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AN EASY WAY TO REMOVE FOSSILS FROM SANDSTONES: DMSO DISAGGREGATION

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MANY SANDSTONES (89 of 127 tested) disaggregate in warm dimethyl sulfoxide (DMSO); no crushing is necessary and there is no known effect on minerals other than kaolinite. Fossils should be cleanly released from the sandstone matrix by gentle washing with water. Treatment is simple and relatively inexpensive. DMSO is not a serious chemical hazard or environmental problem (but see necessary precautions discussed later). Some sandstones disaggregate overnight; others require a month or so. It has been proven to work on some very hard, supposedly silica-cemented sandstones and on some carbonate-cemented concretions in sandstones. In general, disaggregation in DMSO appears to be associated with the presence of kaolinite (which is more abundant in non-marine depositional environments) and with the absence of deep burial or deformation. Even so, there is no way to predict the behavior of a given sandstone; susceptibility to disaggregation must be established by trial.

This treatment should permit extraction of fossils without the extensive hand labor needed to mechanically remove the enclosing sandstone. It is applicable to phosphatic fossils such as bones or teeth and carbonate shells as well as any fossils replaced by minerals such as silica, apatite, pyrite, or carbonate. It is applicable at all size scales, and may be particularly useful for recovering fossils as small as a few millimeters in size, or fragile fossils that might be destroyed by other methods of extraction.

Small bones and teeth have been recovered by using DMSO, but none of the sandstones tested contained fossils composed of carbonate. However, a few bioclastic, kaolinite-bearing limestones proved to disaggregate readily in DMSO, so although no calcareous shells have been recovered so far from sandstones, this should be possible. Further testing of sandstones containing carbonate fossils, with or without carbonate cement, is encouraged. Although the focus here is on megafossils in sandstones, it may be of interest that kaolinite-bearing shales, mudstones, and paleosols are also readily disaggregated with DMSO, yielding calcareous and phosphatic microfossils as well as small bones.

Lab techniques for DMSO disaggregation of sandstones.—Following is a discussion of my methods: they are probably not optimum and are intended only as a starting point for further investigation. Readers are encouraged to experiment with different techniques.

To test the susceptibility of a sandstone, single pieces about one inch in diameter are placed in glass jars with lids in about 25 ml of DMSO. Mason jars are used because they are inexpensive, heat resistant, and readily available in a variety of sizes. It is important to use the plastic lids available for Mason jars because the metal lids and their gaskets are severely corroded by DMSO. Plastic containers should not be used without prior testing because warm DMSO softens or dissolves some kinds of plastics. Samples are placed in a warm oven at about 125°F (~50°C): higher temperatures probably would be faster, but the vapors can be harmful and DMSO is potentially flammable. For these reasons the amount of DMSO should be kept to the minimum necessary to treat the sample and precautions taken to avoid fumes or fires in case of accidents. Containers may break, so samples are placed on a metal cookie sheet with a half-inch raised edge to prevent liquid from falling onto the oven heating coils. Exhaust ventilation is essential to remove any vapors released.

Although it is not known to react with any common minerals, DMSO dissolves some organic compounds; not surprising in that its main industrial application is as an organic solvent. If coaly or oily material is present in samples the DMSO may become very dark, but this does not appear to affect its effectiveness when re-used.

Samples should be checked daily for safety purposes and to detect disaggregation. If kaolinite is abundant it may absorb all of the DMSO. To promote further disaggregation a small increment of DMSO is added and re-checked after several days of additional heating. This is repeated until some liquid remains. In such cases samples can expand significantly, potentially breaking the glass jars, so space should be allowed for expansion.

The results of DMSO treatment can be startling. For example, five samples of hard, bone-bearing Morrison Formation sandstone were reduced to loose sand overnight. Other samples take weeks or even a month to disaggregate; after that, samples are regarded as not susceptible to DMSO disaggregation.

Often the disaggregation is not complete down to individual sand grains: 1–2 mm aggregates are common, reflecting spotty occurrence of calcite or silica cement. Sometimes the rock does not collapse to loose sand but remains as a softened mass that disaggregates during washing. Before washing, any remaining liquid DMSO is saved by decanting it through filter paper, thus reducing costs and decreasing the amount of DMSO for disposal. DMSO works on wet or dry samples, and limited experimentation has shown that it may be diluted with up to 25 percent water, with which it is readily miscible. Such dilution slows reaction time, but not much. Disaggregated samples were washed into a small bucket and left to stand for several hours before the wash water was decanted. Repeated washing may be necessary to remove the garlicky DMSO odor.

For very large samples or large numbers of samples, oven heating may not be practical. Success has been achieved by simply placing samples in sealed containers on a windowsill, exposed to sunshine; large samples could be similarly treated outside. In any case, a clear enclosure, to produce a greenhouse effect, would be very helpful. An interesting possibility would be to try this in the field, perhaps for very large bones during hot, dry days. Specimens could be lightly treated with DMSO and then covered with clear plastic sealed at the edges, with additional DMSO applications as needed (although, as mentioned below, do not allow DMSO to enter open waterways).

Obtaining and handling DMSO.—DMSO is readily available at feed and pet stores, usually in pint bottles. Prices are as low as $5 to $7 per pint, a rate of $40 to $56 per gallon. From one of the many DMSO Internet sites I obtained five gallons delivered to Alaska for $49 per gallon. Purchase of reagent-grade DMSO through one of the standard chemical supply firms is not recommended; a quick check shows prices ranging from about $560 to $830 per gallon exclusive of shipping.

DMSO is a common industrial solvent and is widely used for external medical treatment of animals and humans. It is relatively safe compared to most laboratory chemicals, but there are hazards, so users should note warnings on the label and read the Materials Safety Data Sheets. An unusual and important property of DMSO is that it readily penetrates the skin, carrying with it any soluble material on the skin or in the DMSO. This could be harmful or even fatal. Avoid contact and breathing fumes. Good ventilation, goggles, and butyl or nitrile rubber gloves are essential; work in a hood is recommended. Wash water should be diluted and flushed to wastewater treatment; do not allow DMSO to enter streams or waterways. Testing of small samples should require disposal of no more than a few ml per sample if efforts are made to keep the amount of DMSO to no more than that required to achieve disaggregation. Large-scale processing of large or numerous samples to recover fossils is another matter, and may require more extensive precautions than the small-scale techniques described here.

Heating a flammable organic liquid is of particular concern because it increases the danger of vapors and fire. Such hazards increase substantially with the scale of operations. It may be desirable to reduce the temperature or eliminate the oven heating if longer treatment times are acceptable.

A serious matter not addressed here is the long-term effect of DMSO on specimens, and these specimens' storage and usefulness for future biochemical analysis. Non-reagent grade DMSO has unknown and probably variable amounts of impurities that could adversely affect the treated specimens, or remain in the specimens and later affect other specimens in the same storage cabinets (and the persons handling them). While there is no specific reason to expect problems, only long-term research by trained conservators can answer such questions.

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