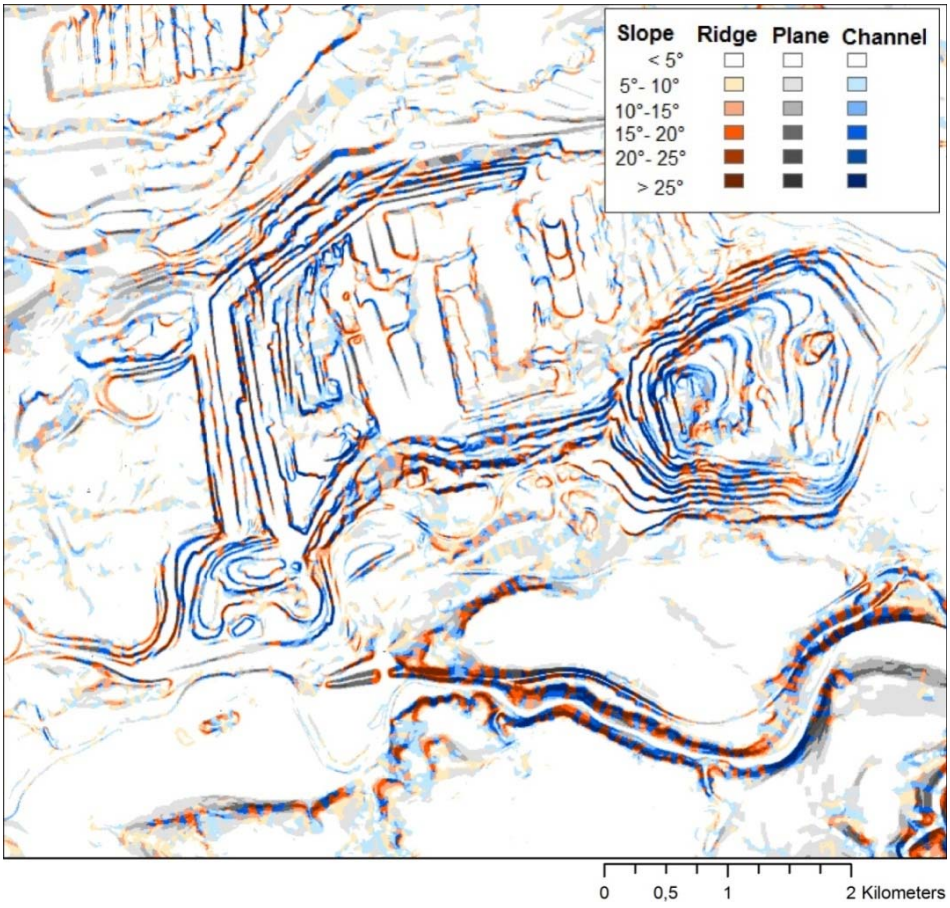
B MASS FLOWS

B1 - Waste Volumes Generated	
This indicator is related to A1, but would require the determination of volume changes in deposited materials. Such an indicator points towards the ore-grade mined, the depths of the mine and the efficiency of the mining technique. When properly contextualized, this indicator allows comparisons between mines/mine types and the analysis of time series for a particular mine.	
Requirements	• Multi-temporal volume estimation of selected deposit sites.
Variable(s) to be determined	• Volume changes in deposited materials • Amount of marketable product produced
Data acquisition	
Source of information	• Precise information about the surface topography of the waste heaps and the surrounding area obtained from an accurate digital terrain model (DTM) using photogrammetric sensor systems (or LIDAR). • When measurements are repeated, changes over time allow the calculation of deposited volumes. • In the case of new waste management facilities the baseline would be a DTM of the original topography. • Statistics of the mine/mill output of marketable product
Methods & Standards	• Optical airborne sensor systems, radar sensors (radar interferometry) • LIDAR (laser scanning), photogrammetry
Suggested sensor systems	See A1
Pre-processing & auxiliary data	See A1
Caveats: • Deployment requires clear days without significant cloud coverage for the optical systems • Higher cost of acquisition for LIDAR • Delineation/distinction of the deposited materials from the surrounding soils may be difficult and require additional information (e.g. vegetation cover). • Statistical information on mine/mill output requires co-operation from the producer as the data may be confidential, being commercially sensitive.	

B2 – Erosion	
Erosion of residues heaps can lead to the dispersion of contaminants and the degradation of agricultural soils.	
Requirements	• Mono-temporal identification & mapping of residual heaps. • Multi-temporal erosion mapping on the identified areas.
Variable(s) to be determined	• Spatial distribution of areas affected by soil erosion • Soil erosion intensity • Soil erosion susceptibility • Amount of eroded/deposited material per area
Data acquisition	
Source of information	• Ground surveys, analysis of remote sensing images
Methods & Standards	• Erosion can be mapped using optical sensors with high spatial resolution data. Changes in the abundance of three basic components of soil (organic horizon, alluvial horizon, alluvial horizon) indicating erosion processes can be detected optimally by very high spectral resolution remote sensing – imaging spectroscopy. • Sediment loads in surface waters measured at the discharge point of catchment and sub-catchment areas gives an averaging figure of soil losses due to erosion.
Suggested sensor systems	• Very high spatial resolution (< 1 m) remote sensing optical imagery • In some cases also high spatial resolution data (< 100 m) from e.g. Landsat TM, ASTER, also depending on the extent of test area • Very high spectral (> 100 bands) and spatial resolution data - airborne hyperspectral imagery • Supplementary, radar interferometry, LIDAR, high resolution DEM • Stream water sampling and sediment traps at discharge points. Gravimetric determination of suspended loads. Mineralogical analyses of suspended sediments give further insights.
Pre-processing & auxiliary data	See A1, A2
Caveats: • Link to land use (absence of vegetation) • Sampling, installation of sediment traps and analyses are labour-intensive. Measurement must be either continuous or carried out during high-flow. • Additional analysis of morphology/hydrology is beneficial (cf. indicator B1)	

Examples

Sokolov site: Advanced morphometric classification method (Kopačková et al. 2011), moderate to steep-slope ridges and channels (slope> 15°) represent areas prone to erosion. © Czech GS



Erosion of a tailings heap partially covered with waste rocks and vegetation ((Ikonos imagery, East Rand, South Africa), © BRGM - CGS