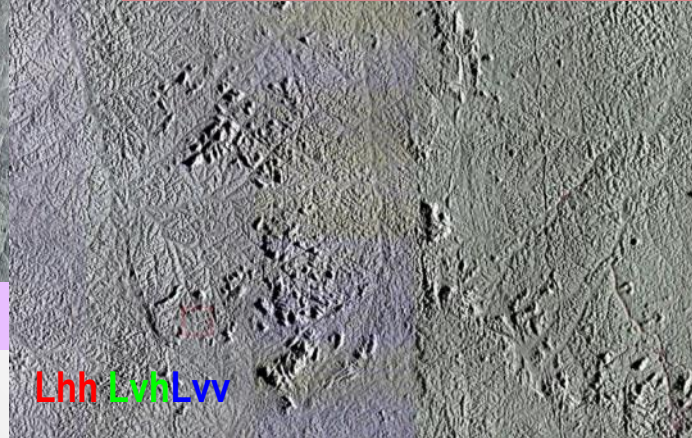
Work field planning, structural and textural analysis, land use-land cover, flood areas mapping



Lourenço– Amapá State

Repartimento– Pará State

Rio Machado– Rondônia State





## The Spectral Library of the Geological Survey of Brazil

The Geological Survey of Brazil, as an example of another geological surveys and research laboratories around the world (like USGS, John Hopkins University and JPL-NASA), is developing its own spectral library. The initial goal of this library was to analyse rocks occurring in Brazil and their mineral alterations under tropical climate, and, more recently, to incorporate the mineral assemblages associated to Brazilian mineral deposits. The Spectral Library project was developed in a partnership between CPRM and UNICAMP (Universidade Estadual de Campinas) and the data will soon be available in GEOBANK (Geological database of the Geological Survey of Brazil).



The analyses are accomplished in the FieldSpec® 3 High-Resolution spectroradiometer developed by Analytical Spectral Devices (ASD). Its spectral coverage ranges from 350 to 2500 nm and the spectral resolution is 3 nm between 350 -1000 nm, 8.5 nm between 1000 - 1800 nm and 6.5 nm between 1800 - 2500 nm).




## Preparing samples: Labeling of analysis



	AMOSTRA	FIELD_SPEC	ROCHA	FACE	GRAU INTEMPERISMO	COR	RELACAO COM_SN	RELACAO CRISTAIS_FRAG MATRIZ
1								
2	2140-SM-R-004A	BAR_001	Calcario Cristalino	Exposta	Moderadamente intemperizada	Bege	Perpendicular	
3	2140-SM-R-004A	BAR_002	Calcario Cristalino	Serrada	Intemperizada	Cinza	Perpendicular	
4	2140-SM-R-004A	BAR_003	Calcario Cristalino	Exposta	Pouco intemperizada	Bege claro	Paralela	
5	2140-SM-R-005	BAR_004	Granito	Quebra natural	Moderadamente intemperizada	Bege		
6	2140-SM-R-005	BAR_005	Granito	Exposta	Muito intemperizada	Bege		
7	2140-SM-R-006	BAR_006	Filito	Quebra natural	Não intemperizada	Cinza esverdeado	Paralela	
8	2140-SM-R-006A	BAR_007	Granitoide	Quebra natural	Saprolitizada	Cinza rosado		
9	2140-SM-R-007	BAR_008	Basico	Quebra natural	Moderadamente intemperizada	Cinza esverdeado	Obliqua	
10	2140-SM-R-007A	BAR_009	Granito	Quebra natural	Pouco intemperizada	Cinza rosado		Matriz+Fenocristais
11	2140-SM-R-016	BAR_010	Filito	Quebra natural	Não intemperizada	Bege	Obliqua	
12	2140-SM-R-016	BAR_011	Filito	Quebra natural	Moderadamente intemperizada	Cinza esverdeado	Obliqua	
13	2140-SM-R-016	BAR_012	Filito	Exposta	Muito intemperizada	Vermelho	Obliqua	
14	2140-SM-R-021B	BAR_013	Gnaisse	Quebra natural	Pouco intemperizada	Vermelho claro	Perpendicular	
15	2140-SM-R-021B	BAR_014	Gnaisse	Exposta	Intemperizada	Bege	Paralela	
16	2140-SM-R-021B	BAR_015	Gnaisse	Exposta	Intemperizada	Bege escuro	Perpendicular	
17	2140-SM-R-032	BAR_016	Gnaisse	Quebra natural	Moderadamente intemperizada	Bege	Perpendicular	

# Organization and making available on GEOBANK (Geological Information Database )

Fale Conosco | Ajuda
 


 Quinta-Feira, 17 de Setembro de 2015

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**CPRM - GEOBANK - Biblioteca espectral**

**GEOBANK GIS**

Riscos Geológicos GIS

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Apresentação

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Informações importantes

Estatísticas de acesso

Mapas em PDF

 **One Technology Portal**

Data de cadastro do registro\*  
15/08/2015

Amostra coletada (Geobank)\*  
HL-128 (Metadacito)

Rocha analisada\*  
Metadacito

Responsável pelo preenchimento  
Monica Mazzini Perrotta

Código da amostra\*  
1405-HL-R-0128

Amostra análoga

Mineral analisado

[Voltar](#)

Medições da amostra							
Arquivo de análise	Data da análise	Responsável pela análise	Grau de intemperismo	Face	Cor da face	Relação matriz/clasto	Relação com Sn
 IRC.281		Monica Mazzini Perrotta	Moderadamente intemperizada	Quebra natural	Cinza claro		Perpendicular
 IRC.282		Monica Mazzini Perrotta	Moderadamente intemperizada		Cinza claro		Paralela
 IRC.283		Monica Mazzini Perrotta	Intemperizada		Cinza claro		Obliqua
 IRC.284		Monica Mazzini Perrotta	Intemperizada		Laranja		Paralela

Identificação mineral					
Método	Mineral (1)	Mineral (2)	Mineral (3)	Mineral (4)	Mineral (5)
Automático	Caolinita	Fengite	Quelita		

**Difração de raios X - Semi-Quantitativa**

pr = Mineral presente na amostra não quantificado  
tr = Mineral com quantidade inferior a 1%

Método	Mineral	Valor
Fração argila	Ilita	60-65
Fração argila	Caolinita	35-40

**Ilustrações**

 AED000293\_F002590.JPG

**Afforamento**

Nº de campos: HL-128  
Projeto: Ibitara-Rio de Contas  
Tipo do afloramento: Corte de estrada  
Geólogo: Herman Santos Chatall Loureiro

**Localização da amostra**

Nome da folha: Ibitara  
Código Internacional: SD-23-X-B-VI  
Datum: SAD69  
Latitude: -12.6219820  
Longitude: -42.13595230

**Rochas**

Nome da unidade: [PBterr\\_alfa\\_n1 - Lito/fácies Novo Horizonte, metadacito porfirio](#)

