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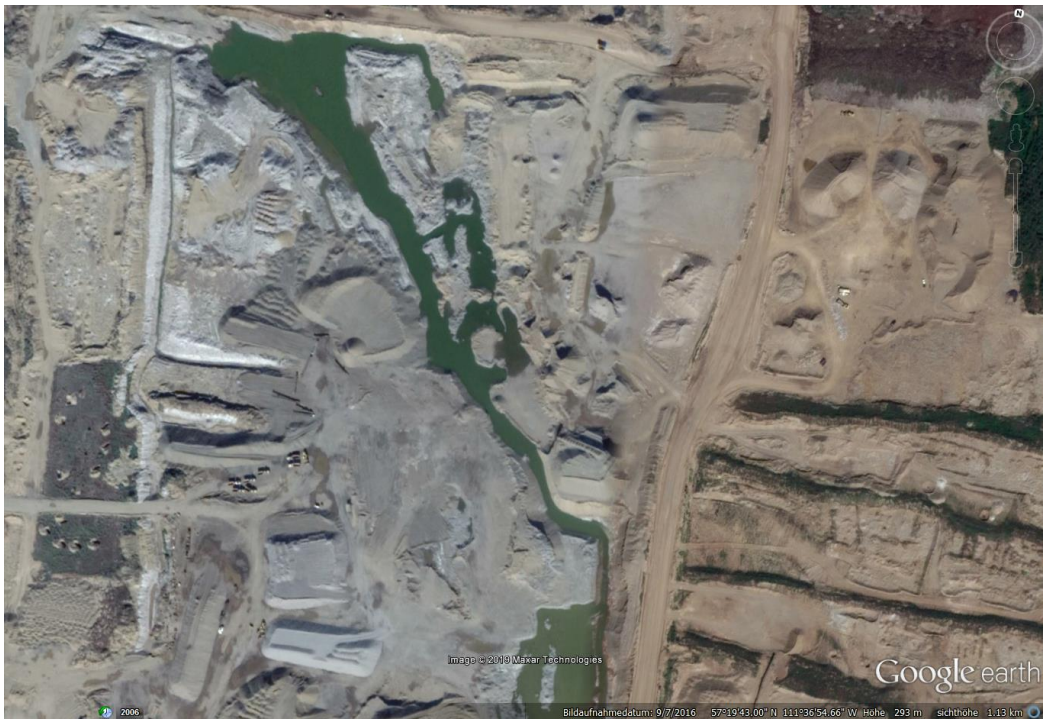
STOCKPILE MONITORING



Stockpiles (Source: Google Earth)

PRODUCT DESCRIPTION

Category

☐ Topographic information	☐ Surface deformation
☐ Impact assessment	☐ Precision ortho-images
☒ Change detection / continuous monitoring	☐ Terrain information
☐ Land cover / use	☐ Water quantity & quality
☐ Near surface geology	

Uses

Operations – Stockpile monitoring

Operations – Stockpile volume

Operations – Stockpile changes

Challenges addressed

Development and Operations – Stockpile Monitoring

Geo-information needs

DO-10: Raw material stockpiles

DO-11: Ore stockpiles

DO-12: Final product stockpiles

Description

It is essential in terms of managing a mine to continuously get information on raw material, ore and final product stockpiles. This product provides a monitoring service that helps to monitor any changes within the stockpiles as well as to calculate volumes.

High resolution satellite imagery such as Pléiades could be used to address this issue. New methods with Stereo and Tri-Stereo images that are especially used for elevation modelling make it now easier to generate a 3D-model that is used a basis for further assessment. With this input data, further steps are applied, generating different models:

- A Digital Surface Model (DSM) pictures the earth's surface including all objects on it, such as trees or houses.
- Whereas a Digital Elevation Model (DEM) covers the surface without such objects, representing the relief.

The volume of stockpiles is then calculated bringing those two input models together and calculating the differences between them. Also, changes in volume can be measured when comparing models from different points in time.

