COMBINATION OF MORPHOMETRIC INDICES AS A METHOD FOR THE QUANTIFICATION OF NEOTECTONIC EVOLUTION IN ACTIVE AREAS

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ABSTRACT

The linkage between tectonism and erosion may lead to the extraction of quantitative information regarding to the uplift rate of a fault block, based on the current relief. For this purpose different methodologies have been developed relating the differential block uplift with the eroding pattern of the stream channels. It is generally accepted that steep landscapes are associated with regions of rapid rock uplift, even if some exceptions exist. The fluvial network consistently maintains its connection to tectonic forcing and therefore contains potentially useful information about variations in rock uplift rates across the landscape. A number of studies have laid the groundwork for extracting this information, by exploring the theoretical response of channels to variations in rock uplift rate, and by analyzing fluvial profiles in field settings where the tectonics have been independently determined.

The methodologies discussed in this paper are used for the extraction of as much as possible tectonic information from the landscape, by interpreting high resolution digital elevation models (DEMs). The discussion focuses on the use of DEMs, which are inexpensive, easily obtained, and can be used to extract much of this kind of information quickly and easily, prior to field work. Such DEMs can be used for calculation of several morphometric parameters, providing a powerful tool for the exact delimitation of neotectonic structures and potentially the estimation of the uplift rate. We summarize the basic theory published in previous researches, giving an idea of research needs which must be met before we can have a reliable quantitative tool for neotectonic procedures, in conjunction with quantified tectonic information derived from stream profile interpretation. The transition from the published theory to the accurate estimation of these geomorphometric indices is a complicated series of procedures based on calculations between arrays of pixels and visualize the results in a GIS platform. However, some uncertainty remains as to what can and cannot be learned from an analysis of river profiles, as a standard method for extracting tectonic information from these data does not exist.

The southern coastal zone of the Gulf of Corinth seems to be an ideal case for the application of kinds of methodologies, thanks to the conventionally calculated uplift rates. The combination of the calculated morphometric parameters with the tectonic uplift rates derived by previous studies led to the calculation of the average erosional coefficient. The interpretation of these results is in very good agreement between the variance of the values of every morphometric index and the irregularities of the drainage network, caused mainly by tectonism (active faults, block tilting). Strong variations of the index values combined with field data reveal probable unmapped tectonic structures which may have been significant in the evolution of the Gulf of Corinth rift.

