LEAF DESIGN: *A beautifully preserved leaf is found in lake deposits at Fossil Butte.*

Definition of a fossil

By Vincent L. Santucci
Fossil Butte

Paleontology is unquestionably an established and recognized scientific discipline. Professional paleontologists have become highly specialized and employ a wide range of scientific methodologies in pursuit of data. Research into the functional morphology of ancient organisms, the physics of tetrapod locomotion, the development of extinction models, the application of molecular biology in systematics, comparative bone histology and other practices are certainly based upon the scientific method.

What common denominator unifies all of the diverse fields within paleontology? The answer is clearly — FOSSILS. However, a close examination of the use of the word *fossil* in modern society demonstrates that the definition of a fossil is less than scientific.

"What is a fossil?" is a common interpretive theme presented in museum exhibits, educational activities, natural history programming, books, media and more. Each individual has his or her own perception of a fossil. To many children fossil means dinosaur. To a ranger at Petrified Forest, a fossil may be an object that visitors occasionally collect illegally. To a commercial dealer a fossil may mean dollars. Grandma sometimes even calls grandpa a fossil! What variables should be included in a scientific definition of a fossil? Likewise, what variables should be omitted from the definition?

To begin on some common ground, it is widely accepted that a fossil is evidence of life. This includes the physical components of the biological organism (leaves and teeth) or some indication of biological activity (footprints and burrows).

The term fossil has been inappropriately applied to geologic features such as "fossil sand dunes" or "fossil ripple marks." Although these descriptions have become commonly accepted, this usage adds to the subtle consternation that exists in the use of the word *fossil*.

Another area of confusion relates to the use of the word *fossilization*. The word *fossilization* implies some process, transition or metamorphosis resulting in preservation of biological remains. To some, the word *fossilization* is considered synonymous with the word petrification. Both words denote a process, however, petrification is a specific type of fossilization involving the conversion of organic material to stone (more precisely minerals). Furthermore, there are various types of petrification including mineral replacement, permineralization and recrystallization. Not all types of fossilization involve petrification. Fossilization can occur through other processes, such as freezing, desiccation or encasement of organic remains within other materials (amber), and does not necessarily involve any mineral replacement (petrification).

The preservation aspect of a fossil needs further analyzing. Perhaps the concept, "I am, therefore I exist," could be applied directly toward limiting our definition of the word *fossil*. For a fossil to be a fossil it must exist, and therefore, it must be preserved in some form or state. It should be noted that the use of the words *preserve* and *preservation* does not necessitate mineral replacement or chemical alteration.

Does the degree or mode of preservation need to be incorporated into the definition of a fossil? Do the remains from the past need to be chemically replaced, recrystallized or turned to stone (petrified) in order to be accepted as a fossil? Indeed, we can answer "no" to both of these questions. The fossil record includes many examples of unaltered animal and plant remains. Conversely, are the bones of a coyote that fell into a Yellowstone hot spring a few years ago fossils? The mineral-rich waters of the hot spring promote rapid mineralization of recent bones. In some cases, these recently trapped bones show a higher degree of mineralization than do some bones that are millions of years old. The fact that a fossil simply exists and is therefore preserved is more meaningful in defining a fossil than the degree or mode of preservation.

The word *subfossil* appears in scientific publications. What does this mean? Perhaps it means small fossils, or material incompletely fossilized or something beneath/below the fossil. There are two common uses of the term *subfossil*. The first is in reference to the degree of preservation. It suggests a minimal degree of mineral alteration or a partial replacement. The second use is common when references are made to remains of life from the Holocene (recent). This use of subfossil is related to the acceptance of the idea that a fossil must be from a previous time period. Subfossil is a term that is used inconsistently, and its ambiguity hinders the ability to rigorously define the term *fossil*.

FOOTPRINTS: *Early dinosaur tracks are preserved in sandstone at Glen Canyon.*

Definitions of fossil that incorporate a time reference or date result in interpretations that are unscientific. Many sources have presented a definition that indicates a specimen must be older than 10,000 years or from a previous geologic time period to qualify as a fossil. Establishing a boundary or date may make classification easy, but does this make real scientific sense?

Shall biological remains that date to merely 9,000 years ago be denied space in the paleo cabinets? Do we need to consider waiting another 1,000 years until these remains can officially be called fossils?

