The Yellowstone Petrified Forests

by Harold G. Coffin

The Petrified Forests of Yellowstone have been known for nearly 100 years, but only a few of the thousands who visit the park see this world-famous attraction. Those who take the effort to climb to the sites are impressed by the upright position of many of the stumps and come away with the conviction that each level of petrified stumps represents an ancient forest buried in position of growth.

This interpretation is so obvious that any alternate explanation runs the risk of appearing incredible. Despite this risk, I propose that the stumps (both prostrate and erect), leaves, needles and other plant debris floated to their present location and settled onto the surface of successive underwater volcanic mud slides. Thus, many levels accumulated in a relatively short time. The Genesis flood makes an attractive source for the water in this model.

We will now examine the evidence that supports this interpretation.

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The Petrified Trees

The most striking feature of the petrified trees is the erect position of many of the stumps. Without doubt, this is the strongest argument for the trees being *in situ*. Nevertheless, many features of the petrified trees are inconsistent with an *in situ* interpretation.

Abrupt Root Terminations. If the trees were washed out of a growing forest and transplanted to their present location, some of the roots, especially the large roots, would be broken. Observations of roots of trees bulldozed out of the ground in clearing operations have shown that although the smaller roots are usually intact the larger roots are sometimes broken. I have found seven examples of abruptly terminating "broken" roots in the Yellowstone Fossil Forest. Many other examples are suggestive of sudden root terminations, but a positive field identification of this feature is often difficult because of postpetrification breakage and the difficulty of digging into the well-indurated rock in order to expose the roots.

Overlapping trees. Superposed levels of upright stumps are sometimes only a vertical foot apart. Occasionally, a stump arising

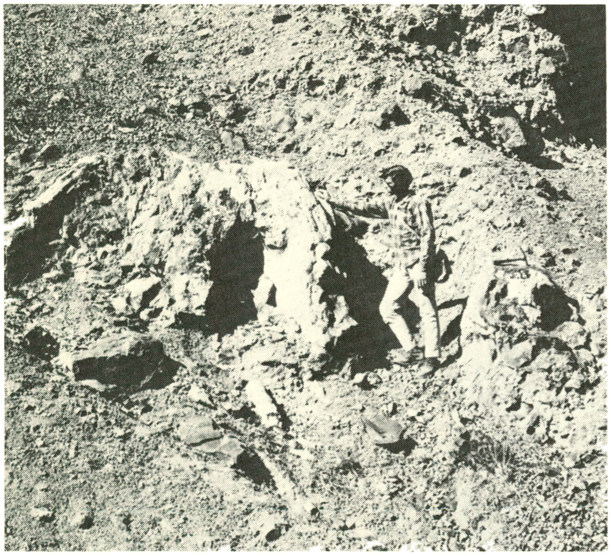

Figure 1. Overlapping trees in the classic Fossil Forest in the Lamar Valley. The roots of the larger tree are to the left of the person (Lanny Fisk) and the smaller tree which arises from a lower level is to the right.

from a lower level extends through or into the "forest" level above it. These "overlapping" stumps are compatible with the growth interpretation *if* the upper level trees are small because a protruding snag from a lower level would then be exposed to decay only during the short lifespan of the small trees on the upper level. If, however, the stumps on the upper forest level are from large trees, there should have been sufficient time for decay of the exposed top of the overlapping stump. For example, in the classic Fossil Forest, the top of a Sequoia 45 centimeters in diameter terminates at the root zone of an adjacent large stump rooted in a higher level (Figure 1). Since most of the top of the large stump is still covered by hard rock, its age cannot be determined by a ring count, but other petrified Sequoia stumps of comparable size have approximately 500 rings. Although Sequoia is known to be durable wood, a small dead Sequoia snag only 45 centimeters in diameter should suffer extensive decay after 500 years of exposure in a semitropical forest. Instead, it possesses distinct rings and shows no signs of decay.

