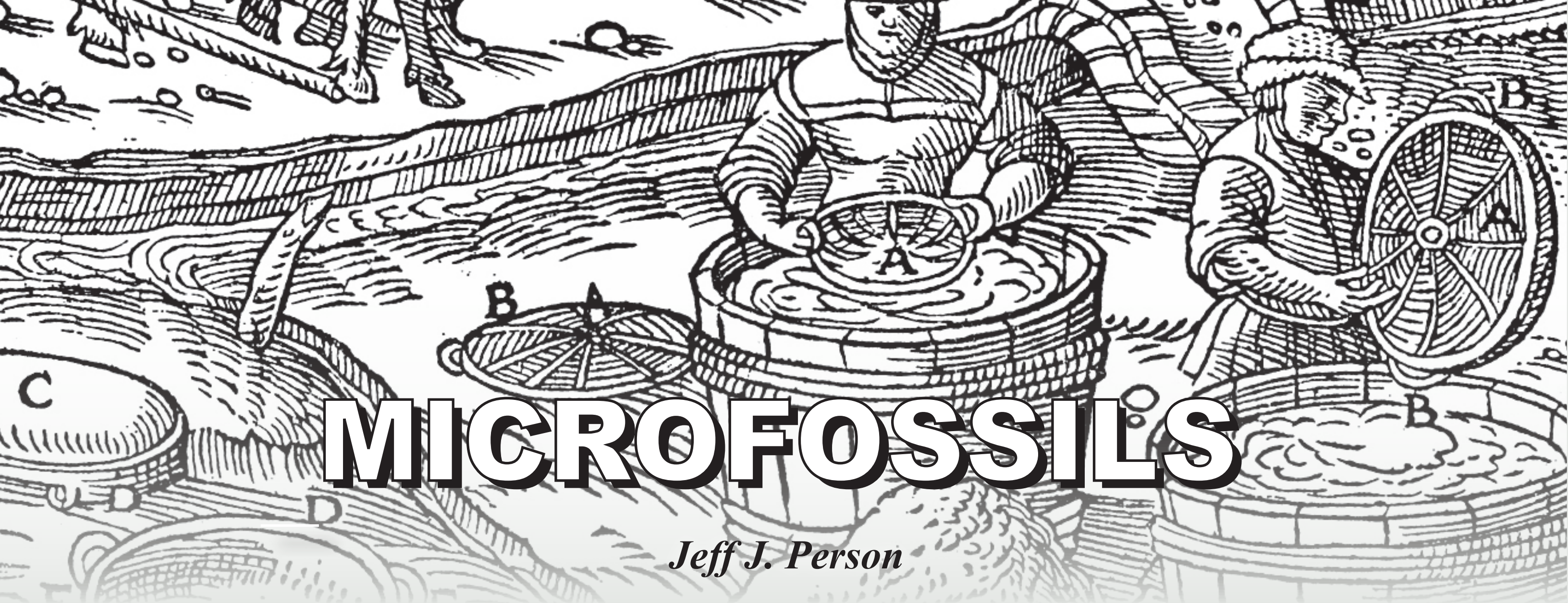

MICROFOSSILS

Jeff J. Person

Have you ever lost your keys? Lost some loose coins out of your pocket? Spent an hour on your hands and knees looking for a contact lens? Searching for microfossils can be a similar task. Paleontologists often scour the landscape, either on foot or on hands and knees, for hours on end looking for clues leading them to fossils. A scrap of bone, the glint of the sun on an exposed tooth, or even examining a funny looking object that does not quite fit with the surrounding rock hoping it is a fossil.

The search for microfossils is sometimes a very unrewarding task. I have collected, washed, and scoured through, quite literally, tons of rock looking for a single mammal tooth. But however tedious and arduous the task of looking for microfossils is, the rewards greatly outweigh the time spent looking. Microfossils are, as you may have guessed, very small fossils. These small fossils can be anything from microscopic animals (for example dinoflagellates and foraminifera) that lived in water environments to very small bone fragments to very, very small teeth and everything in between. In this case I am referring to very small mammal teeth. These teeth are so small they can be glued on the head of a pin (fig. 1).

Figure 3 A. Collecting matrix with shovels at a microsite in southwestern North Dakota.

Figure 2. This is an example of a thin fossiliferous horizon. The black specks in the overturned chunk are fish scales.

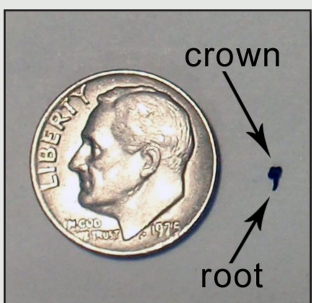

Figure 1. Image of a mammal tooth next to a US dime for scale.

The recovery process of these teeth begins with collecting rock. However, paleontologists do not just randomly stick a shovel in the ground and hope to hit pay dirt. Sites used to study microfossils are chosen very carefully. These sites, called microsites, are usually places where other fossils are already weathering out at the surface. Small fossils, easily visible with the naked eye, are usually common, and the fossils tend to be concentrated within a definable, thin horizon (fig. 2). This horizon is then collected by hand or by shovel and brought back to the laboratory (fig. 3). Since tons of material can be collected at one time it is greatly beneficial to reduce the amount of sediment and rock that needs to be looked at.

