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Geophysical Method Contribution to the Super Sauze (South France) Flowslide Knowledge

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PROBLEMATIC AND INTRODUCTION

Figure 1a. Site location with authorization from Malet JP

In the southern alpine mountain, the Barcelonnette basin (Figure 1a) provided many examples of complex landslides that associate a landslide to the upstream and a debrisflow to the downstream (Flageollet and al., 1999). These landslides, of all dimensions, in activity, happen on strongly gullyed slopes. They are localised in callovo-oxfordian marls (black marls) that are the base of the Autapie and the Parpaillon thrust sheet flysch. This phenomena is very widespread around the world (Keefer and Johnson, 1983; Dikau and al., 1996).

The aim of this paper is to discover the internal structure of these phenomena. The structure is an important parameter in the natural hazards study, because it allows us to determine the volume of a landslide and then to classify it. This parameter is also important to understand the triggering and evolution mechanisms, and to deal with the problem of natural hazards using modelling techniques and not only with cartography. The major difficulty when doing modelling is the lack of data needed to build good models.

The structure can be determined by geotechnical and/or geophysical methods. The geotechnical methods allow accurate data to be obtained which locate precisely the substratum. In return, according to the high cost and / or the heavy implementing for the destructive borings, it is not possible to have a lot of information. Where the light geotechnical measures are concerned, there interpretation is not easy and sometimes impossible. This is why geophysical methods are employed. The main advantages are that it is possible to measure at the soil surface the soil response along continuous (or pseudo-continuous) profiles. Nevertheless, they need validation points, like geotechnical borings.

The main problem in investigating the landslide is the large heterogeneity. First of all, the paleotopography consists of a succession of gullies more or less buried by the flowslide. The consequence is an important flowslide thickness variation: from 0m at the apparent crests location, to about 20m for the deapest gullies. Therefore, the surface topography is very irregular. This irregularity is a problem when bringing instrumentation onto the site, as well as a problem for the geophysical data interpretation. The last heterogeneity type, but not the least, is the mass heterogeneity. Effectively, the flowslide mass has a lot of blocks and panels that are more or less dislocated. The consequence is an additional geophysical interpretation difficulty, and a problem to do geotechnical investigations with light means (dynamic penetrometer light and heavy and vibropercutor), these are the only investigation means can be easily be brought onto the flowslide.

The working hypothesis is that the physical characters differentiating the substratum from the moving mass are: compaction difference and water content difference. Therefore, the following geophysical methods were chosen: refraction seismic to detect the compaction differences and electrical resistivity (DC and Time Domain Electromagnetism) to detect the water content variation. Of course the resistivity is not only a function of water content, but as a first estimation there was no infuence of metallical and clayish minerals. To justify this, some physical rock measures are presently being done.

It should be noted that the TDEM method has only been used by the authors (Schmutz and al., 1999) upto now on landslides. This method is more commonly used for hydrogeological or mining questions (Fitterman and Stewart, 1986; Nabighian and MacNae, 1991; Goldman et al., 1991)

SITE DESCRIPTION

The Super Sauze flowslide (Figure 1b), which occurred in 1950, spread a distance in the order 800m, between altitudes of 2105m from the crown and 1740m at the foot of the flows, to the confluence of torrents, and occupies an area of approximately 17ha. It is a good example for the comprehension of such phenomena because of its entirely natural evolution (no trace of hydraulic planning), and on the other hand, available information thanks to numerous studies carried out in recent years: topometric measures since 1991 (Flageollet and al., 1996), multi-dated photograph-interpretation (Weber and Bolley, 1998), geotechnical investigation (Flageollet and al., 1996; Flageollet and al., 1999a; Flageollet and al., 1999b) and geophysical prospectings (Schmutz and al., 1999).

INTERPRETATION METHOD

Seismic data are interpreted most of the time in 1D with delay time method (LGIT Grenoble with Dietrich M.). The advantage of this method is that information can be obtained for each geophone. Moreover, we dispose of records every 6 geophones. This allows us to better constrain the limits of the flowslide mass. Nevertheless, the flowslide extremities would require other treatments because of irregularities in the hodochrons. Unfortunately, our acquisition doesn't allow that.

Electrical data are here interpreted in 1D with the probabilistic bayesian method (Grandis et al., 1999 ; Schott et al., 1999). The way we use the bayesian analysis for our study consists in dividing the soil into many layers. The layer thickness being in geometric progression. It should be noted that these layers do not correspond to any physical reality. In return, the advantage is that the only parameter unknown is the resistivity. Then a continue resistivity variation with depth is obtained. The results have also been interpreted in 2D. Even if the results are not exactly the same, the trend is similar. All geophysical results are compared with the geotechnical results.

