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Developing Criteria for Identifying Fossil Raindrop Prints

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DEVELOPING CRITERIA FOR IDENTIFYING FOSSIL RAINDROP PRINTS

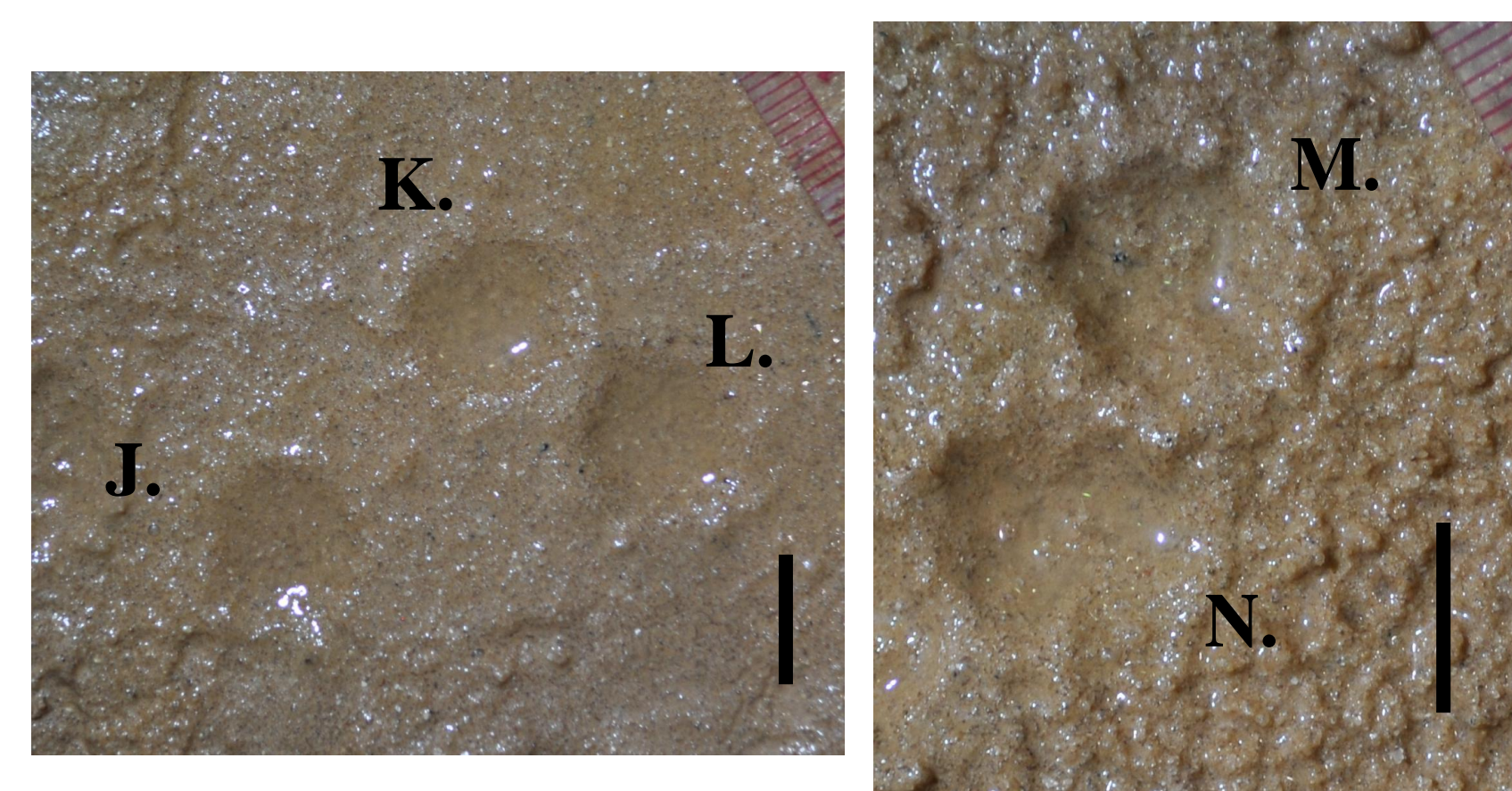
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Abstract:

