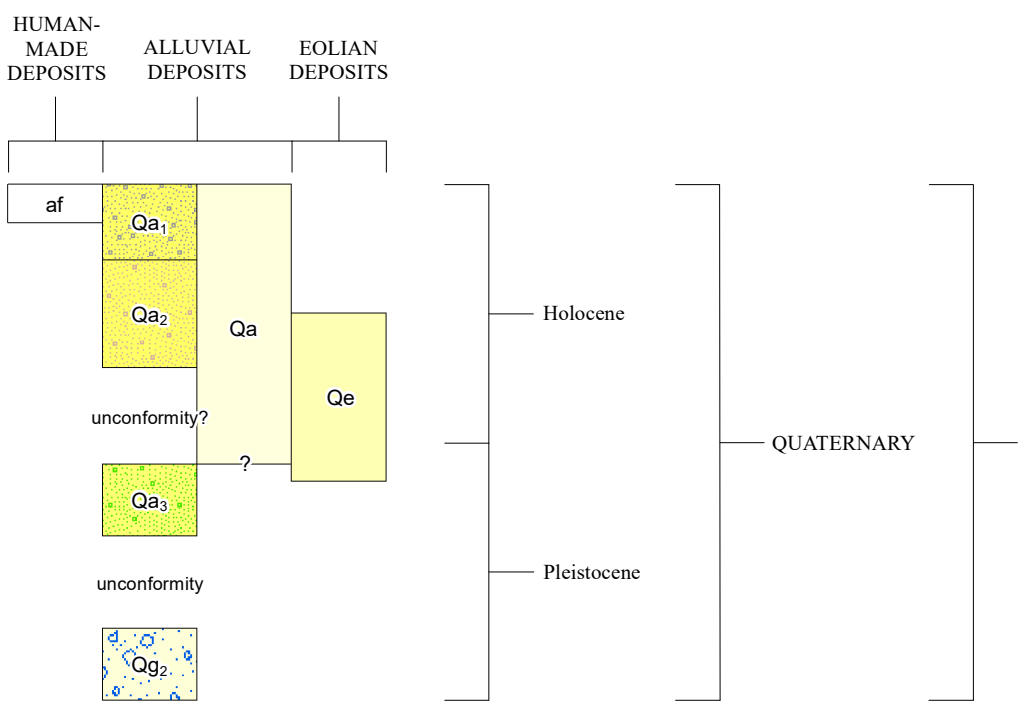
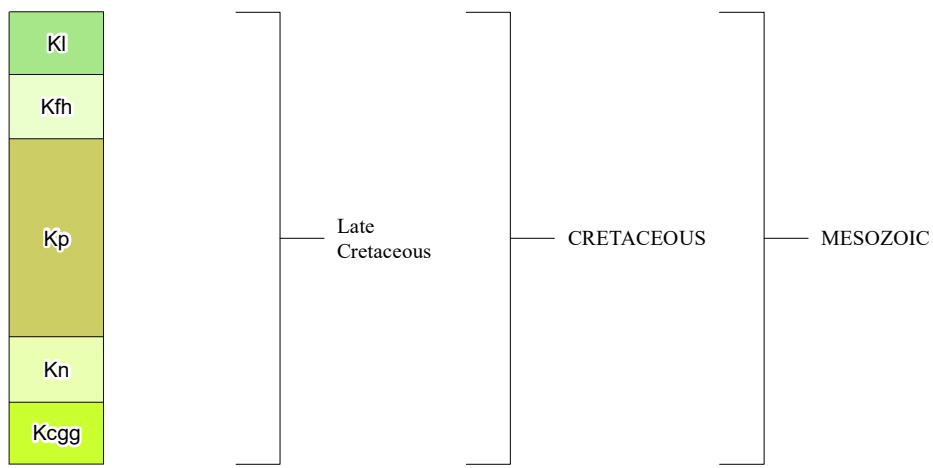


