

MAXIMIZING SITUATIONAL CONSERVATION AND MINIMIZING VISUAL
AMBIGUITY TO REVEAL TOOTHMARKS ON AN OSTEODERM OF
TYPOTHORAX COCCINARUM, IN TYPICAL LATE TRIASSIC CHINLE
FORMATION PRESERVATION, USING CYANOACRYLATE AND GROUND
MATRIX EXCLUSIVELY

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ABSTRACT—Vertebrate material from this formation is usually collected in mudstone or siltstone that infiltrates the many cracks and fissures. Dissolution and re-cementation occurs in these joints with some movement of the fragments.

The goal of preparation is to provide structural integrity by gluing weak joints while correcting deformation to, the extent possible, by re-aligning drifted fragments during this process. A parallel goal is to reduce the amount of possible chemical interactions by introducing the smallest number of new materials into the finished specimen. Here, since the matrix in the lattice of fractures is already a significant and irreducible component, only cyanoacrylate is introduced to join fragments and as a binder in the ground matrix used to fill gaps and restored areas. The fill, produced and placed in this procedure, is planed to contour producing a crisp line of demarcation between actual bone and restored sections. It also provides mechanical security since the resin and matrix mixed together are stronger than either as isolated material. This then allows detailed analysis of morphology and surface features to proceed. There is also an aesthetic benefit since the color of the fill is natural to the specimen while being distinctly defined.

This is a case study and we do not wish to advocate relevance beyond it.

The procedure and materials choice described here developed from specific circumstances at Petrified Forest National Park, Arizona. And, also involved a specific specimen which is a paramedian scute, or osteoderm, of *Typothorax coccinarum* (No. PVF70, 23388, Prep. # 014). These circumstances included the nature of the fossil material itself such as degree and type of mineral replacement. Now, fossil wood found in the park is world famous for the hard and durable silica mineral replacement. But this is not the case with the vertebrate fossils. The bone, with few exceptions, is not well mineralized. It is more frangible than usual, for instance, and mechanically weak in that it easily fractures under extension or torque and crumbles under moderate compression. It is the same type of preservation found in material from the Ghost Ranch *Coelophys* quarry.

The institutional environment after preparation is another consideration. This unit of the Park service can be considered remote from a scientific collections standpoint. Electrical service was lost several times a year in our experience. This could lead to very high ambient temperatures in summer. Various other facility maintenance problems arise with enough regularity to confidently predict that untrained personnel would handle the

specimen in any given future decade. Added to these predictable hazards was the fact that the specimen would be on exhibit in a park building miles away from the collections facility. So the strategy, then, was to prepare this thin, flat, and delicate element to survive rough handling, temperatures in excess of 100 degrees F., and being supported on a steel exhibit armature with only a few weight bearing points of contact.

Vertebrate material from the Chinle Formation is usually collected in mudstone or siltstone and is run-through with a network of fractures infiltrated by the matrix that cements these fractures tightly in some places and loosely in others. It is typical for dissolution and re-cementation to occur in these joints with some dislocation of the fragments. One of the purposes of this preparation is to provide structural integrity by gluing the loose joints while correcting fragment miss-alignment to the extent possible.

To proceed, the original applications of Butevar and Vinac consolidant had to be removed for the following reasons. They:

- Glued excess matrix and detritus to the specimen.
- Perpetuated correctable miss-alignment.
- Did not reliably bond to the substrate.
- Were mechanically weak in and of themselves.
- Covered the entire surface creating a problematic microclimate underneath it.
- Prevented a bond from a stronger adhesive.
- Would melt during projected temperature spikes.
- Interfered with the conservational goal of reducing the number of applied substances to reduce the complexity of long-term interactions between materials.

It is impossible however to remove all of a previously applied material. In this case it was lifted off the substrate under the microscope on all the external surfaces and in almost all of the joint faces.

Cyanoacrylate was then used as the adhesive because of its inherent cured strength, strong bonding characteristics, and relative resistance to high temperatures. This resin would act as a binder cementing tiny clasts of ground matrix into a durable composite stronger than its components. This will form an internal armature supporting the weak bone fragments by surrounding them in the connected lattice of filled cracks. Note though, that the bone is nevertheless stable and best preserved without a coating. So, the external surfaces are uncoated and only the joint faces are in contact with the resin.

Since matrix was already an irreducible part of the fossil bone, introducing cyanoacrylate added only one substance to the finished object. Admittedly this is a commercial product containing some unknown material since the formula is proprietary. But, it comes from a long established supplier (PaleoBond) and the long-term behavior is partially known and under observation. It is also widely used on fossil material in collections around the world, hence, the documentation of this use.



