OPEN-FILE REPORT 03-06

Geologic Map of the Black Forest Quadrangle, El Paso County, Colorado

By Jon P. Thorson

DOI: https://doi.org/10.58783/cgs.of0306.mxso5099

Colorado Geological Survey
Division of Minerals and Geology
Department of Natural Resources
Denver, Colorado
2003

FOREWORD

The purpose of Colorado Geological Survey Open File Report 03-1, *Geologic Map of the Black Forest Quadrangle, El Paso County, Colorado* is to describe the geologic setting, distribution, and properties of the rock units, including the mineral resource potential and characteristics that may affect development of this 7.5-minute quadrangle located along the I-25 corridor about 40 miles south of Denver. Dr. Jon P. Thorson, contract geologist for the Colorado Geological Survey, completed the field work on this project in the summer of 2002.

This mapping project was funded jointly by the U.S. Geological Survey through the STATEMAP component of the National Cooperative Geologic Mapping Program which is authorized by the National Geologic Mapping Act of 1997, Agreement No. 00HQAG0119, and the Colorado Geological Survey using the Colorado Department of Natural Resources Severance Tax Operational Funds. The CGS matching funds come from the Severance Tax paid on the production of natural gas, oil, coal, and metals.

Vince Matthews
Senior Science Advisor

Ronald Cattany
Interim State Geologist

CONTENTS

INTRODUCTION

The Black Forest 7.5-minute quadrangle is located near the northern edge of the Colorado Springs metropolitan area, which is in the southern part of the Colorado Piedmont section of the Great Plains (Fig. 1). This section of the Great Plains is distinguished by having been stripped of the Miocene fluvial rocks (Ogallala Formation) that cover most of the Great Plains. Some middle Cenozoic rocks once present in the quadrangle, the Castle Rock Conglomerate and Wall Mountain Tuff, also have been largely, or completely, eroded from the Black Forest quadrangle. The Black Forest quadrangle lies across the Palmer Divide, the interfluve between the South Platte and Arkansas Rivers, and includes the headwaters of Kettle Creek, East Cherry Creek, West Kiowa Creek, and Black Squirrel Creek.

Geologic maps produced by the CGS through the STATEMAP program are intended as multi-purpose maps useful for land-use planning, geotechnical engineering, geologic-hazards assessment, mineral-resource development, and ground-water evaluation. Figure 2 shows the status of geologic mapping of 7.5-minute quadrangles in the Colorado Springs area.

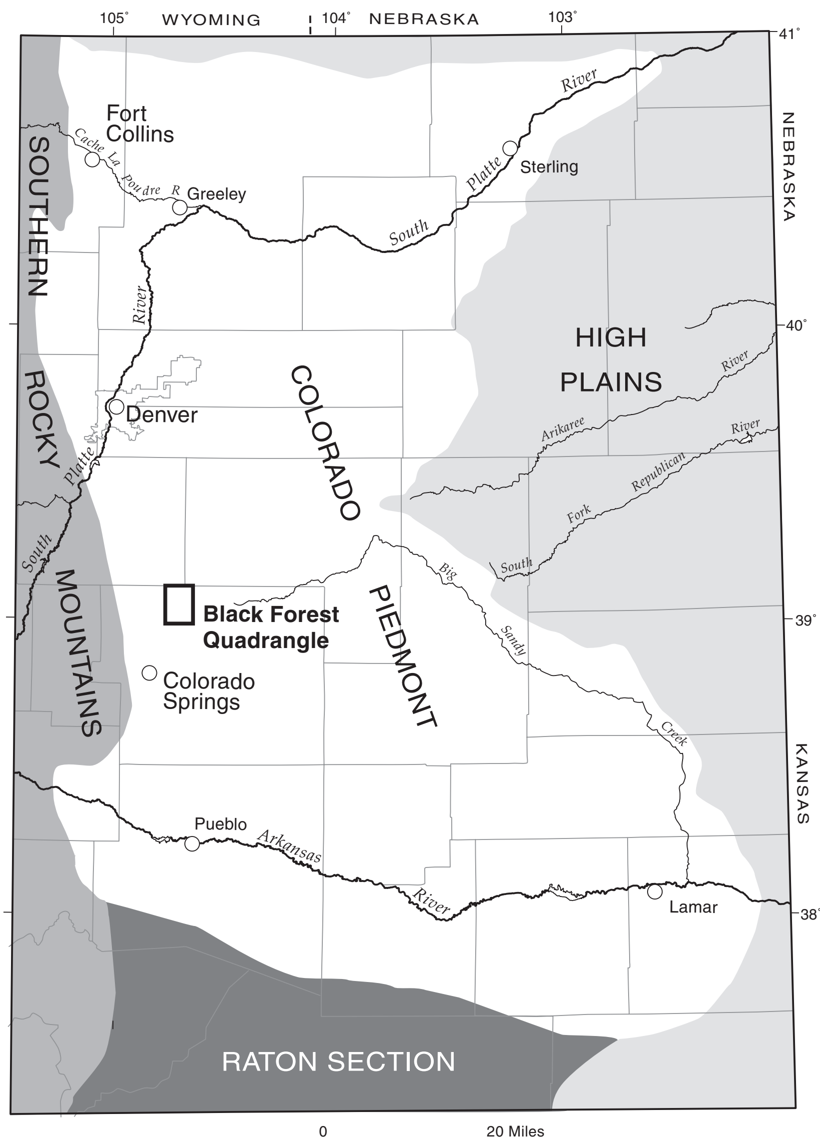
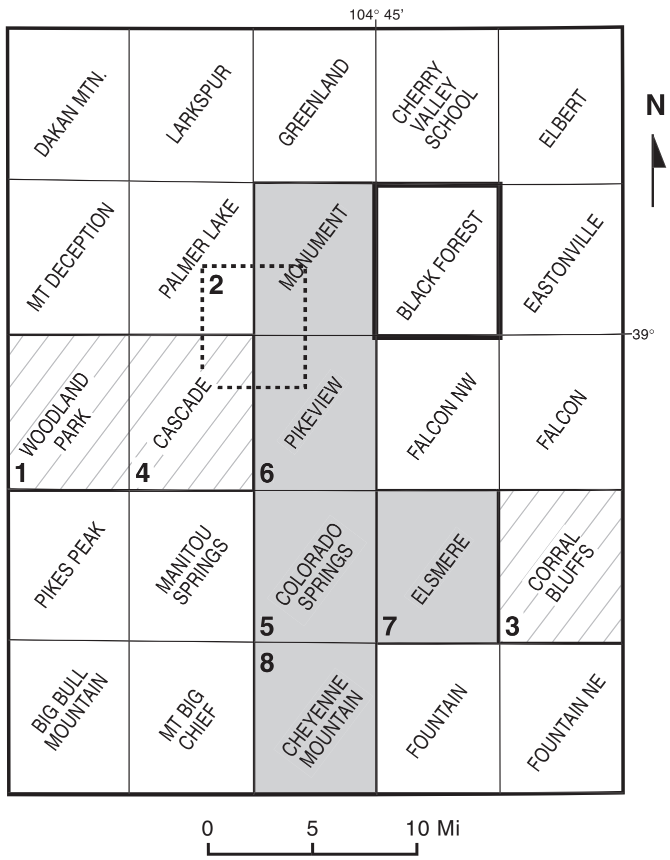


Figure 1. Map showing the location of the Black Forest quadrangle and Colorado Piedmont with respect to the Southern Rocky Mountains and the Colorado Piedmont, High Plains, and Raton sections of the Great Plains (modified from Madole, 1991; physiographic nomenclature from Fenneman, 1931.



