Table 2. Oxygen-isotopic composition of quartz isolated from selected soils of the Hawaiian Islands.

Soil description	Sample No.	Quartz (%)	$\delta^{18}O$*
	Oahu		
Wahiawa A1	66-15	1.6	17.14
Paaloa A1	G-14	12.6	17.48
Paaloa A2 No. 1	66-20	13.4	17.75
Paaloa A2 No. 2	66-21	22.3	17.83
Paaloa B	66-22	12.1	18.03
Olokui A1	66-23	44.6	17.99
Olokui A2	66-24	34.4	17.63
Pali A	C-25	3.4	17.21
	Kauai		
Plastic underclay	Mc8B	17.1	17.41
Plastic underclay	A110C	7.8	17.37
Plastic underclay	Mc4A	12.7	17.08
Kauai No. 38	K-38	2.4	16.77
	Molokai		
Titaniferous laterite	66-52	10.7	17.53
	Hawaii		
Plastic clay lens	66-50	10.3	17.61
	Maui		
Maui No. 55	M-55	1.8	17.83
		Mean	17.51 ± 0.36

$$* \ \delta^{18}O = \left[\frac{^{18}O/^{16}O \text{ (sample)}}{^{18}O/^{16}O \text{ (standard)}} - 1\right] 1000$$

relative to standard mean ocean water.

that this is an unusual isotopic composition for quartz, being at the high end of observed values for igneous and metamorphic rocks, and at the low end of the distribution of values for low-temperature chemical sediments.

The quartz content of tropospheric dusts collected in Japan (*6*) and in Barbados are 32 and 10 percent, respectively. Furthermore the particle-size distribution of these materials (dominantly 10 to 2 μ) and the oxygen isotopic composition of the quartz ($\delta^{18}O$ = approximately 16) are almost identical to those of the quartz isolated from soils of the Hawaiian Islands and the pelagic sediments of the east-central Pacific.

These findings indicate an eolian origin for the quartz in virtually all Hawaiian soils, and negate the possibility of a pedogenic origin (*1, 3*). Transport of eolian material by the principal wind systems of the troposphere from semiarid and arid land areas with subsequent deposition in rain appears highly probable. An eolian origin is the only evident mechanism which can provide for the distribution of quartz both to the subaerial surfaces of the Hawaiian Islands and across the entire Pacific Ocean.

Table 3. Oxygen isotopic composition as related to the origin of quartz.

Origin	Analyses (No.)	$\delta^{18}O$ (mean)
Hawaiian soils	15	18
Pacific pelagic sediments	22	18
Tropospheric dust	2	16
Hydrothermal (Oahu)	3	6
Chert, Cretaceous (*13*)	12	32

In addition to quartz, the tropospheric dusts analyzed usually contained appreciable amounts of mica and feldspars and often smaller quantities of vermiculite, chlorite, amphibole, calcite, and dolomite. The covariant relation between the mica and quartz contents of Hawaiian soils, both increasing with an increase in rainfall and both concentrated in the surface of the profile (*1*), may suggest that at least a portion of the mica in soils of the Hawaiian Islands also has a tropospheric origin.

R. W. REX
Department of Geology,
University of California, Riverside
J. K. SYERS, M. L. JACKSON
Department of Soil Science,
University of Wisconsin, Madison
R. N. CLAYTON
Enrico Fermi Institute, University
of Chicago, Chicago, Illinois

References and Notes

1. T. C. Juang and G. Uehara, *Soil Sci. Soc. Amer. Proc.* **32**, 31 (1968).
2. H. T. Stearns and K. N. Vaksvik, *Bull. Hawaii Div. Hydrography* **1** (1935).
3. G. D. Sherman, H. Matsusaka, H. Ikawa, G. Uehara, *Agrochimica* **8**, 146 (1964).
4. R. N. Clayton, R. W. Rex, J. K. Syers, M. L. Jackson, abstracts of papers presented at the Geological Society of America meeting, Mexico City, Mexico, November 1968 (Geological Society of America, Boulder, Colo., 1968).
5. J. K. Syers, S. L. Chapman, R. W. Rex, M. L. Jackson, R. N. Clayton, *Geochim. Cosmochim. Acta* **32**, 1022 (1968).
6. Y. Miyake, Y. Sugiura, Y. Katsuragi, *J. Meteorol. Soc. Jap. Ser. 2* **34**, 226 (1956).
7. M. L. Jackson, *Soil Chemical Analysis—Advanced Course WI 53706* (Department of Soil Science, Univ. of Wisconsin, Madison, 4th printing, 1968).
8. R. N. Clayton and T. K. Mayeda, *Geochim. Cosmochim. Acta* **27**, 43 (1963).
9. We thank Drs. G. D. Sherman, G. Uehara, L. D. Swindale, and S. H. Patterson for assistance with sample collection.
10. M. L. Jackson, Th. W. M. Levelt, J. K. Syers, R. W. Rex, R. N. Clayton, G. D. Sherman, *Agron. Abstr.* (1968), p. 153 (paper presented at Soil Science Society of America meeting, New Orleans, Louisiana, November 1968).
11. S. H. Patterson, *Clays Clay Minerals* **12**, 153 (1964).
12. C. K. Wentworth, R. C. Wells, V. T. Allen, *Amer. Mineral.* **25**, 1 (1940).
13. E. T. Degens and S. Epstein, *Amer. Ass. Petrol. Geol. Bull.* **46**, 534 (1962).
14. R. N. Clayton and S. Epstein, *J. Geol.* **66**, 352 (1958).
15. R. W. Rex and E. D. Goldberg, *Tellus* **10**, 153 (1958); in *The Sea*, M. N. Hill, Ed. (Interscience, New York, 1962), vol. 1, pp. 295–312; G. Arrhenius, in *ibid.*, pp. 655–727.
16. We thank Dr. J. Prospero for the sample of dust collected in Barbados. Supported in part by NSF GA1108 and AEC COO AT(11-1) 1515 to M.L.J.; GA514 to R.N.C.; and academic Senate grant, U.C. Riverside, to R.W.R.