(1) This is the dorsal surface of the scute before preparation. You can see roots and debris glued to it by the field consolidant as well as islands of matrix standing up above the bone surface and bound to it. Not visible in this view, are the microscopic calcite crystals that have grown into the bone, penetrating and slightly distorting the cortex. These crystals can't be removed with an airscribe because too much cortical bone gets blown away. They have to be sheared off flush with the bone surface by hand with a very small chisel that will be described presently. They also proved to be beyond our our capacity to effectively photograph because we do not have a three port microscope. All the images in this presentation were taken with a conventional camera with a macro lens.



(2) The two halves of the scute were prepared to an advanced stage before joining them together. Half a scute is easier to handle than a whole one during most phases of preparation. This half fell from the bench to the concrete floor shattering into the pieces you see before you. The larger pieces are placed together in their relative positions and the smaller ones in the box were all reincorporated. It landed on the restored corner seen on the left but it broke through the un-restored bone. This demonstrates that, when complete, the system imparts the maximum strength possible. The amber colored areas are places where field consolidant has not yet been removed although it has been removed from the glue joints. Eventual removal is much easier after enough fragments have been joined together to make it large enough to handle. Carving the glue joints and restorations to contour is so similar to removing the old consolidant that it is more efficient to do both at the same time.



(3) Matrix, processed to make aggregate for the system, was pounded with a hammer on a steel plate and the crushed rubble swept onto the newspaper underneath it.



(4) The rubble is then put through a 14-mesh (14 openings to the inch) kitchen strainer.. This produces the large grain fraction of the aggregate we will use. It is what you see in the bowl under the strainer.



(5) Some of the large grain fraction is then put through a 30-mesh strainer producing the fine grain fraction. What we are producing is something like the sand and gravel used as aggregate to mix with portland cement and water to make concrete. They make it stronger. Another similarity here is that by using only the fine grain fraction a sort of superglue mortar is produced for filling and adhesion in very small gaps.



(6) This is how the “mortar” is mixed on top of a dental mixing pad of treated paper. After each batch the top sheet is torn off exposing a new clean sheet. A large drop of cyanoacrylate resin is placed next to a pile of the ground matrix that’s about 30% large grain and 70% small grain. This will allow two or three sub batches but the aggregate greatly accelerates the curing time. Once the two are mixed, there are only seconds available to place it. Some of the resin is mixed with the matrix and held as a drop in the bend of the pick. It will flow off when touched to the work.



(7) Everything must be done in a quick but fluid motion under the 'scope. This is a dry run to visually locate everything so there will be no searching to bring the pick into the field of view during the real thing. The object, in this instance, is to fill the void seen at the sharp end of the pick. But the same method is used in filling cracks. The specimen rests on a sandbag made of denim.



(8) The placement sequence begins and runs through plate number 15. For the observer seeing this as it happens, understanding of the procedure is intuitive. It is a little harder to convey in words and pictures. Here, the pick is brought over the target area with the drop of mixed resin and matrix hanging below it but not touching the work. On contact, surface tension takes over and drains the drop off the pick at the point of contact. So the batch is wasted if it touches down at the wrong spot.



(9) Homing in with the drop of mix on the pick.



(10) Contact is made and in the same motion the pick is moved towards the void so, in the second or two remaining, the fluid will fill it from the bottom up as it flows in, and avoid trapping air.



(11) The pick slides along in contact with the work so the maximum amount of fluid will transfer from it.



(12) The pick lifts out of the fluid.



(13) The pick re-contacts the fluid meniscus to pull it a little into a better position while it can still move.



(14) The fluid goes into the gel stage.



(15) The resin has fired and the mixture now fills the hole and has shrunk in volume.



Ventral scute showing masking tape used to contain the filler during multiple applications on the edges of the piece. There is a slight drawback in that the mastic residue from the tape has to be scraped off under the 'scope. But that is far less time consuming than trying to do it without the tape.



The dorsal surface of the same half-scuta showing the uneven surface of the filler from multiple applications.



