The role of mass movements in landscape development, Tigray, Ethiopia.

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Résumé:
La cartographie géomorphologique de la région de Hagere Selam (Tigré, Ethiopie) montre l'existence de nombreux glissements, holocènes et modernes. Une distinction se fait entre des glissements profonds et larges (profondeur de dizaines de mètres, largeur et longeur de centaines de mètres ou davantage) du type rotationel et le fluage lent que subissent des assises épaisses d'argiles gonflantes, reposant sur des replats entre les escarpements des séries volcaniques. Ces argiles ont localement débordé le bord du plateau et se sont déposées en forme de 'langues' sur l'escarpement. La surface affectée par les mouvements de masse occupe au total 10% du paysage, ce qui souligne leur rôle morphogénétique. Leur cartographie constitue un document d'évaluation du risque de mouvements de terrain.

1 Introduction:

Geomorphological investigations reveal that ancient and active mass movement deposits occupy some 10% of the total land surface in the stepped piedmont plains around the Hagere Selam, Damaryam, Mikael Abiy, Guyeha, Tsili, Medayk and other ridges at the western edge of the Mekele outlier, Tigray, Ethiopia. The geology consists of a subhorizontal succession of marine Antalo limestones of Jurassic age, some 450 m thick, truncated by an erosive planation plain, overlain by Amba Aradam sandstone of Cretaceous age and by two series of Tertiary volcanics. The latter are separated by partially silicified lacustrine deposits. The base and lower part of these ridges typically contain outcrops of Antalo limestone. The Cretaceous and Tertiary occur at the upper part of the ridges, table mountains or plateaus.
The role of mass movements as a morphological agent was facilitated by the tectonic upheaval of the area, related to rift tectonics. At Hagere Selam this upheaval is of the order of 2,000 m. Subsequent landscape dissection led to steep canyon-like incisions and slope instabilities.

2 Materiels and methods:

2.1 The study area

- highland climate; mean annual precipitation: 770 mm, mainly concentrated from June to September.

- soils: the basalts carry (Luvisol-)Regosol-Cambisol-Vertisol catenas. Limestone weathering led to calcaric Regosols, Cambisols and Calcisols.

2.2 Methods

- geomorphological mapping: based on field observations and stereoscopic aerial photo interpretation in a GIS environment.
- laboratory measurements of soil shear strenght.

3 Results and discussions

Field investigations around Hagere Selam show four main types of mass movements. The first type is rockfall from steep cliffs. Measurements indicate that rockfall alone is responsible for cliff recession up to 3.7 cm/century .

The second type is characterized by the mobilisation of earth masses, several tens of meters thick, tens to hundreds of meters wide and hundreds to thousands of meters long. They typically rest upon impervious layers of shales or marls in the Antalo limestones. Their head scar generally affects a ridge top or table mountain shoulder, where Antalo limestone and overlying sandstones and basalts clearly show reverse rotational slump displacements. Their morphological impact is thought to result in more or less parallel escarpment retreat.

A third type of mass movements consists of creep-like displacements of black clays, resting generally on tabular extensions on hill shoulders and in passes where the lower basalt is present. Argilloturbation creep at Enda Maryam into the direction of a recent gully exceeds 20 cm/year (Moeyersons et al., 2005 in press).

The fourth type of mass movement seems to result from sudden local surges of these black swelling clays over the Amba Aradam sandstone cliff. The result is the presence of elongated tongue-like black clay deposits in escarpment valleys. One of such 'valley-tongues' is the May Ntebteb-"flow". Creep amounts of several cm/year have been measured after its remobilisation by gully incision. Ancient, but comparable flow surges from the hill tops into the valleys seem to have been generated within the lacustrine deposits between the volcanics.

4 Conclusions

mass movements as a morphogenetic process: The described mass movements are believed to be of Late-Pleistocene to present-day age (Nyssen et al., 2002). Their mapping shows that traces of landsliding are very numerous. Therefore, mass movements should be considered as an important morphogenetic process in the study area.

mass movement risk assessment: Given that present-day mass wasting is often due to the reactivation of parts of ancient land movements, maps of mass movements are in the same time mass wasting risk assessment maps. In the perspective that global change prognoses for northern Ethiopia (Hulme et al., 2001), are such that mass wasting is expected to increase in frequency and intensity risks assessment maps can be the first base for an answer to this threat.

References:

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