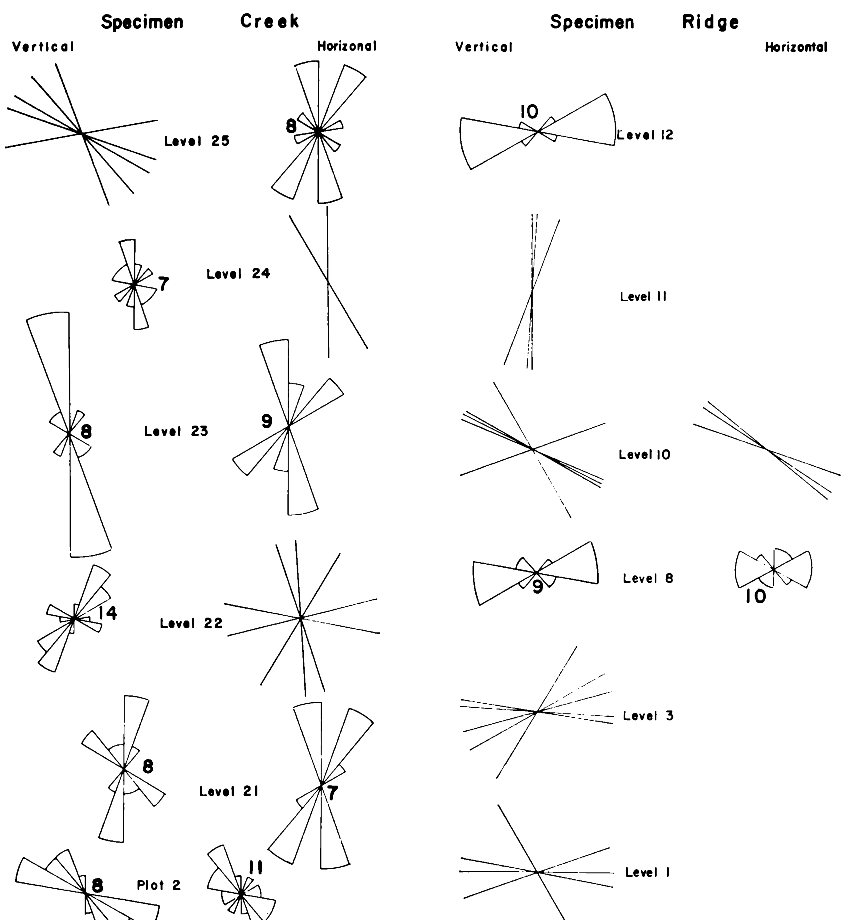

Figure 2. Orientation of vertical and horizontal petrified trees in the Specimen Creek and Specimen Ridge areas, Yellowstone National Park. For levels with five or less measurable trees, each tree is represented by a line. Numerals beside rose graphs represent sample size.

Orientation. Prostrate logs and the long axis of the cross sections of the tops of standing stumps seem to show a tendency to be aligned in the same direction (Figure 2). This type of orientation does not seem to be found in living forests. Observations in three modern forests with flat floors (the fossil forests of Yellowstone have flat floors) not adjacent to clearings or canyon walls have failed to establish a preferred orientation for even the prostrate trees, let alone a common orientation for prostrate trees and the long axis of asymmetrical upright trees.

The similarity of orientation for prostrate logs and upright stumps seems to require a common force (such as moving water) acting on both. A log moving with a current will align with the current direction, but will an upright floating stump with only slight variation in stump symmetry also align itself with the current? I believe it will because the asymmetry is usually a reflection of the major roots which have produced buttressing of the lower tree trunk. Therefore, currents acting on the roots of drifting stumps could produce the observed orientations.

Diverse Flora. Knowlton (1899), Read (1933) and Dorf (1960) have identified over 100 species of plants in the Yellowstone Petrified Forests. Pollen studies increase the figure to over 200.

The ecological diversity represented by the species is unexpected if the trees are in position of growth. Species range from temperate (pines, redwoods, willows) to tropical and exotic (figs, laurels, breadfruit, catsura), and from semidesert to rain forest types. This diversity may be an indication that the Fossil Forests are an artificial assemblage of stumps, leaves and pollen transported during the Flood from several pre-Flood ecological zones.

Dendrochronology. Dendrochronolgy is based on the principle that trees subjected to similar environmental conditions will develop rings that exhibit similar trends of growth. A sequence of wet or dry years will be reflected in the relative thickness of the rings. Although each tree is individualistic in its growth response to the environment, there is enough similarity among the trees of a forest to permit plots of ring width to be matched ring for ring.

The basic requirements for successful dendrochronology are: 1) trees with variable rings; 2) rings that persist all the way around the trunk; and 3) trees that grew in similar habitats.

If they are in position of growth, the petrified trees in Yellowstone meet these minimum requirements. Matching ring patterns from the same level would be strong evidence that the stumps grew where they now stand. But absolutely no matching has been found using the manual skeleton plot technique. Two trial runs with computer matching have also proved unsuccessful. Computer research is continuing on a more detailed and controlled basis.

Figure 3. A small petrified tree from the Specimen Creek area surrounded by coarse breccia.

It is difficult to understand why matching connot be seen with relative ease if the trees are *in situ.* If the trees have been brought together from diverse habitats and geographical areas by water transport, the lack of matching is more readily understood.

Small Erect Trees. Characteristically, neither bark nor limbs are preserved on the trees. Some of the large prostrate logs originally may have had limbs a foot or more in diameter but now only scoured knots are left. If subaerial volcanic mud slides were sufficiently strong to break off the limbs and strip away the bark from rooted trees, why were the very small trees not bent or broken? Small trees down to three centimeters in diameter are seen (Figure 3). The boulders incorporated in the surrounding breccia are sometimes much larger in diameter than are the trees against which they rest, yet of the hundreds of petrified trees examined over the years, only two have been seen with a greenstick fracture (Figure 4). If the trees were transported, that is, if they moved with the mud in which they are buried, they would not have been subjected to horizontal shear.

The Organic Levels

To this point in our discussion, we have been considering only the stumps found in the Yellowstone Petrified Forests. Associated with the erect stumps at root level are bands of organic matter consisting of leaves, needles and plant debris which have been interpreted as the forest floors on which the trees grew. However, in almost every specific detail, study of these levels indicates that they are atypical of true growth levels.

Three aspects of the organic levels have been used as evidence for the *in situ* interpretation of the trees: 1) the organic matter occurs at the root levels of the stumps; 2) the organic matter consists of leaves, needles and debris typical of material that falls from growing trees; and 3) the organic levels and the ash below them contain rootlets.

The location of the organic band at the level of the roots of the upright stumps is indeed similar to modern forests where organic litter is scattered on the forest floor, but the drift model can also account for this feature. Wood and plant fragments could settle out of a body of water along with the stumps to produce the observed association between the roots of standing stumps and organic matter.

The fact that the organic material looks like typical forest floor litter might be taken as support for the growth model. However, water that destroyed a pre-Flood forest and transported the plants and trees could also take with it the litter that had accumulated on the pre-Flood forest floor. This litter could then settle out of the water along with the stumps.

