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A multidisciplinary study on lavaka (gully erosion) formation in Central Highlands, Madagascar

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Madagascar is a very important place to study erosion. Due to some forms of gully erosion called lavaka the country is among the first regarding its erosion rate.
Lavakas are very abundant in the highlands of Madagascar (they can reach up to 30/km2). Therefore they have been subject of many studies in the past 60 years.
Lavaka formation seems to be triggered by many regional effects (thin laterite layer on thick saprolite layer, smoothly convex hills, climate) and local causes (rain attack, earth falls, lack of vegetation) both natural and anthropogenic (deforestation, roads, paths) but the real nature of these erosion features are not fully understood.

Based on field surveys, photogrammetrical, geomorphological and lithological-sedimentological methods two different kinds of lavaka (toe-slope and mid-slope) were studied in Tsiafahy, Central Highlands.
Our main goal was to understand the formation of lavakas in order to prevent their consequences such as the degradation of agricultural lands, villages and nearby roads.

For this purpose we digitalized geological and hydrological maps of the country and compared them with maps showing the occurrence of lavakas in Madagascar.
3D (three-dimensional) modeling of the actual eroding surface was achieved with photogrammetric methods applying the few hundred photos we made during the field surveys. We tested several 3D modeling software and used the best ones (with higher accuracy and resolution) to model a toe-slope lavaka. In order to model a more complex mid-slope lavaka a new program has been developed in MATLAB as well. Such photogrammetric evaluation and 3D modeling of lavakas were achieved for the first time and therefore the results are yet preliminary.
Sedimentological features (grain size distribution and mineral composition) of an active mid-slope lavaka were also investigated to define the difference between the lateritic and saprolitic layers of the lavaka.

Preliminary results show that the most important causes of lavaka formation are the climate and the lithological features of these areas. According to our field surveys and analysis lavaka's saprolitic layer can be divided into two different units: a yellow colored saprolitic layer with smaller hydraulic conductivity and a reddish saprolitic layer which could be interpreted as the transition between the yellow saprolitic and the upper red lateritic layer. Field surveys and photos show that the complex structure of the lavakas strongly correlate to the distribution of these different saprolitic units. The understanding of 3D distribution of these material types is the key to the lavaka formation.
Further studies will concentrate on improving the obtained models and using them for geomorphologic studies including calculating relief, aspects and volume.