Figure 3 B. Hauling matrix out of the microsite in burlap bags.

There are numerous ways to separate sediment from fossils. Cifelli and others (1996) give a more detailed description of many of the techniques discussed here.

Screenwashing

Screen washing or wet sieving, that is, the use of water to separate fossils from the surrounding rock matrix, has been in use for more than 100 years. Jacob Wortman (Osborn and Wortman, 1892:146) describes a form of wet sieving he used to recover pieces of a single skull he had found weathering out of a hillside. He collected large amounts of rock from the surrounding area where the skull was found and "hauled it all to the river where we carefully washed it after the manner of the placer miner." A few years later Barnum Brown of the American Museum of Natural History discussed using wet sieving for microfossils in a letter to Henry Fairfield Osborn in 1906 (McKenna et al., 1994). Brown was likely using his technique to recover a variety of fossils, rather than fragments of a single specimen, which is similar to the majority of what we use screen washing for today.

Although Malcom McKenna later streamlined and perfected the technique (McKenna et al., 1994), the modern methodology of screen washing was independently invented by Claude Hibbard in 1928 (Hibbard, 1949; Hibbard, 1975). The driving force behind screen washing is to separate as much of the rock matrix from the fossils as possible, reducing the amount of material that needs to be examined under the microscope. A great deal of rock can be eliminated from the screen washing process right away in the field by only collecting the producing layer. Owing to the nature of some sites this is not always possible, but simply being more efficient with what you do collect enables you to collect more and wash less. The collected material is brought back to a screen washing area and washed through one, or sometimes two, sets of screens, the smallest screen is usually smaller than the screen on your windows and doors at home, which is less than ¼ of an inch wide (fig. 4). What remains on the screens after washing is dried

Figure 4. Rock matrix in a screen "box." The rock is sitting on top of fine mesh screen and water is just beginning to cover it.

and then systematically examined under a microscope where microfossils are picked from the remaining dirt and rock (fig. 5). The most common fossils that come out of this concentrate are usually fish bones and teeth. Rarely though, a mammal tooth will be found.

Figure 5. A volunteer in the Johnsrud Paleontology lab looking for microfossils.

Acid washing

The optimal way to view and study microscopic fossils is to view them free of their surrounding rock matrix. When this matrix is comprised of very hard or indurated rock, this can be problematic or dangerous (to the fossils) to remove with typical hand tools. If the rock matrix is held together by a carbonate cement, a weak solution of acid can be used to dissolve the carbonates. While a variety of acids can be used depending on the composition of the rock matrix, acetic and formic acid are the most common because of their relatively weak nature. A 10-15% solution of acetic acid has been shown to be optimal (Rixon, 1976). The rocks to be acid treated should first be thoroughly dried, and then submerged in just enough acid solution to cover all exposed rock. This process should be performed under a fume hood or in a location with adequate ventilation. The mixture of rock and acid should be monitored daily and when effervescence ceases the rock should be removed and placed in a water bath to removed excess acid. Any exposed bone should be covered in a protective layer of adhesive to prevent damage while exposed to acid. This process can be repeated until the bones have been completely removed or the rock matrix ceases reacting to the acid.

Ants

The collection of fossils from anthills has been mentioned numerous times since the late 1800s (for example, Hatcher, 1896; Lull, 1915; Turnbull, 1959; Adams, 1984; Croft et al., 2004), but only rarely discussed in detail (Schoville et al., 2009). The western

Figure 6. An anthill made by the western harvester ant.

harvester ant (*Pogonomyrmex occidentalis*) is a mound building ant, so named because of its propensity to harvest seeds and other small food items. The colony builds and lives within dirt mounds that are usually 2-3 feet high and 2-3 feet across (fig. 6). These mounds are generally covered with an armored skin of small pebbles or bits of hard debris found in the general vicinity of the anthill, protecting the anthill and colony from wind and rain. However, they are still vulnerable to predators and curious paleontologists. The small pieces of armor are generally of similar size and shape and are uniformly placed all across the surface of the anthill. These pieces are indiscriminately retrieved from the area and if there are small fossils nearby those will be incorporated into the anthill armor with the rest of the rocks and debris. Paleontologists can visit these anthills, preferably on cool mornings when ant activity is low, and scour the surface looking for small fossils. Generally the fossils found belong to shelled invertebrates or to fish, amphibians, or reptiles but some anthills contain the teeth and sometimes jaws of small mammals. The types of rocks and fossils found on the surface of the anthill will obviously depend on what is in the area being used as source material.

If an anthill is discovered that contains fossils on the surface, it can either be scrutinized in the field where all the fossils would be recovered or the surface of the anthill would be collected and scanned under a microscope looking for fossils (fig. 5).

