AAAS-Newcomb Cleveland Prize
To Be Awarded for a Report Published in *Science*

The AAAS-Newcomb Cleveland Prize, which previously honored research papers presented at AAAS annual meetings, is now awarded annually to the author of an outstanding paper published from September through August in the Reports section of *Science*. The second competition year under the new rules starts with the 2 September 1977 issue of *Science* and ends with that of 25 August 1978. The value of the prize is $5000; the winner also receives a bronze medal.

To be eligible, a paper must be a first-time publication of the author's own research. Reference to pertinent earlier work by the author may be included to give perspective.

Throughout the year, readers are invited to nominate papers appearing in the Reports section. Nominations must be typed, and the following information provided: the title of the paper, issue in which it was published, author's name, and a brief statement of justification for nomination. Nominations should be submitted to AAAS-Newcomb Cleveland Prize, AAAS, 1515 Massachusetts Avenue, NW, Washington, D.C. 20005. Final selection will rest with a panel of distinguished scientists appointed by the Board of Directors.

The award will be presented at a session of the annual meeting at which the winner will be invited to present a paper reviewing the field related to the prizewinning research. The review paper will subsequently be published in *Science*. In cases of multiple authorship, the prize will be divided equally between or among the authors; the senior author will be invited to speak at the annual meeting.

Reports

Direct Evidence of Particle Migration in the Soil Solution of a Podzol

Abstract. *Particles were isolated from soil leachates from the genetic horizons of a subalpine Podzol from the central Cascades, Washington. Organic particles containing traces of aluminum, iron, silicon, and sulfur were predominant in the migrant material through the upper horizons (horizons A + B); their movement was arrested in the B2hir horizon. Below B2hir and at depth, phyllosilicates, quartz, and silicate minerals were the predominant suspended materials. Elements of the podzolic mechanism and the duality of the B2hir horizon are shown.*

A very important process in soil development is the migration of ions, radicals, molecules, and particulate matter through the soil material. The stream of solutes and suspended material passing through the soil reacts with varying intensity at different levels within the soil column. With the passage of sufficient time, the original substratum is altered into genetic soil horizons. These horizons represent loci of chemical reactivity as well as specific zones characterized by the addition or removal of components such as Fe, Al, organic material, clay, and soluble salts, among others. The soil under consideration is a Podzol (*1*), a soil that dramatically shows horizon differentiations (Table 1). The upper mineral horizon, A2, is strongly leached, extremely acid, and whitish in color; this is the eluvial horizon. Below A2, the B2hir (the illuvial horizon) displays a dark brown color and an accumulation of organic material and amorphous Fe and Al transported from A2. Transportational processes are very important in soil development, and water is the essential transport vehicle. The composition of the soil solution (*2*) is extremely important in disclosing the processes occurring within soil; studying the soil solution should be the most direct way to investigate present soil processes.

Tension lysimeters, 700-cm^2 ceramic disks, were used to extract soil solutions. These were installed below each of the following genetic horizons of the Podzol: O2, A2, IIB2hir, and within IVB32 (*1*). A 0.1-bar tension applied to the lysimeters through a vacuum system (*3*) made it possible to withdraw soil solutions held below this tension. Solutions were collected biweekly during the summer and approximately monthly in the winter.

The study area is located in the Findley Basin in the central Cascades, Washington, at an elevation of 1200 m. Findley Lake Basin is a small, north-facing cirque (129 ha) that was cut into andesitic bedrock by an alpine glacier 15,000 to 20,000 years before the present (B.P.) (*4*). The parent material from which the soil is forming consists of fractured andesitic rocks mantled by tephra. The tephra belongs to three ash deposits: Mazama, 6600 years B.P. (*5, 6*); Mount St. Helens-Y, 4000 years B.P.; and Mount St. Helens-W, 400 years B.P (*6, 7*). The mean annual temperature at nearby Snoqualmie Pass (920 m) is 5.4°C, and the annual precipitation is 273 cm, 80 percent of which is in solid form (*8*). Findley Lake is in the *Abies amabilis* (Pacific silver fir) zone (*9*), and the vegetation at the study site consists of *A. amabilis* in association with *Tsuga mertensiana* (Bong.) Carr. (mountain hemlock) (*10*). Temperatures recorded over a 3-year period show that the soil remains above 0°C. We analyzed soil solutions together with precipitation, throughfall, and lake inlet and outlet water for *p*H, electrical conductivity, major cations (Ca^{2+}, Mg^{2+}, Na$^+$, and K$^+$), total N, total P, and total organic C (TOC). Silica, Al, and Fe were determined in the solution after passage through a 0.45-μm Millipore filter.

