User Dossier
And
Technical Specification Sheet

Karkar / Dudkash, Afghanistan

Coal Mining Activities

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Abbreviations and Acronyms

Term	Description, Explanation
AOI	Area of Interest
GIS	Geographic Information System
GPS	Global Positioning System
VHR	Very High Spatial Resolution

1 Introduction

Purpose

This user dossier intends to assist potential users as cadastre or inspectorate officers of the Ministry of Mines in getting a better understanding on:

1. What can be recognized on the optical satellite imagery – in general and specifically concerning mining activities,
2. The interpretation and analyses of the satellite images,
3. How features might be evaluated and compared with cadastral and other information.

This dossier deals with coal mining activities at the coal deposits of Karkar and Dudkash in Baghlan province, Afghanistan, derived by the analysis of optical very high spatial resolution (VHR) satellite data. Figure 1 below gives an overview of the area of interest (AOI).

Figure 1: Area of Interest (AOI).

Suitability for business processes

The products and services described below are major work contributions to the typical business process activities of

1. Mining inventory,
2. Mine verification,
3. Title / Application Availability, and
4. Compliance monitoring works

as specified in the service trial specification document D3, 1.1, of July 2012.

Results of Demonstration service

The present service shows principally three major results:

1. The map products - described in more detail below,
2. The Geographic Information System (GIS) compatible interpretation and analysis layers - described in more detail below,
3. And the documentation at hand (User Dossier and Technical Specification Sheet).

The map products (see annex 2) show the coal mining activities at the coal deposits of Karkar and Dudkash in Baghlan province southeast of Baghlan, Afghanistan. The EO-data used for the image interpretation and analysis are VHR optical QuickBird and GeoEye satellite data acquired on 31.07.2006 and 27.02.2009, respectively. Further information on this data is given in the Technical Specification Sheet (see annex 1).
The satellite images are shown as backdrop in the map products and overlaid by further GIS-compatible vector data specified in chapter 2 (Content of map products). The generation of vector data by visual interpretation and semi-automatic image analysis is explained in chapter 3 (Image interpretation and analysis guide). Beyond that, in this chapter examples for satellite data interpretation are given in order to facilitate the understanding of the imagery used as backdrop on the maps. The conclusions of chapter 5 mainly cover aspects of the satellite imagery and to a lesser extent additional data (see below).

Further evaluation possibilities of imagery

In addition to the general description of methods and results in chapter 3, chapter 4 describes the coal mining interpretation and analysis layer, possible measures to enhance the value of this layer and possible further interpretations that result from the combination of the imagery with other GIS compatible data sets (e.g. ground truth data, cadastral information, infrastructure, topography or geology).
Please note that no cadastral information was available for coal mining areas. Thus some points raised in chapter 4 are only on a theoretical basis and are currently not applicable for the coal mining test sites.

2 Contents of the map products

All maps are in geographic projection, i.e. maps units are degrees, minutes and seconds and the rectangular x, y axes are defined by longitude and latitude. This projection was selected as it equals the one used in the cadastre. However, this projection is not suitable for direct – on the map – distance, area and angular measurements. More technical details about the datasets and maps are given in annex 1 and 2.
The content of the map products shows in general the following information:

1. Optical satellite image as background
2. GIS-compatible image interpretation and analysis layers detected at two different points in time, including:
    a. The coal mining area,
    b. Further information on features related to mining activities,
    c. Other basic geo-information - including information on population, infrastructure and hydrology,
3. Marginalia (including map legend, interpretation text etc.) providing further information on the map content and the datasets used.

3 Image Interpretation and Analysis Guide

3.1 Methodological approach

For a better understanding of the results the methods used for the image interpretation and analysis will shortly be described in the following. In order to get best possible results, the interpretation and analysis of the satellite data were performed both

i) by semi-automatic image analysis, i.e. the interpretation of the satellite image is performed partly automatically by using a remote sensing analysis software package and partly manually by an image interpretation expert. Thereby, focus for the automatic part is set on the definition of robust and stable parameters in order to transfer the developed algorithm to different satellite scenes and/or other areas with only minor manual adjustments.

ii) on a visual basis, by manually digitizing features of interest.

For a fast feature extraction the whole satellite scene was first analysed by semi-automatic image analysis to identify potential hot spots of mining areas, which are shown in the overview maps. The designated areas and its surroundings were then further analysed on a more detailed level by visual interpretation to detect additional features related to mining activities. Furthermore basic geo-information such as population features, infrastructure and hydrology have been digitized by visual interpretation of the satellite data and in case of the settlement names complemented with information provided by the Afghan Geodesy and Cartography Head Office. The results of the interpretation have not been verified in the field. Photographs taken during field visits were used to facilitate the interpretation.