Completed 1:24,000-scale and larger geologic maps

Index Map No.	Publication No.	Scale
1	USGS MF-842 (Wobus and Scott, 1977a)	1:24,00
2	USGS PP-551 (Varnes and Scott, 1967) covers parts of four quads	1:12,000
3	USGS GQ-783 (Soister, 1968)	1:24,000
4	USGS OFR 77-138 (Wobus and Scott, 1977b)	1:24,000
5	CGS OFR 00-03 (Carroll and Crawford, 2000)	1:24,000
6	CGS, OFR 01-03 (Thorson, Carroll, and Morgan, 2001)	1:24,000
7	CGS OFR 02-02 (Madole and Thorson, 2002)	1:24,000
8	CGS OFR 02-05 (Rowley and others, 2002)	1:24,000

Figure 2. Index map showing the location of the Black Forest quadrangle and other geological maps in the area published at a scale of 1:24,000 and 1:12,000.

This map was based on prior published and unpublished geologic maps and reports, interpretation of aerial photography, and field investigations in 2002. Previous geological mapping in the Colorado Springs area includes the work of Emmons and others (1896), Richardson (1915), and Finlay (1916). Scott and Wobus (1973) mapped the Colorado Springs area, which is just southwest of the Black Forest quadrangle, in reconnaissance fashion and published a geological map at a scale of 1:62,500. Trimble and Machette (1979a) published a 1:100,000-scale geologic map of the southern part of the Front Range urban corridor, which includes the Black Forest quadrangle.

The geology of the Black Forest quadrangle was mapped on aerial photographs and transferred to a digital topographic base map with the ERDAS plotting system. Two sets of aerial photographs were used; black and white, 1:24,000-scale photography flown in 1992, and color infra-red, 1:40,000-scale aerial photography flown in 1988. The topographic base map was published in 1954 and photo revised in 1969 and 1975. Thus, roads, reservoirs, and buildings that were constructed after 1975 are not on the map, and some of the human-made deposits that postdate the 1992 aerial photography may not be on the map. Particle size in both bedrock and surficial deposits is expressed in terms of the modified Wentworth scale (Ingram, 1989), and the terms used to describe sorting (a measure of the range in particle sizes present) are those of Folk and Ward (1957).

ACKNOWLEDGMENTS

This mapping project was funded jointly by the Colorado Geological Survey and the U.S. Geological Survey through the National Geological Mapping Program. Many people have earned my thanks: Vincent Matthews of the Colorado Geological Survey; Kirk R. Johnson, Curator of Paleontology, Denver Museum of Nature & Science; and Richard F. Madole reviewed the map and text. Robert G. Raynolds, Denver Basin Project Research Associate, Denver Museum of Nature & Science was particularly helpful in discussing details of Denver Basin geology.

George D. VanSlyke, Colorado Division of Water Resources, provided generous access to his department's files of water-well logs. Matt Morgan of Colorado Geological Survey was very helpful in the process of transferring geological data from airphotos and field notes to a digital map. Jason Wilson and Cheryl Brchan produced the geologic map and booklet. Jane Ciener served as technical editor. Special thanks go to the landowners and developers who granted permission to enter their property.

GEOLOGIC SETTING

The Black Forest quadrangle is located near the western edge of an asymmetrical, oval-shaped, geological structural depression called the Denver Basin (Emmons and others, 1896). This structural basin lies immediately east of the Front Range and covers a large part of eastern Colorado north of Pueblo, southeastern Wyoming, and southwestern Nebraska. Bedrock in the Black Forest quadrangle dips gently northeast towards the axis of this basin.

The bedrock in the Black Forest quadrangle is the assemblage of lithologies shown on the geological map as facies units of the upper part of the Dawson Formation (TKda). At the time of deposition of this unit during the Paleocene and Eocene Epochs (about 65 to 50 million years ago) the uplift of the Front Range was well underway. Braided streams were delivering to the basin a mixture of gravel, sand, silt and clay derived from weathering and erosion of that uplifted area. The source of the granitic arkosic materials was mostly the Precambrian Pikes Peak Granite located immediately to the west of the Rampart Range mountain-front fault system. Stream flow was generally towards the east (Morse, 1979; Crifasi, 1992). The pebble conglomerate and arkosic sand beds are cross-bedded and fill broad channels generally cut into finer-grained deposits of clayey sandstones and sandy claystones. Interbedded with the channel deposits are occasional structureless beds deposited by mudflows. Also interbedded between the coarse-grained beds are finer-grained and thinner-bedded strata of light-gray to gray-green clayey sandstone and brown or brownish-gray sandy claystone containing fragments of organic material and plant fossils. The fine-grained parts of the upper Dawson were deposited by gentler currents in areas between the braided stream channels and probably were covered with vegetation.

In a period of intense weathering during upper Dawson deposition in the earliest Eocene a strongly developed paleosol horizon was locally developed across the Denver Basin (Farnham and Kraus, 2002; Nichols, and Fleming,, 2002; Raynolds, 2002). This paleosol was proposed to be the boundary between the Paleocene and Eocene Epochs by Soister and Tschudy (1978), but recent work has shown that the paleosol formation occurred in the early Eocene shortly after the formation of an unconformity that is now recognized as the Paleocene-Eocene (K. R. Johnson, 2002, written commun.). In the present work the projected location of the strongly developed paleosol has been used as the boundary between Dawson facies units four and five, although this major paleosol is not well developed in the quadrangle. After the period of landscape stability and weathering, mountain uplift resumed and Dawson facies unit five ($TKda_5$) was deposited in the basin. The uppermost part of the Dawson Formation was removed by an extended period of erosion in the Late Eocene.

Following the erosion of some of the upper part of the Dawson Formation, the Conglomerate of Larkspur Butte (Thorson, 2003) was deposited in a series of channels and broad valleys occupied by streams which drained the newly rejuvenated mountains. In the northwest part of the Black Forest quadrangle the Conglomerate of Larkspur Butte was deposited in a broad paleovalley. The late Eocene-age Wall Mountain Tuff, an ignimbrite or glowing hot volcanic ash flow, was erupted in the late Eocene and caps the Conglomerate of Larkspur Butte in the Greenland quadrangle. Erosional remnants of this volcanic unit are still present in the Cherry Valley School quadrangle about 2 mi to the north of the Black Forest quadrangle. The Castle Rock Conglomerate was deposited near the end of the Eocene on an erosion surface that cuts across the upper Dawson and Larkspur conglomerate strata and is younger than the Eocene surface upon which the Wall Mountain Tuff was deposited.

Since the deposition of these Eocene rocks, the area experienced continued periods of erosion and deposition. During the Miocene, the Ogallala Formation was deposited across much of eastern Colorado and probably once covered the quadrangle but has since been removed by erosion. During the Quaternary, deposits of unconsolidated sands and gravels were left in paleochannels, former flood plains along stream courses, and on various upland erosion surfaces as streams eroded the landscape.