Properly identifying sedimentary structures is an important aspect to understanding the past in light of the rocks. Paleoenvironments are determined based on features in the layers and cannot be determined correctly if a wrong interpretation of those features is made. Raindrop imprints have been identified many times in the rock record as stated in these papers by Rindsberg, Shul'ga 2004 and Kahle 2009. However, there is a question of whether those raindrops have been determined accurately or if the spherical depressions are caused by some other occurrence. Studies by Twenhofel have been done that describe raindrop prints in modern sediment, and the research conducted during this project continues to broaden that field of information. During this research project, experiments were carried out to collect the appearance of raindrop prints in sand, both wet and dry. After photographs of the imprints were taken, the pictures and measurements of the gathered raindrop prints were compared to fossil raindrop prints, so as to determine if the depressions identified as raindrop prints in the rock record are accurately labeled, or were caused by some other process, such as air bubbles. The method to simulate raindrops consists of dropping 0.1mL drops of water from a third floor down to the first floor, onto a flat pan of sand sifted to 3 phi (ϕ) size and under. At this distance, raindrops are properly replicated as they would be in nature. The imprints were then examined, measured – both their width and their depth, and photographed. Most raindrop imprints in dry sand were approximately 4-2mm deep and 1cm wide, while those in wet sand were wider, a few millimeters over 1cm, but not as deep, ranging from 1.5-2mm deep. These raindrop prints have distinctive features, such as their wide spherical shape and the ledge around the imprint from pushed sand, and while some fossil depressions have these characteristics and may be fossilized raindrop prints, many do not have these aspects and need to be reexamined under the new information and perhaps categorized as gas escape structures.

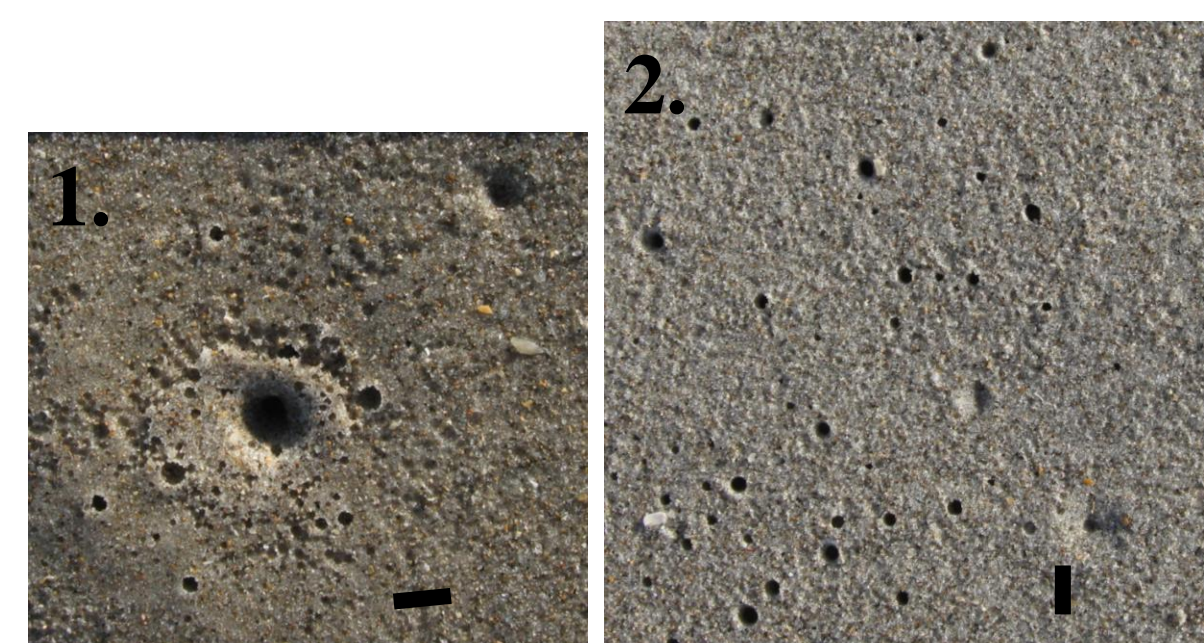
Methods:

