Soil profile relative-age dating and west-to-east decrease in dust influx across the central Wasatch Mountains, Utah

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ABSTRACT

Following methods of relative-age dating developed by Peter Birkeland and colleagues, in 1979-1983 we described 105 soil profiles in the eastern valleys of the central Wasatch Mountains and the western Uinta Basin (~7000 km²) to estimate landform ages as part of seismic hazard studies for U.S. Bureau of Reclamation (USBR) dams in the region. The variability in source rock lithologies, parent material texture, site surface stability, rainfall, and distance from major dust sources for our soils is greater than for many studied soil chronosequences in the western U.S. Profile development indices (14) for soils on landforms of uncertain age were compared with indices for 16 soils on landforms whose ages we inferred from regional relative-age dating studies or nearby numerical ages (e.g., Table 1; Fig. 2). The indices most successful in placing landforms into five relative-age groups were rubification, non-arid total profile index, and g/m²/a of secondary clay (Figs. 2 and 3). Results from 8 dust traps show at least a 5-fold, west-to-east decrease in the influx of silt and clay between the crest of the Wasatch Range and the northwestern Uinta Basin (Fig. 4). The Morgan Valley trap, 120 m above the western Bonneville shoreline in the valley (Fig. 1), accumulated 57 gm²/a of silt+clay. A trap along the Lake Fork River in the northwestern Uinta Basin on Pinedale moraines, recently dated at 19 ka with ^{10}Be surface exposure ages, yielded 4 g/ m²/a, similar to values obtained in recent studies of dust influx in the Uinta Mountains and Wind River Mountains. About 16 km farther south in the central basin a trap on a fluvial surface incised 200 m showed 10 g/m²/a of silt+clay. Discussion of the soil profile and other relative-age data can be found in unpublished reports and related publications (references listed below), with additional unpublished profile (e.g., soil profile descriptions, lab data, development indices for each of the 105 profiles) and dust trap data at: https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/BAAYFC.

