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Huge slides in cemented sands according to the tectonic setting and structures in Basilicata Region: the case of Aliano

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1 **Layered sands over clays are a typical geological frame in many environments, like the Bradanic foredeep and its satellite basin, the Sant'Arcangelo basin in the South of Italy. In this case, hydrogeological conditions led the sands to acquire in time an appreciable cementation, so in undisturbed sedimentary arrangement, they collapse mainly for falls. But a large part of the above mentioned area has been subjected to a complex tectonics, which results in the failure of the soil mass in repetitive monocline faulted structures, with bedding planes inclined in the range 20°-30° and prevailing immersion towards NNE. In these situations, structural features of the soil bodies are recognised as determining stability conditions, while the groundwater plays with a mechanism which is different from the well known of the pore pressure surge. A huge landslide near Aliano is the field of a number of relevant observations.**

2 1 Introduction

The Bradanic foredeep, in the middle part of the Basilicata region (South of Italy) is a geological structure, where sands and silty sands, are largely outcropping, layered over marly clays, of plio-pleistocene age.

The south western part of the area was subjected, starting from pleistocene to a distensive tectonics, which led to a number of consequences in many fields of observation all around. The most remarkable signs, from a morphological point of view, are the broadly vertical scarps of long faults, and the associate counterslope of the bedding planes, which define a recurrent and typical faulted monocline structure.

Moreover the area seems to have been involved in a recent tectonic uplift. As a result of such intense tectonics, the soil bodies are generally tilted with a typical slope of about 20˚-30˚ and numerous fractures are associated with the main fault planes.

The outcropping of sands enhances processes of infiltration of water and of water migration for capillary flow; the same cementation of the sand layers derived from aged capillary rise.

There are signs of an old water circulation in the sands, not compatible with the present bedding of layers, after the tectonic tilting of the soil bodies. In no way water level has been measured in the piezometers, even though water from atmospheric precipitation is responsible of acceleration of landslide movement.

In the above depicted environment, common to many landslides in the Basilicata Region, in 1998 fall a large landslide occurred and broke the Aliano-Alianello road, putting in some trouble the inhabitants of the two towns.

The landslide began with the detachment of a sandy body at the toe of a valley slope; this displacement produced with some delay and with a mechanism of progressive failure, the sliding of the cemented sands overlaying the clays, confined from the vertical plane of a tectonic fracture and near the stratigraphic plane of contact of sands with the clays. The max height of the sliding body is almost 45 m and the overall volume about 2 Mm^3.

The kinematics of the slide, monitored for three years, reveals a sequence of quasi equilibrium states, with accelerations after rain periods, even though infiltrated water does not act with mechanism of surge of pore pressure.

3 2 Geology and tectonics

Aliano area (Basilicata Region, South of Italy) lies along southern Appenines front, in the northern part of the Sant'Arcangelo basin, currently described as a "piggyback" basin, developed from upper Pliocene to middle Pleistocene. In the same period the translation of the Apennine beds towards the foreland is recorded (Caldara et Al., 1988).

The deposits of the Sant'Arcangelo basin form a silicoclastic sequence, with a max thickness of about 3500 m , made of clays, sand and conglomerates, which lie in discordance on the meso-cenozoic bodies of the Apennine chain (Pieri et Al.,1994 and 1996).

More particularly, the landslide described in this paper and many others in the Aliano area involve two specific terms: the blue clays and the cemented sands.

Blue clays are constituted by a mix of fine sands, silts and clays; they are normally stiff to hard and outcrop in layers of metric height. The mineralogy of the clays is mainly illitic and caolinitic.

Cemented sands are constituted by fine to coarse sands with silts, well layered with strata normally very thick.

Thin layers of clays can be found inside the sands and small layers of sands in the clays; an increasing frequency of tiny clayey layers sometimes announces the transition from the sand formation to the clay one.

The widely generalized tectonics of the area gives to the strata an apparent regular bedding with direction NNE and an average inclination of about 25˚, deriving from faulted monocline structures. In spite of the morphological evidences (Guerricchio et Al., 1977) the phenomenology is sometimes still attributed to the erosional activity. Moreover, a series of important regional faults, such as Scorciabuoi, Alianello and S. Lorenzo, having about NW-SE direction (Lentini & Vezzani, 1974; Bonini & Sani, 2000) cross significantly the area.

The area of interest is located South East of Aliano town, on the right side of an asymmetric valley, up to 150 m deep, engraved in cemented sands and very difficult to access.

The valley is the result of the morphologic evolution of a long fracture which divides a large clod, displaced and tilted for the above mentioned extensive tectonics. In fact, on the previous failure pattern, a new one has been superimposed, coming from the stress field deriving from the displaced geometries.

The comprehensive description of the fracture measured on the field is defined by two main groups of lineations, NNE and ESE. The main tectonic lineations recognizable in the area through the study of aerial photos, lead to the three most representative systems oriented NW-SE, N-S and E-W.

4 3 Mechanics of the landslide

In the above described context, only the presence of man made works allows us to distinguish recent failures in the cemented sandy soils from the ancient ones, both characterized by cuts and/or fractures with sub vertical scarps.

The landslide which damaged the Aliano-Alianello road was triggered some time before due to the sliding of a big clod at the toe, as it could be verified through the comparison of aerial photos of different epochs. The toe displacement generated a distension and a progressive failure of a more large clod, 108 m width, 387 m long and with a thickness between 15 and 45 m.