The sand used was first sifted to ϕ size 3 and under, so as to simulate the composition of most sandstones, and was then spread evenly into a small pan. After setting the pan of sand on the 1st floor, water was dropped from the 3rd floor by using a dropper bottle. Measuring out 1mL into the bottle, an average of 11 drops fell by the force of gravity into the sand. These imprints were then photographed and the depth was measured to within the nearest 0.01mm using a depth gauge. This process was then repeated with wet sand. The first attempt was by using 250mL of water to mix in with the sand, and while the raindrop prints formed, the sand was much too pliable for the prints to exist for long in the settling wet sand. In the next experiment, 100mL of water was added to the dry sand and stirred so that the sand was saturated. While this mud allowed the raindrop imprints to remain sturdy for longer, the prints eventually smoothed out and could not be accurately measured. Attempts at taking the depth measures were made, and were recorded, although to a lesser accuracy of to the nearest 0.10mm. In order to compare modern raindrop prints to air escape structures, air bubbles were observed forming on the shore of a beach. Photographs were taken of the sedimentary structures. The cylindrical holes formed after a wave had covered portions of unsaturated sand and the air had bubbled up through the surface wet sand.



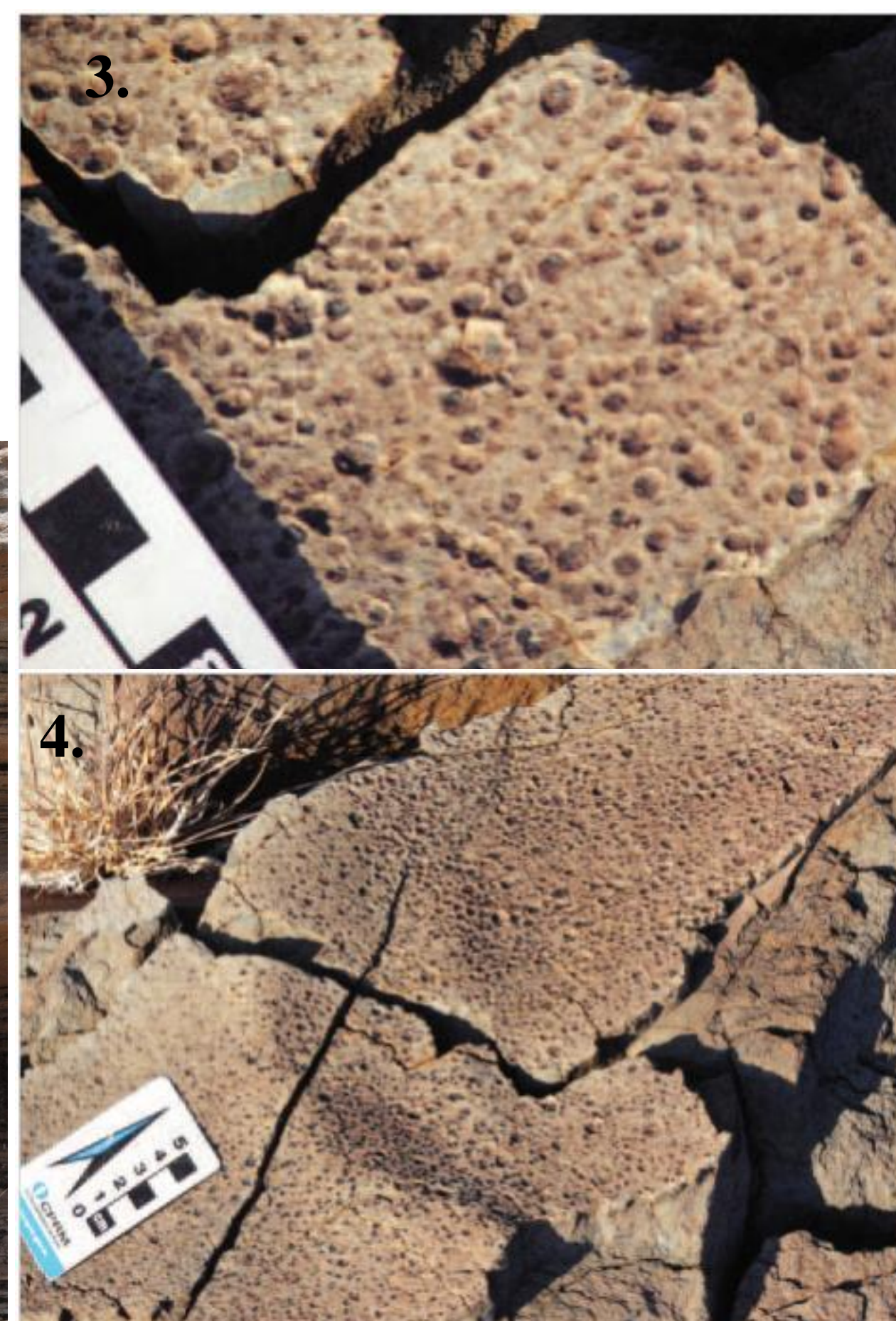
Raindrop prints in wet sand and the depth of the impression:
 (Bar length: 1cm)
J. 3.02mm; **K.** 2.56mm; **L.** 2.03mm; **M.** 1.58mm; **N.** 1.78mm