The distance ants will travel to bring material back to the anthill for use as armor is unknown. Studies using glass beads (Clemens, 1963; Mattias and Carpenter, 2004; Schoville et al., 2009) showed the ants collected material up to 48 meters away but the majority of collected material was within 20 meters of the anthill. Fossils collected from anthills should be used carefully. Since there is no stratigraphic control on where the ants retrieve the rocks and fossils they should not be used in any detailed study concerning the broader questions about changes through time. However, they can be used in qualitative studies of faunas, for example using them to give specific measurements of a species' teeth.

UV light

The use of ultraviolet (UV) light to make certain fossils fluoresce is not a new concept. It was first mentioned in a North American publication by G. G. Simpson in 1926, although E. Wagner in Germany published on studying fossil fish with UV light in 1928, most

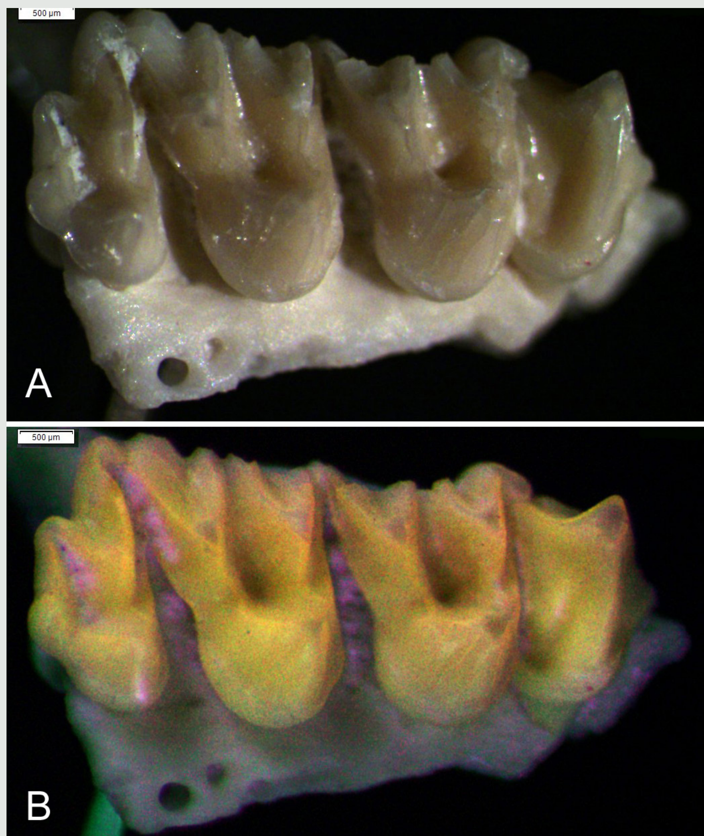

Figure 7. An upper tooth row from a bat in A) white light, and B) ultraviolet light. Notice the yellow-orange glow of the teeth and the purple color of the remaining rock matrix under UV light. Scale bar is 500 microns or half of a millimeter.

likely discovering the fluorescent properties of some fossils independently from Simpson. Over the next few decades very little was published, most likely because of the relatively limited availability of products and techniques. Today, the most common use of UV light research is in the detection of fossil forgeries and chimeras. Not all rocks and fossils fluoresce in the same way and some do not fluoresce at all, so a forged specimen can be spotted by the telltale inconsistency of its fluorescence patterns.

The use of UV light to aid in the discovery of microfossils in the field was first published in 2004 (Croft et al., 2004). The concept has received little field testing but the theory is legitimate. Researchers simply shine UV flashlights over the ground as they crawl across the surface looking for fossils. This must be done under very low light conditions, preferably at night (fig. 7).

Importance

So why do we look for these tiny teeth? They are not as "flashy" as a *T. rex*, they are difficult to study, and difficult to see in an exhibit. So why do we put forth all this effort to find them? Well, size can be a limiting factor on how far an animal can travel in its lifetime. Large animals like African Elephants can travel hundreds of miles across a continent, whereas a small frog or mouse might not travel much more than a few hundred feet from where it was born. Small animals are also much more restricted on the types of environments they can survive and thrive in due to temperature fluctuations, or to food or water limitations. These factors can give us clues to the types of environments that a particular animal is found in, giving us small glimpses of a much larger picture of past environments through time.

In vertebrate paleontology mammal teeth are held in special regard. An entire system of age dating has been developed around the appearance and disappearance of mammals through time. This system, known as biostratigraphy, utilizes the first known occurrence of specific animals through time as markers for the beginning of certain chunks of time known as ages. Other animals have been used to divide up chunks of time earlier in the fossil record, but since the dinosaurs went extinct and mammals began to become much more prevalent, the last 65 million years or so is divided up into chunks called North American Land Mammal Ages. We can divide some of these chunks of time into increments as short as a few million years. This system uses mammals because small mammals tend to have much more rapid generation turnover and reproduce in larger numbers, meaning they can adapt and evolve at much faster rates. Owing to the fact that larger species tend to reproduce at much slower rates and tend to evolve much more slowly, large species, such as most dinosaurs, are virtually useless for detailed age dating.

It is these rare mammal teeth that can potentially tell us the most about one particular site. From being able to restrict the age of the site to within a few million years or to give us greater detail about the paleoenvironment, fossil mammals, especially the small mammals, play an important role in paleontology.

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