Modern forest soils are riddled with rootlets. Although small streaks of vegetable structure can be seen occasionally in the fossil organic levels or below them, our survey of hundreds of cross sections of levels confirms our statement that rootlets are rare. Since they are so uncommon and could easily be the result of the fortuitous vertical arrangement of small plant fragments that became mixed into the volcanic mud slides, this feature cannot be used as a strong argument for the growth model. Decay of most of the original rootlets cannot be defended because bits and pieces of well-preserved, very small, fragile plant fragments are found scattered in the ashy matrix of the breccia layers as well as in the organic zones.

Preservation. Only once have I seen fossil organic matter that appears like ancient humus. In the hundreds of other cases, leaves, needles and wood chips are obvious. In some instances, the preservation is phenomenal — so perfect that the plant struc-

Figure 4. A petrified tree from Tom Minor Basin near the northwest portion of the park that illustrates the only green-stick fracture so far discovered. Notice the complete absence of an organic level.

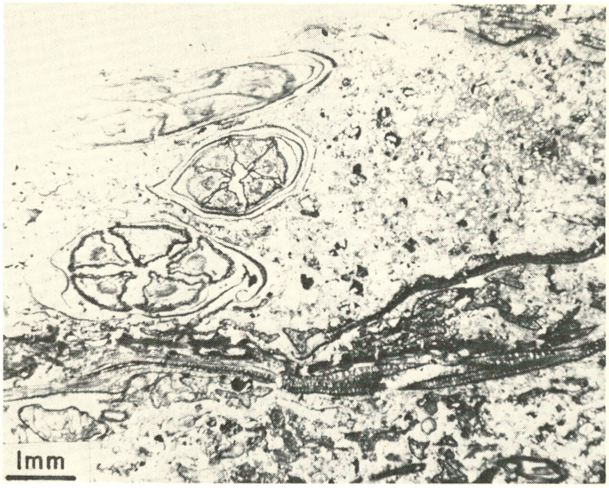

Figure 5. Beautiful preservation of buds and leaves from the Specimen Creek Petrified Forest.

tures in the thin sections look like fresh living tissue (Figure 5). Quick burial by volcanic lahars would provide the mechanism for good preservation of organic matter in either model. However, there is an aspect of preservation which seems difficult to explain by a growth model. In a living forest floor, decay increases downward into the ground. Recently fallen litter may be little decayed, but that which has fallen in successively more remote seasons shows progressively increasing decay until eventually only dark unidentifiable humus remains. The absence of differential decay is universal in the petrified forests of Yellowstone. It might be said that the volcanic lahars have mixed and disturbed the natural forest floor. However, if the organic matter was so consistently and thoroughly mixed by the volcanic mud slides, one would expect irregular thick lenses of organic matter. Instead, the organic bands are remarkably consistent horizontally. Reference to Figure 6 shows that although the bands have hiatuses and split and recombine, the thickness of the bands changes little.

Spatial Relationships. Fifty-nine organic levels on the slopes above Specimen Creek ranged in measured thickness from only a trace to 15 centimeters. The average is about three centimeters. Trees arising from within breccia beds and lacking *any* organic level at their base have been found in all of the petrified forest exposures I have seen.

It is possible to see mature living trees growing on rocky slopes almost devoid of humus. Usually, humus has not accumulated because of the steepness of the slope or because of the porous nature of the rocky terrain. The Yellowstone Petrified Forests are almost flat, and the ashy nature of the matrix in which the organic debris is located makes the use of such modern examples irrelevant.

The horizontal bedding in almost all the organic levels is striking. Of course, most needles, leaves and branches that fall from growing trees accumulate on the ground horizontally. However, ground-level shoots and the buried roots of growing herbs, shrubs and trees constitute an important fraction of vertically oriented material. This is seldom seen in the organic levels.

Sedimentary Features Typical of Water Deposition. One hundred and ten thin-section slides of organic horizons have been examined. The evidences of water action are striking. Table 1 tabulates 15 different features associated with water activity but not with gradual soil formation. Normal grading (from coarse to fine upward) is obvious for nearly half of the slides (Figure 7). In many instances, the grading starts several centimeters below the organic matter and con-

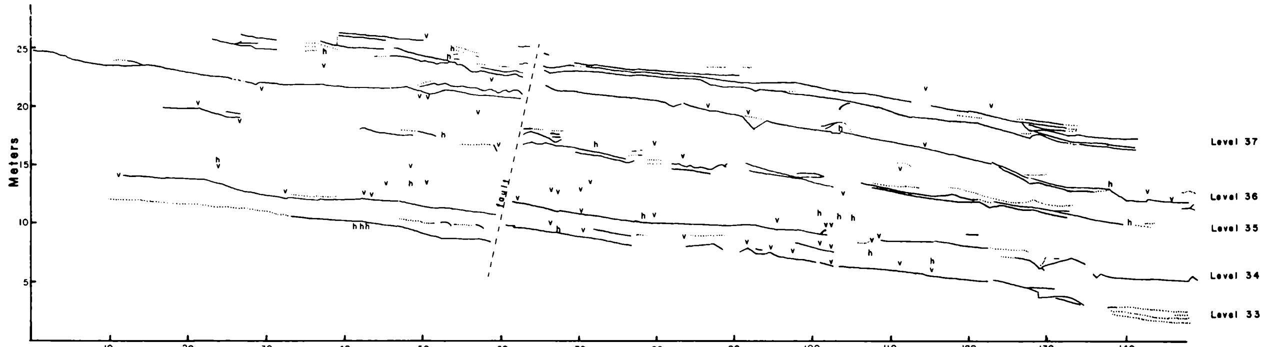

Figure 6. Survey of levels 33 to 37 on the Specimen Creek petrified forest. Each level is multiple and complex; v = vertical trees; h = horizontal trees.

