A Pedological Study in the Wellington Formation

JAMES R. CULVER and FENTON GRAY

Oklahoma State University, Stillwater

The Permian and Post-Permian sediments in many localities of Oklahoma lack readily identifiable characteristics for accurate surface geology or pedological work. The genetic relationship of soil material to underlying bedrock is important in making interpretations of weathering processes and soil-forming processes.

Mechanical, chemical and mineralogical properties of geological material of the Wellington Formation and pedons correlated as the Waurika series (Culver and Bain, 1964) were determined to ascertain if this soil is pedogenetic to the underlying geological formation. The Wellington Formation is about 700 ft at its outcrop and extends from northcentral Oklahoma across Kansas (Swineford, 1955).

Location of sample sites—Sites selected for collecting geological material of the Wellington Formation (Miser, 1954) were approximately 20 miles apart in a north-south traverse. Site No. 1 is about 10 miles northwest of Blackwell or 1900 ft north of the NW corner of sec. 24, T. 28 N., R. 1 W.; and site No. 2 is southwest of Tonkawa near Interstate 35 at a shale pit located 2000 ft north of the SW corner sec. 31, T. 25 N., R. 1W. Weathered and unweathered gray to greenish-gray shales and clays were collected at each site. The Waurika pedon[1] was sampled 360 ft north and 100 ft east of the SW corner of sec. 4, T. 25 N., R. 1 E.

[1]A pedon is the smallest volume of soil showing all horizons.

Physical, chemical, and mineralogical properties of weathered and unweathered Wellington samples—The particle size distribution of the Wellington sample sites in Table I show the weathered material to be slightly higher in clay. Adequate dispersion of the samples was difficult, and much of the material in the coarse sand to the very fine sand was strongly cemented shales. Fine silt and clay are the dominant particle sizes in all samples.

The cation exchange capacity (CEC) of the weathered soil material of both sites was greater than for the unweathered clays and shales of the Wellington Formation. The cation exchange capacity of the total clay shows no significant difference between the weathered and unweathered clays and shales. This suggests that the higher CEC of the weathered material may be due to the increase of organic matter. Calcium and magnesium are the dominant exchangeable cations in all samples. Calcium is higher in the weathered material. Swineford (1955), from a Wellington Formation study in Kansas, reported a lower percentage of calcium and a higher percentage of magnesium in unweathered material. The organic matter is higher in the weathered material.

The predominant clay minerals of these Wellington clays and shales are illitic and chloritic with some indication of interstratified montmorillonitic clays. The x-ray diffraction patterns in Fig. 1 indicate no trends of clay mineralogy between the weathered and unweathered samples. The differential thermal curves of the weathered and unweathered clay in Fig. 2 suggests interstratified illitic clay minerals. The cation exchange capacity of the total clay reflects a high micaceous content and is supported by low ethylene glycol retention and high K_2O values. The C horizon of the pedon has higher CEC of clay and ethylene glycol retention and lower K_2O values than the Wellington samples.

Physical, chemical and mineralogical properties of Waurika pedon—The Waurika pedon has a light-colored, silt loam A horizon containing 16% clay. At 12″, there is an abrupt boundary to a dark clayey B2t horizon containing 55% clay. Below a depth of 32″, there is a gradual decrease of clay, and the C2 horizon from 76″ to 106″ contains 33% clay.

Calcium and magnesium are the major exchangeable cations in the Waurika pedon. The pH vales of the Waurika ranged from 5.7 in the surface to 8.3 in the lower B horizons and decreased to 7.1 in the C2 horizon.

The x-ray diffraction patterns of the Waurika pedon depict illitic clay minerals in the Ap horizon, interstratified illitic and montmorillonitic in the B21t horizon and montmorillonite in the C horizon. The differential thermal curves have endothermic reactions strongly supporting the x-ray diffraction patterns. A comparison of the coarse, fine, and total clay of the C2 horizon in Fig. 3 has x-ray diffraction peaks showing the coarse clay to have largely illitic clay minerals; and the fine clay, interstratified montmorillonitic and illitic clay minerals.

Summary and conclusion—The Wellington weathered and unweathered samples are higher in illitic and chloritic clay minerals, while the C horizon of the Waurika pedon contained mostly montmorillonitic. The coarse clays of the C horizon are mainly illitic and fine clay; the dominant fraction—montmorillonitic. These differences of clay mineralogy have been interpreted as evidences that the Waurika soils sampled did not develop in place but formed into Post-Permian sediments laid over the older land form of the Wellington Formation.