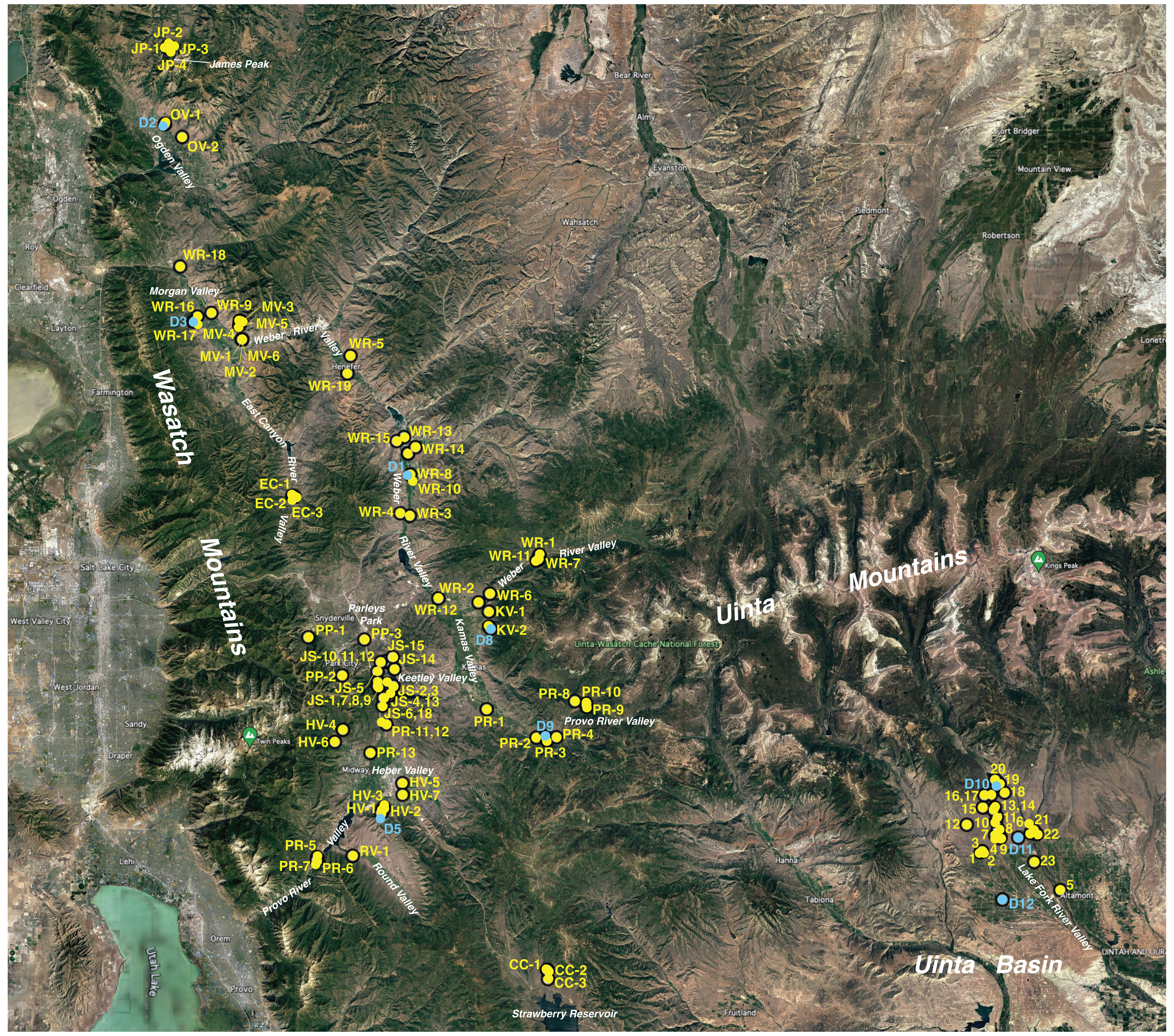

Figure 1. Google Earth image (28Aug21) of the central Wasatch Mountains, western Uinta Mountains, and northwestern Uinta Basin showing the location of soil profiles (double letters and number) and dust traps (D and number) described in 1979-1983 as part of seismic hazards studies for U.S Bureau of Reclamation dams. Soil profile labels correspond with associated landforms (PR = Provo River Valley; JP = James Peak; PP = Parleys Park).