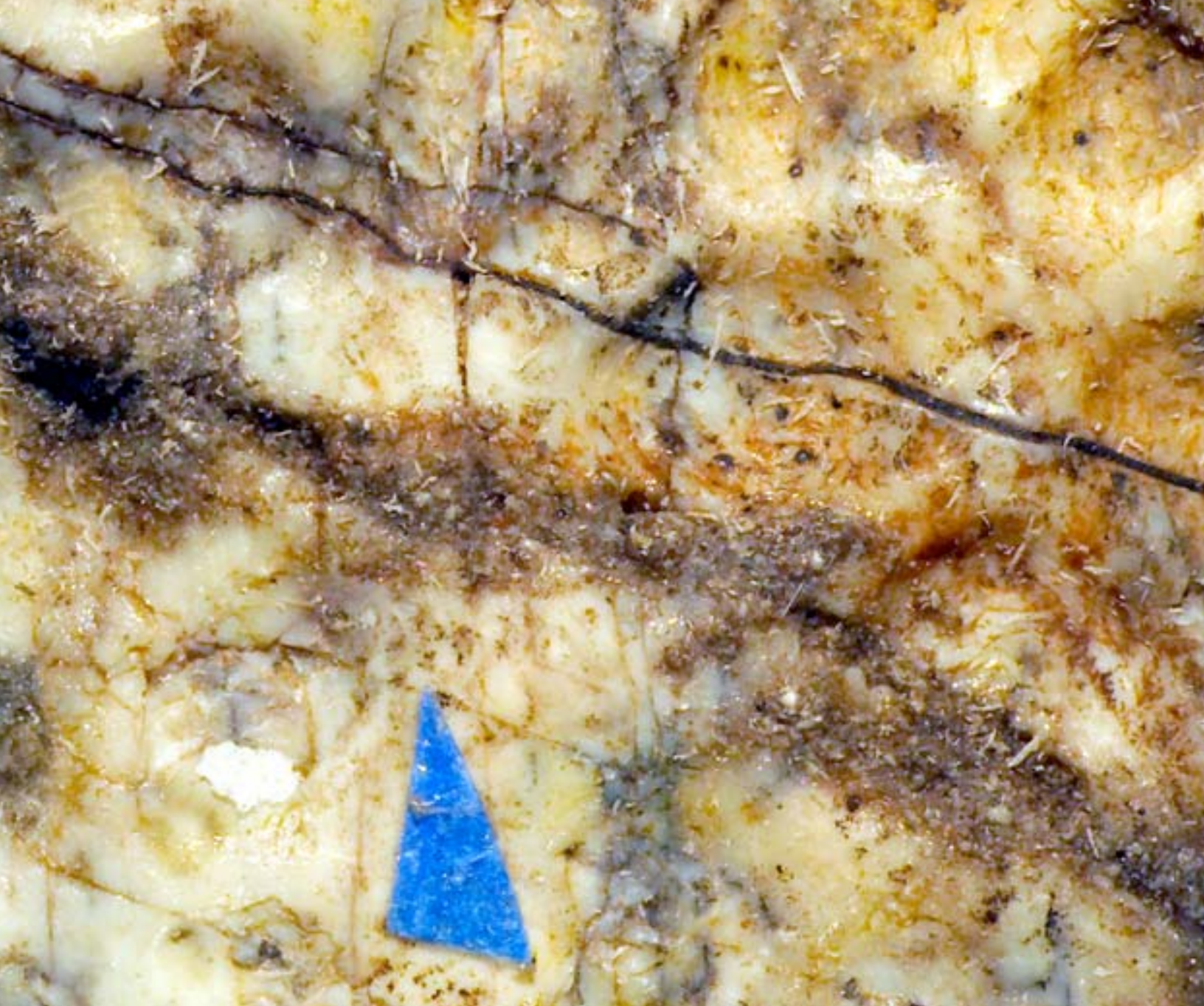
The excess filler must now be carved away. The blur in this picture is a spinning, 1/8" shank, single cut, oval head, carbide burr chucked in a pneumatic pencil grinder. This is used for roughing-out or bulk removal. If you always keep it moving in a circular pattern and start doing this in the air before touching down, you can produce a nice even surface like that in the right hand third of the image. But if you ever stop it will dig a divot like the one under the burr. This takes practice that should not be done on real specimens.