TABLE I. ANALYSIS OF WELLINGTON FORMATION SAMPLES

PARTICLE SIZE DISTRIBUTION

Site	Very Coarse Sand 2-1 mm	Coarse Sand 1-.5 mm	Medium Sand .5-.25 mm	Fine Sand .25-.1 mm	Very Fine Sand .1-.05 mm	Coarse Silt .05-0.2 mm	Fine Silt .02-.002 mm	Clay .002 mm
No. 1 Weathered	—	2.4	7.1	13.8	8.1	8.3	26.9	33.4
No. 1 Unweathered	.1	1.9	4.9	10.2	5.9	9.0	39.6	28.3
No. 2 Weathered	—	.5	2.1	5.7	3.8	5.3	39.3	43.3
No. 2 Unweathered	—	4.2	8.2	9.8	5.2	4.2	26.3	41.9

CHEMICAL MEASUREMENTS

Site	Cation Exchange Capacity	Extractable Cations: Ca	Mg	Na	K	% Organic Matter	pH with 1:1 Soil-Water Ratio	pH with 1:1 Soil-KCl Ratio
	meq/100 g of Soil							
No. 1 Weathered	20.84	22.4	13.7	.19	.49	.48	7.9	6.8
No. 1 Unweathered	17.30	7.8	15.7	.09	.49	.24	8.0	6.8
No. 2 Weathered	20.97	24.9	13.7	.09	.82	.51	8.0	6.9
No. 2 Unweathered	17.57	15.1	18.5	—	.60	.41	8.1	6.9

MINERALOGICAL MEASUREMENTS

Site	C.E.C. meq/100 g.	Ethylene Glycol Retention—Total Mg/2	% K_2O	X-ray Analysis**	D.T.A.**
No. 1 Weathered	27.7	111.6	4.74	I/C M*	IM
No. 1 Unweathered	27.7	114.4	4.59	I/C	IM
No. 2 Weathered	25.0	108.2	6.01	I/C	IM
No. 2 Unweathered	26.3	89.4	2.75	I/C M	IM

