

NOTES

LAMINAR OPALINE SILICA FROM SOME VOLCANIC ASH SOILS IN NEW ZEALAND

Key Words—Andosols, Opaline silica, Volcanic ash soils, Weathering.

Shoji and Masui (1969a, 1969b) first discovered laminar opaline silica with a unique disc shape in some recent soils developed on volcanic ash less than 500 years old at Hokkaido, Japan. The laminar opaline silica was found only in the 0.2–5- μm fractions (mainly in the 0.4–2- μm fraction) and was considered to be of pedogenic origin. It was thought to be responsible for the highly siliceous nature of the clay fractions in these soils, which contrasts with other opaline silicas, such as plant opal and diatoms, usually found in larger size fractions. They showed that the opaline silica was more abundant in the A horizon than in the underlying B or C horizons (Shoji and Masui, 1971, 1972).

Laminar opaline silica has been found in relatively young Andosols in Tohoku, Kanto, and Kyushu, Japan (Shoji and Masui, 1971; Tokashiki and Wada, 1975; Mizota, 1976; Shoji and Saigusa, 1977); Papua New Guinea (Bleeker and Parfitt, 1974; Parfitt, 1975); and Oregon, USA (Shoji and Saigusa, 1977). Discrete, amorphous hydrous silicas were reported by Fieldes and Furkert (1966) in some volcanic ash soils in New Zealand who thought that laminar opaline silica might also be present in these soils.

The present study describes the occurrence of such laminar opaline silica in some volcanic ash soils in New Zealand.

MATERIALS AND METHODS

The soils used in this investigation were formed under the predominantly mild and humid climate of New Zealand from tephra of various lithologies erupted over the last 100,000 years. They represent a variety of volcanic ash soils in the North Island of New Zealand from the andesites of Mt. Egmont and Mt. Ngauruhoe, to the rhyolites of Taupo and Okataina (near Rotorua), and the basalts north of Auckland. Descriptions of these soils (Table 1) are given in New Zealand Soil Bureau (1968).

The air-dried soils, <2 mm, were subjected to a H_2O_2 (30%) treatment on a hot plate to remove organic matter. The <2- μm fractions were separated after dispersion at pH 4 or 10 and stored as suspensions of approximately equal concentration. A drop of each suspension was dried on a collodion film reinforced with carbon. Electron optical observations were made using Philips Model EM200 electron microscope at 60 kV. The relative abundance of the laminar opaline silica was estimated visually, and the results are presented in Table 1.

RESULTS AND DISCUSSION

Electron micrographs of selected samples of laminar opaline silica are shown in Figures 1–6. Four morphological types were recognized: (1) circular (Figure 1a), (2) elliptical (Figure 1b), (3) rectangular (Figure 1c), and (4) rhombic (Figure 1d) (Shoji and Masui, 1971), with the circular and elliptical types

predominating. The opaline silica is morphologically similar to those of Japanese Andosols reported by Shoji and Masui (1971).

Under high magnification ($\times 110,000$) in Figure 1e an eroded edge of the opaline silica can be seen which suggests that dissolution occurs during weathering. Figure 1f shows a highly weathered, partially disintegrated particle that may have been a source of soluble silica in the soil. These particles differ from glass fragments which are not platy but are more angular and appear to be denser in electron micrographs.

From the data in Table 1, the opaline silica appears to be most abundant in humus-rich horizons and in buried A horizons of volcanic ash soils, >2000 years old, such as in the Rotomahana soil, irrespective of lithologic composition. The relative abundance of the opaline silica is commonly lower in the underlying B or C horizons, similar also to its distribution in Japanese Andosols (Shoji and Masui, 1971; Tokashiki and Wada, 1975). These observations suggest that opaline silica forms in the early stage of weathering of volcanic ashes when sufficient soluble silica is available to supersaturate the soil solution, and when surface evaporation occurs (see also, Shoji and Masui, 1969b, 1972). Suppression of aluminum ion activity in soil solution caused by the formation of Al-humus complexes, may favor the formation of opaline silica in humus-rich A horizons of relatively young volcanic ash soils (Wada and Harward, 1974; Wada, 1977).

The abundance of the opaline silica (Table 1) tends to decrease with the increase in age of New Zealand volcanic ash soils as a result of weathering of the particles. No opaline silica was observed in any of the horizons of older Hamilton ash falls (>40,000 years), in which the clay fraction is predominantly short-tube halloysite.