In addition the consultant refers to literature that describes various studies concerning the EO image analysis for mining activities. A summary of typical mining activity indicators is given by the website EO-Miners - Preliminary results - Indicators - Application of EO techniques.

3.2 General features

The images below depict general features visible on the satellite imagery in order to facilitate the understanding of the imagery used as backdrop on the maps.
The recognition of specific objects generally is not a direct question of size, but of size in its environment context. For example, even a single car (2 pixels) might be recognized in this resolution if it appears as bright dots on a road. However it will probably not be recognized as a single object that is off-road.

Built-up area: buildings (Scale 1:1,500)

Built-up area: ruins (Scale 1:1,500)

Bare ground covered with coal dust (1:5,000)

Road network (Scale 1:5,000)

River network (Scale 1:5,000)

Mountainous terrain with river valley (Scale 1:5,000)

Figure 2: General features visible on the satellite imagery.

3.3 Coal mining activities and features

Similarly to general features, mining activities are also best recognized if they appear in an appropriate context. In the following some examples of the image interpretation are shown and a comparison of features relevant to mining activities detected on the satellite imagery with photographs is given.

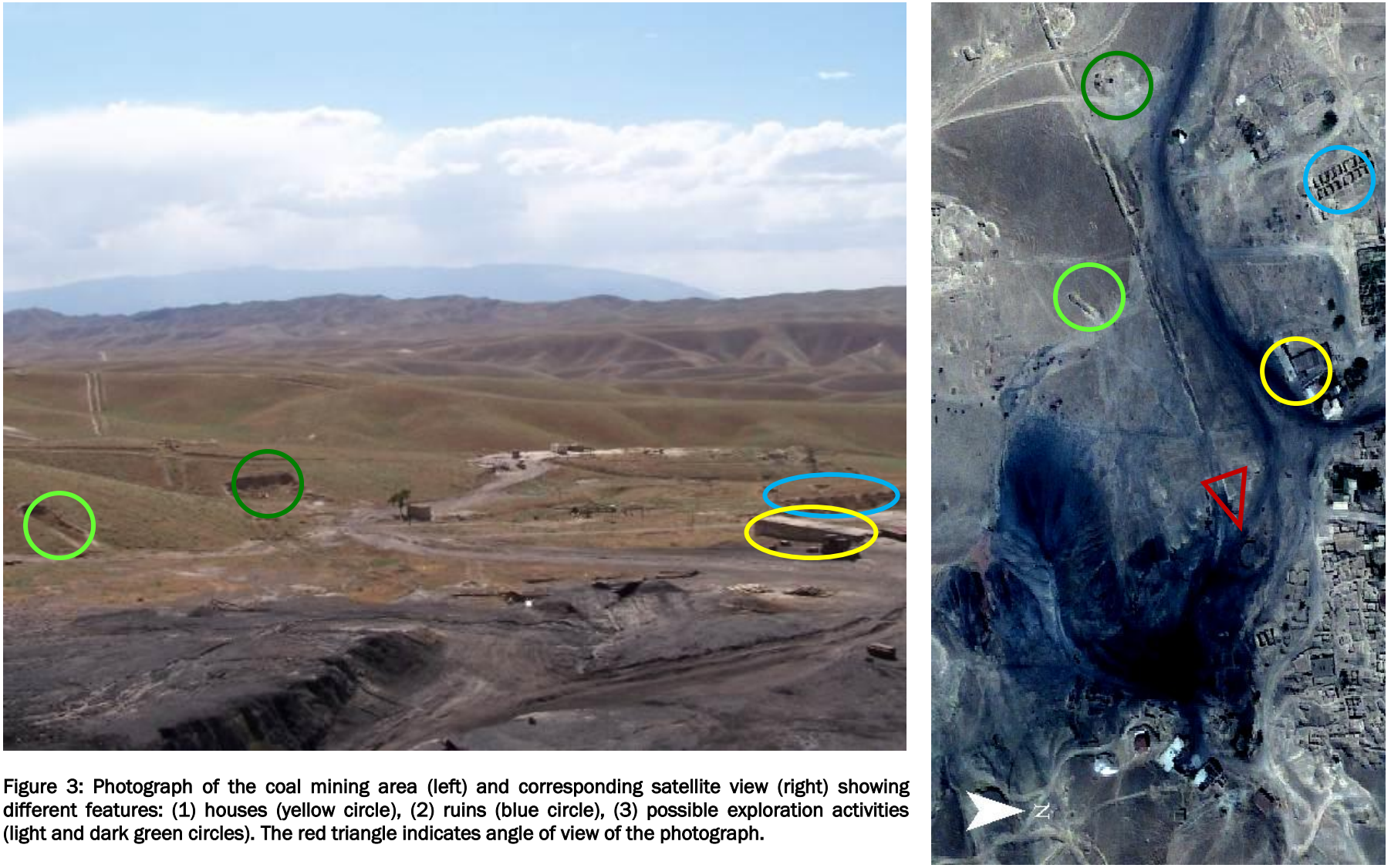

Figure 3: Photograph of the coal mining area (left) and corresponding satellite view (right) showing different features: (1) houses (yellow circle), (2) ruins (blue circle), (3) possible exploration activities (light and dark green circles). The red triangle indicates angle of view of the photograph.

Figure 4: Photograph of an adit (left; yellow circle) and corresponding satellite view (right; yellow circle). The red triangle indicates angle of view of the photograph on the left.

Figure 5: Photograph of the coal mining area showing different features: (1) buildings (yellow and orange circles) and (2) stock pile (purple circle). The red triangle indicates angle of view of the photograph.

4 Coal mining interpretation and analysis layer

The analyses of satellite images resulted in the generation of GIS compatible vector layers that provide additional information and several advantages to the map products:

1. Attribute information (see 4.1) was added.

2. It might be compared and value-added with ground truth, cadastral or any other spatial layers in a GIS (chapter 4.2) for inspectors and cadastre officers of the Ministry of Mines.

3. The final coal mining interpretation layer is GIS compatible making it suitable for
    a. mobile, i.e. Global Positioning System (GPS) supported GIS solutions, e.g. GeoRover® software,
    b. adaptable layouts as selective attribute displays, transparency etc.,
    c. multi-spatial layer analyses and intersection methods used in standard GIS.

Below the consultant explains the possible design and possible evaluation methods of this vector layer. Since no cadastral information was available for coal mining areas, some of the following points are only discussed on a theoretical basis and are not applied for the coal mining test sites.

4.1 Layer attributes