SURFICIAL GEOLOGY

The names and symbols used for surficial units in the Black Forest quadrangle conform as much as possible to those employed previously on geologic maps of nearby areas prepared by the Colorado Geological Survey (Fig. 2). Map units were delineated mainly by airphoto interpretation that was verified and supplemented with data collected along traverses on the ground. The scale of the base map and aerial photographs governed the minimum size of the deposits shown. With few exceptions, deposits that have minimum dimensions of less than 150 ft were not mapped. Also, deposits that are less than 5 ft thick were not mapped unless they are coincident with landforms that can be delineated on aerial photography. Some of the surficial deposits of the Black Forest quadrangle are not well exposed. Consequently, the thickness of most units is estimated and descriptions of physical characteristics such as texture, stratification, and composition are based on observations at a limited number of localities.

The sidereal age limits adopted for early, middle, and late Pleistocene time are 1,806-778 ka (kilo-annum, 10^3 yr), 778–127 ka, and 127–11.15 ka, respectively (Madole and Streufert, 2001; Madole and Thorson, 2002). The date for the Pliocene-Pleistocene boundary, 1.806 Ma (Mega-annum, 10^6 yr), is the astronomically tuned age calculated by Lourens and others (1996). The 11.5 ka date for the Pleistocene-Holocene boundary is the calibrated equivalent of 10,000 radiocarbon years, the date proposed in 1969 for this boundary by the INQUA Commission for the Study of the Holocene (Farrand, 1990). The boundary between the early and middle Pleistocene is the time of the Matuyama-Brunhes magnetic reversal, which occurred about 778 ka (Tauxe and others, 1992). The boundary between oxygen-isotope ($\delta^{18}O/^{16}O$) stage 6 and stage 5 is the boundary between middle and late Pleistocene time. Bassinot and others (1994) place the isotope stage 6-stage 5 boundary at 127 ka, which is a refinement of the 128-ka date calculated by Imbrie and others (1984).

The age limits used here for divisions of the Holocene are informal and arbitrary. They are based chiefly on paleontological data compiled for the southwestern United States, including the Colorado Plateau, such as described by Van Devender and others (1987). The data define times of widespread climatically driven shifts in the limits of vegetation associations, changes in lake levels and chemistry, and so forth. However, some changes may be time-transgressive and some records are imperfectly dated. Holocene chronostratigraphy is a work in progress and informal divisions of the epoch are not well defined. The age limits used for early, middle, and late Holocene are 11.5–8 ka, 8-4 ka, and 4–0 ka, respectively.

The ages assigned to the surficial deposits of the Black Forest quadrangle are estimates that are based chiefly on stratigraphic relations and positions in the landscape. Ordinarily, differences in degree of soil-profile development play a major role in determining the relative ages of surficial deposits, but this is not true for much of the Black Forest quadrangle. Degree of soil development refers to attributes such as profile thickness, horizon complexity, soil structure, quantities of translocated clay or calcium carbonate present, depth of leaching, and so forth. Over much of the southern and eastern Black Forest quadrangle, soils are very weakly developed (that is, lack even a rudimentary B horizon) regardless of the age of the deposit in which the soil is developed. In the central and northern parts of the quadrangle, in the drainage of East Cherry Creek, soil development is much stronger, suggesting a much longer period of soil development and landscape evolution. This contrast in soil development between East Cherry Creek drainage and the rest of the quadrangle is particularly noticeable over Dawson Formation bedrock. In the drainages of both Black Squirrel Creeks, Kettle Creek, and Kiowa Creek only very rudimentary soils are developed on the Dawson Formation. In the East Cherry Creek drainage, particularly on the upper slopes near the drainage divide, Dawson bedrock is covered with 3 to 5 ft thick soils with well developed B horizons. The remnants of sandy alluvial deposits possibly as old as Pliocene in the East Cherry Creek drainage (unit QTa) also support the hypothesis that this drainage is part of an older landscape. In the upper part of the West Cherry Creek drainage in the Monument quadrangle (Thorson and Madole, 2002) similar older sandy alluvial deposits are associated with boulder and cobble gravels that pre-date the capture of the head of West Cherry Creek through stream piracy by Monument Creek.

BEDROCK GEOLOGY

NOMENCLATURE OF THE DAWSON FORMATION

The sedimentary rocks lying above the Laramie Formation were first called Dawson "arkose" (with a lower case "a") by Richardson (1912) from a type locality on Dawson Butte near the town of Castle Rock, about 15 mi northwest of the Black Forest quadrangle (Fig 3). Richardson (1915, Fig. 3) showed the Dawson "arkose" of the Castle Rock area as equivalent to, and interfingering with, the Arapahoe and Denver Formations of the Denver area. Finlay (1916) recognized that the Dawson "arkose" extended into the Colorado Springs area and contained an andesitic sandstone unit at the base. Varnes and Scott (1967) used the name Dawson Arkose (upper case "A") and recognized that there are two "beds of andesitic material" in the area south and east of the U.S. Air Force Academy. Scott and Wobus (1973) changed the name to Dawson Formation, in recognition that the unit was not entirely composed of arkose; they mapped a lower part (andesitic) and upper part of the Dawson Formation. In the Pikeview quadrangle (Fig. 2) Thorson and others (2001) mapped three informal members in the upper part of the Dawson

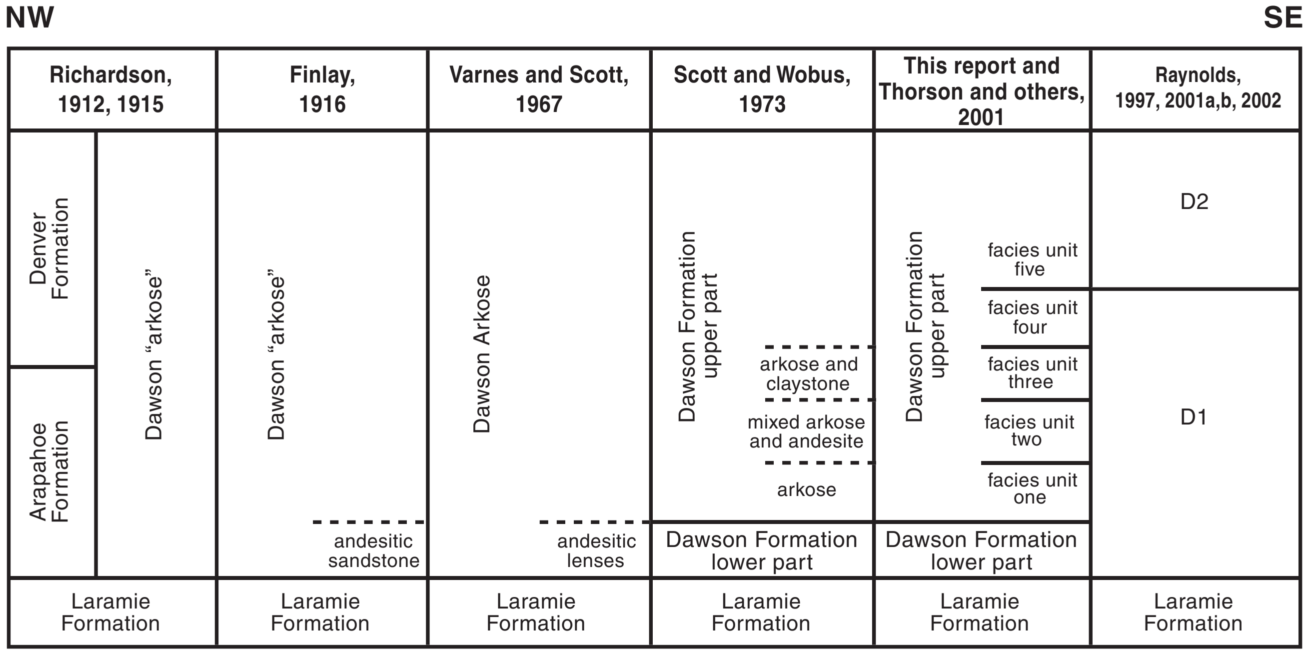


Figure 3. Nomenclature diagram for subdivisions of the Dawson Formation as used in various publications pertaining to the Colorado Springs area.