Pictures 1. and 2. of air escape structures on the beach shore
 (Bar length: 1cm)

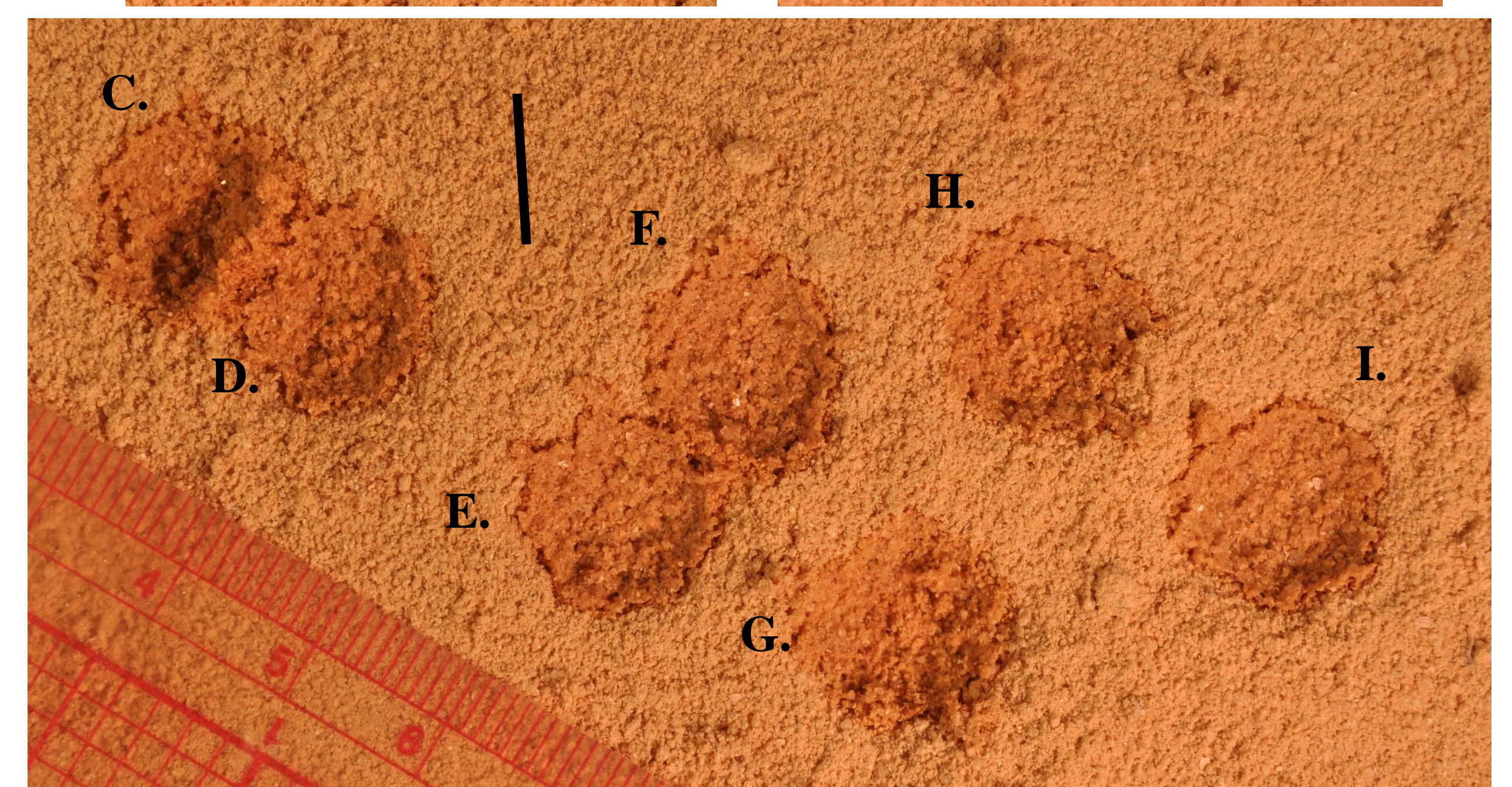
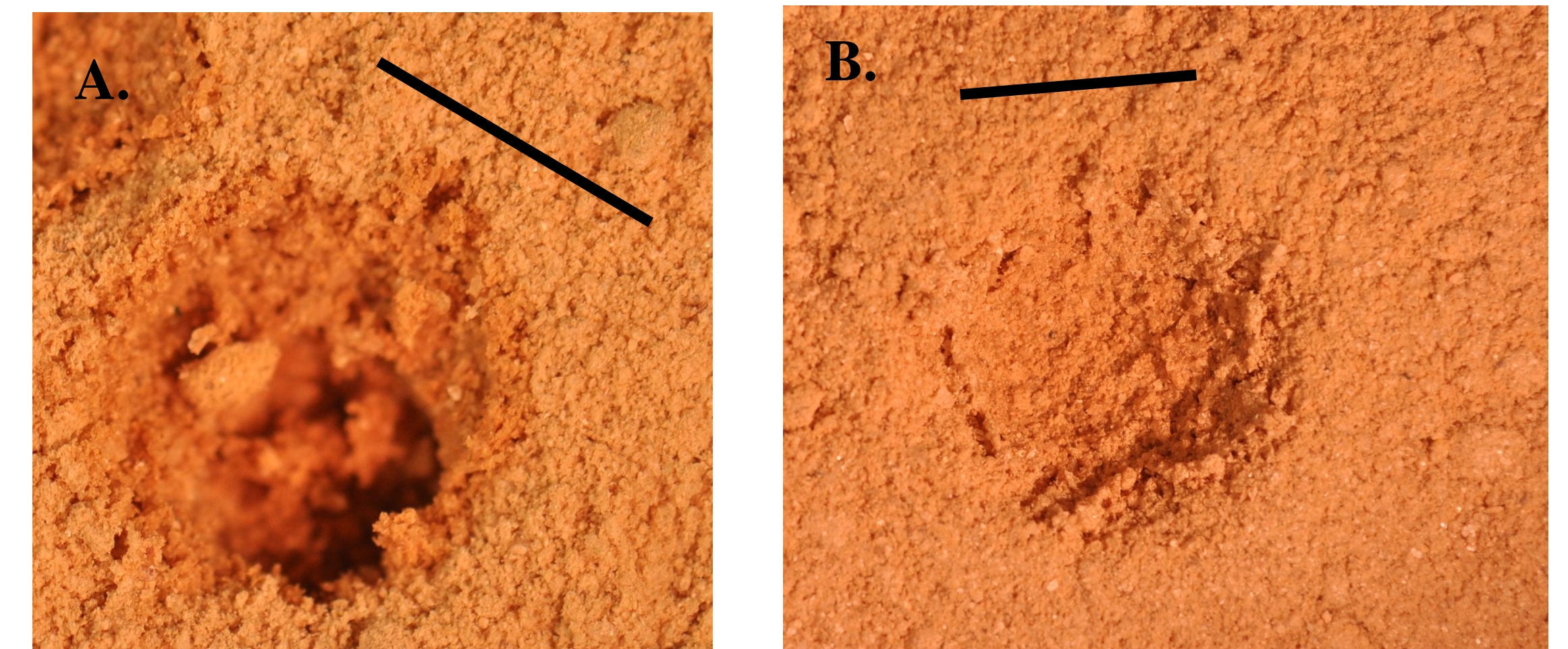


