Geophysical Research Abstracts
Vol. 21, EGU2019-6991, 2019
EGU General Assembly 2019

Arcades and other products of stress-controlled and discontinuity-related weathering of sandstone

Michal Filippi (1), Alexander Safonov (2), Jiří Bruthans (3), Jaroslav Řihošek (3), Martin Slavík (3), Jiří Adamovič (1), and David Mašín (3)

(1) Institute of Geology, Czech Academy of Sciences, Prague, Czech Republic (filippi@gli.cas.cz), (2) Center for Design, Manufacturing and Materials, Skolkovo Institute of Science and Technology, Moscow, Russia (a.safonov@skoltech.ru), (3) Faculty of Science, Charles University, Prague, Czech Republic (bruthans@natur.cuni.cz)

A specific group has been recently defined among cavernous weathering forms based on critical field evaluation of sandstone/quartzite/granite outcrops around the world, numerical modelling using finite element method and physical in situ modelling of friable sandstone. This group includes pits to cavities (depending on their size) which are similar in shape and are coalesced into "trains [U+02EE] along natural discontinuities in the rock, separated from each other by hourglass-shaped pillars. Due to their striking similarity with elements known from architecture, these forms have been introduced as "arcades" or arcade-like forms (Filippi et al., 2018).
Arcades have been shown to differ from honeycombs/tafoni and some other types of cavities and rock shelters in their clear association with planar discontinuities, distribution on the cliff face, geometry, and also their origin. They can be characterized as a product of redistribution of gravity-induced stress along planar discontinuities originated due to accelerated weathering and erosion in stress shadows. Arcades usually form more or less regular pits developed symmetrically (lenticular arcades) or asymmetrically (half-lenticular) along the planar discontinuities. At sites with heterogeneous lithologies, complex 3D multilevel structures develop.
To better understand the nuances of stress-controlled and discontinuity-related weathering form geometries and their evolution, we conducted sophisticated numerical experiments on multiscale modelling of their formation during erosion of sandstone rock masses containing discontinuities (Safonov et al., in prep). We employed advanced numerical modelling of material properties degradation during natural erosion involving evolutionary algorithms with stress/strain-dependent constitutive relationships.
We found that the formation of various arcade types can be adequately described by an erosion model presuming erosion to take place when the stress tensor trace exceeds a certain critical value. Setting variable rock pressure values and critical stress values for rock, we were able to reproduce the formation of various arcade types such as lenticular, half-lenticular, 3D rhombic, and rock pillars as their by-products.
Although as yet overlooked, arcades and their related forms have a strong effect on rock surface morphology and possibly also speleogenesis in some insoluble rocks. The stage of arcade evolution in combination with the effects of rock lithology provides a new challenge for geomorphologists studying weathering of sandstone and other granular rocks.
The research was funded by the Czech Science Foundation (GA CR No. 19-14082S).

References

Filippi M., Bruthans J., Řihošek J., Slavík M., Adamovič J., Mašín D. 2018. Arcades: Products of stress-controlled and discontinuity-related weathering. Earth-Science Reviews. 180, 159–184.
Safonov A. et al. (in prep). Multiscale simulation of arcades formation.