U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

A SPATIAL DATABASE OF BEDDING ATTITUDES

Compiled By

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to accompany

GEOLOGIC MAP OF BOULDER-FORT COLLINS-GREELEY AREA, COLORADO

By

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Base from U.S. Geological Survey, Digital Line Graphs (PLSS and Hypsography), 1995
County boundaries from Colorado Department of Local Affairs, 2001
Major highways and roads from NTAD 2001, U.S. Department of Transportation

Universal Transverse Mercator projection, zone 13, 1927 North American Datum

Geology compiled in 1976
Spatial database by Theodore R. Brandt and Kyle E. Murray
Digital cartography by Theodore R. Brandt
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This digital map shows bedding attitude data displayed over the geographic extent of rock stratigraphic units (formations) as compiled by Colton in 1976 (U.S.Geological Survey Map I-855-G) under the Front Range Urban Corridor Geology Program. Colton used his own mapping and published geologic maps having varied map unit schemes to compile one map with a uniform classification of geologic units. The resulting published color paper map was intended for planning for use of land in the Front Range Urban Corridor. In 1997-1999, under the USGS Front Range Infrastructure Resources Project, Colton's map was digitized to provide data at 1:100,000 scale to address urban growth issues (see cross-reference). In general, the west part of the map shows a variety of Precambrian igneous and metamorphic rocks, major faults and brecciated zones along an eastern strip (5-20 km wide) of the Front Range. The eastern and central part of the map (Colorado Piedmont) depicts a mantle of Quaternary unconsolidated deposits and interspersed Cretaceous or Tertiary-Cretaceous sedimentary rock outcrops. The Quaternary mantle is comprised of eolian deposits (quartz sand and silt), alluvium (gravel, sand, and silt of variable composition), colluvium, and few landslides. At the mountain front, north-trending, dipping Paleozoic and Mesozoic sandstone and shale formations (and sparse limestone) form hogbacks, intervening valleys, and in range-front folds, anticlines, and fault blocks. Localized dikes and sills of Tertiary rhyodacite and basalt intrude rocks near the range front, mostly in the Boulder area.

This digital map can serve various purposes. It shows potential shallow aquifers and rock units that are suitable for waste disposal, and aggregate mining, for example. The map distinguishes rock units that are somewhat predictable in physical properties and mineral content, making the map useful in planning for urban growth and zoning. Ideally, qualified experts can use the map to make derivative maps that show the suitability of rock units for various uses by man.

DESCRIPTION OF MAP UNITS

ARTIFICIAL FILL—Only large rock and earth fills shown

POST-PINEY CREEK ALLUVIUM (UPPER HOLOCENE)—Dark-gray humic, sandy to gravelly alluvium. Underlies flood plains of major streams and terraces less than 3 m above stream level. Thickness is from 2-5 m

TALUS (UPPER HOLOCENE TO PLEISTOCENE)—Slide rock at the bases of cliffs. Locally as much as 9 m thick

COLLUVIUM (UPPER HOLOCENE TO PLEISTOCENE)—Bouldery to pebbly sandy silt and clay deposited by gravity and sheet wash on slopes. May contain and interfinger with alluvium of various ages. Thickness as much as 7.5 m but generally not more than 1.5 m

EOLIUM* (WINDBLOWN CLAY, SILT (LOESS), SAND, AND GRANULES) (UPPER HOLOCENE TO BULL LAKE GLACIATION)—Light-brown to reddish-brown to olive-gray deposits of windblown clay, silt, sand, and granules mainly as sand dunes in the east half of the area but also as a blanket of loess between the Front Range and the South Platte River. Loess is as much as 4.5 m thick but generally is less than 1 m thick; sand dunes are as much as 15 m thick but generally are less than 4.5 m thick.
*New term introduced here to include deposits of windblown silt (loess) and wind-drifted sand (dunes) granules, and pebbles and gradations between

LANDSLIDE DEPOSITS (HOLOCENE TO PLEISTOCENE)—Slumps, rockfalls, and earthflows that range from active to inactive. Size of material in deposits ranges from clay and silt to blocks a meter or two in diameter

PINEY CREEK ALLUVIUM (UPPER HOLOCENE)—Dark-gray humic sandy to gravelly alluvium containing organic matter. Underlies terraces whose surfaces are 3-6 m above a nearby flood plain. Areas underlain by this formation along the South Platte River were partly flooded in 1965 and again in 1973