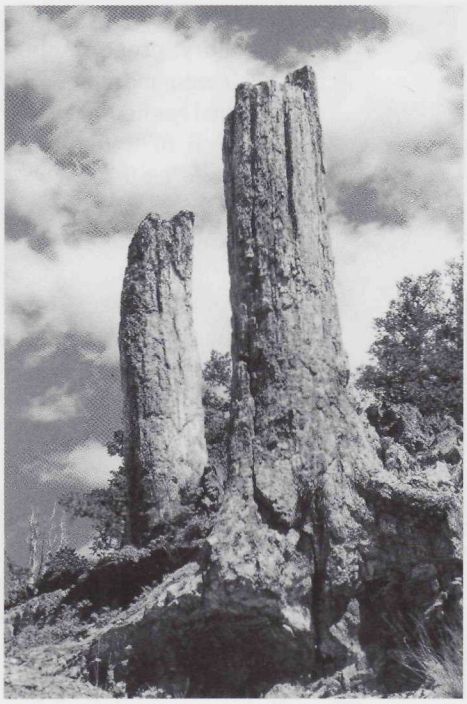
Likewise, what is significant about defining a fossil through its occurrence in a past geologic time period? Humans establish these boundaries. What intrinsic relationship do these boundaries have with determining whether biological remains are fossils?

Are the Wrangell Island mammoths to be excluded from being recognized as fossils? In the late 1980s the remains of mammoths were discovered in the Russian Arctic. These mammoths underwent exhaustive research. Scientists from St. Petersburg established isotopic dates of 4,000 years B.P. (before present) for the mammoth remains. Other researchers confirmed this work independently. Does this discovery support a definition for fossil, which includes a reference to a particular date or time period?

If the definition of a fossil is free of time association, then what are the limits defining a fossil? Is there rationale for including extinction as a criterion in the definition of a fossil? A cursory look at the fossil record indicates that there is no basis for including extinction as a criterion. For example, the extant genus *Lingula* (a bivalved marine organism) extends back to the Cambrian, whereas many species of plants and animals have succumbed to extinction within the last century. There doesn't seem to be a unified taxonomic component suitable for inclusion as a criterion in the definition of a fossil.

As clever government bureaucrats, perhaps we could establish some useful acronym to help us with our fossil definition. The following acronym came to me during a late night attack of insomnia: F.O.S.S.I.L. (Fairly Old Stone-like Specimen Indicating Life). It is apparent, however, that this approach is still not scientifically sound.

In consideration of the discussions presented above, there appears to be one important element missing from the various definitions currently being used for the word *fossil*. This element is the geologic context in which the fossil is preserved. The geologic context refers to the environment, both components and conditions, in which the organic remains occur. The preservation of biological organisms is directly dependent upon the geologic context or the ancient environmental (paleoenvironmental) conditions to which they are exposed. Evidence of this environment is often preserved itself in the form of sediments, soils and other geological resources.



SENTINELS: *These standing petrified trees are in an ancient forest in Yellowstone.*

As most paleontologists recognize and advocate, the geologic context in which fossils occur provides some of the most important information regarding the fossil. Fossils removed from strata without documentation of the associated geologic and stratigraphic data have limited value to science. The associated geologic information can yield valuable information relevant to the fossil including: climate, sedimentary environment, age, contemporary organisms and other data.

What, then, do we propose as a scientifically sound definition for the word fossil?

Fossil: ***evidence of life preserved in a geological context.***

It appears that the concept of geologic context may be the critical missing element and may resolve some of the "gray areas" existing in the current definition for the word fossil. The geologic context helps to differentiate a fossil from fresh road kill along the highway. Placing biological remains in a geologic context seems more congruent with the actual scope of paleontology than to reference a relative time marker or a degree of preservation.

The lack of a consistent and scientifically based definition for what we recognize to be a fossil is problematic. As the foundation for the science of paleontology, fossils should be more clearly defined. The definition should be based upon science and logic in order to minimize the ambiguity and to maximize understanding. We should establish a consistent definition to facilitate our efforts in resource stewardship and public education. Furthermore, the lack of a sound scientific definition for fossils limits our ability to establish an acceptable legal definition for fossils.

As a final note, we have come to learn in the science of paleontology that our knowledge of the history of life is only as good as our previous field season. Our interpretations may need to be modified as our fossil database grows.

