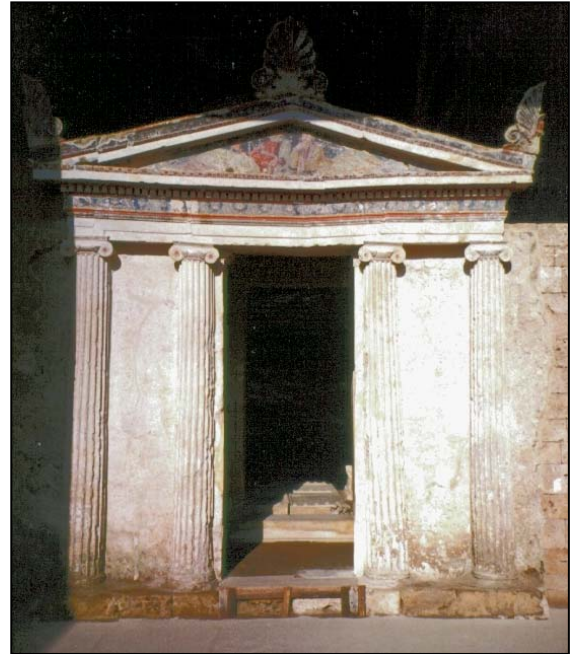


Lefkadia Macedonian Tombs

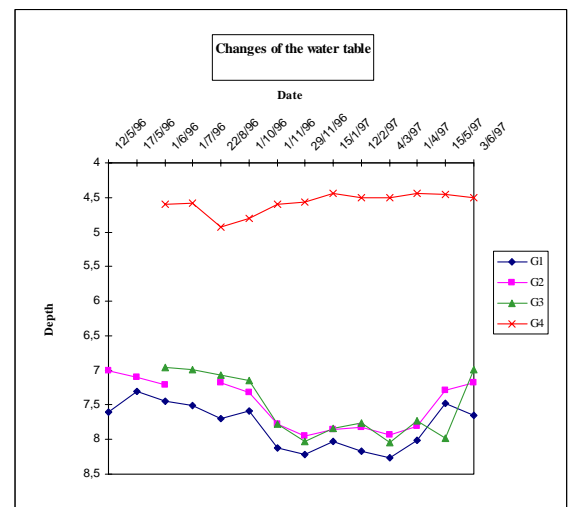
Engineering geological conditions and problem:

- The damages are mainly related to the groundwater, which, usually covers, the floor of the monuments.
- Differential settlements also cause damage to the stability of the monuments while the existed humidity causes damage to the frescos.
- The formations in which the Tombs are buried, consist mainly of sand, gravel and conglomerates with thin clay layers. The soil materials are generally loose and coarse grained, presenting, active porosity and permeability. The depth of the groundwater varies from 7.5 to 8 m. The permeability of the soil is $2-3 \cdot 10^{-2}$ and the hydraulic gradient 12-14 ‰



Protection measures already taken or have to be taken:

- The tombs need permanent drainage.
- A pumping borehole system is already established
- A drainage trench could involve to the better drainage
- Impermeation grouting techniques were studied by calculating the type of the grout mix and the influence radius of the grout.
- Grout mixes at depths 10.40-15.0 m ($D_{10} = 0.02-0.5$ mm): colloidal solutions or polymers such as silica or ligno-chrome gels, tannins, organic colloids on polyurethane.
- Grout mixes at depths 3.2-7.50 m ($D_{10} = <0.02$ mm): pure chemical solutions such as acrylamides, aminoplast or phenoplast. The viscosity is 10 cp.
- For the impermeation of Krisis tomb, including the protection building, 46 grouting boreholes are needed while for Krisis tomb it self only 24 are necessary. The total length of boreholes for the first case is 750,54m while for the second is 297,62m



Other information: The Macedonian Tombs of Krisis, of Anthemion and Kaliklis (3rd c. B.C., found outside the walls of the ancient city Mieza) were located along the road connecting Pella, the capital of Macedonia, to Mieza, which was one of the important commercial cities during the period of the 4th - 2nd c. B.C.

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