CORRELATION OF MAP UNITS
SURFICIAL DEPOSITS



BEDROCK UNITS



3-D OBLIQUE

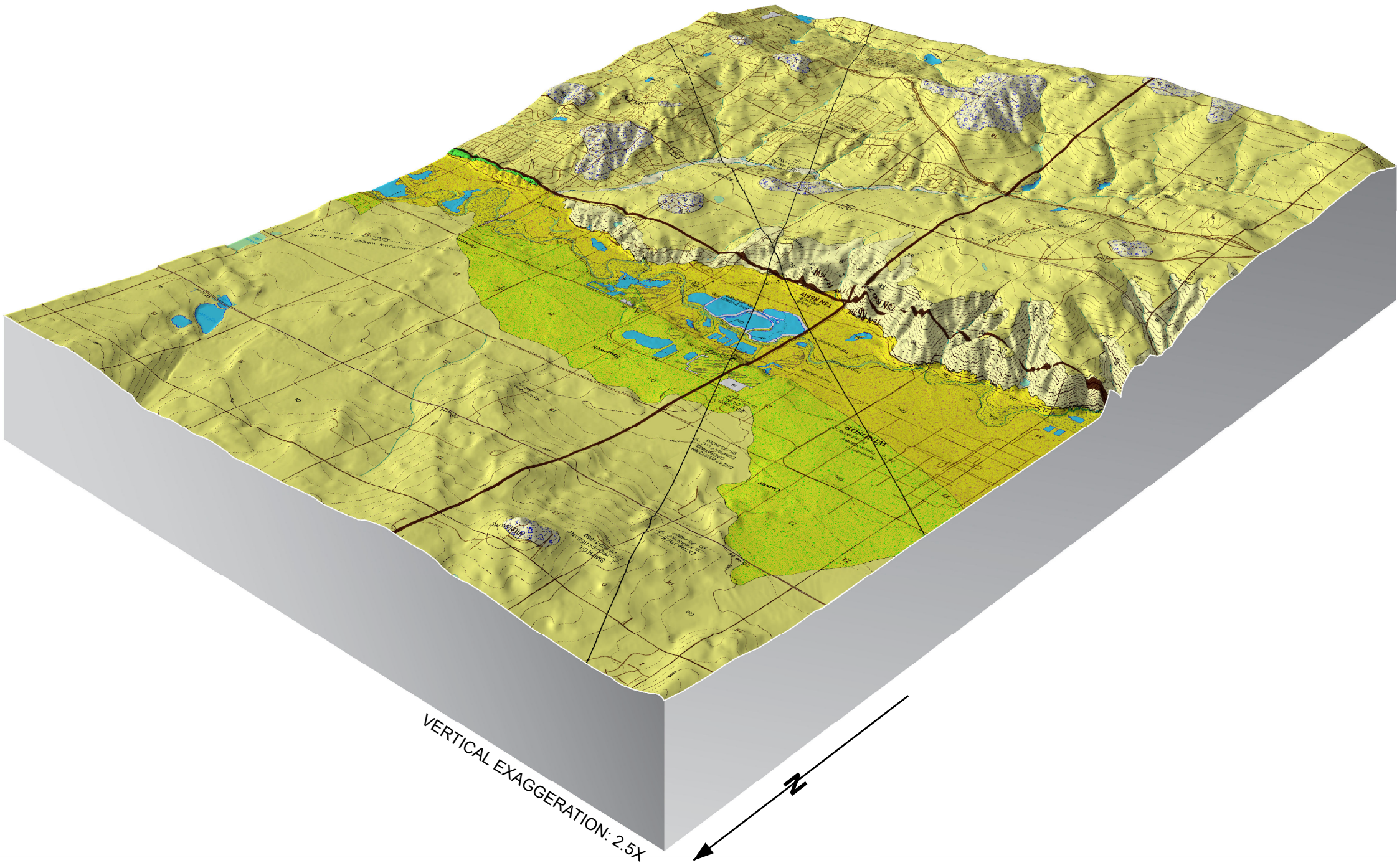


Table 1. Optically Stimulated Luminescence (OSL) age estimates.

Field Number	Lab Number ^a	Map Unit	Grain size (µm)	UTM Easting ^b	UTM Northing ^b	Latitude	Longitude	Approximate Depth (m below ground surface)	Aliquots ^c	Central/Minimum Age Model D _e (Gy) ^d	Over-dispersion (%) ^e	U (ppm) ^f	Th (ppm) ^f	K (%) ^f	Cosmic Dose rate (mGray/yr)	Dose Rate (mGray/yr) ^f	Central/Minimum Model SAR age (yr) ^g
BW064a	BG4852	Qa3	150-250	514424	4478017	40.4526	-104.8298	2.0	35/36	89.16 ± 7.11	32 ± 4	2.28 ± 0.01	9.09 ± 0.01	2.15 ± 0.01	0.221 ± 0.022	3.16 ± 0.10	28,225 ± 2350
BW064b	BG4853	Qa3	255-355	514424	4478017	40.4526	-104.8298	3.2	37/44	141.30 ± 5.88	21 ± 3	1.50 ± 0.01	4.85 ± 0.01	3.20 ± 0.01	0.194 ± 0.019	3.58 ± 0.10	39,600 ± 1940