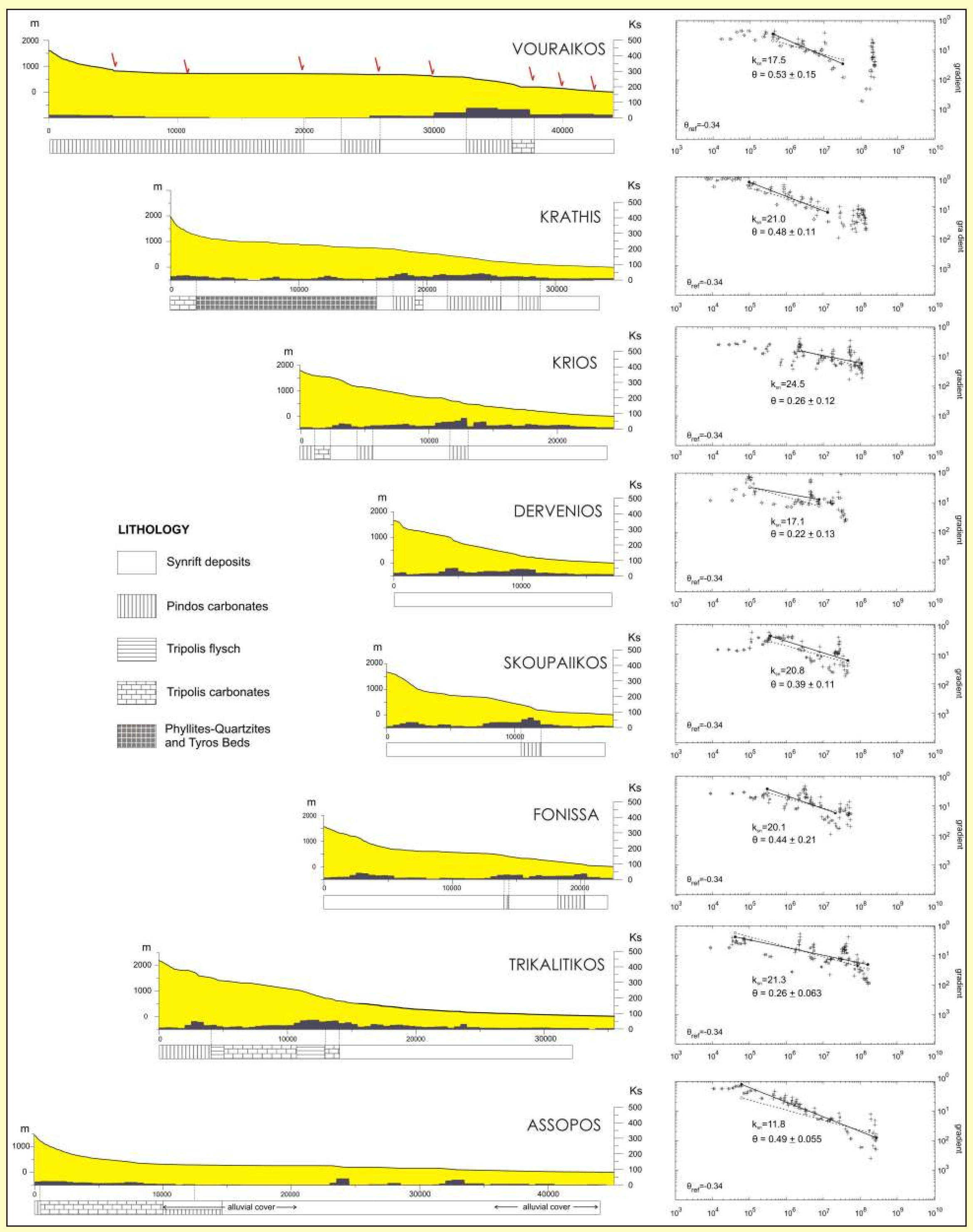


Fig. 4. The profiles of the eight main streams studied and the lithology changes in combination to the calculated *ks* index distribution along them. For every basin there is a slope/area graph, to the right, showing the θ and *ksn* estimation for reference concavity θ=0.34.