Formation (Fig. 3) that Scott and Wobus (1973) described but did not map separately. In the mapping of the Monument quadrangle (Thorson and Madole, 2002) five informal members were recognized. The nomenclature used in this description for the Dawson Formation follows that of Scott and Wobus (1973) and Trimble and Machette (1979a) in referring to Dawson Formation rather than Dawson Arkose. The use of the symbol "TKda" for the upper part of the Dawson Formation follows the usage of Trimble and Machette (1979a).

FACIES OF THE UPPER DAWSON FORMATION

The upper part of the Dawson Formation consists of five facies units in the Colorado Springs area: facies unit one ($TKda_1$), facies unit two ($TKda_2$), facies unit three ($TKda_3$), facies unit four ($TKda_4$), and facies unit five ($TKda_5$). Figure 4 shows the regional relationships between these units. Facies unit one occurs in part as a very thick "basin edge" deposit close to the mountain front on the western edge of the basin in the Pikeview and Monument quadrangles (Fig. 2). Facies one also occurs as a coarse basal unit of the upper Dawson, beneath finer-grained facies that crop out from the Pikeview quadrangle (Fig. 2) southeastward into the Elsmere quadrangle (see Figs. 2 and 4, this paper; and Madole and Thorson, 2002). Finer-grained basinal facies units two and three interfinger with and overlie the coarser mountain front and basal facies unit one. Facies units one and two do not crop out in the Black Forest quadrangle but are projected from drill holes and outcrops in adjacent quadrangles to occur in the subsurface. In the Black Forest quadrangle, facies units four and five, dominated by light-colored arkoses, were deposited over the top of the finer-grained facies unit three. Contacts between facies units within the basin are both gradational and interfingering. Erosion has removed the uppermost part of facies unit five in the Black Forest quadrangle.

The relationship of the subdivisions of the Dawson Formation in the Colorado Springs area to those used in the Denver area is uncertain. Trimble and Machette (1979b) summarized the current usage of Arapahoe, Denver, and Dawson Formations (in ascending order) for the greater Denver area (Fig.5). The Arapahoe and Dawson Formations consist of arkosic sandstone, siltstone, claystone, and minor amounts of conglomerate. Where this arkosic and conglomeratic lithology underlies the Denver Formation it is called the Arapahoe Formation. The Denver Formation consists of claystone, siltstone, sandstone, and conglomerate composed primarily of altered andesitic volcanic debris. The Denver Formation pinches out to the south and east. Beyond the pinchout all the strata equivalent to the Arapahoe and Denver Formation are included in the Dawson Formation.

The interfingering of the Denver Formation with the Dawson Formation, and the pinchout of the Denver Formation to the southeast, has been mapped along the southern edge of the Denver metropolitan area. Scott (1962, p. L19–L20) described apparent interfingering of the Denver Formation with the Dawson "arkose" in the Littleton quadrangle and concluded that "southward they (andesitic beds) probably dwindle to a thin tongue in the Dawson arkose". In the Kassler quadrangle Scott (1963) retained the usage Dawson "arkose" for the whole unit and did not find a mappable unit dominated by andesitic debris. Maberry and Lindvall (1972, 1977) mapped an upper tongue of Denver Formation that interfingers with the Dawson Arkose (Fig. 5) in the Parker and Highlands

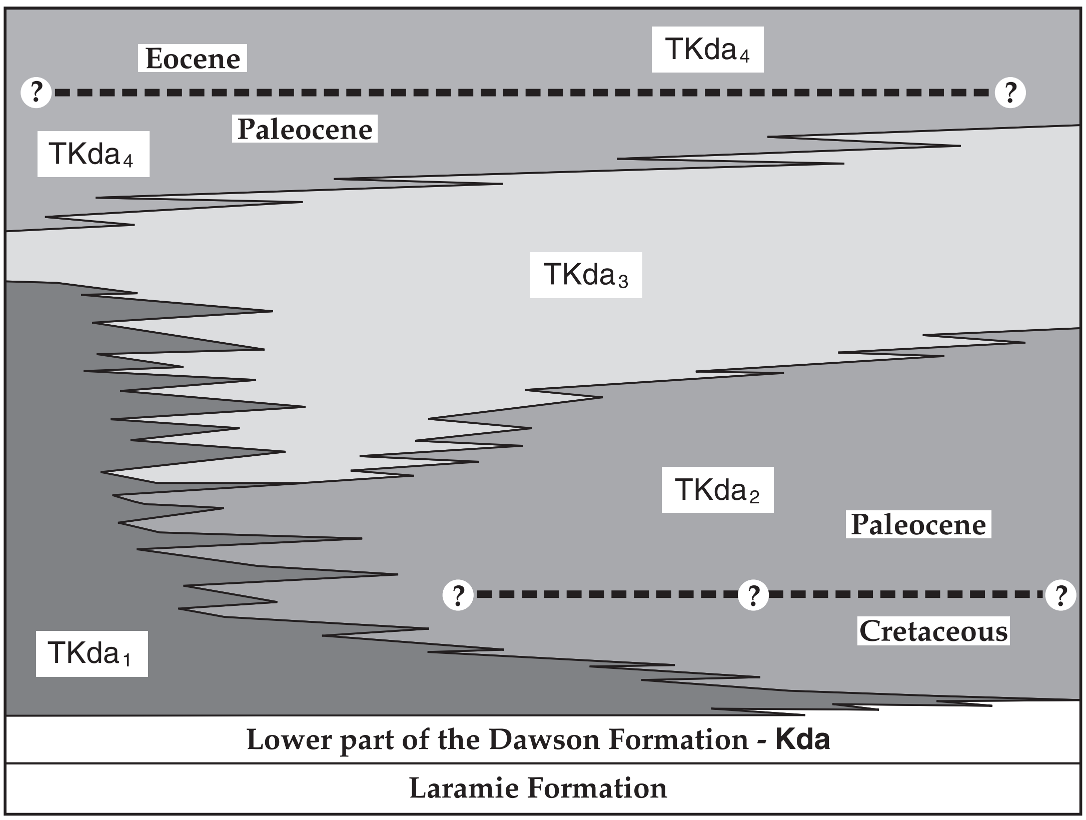


Figure 4. Diagrammatic sketch showing the regional relationships between facies units of the upper part of the Dawson Formation in the Colorado Springs area. The Black Forest quadrangle is roughly represented by the upper right corner of the diagram. Heavy dashed lines indicate the approximate stratigraphic locations of geologic time lines. The heavy dashed line in the upper left represents the approximate location of outcrops of the paleosol though to be the Paleocene-Eocene boundary.

Ranch quadrangles. Trimble and Machette (1979b) summarized this relationship and chose to use the name Dawson Arkose rather than Dawson Formation.