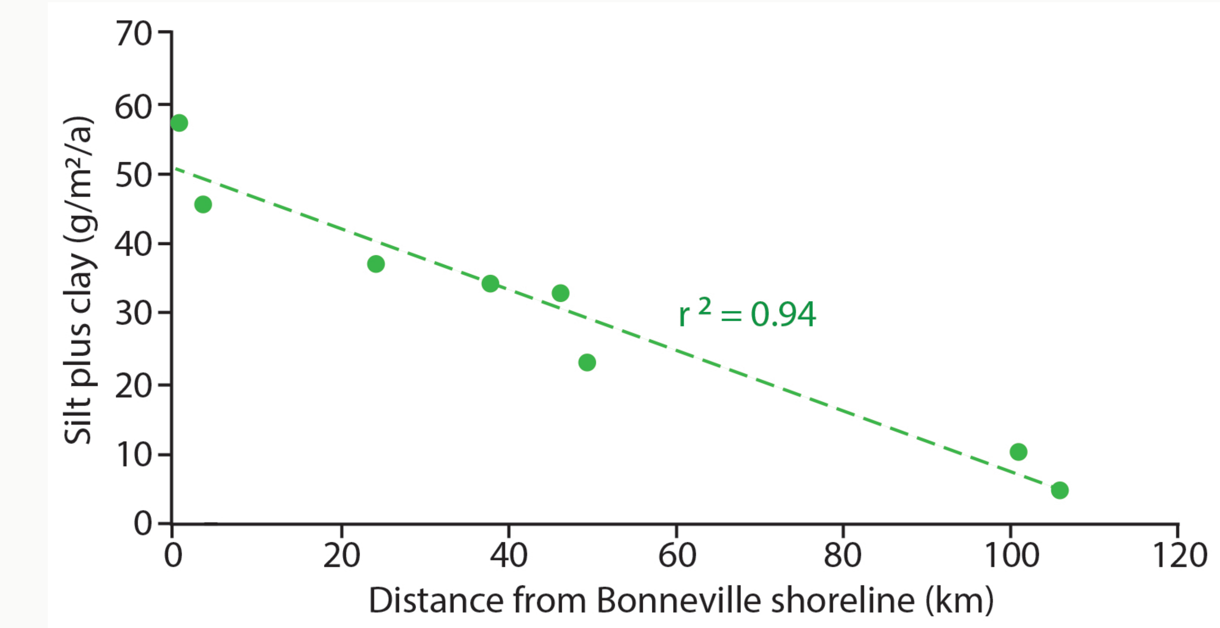

Figure 4. West-to-east decrease in the influx of silt and clay between Morgan Valley and moraines and fluvial surfaces in the northwestern Uinta Basin as measured in 8 dust traps (Fig. 1) placed on plywood sheets on the ground for 1-2 years (1981-1983).