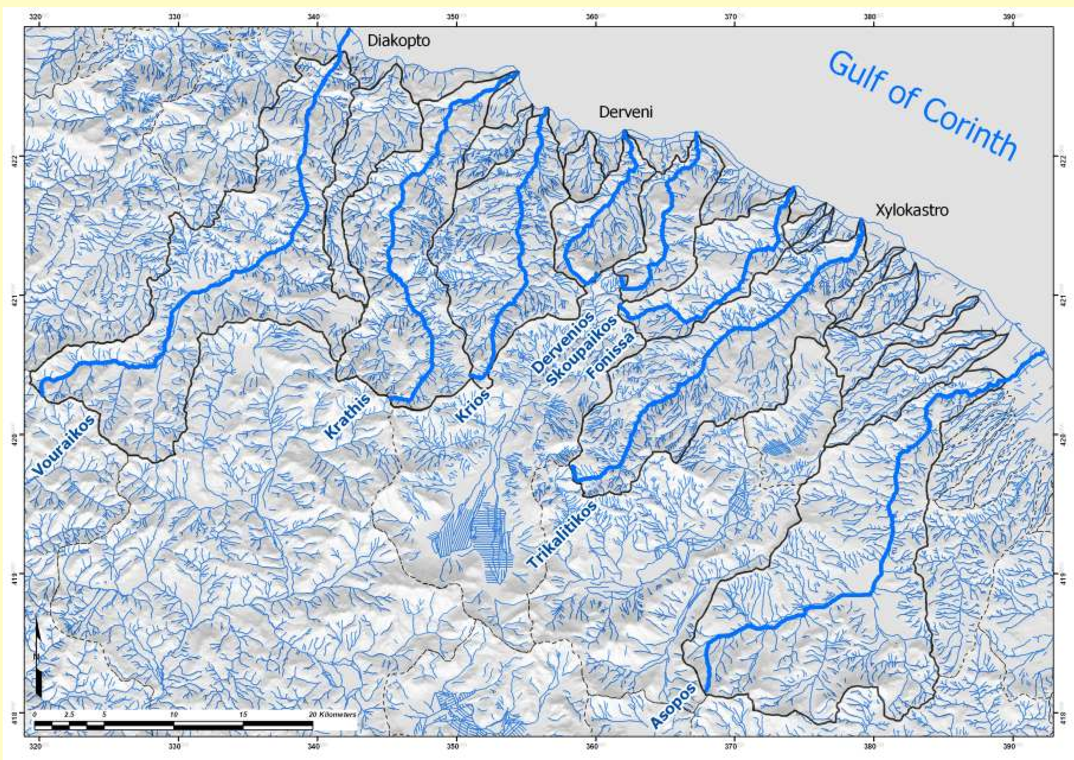


Fig. 1. The drainage network of the broader area extracted from a high resolution DEM (20m pixel size). The thick lines represent the main streams of the basins that were analyzed in detail by applying methodologies for the calculation of several morphometric indices and especially the **Steepness Index (*ks*)**. The results were combined with the geology of the area and the observed neotectonic structures.