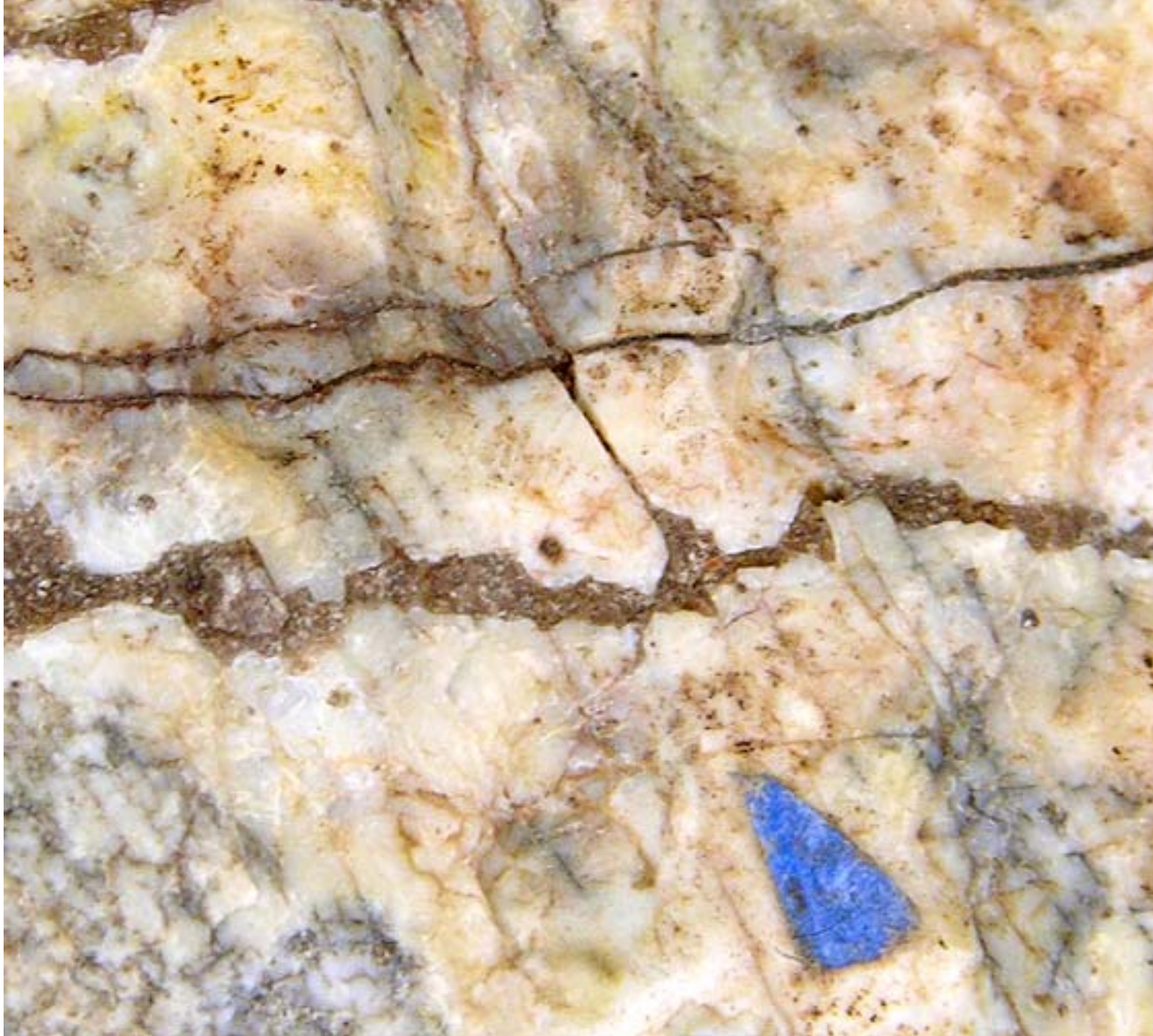
The final carving is done by hand with sewing needle ground to a chisel edge and chucked in a pin vise. We use at least four because you need to have a selection ground to various angles to accommodate carving in high-relief areas of the bone like the ornamentation. The chisel is floated across the surface and carves away anything, not bone, above it. Here it is pulled back slightly from trimming the excess filler in a crack.



The needles are sharpened on this diamond impregnated rubber wheel that is mounted on a miniature Foredom bench grinder. The wheel rotates away from the acute edge and final touch-up is done on silicone carbide wet or dry sandpaper 1000 grit or higher.



Pieces are glued together with straight cyanoacrylate (Paleobond 1500) and all the gaps in the joint are then bridged with the filler. This shot shows a glued and filled joint not yet carved down. It's just above the triangle of masking tape and just under a naturally filled crack running parallel to it. You also see the "sawdust" from using the grinder for bulk removal.



The same shot after the filler has been carved to surface contour. The amber patches at the top of the image are old consolidant that will be removed the same way.



The complete scute in dorsal view. There is a sharp, definite line of demarcation between bone and filler. All voids that are not part of the original morphology are filled and there is nothing above the bone surface. The filler is also very close to the color of the natural matrix-filled cracks while still being distinct from them. This removes as much visual ambiguity as possible, making the piece easy to read.



Plaster cradle to support the specimen in collections. The cut-out allows thumb and forefinger to grasp the piece for easy removal and replacement.



The specimen in its cradle.



Ventral view of the complete scute.



These grooves were gouged into fresh bone on that same ventral surface, as shown by the clean rounded edges with no fracturing and the compression rather than cutting of the cortex. We've interpreted them as tooth-marks. Removing as much visual ambiguity as possible in this preparation process greatly simplifies examination and interpretation. You can see that some of the post-depositional cracks go right across these grooves and have been filled and carefully carved to contour so they can be distinguished from them. Any consolidant covering the surface would have obscured the difference to some extent. And, in fact, the grooves were not recognized until after this treatment.