Data collected over a 3-year period have shown the existence of two distinct compartments: one starting from the top of the canopy and ending at the lower boundary of IIB2hir and the second below this horizon. The ionic transport in the upper compartment, the biopedological compartment, is governed by the soluble organic materials that depress the pH value of the soil solution and thus the bicarbonate concentration (*11, 12*). The lower compartment, the geochemical one, experiences higher pH, and bicarbonate dominates the leaching of ions (*12*). Mobile fulvic acids were detected in the biopedological compartment with a 60 to 70 percent reduction occurring across B2hir. Electrodialysis and adsorption studies indicate that mobile fulvic acids are present in colloidal or particulate form (*13*). To obtain direct evidence for the presence of these organic particles and their mobility in the soil profile, solutions collected below O2, A2, and IIB2hir and within IVB32 were passed through 0.1-μm Nuclepore filter until the filters were clogged. Portions of the filters were cut and mounted on Al studs, coated with Pd, and examined under a scanning electron microscope (Cambridge Mark IIA), equipped with Edax-energy dispersive x-ray detection for elemental analysis.

Figures 1 and 2 show the scanning electron micrographs. Figure 1, depicting the particulate matter collected below A2, is representative for this horizon and shows the predominance of organic particles over mineral ones. Most of the organic particles are oblong or ellipsoidal in shape; however, a few spherical particles were also seen. They range in size from about 0.5 to 1.5 μm. Magnification up to ×8850 shows no ordered features. The particle surfaces appear smooth, unbroken, and rounded. In addition to the organic particles, a fine organic film covered portions of the filter. Analysis before and after filtration indicated that the organic particles represent 5 to 10 per-

Table 1. Profile description of a Podzol soil, Findley Lake, Washington. Munsell soil color designations (Munsell Color Company, Inc., Baltimore, Maryland, 1954 edition) are given in parentheses.

Horizon	Depth (cm)	Description
O1	5.0 to 3.0	Partially decomposed conifer needles and broken twigs.
O2	3.0 to 0.0	Well-decomposed and humified organic material.
A2	0.0 to 11.0	Gray (N5/0) sandy clay loam, weakly structured, strongly leached with plentiful roots and extremely acid in reaction (pH 4.3). This horizon is developed from Mount St. Helens-W and Mount St. Helens-Y ash.
IIB2hir	11.0 to 31.0	Mostly dark yellowish brown (10YR4/4) but with reddish brown mixed with yellowish red, coarse sandy loam, weakly structured with a few firm to very firm aggregates; plentiful roots and very strongly acid (pH 4.7). The Roman numeral indicates a lithological discontinuity; that is, the material on which the horizon developed had different lithology from the horizon above it. In fact, this horizon is developed on Mazama ash.
IIIB31	31.0 to 53.0	90 percent dark yellowish brown (10YR4/4) very gravelly clay loam with moderate structure and a few firm aggregates. It contains more than 80 percent coarse fragments, a few roots, and is very strongly acid (pH 4.8). This horizon is made of fragments of andesitic rocks in a matrix of Mazama ash.
IVB32	53.0 to 100.0	> 90 percent coarse (> 5 cm in diameter) fragments mostly of broken andesite blocks; the rock fragments are coated with both organic and clayey material. Very strongly acid (pH 4.6).
IVC	> 100.0	Fragmented andesite; gravelly in the upper 5 cm, becoming bouldery below; the boulders are partially stained.