TABLE I. Analysis of 120 Vertical Thin Sections of Organic Levels from Seven Yellowstone Petrified Forests

Features	Specimen Creek	Specimen Ridge	Fossil Forest	Mount Norris	Mount Hornaday	Cache Creek	Miller Creek	Totals
Total number of slides	85	2	3	11	11	3	5	120
Total number of levels	69	2	3	4	6	3	4	91
Grading of sediments (normal and reverse)	31		2	3	4	1	3	44
Other features of water deposition (ripples, loading, cross laminations)	16		1	2	3	1	2	25
Unweathered feldspar crystals	82	2	3	11	8	3	4	113
Grading of sediments between leaves	26		1	3			1	31
Sorting of organic matter	12		1	3		1	3	20
Atypical soil profile	60	1	2	9	9	3	2	86

tinues up into the vegetable matter where it terminates as fine ash. Reverse grading (fine to coarse upward) is seen occasionally. Thin beds of sediments (laminations) a fraction of a centimeter thick often make up the profile as seen in the slides. This is certainly atypical of true soils and requires water movements. Other sedimentary features typical of water deposition occasionally seen are cut-and-fill, loading and rippling.

There also is size sorting of organic material in some levels. Figure 8 shows a relationship between the size of the ash sediment and

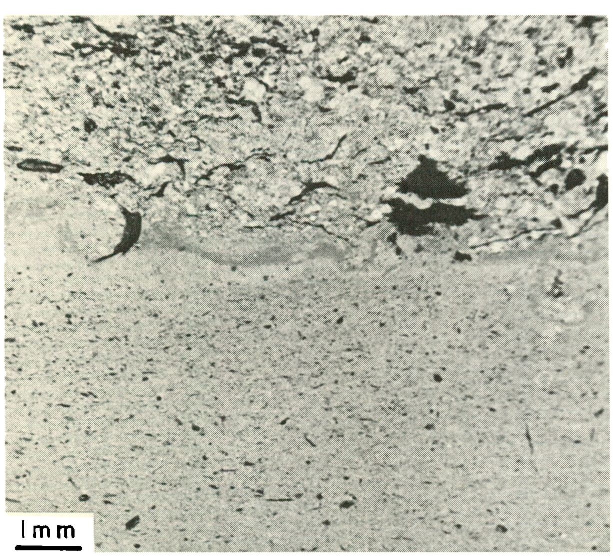

Figure 7. A vertical thin section of an organic level from Mt. Hornaday. Note the sorting of both organic and inorganic matter. The dark streaks and spots are vegetable matter.

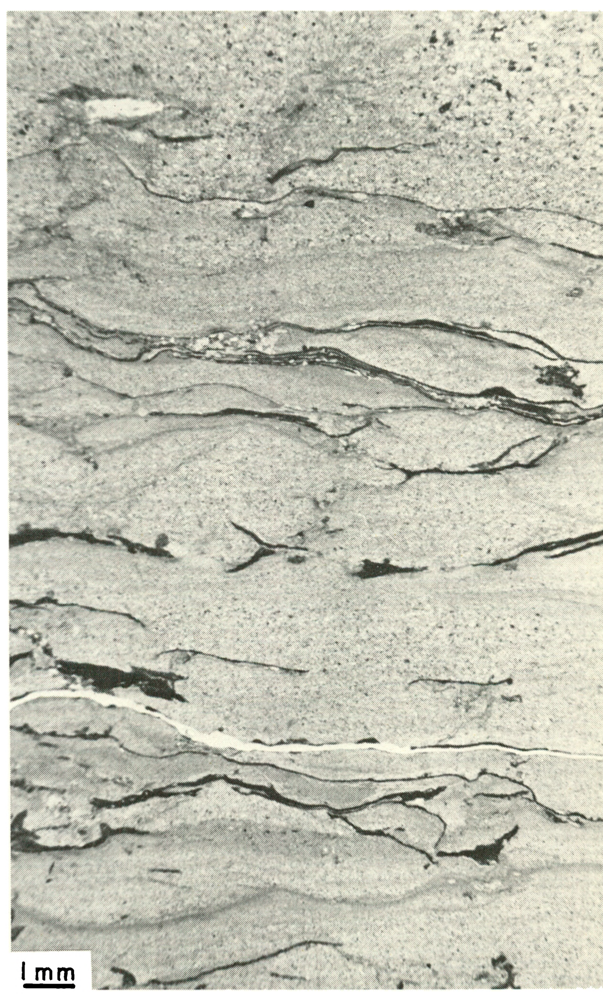

Figure 8. A vertical thin section of an organic level from Specimen Creek. Normal bedding of sediments exists between the dark lines which are cross-sections of the horizontally bedded deciduous leaves.

the size of the organic material — fine sediment, fine organic matter; coarse sediment, coarse organic matter. There is even size sorting of the inorganic particles *within* the organic matter. Figure 8 is characteristic of several levels that show sorting of inorganic matter between petrified leaves. To my knowledge, there is no way of achieving such a sedimentary feature in a normal forest floor. Only the simultaneous settling of ash and leaves from a fluid suspension could achieve this phenomenon.