*I — Illite, C — Chlorite, M — Montmorillonite

**X-ray Analysis and D.T.A. by Dr. Mankin, Geology Department, University of Oklahoma

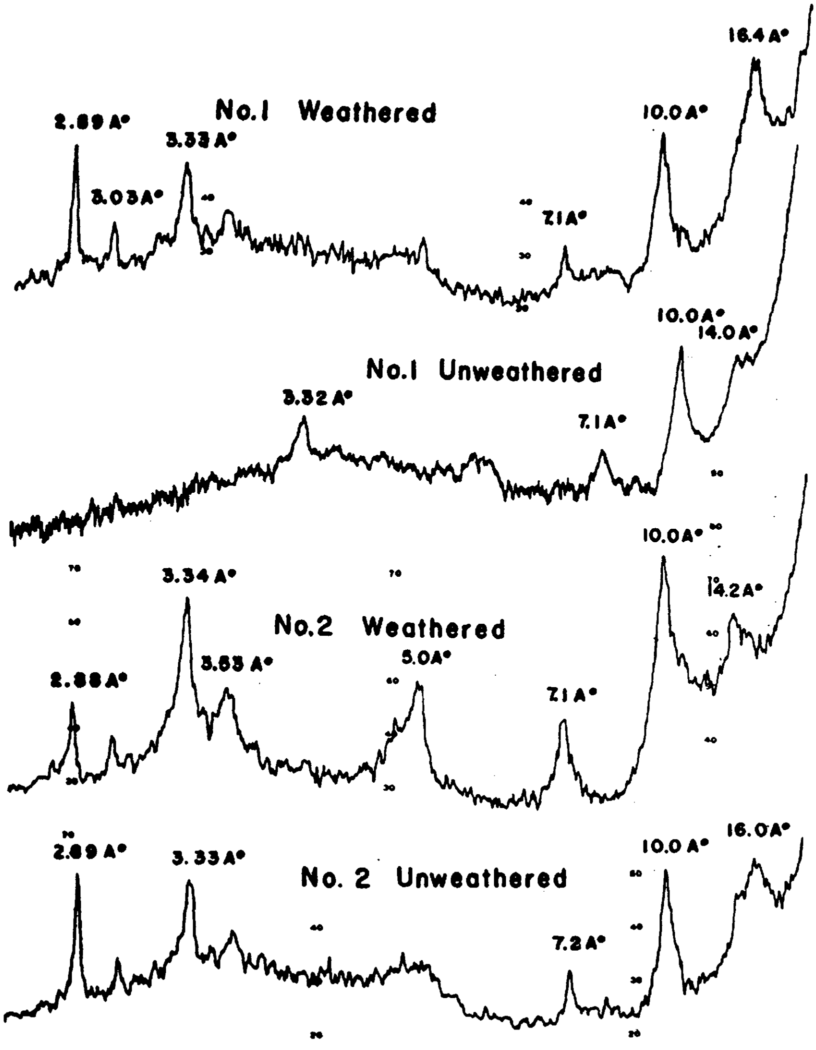

Fig. 1. Total Clay X-ray Spectrographs of Wellington Formations Samples

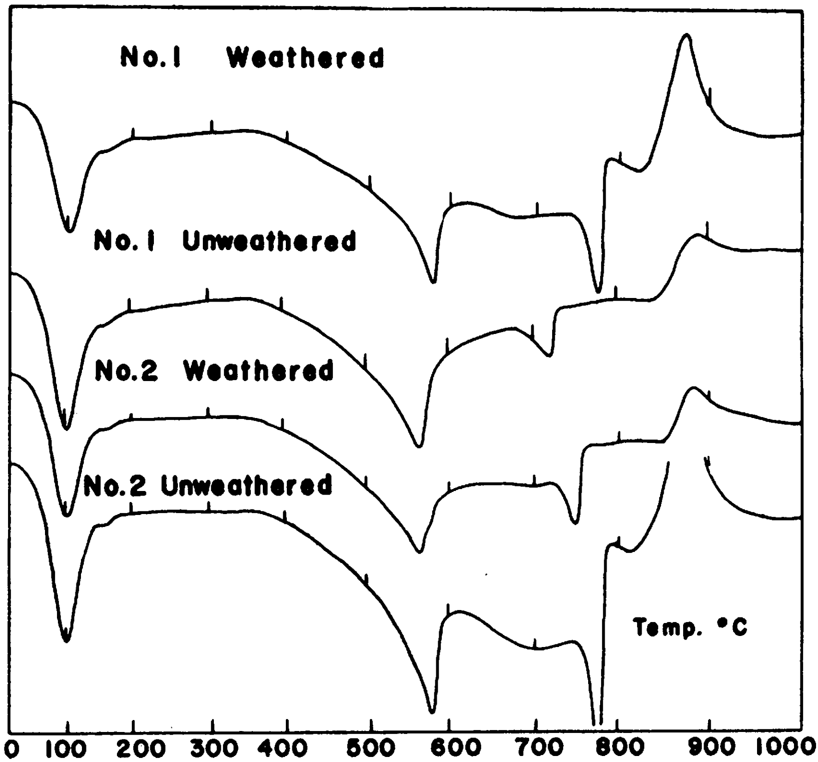

Fig. 2. Differential Thermal Curves for Total Clay of Wellington Formation Samples

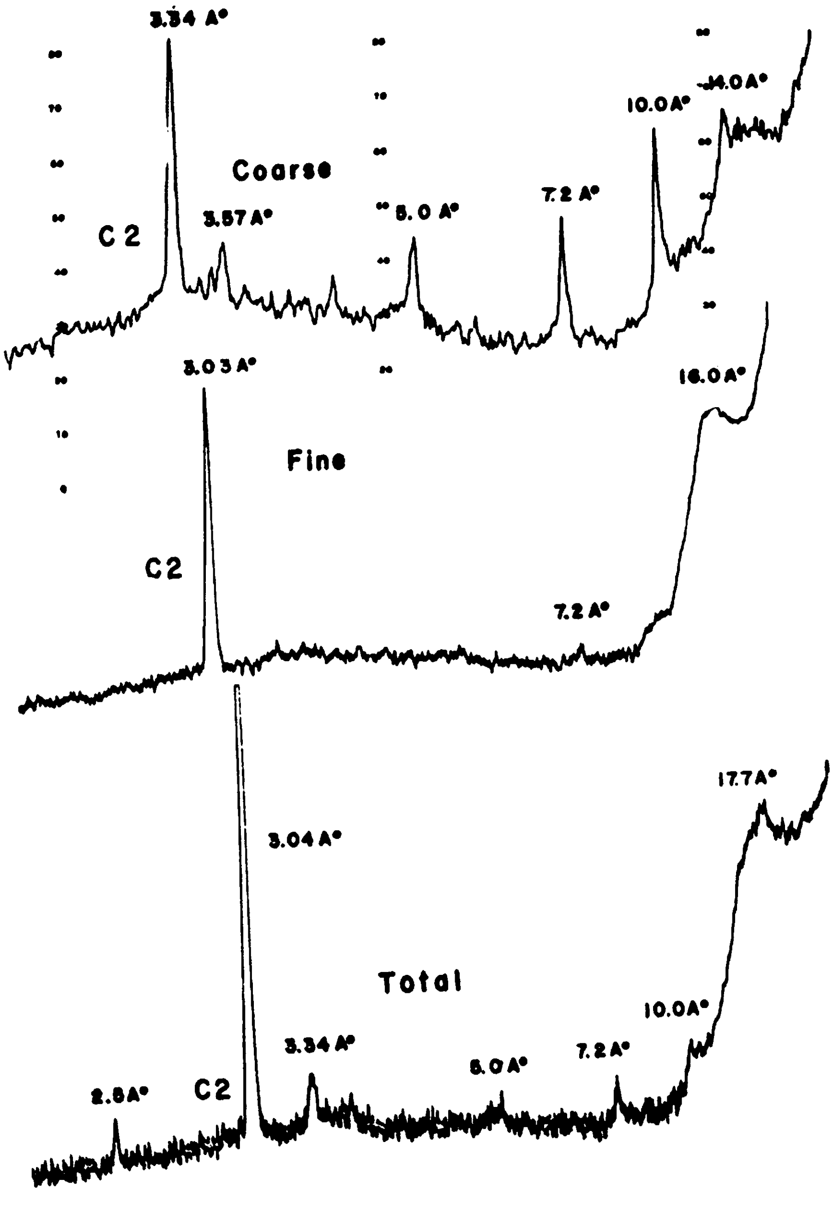

Fig. 3. X-ray Spectrographs of Waurika No. 1 C2 Horizon Showing Coarse, Fine, and Total Clay

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