REMOTE SENSING IN TERRAIN ANALYSIS

SCANEX R&D CENTRE DESCRIBES HOW REMOTE SENSING DATA IS USED FOR TERRAIN STABILITY ANALYSIS AS PART OF THEIR WORK IN ENGINEERING AND GEOMORPHOLOGIC SURVEY OF MOUNTAIN REGIONS

Plotting special analytical maps is one of the most important stages in engineering and geomorphologic surveys. Making large-scale geomorphological maps requires knowledge of origination, structure and stability of terrain forms as well as that of terrain dynamics and transformation mechanisms.

Solution to this issue for mountain regions appears to be the least developed particularly in plotting large-scale geomorphologic maps and schematic maps, assessment and prediction of dangerous phenomena, assessment of terrain stability and identification of anthropogenic activity safeguards.

Terrain transformations take place in various timeframes. In mountain regions they might be caused by surface seismic shocks, gravitation activities, changes in hydroclimatic conditions, etc. These changes often result in occurrence of dangerous and catastrophic processes and change of environmental situation. All this needs to be taken into consideration for an engineering and geomorphologic survey in the process of exploring mountain regions.

Remote sensing data are increasingly finding application in large-scale geomorphologic mapping. This is particularly important for surveying mountain regions, which are difficult to access. Images allow obtaining various information on terrain morphometry, interface of different terrain forms and form elements, lithology of constituent rocks, structural and tectonic framework of a region. Advantages of space imagery are as follows:

1. Large areal coverage, which includes locations inaccessible for direct ground surveys but representing a source of potential hazard for national economy entities (mudflow sites, glacial lakes, hanging glaciers, landslide slopes, etc).
2. Possibility of obtaining and further analysis of high resolution (2 meters and higher) images as well as stereo images,
3. Possibility of multitemporal imagery of an area of interest for analyzing dynamics of geomorphologic processes for the purpose of predicting adverse and dangerous phenomena.
4. Possibility of prompt (initial hours upon data reception until obtaining first results) monitoring of an area of interest with respect to risk of potential dangerous geomorphologic process and prevention or mitigation of possible damage in event of its occurrence.

Analysis of lithogenous terrain base is one of the key problems in engineering and geomorphologic surveys. This information sometimes is not reflected on geomorphologic maps and even on

TABLE 1. SATELLITES, RESOLUTION AND TYPICAL APPLICATIONS.

Satellite	Spatial resolution (m) (for maximum resolution channel)	Application
Landsat 7	15	General surveys of large mountain areas, identification of geomorphologic, geologic, and landscape – climatic boundaries, mapping of basic terrain forms, their relative positioning and interface of structures different in terms of
Spot 2,4		
IRS P5 (Cartosat)	2,5	Detail terrain surveys, potential analysis of lithogenous base. Use of stereo image to produce digital elevation model, analysis of surface elevations. Vegetation cover analysis.
EROS-B	0,7	Detail terrain analysis down to 1-2 meter detail. Detail analysis of vegetation cover for surface stability analysis, possibility of studying terrain lithogenous base, age estimation of certain terrain forms (vegetation cover in rockfall and avalanche channels, in dry washes and debris cones)

large-scale ones. Earth remote sensing data may also be extensively used in morpholithogenous analysis. This statement is particularly true for high resolution data.

Morpholithogenous analysis is based on the fact that evolution of ground surface is not possible without fragmentary material moving across. This is accompanied by joint evolution of the terrain and its lithogenous base. Almost every type of fragmentary deposits is a product of morpholithogenesis.

Introduction of morpholithogenous analysis in engineering and geomorphologic activities and in particular in large-scale mapping, provided opportunity to define several terrain properties. First, surface stability assessment is now possible. Secondly, terrain dynamics for a certain time interval can now be mapped with higher confidence, i.e. indicating tendency in surface changing and intensity of mortholithogenous processes.

Types of morpholithogenesis observed in mountains possess several features:

1. Slope surfaces are dynamic formations. This is due to relatively high rates of fragmentary material movement.
2. Morpholithogenesis on slopes responds to changing structural – tectonic and landscape – climatic factors with a certain lag thus leading to chances of observing processes, which are irrelevant to current geomorphologic conditions.

Thus, Earth remote sensing data may find wide application in analysis of mortholithogenous conditions being part of engineering and geomorphologic surveys.

The most important parameter of space images that affect quality of a survey being performed is their resolution. Table 1 lists several types of satellites, their spatial resolution and distinctive features associated with using the data in surveys.

The above table shows that data of different resolution are used for solving different tasks of geomorphologic mapping. Use of high resolution data increases mapping detail but masks certain terrain features, which are visible only on lower resolution images covering larger areas. This concerns continuous extensive forms of terrain (for instance dry wash, where microrelief is not visible on lower resolution images whereas interface of its different parts – mudflow origination zone and lithogenous base, transit zone and accumulation zone of mudflow cone – are clearly seen). This leads to the conclusion that in analyzing area terrain and its mapping use of data types that differ from each other (in resolution and spectral band) is more preferred and helps to obtain more information of the area under survey.

As an example of a high resolution image please see below the fragment of the image taken over the Adyl-Su River basin (the Elbrus region). The Eros-A image (spatial resolution is approximately 2 meters) (see Figure 1) clearly shows the glacial lake complex in the tongue section of the Bashkara glacier – potentially dangerous mudflow site.

Analysis of such image by means of comparing it to previous images and topographic maps allows remote analysis of the glacier tongue relief changes, building digital elevation model, monitoring level dynamics of lakes and changes in their quantity and area. All this can provide objective information on processes ongoing on this glacial mudflow site, enable prediction of situation development and identification of mudflow response actions. Application of remote methods will assist in monitoring mudflow sites, which cannot be directly observed due to their hard-to-reach location.

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Figure 1. The complex of glacial lakes in the bottom part of the Bashkara glacier (Kabardino-Balkaria, the Elbrus region). Image acquired by Eros-A, resolution is 1.9 m.]