^aAnalyses performed by Baylor University Geology Department

^bNorth American Datum (NAD) 1983, zone 13N

^cAliquots measured, used, and that defines lowest most D_e

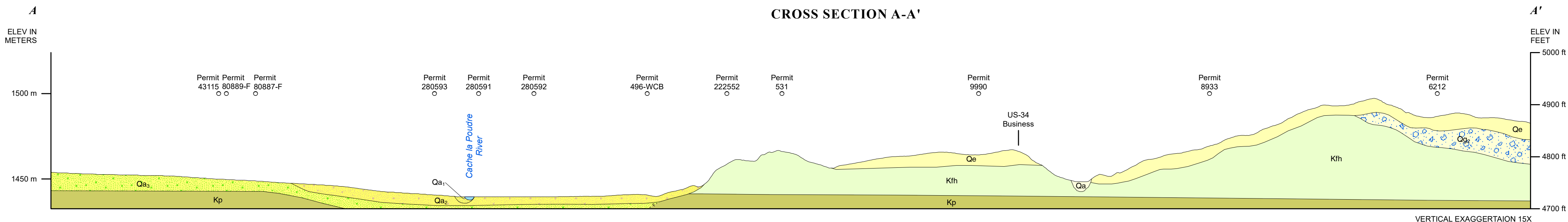
^dEquivalent dose calculated on a pure quartz fraction with ultra-small aliquots with 20-80 grains/aliquot and analyzed under blue-light excitation (470 ± 20 nm) by single Aliquot Regeneration protocols (SAR; Murray and Wintle, 2003; Wintle and Murray, 2006). Equivalent dose (D_e) was calculated by the Finite Mixture Model (Galbraith and Green, 1990) and the four parameter Minimum Age Model (Galbraith and Roberts, 2012).

^eOverdispersion values reflects precision beyond instrumental errors; values of ≤ 25% (at 1 sigma limit) indicate low dispersion in equivalent dose values and defines a unimodal distribution. Values > 25% are associated with mixed equivalent dose signature reflecting multiple grain populations or partial solar resetting.

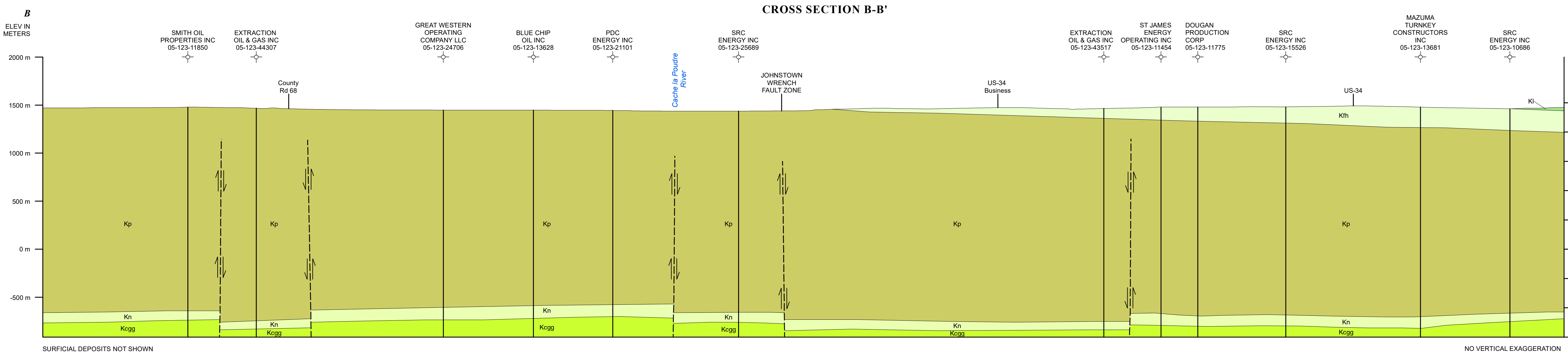
^fU, Th, Rb and K content analyzed by inductively-coupled plasma-mass spectrometry by ALS Laboratories, Reno, NV; and includes dose contribution from Rb and an assumed moisture content of 10 ± 3% for the burial period.

^gCosmic dose rate calculated from parameters in Prescott and Hutton (1994) and includes soft components. Systematic and random errors calculated in a quadrature at one standard deviation by the Luminescence Dating and Age Calculator (LDAC) at <https://www.baylor.edu/geosciences/index.php?id=962356> (Peng and Forman, 2019). Datum year is AD 2010.

CROSS SECTION A-A'



CROSS SECTION B-B'



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REFERENCES

Birkeland, P.W., 1999, Soils and geomorphology: New York, Oxford University Press, 430 p.