Drones and UAV provide images can help with the detection of stockpiles and support the satellite imagery. They provide a higher resolution and can take pictures at a higher frequency. With the points clouds that can be derived, the volume is measured.

Findings can be provided in reports providing statistical data, changes and progress.

Known restrictions / limitations

How well a product gives information on volume of stockpiles is highly dependent on the quality and resolution of satellite imagery. Using open source data, a resolution of 10 m is possible. However, depending on the dimension of stockpiles, this might be too coarse. Concerning change products consistent data from the same sources and the same period for the area of interest is needed.

In case a further differentiation between types of material is needed, a hyperspectral analysis is obligatory. However, this analysis presumes bigger deposits as resolution is not as subtle as required for analysing such information.

The courses of the Pléiades satellites are designed to cover every point on earth every day, however, a continuous monitoring every day might not be possible as clouds, shadows or other might influence the quality of imagery.

Additionally used data such as drones and UAV may be costly.

Lifecycle stage and demand

Exploration	Environmental	Design, Construction	Mine Closure &

	Assessment & Permitting	& Operations	Aftercare
		■■■■■	

Design, Construction & Operations:

- Information to monitor raw material stockpiles.
- Information to monitor ore stockpiles.
- Information to monitor final products.

Geographic coverage

Globally available.

EARSC Thematic Domain

DOMAIN	LAND
Sub-domain	Land use
Product description	Monitor land cover and detect change

PRODUCT SPECIFICATIONS

Input data sources

Sampling of available products:

Satellite	***Sentinel 2***	***Worldview 1, 2 and 3***	***SPOT 6, 7***	***Pleiades***	***Pléiades Neo***
Status	In operation	In operation	In operation	In operation	Planned
Operator	ESA	Digital Globe	Airbus Defence and Space	Airbus Defence and Space/CNES	Airbus Defence and Space
Data availability	Public	Commercial, on demand	Commercial, on demand	Commercial, on demand	Commercial, on demand
Resolution (m)	10 - 60	0.31 - 0.46	1.5	0.5 – 2	0.3 – 1,2
Coverage	Global	Global	Global	Global	Global
Frequency (days)	5	< 2	< 1	< 1	< 2
Launch year	2015	2007 / 2009 / 2014	2012 / 2014	2011	2020
Website	link	link	link	link	link

Minimum Mapping Unit (MMU)

Variable, depending on source data resolution. A MMU as small as the pixel size of the chosen satellite is possible.

Accuracy / constraints

Thematic accuracy:

Detection of stockpiles within defined area; volume as well as changes in volume can be derived.

Spatial accuracy:

Dependent on input pixel resolution; Sub-pixel accuracy (i.e. <10m for Sentinel products)

Accuracy assessment approach & quality control measures

N/A

Frequency / timeliness

Observation frequency:

Every one or more days, depending on satellite.

Timeliness of delivery:

Within five (working) days of sensing.

Availability

Data from all Sentinel satellites are freely available through the open data policy of the operator ESA (Sentinel-2A since 2015, Sentinel-2B since 2017).

WorldView, SPOT and Pleiades data are commercially satellites and must be purchased through the operator/vendor Digital Globe (WorldView) or Airbus Defence and Space (SPOT, Pleiades). Usually available within hour(s) of satellite fly-over.

Delivery / output format

Further delivery formats: Statistical progress/change reports

USE CASE

Tucci, G.; Gebbia, A.; Conti, Al; Fiorini, L.; Lubello C. (2019) Monitoring and Computation of the Volumes of Stockpiles of Bulk Material by Means of UAV Photogrammetric Surveying. In: Remote Sensing 11, 1471.

In this study the monitoring and computation of stockpile volume was exercised using UAV photogrammetric techniques. 3D models were generated out of point clouds. A DEM was then needed to calculate the volumes. With the boundaries of the stockpiles, the DEM of the surface and the computed stockpile model, the volume was calculated.