However, it is common usage in the Colorado Springs area to map the andesite-bearing strata, (mapped here as upper Dawson Formation facies unit two) as the Denver Formation (John Himmelreich, Jr., oral commun., 2000). This correlation has largely come about through the use of the Denver-area formation names (Arapahoe, Denver, and Dawson) for regional aquifer units that have been extended throughout the hydrologic Denver Basin (see for example, Robson, 1987). The extension of the Denver-area formation nomenclature throughout the Denver Basin was accomplished largely by correlating geophysical log signatures of hydrologic units in water and oil wells. Unfortunately, the hydrologic units do not correlate precisely with the mappable geologic units exposed at the surface (George VanSlyke, oral commun., 2000). The geophysical logs used for this correlation can separate porous and permeable sandstones and conglomerates from "tight" shales and claystones, but they can not reveal the lithologies of the sandstones and pebble conglomerates. The geologic units mapped at the surface are based on lithological criteria, largely the presence or absence of andesitic debris, a distinction which can not be made from geophysical logs from wells. Thus, the extension of the Denver Formation to Colorado Springs remains suspect, especially since Scott (1962, 1963), Maberry and Lindvall (1972, 1977), and Trimble and Machette (1979b) described the Denver Formation as intertonguing with the Dawson Formation and pinching out towards the south and east. Furthermore, current directions and facies relationships of facies unit two suggest that the source for the sediments of this unit was south and west of the Elsmere quadrangle (Madole and Thorson, 2002). It is likely that the andesitic conglomerates of the Denver Formation, which are in part coarser than those of facies unit two, were transported from a separate source that was far to the north of the source for facies unit two. Crifasi (1992) has analyzed the thickness and sand/shale ratios of the hydrologic aquifers of the Denver Basin and also argues for multiple sediment distribution systems for each of the units.

In defense of the possible extension of the Denver Formation south to Colorado Springs, both Robson (1989, p. 10) and Crifasi (1992, p. 26)

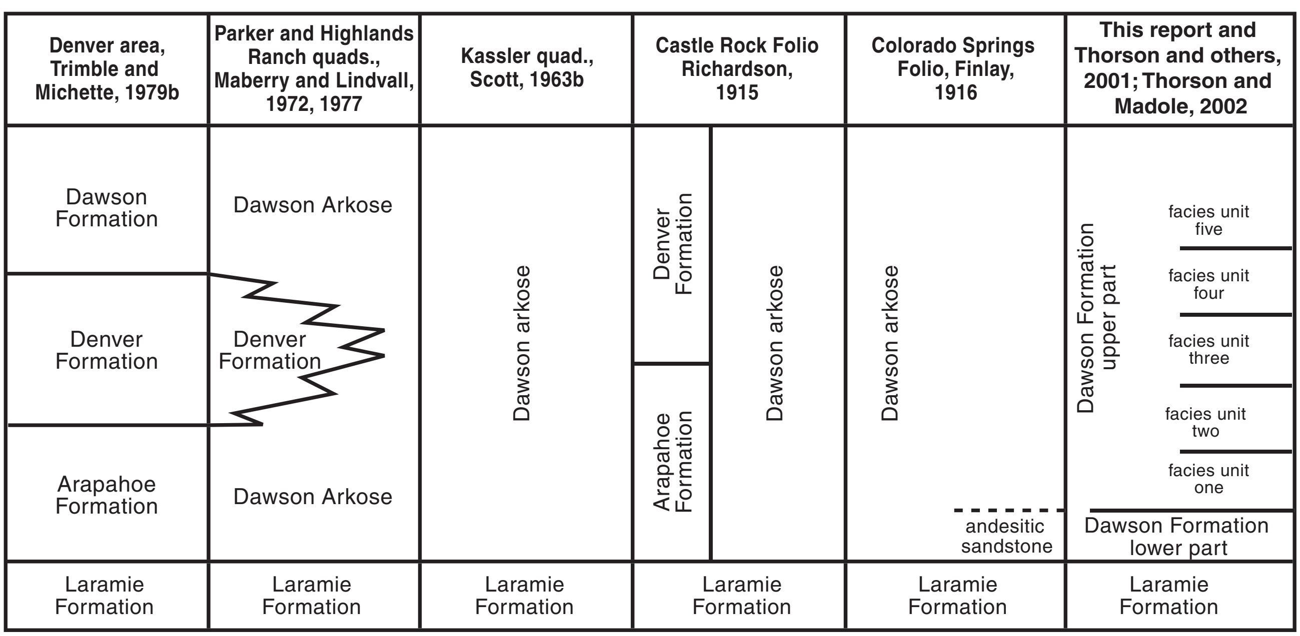


Figure 5. Relationship between the subdivisions of the Dawson Formation used in this report and the stratigraphic nomenclature of the Denver area.

have shown that the Denver aquifer contains more shale and less sandstone than the units above and below it. The geologic subdivisions of the upper part of the Dawson Formation used here also follow this general grain-size relationship. Facies units two and three are finer grained and contain more claystone and sandy claystone beds than facies units one and four. Facies units two and three are at least partially derived from an andesitic source area. However, until the subdivisions of the Dawson Formation between the Monument (Fig. 2) and Kassler quadrangles can be described lithologic samples from taken from the subsurface, the stratigraphic relations between the Arapahoe, Denver and Dawson Formations of the Denver area and the Dawson Formation of the Colorado Springs area will probably remain unclear.

AGE OF THE UPPER DAWSON FORMATION

The upper part of the Dawson Formation spans the Cretaceous-Tertiary (K-T) boundary, but the exact location of the time boundary near the western edge of the basin has not been located. Kluth and Nelson (1988) reconfirmed the Late Cretaceous (late Maastrichian) age for the upper part of the Dawson Formation on the U.S. Air Force Academy. In the Elsmere quadrangle (Fig. 2) the K-T boundary has been approximately located about 370 ft above the base of the upper part of the Dawson Formation (Benson, 1998; Benson and Johnson, 1998; Johnson and Raynolds, 2001; Madole and Thorson, 2002). This boundary is projected to lie to the southwest of the Black Forest quadrangle, so facies units three and four of the Dawson Formation in the Black Forest quadrangle are thought to be Paleocene.

The well-developed paleosol proposed to mark the Paleocene-Eocene boundary and found at numerous localities in the Denver Basin has not been recognized in the Black Forest quadrangle (Soister and Tschudy, 1978; Farnham and Kraus, 2002; Nichols and Flemming, 2002; Raynolds 2002). This paleosol was recognized in the Monument quadrangle (Fig. 2) and used as the boundary between facies units four and five. Numerous thinner and more poorly developed paleosols occur in upper Dawson facies unit five of the Black Forest quadrangle, however. In the Black Forest quadrangle, the presence of common oxidized paleosol horizons in facies unit five was used to distinguish that map unit from facies unit four in which oxidized paleosol horizons are absent. Thus, in the Black Forest quadrangle, facies units three and four are probably of Paleocene age, and facies unit five probably early Eocene (Nichols and Fleming, 2002).

CONGLOMERATE OF LARKSPUR BUTTE

The Conglomerate of Larkspur Butte (Tlc) is a newly recognized unit of late Eocene age that underlies the late Eocene-age Wall Mountain Tuff on Larkspur Butte, and on several other buttes, in the Greenland quadrangle (Fig. 2), about 15 mi to the northwest of the Black Forest quadrangle. In this report the name “Conglomerate of Larkspur Butte” is used informally. The occurrence and distribution of this unit is described in greater detail in the open-file report on the Greenland quadrangle (Thorson, 2003).