Cross sections through true growth surfaces show a typical profile of organic density from top down. The profile is revealed by increased blackness or richness of humus toward the surface of the ground. Most of the Yellowstone organic levels have the organic matter mixed into the sediments with no prevailing order of density or with the greatest accumulation of organic matter at the bottom.

The complexity of the organic levels is particularly outstanding in the Specimen Creek and Cache Creek areas. Figure 6 illustrates five surveyed levels from Specimen Creek. Notice that the organic levels often are multiple, split and recombine, appear suddenly and end abruptly, and exhibit other odd characteristics. Modern multiple growing surfaces could result from flash floods in arid areas or from periodic burial by river mud spilling over banks during high water. However, the Yellowstone Petrified Forests do not represent these two types of environments. Erosion channels are infrequent in the Yellowstone exposures and no paleobotanist has suggested that this was an arid region.

Could the upper streaks of these multiple levels represent the leaf fall zones associated with air drop ash in volcanic eruptions? My field observations and thin section studies have failed to distinguish any significant difference between surfaces from which visible trees arise and adjacent organic levels containing no visible upright trees. If leaf drop zones are present, they are not readily apparent and cannot be distinguished from the other levels.

Taxonomic Characteristics. Taxonomic sorting of the constituents in the organic bands was noticed early in my research. Broad leaves occur at the top of the organic zone, mixed broad leaves and needles below, and only needles at the bottom. Leaves, needles, cones, limbs and bark fall as a well-mixed litter onto the floor of living forests. But in water, needles saturate and sink to the bottom before broad leaves. Thus, the taxonomic sorting of the organic levels appears more readily explained by water transport.

There is also a lack of taxonomic agreement between the fossils preserved in the organic levels and the dominant trees arising from the levels. One would expect to find many Sequoia needles and some cones since most of the upright trees are Sequoia. How-

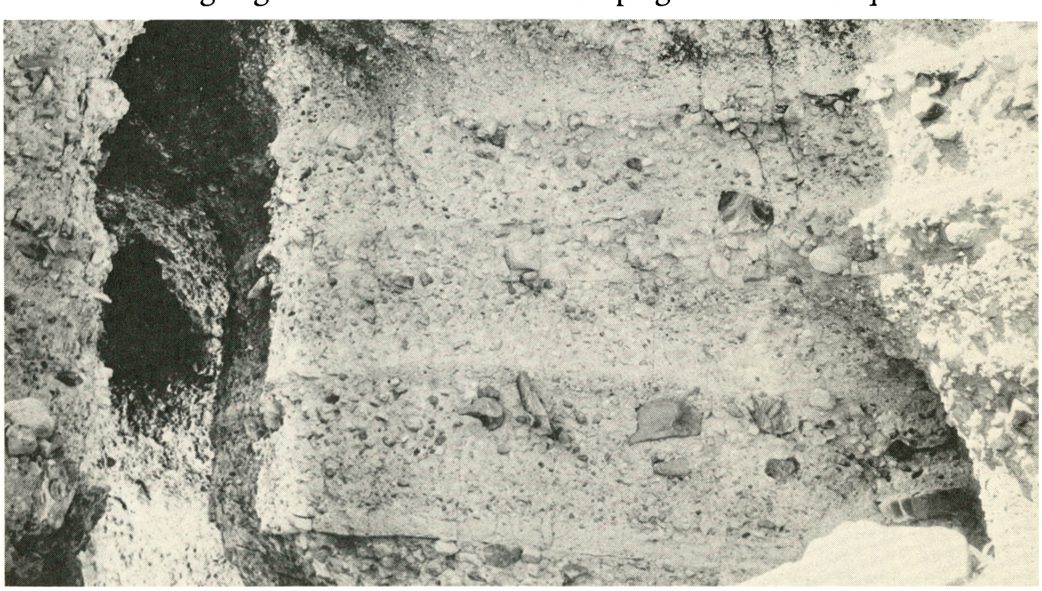

Figure 9. Successive beds of reversely graded breccia seen on Mt. Hornaday.

ever, large numbers of broad leaves and only a few pine needles are seen in the organic levels and cones of any type are rare.

Fisk's (1976) palynological study found little pollen of sycamore that is well represented by fossil leaves. Wind-transported pollen such as sycamore should have left a rich pollen record in the forest floor. In another palynological study, De Bord (1977) studied four levels intensively. He found no positive correlation between fossil pollen abundance and the proximity of possible source trees. Pine pollen, for example, was underrepresented in three of the four levels analyzed. Sufficient difference existed between individual samples on the same level that single sample analysis could not be used to adequately describe the level.

Chemistry and Mineralogy. Minerals such as feldspar weather into clay under attack of the carbonic acid that percolates into the ground as rain falls on a humus-mantled surface. Thus, the presence of clay would argue for time and a normal soil development. Over 300 samples from the Specimen Creek area have been subjected to X-ray diffraction and infrared analyses. Samples from other areas have also been tested. No clay has been detected except for relatively infrequent bands that show little relationship to the organic levels. The tentative conclusions from this study appear to rule out the passage of time that would result in mineral weathering and true soil formation. Spark source mass spectrometry research appears to corroborate the above data that suggest the rapid laying down of the breccia beds.

X-ray diffraction study has also shown that the mineral content of the sediments through hundreds of vertical feet appears identical. Would successive eruptions over a period of tens of thousands of years continue to lay down ash with identical suites of minerals? This question is being pursued by comparative studies with other volcanic areas whose major volcanic episodes with many pulses within each episode better explain the Yellowstone breccia beds, especially those of Specimen Creek.

