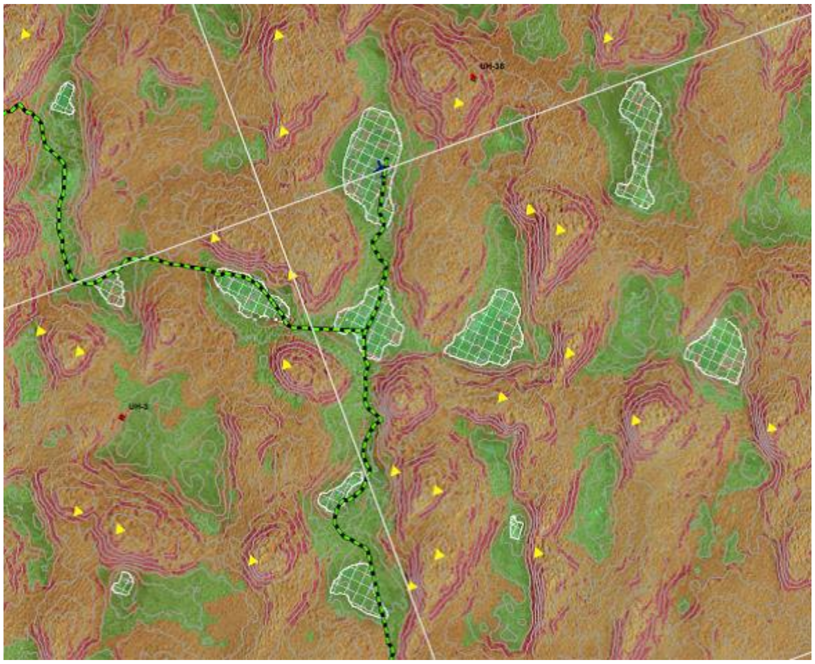
Product Sheet: Lithology and surficial geology mapping

LITHOLOGY AND SURFICIAL GEOLOGY MAPPING



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PRODUCT DESCRIPTION

Category	Component products
Near Surface Geology	N/A

Uses

- Seismic planning – areas of poor coupling
- Seismic planning – identification of adverse terrain for trafficability
- Surface geology mapping – structural interpretation
- Surface geology mapping – lithological discrimination
- Surface geology mapping – terrain evaluation and geo-morphology characterization
- Surface geology mapping – engineering geological evaluation
- Environmental monitoring - baseline historic mapping of environment and ecosystems
- Environmental monitoring - natural hazard risk analysis
- Logistics planning and operations – facility siting, pipeline routing and roads development

Geo-information requirements

- Lithology, geology and structural properties of the near surface
- Terrain information

Description

Lithological features, lithology and surficial geology (soils) can be distinguished and mapped utilising a wide range of EO sensors and analytical techniques, often incorporating use of multiple EO datasets.

Products may include:

- Geological maps, lithology maps, soils/surficial geology maps;
- Terrain unit maps (incorporating lithology with terrain classes); and
- Onshore hydrocarbon seep maps.

Products will vary according to particular user requirements and may range widely in geographic scale and level of detail and accuracy required.

Spectral analysis is an established key tool utilising spectral signatures of surface materials (using a variety of techniques including band-combination, band-ratio and PCA). Litho-types can be distinguished by spectral signature (of outcrop and/or vegetation) together with relationships with topography/geomorphology, in particular texture (surface roughness) and pattern (including drainage pattern). Altered rocks and soils (e.g. ferric iron alteration enrichment and clay mineral alteration) associated with onshore hydrocarbon seepage can provide important clues for basin geological modelling and exploration.

Multispectral analysis techniques use reflected infrared (VNIR, MIR) and thermal (emitted) wavelengths measured from a wide variety of sensors at different resolutions. Landsat and ASTER are widely utilised. Data fusion between different sensors and other datasets including DEM and geophysics allow for improved interpretation and lithological classification.

In addition to identification of broad litho-type groups, further distinction and characterisation can be made by remote sensing analysis including stratigraphic relationships (between litho-types) and tectonic relationships to further enhance geological modelling of the project area.

Geomorphological analysis including DEM and shaded-relief analysis can be used to identify soils by geomorphic form such as fluvial deposits (river terraces, alluvial fans, deltas) and sand dunes. Surface roughness and moisture content can provide an indication of degree of weathering and soil formation. High resolution DEM (e.g., derived from VHR1 sensors) are beneficial for mapping geomorphic form related to surficial deposits. Multi-temporal analysis can provide information on mobility of surficial deposits such as mobile dunes and fluvial (river/delta) systems.

Hyperspectral data can allow for distinction of finer levels of detail of spectral class and mineral identification allowing for more precise lithological differentiation, including variation within a formation unit (e.g., due to facies change, intrusions such as dykes and sills, hydrothermal alteration, weathering, duricrusts and hydrocarbon seepage). Future planned hyperspectral sensors, including EnMAP (2017), are anticipated to have good potential for lithological mapping.