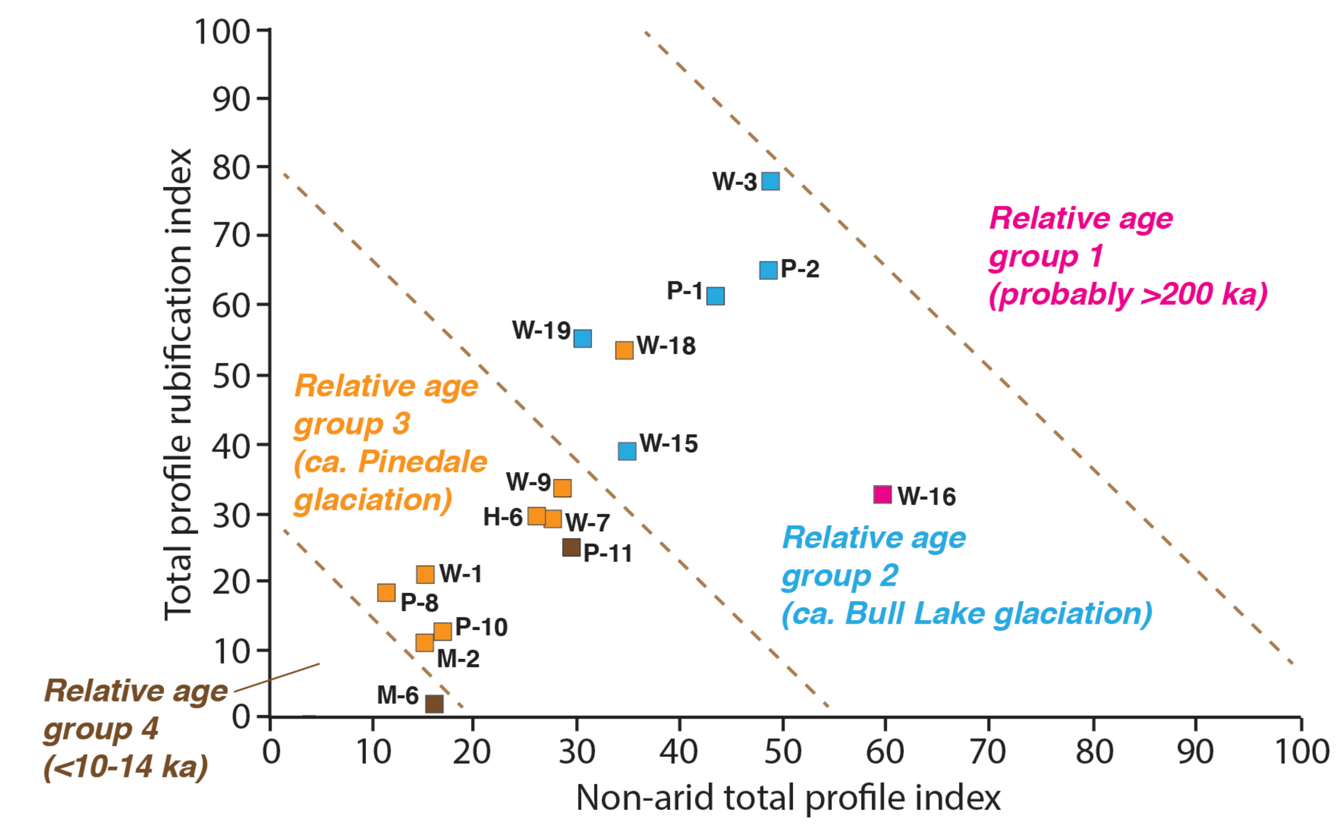

Figure 2. Total profile rubification index versus non-arid total profile index of Harden (1982) for 16 soils in the study area. Age control for these 16 soils consisted of direct association of deposits with moraines inferred to be of Pinedale (15-18 ka) or Bull Lake (130-150 ka) age, amino acid ratios on snails from deposits beneath soils, and, in one case, a radiocarbon age beneath a soil. All of the soil development indices of Harden (1982) and Harden and Taylor (1983) and g/cm² and g/cm³ clay and carbonate values for these 16 soils were compared using similar two-variable plots. The plots demonstrated the general age dependency of changes in color, textural, and structural properties and clay and carbonate accumulation, but no plot produced distinct, widely-separated groups of soils. The above plot provided groupings most consistent with our inferred ages.

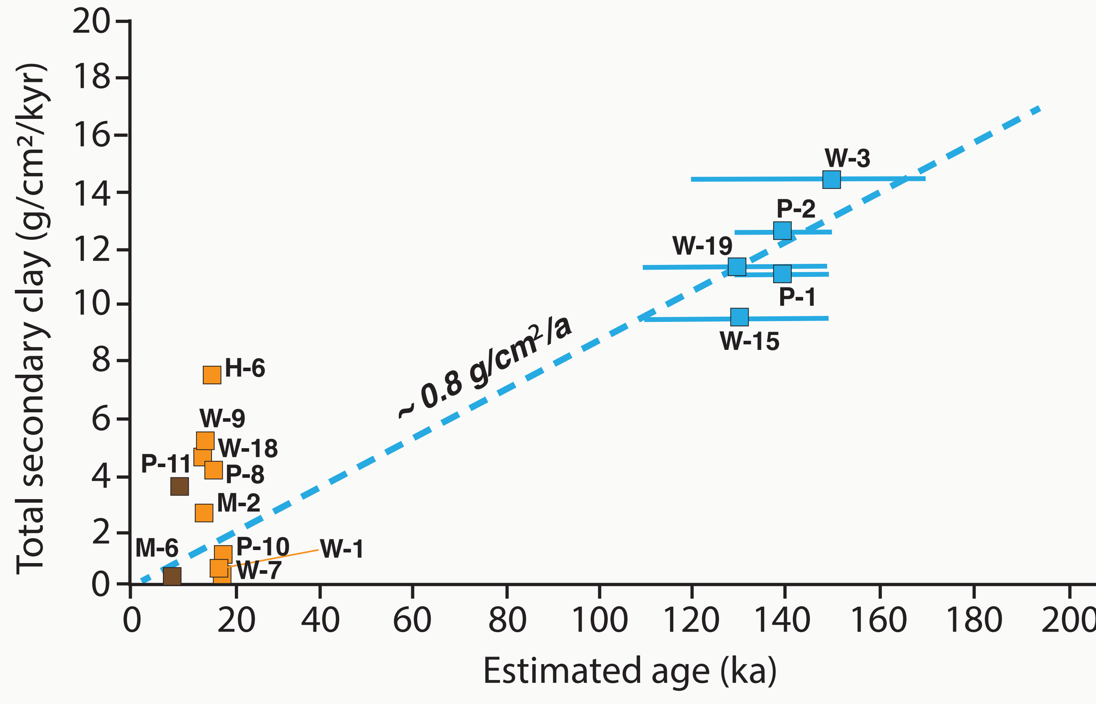

Figure 3. Total secondary clay versus estimated age for 15 soils in the study area whose ages we inferred from regional relative-age dating studies or nearby numerical ages (e.g., Table 1; Fig. 2). We estimate an average late Pleistocene rate of clay influx for the eastern Wasatch Mountains of 0.8 g/m²/a. But because clay accumulation is so variable in latest Pleistocene soils, using the average rate is problematic for estimating their ages.

