

The following relevant material for the C16 webpages has been collected by Engineering Geology students of Prof. Scott Burns at Portland State University (USA) in the framework of a students assignment. This material has not yet been screened and commented nor approved by the C16 chair and membership.

JOURNAL PAPERS:

- Andre, M., Etienne, S., Mercier, D., Vautier, F., and Voldoire, O., Assessment of sandstone deterioration at Ta Keo temple (Angkor): first results and future prospects: *Environmental Geology*, v. 56, no. 3-4, p. 677-688.

A first application of geomorphological methods to the assessment of sandstone deterioration at Angkor is presented. Damage diagnosis was carried out on the first eastern tier of the central pyramid of the 1,000 year-old Ta Keo temple. Methods combine field observations and measurements at 230 sampling points, high-resolution lasergrammetry and stereophotogrammetry on a 2-m² test zone, and SEM observations. The first results indicate that decay operates through a synergistic combination of weathering phenomena dominated by scaling and solution, and exhibits a high spatial variability. Percentages of deteriorated surfaces vary from 17.6 to 93.8%, and average stone recession values from 0.00 to 2.71 cm (minimum) and 0.34 to 5.49 cm (maximum). On the test-zone, stereophotogrammetry and 3D-mapping of the present and reconstructed initial states using lasergrammetry indicate that erosion scars up to 6 cm deep have formed since 1963. On the whole, the amount of deteriorated surfaces more than tripled between 1963 and 2008. The degree of implication of salts in stone decay remains unclear for most efflorescences are composed of calcite (CaCO₃), with secondary importance of barite (BaSO₄) and gypsum (CaSO₄·2H₂O). Future prospects aim to evaluate the impact on stone decay of the clearing out of the temple from the forest in the 1920s.

- Fitzner B (2004a) Documentation and evaluation of stone damage on monuments. In: Kwiatkowski D, Lořvendahl R (eds) Proceedings of the 10th international congress on deterioration and conservation of stone, 27 June–2 July 2004, Stockholm, vol II. ICOMOS, Sweden, pp 677–690
- Heinrichs, Kurt, 2008, Diagnosis of weathering damage on rock-cut monuments in Petra, Jordan: *Environmental Geology*, v. 56, no. 3-4, p. 643-675

Studies of many years—combining in situ investigation and laboratory analysis—have provided comprehensive information on weathering damage on the rock-cut monuments in the ancient city of Petra in Jordan. These rock-cut monuments represent outstanding world heritage. Many hundred monuments were carved by the Nabataeans from bedrock about 2000 years ago. The awareness of increasing weathering damage on the monuments has resulted in international efforts towards their preservation. The damage diagnosis has addressed the complex mutual relationships between stone types, stone properties, monument exposure regimes, environmental influences, weathering phenomena, development and extent of weathering damage and weathering progression. The rocks were classified lithostratigraphically and petrographically. Results on weathering forms, weathering profiles and weathering products obtained from monument mapping, in situ measurements and laboratory studies revealed a complex diversity of weathering phenomena with respect to type

and intensity. Damage categories and damage indices were used to create a reproducible quantitative rating of weathering damage. Detailed results on weathering forms allowed the characterization and quantification of weathering progression including weathering prognoses. Stone properties and states of weathering damage were jointly considered for the rating of the rocks' susceptibility to weathering. The systematic evaluation of weathering damage and monument exposure regimes can enhance the assessment of weathering factors and processes.

- Leisen, H., Plehwe-Leisen, E., Verbeek, C., Jurgens, Christine., and Krause, S., Aspects of conservation in the excavation site of the Athribis temple in Egypt: *Environmental Geology*, v. 56, no. 3-4, p. 689-697.

The late Ptolemaic temple of Athribis in Upper Egypt is built of regional limestone and preciously decorated with reliefs, inscriptions, plaster and polychromy. It is collapsed and only partly preserved and it disposes of some still buried rooms. The temple is situated in a desert climate and highly contaminated with soluble salts. Based on mappings of materials and preservation conditions, on investigations into the materials used and the damaging factors the development of a conservation conception for the limestone remains has been started. Conservation materials have been selected or are specially developed. A test area for some tasks has been prepared and controlled after 1 year of exposure. The paper shows the status quo of the work of the stone conservation group in an archaeological site in desert climate.

- Kak, R.C., 1933, Review of Ancient Monuments of Kashmir: *Geographical Journal*, v. 82, no. 2.
- Marinos, P.G., and Koukis, G.C., 1990, The engineering geology of ancient works, monuments, and historical sites: *Environmental Geology and Water Sciences*, v. 16, no. 1,
- Mohammadi, P., 2008, Biodeterioration of ancient stone materials from the Persepolis monuments (Iran): *Aerobiologia*, v. 24, no. 1, p. 27-33.
- Siegesmund, S., Ruedrich, J., and Koch, A., 2008 Marble Bowing: comparative studies of three different public building facades: *Environmental Geology*, v. 56, no. 3-4, p. 473-494.
- Truscott M, Petzet M, Ziesemer J (2005) Heritage at risk—ICOMOS World Report 2004/2005 on monuments and sites in sanger.Munchen
- Viggiani, Carlo, *edt.*, 1996, Geotechnical engineering for the preservation of monuments and historic site: Proceedings of the International Symposium on Geotechnical Engineering for the Preservation of Monuments and Historic Sites, Napoli, Italy