Photos 3.-6. are fossil depressions.

3. and 4. are Ventersdorp Supergroup imprints lithified in tuff at Omdraaivlei, South Africa
 (Buick et al. 2012).



5. and 6. are of Coconino sandstone with depressions present.



Raindrop prints in dry sand and the depth of the impressions:

(Bar length: 1cm)

A. 2 drops on top of each other, 4.29mm; **B.** 4.50mm; **C.** 3.27mm; **D.** 2.13mm; **E.** 2.50mm; **F.** 2.22mm; **G.** 3.93mm; **H.** 2.35mm; **I.** 2.62mm

Results:

The raindrops produced circular impressions in the sand, both dry and wet. Most raindrop imprints in dry sand were approximately 4-2mm deep and 1cm wide. Imprints in dry sand would preserve well as the sand is stable and the cohesion of the water from the drops holds the grains in place. Those prints in wet sand were wider, a few millimeters over 1cm, but not as deep, ranging from 1.5-2mm deep. When the sediment was over saturated with 250mL of water and there was a thin layer of water over the sand, the artificial rain formed prints, but as time progressed, the prints lost their form. Naturally, the sand evened out, destroying the distinct characteristics of the raindrop prints. Less water was used in the subsequent experiment, and the sand was dampened with 100mL of water which just saturated the sediment. The imprints produced in these conditions lasted longer and were able to be measured. However, the sand still had a low viscosity and sank, making the depressions lose their full circular shape as well as decrease in depth over a short time. These raindrop prints have distinctive features, such as their wide spherical shape and the ledge around the imprint from sand pushed from the center of the crater. In comparison to these raindrop imprints, air escape structures along the beach differed in obvious formation and appearance. While both depressions are nearly perfectly circular, air escape holes do not always have a clear ridge around the depression, nor a visible bottom to the crater. Many of the air escape structures are also smaller in width compared to raindrop prints, the former ranging from 1mm to 5mm, with minor exceptions such as one hole that was photographed being 1cm wide. The obvious differences between raindrop prints and air escape structures can be seen from the photographs, as well as their size differences and the appearance of the bottom of the depression in a raindrop print instead of the unclear end of the circular tube in many air escape structures.

Buick, Roger, Catling, David C., Harnmeijer, Jelte P., Polivka, Peter M., and Som, Sanjoy M., 2012, Air density 2.7 billion years ago limited to less than twice modern levels by fossil raindrop imprints: *Nature*, v. 484, p. 359-362.
 Kahle, Charles F.J., 2009, Subaerial gutter marks, raindrop impressions, scour marks and other sedimentary structures, Silurian Tymochee dolomite, Waterville, Ohio: *Carbonates and Evaporites*, v. 24, no. 1, p. 33-44.
 Rindsberg, Andrew K., Gas-escape structures and their paleoenvironmental significance at the Steven C. Minkin Paleozoic Footprint Site (Early Pennsylvanian, Alabama), 177-183 p.
 Shul'ga, V.F., 2004, Carboniferous raindrop imprints at the southwestern margin of the east European platform: *Lithology and Mineral Resources*, v. 39, no. 4, p. 382-387.
 Twenhofel, W.H., 1939, Principles of sedimentation: New York, McGraw-Hill Book Company, Inc., p. 566-567.