The Conglomerate of Larkspur Butte is a brown, pinkish-brown, or pink arkosic conglomerate which was previously included as the top part of the upper Dawson Formation (Richardson, 1915; Trimble and Machette, 1979b; Morse, 1979). It is predominantly composed of pebbles and cobbles of pink granite in a coarse sand-size to pebble-size matrix of quartz and pink feldspar. Clasts of white quartz are common; less abundant are clasts of gneiss, quartzite, red sandstone, and chert. Large clasts of eroded Dawson Formation arkose are common near the base of the unit. In the Black Forest quadrangle, the largest clasts are cobbles as much as 3 in. in largest dimension, but in the Greenland quadrangle (Fig. 2) the unit contains granite clasts up to 8 in. in diameter. Minor interbeds of coarse to very coarse light-brown sandstone occur sporadically. The unit is strongly cross bedded. In the northeast corner of the Black Forest quadrangle (sec 2, 3, 4, T. 11 S., R. 65 W.) , the Conglomerate of Larkspur Butte appears to be deposited in a broad paleo-channel eroded into the upper Dawson (Fig. 6). That filled channel is overlain by another, filled with Castle Rock, Conglomerate (Tcr).

This unit should not be included as the uppermost part of the upper Dawson Formation for the following reasons. The Conglomerate of

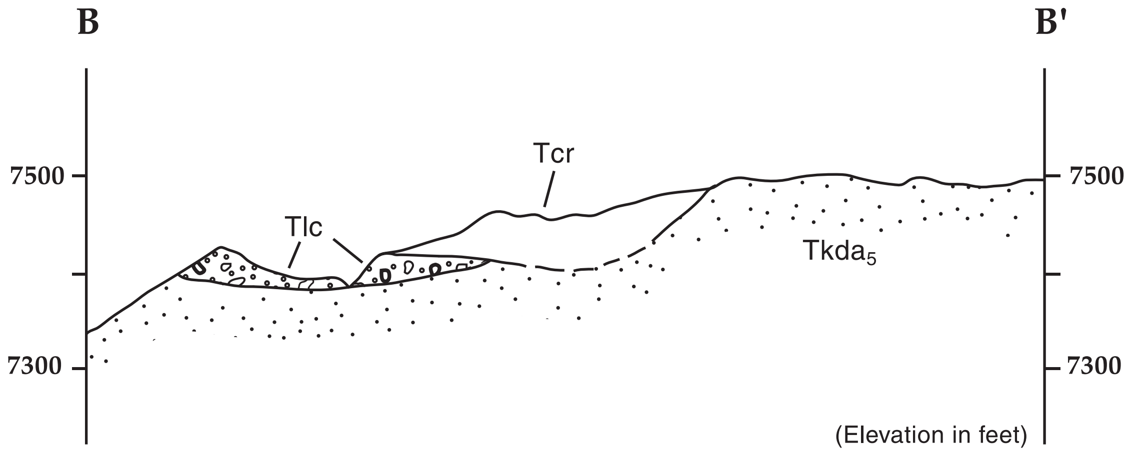


Figure 6. Cross section B-B' showing the relationship between the conglomerate of Larkspur Butte (Tlc), Castle Rock Conglomerate (Tcr), and the upper part of the Dawson Formation ($Tkda_5$). Tlc fills a paleochannel eroded into the Dawson; Tcr fills a later paleochannel. Deposition of the Wall Mountain Tuff occurred between deposition of the two conglomerates (Tlc and Tcr). Location of cross section shown on the geological map; vertical exaggeration, 10X.

Larkspur Bujtte was deposited on a significant erosional unconformity across the top of the Dawson Formation and is lithologically distinct from strata above and below. The Dawson strata below this conglomerate are finer-grained arkoses with a very high content of light-colored sandy clay matrix filling intergrannular spaces between coarse sand or pebble clasts. The Conglomerate of Larkspur Butte is distinctly matrix-poor and has well preserved, empty, intergranular porosity between the pebble-size clasts. In the Black Forest quadrangle, the Conglomerate of Larkspur Butte is overlain by the Castle Rock Conglomerate, which is similar but contains clasts of Wall Mountain Tuff.

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

HUMAN-MADE DEPOSITS—Earth materials emplaced or modified by human beings or deposited as a consequence of human activities.

af	**Artificial fill (late Holocene)**—Gravel, sand, silt, clay, and rock or concrete debris emplaced for constructing roads and small dams. Thickness generally is between 5 and 30 ft.

ALLUVIAL DEPOSITS—Sand, silt, gravel, and clay transported and deposited by flowing water in channels or as unconfined runoff. The alluvial deposits in the Black Forest quadrangle are predominantly composed of quartz, feldspar, and granite fragments derived mostly from arkosic source materials in the Dawson Formation. Most of the fragments in the channel and flood-plain (Qa and Qau), and terrace (Qt_1, Qt_2, Qt_3) deposits are subrounded coarse pebbles (less than 1.25 in.) or smaller grains. Occasional larger pebbles and small cobbles (up to about 4 in.) of well rounded light-colored quartz and rare subangular to subrounded yellow-brown chert found in the channel and flood-plain, and terrace deposits can not have been derived from the Dawson and appear to be recycled from either the piedmont-slope alluvium or the alluvium of Palmer Divide, which contain fragments of this size and lithology. Rare larger cobbles (up to 8 in.) in the channel and flood-plain, and terrace deposits are either subrounded Dawson Formation arkose, subrounded to round light-red to dark-pink Pikes Peak Granite, or light brownish-gray welded tuff. The large granite cobbles can not be derived from the Dawson as they are much larger and much less altered than Dawson fragments. The large granite cobbles were probably recycled from the Conglomerate of Larkspur Butte (Tlc), Castle Rock Conglomerate (Tcr), or the alluvium of Palmer Divide (QTa). The welded tuff fragments were originally derived from the Wall Mountain Tuff, a volcanic deposit of late Eocene age, that no longer occurs within the Black Forest quadrangle (Fig. 2). Redistributed fragments of Wall Mountain Tuff from the Castle Rock Conglomerate (Tcr) or the alluvium of Palmer Divide (QTa) are the probable source of this lithology in the younger alluvium.

The piedmont-slope alluvium (Qp_2) also locally contains small cobbles of materials that can not have been derived from the underlying bedrock because the Dawson is not this coarse. The deposit in NW 1/4 sec. 1 and NE 1/4 secs. 2, T. 12 S., R. 66 W. contains common large pebbles of greenish-gray to gray limestone and dolomite to 2 in. diameter, small cobbles of pink and red Pikes Peak Granite and white quartz up to 3 in., and minor chert and petrified wood up to 4 in.

The alluvium of Palmer Divide may also contain large pebbles and small cobbles which can not be derived from the Dawson. The deposit of QTa on Volmer Hill (common corner of sec. 3, 4, 9, and 10, T. 12 S., R. 65 W.) contains common white, tan, pink and light-red feldspar and granite, and well rounded white quartz up to 4 in. diameter, plus rare angular to subangular cobbles of light-gray to brownish-gray welded tuff.