These observations confirm that laminar opaline silica is characteristic of the early stages of weathering of volcanic ash in humid temperate climatic zones (Wada, 1977), and partly account for the discrete amorphous hydrous silica found in the clay fraction of these New Zealand soils developed on volcanic ash.

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Figure 1. Electron micrographs of laminar opaline silicas. (a) Circular particle from Ngauruhoe sand, 30–40 cm depth. (b) Elliptical particle from Ngauruhoe sand, 0–3 cm depth. (c) Rectangular particle from Kaingaroa loamy sand, 3–0 cm depth. (d) Rhombic particle from Ngauruhoe sand, 0–8 cm depth. (e) Weathered particle from Stratford sandy loam, 0–8 cm depth. (f) Highly weathered particle from Tirau silt loam, 0–8 cm depth.

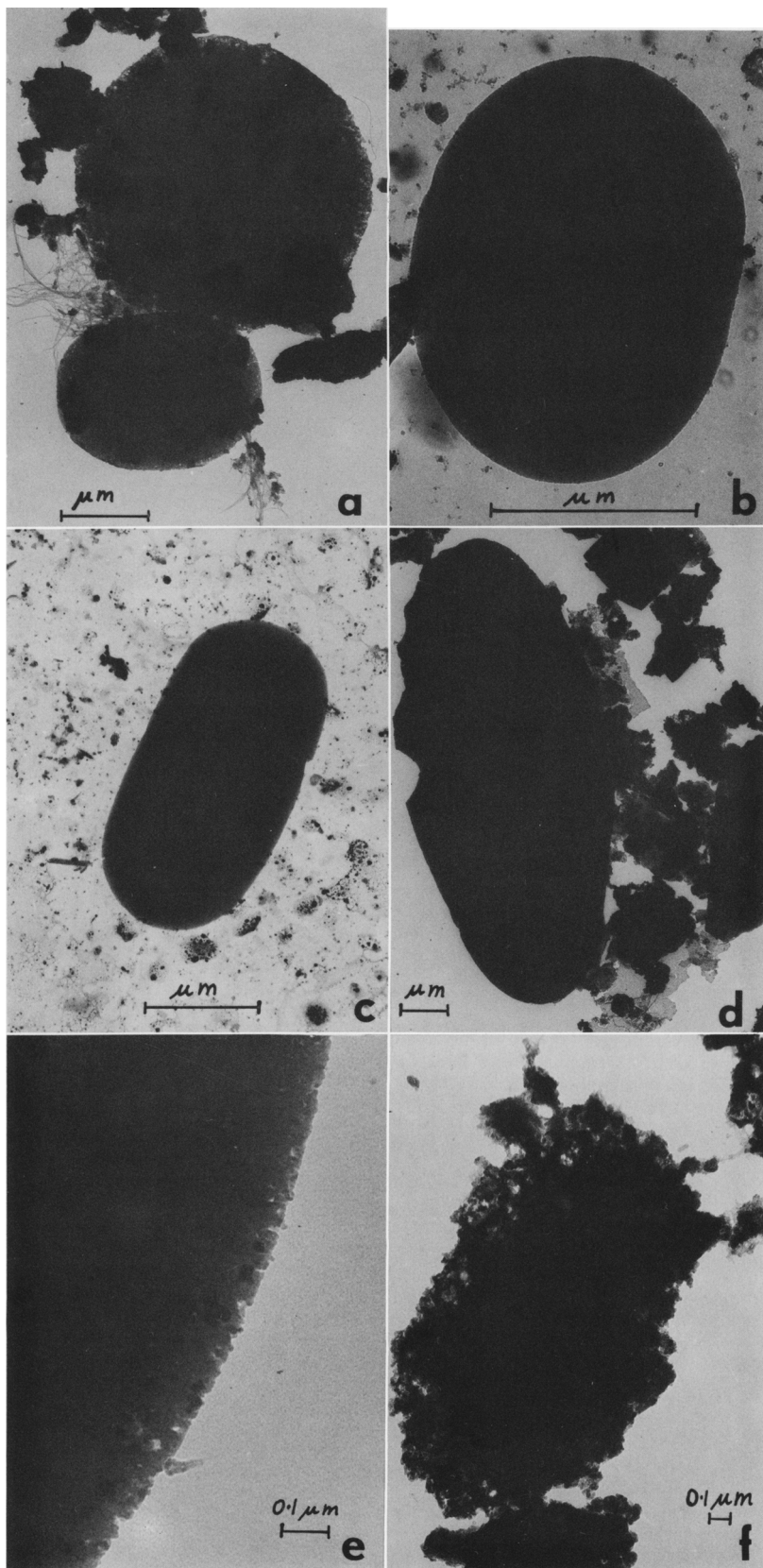


Table 1. Description of soils (New Zealand Soil Bureau, 1968) and relative abundance of opaline silica.