Rocha: Metadacito  
Grau de intemperismo: Intemperizada  
Análise(s): HL-128 (Petrográfica)

Cor da rocha intemperizada:  
Tipo da amostra: Rocha

Classe: Metamórfica  
Cor da rocha sã: Cinza claro  
Geometria:

Subclasses: Metamorfismo regional  
Índice da cor:  
Granulação:

**Metamorfismos**

Tipo do metamorfismo: Hidrotermal  
Tipo do metamorfismo: Regional (Dinamotermal)

**Texturas**

Descrição da textura: Porfírbica



# Organization and making available on GEOBANK (Geological Information Database )

## Arquivo de análise



IRC.281

## Ilustrações

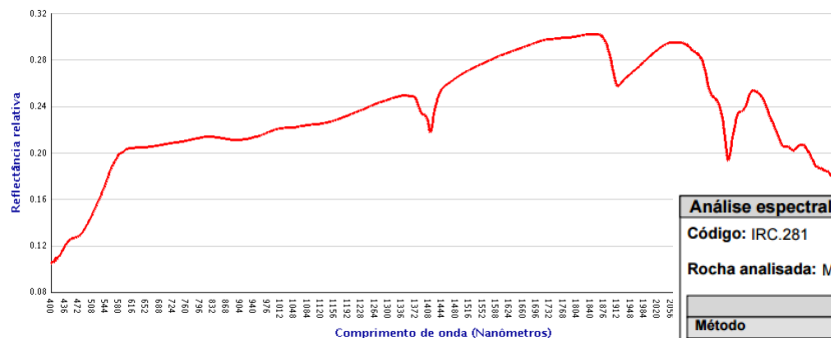
AE000293\_F003590.JPG

## Assinatura espectral

Equipamento de análise: Espectrorradiômetro ASD/PANalytical FieldSpec® 3 Hi-Res (350-2500 nm)

Amostra: 1405-HL-R-0128 (Metadacito)

Código da análise: IRC.281



## Análise espectral

Código: IRC.281

Data:

Responsável: Monica Mazzini Perrotta

Rocha analisada: Metadacito

Mineral analisado:

## Identificação mineral

Método	Mineral (1)	Mineral (2)	Mineral (3)	Mineral (4)
Automático	Caolinita	Fengita	Goetita	

## Análise por difração de raio X - Semi-quantitativa

Método	Mineral	Valor
Fração argila	Ilita	60-65
Fração argila	Caolinita	35-40

## Dados do afloramento da amostra

Nº de campo: HL-128 (Metadacito)

Tipo: Corte de estrada

Geólogo: Herman Santos Chatalá Loureiro

Projeto: Ibitiara-Rio de Contas

## Localização do afloramento da amostra

Base cartográfica: SD.23-X-B-VI - Ibitiara

Latitude: -12.82195820

Longitude: -42.13595230

Datum: SAD69

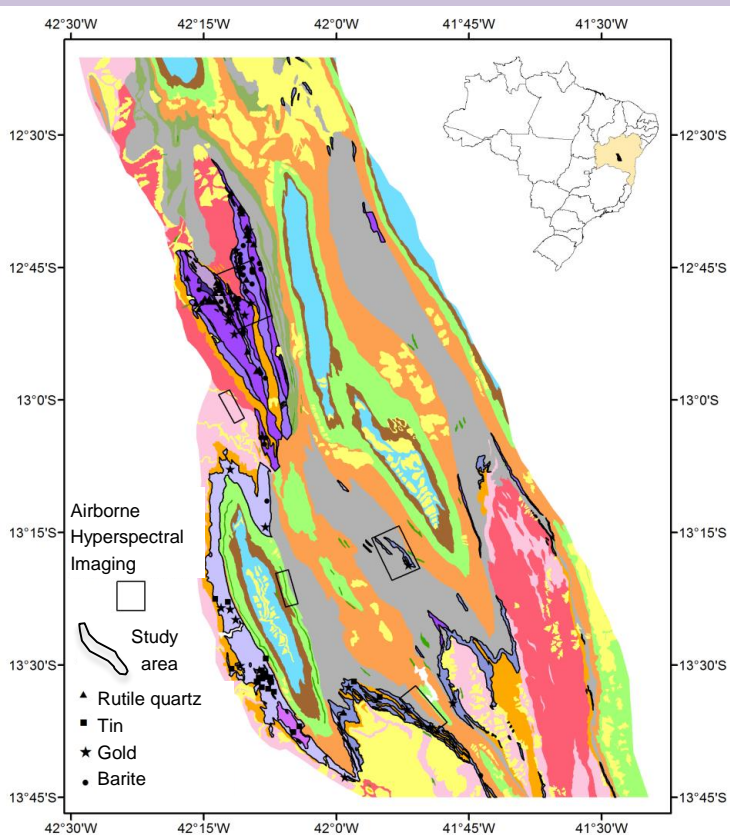


# Organization and making available on GEOBANK (Geological Information Database )

<b>Dados da rocha</b>		
Unidade estratigráfica: PP4rr_alfa_n1 - Litofácies Novo Horizonte, metadacito pórfiro		
Rocha: Metadacito	Classe: Metamórfica	Subclasse: Metamorfismo regional
Grau de intemperismo: Intemperizada	Cor da rocha intemperizada:	Cor da rocha sã: Cinza claro
Índice da cor:	Geometria:	Granulação:
<b>Texturas</b>		
Tipo		
Porfíritica		
<b>Metamorfismo</b>		
Tipo		Fácies
Hidrotermal		
Regional (Dinamotermal)		

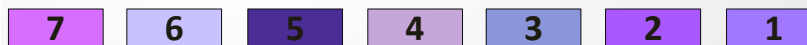
<b>Análise petrográfica</b>		
Litologia de campo: Metadacito		
Identificação da lâmina: 1405-HL-R-0128	Localização: SUREG-SA	Responsável: Raymundo José B. Froes
Rochas encontradas na lâmina: Dacito		
Descrição da lâmina: Rocha vulcânica porfíritica, com fenocristais tabulares de plagioclásio, estirados e deformados, orientados, e outros, de quartzo azulado, arredondados a estirados, dispersos em matriz afanítica, cinza clara, foliada.		
<b>Composição mineralógica</b>		
Plagioclásio(32% Estimado)		
Quartzo(30% Estimado)		
Muscovita(25% Estimado)		
Feldspato(16% Estimado)		
Opaco (Microscopia)(5% Estimado)		
Biotita(2% Estimado)		

