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Evolution of arched roofs in salt caves: Role of gravity-induced stress and relative air humidity and temperature changes (Zagros Mts., Iran)

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In salt caves in the halite karst in SE Iran the disintegration of rock salt into individual grains can be observed. Highly disintegrated blocks and individual grains form a major volume of debris in many caves on islands in the Persian Gulf. Larger cave rooms have often perfectly arched roof. The perfect geometry of rooms and interlocking of salt grains indicate that evolution of room cross-sections in these caves is controlled by feedback between gravity-induced stress and rock salt disintegration in similar way as in evolution of sandstone landforms (Bruthans et al. 2014). Those portions of rock salt, which are under compressional stress, disintegrate much slower than portions under tensile stress.

Important question is the kind of weathering mechanism responsible for intergranular disintegration of rock salt. The relationship between disintegration, its rate and cave climate was studied. Clearly the fastest disintegration rate was found in caves with strong air circulation (i.e, short caves with large cross-sections, open on both ends). Temperature and air humidity changes are considerable in these caves. On the other hand the disintegration is very slow in the inner parts of long caves with slow air circulation or caves with one entrance. The best example of such caves is the inner part of 3N Cave on Namakdan salt diapir with nearly no air circulation and stable temperature and humidity, where disintegration of rock salt into grains is missing.

Strong effect of cave climate on disintegration rate can be explained by deliquescence properties of halite. Halite is absorbing air moisture forming NaCl solution if relative humidity (RH) exceeds 75 % (at 20-30 oC). In the Persian Gulf region the RH of the air is passing the 75 % threshold in case of 91% days (Qeshm Island, years 2002-2005), while in mountainous areas in mainland this threshold is less commonly reached. In most of nights (91 %) in Persian Gulf the air with RH >75 % is entering the salt caves and air moisture is wetting the dry rock and slightly diluting the percolating brine in ceiling of the caves, which is otherwise just saturated with respect to halite. During days the RH is <75% and brine partly dries up and precipitates halite. By repeating the cycle of dissolution and precipitation of halite and possibly also by temperature changes the rock salt is disintegrated into interlocked salt grains, whose behavior is then strongly controlled by gravity-induced stress.

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Reference: Bruthans J, Soukup J., Vaculíková J., Filippi M., Schweigstillova J., Mayo A.L., Masin D., Kletetschka G.,Rihosek J. (2014): Sandstone landforms shaped by negative feedback between stress and erosion. Nature Geoscience 7(8): 597-601.