BROADWAY ALLUVIUM (PINEDALE GLACIATION, PLEISTOCENE)—Sand and gravel deposited by the South Platte River and its tributaries. Well-sorted and well-stratified; average size distribution is 50% sand, 25% granules and 25% pebbles. Terrace surfaces are about 13 m above major streams near the Front Range and 6 m above near Greeley. Locally, map unit includes some Louviers Alluvium. Along tributaries the Broadway Alluvium is 3-5 m thick. Along the South Platte River Broadway and Louviers Alluviums are as much as 38 m thick, but averages only 11 m

LOUVIERS ALLUVIUM (BULL LAKE GLACIATION, PLEIS-TOCENE)—Reddish-brown pebbly to bouldery well stratified alluvium along perennial streams and sandy to clayey alluvium along intermittent streams. Terrace surface is about 21 m above major streams near mountains but deposit is buried by Broadway Alluvium along South Platte River

SLOCUM ALLUVIUM (SANGAMON INTERGLACIATION OR ILLINOIAN GLACIATION, PLEISTOCENE)—Brown to white cobble and boulder gravel as much as 6 m thick. Most clasts are well-rounded igneous and metamorphic rocks; some are sedimentary; most are weathered and have thin rinds of calcium carbonate. Upper surface of deposits is generally 30-40 m above major streams—less in the northeast corner of area

VERDOS ALLUVIUM (YARMOUTH INTERGLACIATION OR KANSAN GLACIATION, PLEISTOCENE)—Brown sand and gravel (in part boulder gravel). Pebbles, cobbles, and boulders are weathered and partly decomposed. Upper 1 m consists of fine- to coarse-grained flood-plain and eolian deposits; well-developed Brown soil profile. At most localities, upper part of soil profile has been truncated and Cca (calcium carbonate enriched or caliche) horizon is near the surface. Secondary calcium carbonate fills interstices and coats all stones. Most stones are granite, gneiss, or schist; some are quartzite, sandstone and limestone. Deposits are as much as 6 m thick but generally are 3-4.5 m thick. Upper surfaces of deposits are generally 60-75 m above major streams but are less in northeast part of area

ROCKY FLATS ALLUVIUM (AFTONIAN INTERGLACIATION OR NEBRASKAN GLACIATION, PLEISTOCENE)—Brown to white, coarse, poorly sorted, poorly to well-stratified gravel. Maximum diameter of clasts is about 0.3 m. Clasts mostly of rounded granite, granodiorite, tonalite, gneiss, schist, and quartzite; subordinate sandstone and limestone. Deposit is as much as 3 m thick but generally less. Thick layers of secondary calcium carbonate occur in deposit. Upper surface of deposits is generally about 100 m above local major streams near mountains but is only about 73 m above streams in northeast part of area

PRE-ROCKY FLATS ALLUVIUM (NEBRASKAN(?) GLACIATION, PLEISTOCENE)—Brown to white cemented gravel and sand 1-2 m thick capping Gunbarrel Hill. Approximately 38% of the clasts are sandstone, 37% are pegmatite, 8% are gneiss, 7% are quartzite, 5% are shoshonite, and 5 % are amphibolite. Size analyses indicate that 44% is sand, 8% granules, and 48% pebbles and cobbles. Maximum diameter of clasts is about 13 cm; weathered pegmatitic and biotitic clasts crumble. Upper surfaces of gravel deposits are 103-115 m above local major streams

BOULDER DEPOSITS (PLIOCENE?)—Boulder and cobble gravel deposits composed mostly of weathered clasts of pegmatite and tonalite. Thickness unknown but might be as much as 10 m

QUARTZ MONZONITE (EOCENE)—Fine- to medium-grained, biotite-hornblende quartz monzonite; small irregular intrusive bodies and stocks. Radiometric age (Marvin, Young, Mehnert and Naeser, 1974, p. 11 (no. 69)) is 45.4±1 Ma or 50.6±7.1 Ma

RHYODACITE AND BASALT (PALEOCENE)—Rhyodacite in sills between Lyons and Boulder is light-gray, very fine grained felsite and felsite porphyry. Sills are as much as 46 m thick, but most are about half that. Radiometric age (Larson and Hoblitt, 1973, p. 3) of Flagstaff Mountain sill is 64.6±2.4 Ma. The Valmont dike (east of Boulder) is thought to be a medium-grained holocrystalline basalt, basaltic andesite, mafic latite, or alkalic basalt (according to Larson and Hoblitt, 1973) or shoshonite (according to Trimble, 1975). The dike is 6-12 m wide and nearly vertical; magnetic surveys indicate it is about 8 km long

DENVER (PALEOCENE AND UPPER CRETACEOUS) AND ARAPAHOE (UPPER CRETACEOUS) FORMATIONS—Olive-gray claystone and siltstone interbedded with tuffaceous sandstone and conglomerate. Weathered sandstone and conglomerate contain montmorillonite and related expanded clay minerals. Thickness at least 170 m