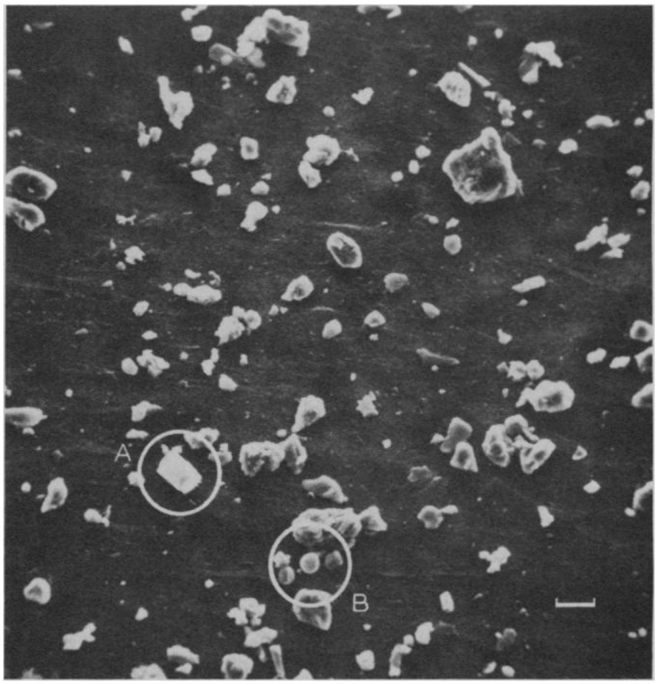

Fig. 1 (left). A scanning electron micrograph photograph of organic particles retained on a 0.1-μm Nuclepore filter from the soil solution collected below the A2 horizon of a Podzol soil from Findley Lake, Washington. Scale bar, 1 μm (× 5400). Fig. 2 (right). A scanning electron micrograph photograph of silicate particles retained on a 0.1-μm Nuclepore filter from the soil solution collected below the IIB2hir horizon of a Podzol soil from Findley Lake, Washington. Circle A points to a diatom; circle B, to a spherical siliceous particle. Scale bar, 10 μm (× 450).

cent of the TOC in the solutions. Edax spectra for these amorphous organic particles show minor amounts of Al, Fe, P, S, and Si. The presence of Al and Fe in the Edax spectra illustrates the active role of the organic components in transferring these metals through the soil.

To determine the effect of air-drying on the shape of the organic particles, freeze-dried filters from O2 and A2 were also examined. The freeze-dried, filtered material from O2 was much different from its air-dried equivalent. The freeze-dried organic material consists of filaments 5 to 12 μm long emanating from oblong bodies as compared to the distinct, smooth air-dried particles (Fig. 1). Both air- and freeze-dried organic particles from A2 appear to have the same shape and size.

Figure 2 shows particular material collected below IIB2hir. The difference between Figs. 1 and 2 is striking. Solutions percolating through O2 and A2 are mainly charged with mobile organic particles. In passing through IIB2hir, these organic bodies are arrested, and the solutions become charged almost exclusively with mineral particles. These mineral particles range in size from about 2.0 to 22 μm, with 8-μm particles predominating. Edax spectra for a number of the inorganic particles show a prevalence of silicate minerals containing Si, Al, and minor quantities of Fe, Ca, and K. The high Fe content of other particles indicates the presence of pyroxene or amphibole minerals. X-ray analysis of the Nuclepore filter retaining the inorganic particles reveals diffraction lines for chlorite, feldspars, and quartz. Chlorite, however, is the dominant mineral, and it is thought to be of pedogenic origin, the same as detected in IIIB31 (*14*). Solutions collected within the IVB32 have the same silicate load and the same elemental composition as those below IIB2hir. Clay minerals for the horizon below IIB2hir show the predominance of pedogenic chlorite and vermiculite. Figure 2 suggests the illuvial origin of at least a portion of these phyllosilicates.

This study indicates that the suspended material in the soil solution reflects the same trend as the solution itself. The reduction in the TOC and the 60 to 70 percent reduction of the fulvic acids as the solution passes through IIB2hir are verified by the presence of organic particles in Fig. 1 and their absence in Fig. 2.

