Preliminary Studies of Opaline Phytoliths From Selected Oklahoma Soils

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INTRODUCTION

A study was conducted to observe characteristics and determine quantities of opaline phytoliths in Oklahoma soils on which kinds of vegetation varied as a soil-forming factor.

Opaline phytoliths are composed of amorphous silica, $SiO_2 \cdot nH_2O$, (Parry and Smithson, 1958) which accumulates in soils after the decay of cells of plants and plant parts where the opaline phytoliths form. Although opaline phytoliths (also referred to as plant opal, grass opal, opaline silica, and biogenetic opal) are found in most plants, they are more abundant in grasses. Opaline shapes depend somewhat on the plant species in which they form. Within a species, shapes may vary with the plant part (Parry and Smithson, 1966). The variation between plants allows some analysis of vegetative history and soil formation. Jones and Beavers (1963) noted the presence of occluded carbon in opaline phytoliths thereby making C^{14} studies feasible as an indicator of chronological soil age. Wiling (1967) made some initial C^{14} determinations using opaline. Wilding et al. (1967) further determined what types of opaline contained the largest carbon content and studied methods of extraction in order to obtain some reliable results from C^{14} dating.

Opaline has been correlated with soil drainage and soil age (Jones and Beavers, 1964), rate of loess deposition (Beavers and Stephen, 1957), and the stability of grassland-forest boundaries (Witty and Knox, 1964). Since the presence of plant opal is a permanent record of past vegetation, it is valuable as a tool of soil genesis.

Methods and Materials

Plants—Plant opal was determined separately from leaves and roots of big bluestem (*Andropogon gerardi*), little bluestem (*A. scoparius*), Indian-grass (*Sorghastrum nutans*), buffalograss (*Buchloe dactyloides*), post oak (*Quercus stellata*), and blackjack oak (*Q. marilandica*). Plants were dried at 75 C. Opaline determinations were made by a wet-ashing method modified from the method of Gieseking et al. (1935).

Samples were quantitatively collected in weighed crucibles fitted with fine-porosity, fritted-glass disks. The residue from the fritted glass was transferred to a vial. Samples were then mounted on glass slides with Cadex and observed under a polarizing microscope.

Soils—The "A" horizons of three Payne County soils were studied for variance in amounts and types of opaline phytoliths. Site 1 was a Zaneis loam, a Udic Argiudoll located 1950' W and 132' S of the NE corner of Sec. 10, T19N, R2E. The native vegetation was that of a tall-grass prairie comprised primarily of big bluestem (*Andropogon gerardi*) and little bluestem (*A. scoparius*) along with various forbs. Site 2 was a Kirkland loam, an Abruptic Paleustoll, located 2130' W and 495' S of the NE corner of Sec. 10, T19N, R2E. The vegetation present consisted of short-grass prairie species dominated by buffalograss (*Buchloe dactyloides*). Site 3 was a Dougherty soil,[1] an Arenic Haplustalf, located 897' E and 212' S of the center of Sec. 36, T18N, R2E. The vegetation is predominantly oak forest. Post oak (*Quercus stellata*) is the dominant species. Various other oaks and understory make up the remainder of the vegetation. Very few grasses are present on the forest floor.

Analyses—Soils were air dried and fractionated according to the method of Kilmer and Alexander (1959), and siphoned at 30 cm in a constant temperature room.

Opaline phytoliths were separated from 2-5μ, 5-20μ, and 20-50μ soil fractions by the method of Jones and Beavers (1964). The samples were centrifuged in a specific gravity liquid of 2.3 (composed of 1,1,2,2-tetrabromoethane and nitrobenzene). The 2.3 value was the maximum specific gravity of opaline found by Jones and Beavers (1963). The surface of the centrifuged sample was poured off from the lower portion which was frozen in acetone cooled with dry ice (Jones and Beavers, 1964). Samples were collected on #3 Whatman filter paper, washed with acetone, transferred to aluminum weighing pans, and dried at 105 C. After drying, opaline grains were mounted on slides in Cadex and observed under a polarizing microscope.