## Spectroscopy - Example of Application: Espinhaço Oriental Basin Metavolcanic Rocks, Bahia State

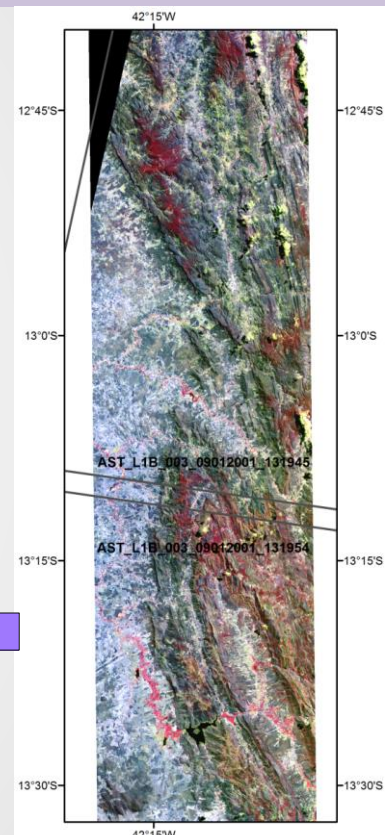


## Mineralogical characterization of hydrothermal alteration and Imaging Spectroscopy applied to atmospheric corrected ASTER data

### Paleoproterozoic

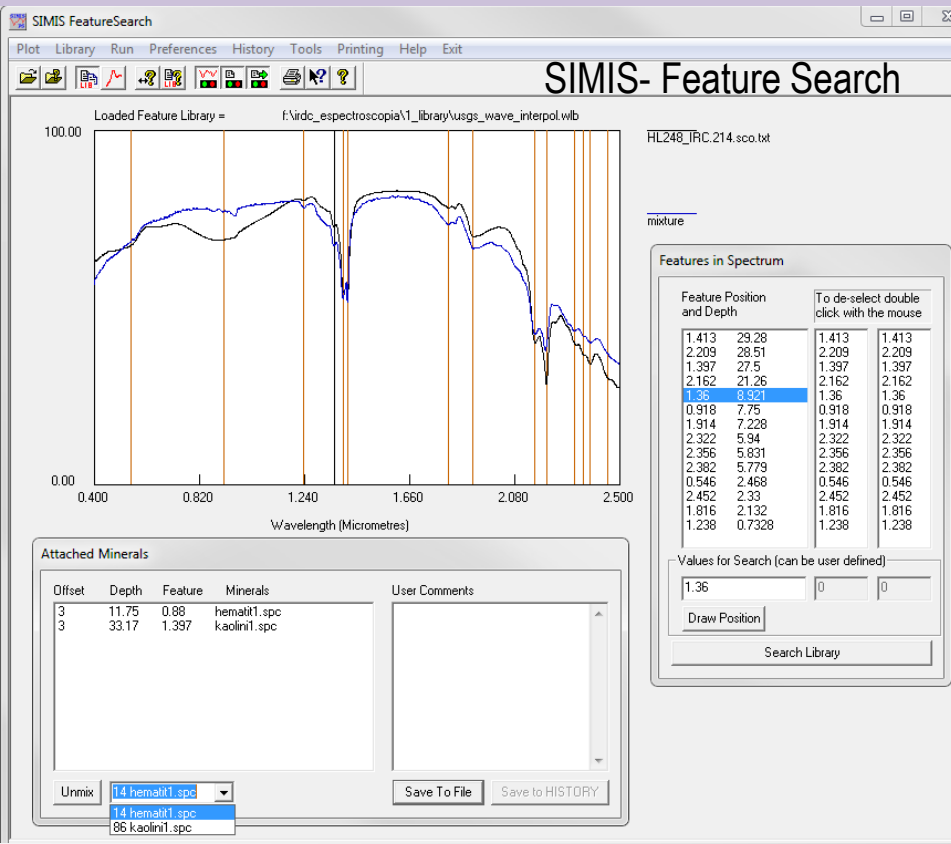
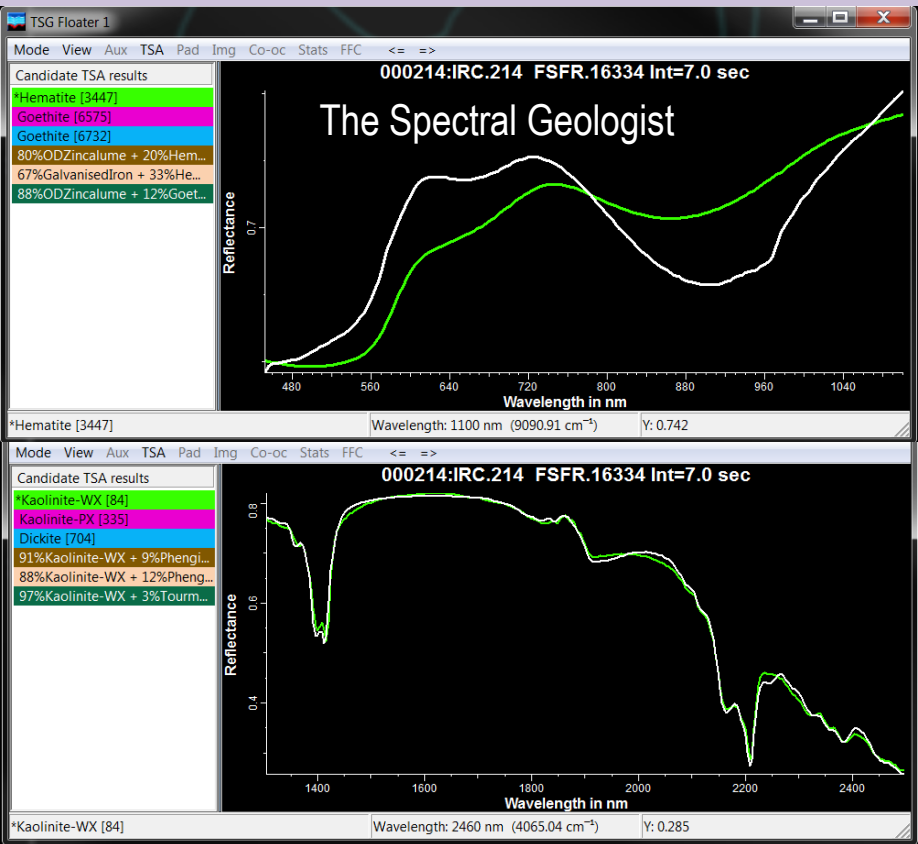


Novo Horizonte Formation: 7- rhyolitic subvolcanic rocks, 6-acid metavolcanic and pyroclastic rocks, 5-metaeplastic rocks, 4-metapyroclastic rocks, 3-metaporphry, 2-metarhyolite porphyry, 1- metadacite porphyry