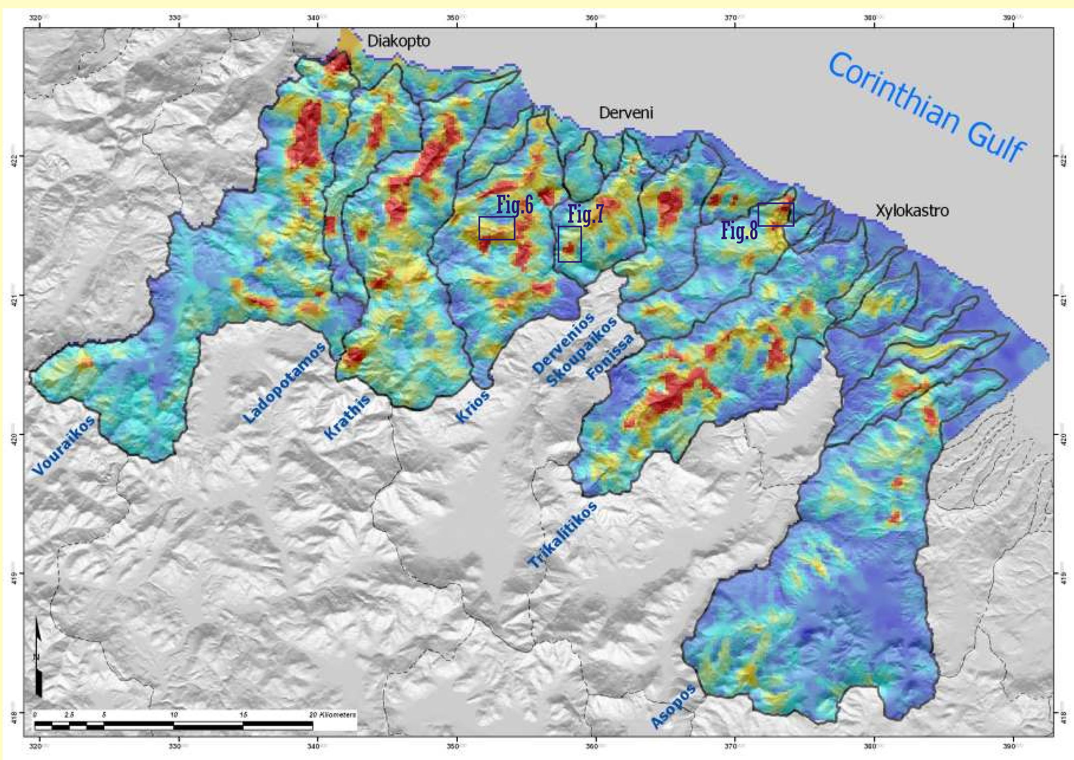


Fig. 2. Color composite shaded relief map of the study area. The colors of this map refer to the values of the calculated *ks* index. More than 800 points in the selected basins were used for the creation of a grid using the inverse distance weighted method. The resulting image is a cold to hot color scale map on which red areas are related to high *ks* values and reveal the uplifted blocks. Sudden changes from cold to hot colors are connected with the marginal areas of the fault blocks which are tilted towards SW. These observations are in agreement with the general tectonics of the area and were confirmed during fieldwork.

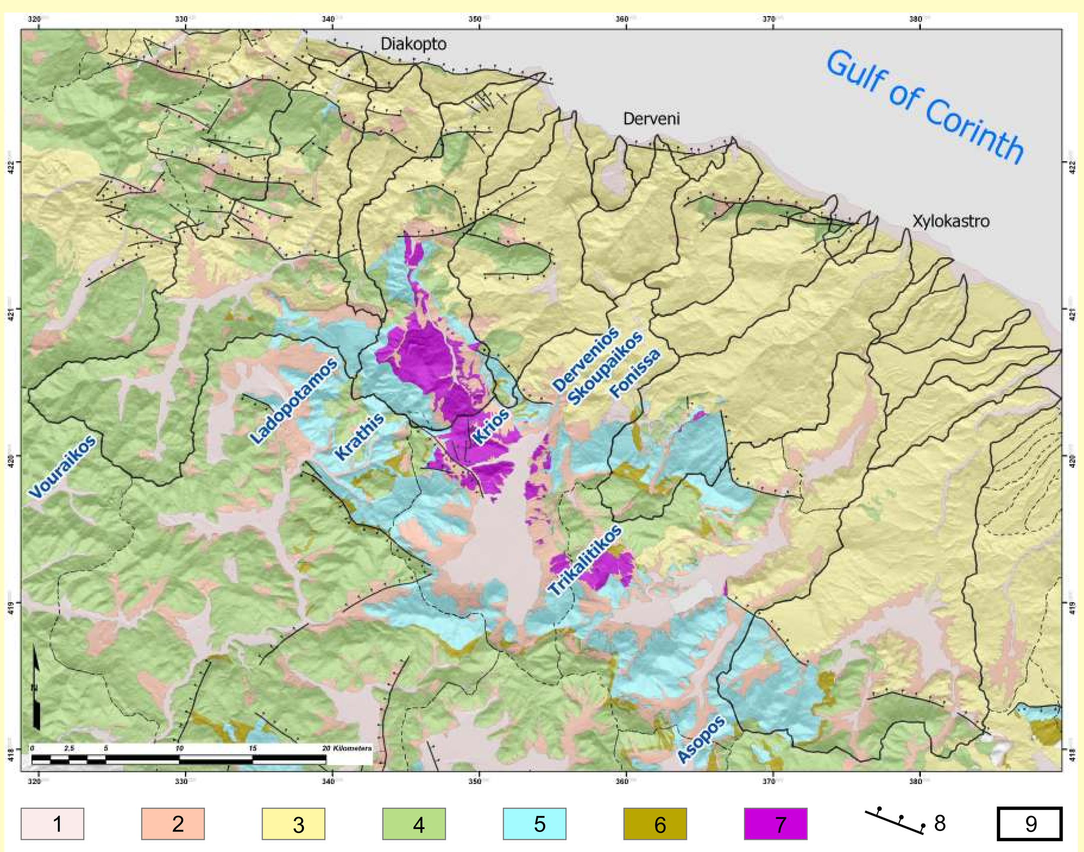


Fig. 3. General geological map of the broader area of interest *[1.Alluvial, 2.Debris, 3.Plio-Pleistocene marine deposits, 4.Pindos unit, 5.Tripolis unit (carb.), 6.Tripolis unit (flysch), 7.Zarouchla metamorphics (Tyros beds and Phyllites-Quartzites), 9.Normal fault, 10.Watersheds]*