23 September 1968; revised 30 October 1968

Cloud Condensation Nuclei from a Simulated Forest Fire

Abstract. *Measurements made downwind of a simulated forest fire showed that the concentration of cloud condensation nuclei active at a supersaturation of 1 percent was increased by a factor of about 2.5. Smaller increases were observed at lower supersaturations.*

Particles in the atmosphere which act as centers for the condensation of water vapor at supersaturations of less than a few percent are important as potential condensation nuclei in the formation of water droplets in clouds and fogs. The concentration of these cloud condensation nuclei (CCN) in the air determines the concentration of cloud droplets, and this in turn controls the size of the droplets and the efficiency with which precipitable particles can be produced in a cloud (*1*).

The principal sources of CCN are not well known. In general, however, the continents are a source and the oceans are a sink. Twomey (*2*) and Squires (*3*) have shown that on a global scale the anthropogenic production of CCN is only a few percent of the production by natural sources. In the United States it is about 15 percent, whereas in highly industrial cities the anthropogenic production might approach that due to natural causes.

Smoke from sugar cane fires is a prolific source of CCN, and these fires can greatly increase the concentration of droplets in clouds which form downwind (*4*). Moreover, Warner (*5*) indicates a progressive decrease in rainfall at stations in the Bundaberg district of eastern Australia lying downwind from areas where sugar cane is regularly fired prior to cutting. We describe here measurements of the concentration of CCN downwind from a simulated forest fire.

At the University of Washington's research station at Pack Forest near Eatonville, Washington, a roughly rectangular area (about 12 hectares) was piled with small trees (mostly browned evergreens), brushwood, and logging wastes to simulate a wooded area. When the fire was ignited they initially burnt fiercely but the intensity decreased significantly within an hour. The fire would probably be classified as "cold," since although small branches were burnt the larger tree trunks were only blackened.

The concentrations of CCN in the air were measured with the automatic counter described by Radke and Hobbs

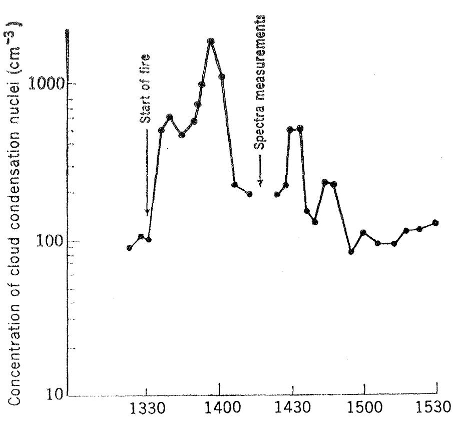

Fig. 1. Concentrations of cloud condensation nuclei at 1 percent supersaturation measured during the fire.

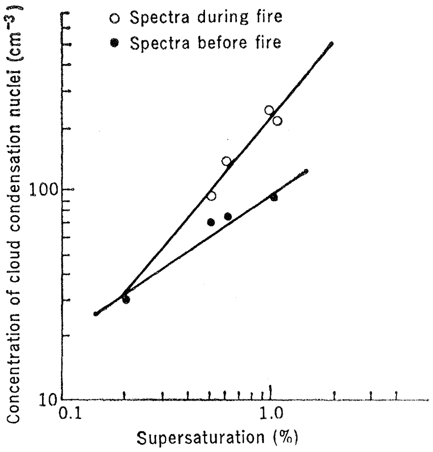

Fig. 2. Supersaturation spectra of cloud condensation nuclei before and during the fire.