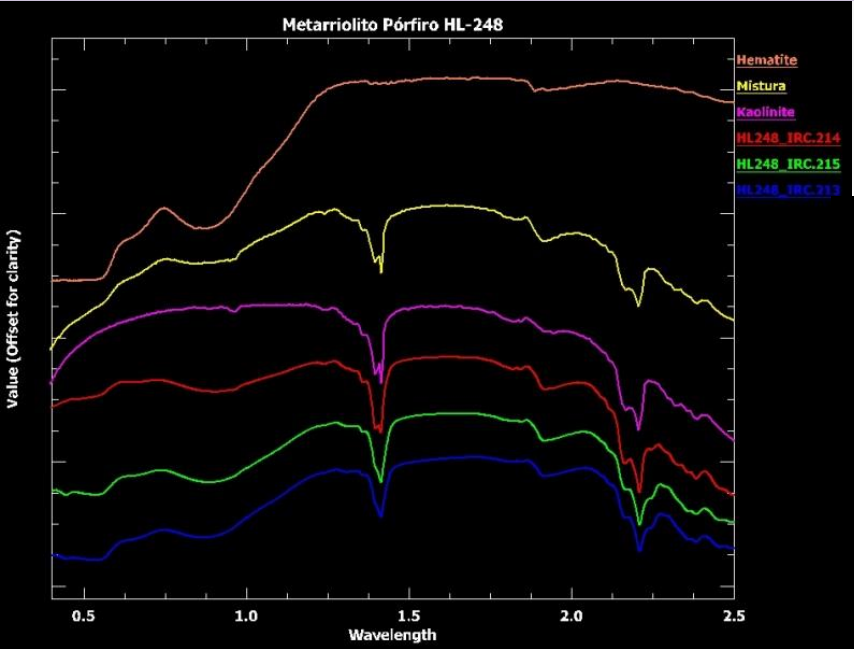




# Spectroscopy - Example of Mineral Identification

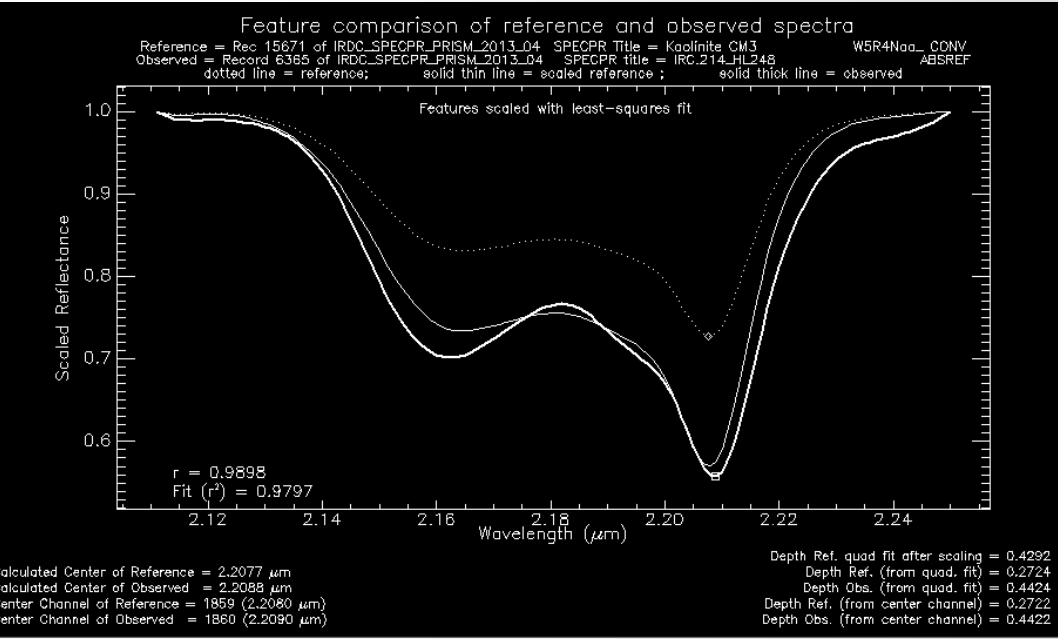


# Spectroscopy - Example of Mineral Identification

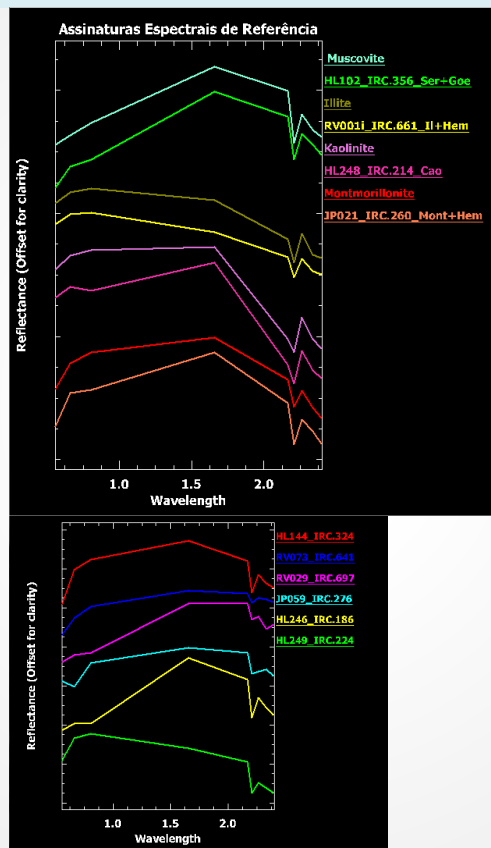
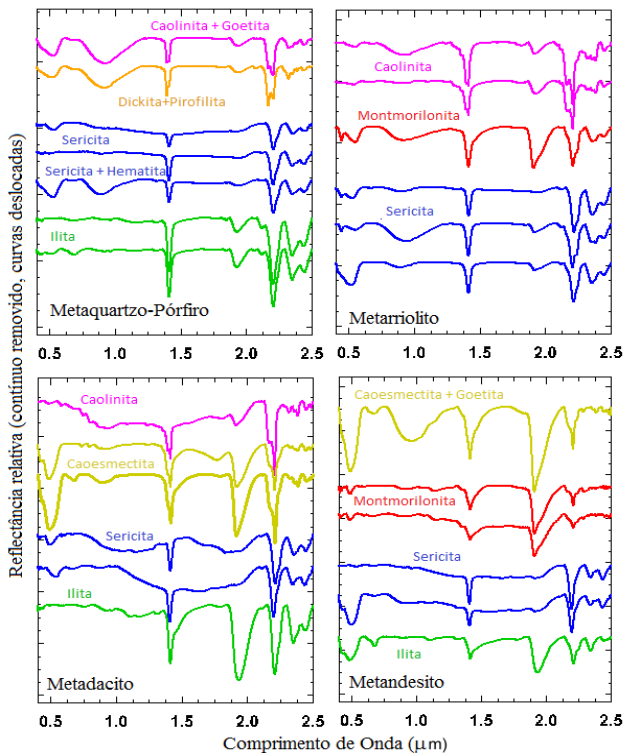