Considered as a whole, the characteristics of the organic levels constitute a strong denial of the view that they are true soils or growth surfaces (Table II).

TABLE II. Summary Comparison Between a Living Forest and the Yellowstone Petrified Forests

As Expected in a Living Forest	As Actually Seen in Yellowstone
1. All roots intact	1. Some roots abruptly terminating or broken
2. Smaller trees torn out or pushed over by breccia slides	2. Small trees upright and unbroken
3. Buried upright snags in various stages of decay	3. Upright trees showing no difference in decay above or below ground level
4. Ring patterns of trees should cross-match	4. Ring patterns of trees do not cross-match
5. Upright and prone trees without similar orientation	5. Upright and prone trees with similar orientation
As Expected in a Normal Forest Floor	**As Actually Seen in Yellowstone**
1. A thick humus layer, especially if the trees are large	1. Organic level usually thin and sometimes absent
2. Increased decay of humus from top down	2. Good preservation all through the level
3. A normal soil profile — organic matter increasing toward top	3. No trend in the arrangement of organic matter of profile reversed
4. Kinds of organic matter unsorted	4. Kinds of organic matter often sorted
5. One main layer of humus for each living forest	5. Multiple and complex layers that split and recombine
6. Some evidences and remains of animals expected on or in soil	6. Absolutely no evidences or remains of animals found in organic levels
7. Leaves and needles on forest floor will agree with the trees	7. Leaves and needles often do not agree with dominant or adjacent trees
8. Pollen will agree with the trees and be present in great abundance	8. Pollen may not agree with trees or represented disproportionately
9. Clay produced as a result of weathering over time	9. Clay absent
10. Cones of the dominant conifer present on the forest floor	10. Sequoia cones absent

The Sediments

The volcanic breccias of the Yellowstone area have been difficult to interpret. Most volcanologists who have studied the area believe that they are mud slides or lahars that spread out along the bases of volcanoes (Parsons, 1969). However, many problems are associated with this view.

The material is extremely variable, ranging all the way from agglomerate (large, rounded boulders) to breccia (angular rocks of variable size). Some beds are extremely coarse with little matrix, whereas others are mostly ash with a free-floating framework of pebbles. Green to light gray beds of ash may be interspersed between breccia beds. These usually cannot be traced far horizontally. The beds of breccia range in thickness from 30 centimeters or less to ten meters thick. Most are from one to three meters thick. The discontinuous nature of the breccia beds and the rapid changes of sediment type would seem to require many local eruptive centers or source areas but these eruptive centers are hard to find.

The relatively low dip of the strata and the flow characteristics of breccia pose a problem. Most of the beds are so flat (less than 5° dip), that it is difficult to see how they could represent mud slides over dry land. Some lubricant such as water seems to be needed to facilitate the movement of these slides over slopes of such low gradient.

One feature of the Yellowstone volcanic breccias that has previously gone largely unreported is the reverse bedding (Figure 9). Upward grading from fine to coarse (instead of from coarse to fine) is not common in the geological record (Fisk, 1974). Fisher (1971) gives both subaerial and submarine examples, but the latter are most like those of Yellowstone. Walker (1975) would classify deposits of this type as turbidites — underwater slides of water-saturated sediments of greater density than the surrounding water. Although turbidites composed of such coarse materials as volcanic breccia are difficult to reproduce in laboratory experimentation, the presence of reverse grading may indicate that the beds were emplaced under water.

If these sediments were deposited under water, one would expect to find some evidences of water-dwelling animals. However, fossil remains of any animals are unknown. The absence of animal remains is difficult to explain with either "ingrowth" or "transport" models.

The Vertical Flotation of Trees

Under normal conditions, an upright tree is located where it grew. Therefore, it is only natural that the Petrified Forests of Yellowstone have been interpreted as trees in position of growth. No challenge of this interpretation can succeed unless some other satisfactory explanation for the vertical stance can be found.

Could water have transported the Yellowstone petrified stumps and deposited some of them upright in their present locations? Experiments I have conducted, evidence cited in the literature and observations in nature, lead me to conclude that trees as well as other plant parts such as horsetail stems will float vertically if given sufficient time and water.

To test the feasibility of upright flotation, I placed 12 small white fir stumps with roots in fresh and salt water. The stumps were two to seven centimeters in diameter and three to 15 centimeters long. After from three to more than 21 days, *all* of the trees assumed a vertical position suspended from the surface of the water. Then, after a few hours to several days, the vertically floating trees slowly settled onto the bottom of the tanks *still erect.* Because the density of the trees was so near that of the water, they often would appear to be suspended in the middle of the water, but closer observation revealed a rootlet touching the bottom. This experiment duplicates some of the results achieved by Henry Fayal's flotation experiments conducted in the late nineteenth century and published in an 1886 monograph.

At one Yellowstone location, short sections of *Equisetum* (horsetail) not over four inches tall were found in the organic level. *Equisetum* is rare in the Yellowstone fossil forests but near Clarno, Ore., great numbers of vertical petrified horsetails, level above level, can be seen in sediments similar to those in Yellowstone. Horsetails are like large hollow straws and do not seem to be good candidates for vertical flotation. Therefore, an experiment on the flotation of horsetails in salt and fresh water was undertaken (Coffin, 1971, p. 2019). Surprisingly, nearly two-thirds (63 percent of 140 sections of *Equisetum)* ultimately floated vertically or stood erect on the tank bottom. In this experiment, vertical orientation occurred after three to 20 days depending upon the length and size of the horsetail stems and whether the stems were fresh or dead.