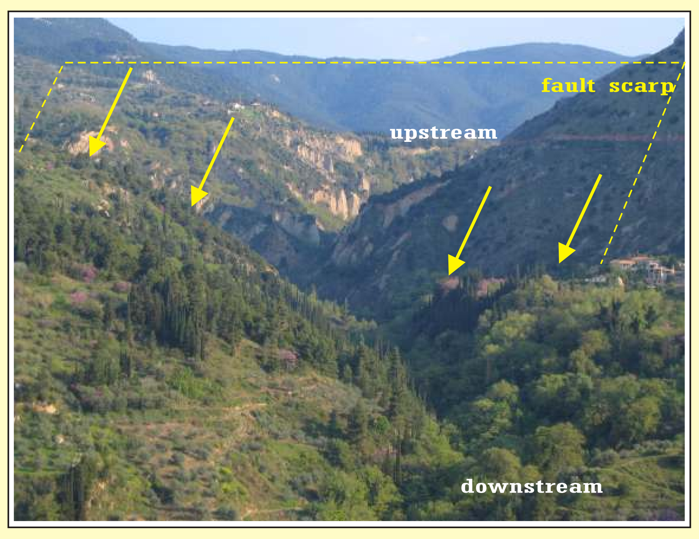


Fig. 6. Differences at the shape of the valley along a stream could be related to the change of the lithology and/or the presence of an active tectonic contact normal to the stream flow (in an ideal case scenario). In both cases the calculated *ks* index values are relatively high and only fieldwork can discriminate the mechanism that controls the area. In the photo the steep gorge area (upstream) is suddenly transformed to a smoother valley, after crossing an active fault zone.

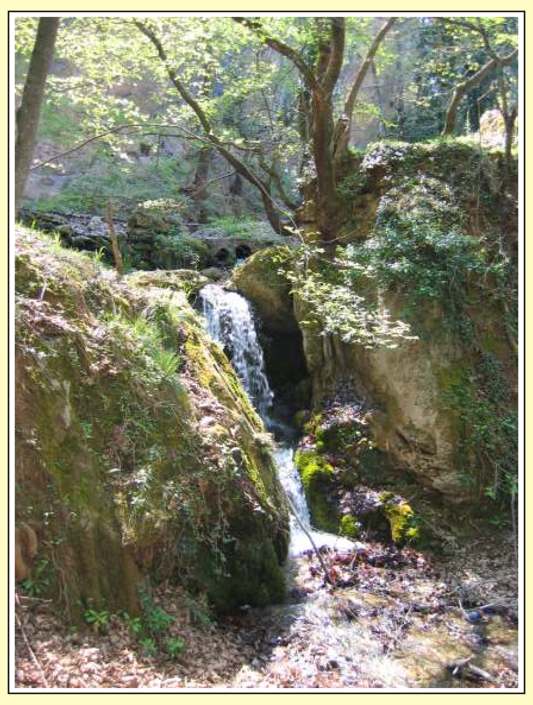


Fig. 7. Characteristic knick points associated with recent tectonic movements are found on Post-alpine sediments. The *ks* index values at such geomorphs are high and are represented by hot colors at the map of figure 2. More often they are related to the uplifted marginal areas of the tilted fault blocks.

Fig. 8. Deep gorges are also formed on alpine basement rocks caused by the erosion due to rapid uplift of fault blocks. The steepness index values are relatively high in such areas.