The displaced clod is confined laterally by subvertical tectonic surfaces; in particular, the traction detachment surface coincides with the NNE fracture plane. The sliding surface is a planar surface, having a ESE direction and NNE immersion. It locates in sands, near the contact with clays. Natural radioactivity γ log shows in this point a structural weakening of the silty sands, with a total loss of the fine fraction. The remaining soil is formed by monogranular sand , deprived of matrix, with no dilatant stress strain behaviour and with a low frictional resistance.

The location and the type of involved soils on the failure plane exhibit an interpretation of the mechanism of the sliding very different from those already presented in literature (Cotecchia et Al., 1996) on landslides in the same area, which assign the sliding surface on the top of the clays, presumably softened by water.

It has never been possible to record the presence of water in any drilling, even when conveniently instrumented and in proximity of the contact between sands and clays. There are several reasons: water from meteoric infiltration flows preferably on more superficial levels, within fractures of cemented sands, with erosion and internal transport of the silty-sandy fraction. The vertical downward movement through the pores is not privileged, because water is then nearly totally absorbed through capillarity from the sand mass and the capillary flow develops in almost every direction. The remaining part of the circulating water, come out through fissures or holes on the walls of the deep valleys. The structural weakening of sands near the passage to clays is typical and is due to underground water circulation under small gradient, compatible only with an old horizontal bedding of the sands and the clays, for a long time stable.

Even in other failures in the same geolithological environment (i.e. the well studied Senise landslide, 1991) no water pressure was recorded on the sliding plane.

The landslide, thus, moved on a planar surface, with a movement that had two components: the detachment under traction stress from the surrounding mass, according to a tectonic subvertical fracture defines the first; the sliding occurs soon afterwards according the slope of the bedding planes. The double direction of the movement is well documented by inclinometric measurements, before the full rupture of the casing.

The landslide mass didn't slide as a unique rigid body, but according to the preimpressed fracture patterns and to the progressive distensive failure (Spilotro et Al., 2001)**,** the mass itself moved in elongated clods of cemented and fissured bodies, separated from a filling of loose sands, all sliding on the same plane. The movement has been transmitted on the right side also to another big clod, that exhibits signs of a strong passive thrust and of recent failure patterns, but not up to now, relevant displacements.

The movement has been checked for about three years (Fig. in different points of observation located on the sliding mass. The displacement vs time recording of one of the observed points shows winter accelerations correlated to rainy events. Unable to produce a surge in pore pressure on the sliding surface, rains are thought to cause essentially increase in the weight of the upper layers of the sliding mass and, through mechanisms of internal erosion and of rearrangement of the loose sands, variations of horizontal forces and of equilibrium conditions of the rigid blocks of cemented sands, through a push-pull interaction mechanism.

At present time, various kinds of stabilization works carried out on the landslide body seem to produce a slow down of the displacements.

It may be important to observe that only models of forecasting the landslide hazard, based on the structural features of the soil body, can successfully operate in these contexts.

5 4 references

Bonini M. & Sani F. 2000. Thrusting, strike-slip faulting and syntectonic deposition in the Potenza-Guardia Perticara Area (Basilicata, Southern Apennines, Italy). *Mem. Soc. Geol. It.*, 55, pp. 123-132.

Caldara M., Loiacono F., Morlotti E., Pieri P. & Sabato L. 1988. I depositi pliopleistocenici della parte Nord del Bacino di S. Arcangelo (Appennino lucano): caratteri geologici e paleoambientali. *Mem. Soc. Geol. It.*, 41, pp. 391-410.

Cotecchia V., Cherubini C., Guerricchio A., Mastromattei R. 1995. Aliano, città fragile della Basilicata per accentuati fenomeni erosivi e frane indotte da una evoluzione tettonica recente. *Geol. Appl. e Idrog.*, Guerricchio A, Salvemini A., Spilotro G. 1977. Movimenti di massa connessi con fenomeni neotettonici nelle argille grigio-azzurre calabriane nella media valle del F. Sinni (Lucania). *Atti 2° Congresso Nazionale sulle Argille dell'AIPEA, Bari, Ottobre 1976, su Geol. Appl. e Idrog.,* Vol. XII, Parte II, pp. 261-285, Bari.

Lentini F. & Vezzani L. 1974). Note illustrative del Foglio 506 "S. Arcangelo". I.R.P.I. CNR (Cosenza).

Pieri P., Sabato L., Loiacono F. & Marino M. 1994. Il Bacino di piggyback di Sant'Arcangelo: evoluzione tettonico-sedimentaria. *Boll. Soc. Geol. It.,* 113, pp. 465-481.

Spilotro G., Coviello L., Trizzino R. 2000. Post Failure Behaviour of Landslide Bodies. *VIII Int. Symp on Landslides*, Cardiff, June 2000.

Vezzani L. 1967. Il bacino pliopleistocenico di S. Arcangelo (Lucania). *Atti Acc. Gioenia Sc. Nat., s.* VI, 18, 207-227, Catania.

Viggiani C., Di Maio C. 1991. Resistenza a taglio mobilitata nella frana di Senise. Atti del convegno sul tema deformazioni in prossimità della rottura e resistenza dei terreni naturali e delle rocce. Lavello 1991.