Qa

Channel and flood-plain alluvium (late Holocene)—Pale-brown to brown sand, gravel, silt, and minor clay underlying narrow flood plains, stream channels, and, locally, low terraces flanking flood plains. Unit is generally coarser, lighter in color, and more poorly sorted than unit Qt_1. In many places, the unit is so young that plant roots have scarcely disturbed or destroyed stratification that extends nearly to the ground surface. Typically soil has not developed. Unit is subject to frequent flooding. Estimated thickness is 3–7 ft.

Qt_1

Terrace alluvium one (Holocene and late Pleistocene)—Pale-brown and brown to grayish-brown and dark-grayish-brown beds of sand, silty fine sand, sandy silt, clayey silt, and gravel. Generally, stratification is weakly expressed, and texture and composition vary along the valley axis. The upper surface of the unit is 5–25 ft higher than some of the larger streams, but is only about 3–10 ft higher than the smaller streams of the area. In places, along East Cherry Creek particularly, the height of the upper surface of this terrace above the stream decreases in an upstream direction until this terrace merges with the alluvium of the stream valley bottom, either Qa or Qau. Infrequent large floods may inundate Qt_1 in places. Thickness is estimated to be 5–35 ft.

Qt_2

Terrace alluvium two (late middle Pleistocene)—Very pale-brown to light- grayish-brown, extremely poorly sorted sand and subordinate amounts of gravel. The unit may correspond to the Kettle Creek Alluvium of Varnes and Scott (1967). The upper surface of the unit is typically 20–40 ft higher than the larger streams. In places the height of the upper surface of this terrace above stream level also changes in an upstream direction. Along East Cherry Creek particularly, terraces that appear to be Qt_2 at one location decrease in height in the upstream direction until this terrace surface would otherwise have been mapped as Qt_1. Thickness is 5-20 ft.

Qt_3

Terrace alluvium three (late middle Pleistocene)—Chiefly pale-brown to slight grayish-brown, extremely poorly sorted sand and gravel that underlies terrace remnants along the larger streams of the area. The upper surface of the unit is 20–50 ft higher than the Black Squirrel Creek in the southeast corner of the quadrangle. The height of the upper surface of this terrace above stream level also appears to decrease in an upstream direction. Estimated thickness is 5–30 ft.

Qau **Alluvium, undivided (Holocene and Pleistocene)**—Chiefly pale-brown to brown, poorly sorted sand and fine gravel in valley heads in the upper parts of drainages. The unit includes sheetwash and stream-deposited alluvium that are undivided. Reasons for not differentiating these deposits include 1) different ages of alluvium may be superposed but incision has not differentiated them, 2) exposures are poor, and 3) two or more units are present but are too small to show separately at the map scale. These alluvial-filled valley heads are not exhumed or deeply incised. The unit probably includes sediment that is correlative with units Qa, Qt_1, and possible Qt_2. Estimated thickness is 3–20 ft.

Qp_1 **Younger piedmont-slope alluvium (Holocene and late Pleistocene)**—Unit is similar in form and origin, and presumably character, to unit Qp_2, but less well exposed. Most of the unit consists of thin alluvium on slopes that grade from areas where bedrock is at or close to the surface toward Kettle Creek in the southwestern part of the quadrangle. The unit includes both sheetwash and stream-deposited alluvium. These alluvium-covered surfaces are correlative with, and continuous with, similar piedmont slope deposits in the adjacent Monument quadrangle (Fig. 2) to the west (Thorson and Madole, 2002). Estimated thickness is 5–15 ft.

Qp_2 **Middle piedmont-slope alluvium (middle Pleistocene)**—Unit consists of thin beds of very pale-brown to brown, poorly sorted sand, sandy pebble gravel, and occasionally small cobbles. Unit comprises sheetwash and stream-deposited alluvium. Individual channel fills and terrace deposits within this unit were not differentiated because they are products of a complex history that includes non-synchronous channel abandonment and stream piracy. These alluvium-covered surfaces are also, like Qp_1, correlative with similar piedmont slope deposits in the adjacent Monument quadrangle to the west (Thorson and Madole, 2002). In mapping this unit the designation as the "middle" piedmont slope alluvium has been retained for consistency with the Monument quadrangle. An "older" piedmont slope deposit, Qp_3, which pre-dates Qp_2, was recognized in the Monument map area. Estimated thickness 5–40 ft.

QTa **Alluvium of Palmer Divide (early? Pleistocene or Pliocene?)**—Unit is variable but similar to high level, alluvial deposits along the divide between tributaries of the South Platte River (West Cherry Creek) and the Arkansas River (Monument Creek) in the adjacent Monument quadrangle (Fig. 2). In Thorson and Madole (2002), the probable lower Pleistocene or Pliocene age of these deposits has been discussed at length. The deposits included in this oldest alluvial category include predominantly sand deposits in the northwestern part of the quadrangle, and deposits of sandy pebble and cobble gravel on the divide in the southeastern part of the quadrangle. The alluvium of Palmer Divide is up to 30 ft thick in the Black Forest quadrangle (Fig. 2).

The sandy deposits are composed generally of very pale-brown and pinkish-brown, fine to coarse sand interbedded with pinkish-gray to light brownish-gray pebble gravel. The sand is poorly sorted, medium to thin bedded, thinly laminated, and composed largely of quartz grains. The sand exhibits bedding and lamination features characteristic of fluvial deposition. The distribution and slope of these deposits suggest that they once filled an ancestral valley of East Cherry Creek.

The sandy pebble and cobble gravel is composed largely of subangular to subrounded fragments of white or light-gray quartz, light-pink to light-red and reddish-brown feldspar, a few fragments of pink to light-red to reddish-brown granite, and rare fragments of brownish-gray Wall Mountain Tuff. Weathered and deflated surfaces of the gravel deposits are covered with a lag of subrounded pebbles in which white quartz stands out prominently.

MASS-WASTING DEPOSITS—Earth materials that were translocated downslope under the influence of gravity. Colluvium deposits are the principal products of mass wasting in the Black Forest quadrangle. Colluvium, as used here, adheres in most respects to Hilgard's (1892) definition. According to Hilgard, the principal attributes of colluvium are that it 1) was derived locally and transported only short distances, 2) may contain clasts of any size, 3) has no structures indicative of sedimentation or stratification by water flowing in channels, and 4) has an areal distribution that bears no relation to channelized flow of water (Madole and Streufert, 2001). Hilgard's definition allows colluvium to include a minor amount of sheetwash alluvium.

Qc

Colluvium (Holocene and late Pleistocene)—Unit comprises slope deposits that consist chiefly of very pale-brown to brown sand and fine gravel, plus cobbles and boulders of Dawson Formation arkose and Larkspur conglomerate around Table Rock. A similar deposit containing large boulders of Castle Rock Conglomerate has accumulated below steep outcrops in the east central part of sec. 9, T. 11 S., R. 65 W. Deposits typically are massive and very poorly sorted to extremely poorly sorted. Although primarily the product of mass wasting, the unit may include minor amounts of sheetwash. Unit is estimated to be 2–50 ft thick.