Reports of the vertical flotation of trees and plants can be found in the literature. In a reference work on coal, Francis (1961, p. 28) reports, ". . . it is natural for short stems attached to the heavy roots of trees to float upright, with the roots downward, when transported by deep water, particularly if the roots enclose a ball of clay or gravel." The volume on paleoecology by Ager (1963, p. 85) makes the following comment: "E. D. McKee (personal communication, 1963), has told of palm trees being swept from a Pacific atoll during hurricanes and coming to rest in considerable depths of water in an upright position because of their heavy, stone-laden roots, so that even trees in position of life may not be completely beyond question."

"In spite of many unanswered questions, I am convinced the transport hypothesis merits serious consideration because it seems to account for more of the available facts than the *in situ* hypothesis."

While sailing along the coast of New Guinea, the famous Challenger expedition encountered long lines of drift brought down by flooding rivers. "Much of the wood was floating suspended vertically in the water, and most curiously, logs and short branch pieces thus floating often occurred in separate groups apart from the horizontal floating timbers. The sunken ends of the wood were not weighted by an attached mass of soil or other load of any kind; possibly the water penetrates certain kinds of wood more easily in one direction with regard to its growth than the other, hence one end becomes water logged before the other" (Challenger, 1885, p. 459).

In his classic monograph on the formation of coal beds, John Stevenson (1911-1913) discussed the upright flotation of trees. Although it was his opinion that the majority of coal beds were *in situ,* he hesitated to use the upright position of the petrified trees in these beds as an argument in support of his view.

Vertical flotation can also be observed today in nature. I have observed stumps of trees sitting upright along beaches and shores where high tides have left them. Along the shores of Lake Powell, Ariz., when spring water was higher than usual, I have seen many twigs, rootlets and stems floating vertically. I have observed the same phenomenon in quiet waters among the Florida Keys.

Actually, the chances that trees will float upright in water are very good. The root system gathers water to maintain the life of the tree. It is only natural that in water the lower portion of the trunk with its roots will absorb moisture faster than the other parts. The result can be vertical flotation — given enough time and water.

If the Yellowstone Petrified Forests were transported by water to their present locations these two requirements — sufficient time and water — must be considered. What kind of model can we develop that meets these requirements and fits better the facts obtained from the study of the Yellowstone Petrified Forest than the *in situ* model?

An Alternative Hypothesis

At present, I propose the following model as best accounting for all the data gathered. Volcanic activity in the Yellowstone region occurred while the area was at least partly under water. Trees, some vertical, floated in the water along with organic debris. As trees and vegetable matter became water saturated, they settled down onto the breccia at the bottom. Within a relatively short time (days or weeks), another slide moved over and around the trees and organic debris. Before the appearance of each succeeding breccia flow, more trees and organic matter settled to the bottom. Thus, layer upon layer of trees and organic zones were built up in a relatively short period of time (See Figures 10 and 11).

After the burial of the trees and organic debris, the water receded and/or the land was uplifted. Petrification occurred quickly before decay became pronounced. As the water drained, erosion on a large scale sculptured the landscape and exposed the petrified trees. In the course of time, glaciation also left its mark on this mountainous region.

Such an origin of the petrified forests not only accounts for the upright stance of many of the stumps, but also explains why they are without bark and limbs. It not only accounts for the organic levels at the position of the tree roots, but also explains the thinness and complexity of many levels and the occasional occurrence of stumps lacking any organic horizon at root level. The lack of agreement of ring plots between adjacent stumps and the disagreement between the components of the organic zones and the types of upright trees becomes understandable. Obviously, the evidences of water deposition, both the large-scale features such as the reversely graded beds and the small-scale features such as the microgradation between leaves in the organic levels, would be expected.

The best explanation is the simplest one that accommodates the known data. The growth position model is a simple explanation familiar to everyone, but the data reported here raise serious doubts concerning the adequacy of this model. In spite of many unanswered questions, I am convinced the transport hypothesis merits serious consideration because it seems to account for more of the available facts than the *in situ* hypothesis.

I wish to acknowledge the research done by Ivan Holmes (X-ray diffraction and infrared analyses of sediments), Lanny Fisk and Phil DeBord (palynology of organic levels) and Don Jones (complexity of organic levels—Figure 6) reported in this paper. A more quantitative and detailed report of this research on the Yellowstone Petrified Forests (from which this report has been condensed) is available from the author, Geoscience Research Inst., 600 College Ave., Berrien Springs, Michigan 49103.