This study provides direct evidence for the mechanism of podzolization. It shows that mineral particles, mostly phyllosilicates and feldspars from 2 to 22 μm, are mobilized in IIB2hir and transported at depth. The B2hir horizon of this Podzol is primarily an illuvial horizon for the suspended organics and complexed metals and an eluvial horizon for the silicates. The scanning electron micrograph and Edax proved to be excellent tools for studying suspended particles in the soil solution and for clarifying one of the theories of soil-forming processes.

F. C. UGOLINI
H. DAWSON
J. ZACHARA
College of Forest Resources, University of Washington, Seattle 98195

References and Notes

1. We prefer to call this soil a Podzol rather than the current term Spodosol because, in spite of having the morphology and chemistry of a Spodosol, it fails to meet the strict criteria of soil taxonomy of a Spodosol (Handbook No. 436, U.S. Department of Agriculture, Washington, D.C., 1975). Similar soils are called Ferro-Humic Podzols in the Canadian soil classification system. Because the original field description for the Podzol profile makes use of specific terminology, an abridged and less technical version is given in Table 1.
2. The term "soil solution" traditionally represents the liquid phase in the soil. We use "soil solution" here to mean both solute and suspended components; in actuality, the soil solution is a suspension.
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15. References to trade names of material and equipment used in this study do not constitute endorsement. Supported by NSF grant GB36810X to the Coniferous Forest Biome (Contribution No. 272), Ecosystem Analysis Studies, U.S.-International Biological Program. We thank Mrs. K. Trafton for assistance in the laboratory and Dr. J. A. Kittrick for suggesting that we freeze-dry the filters.

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Interstitial Nitrate Profiles and Oxidation of Sedimentary Organic Matter in the Eastern Equatorial Atlantic

Abstract. *Pore-water nitrate concentrations in six pelagic eastern equatorial Atlantic cores increase from bottom water values (22 micromolar) to 40 micromolar at a depth of about 5 centimeters, then decrease to undetectable levels at depths as shallow as 40 centimeters. These nitrate concentrations and concentration gradients reflect zones of oxygen reduction, nitrate reduction, and sulfate reduction in the sediments. The estimated benthic flux of nitrate to the ocean from our data is much less than the total global flux of nitrate to deep waters, even though these equatorial sediments underlie a productive upwelling zone. The estimated denitrification rate in our study area suggests that pelagic sediments may be important sites of marine denitrification.*

Inorganic carbon, nitrogen, and phosphorus are fixed into organic matter at the sea surface during photosynthesis. A small portion of the particulate organic matter is delivered to the deep sea and incorporated into marine sediments. The organic matter thus buried is partly oxidized and regenerated within the sediment by oxidants (O_2, NO_3^- plus NO_2^-, and SO_4^{2-}) which are either derived from pore waters, provided by diffusion from the overlying water, or produced by diagenetic reactions within the sediment column (NO_3^- plus NO_2^- only). Metabolites, oxidants, and reductants are all present in pore waters. Concentrations of these products are controlled by C : N : P ratios in the organic matter undergoing diagenesis, by relative rates of diffusion, and by rates of reaction, sedimentation, and bioturbation (*1*).

The purpose of this report is to discuss the fate of nitrate produced by diagenetic reactions in a suite of cores from the Guinea Basin in the eastern equatorial Atlantic, to show that pore-water nitrate profiles can provide much information about the early diagenesis of deep-sea sediments, and to make preliminary assessments of the global significance of the pelagic benthic flux of nitrate and pelagic denitrification.

Before discussing the pore-water data, it is worthwhile to review a simple model of organic diagenesis (*2*–*4*). In doing so we will make the following simplifying assumptions: (i) all the organic matter undergoing oxidation has C : N : P atom ratios of 106 : 16 : 1 (the Redfield ratios); (ii) there are no solid-phase reactions (other than the breakdown of organic matter itself) releasing metabolities to or consuming them from pore waters; (iii) ammonia released by deamination during oxidation of organic matter by dissolved oxygen is immediately con-