The vector interpretation and analysis layer contains not only spatial information as given in the produced maps, but some ordinal and numerical attribute information that might be essential for the mine verification and monitoring activities. To realize these activities the data have to be handled in a GIS.
Typical attributes of the interpretation layer, respectively each spatial unit in this layer, should be defined, if applicable, and thus might be attributed accordingly:

1. Interpretation date.

2. Satellite image acquisition date used.

3. The mine feature identified in the image (e.g. in this dossier: coal mining area, adit, stock pile, possible exploration activities).

4. Possible status or activity of this mine feature, if applicable (e.g. gone, new, extant).

5. Its area (in case of polygon) or length (in case of line features). These geometric attributes may be generated semi-automatically in modern GIS systems.

6. Its relation to the cadastre layer (if available) (e.g. “within license/application area”, “intersects license/application area” or “outside license/application area”).

7. Conclusions drawn from comparison with other geo-information layers (e.g. comparison with geological map/mineral occurrences: “possibly coal mining area”).

8. Compliance status according interpretation and satellite image acquisition date and relation to cadastral or inspectorate information (e.g. “compliant”, “non-compliant” or “un-defined”).

9. Possible monitoring activities of the cadastre/inspectorate identified (e.g. “check extent”, “check activity”, etc.).

Points 1-9 may be used for quantitative, semi-quantitative and multi-temporal statistical analyses and points 6-9 have specific significance for compliance studies, i.e. the business process mentioned above.

4.2 Comparison with independent information

The interpretation may be further compared with all kind of independent information, e.g. infrastructure, geology or hydrographic information, if the data are available.

Below we describe possible conclusions that can be drawn from intersection of the interpretation layer with spatial layers of the cadastre or other geo-information.

Principally five situations are recognized concerning the cadastral compliance:

1. Interpretation of image map and other information complies with the status of the cadastre and inspectorate. No action required.

2. The image map hints to a mine activity or feature but no corresponding entry in the cadastre or inspectorate exists. This hint should initiate a ground check for mine verification and/or mine inventory purposes.

3. The cadastre/inspectorate entries/layers indicate a license/application, but nothing is visible in the satellite image map. This is the contrary case as above but should result in the same action, if the application or title is older than the satellite image.

4. A geometric offset exists between the cadastre/inspectorate entries and the image map feature. If an artefact (calculation/projection/classification error) may be excluded, this should also trigger a ground check for mine verification or compliance monitoring purposes.

5. Activities interpreted from the image map do not correspond to title rights.

These examples demonstrate the power of the monitoring possibilities if careful image analysis and comparison with other data is applied in a GIS environment to give full information potential to the interpretation layer.