This discussion was not presented to be dogmatic, nor was it presented to be adversarial. On the contrary, this discussion is intended as a means to generate meaningful discussions between those of us who manage and care for fossils. Perhaps paleontologists and public land managers should work together and discuss topics such as definition of a fossil in order to better attain consistency and the highest level of understanding in our management, protection and interpretation of the nonrenewable resources known as fossils.

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Photos courtesy of the author.

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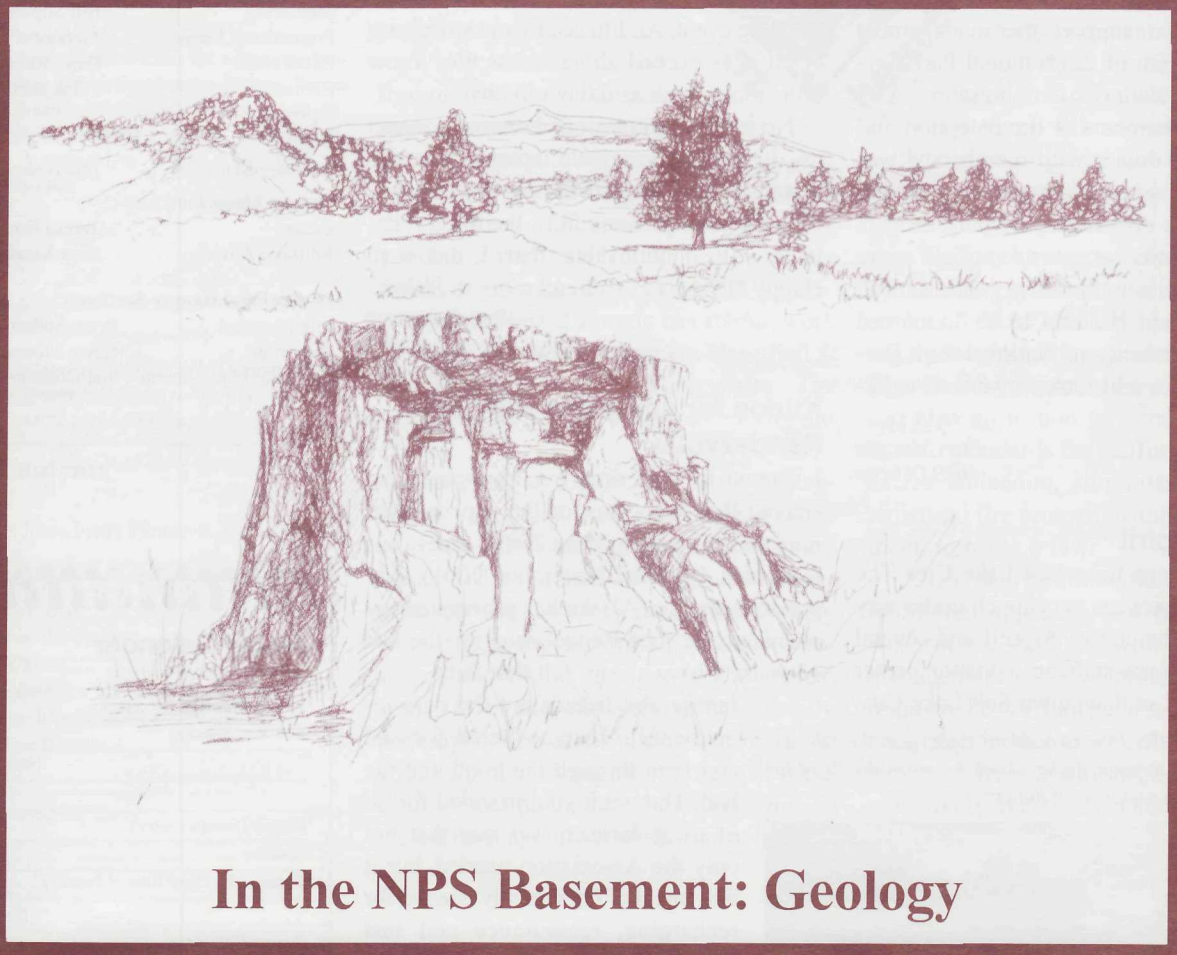

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