ENVI's Spectral Analyst

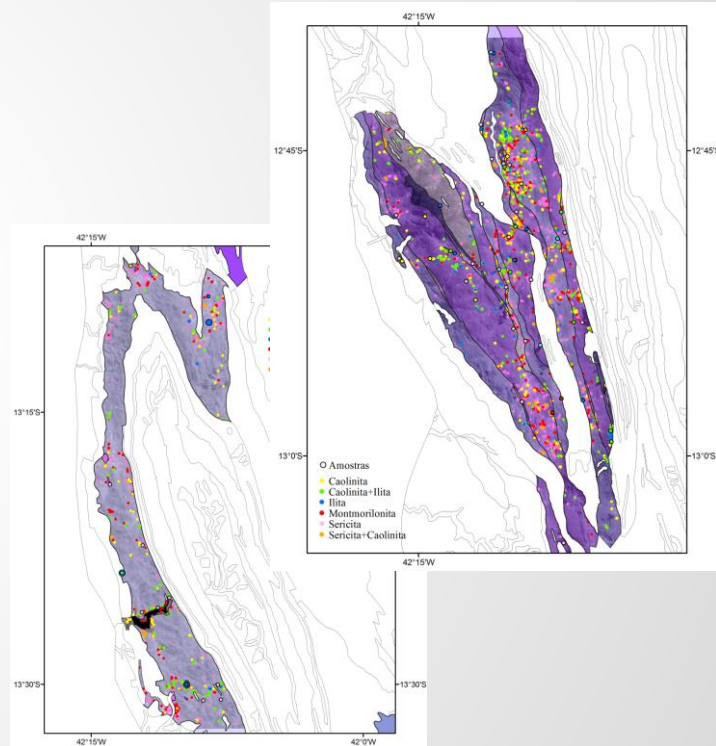
## USGSPRISM



## Imaging Spectroscopy - Spectral mapping using SAM (Spectral Angle Mapper) method

Spectral resample to ASTER (VNIR-SWIR)  
spectral resolution

## Distribution map of clay-minerals

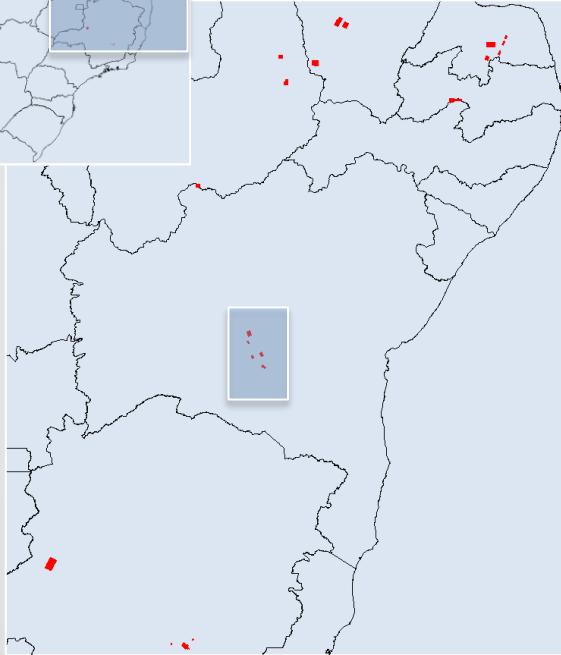




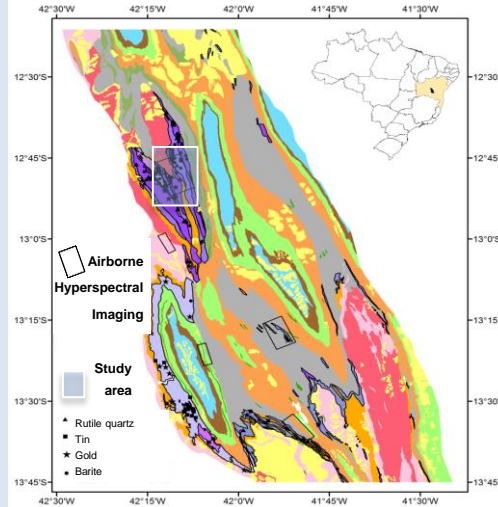
# Airborne Hyperspectral Imaging – ProSpecTIR-VS Sensor (357 bands distributed between 350 and 2450 nm)



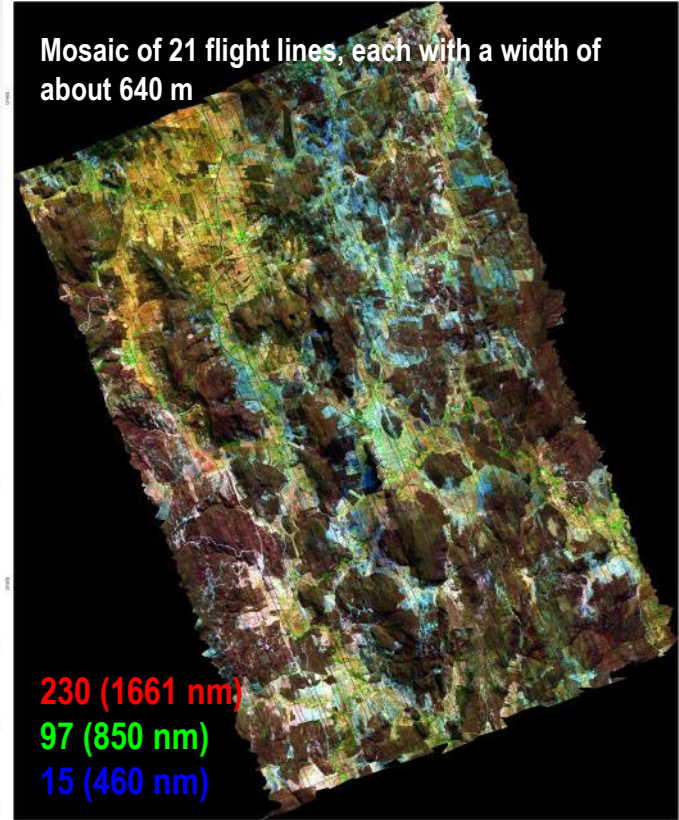
Area covered in Brazil: 2500 km<sup>2</sup>  
Spatial resolution: 2 m



Example of application in  
Bahia state



Mosaic of 21 flight lines, each with a width of  
about 640 m

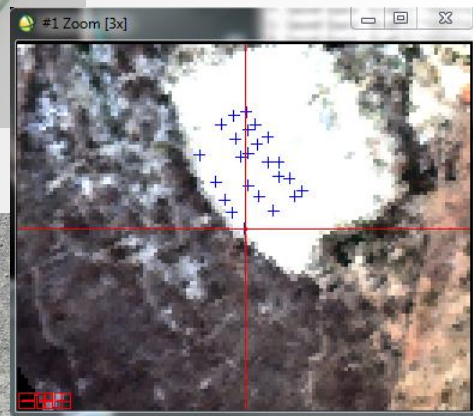


## Validation of Hyperspectral data in the field and laboratory

Made by comparing the spectral signatures of pixels of hyperspectral imagery with spectral curves obtained in the field and laboratory for reasonably homogeneous materials (mainly soil) arranged evenly in sufficiently large areas containing more than 100 pixels of the image.