4.3 Selected quantitative and multi-temporal analysis

The geometric, date and status attributes mentioned in chapter 4.1 (1-5) may be used to generate – at least in cases where the information is completely available - quantitative and multi-temporal analyses. For the coal mining area satellite data of two time stamps have been delivered. No major changes of mining activities could be observed.

5 Conclusions

1. The image analysis and the resulting products show that features related to mining activities such as coal mining deposits could be detected within the defined area of interest. Coal mining hot spots could be well detected by semi-automatic image analysis. Furthermore, features related to mining activities such as adits, stock piles, and possible exploration activities could be recognized within the defined area of interest and captured by visual interpretation and manual digitizing. While stock piles and exploration activities were clearly visible on the satellite image, small-scale features such as adits could hardly be identified. In those cases photographs taken during field trips provided valuable information supporting the image interpretation.

2. Similarly specific mine and ground activities may be identified in the optical imagery if the time window of the image acquisition is suitable for the relevant purpose. Thus a clear awareness of the significance of the acquisition dates of the satellite images is important.

3. If ground truth data are available – even if they are historically – they should be used to verify, check consistency, and to add and correct valuable information in the interpretation layer.

4. If recent imagery data are available for reasonable prices they should also be acquired to get the possibility to monitor changes in the mine features detected in older imagery.

5. The attributes of the interpretation layer should be standardized as far as possible – to facilitate database querying and thus enhance use and usefulness of following GIS and database works.

6. Any other geo-information layer is useful to enhance the value of the image maps in a GIS environment: This concerns in particular any kind of ground truth and cadastral data, but also any other data that may give information about legal (administrative boundaries, toponyms), infrastructural (traffic lines, power facilities), environmental (land use and management), or geologic issues.

6 Annex 1: Technical Specification Sheet

PARAMETER	SPECIFICATIONS		
Data sets	*Raster and vector data*		
Satellite sensor	QuickBird; GeoEye		
Image quality	Cloud and haze free <10%		
Image acquisition date	31.07.2006; 27.02.2009		
Spatial resolution	0,6 m and 0,5 m pan-sharpened		
Spectral range		QuickBird	GeoEye
	Panchromatic	445 - 900 nm	450 - 800 nm
	Blue	450 - 520 nm	450 - 510 nm
	Green	520 - 600 nm	510 - 580 nm
	Red	630 - 690 nm	655 - 690 nm
	Near Infrared	760 - 900 nm	780 - 920 nm
	Back drop used in the maps: natural colour composite		
Image analysis	Semi-automatic image analysis and visual interpretation		
Geo-location accuracy (CE90)	QuickBird: 23 m (at nadir, exclusive of terrain distortions); GeoEye: 5 m (horizontal, without GCP, exclusive of terrain displacement)		
Geographic coverage	NW Lat: 36.061935 NW Long: 68.706896 SE Lat: 35.984596 SE Long: 68.830019		

Table 1: Technical specification of satellite data used

7 Annex 2: List of map products and geo-information layers

All images and layers are produced or re-projected in geographic coordinates with datum WGS 84, angular unit degree and prime meridian Greenwich.

Type	Title	Scale, Size or Accuracy	Format
Overview Map	Coal Mining Area, Karkar/Dudkash – Afghanistan	1:15 000, ISO A1	pdf.
Detail Map	Coal Mining Activities in 2006, Karkar – Afghanistan	1:3 000, ISO A1	pdf.
Detail Map	Coal Mining Activities in 2006, Dudkash – Afghanistan	1:2 500, ISO A1	pdf.
Detail Map	Coal Mining Activities in 2009, Karkar – Afghanistan	1:3 000, ISO A1	pdf.
Detail Map	Coal Mining Activities in 2009, Dudkash – Afghanistan	1:2 500, ISO A1	pdf.
Detail Map	Comparison of coal mining activities between 2006 and 2009, Karkar – Afghanistan	1:3 000, ISO A1	pdf.
Detail Map	Comparison of coal mining activities between 2006 and 2009, Dudkash – Afghanistan	1:3 000, ISO A1	pdf.
GIS layers Included in Overview Maps	- Population (Settlement) - Infrastructure (Primary route, Secondary route, Cart track/footpath) - Hydrology (River) - Mining (Coal mining area)	< 23 m	ESRI Shapefile
GIS layers Included in Detail Maps	- Population (Houses, Ruins) - Infrastructure (Primary route, Secondary route, Cart track/footpath) - Hydrology (River) - Mining (Adit, Stock pile, Possible exploration activities)	< 23 m	ESRI Shapefile

Table 2: Overview of map products and geo-information layers