Depth (cm)	Horizon	% Carbon	Parent material	Age (years)	Opaline silica
Soil: Ngauruhoe sand (Typic Cryandept or Frigid Vitrandept)					
1300–1500 mm rainfall					
0–3	A ₁₁ C	4.9	Ngauruhoe Ash (andesitic)	10–100 ¹	Abundant
3–12	A ₁₁ C	2.9		10–100	Abundant
20–30	C	2.0		10–100	Present
33–38	IuA	2.0		<400	Abundant
40–50	IuC	0.4		<400	Trace
Soil: Rotomahana sandy loam (Typic Ustorthent)					
1300 mm rainfall					
0–3	A ₁	9.9	Rhyolitic ejecta	93 ¹	Abundant
3–8	A ₃	1.3		93	Abundant
74–79	uA	3.6	Taupo Pumice (rhyolitic)	2000	Abundant
84–91	uB	3.4		2000	Present
Soil: Kaingaroa loamy sand (Andic Haplohumod)					
1300–1400 mm rainfall					
3–0	O ₁	—	Taupo Pumice (rhyolitic)	2000 ¹	Present
12–20	B	3.6		2000	Present
Soil: Stratford coarse sandy loam (Entic Dystrandept)					
2000 mm rainfall					
0–8	A ₁₁	10.9	Andesitic ash	~5000 ²	Present
8–15	A ₁₂	9.0		~7000	Present
40–52	BC	3.0		~7000	Present
Soil: Egmont black loam (Entic Dystrandept)					
1000 mm rainfall					
0–8	A ₁₁	12.0	Andesitic ash ³	~2000 ³	Abundant
74–89	C	1.0	Tephric loess ³	~10,000	Trace
Soil: Patua loam (Placandept)					
4000 mm rainfall					
0–8	A ₁	20.3	Andesitic ash	<7000 ²	Present
15–27	B	11.7		~7000	Absent
38–52	BC	8.7		~7000	Absent
Soil: Tirau silt loam (Entic Dystrandept)					
1400 mm rainfall					
0–8	A ₁₁	10.6	Taupo pumice	2000 ¹	Present
20–30	AB	2.3	Rotorua ash ⁴	13,450 ⁵	Absent
Soil: Naikē clay (Typic Haplohumult)					
1400 mm rainfall					
0–8	A ₁₁	7.0	Hamilton ashes, possibly reworked (andesitic)	<40,000	Absent
8–15	A ₁₂	4.0		100,000 ¹	Absent
18–30	B ₂₁	2.3		100,000	Absent
33–50	B ₂₂	1.4		100,000	Absent
53–71	C ₁	0.8		100,000	Absent
76–91	C	0.3		100,000	Absent
Soil: Hamilton clay loam (Typic Haplohumult)					
1300 mm rainfall					
0–8	A ₁₁	4.6	Hamilton ashes, possibly reworked (andesitic)	<40,000	Absent
8–15	A ₁₂	3.5		100,000 ¹	Absent
30–40	A ₃	0.5		100,000	Absent
40–60	(II)B ₂₁	0.4		100,000	Absent
63–79	(II)B ₂₂	0.6		100,000	Absent

Table 1. Continued.

Depth (cm)	Horizon	% Carbon	Parent material	Age (years)	Opaline silica
Soil: Papakauri clay loam (Entic Dystrandept)					
1600 mm rainfall					
0-8	A ₁	12.7	Scoria (olivine basalt)	~10,000	Present
12-20	A ₃	7.8		~10,000	Trace
23-48	B ₂₁	5.0		~10,000	Absent
50-79	B ₂₂	2.9		~10,000	Absent
>79	C	0.4		~10,000	Absent
Soil: Kiripaka clay loam (Typic Dystrandept)					
1600 mm rainfall					
0-10	A _{1p}	8.1	Basaltic ash and scoria	~20,000	Present
10-23	A ₁₂	5.1		~20,000	Trace
23-43	B ₁	2.1		~20,000	Absent

¹ Gibbs (1968).

² Neall (1972).

³ Stewart *et al.* (1977).

⁴ Pullar and Birrell (1973).

⁵ Pullar *et al.* (1973).

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