LARAMIE FORMATION (UPPER CRETACEOUS)—Upper part, 185-210 m thick, is mostly gray claystone, shale, sandy shale, and scattered lenticular beds of sandstone and lignite. Lower part, about 25-38 m thick, is light-gray to light yellowish-gray sandstone and sandy shale interbedded with clay, shale, and several beds of coal

FOX HILLS SANDSTONE (UPPER CRETACEOUS)—Upper part of formation consists of crossbedded tan sandstone. Grades downward into brown, fine-grained silty sandstone interbedded with gray fissile shale. Locally it may contain a thin coal bed. Thickness about 92 m to 152 m

PIERRE SHALE, UNDIFFERENTIATED (UPPER CRETACEOUS)—This formation has been subdivided into the follow members on the basis of lithology and stratigraphic position: (adopted from Scott and Cobban, 1965)

Upper transition member—Friable sandstone, soft shaly sandstone containing thin-bedded sandy shale and large calcareous sandstone concretions. The member is about 620 m thick

Upper shale member—Gray concretionary silty shale. Thickness about 865 m

Richard Sandstone Member, unnamed shale member, Larimer Sandstone Member, unnamed shale member, and Rocky Ridge Sandstone Member. Sandstones of these members pinch out in eastern and southern part of area. Richard Sandstone Member consists of pale-brown clayey micaceous siltstone and sandstone; the Larimer Sandstone Member is a hard to soft yellowish-brown sandstone; the Rocky Ridge Sandstone Member is a light-brown fine- to medium-grained glauconitic sandstone. Thickness of unit varies from 71-161 m

Middle shale member—Claystone and sandy siltstone; about 450 m thick. Map unit includes Terry Sandstone member (not mapped) near middle; about 18.5 m thick

Hygiene Sandstone Member—An upper, hard, glauconitic, ridge-forming sandstone separated from a lower friable sandstone by a shale. Member is 185-242 m thick. Pinches out in eastern and thins in southern part of area

Lower shale member—Consists of Mitten Black Shale Member, Sharon Springs Member, and Gammon Ferruginous Member; these three members are mostly dark olive-gray bentonitic shale. Thickness about 500 m

NIOBRARA FORMATION (UPPER CRETACEOUS)—Total thickness about 115 m at Boulder, 79 m near Ft. Collins, and 124 m near Greeley. Consists of two members

Smoky Hill Shale Member—Grayish-orange to grayish-yellow chalky shale and chalky limestone. About 110 m thick near Boulder and 70 m thick near Ft. Collins

Fort Hays Limestone Member—Gray, hard, thickbedded fossiliferous limestone containing thin silty shale and bentonite layers near the middle. About 6-11 m thick

CARLILE SHALE, GREENHORN LIMESTONE AND GRANEROS SHALE—Total thickness 140-150 m in Boulder area, 165 m in the Ft. Collins area, 180 m near Loveland, and 106 m near Milliken

Carlile Shale (Upper Cretaceous)—Olive-gray silty claystone and sandy siltstone; about 23 m thick

Greenhorn Limestone (Upper Cretaceous)—Interlayered dark-gray limestone and olive-gray calcareous silty claystone and siltstone; about 80 m thick

Graneros Shale (Upper and Lower Cretaceous)—Dark-gray to grayish-black siltstone and claystone; about 49 m thick

DAKOTA GROUP (LOWER CRETACEOUS)—Total thickness about 88 m near Ft. Collins, 84 m near Boulder, and 81 m near Milliken. Consists of two formations

South Platte Formation—Light- to dark-gray well-sorted fine-grained cross-stratified and ripple-laminated sandstone, siltstone, and gray carbonaceous shale. Thickness about 69 m

Lytle Formation—Yellowish-gray conglomeratic sandstone containing pebbles of chert and quartzite. About 16 m thick

MORRISON, CANYON SPRINGS MEMBER OF SUNDANCE AND JELM FORMATIONS

Morrison Formation (Upper Jurassic)—Upper part of unit is brown sandy marly shale underlain by red and gray shale with beds of silty limestone. Lower part is fine- to medium-grained sandstone 3-4.5 m thick underlain by dark greenish-gray impure limestone and marlstone beds and interbedded with marly shales. Thickness and lithology variable but in the Lyons area is about 77 to 92 m thick and consists of 60% shale, 25% limestone and marl, and 15% sandstone

Canyon Springs Member of Sundance Formation (Upper Jurassic)—Light-pink to grayish-white, crossbedded, fine-grained, well-sorted sandstone; about 9 m thick at Boulder and Lyons but only 4.5 m thick near Ft. Collins

