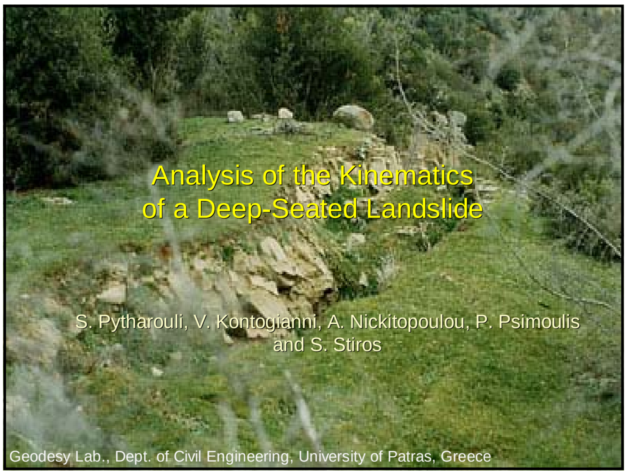

Analysis of the Kinematics of a Deep-Seated Landslide

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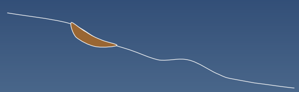
Landslides

- Represent a potential threat for people and constructions
- In most cases they cannot be fully stabilized, and it is essential to monitor their kinematics using geotechnical and geodetic methods

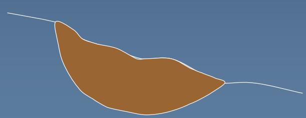
A typical landslide

Landslides represent slope instability of shallow or deeper strata

- Shallow (usually mud flows), < 1-2m deep



- Deep-seated, up to 30-40, even 100+ meters deep



Monitoring unstable slopes: A headache for surveyors and geotechnical engineers!

- surface monuments are easily destroyed
- conventional geodetic work (systematic, long-
- term monitoring) is expensive
- changes in the surveying technology are frequent → GPS landslide records are still short

For these reasons we know very little about the long-term kinematics of major landslides

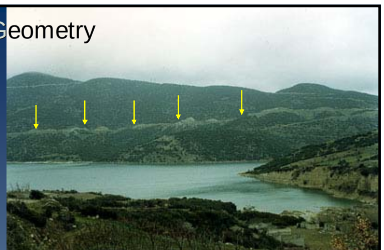
Questions …

- Does the surface movement of various parts of a landslide follow similar displacement trends?
- Is the movement of control stations linear, chaotic or is characterized by some periodic signals?

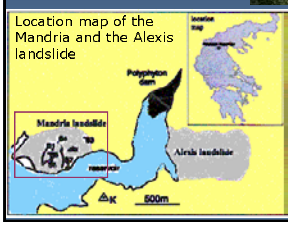
In our study we are trying to shed some light to these problems

analyzing the >20 yr!!! long geodetic record of the Mandria landslide, Northern Greece

Mandria Landslide: Geometry



Location:
1km away
from the Polyfyton Dam,
Northern Greece

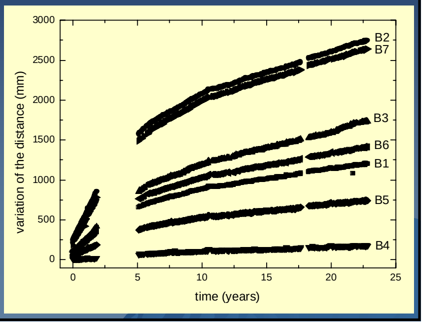


Geometry:
slipping mass of $10^7 m^3$
tectonized gneiss
curvilinear, shear failure plane
max depth 35m
length 750m
width 450m
slip rate 15cm/yr

Mandria Landslide: Monitoring Data

- The geodetic monitoring record consists of > 500 epochs of distance changes and spirit leveling of 7 control points from a stable reference station and covers a period of 23 years

- Distance changes of control stations B1 to B7 of the Mandria landslide were found representative of the landslide kinematics



Methodology

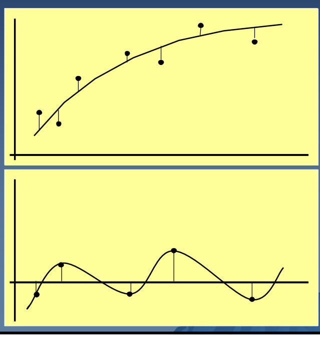
1. Modeling large-scale movements of the Mandria landslide using best fitting curves with a physical significance

2. Test the inferred model of the Mantria landslide to the neighboring Alexis landslide.

- The Alexis landslide, next to the Polyfyton Dam, corresponds to a larger sliping mass, in similar geologic conditions with those of the Mandria landslide.
- The monitoring record examined consists of distance changes of 3 control points, covering a period of 17 years.

Methodology (con't)

- Spectral analysis was applied to the residuals of the curve fitting to all seven control stations of the Mandria landslide



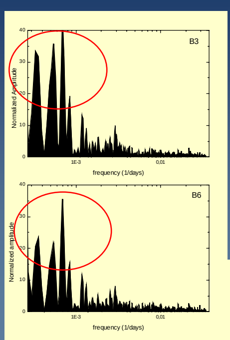
Results of Curve fitting

- All control stations were found to follow the same trend

$$d = A(1-e^{-t/B})+C$$

This is a physically acceptable model.

Results of Spectral Analysis



- A few statistically significant were obtained from the spectral analysis of the residuals of the Mandria landslide.
- These peaks correspond to events with periods of 4 to 7.5 years

Representative spectra of the residuals of the distance changes. The statistically significant peaks were common in the spectra of *ALL* control points

Conclusions

- The long-term kinematics of all control stations of the Mandria and the Alexis landslides can be described by the same exponential function.

  → For major deep-seated landslides the long-term kinematics of all their parts reflect an overall exponential trend.

- Events of accelerated movement with a mean return period of 4 to 7.5 years, possibly triggered by meteorological events, are superimposed on this general trend.

- Monitoring of very few points of such major landslides are representative of their overall movement.