Results

The percent opaline in the vegetative parts sampled is shown in Table . In both aerial and subterranean portions, the opaline residue from grasses is considerably higher than the residue from trees.

[1] The sample area is mapped as Dougherty fine sand loam, 1-3% slopes in the Detailed Soil Survey, Perkins Farm, Perkins, Okla., Feb. 1959.

The percent of opaline for two size fractions from the three soils sampled and the variation with fraction are shown in Table II.

Jones and Beavers (1964) reported that in Illinois, the 20-50μ soil fraction contained approximately as much opaline as the 5-20μ fraction. Our determinations show that in the sampled soils, much more opaline is present in the 5-20μ fraction than in the 20-50μ fraction. Results are erratic for separation of opaline from the 2-5μ fraction, where opaline ranged from .019-.001%. These levels are, however, small compared to most of the 20-50 μ size. This fraction is difficult to study due to its small size, but it should be considered at least quantitatively in order to account for the majority of opaline present in the soil.

The Zaneis shows a high opaline content; however, it is only slightly higher than the Dougherty, a forest soil. The Kirkland, a short-grass prairie soil, was quite high in opaline. The presence of opaline in forest soils in amounts approaching that in the prairie soils is interesting and was unexpected. Perhaps a study of all the soil horizons would give slightly different results. It is also possible that the forest soil was once under prairie vegetation.

TABLE I. OPALINE PERCENT IN VEGETATIVE PARTS

Plant	% Opaline	
	Tops	Roots
Big Bluestem	2.22	2.79
Little Bluestem	5.71	3.80
Indiangrass	3.96	3.64
Buffalograss	6.27	5.54
Post Oak	1.20	0.60
Blackjack	0.34	0.58

TABLE II. PERCENT OPALINE IN SELECTED SOIL HORIZONS

Soil and Horizon	% Opaline	
	5-20μ	20-50μ
Dougherty, A_1	0.19	0.07
Dougherty, A_2	0.11	0.06
Zaneis, A_1	0.43	0.02
Kirkland, A_1	0.32	0.15

Microscopic observations—Only broad separations of phytolith characteristics are possible from the observations made up to this point. Grassland soils appear to contain conspicuously larger numbers of dumbbell-shaped phytoliths (Fig. 1A) than the forest soils. Dumbbell shapes are by far the most common shape in grass residues (Fig. 1B). They are much more common here than in forest soils.

Forest soils appear to contain some phytoliths that are more fibrous than those obtained from prairie soils. Grass and tree root residues also