Airborne geophysics data can be effectively incorporated with EO data analysis for more detailed and accurate lithological mapping. Spaceborne geophysics data currently is not at sufficient resolution to allow for detailed lithological distinction. Data collected from the GOCE satellite (2009-2013) has some benefit for mapping of global and broad regional scale geological structures including mapping depth of crust (depth to Moho) for input to broad regional seismic and tectonic modelling, including thermal gradient modelling.

Known restrictions / limitations

- Lithological mapping is best-suited to arid and semi-arid regions.
- Temperate and tropical regions with deep weathering and dense canopy are more challenging and accuracy of analysis and interpretation is lower, with pattern (e.g., drainage network pattern) and established vegetation associations being important to assist interpretation of underlying lithology.
- For optical imagery, atmospheric effects need to be removed to increase accuracy of interpretation and assist interpretation of underlying lithology.

Lifecycle stage and demand

Pre-license	Exploration	Development	Production	Decommission
**	****	***	**	

Pre-license: Information for geology to support decision-making on a prospect.

Exploration: Information to support geological mapping of surface and sub-surface, lithological and stratigraphic relationships, seep identification and seismic surveys (planning, e.g., trafficability, and data interpretation including seismic production modelling and nearsurface modelling).

Development: Information for planning and design of infrastructure, to support site selection and pipeline routing to determine hazards and risks in a proposed development area.

Production: Monitoring of changes in lithology/soils for asset monitoring of facilities and operations including pipeline leakage.

Decommissioning: Not typically required.

Geographic coverage and demand

Coverage is global.

Demand is global.

Demand is in all terrain areas, excluding polar and permanent snow covered landscapes.

Challenges Addressed

OTM:014 Forecasting sand dune migration

OTM:015 Geological and terrain base maps for development of environmental baseline

OTM:023 Infrastructure planning

OTM:026 Identifying potential hydrocarbon seepage

OTM:036 Geohazard exposure analysis

OTM:044 Identifying steep terrain for seismic vehicles

OTM:045 Identifying soft ground for seismic vehicles

OTM:046 Identifying variations in trafficability for seismic vehicle

OTM:052 Identify the cause of geological movement

OTM:058 Identifying ground conditions susceptible to poor coupling

OTM:059 Understanding outcrop mineralogy

OTM:073 Identifying sources of building resources

OTM:074 Estimating ground bearing capacity

HC:1102 Identify rock-strewn areas to avoid point loading

HC:1103 Identify soft and hard ground as areas of potentially poor source and receiver coupling

HC:1203 Identify areas with soft sediments to plan access and assess hazards

HC:1207 Identify claypan surfaces to be avoided

HC:1212 Identify sabkahs / salt lake areas

HC:2201 Identify geological structure through landform

HC:2301 Identify discreet lithology

HC:2401 Identify geohazards and landscape change rates

HC:2501 Characterization of surface/near-surface structural geological properties for infrastructure planning

HC:2502 Identification of problem soils

HC:2503 Assessment of duricrusts and rock excavability

HC:5301 Planning and assessing borrow pits as source of aggregate material

PRODUCT SPECIFICATIONS

Input data sources

Optical: VHR1, VHR2, HR1, HR2

Radar: VHR1, VHR2, HR1, HR2, MR1

Supporting data:

- Geological maps
- Published literature and reports
- Field geological mapping, field collected spectra, borehole logs
- Airborne geophysics

Spatial resolution and coverage

Varies depending on input imagery used and client needs.

1:50,000 to 1:250,000 scale mapping is typical.

Minimum Mapping Unit (MMU)

N/A

Accuracy / constraints

Accuracy of interpretation is higher in arid and semi-arid regions. Temperate regions and tropical regions with thick soil cover and dense vegetation canopy have lower accuracy of interpretation.

Spectral libraries are inconsistent across differing geographic and terrain groups.

Thematic accuracy: 70-90% for arid/semi-arid regions where vegetation cover is low.

Spatial accuracy: The goal would be 1 pixel, but depends on reference data and ground-truth data.

Accuracy assessment approach & quality control measures

Professional judgment by comparison with any published geological mapping or reports and ground truth data (geological mapping and collection of field spectra, borehole logs).

Frequency / timeliness

Observation frequency: Typically only one date is required (per dataset/sensor used) and can frequently utilise archive data.

Timeliness of delivery: Depends on the requirements of the client and processing required. Archive data is frequently used and is usually available off-the-shelf.

Availability

Availability from commercial suppliers and other agencies. New acquisitions can be requested globally for higher resolution data. Archives products available for public search.	
Delivery / output format	
Data type: • Raster • Vector • Digital or paper maps	File format: • .tif, .ecw • Shapefile • PDF files or plots

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Lead author:	HC / Arup
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