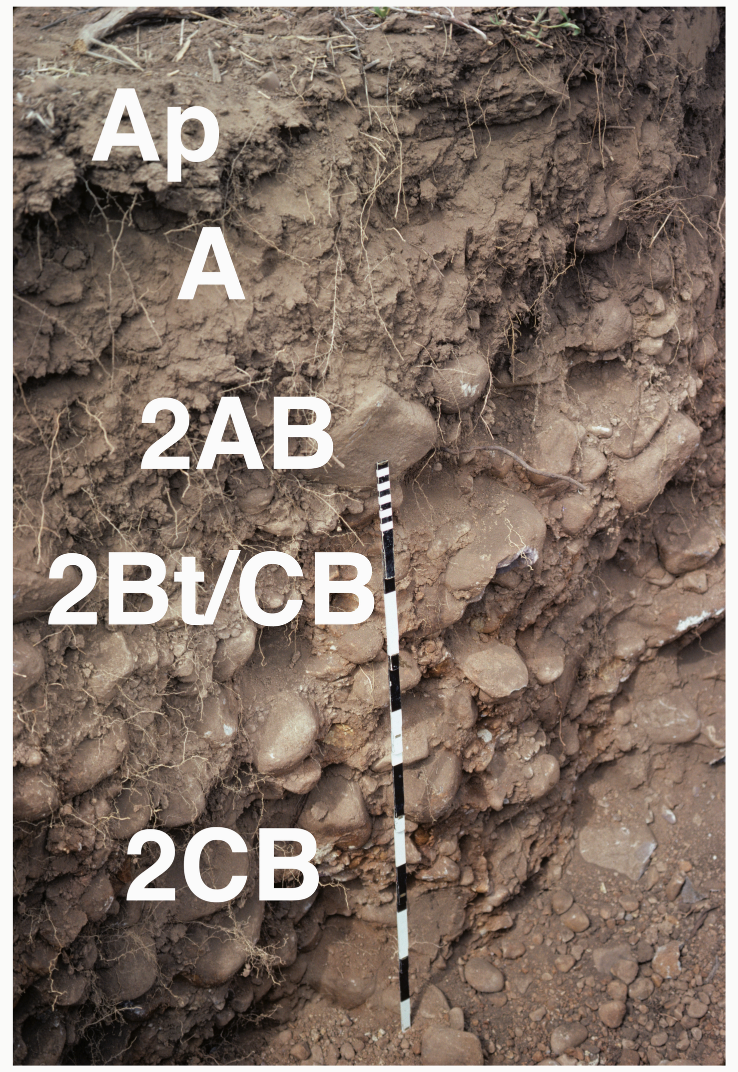

Figure 5. Soil pit site and soil profile PR-2 described on a Pinedale outwash terrace (lat 40.555°, long -111.176°) of relative age group 3 (Fig. 2) along the upper Provo River near the western end of the Uinta Mountains (Fig. 1). Parent materials consist of loess overlying coarse, cobbly outwash.

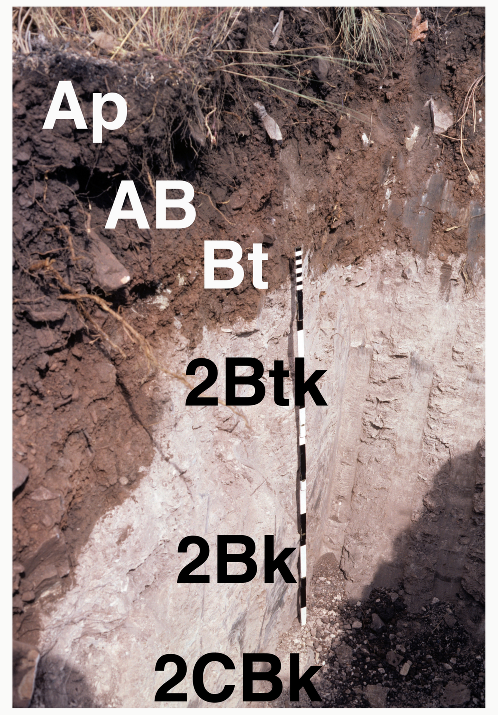

Figure 6. Soil pit site and soil profile KV-2 described on a high terrace remnant (lat 40.693°, long -111.256°) of relative age group 2 (Fig. 2) on the east side of Kamas Valley (Fig. 1). Parent materials consist of loess mixed with distal alluvial fan sediment.