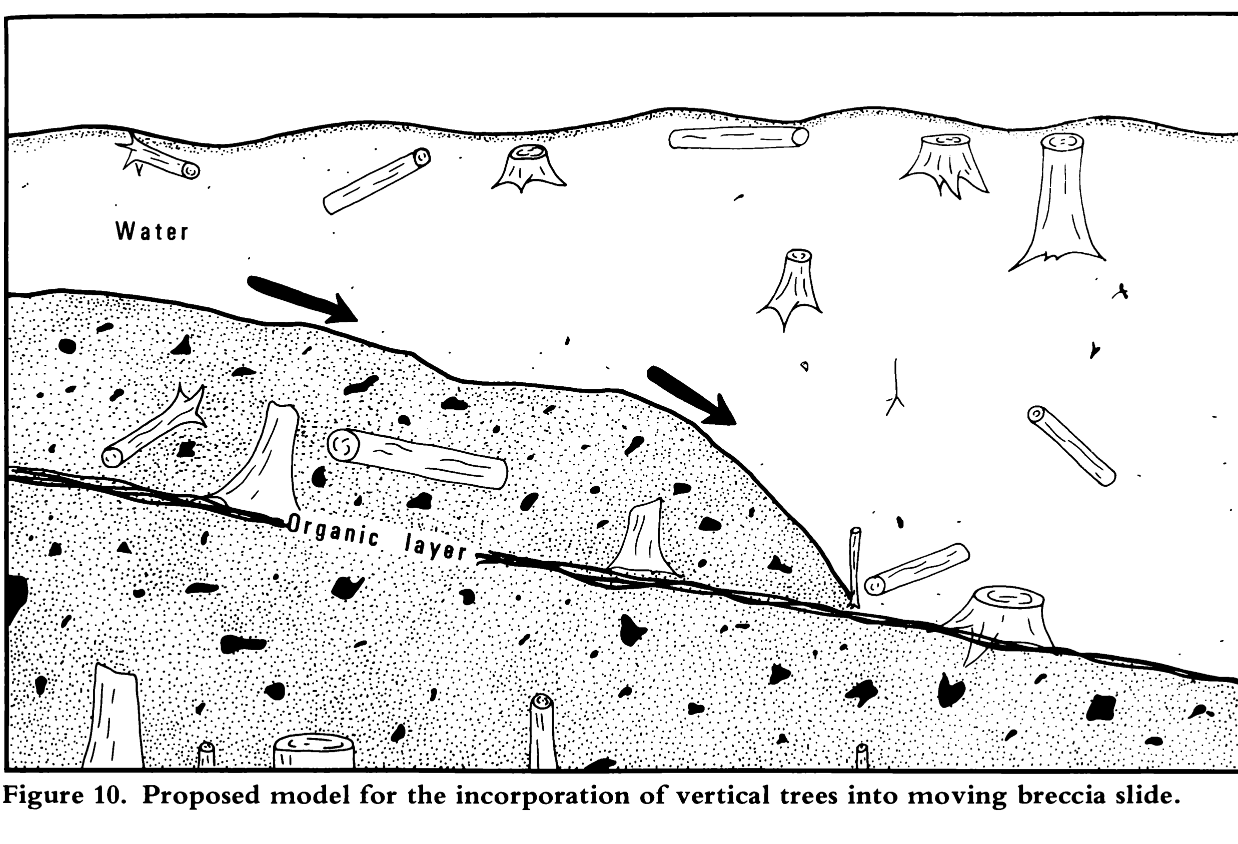

Figure 10. Proposed model for the incorporation of vertical trees into moving breccia slide.

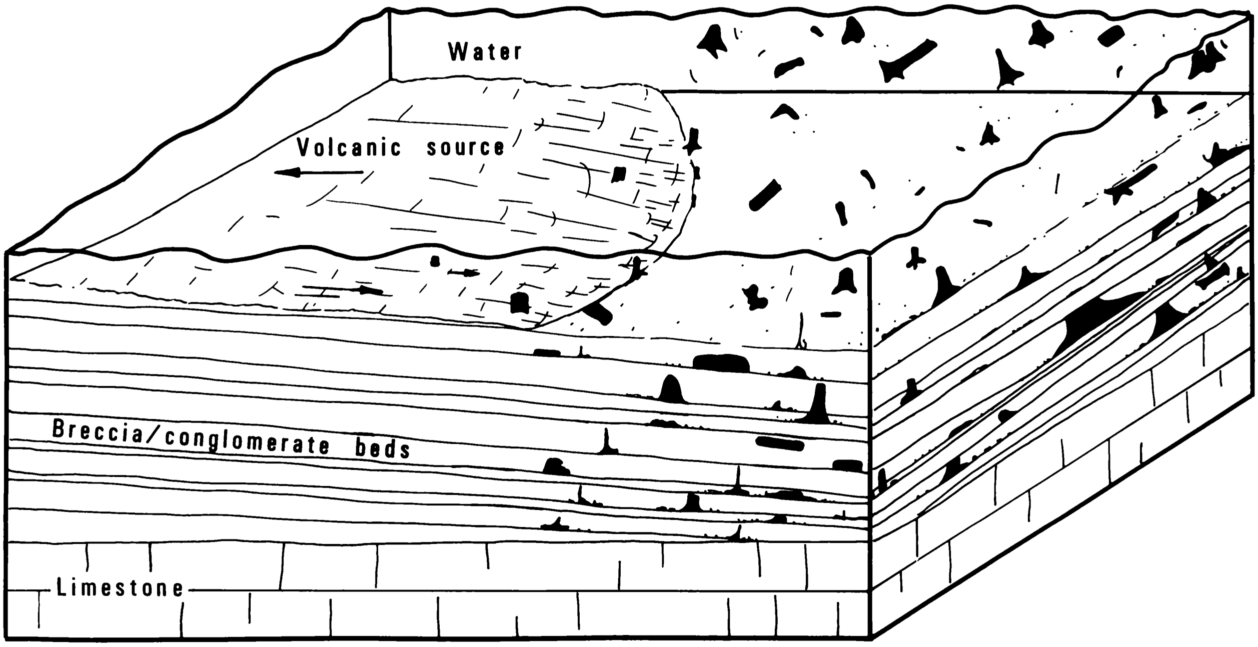

Figure 11. Block diagram illustrating the accumulation of successive beds of breccia with trees and plant debris.

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