Cole, J.C., and Braddock, W.A., 2009, Geologic map of the Estes Park 30' x 60' quadrangle, north-central Colorado: U.S. Geological Survey Scientific Investigations Map 3039, 1 sheet, scale 1:100,000, pamphlet, 56 p.

Colorado Division of Water Resources, 2019, Well Permit Search, accessed July 2019 at URL <https://dwr.state.co.us/Tools/WellPermits>

Colton, R.B., 1978, Geologic map of the Boulder-Fort Collins-Greeley area, Colorado: U.S. Geological Survey Geologic Investigations Series I-855-G, scale 1:100,000.

Dechesne, Marieke, Raynolds, R.G., Barkmann, P.E., and Johnson, K.R., 2011, Notes on the Denver Basin Geologic Maps: Bedrock Geology, Structure, and Isopach Maps of the Upper Cretaceous to Paleogene Strata between Greeley and Colorado Springs, Colorado: Colorado Geological Survey Open-File Report 11-01.

Federal Emergency Management Agency (FEMA), 2020, National Flood Hazard Layer (NFHL), accessed January 2020 at URL <https://www.fema.gov/national-flood-hazard-layer-nfhl>.

Fenneman, N.M., 1931, Physiography of western United States: New York, McGraw-Hill Book Co., 534 p.

Forman, S.L., Oglesby, R., Markgraf, V., and Stafford, T., 1995, Paleoclimatic significance of late Quaternary eolian deposition on the Piedmont and High Plains, central United States: Global and Planetary Change, v. 11, p. 35-55.

Galbraith, R.F., and Green, P.F., 1990, Estimating the component ages in a finite mixture: International Journal of Radiation Applications and Instrumentation v. 17, p. 197-206.

Galbraith, R.F., and Roberts, R.G., 2012, Statistical aspects of equivalent dose and error calculation and display in OSL dating: An overview and some recommendations: Quaternary Geochronology v. 11, p. 1-27.

Globe, 2005, The Globe Soil Color Book: A Pocket Guide for the Identification of Soil Colors. Visual Color Systems, 41 p.

Howard, A.K., 1986, Soil Classification Handbook: Unified Soil Classification System. Bureau of Reclamation, Geotechnical Branch, Division of Research and Laboratory Services, Denver, Colorado

Hunt, C.B., 1954, Pleistocene and Recent Deposits in the Denver Area, Colorado: U.S. Geological Survey Bulletin 996-C, p. 91-140.

Keller, S.M., Lindsey, K.O., and Morgan, M.L., 2017, Geologic Map of the Berthoud quadrangle, Larimer, Weld, and Boulder Counties, Colorado: Colorado Geological Survey Open-File Report 17-03, scale 1:24,000.

Keller, S.M., and Morgan, M.L., 2020, Geologic Map of the Greeley quadrangle, Weld County, Colorado: Colorado Geological Survey Open-File Report 20-05, scale 1:24,000.

Kellogg, K.S., Shroba, R.R., Bryant, B., and Premo, W.R., 2008, Geologic map of the Denver West 30' x 60' quadrangle, north-central Colorado: U.S. Geological Survey Scientific Investigations Map 3000, 1:100,000, scale.

Leonard, E.M., 2002, Geomorphic and tectonic forcing of late Cenozoic warping of the Colorado Piedmont: Geology v. 30, no. 7, p. 595-598.

Macchettie, M.N., 1985, Calcic Soils of the Southwestern United States *in* Soils and Quaternary Geology of the Southwestern United States, D.L. Weide and M.L. Faber, eds. Geological Society of America Special Paper vol. 203, p. 1-21.

Madole, R.F., 2016, Geologic map of the Longmont quadrangle, Boulder and Weld Counties, Colorado: Colorado Geological Survey Open File Report 15-16, scale 1:24,000.

Madole, R.F., 2005, Distribution of Late Quaternary wind-deposited sand in eastern Colorado: U.S. Geological Survey Scientific Investigations Map 2875, 1 sheet, 1 report.

Madole, R.F., 1991, Colorado Piedmont Section, *in* Wayne, W.J., ed., Quaternary geology of the northern Great Plains, Chapter 15 *in* Morrison, R.B., ed., Quaternary nonglacial geology – Conterminous United States: Geological Society of America, The Geology of North America, v. K-2, p. 456-462.

Madole, R.F., 1986, Lake Devlin and Pinedale glacial history, Front Range, Colorado: Quaternary Research, v. 25, p. 45-54.