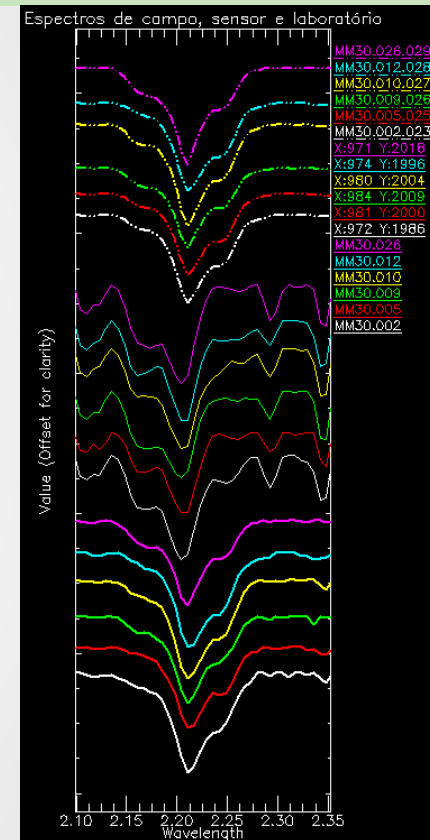
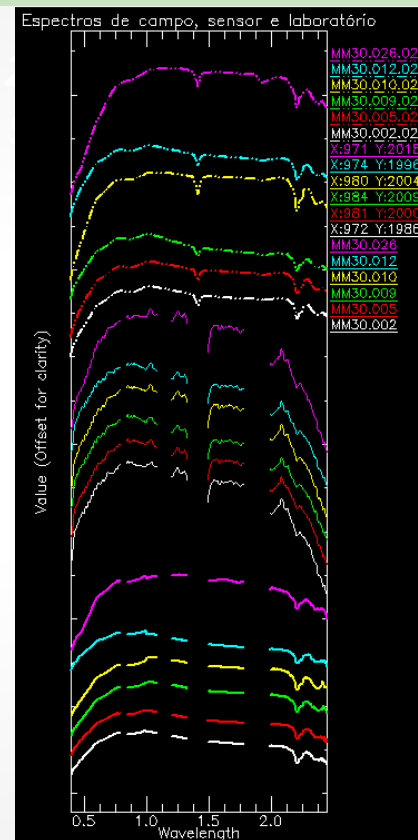
# Validation of Hyperspectral data in the field and laboratory: Comparing spectra



Laboratory Spectra

Imagery Spectra

Field Spectra

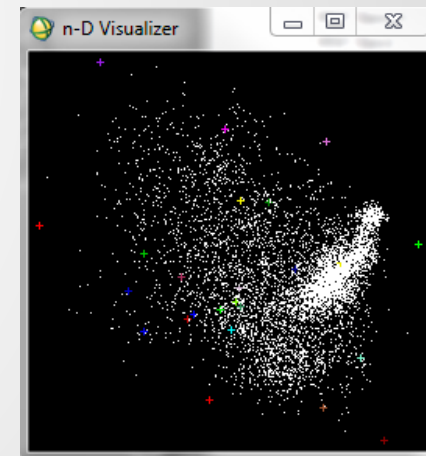
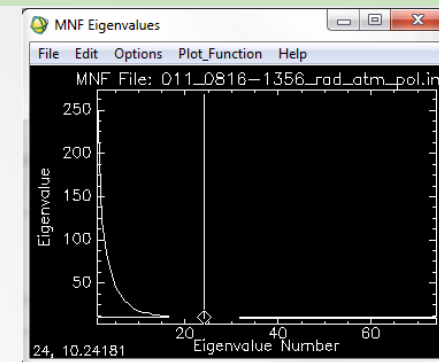
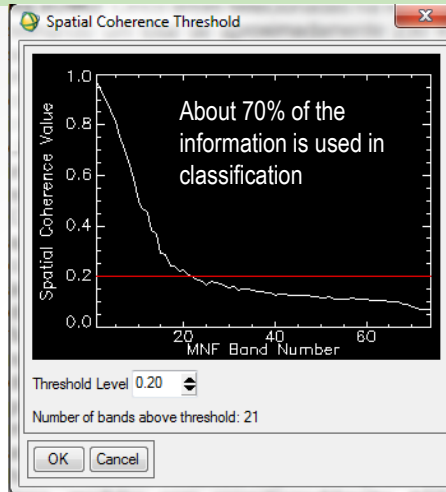




## Spectral Mapping: Finding the Endmembers (Reference Spectra) in imagery

The spectral mapping is done through the ENVI's Spectral Hourglass Wizard for each flight line separately.

The Minimum Noise Fraction (MNF) transform is used to determine the inherent dimensionality of image data, to segregate and equalize the noise in the data, and to reduce the computational requirements for subsequent processing.



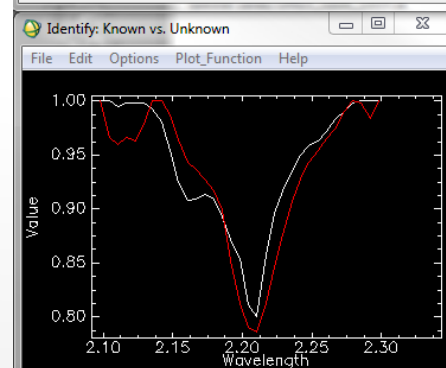
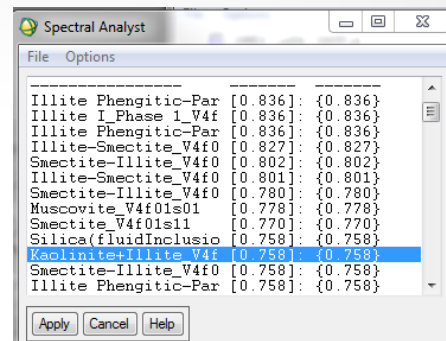
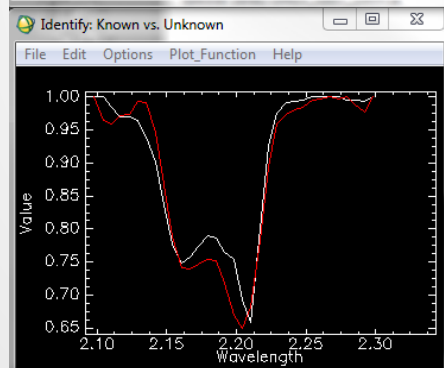
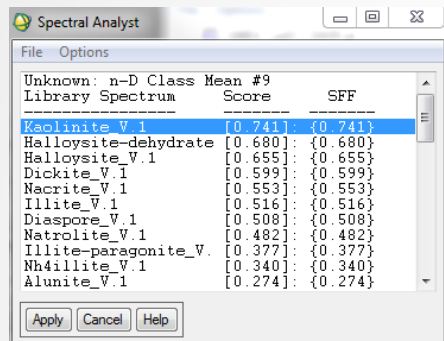
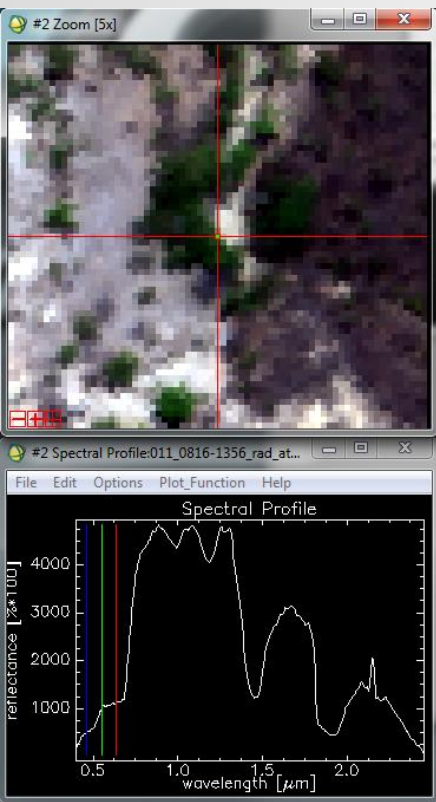
The Pixel Purity Index (PPI) is used to find the most spectrally pure, or extreme, pixels in hyperspectral data, called Endmembers.