Jelm Formation (Upper Triassic)—Pinkish-gray, conspicuously jointed crossbedded fine- to medium-grained sandstone; about 6 m thick near Lefthand Creek, 18 m thick near Lyons, 29 m thick near Boulder, 40 m thick near Masonville, and 35 m thick near Greeley

LYKINS FORMATION (TRIASSIC AND PERMIAN)—Total thickness about 205 m. Consists of following members:

Stain Shale Member of LeRoy (1946)—Maroon or reddish-brown shale and siltstone. Thickness 150 m at Boulder and 92 m at Masonville

Forelle Limestone Member—Yellowish-brown and yellowish-gray finely laminated wavy folded limestone 2.4-5 m thick

Bergen Shale, Falcon Limestone, and Harriman Shale Members of LeRoy (1946)—Moderate reddish-brown thin-bedded silty shale (predominant) and limestone (subordinate) about 46 m thick

LYONS SANDSTONE (PERMIAN)—Moderate-orange, pink to pinkish-gray, fine- to medium-grained, firmly cemented, well-sorted, cross-stratified, quartzose sandstone; about 77 m thick in Boulder area, 108 m in Lyons quadrangle, but only 6 m thick northwest of Ft. Collins; at Greeley it is about 31 m thick

SATANKA AND INGLESIDE FORMATIONS (PERMIAN)—Mapped together north of Little Thompson River

Santanka Formation—Red siltstone and fine-grained thin-bedded ripple-laminated sandstone. About 69 m thick near Masonville; 67 m thick near Milliken but thins southward along the Front Range and pinches out near the canyon of the Little Thompson River

Ingleside Formation—Red calcareous fine- to medium-grained well-sorted crossbedded sandstone. Thickness about 35 m near Masonville; thins southward and pinches out a few kilometers south of Lyons

INGLESIDE FORMATION—Mapped separately south of Little Thompson River (described above)

FOUNTAIN FORMATION (PERMIAN AND PENNSYLVANIAN)—Moderate reddish-brown, iron oxide stained, interstratified arkosic conglomerate and moderately coarse-grained, feldspathic sandstone containing thin layers of dark reddish-brown to purplish shale; thickness varies from 210-480 m. Measured section near Lyons consists of 53% sandstone, 37% siltstone, 10% conglomerate, and a few thin beds of limestone

SILVER PLUME QUARTZ MONZONITE (PRECAMBRIAN Y)—Pale yellowish-orange to pale reddish-gray, equigranular, fine- to medium-grained, biotite-muscovite quartz monzonite; some outcrops are gray to tan, medium- to coarse-grained porphyritic quartz monzonite that contains tabular microcline phenocrysts; commonly shows trachytoid flow structure. Composed of microcline, plagioclase, quartz, and subordinate biotite and muscovite

PEGMATITE (PRECAMBRIAN Y OR X)—Coarse-grained pegmatite which forms concordant to irregular discordant tabular or dike-like bodies that are mostly unzoned. Composed of feldspar, quartz, muscovite, and minor biotite. May be related in age to the Boulder Creek Granodiorite and to the Silver Plume Quartz Monzonite

BOULDER CREEK GRANODIORITE (PRECAMBRIAN X)—Light- to dark-gray medium- to coarse-grained gneissic granodiorite commonly forming concordant bodies; composed of quartz, calcic oligoclase or andesine, orthoclase, biotite and hornblende

TONALITE (PRECAMBRIAN X)—Light-gray quartz diorite consisting of plagioclase (predominant), quartz, and (subordinate) hornblende or biotite or both. Varies from medium-grained and equigranular to very fine-grained and porphyritic; nonfoliated

METASEDIMENTARY ROCKS (PRECAMBRIAN X)—Mineralogic composition varies with grade of metamorphism. Muscovite, quartz, plagioclase, and biotite are common; chlorite, tourmaline, garnet, staurolite, andalusite, microcline, and sillimanite may be present

Quartzofeldspathic schist and gneiss interbedded with mica schist and gneiss—Contains thin beds of knotted mica schist and granule to pebble metaconglomerate

Knotted mica schist—Characterized by porphyroblasts of staurolite and andalusite or by knots of sillimanite. Locally contains thin beds of granule to pebbly metaconglomerate and quartzofeldspathic schist

Porphyroblastic biotite schist—Characterized by abundant porphyroblasts of coarse biotite

AMPHIBOLITE (PRECAMBRIAN X)—Dark-gray to black, well- to poorly-foliated rock composed of hornblende, quartz, and plagioclase; locally contains layers or pods of calc-silicate gneiss

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