Madole, R.F., and Shroba, R.R., 1979, Till sequence and soil development in the North St. Vrain drainage basin, east slope, Front Range, Colorado, *in* Ehrlidge, F.G., ed., Northern Front Range and northwest Denver Basin, Colorado: Geological Society of America Field Guide, Rocky Mountain Section, Field Trip 3, p. 123-178.

Muhs, D.R., Cattle, S.R., Crouvi, O., Rousseau, D-D., Sun, J., and Zarate, M.A., 2014, Loess Records, *in* Knipptertz, P., Stuut, J-B.W., eds., Mineral Dust. Springer Netherlands, Dordrecht, p. 411-441.

Muhs, D.R., Aleinikoff, J.N., Stafford, T.W., Jr., Kihl, Rolf, Been, J., Mahan, S.A., and Cowherd, S.D., 1999, Late Quaternary loess in northeastern Colorado – Part I, Age and paleoclimatic significance: Geological Society of America Bulletin, v. 111, p. 1861-1875.

Muhs, D.R., Stafford, T.W., Cowherd, S.D., Mahan, S.A., Kihl, Rolf, Maat, P.B., Bush, C.A., and Nehring, J., 1996, Origin of late Quaternary dune fields of northeastern Colorado: Geomorphology, v. 17, p. 129-149.

Murray, A.S., and Wintle, A.G., 2003, The single aliquot regenerative dose protocol: potential for improvements in reliability: Radiation Measurements v. 37, p. 377-381.

Nelson, A.R., Millington, A.C., Andrews, J.T., and Nichols, H., 1979, Radiocarbon-dated upper Pleistocene glacial sequence, Fraser Valley, Colorado Front Range: Geology, v. 7, p. 410-414.

Palkovic, M.J., Lindsey, K.O., and Morgan, M.L., 2019, Geologic Map of the La Salle quadrangle, Weld County, Colorado: Colorado Geological Survey Open-File Report 19-03, scale 1:24,000.

Palkovic, M.J., Lindsey, K.O., and Morgan, M.L., 2018, Geologic Map of the Milliken quadrangle, Weld County, Colorado: Colorado Geological Survey Open-File Report 18-02, scale 1:24,000.

Peng, L., and Forman, S.L., 2019, LDAC: An Excel-based program for luminescence equivalent dose and burial age calculations. Ancient TL v. 37, p. 21-40.

Prescott, J.R., and Hutton, J.T., 1994, Cosmic ray contributions to dose rates for luminescence and ESR dating: Large depths and long-term time variations: Radiation Measurements v. 23, p. 497-500.

Schwachow, S.D., Shroba, R.R., and Wicklein, P.C., 1974, Atlas of Sand, Gravel, and Quarry Aggregate Resources Colorado Front Range Counties: Colorado Geological Survey Special Publication 5-B.

Scott, G.R., and Lindvall, R.M., 1970, Geology of new occurrences of Pleistocene bison and peccaries in Colorado: U.S. Geological Survey Professional Paper 700-B, p. B141-B149.

Smith, J.J., Layzell, A.L., Lukens, W.E., Morgan, M.L., Keller, S.M., Martin, R.A., and Fox, D.L., 2016, Getting to the bottom of the High Plains aquifer – New insights into the depositional history, stratigraphy, and paleoecology of the Cenozoic High Plains *in* Keller, S.M., and Morgan, M.L., eds., Unfolding the geology of the West: Geological Society of America Field Guide 44, p. 93-124, doi:10.1130/2016.0044(04).

Weimer, R.J., 1996, Guide to the petroleum geology and Laramide orogeny, Denver Basin and Front Range, Colorado: Colorado Geological Survey Bulletin 51, 127 p.

Wintle, A.G., and Murray, A.S., 2006, A review of quartz optically stimulated luminescence characteristics and their relevance in single-aliquot regeneration dating protocols: Radiation Measurements v. 41, p. 369-391.

Workman, J.B., Cole, J.C., Shroba, R.R., Kellogg, K.S., and Premo, W.R., 2018, Geologic map of the Fort Collins 30' x 60' quadrangle, Larimer and Jackson Counties, Colorado, and Albany and Laramie Counties, Wyoming: U.S. Geological Survey Scientific Investigations Map 3399, pamphlet 83 p., scale 1:100,000, <https://doi.org/10.3133/sim3399>.

GEOLOGIC MAP OF THE BRACEWELL QUADRANGLE, WELD COUNTY, COLORADO
CORRELATION OF MAP UNITS, 3-D OBLIQUE, GEOLOGIC HISTORY, GROUNDWATER AND MINERAL RESOURCES, AND CROSS SECTIONS

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2020