Endmembers are pure spectrally unique materials that occur in a scene. Using a linear unmixing model, you can reconstruct every spectrum in the image as some combination of image endmember spectra.

Applied to  
74 SWIR bands  
(1991 a 2448 nm)

## Performing Classification: The SAM (Spectral Angle Mapper) result

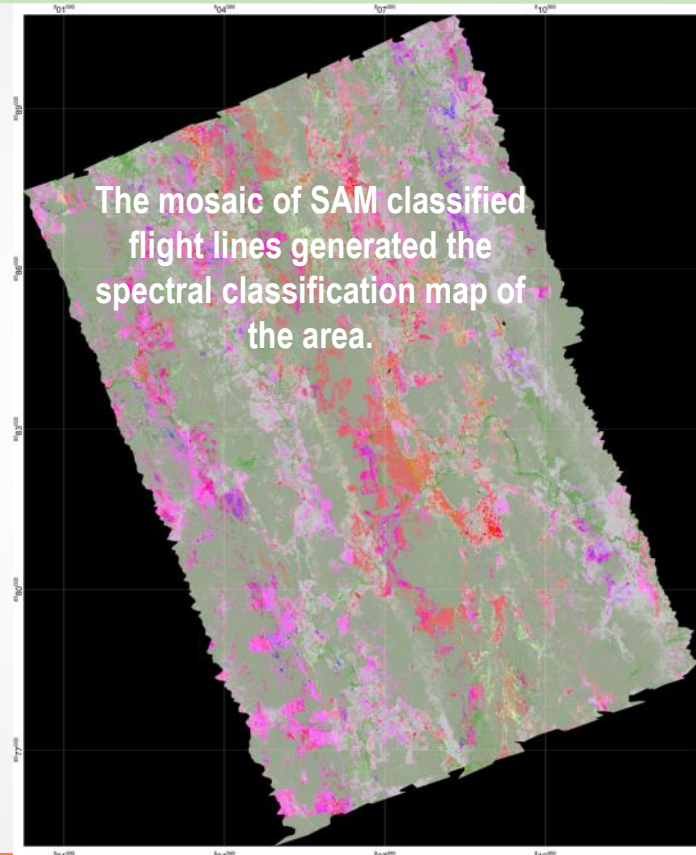
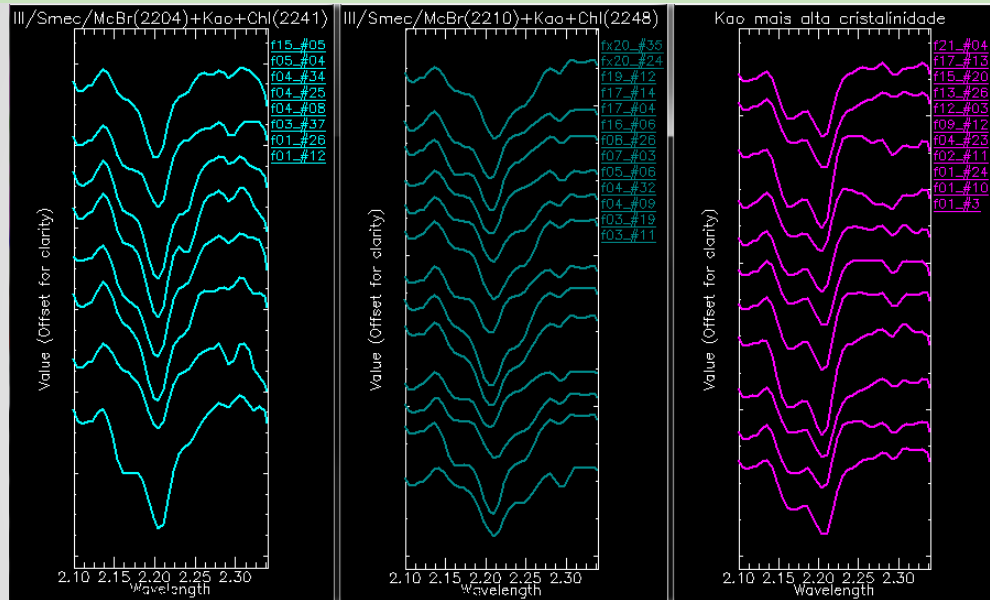
### Spectral Analysis of Endmembers – Identification of minerals, vegetation, etc.



Result of the SAM classification using selected endmembers as reference spectra, and setting as 0.1 the maximum angle in radians acceptable between the endmember spectrum vector and the pixel vector classified



## Spectral Analysis of Endmembers: Recognizing the spectral affinities

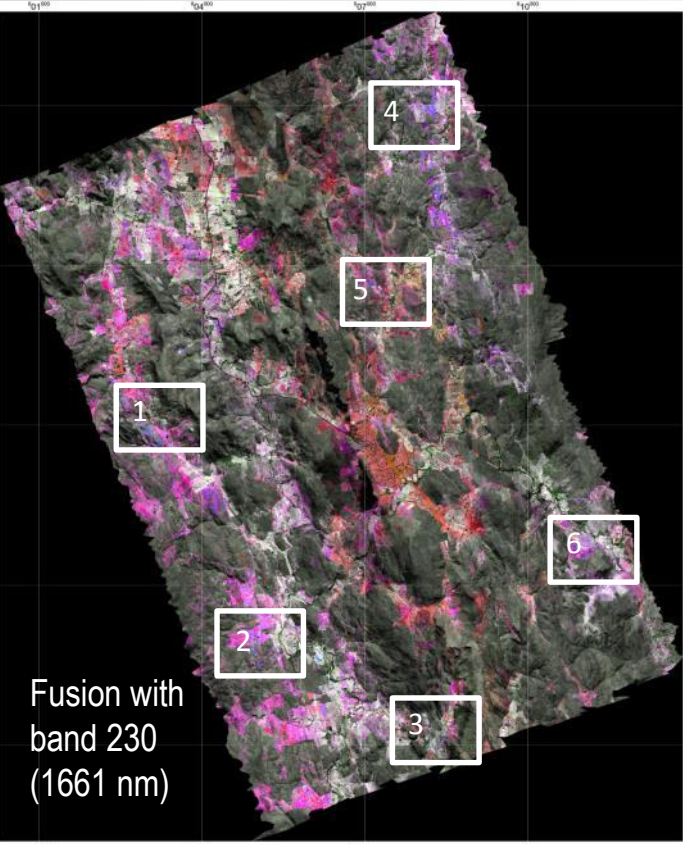


- Between 25 and 37 endmembers were generated for each flight line.
- The more than 600 signatures generated were divided into 36 groups with spectral affinities.
- The SAM classification map of each line were reclassified as these groups.





