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Dimpling in loose granular sediments

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Dimpling is the name given to the centimetre-scale collapse of granular deposits covering the interior of alteration shelters in semi-arid badlands. The development of micro-collapses is favoured by the stable conditions found in these shelters, where they are safe from water flows, rain impact, and animal or human traffic. The floor of these shelters is usually covered by several centimetres of sandy sediment resulting from the alteration of the rocky substratum and characterised by apparently very low density and high porosity. We have observed that the dimpling phenomenon does not depend on the mineralogy of the sands and occurs in dry conditions. The dimples are the shapes resulting from this process and are fragile, conical depressions ranging from 1 to 12 cm in diameter. They are generally over 3 cm in depth, depending on the depth of the sandy layer.

The dimples can be classified into three groups by diameter (Ø): Ø$\leq$1cm, 1cm$\leq$Ø$\leq$10 cm and Ø$\geq$10 cm. These three morphometrical ranges suggest three evolutionary stages of the shapes. The main mechanisms of evolution are the coalescence of neighbouring dimples and the accommodation of the lateral walls towards more open, stable shapes. In this process, the slope of the dimple walls decreases to the angle of equilibrium, or internal friction angle of the sediment, when they acquire a more stable, dense structure. This evolution occurs naturally over several months.

The process begins when sufficient sediment with low apparent density accumulates. This takes place by vertical accretion of particles from the shelter walls, which pile up in a stack-of-cards type structure. The increase in weight of the sediment column causes punctual micro-collapses when the limit of the sediment's self-supporting capacity is reached. The process is gravitational. Thermal variations can also condition the structural instability of the sediment due to the dilation-retraction changes undergone by the sediment grains.

We can thus establish the following stages of evolution in the dimpling process:

1.Accumulation of deposits detached from the shelter walls by gravity. The sediment has a low apparent density, stack-of-cards inner structure.
2.Punctual micro-collapses of the structure (acicular depressions). Some collapses can be repetitive.
3.Shift to open shapes by lateral widening (conical depressions). This occurs through coalescence of micro-collapses or instability of the lateral walls.
4.Shift to senile shapes (plate-shaped depressions) through instability of the lateral walls. During this stage the shapes would become shallower through accumulation of supply in the bottom of the depression. Throughout this process the angle of the walls of the depression decrease to what we suppose must be the internal friction angle of the sediment.