Table 1. Selected soil development indices for soil profiles with inferred (correlatable) age control in the central Wasatch Mountains and western Uinta Basin

Soil profile	Regional climatic event	Relative age group	Estimated age (ka)	Age used (ka)	RUBIFICATION maximum horizon index	RUBIFICATION profile index	RUBIFICATION weighted mean pp	TEXTURE maximum horizon index	TEXTURE profile index	TEXTURE weighted mean pp	ARID profile index	ARID weighted mean pp	NON-ARID profile index	NON-ARID weighted mean pp	Grams/cm² clay	Grams/cm² carbonate	Grams/cm³ clay	Grams/cm³ carbonate
WR-1	Pinedale glaciation	3	15-25	18	13.2	20.6	0.11	11.1	15.3	0.08	9.0	0.05	15.2	0.08	0.90	0.000	0.008	0.000
WR-3	Bull Lake? glaciation	2	>=150	150	34.2	95.8	0.27	11.1	53.4	0.15	50.0	0.14	57.9	0.16	20.16	64.640	0.093	0.221
WR-7	Pinedale glaciation	3	15-25	18	19.2	27.4	0.17	8.1	8.1	0.05	11.4	0.07	19.4	0.12	0.51	0.000	0.000	0.000
WR-9	Bonneville-Provo lake fall	4	15	15	16.1	33.4	0.20	9.8	22.6	0.13	23.8	0.14	28.8	0.17	5.11	0.520	0.049	0.002
WR-15	Bull Lake? glaciation	2	60-140?	100	19.0	38.5	0.30	5.7	6.9	0.05	24.1	0.19	32.2	0.25	8.40	24.790	0.070	0.164
WR-16	pre-Bull Lake	1	>730?	730	16.2	30.8	0.23	92.5	234.4	1.71	82.3	0.60	89.1	0.65	12.87	1.470	0.089	0.022
WR-18	Bonneville-Provo lake fall	4	15	15	23.6	52.7	0.28	6.2	18.1	0.10	29.1	0.16	35.2	0.19	4.83	0.910	0.017	0.007
WR-19	Bull Lake? glaciation	2	>=150	150	12.6	54.5	0.21	-38.2	-48.9	-0.18	17.2	0.06	30.9	0.12	11.30	72.930	0.025	0.175
MV-2	Bonneville-Provo lake fall	4	15	15	2.5	10.7	0.07	58.0	74.8	0.48	22.2	0.14	15.0	0.10	2.69	19.060	0.016	0.105
MV-6	Altithermal?	5	<8	8	3.1	1.5	0.02	1.8	1.8	0.02	10.9	0.11	16.0	0.16	-0.10	7.170	-0.004	0.041
PR-1	Bull Lake? glaciation	2	60-140?	140	23.2	60.9	0.30	19.5	29.7	0.15	33.1	0.17	43.8	0.22	10.93	0.000	0.051	0.000
PR-2	Bull Lake? glaciation	2	60-140?	140	29.5	64.2	0.38	35.0	48.2	0.28	37.3	0.22	48.9	0.29	12.43	0.000	0.051	0.000
PR-8	Pinedale glaciation	3	15-25	18	7.9	18.1	0.21	3.3	8.4	0.10	6.0	0.07	11.3	0.13	1.35	0.000	0.021	0.000
PR-10	Pinedale glaciation	3	15-25	18	4.4	12.3	0.09	4.7	7.7	0.06	8.7	0.06	16.6	0.12	0.37	-0.060	0.000	0.000
PR-11	Holocene	5	<10	10	9.5	24.2	0.12	2.7	2.7	0.01	13.5	0.06	29.3	0.14	3.64	0.080	0.015	0.000
HV-6	Pinedale glaciation	3	15-25	18	13.9	28.9	0.18	9.2	19.5	0.12	17.5	0.11	26.2	0.16	8.60	14.650	0.060	0.036

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Ed Baltzer and Carol Krinsky of the Denver office of the USBR were an intergral part of the mapping of Quaternary deposits, trench siting, trench logging, and description of soil profiles over 5 years. Capable assistance in mapping and logging of trenches was also provided by Rebecca Stoneman and Karen Janowitz.

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