Result: Mineral Distribution Map

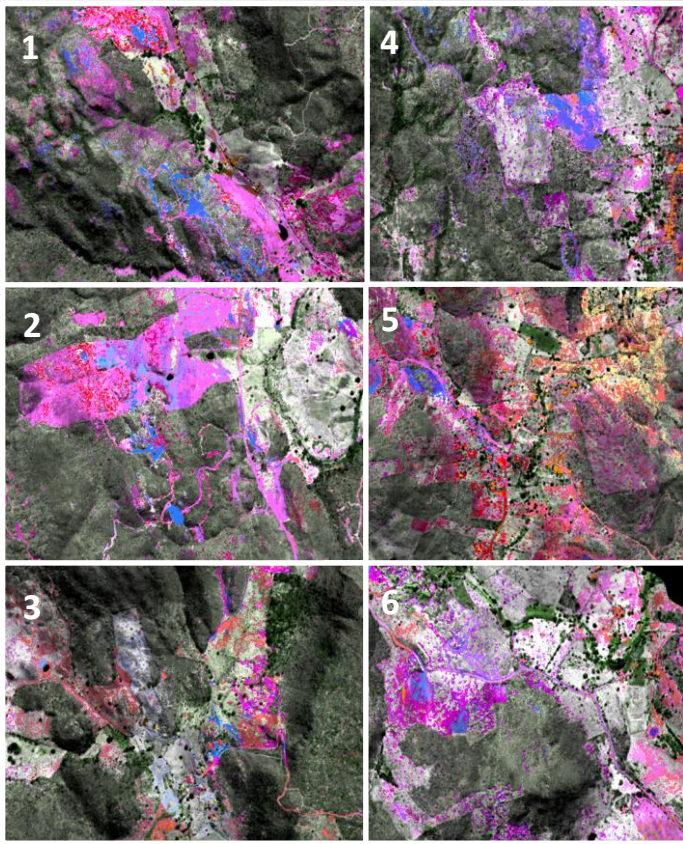


Fusion with  
band 230  
(1661 nm)

Areas in blue and purple  
mapped the rutilated  
quartz known deposits



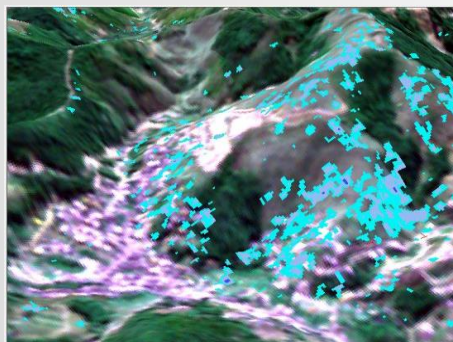
- Poor crystalline Kaolinite
- Moderate crystalline Kaolinite
- High crystalline Kaolinite
- Kaolinite + Goethite
- White Mica + Kaolinite
- White Mica + Kaolinite +/- Chlorite
- White Mica + Kaolinite + Chlorite
- White Mica +/- Kaolinite +/- Chlorite
- White Mica
- Hematite +/- Kaolinite
- Vegetation
- Dry Vegetation + Soil



## Monitoring of mass movements with SAR interferometry - Nova Friburgo (Rio de Janeiro State)

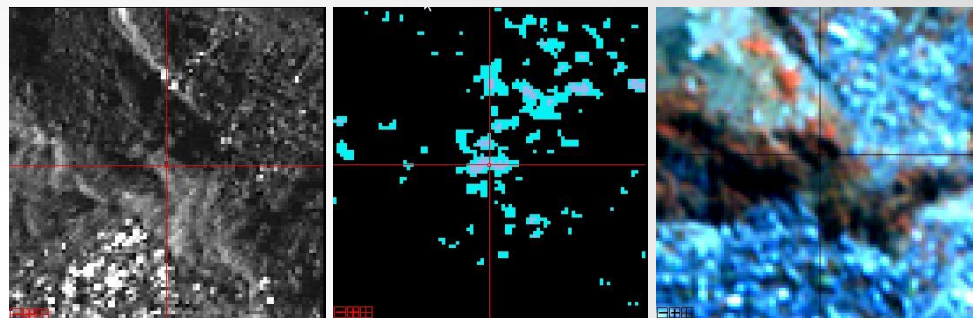
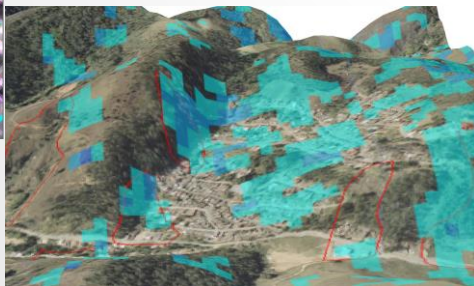
**Interferometric analysis** of SAR scenes dated between 1995 and 2011: sensors **ERS1**, **ERS2** and **ENVISAT ASAR** (53 images Standard mode IMS (25m) and 11 images Widescan Mode (~75m))

**Interferometric analysis** of SAR **Cosmo Skymed** imagery (3m) dated from December 2012 to October 2013 (20 scenes of ascending orbit and 20 scenes of descending orbit considering acquisition after 30-50 mm rainfall)



Moving mass in the order of up to 22 mm in 10 months in the vicinity of densely populated areas.

Shifts of between 5cm and 25cm were observed from the interferometric analysis of Envisat images in the summer of 2007. The polygons in red represent the boundaries of risk areas mapped in field work between 2011 and 2013.



112 points were verified in the field, focusing on populated areas. In all checking points subsidence signals were found.

- Products generated from the SAR images of COSMO SkyMed series sensors and its derivatives represent a new source of information that allows the absolute quantification of altitude differences in the sub-centimeter range, speed and direction of registered movements, but also in generation of Digital Elevation Models with vertical accuracy of approximately 5m.
- In the case of detection of accumulations by depositing the CosmoSkyMed presented accuracy up to 0.5 cm and ENVISAT of 3 to 4 centimeters.







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