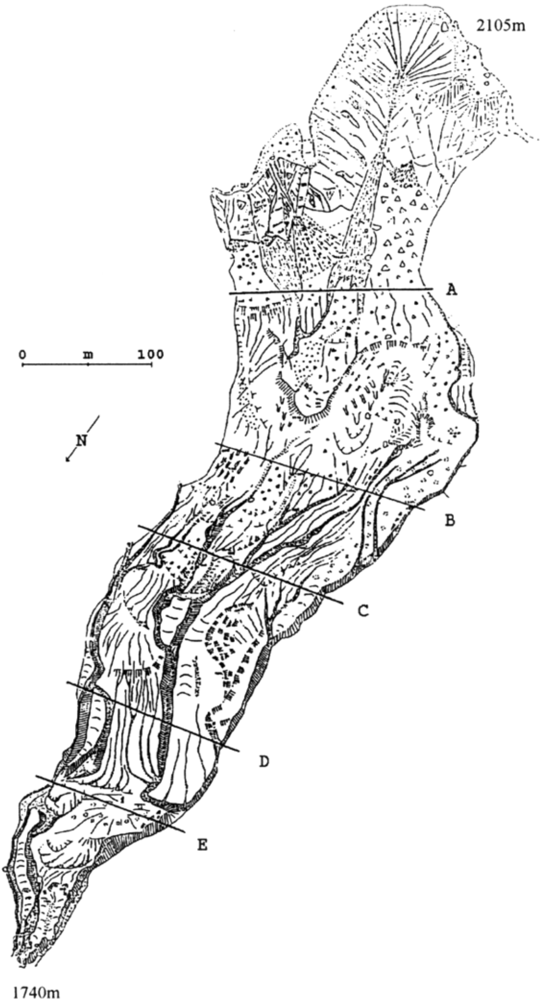

Figure 1b. Super Sauze geomorphological map

RESULTS

It is possible to interpretate the seismic refraction in two ways, because of some uncertaintie these two interpretations are not that different (Figure 2). Three waves were detected. The velocity of the first one is about 500 m/s, that of the second one is about 1000-1500 m/s and the last one is up to 2000 m/s. The thickness of the first layer is between 0 and about 5m, and the second is between about 7 m and 18m.

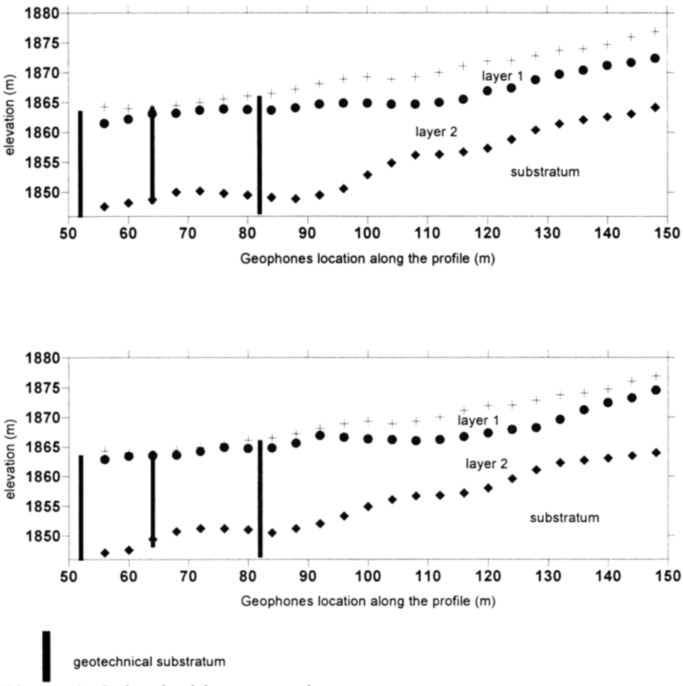

Figure 2. Seismical interpretations

TDEM interpretation (Figure 3) had been done here in resistivity with continuous variation. The picture shows a juxtaposition of 1D interpretation.

The resistivities are comprised of between 5 and up to 500 Ωm, and the weakest one's correspond to the less important depths. They should correspond to the moving mass. In comparing the results with geotechical borings, it appears that geotechnical results are on the same isoresistivity line (280 Ωm). Through this, it is then possible to know the substratum location.

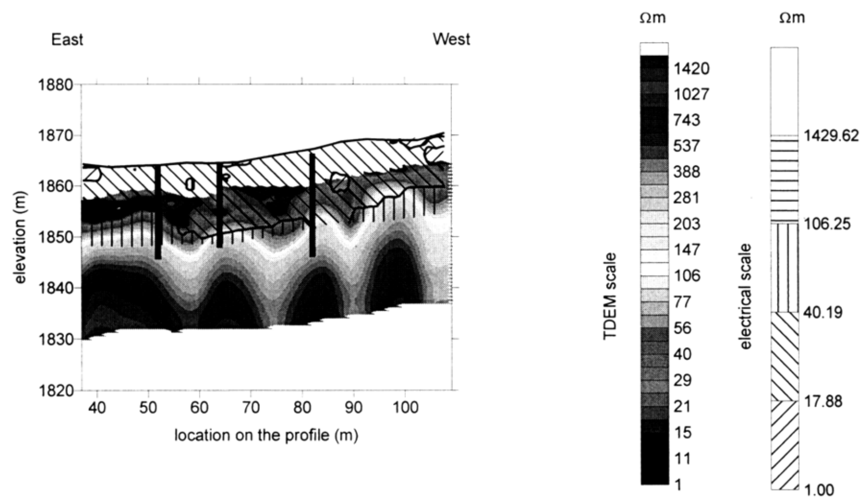

Figure 3. TDEM and electrical interpretations

When comparing the geotechnical results to the seismical one's, it appears the first one corresponds exactly to the substratum basis for the 2 interpretations. However, the seismic do not correspond to the geotechnical basis at the second boring for the 2 interpretations. Nevertheless, both interpretations indicate a depth increase. In this case seismic is not always the leading geotechnical results.

Electrical interpretation do not allow detection of the substratum: the lines were of insufficient length to counterbalance the absorption of the signal due to the weak resistivities. Nevertheless, we notice that the resistivity range is the same for the same depth in electrical and TDEM interpretation, and that the trend between these two methods is more or less conserved.

CONCLUSIONS

Relationships exist between, TDEM and geotechnical results, electrical and TDEM results and some seismic zones and geotechnical results. Therefore, geophysics could be of a real help to know the paleotopography, when used with validating points. The knowledge of this paleotopography is very important and useful when no a priori information exists.

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