(6) at the site of the fire prior to ignition. The counter was then moved to a ridge about 2.5 km downwind of the fire where measurements were taken just before ignition and during the fire (Fig. 1).

The concentration of CCN at the site of the fire an hour before ignition was 50 cm^{-3} at 1 percent supersaturation, and the concentration of CCN at the ridge a few minutes before ignition was about 100 cm^{-3} at 1 percent supersaturation. These relatively low concentrations for land measurements are probably attributable to the proximity of the Pacific Ocean (130 km) and the transport of only slightly modified maritime air to the site of the fire by the prevailing wind (WSW). The variations in CCN count at 1 percent supersaturation measured at the ridge closely followed the intensity of the fire (Fig. 1).

Measurements of the concentrations of CCN at several different supersaturations taken at the ridge before the fire was lit and during the fire (Fig. 2) show that the fire was a significant source of only relatively inefficient CCN. Extrapolation of the supersaturation spectrum taken during the fire shows that the number of CCN active at 0.2 percent supersaturation was unchanged by the fire at this stage.

These observations indicate that the burning of forest products can generate large concentrations of CCN active at about 1 percent supersaturation. However, in order to estimate better the importance of forest fires as sources of CCN, measurements should be made in the vicinity of various types of large forest fires.

PETER V. HOBBS
L. F. RADKE

Cloud Physics Laboratory,
Department of Atmospheric Sciences,
University of Washington, Seattle 98105

References and Notes

1. P. Squires and S. Twomey, *Tellus* **10**, 272 (1958).
2. S. Twomey, *Bull. Observ. Puy de Dome* **1**, 1 (1960).
3. P. Squires, *J. Rech. Atmos.* **2**, 297 (1966).
4. J. Warner and S. Twomey, *J. Atmos. Sci.* **24**, 704 (1967).
5. J. Warner, *J. Appl. Meteorol.* **7**, 247 (1968).
6. L. F. Radke and P. V. Hobbs, in *Proc. Int. Conf. Cloud Physics* (Toronto, 1968), p. 35.
7. The simulated forest fire at Pack Forest was supported by a grant to the College of Forestry, University of Washington, from the U.S. Forest Service grant 4040. The measurements were supported by contract 14-06-D-5970 from the Office of Atmospheric Water Resources, U.S. Department of Interior. Contribution 172 from the Department of Atmospheric Sciences, Univ. of Washington, Seattle.

19 August 1968

Role of Surface Dipoles on Axon Membrane

Abstract. *A physical model of nerve excitation and conduction is proposed based on the discovery of three new axon membrane properties: the negative fixed surface charge, the birefringence change, and the infrared emission.*

The mechanisms of nerve excitation and conduction have not been well understood mainly because little is known about the intrinsic physical properties of axon membrane. Recently (April–June 1968), there were three developments. Segal has shown the existence of negative, fixed surface charges on the giant axons of squid and lobster (*1*). The minimum values of the charge densities determined were 1.9×10^{-8} and 4.2×10^{-8} coul/cm^2, respectively. He also found no evidence that the properties of the shear surface were altered by the loss of resting potential. Cohen, Keynes, and Hille have shown conclusively that there was a birefringence change that coincided with the action potential in a squid giant axon (*2*). It follows from their experiments that the birefringence change has a radial optical axis and that it arises from sources arranged in a cylindrical region at the outer edge of the axon or in the sheath. Fraser and Frey have detected infrared emission—intensity of 6 μw/cm^2—from active live crab nerves. This emission exceeded the blackbody radiation and the stimulus artifact heating by two orders of magnitude and therefore must be located at the surface of the nerve (*3*). The significance of these three new findings is so profound that we wish to explore it at some length in this communication.

An immediate question following Segal's finding is whether there would be fixed charge on the inner surface of the axon. Since the resting potential is positive outside, and since the ionic solutions are conducting media in which the potential change, if any, would be rather small, Segal's result would imply that neutral or positive charge on the inner surface of the axon would be very unlikely, because otherwise the resting potential would be opposite to that observed. The only possibility then is that there might be negative fixed charge on the inner surface of the axon. In order to keep the negative charges on both surfaces (70 Å apart) from repelling each other and also to fulfill the neutrality condition, there must be a positively charged layer standing close to the negative surface charge on each side. Therefore, there would be two dipole layers on the inner and the outer sides of the axon membrane, with their negative ends facing the aqueous phases.

With these surface dipoles, the potential profile will resemble that shown in Fig. 1. The higher potential in the membrane region will trap anions coming from both sides and thus makes that region N-type in the semiconductor language. This explains the well-known fact that an axon membrane is permselective to anions, because they will have the lowest potential energy ($-$ qV) and hence are inclined to stay in the membrane region. On the other hand, cations will have the highest potential energy and hence are rather unstable