



Examples of lateral spreading in carbonate rocks of northern Madagascar

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Madagascar, the fourth largest island in the world, presents several karst areas, involving Mesozoic limestones (locally known as “tsingy”, from the ringing sound emitted when struck) and marls, and Tertiary limestones, marls and chalk. In addition, karst in lavas and quartzites is also present. Since the 1980s, exploration of karst areas by international expeditions and cavers has started. This paper deals with analysis of the northern part of Madagascar, in the Antsiranana (Diego Suarez) district, just north of the Ankarana area, one of the most interesting karst area of the island. Jurassic limestones crop out in this sector, and give rise to a distinctive karst landscape. Deep and narrow, often fault-controlled, canyons characterize the morphology of the area, whilst several caves of great naturalistic and biological relevance open on the canyon walls. Superimposition of rock masses with a fragile behaviour over heterogeneous rocks with a prevalently clayey matrix is one of the most common geological condition for development of deep-seated gravitational slope deformations (DGSD). These large phenomena represent a particularly subtle natural hazard, since they are overall characterized by slow to very slow rate of movement, but, at the same time, their main surface evidence are rock falls and topples with rapid to very rapid kinematics. We present here the preliminary results of a study carried out in northern Madagascar, devoted to analysis of the susceptibility to landsliding in a karst area, and to assessment of the related hazard. The “Montagne des Francais” is a N-S striking mountain ridge located east of Antsiranana, the largest town of northern Madagascar, along the connection route between Antsiranana and the village of Ramena. The area is among the most important tourist resorts of the island, and is developing intensive exploitation. Thus, the evaluation of the landslide hazard, and its likely implications with the

present and future infrastructures and lifelines is an important topic to be addressed. The “Montagne des Francais” is made of carbonate rocks resting with sub-horizontal attitude over a marl-clayey complex of Cretaceous age. The carbonate rock mass is interested by multi-directional lateral spreading and associated block sliding and rock falls, which deposits have in several cases reached the road to Ramena. Similar active DGSD phenomena are also present at other sites of northern Madagascar, few tens of kilometres west from Antsiranana (Windsor Castle, Devon Castle) with a geological and structural setting very similar to that of the “Montagne des Francais”. On the basis of field surveys devoted to acquisition of morphological and structural data, and integrated with the interpretation of aerial photographs, the main characters of the recognized lateral spreads are described, as the first step in the process of landslide hazard assessment in the area.