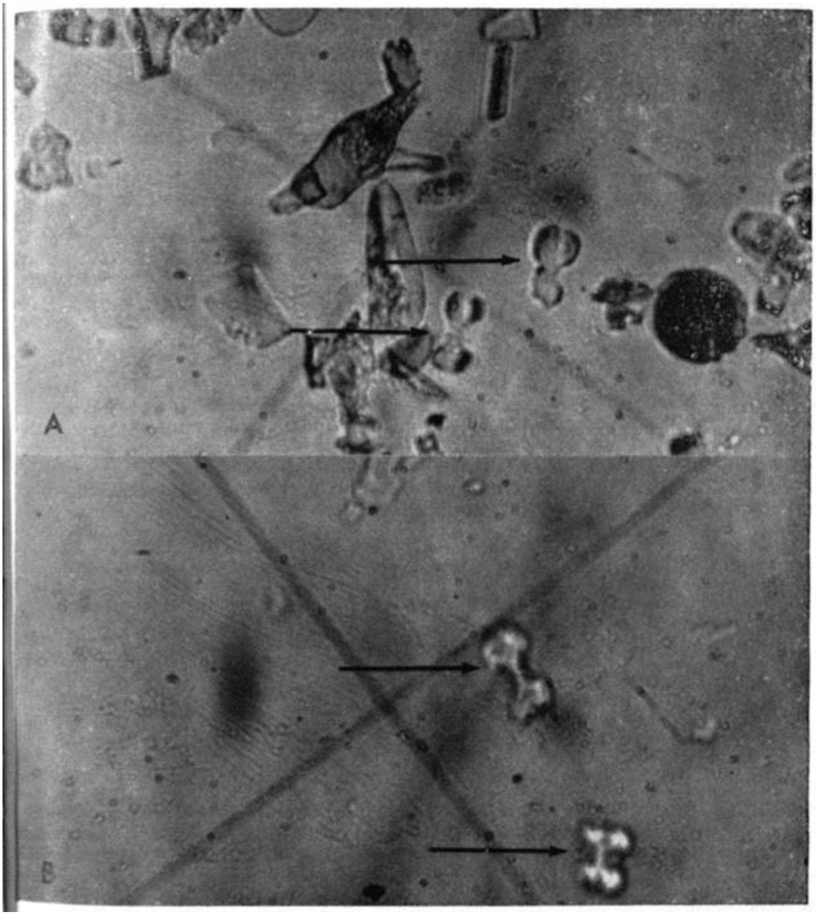

Figure 1. Plant and soil opaline phytoliths. A, Dumbbell-shaped opaline phytoliths from the A_1 horizon of Zaneis soil; B, Dumbbell-shaped opaline phytoliths from Indiangrass leaves.

seem to show a relationship to their related soils. Grass roots have common phytoliths which appear as cells with a nucleus while tree roots commonly have clear, fracturable phytoliths similar to a piece of flint.

The significance of the contribution of phytoliths from roots to total accumulated phytoliths in soils has thus far received little attention. This fact, however, should be considered in order to properly interpret opaline data.

Conclusions

1. Opaline phytoliths present in Oklahoma soils are similar, in most physical properties, to those reported by previous workers in other states. Opaline is most abundant in the 5-20μ fraction of Oklahoma soil studied. The opaline content of the 5-20μ and 20-50μ soil fractions was approximately equal in other states. Thus, opaline must be studied in varying-

size fractions, requiring separate characterization in each soil studied.

2. Broad interpretation concerning native vegetation appears possible from soil phytolith studies. A more intensified study is needed to supply this information.

3. Opaline phytoliths serve as a permanent record of the past vegetation and associated climatic conditions under which soils were formed. This information is of theoretical interest and may be of practical significance by providing a basis for the clearing of trees in order to establish grasses.

4. The use of C^{14} on opaline phytoliths provides a technique of measuring time as a factor of soil formation.

Literature Cited

Beavers, A. H. and I. Stephen. 1957. Some features of the distribution of plant-opal in Illinois soils. Soil Sci. 86:1-5.

Gieseking, J. E., H. J. Snider, and C. A. Getz. 1935. Destruction of organic matter in plant material by use of nitric and perchloric acids. Ind. Eng. Chem. (Anal. Ed.) 7:185-186.

Jones, R. L. and A. H. Beavers. 1963. Some mineralogical and chemical properties of plant opal. Soil Sci. 96:375-379.

———————. 1964. Aspects of catenary and depth distribution of opal phytoliths in Illinois soils. Soil Sci. Soc. Amer. Proc. 28:413-416.

Kilmer, V. J. and L. T. Alaxander. 1949. Methods of making mechanical analysis of soils. Soil Sci. 68:15-24.

Parry, D. W. and F. Smithson. 1958. Techniques for studying opaline silica in grass leaves. Ann. Bot. 22:543-549.

———————. 1966. Opaline silica in the inflorescences of some British grasses and cereals. Ann. Bot. 30:525-538.

Wilding, L. P. 1967. Radiocarbon dating of biogenetic opal. Science 156:66-67.

———————, Robert E. Brown and N. Holowaychuk. 1967. Accessibility and properties of occluded carbon in biogenetic opal. Soil Sci. 103 (1):56-61.

Witty, John E. and Ellis G. Knox. 1964. Grass opal in some chestnut and forested soils in North Central Oregon. Soil Sci. Soc. Amer. Proc. 28:685-687.