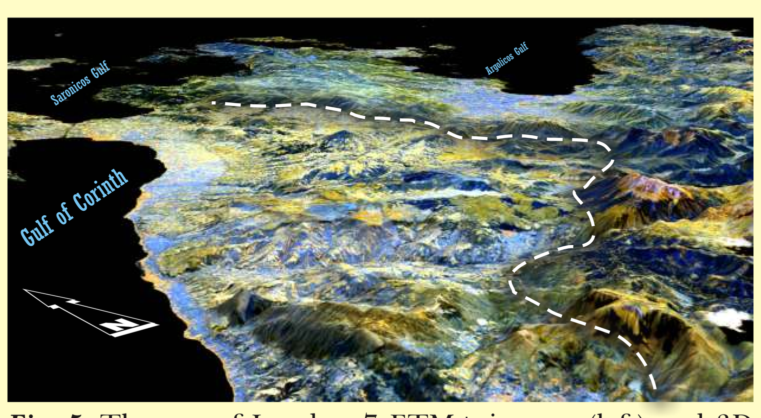
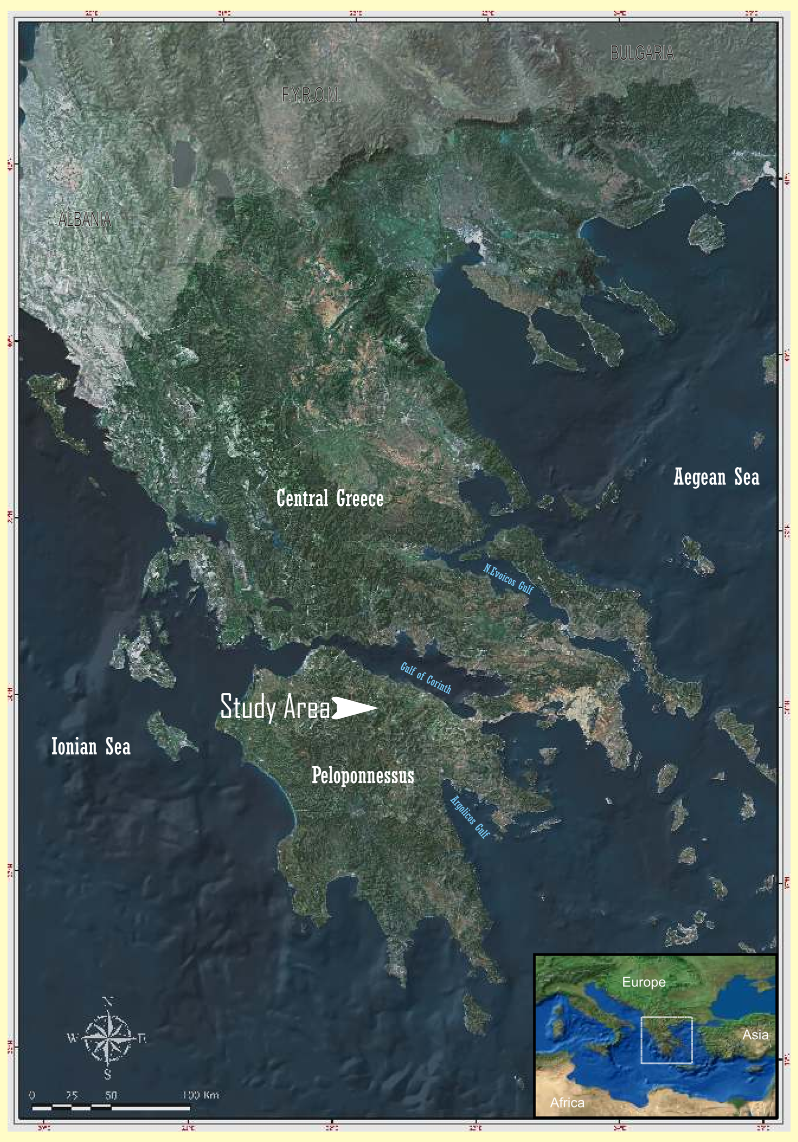


Fig. 5. The use of Landsat 7 ETM+ images (left) and 3D visualizations (top) is very helpful for the understanding of the general tectonics of the surrounding area. The combination of image interpretation and topography exaggeration lead to identification of a potential tectonic surface along the northern coast of Peloponnessus. Marine terraces (yellow) and alluvial fans (cyan) cover unconformably the alpine basement at the hanging wall (top, left side). The darker colors of the foot wall (top, right side) represent the relatively uplifted, basement rocks.



16th DRT Conference
Deformation mechanisms, Rheology and Tectonics
Milano-Oropa, September 27 - 2 October 2007
Session 10 - Interaction between climate, erosion and tectonics