BEDROCK DEPOSITS

Tcr

Castle Rock Conglomerate (late Eocene)—The Castle Rock Conglomerate is a pebble, cobble, and boulder arkosic conglomerate composed of subrounded to round fragments of pink and gray granite and quartz with subordinate amounts of gneissic metamorphic rocks, quartzite, red sandstone and chert. Large clasts of light-colored, clay-rich Dawson arkose occur commonly near the base. The distinguishing characteristic of this unit is the presence of angular to subangular, cobble to boulder-size clasts of gray, brownish-gray, or lavender welded tuff which have been eroded from deposits of the Wall Mountain Tuff. Locally, beds of arkosic sandstone occur within the unit. Large scale cross bedding is very common. The Castle Rock Conglomerate was deposited on an erosion surface cut across the top of the upper Dawson Formation and the Conglomerate of Larkspur Butte. In places the Castle Rock Conglomerate has been reported to overlie the Wall Mountain Tuff (Morse, 1979), but this relationship was not observed in the Black Forest quadrangle (Fig. 2). The Castle Rock Conglomerate is younger than the Wall Mountain Tuff, which has been dated at about 36.7 my (Mcintosh and others, 1992; Mcintosh and Chapin,1994). It must be older than the end of the Eocene (33.7 my; Remane and others, 2002) since it contains bones of titanotheres (late Eocene, K.R. Johnson, written commun. 2002).

Tlc

Conglomerate of Larkspur Butte (late Eocene)—The Conglomerate of Larkspur Butte is a brown, pinkish-brown, or pink arkosic conglomerate predominantly composed of pebbles and cobbles of pink granite in a coarse sand-size to small-pebble matrix composed of quartz and pink feldspar. Clasts of white quartz are common; less abundant are clasts of gneissic metamorphic rocks, quartzite, red sandstone and chert; clasts are subrounded to round. Large clasts of eroded Dawson Formation arkose are common near the base of the unit. In the Black Forest quadrangle, the largest clasts are cobbles up to about 3 in. in largest dimension, but in the Greenland quadrangle the unit contains granite clasts up to 8 in. in diameter. Minor interbeds of coarse to very coarse light-brown sandstone occur locally. The unit is strongly cross bedded in large sets that indicate deposition in channels 5 to 15 ft deep. The Conglomerate of Larkspur Butte rests on an erosional unconformity on the top of the Dawson Formation, which has up to 80 ft of relief in the Black Forest quadrangle (Fig. 2). This unit appears to fill a broad channel in the northeastern part of the Black Forest quadrangle.

The Conglomerate of Larkspur Butte is distinguished from the underlying Dawson by its coarser grain size, pinkish color, predominance of pink granite and unbleached pink feldspar grains, and lack of clay in the matrix material. In the Black Forest quadrangle, it is uncommon for the Dawson pebble conglomerates to contain clasts larger than about 0.75 in. in diameter, while the Conglomerate of Larkspur Butte has coarser clasts up to 3 in. The uppermost strata of the Dawson are generally very light colored (white, cream, light greenish-gray) because most of the feldspar in the Dawson arkose is bleached and essentially all the porosity of the Dawson beds is filled with light-colored clay. The bleaching and clay-filling in the Dawson suggests a prolonged period of weathering and/or diagenetic alteration of the Dawson before deposition of the Conglomerate of Larkspur Butte. The Conglomerate of Larkspur Butte is remarkably free of clay filling in the matrix porosity. The Conglomerate of Larkspur Butte is similar in appearance to the Castle Rock Conglomerate although the latter generally lacks pink tones and is light gray in color. The principle distinguishing characteristic between the two conglomerates is the presence of fragments of Wall Mountain Tuff in the Castle Rock Conglomerate.

DAWSON FORMATION (UPPER CRETACEOUS TO EOCENE)—The Dawson Formation is divided into upper and lower parts in the Colorado Springs area (Fig. 3). The lower part, composed almost exclusively of andesitic debris, is not exposed in the Black Forest quadrangle. The lower part of the Dawson Formation is entirely Late Cretaceous in age. The upper part of the Dawson Formation is a mixture of andesitic and arkosic material deposited during the Late Cretaceous and early Tertiary. The upper part of the Dawson Formation is divided into facies unit one ($TKda_1$), facies unit two ($TKda_2$), facies unit three ($TKda_3$), facies unit four ($TKda_4$), and facies unit five ($TKda_5$). These facies units are differentiated on the relative proportions of andesitic and arkosic material, on the thickness and style of coarse-grained bedding units, and on the relative proportion of fine-grained claystone and siltstone versus coarser-grained beds of sandstone, arkose, pebbly arkose, and pebble conglomerate.

$TKda_5$

Facies unit five (early to middle(?) Eocene) This facies unit of the upper part of the Dawson Formation is similar in lithology to facies units one and four. The $TKda_5$ unit is dominated by very thick-bedded to massive, cross-bedded, light-colored arkose, pebbly arkose, and arkosic pebble conglomerate. Facies unit five contains common beds of white to light-tan, fine- to medium-grained feldspathic, cross-bedded friable sandstone. These sandstones are poorly sorted, have high clay contents, and are usually thin or medium bedded; wavy bedding and ripple cross-laminations are also common. Facies unit five also contains massive structureless beds interpreted to be the mudflows. Facies five is estimated to be about 500 ft thick in the quadrangle; the top of the unit has been removed by erosion.

The prominent and well-developed paleosol horizon that is the contact between facies unit four and facies unit five in other places in the Denver Basin was not recognized in the Black Forest quadrangle. The unit does contain numerous thinner, less well-developed, red, pink, and yellow-brown oxidized zones interbedded with, or developed within thick arkoses. These oxidized zones (some of which are paleosols) comprise the primary criterion used to differentiate facies units four and five in the quadrangle. Facies unit five was deposited under conditions which created numerous oxidized horizons, while the rare soil zones in facies unit four are black or very dark brown deposits characteristic of reducing, swampy conditions. Facies unit five appears to be equivalent to the Dawson Arkose and/or Dawson aquifer in the Denver area (George VanSlyke, 2001, oral commun.).

Facies unit five is generally permeable, well drained, and has good foundation characteristics. Excavation may be difficult, even though the arkoses are friable and easily eroded on weathered outcrops. The massive mudflow beds may be well indurated and may require considerable effort to excavate.

$TKda_4$

Facies unit four (Paleocene)—This facies unit of the upper part of the Dawson Formation is similar to facies unit one ($TKda_1$). The $TKda_4$ unit is dominated by very thick bedded to massive, cross-bedded, light-colored arkose, pebbly arkose, and arkosic pebble conglomerate. Facies unit four contains numerous beds of white to light-tan, fine- to medium-grained, feldspathic cross-bedded friable sandstone. These sandstones are poorly sorted, have high clay contents, and are commonly thin or medium bedded; wavy bedding and ripple cross-laminations are also common. Unit $TKda_4$ contains massive, structureless beds that are interpreted as mudflows; some of these beds have dark-colored tops which were organic-rich soil zones. Facies four contains only rare interbeds of thin- to very thin-bedded gray claystone and sandy claystone, or dark-brown to brownish-gray, organic-rich siltstone and sandstone containing plant fragments. Facies four is about 400 ft thick at the southwestern edge of the quadrangle but appears to be thinning to the southeast. In the Monument quadrangle (Fig. 2), the top of facies unit four is marked by a strongly developed paleosol that was traced around the Denver Basin by Soister and Tschudy (1978). This paleosol has not been recognized in the Black Forest quadrangle. Facies unit four may be equivalent to the Dawson Arkose and/or Dawson aquifer in the Denver area (George VanSlyke, 2001, oral commun.).

Facies unit four is generally permeable, well drained, and has good foundation characteristics. Excavation may be difficult, even though the arkoses are friable and easily eroded on weathered outcrops. The massive mudflow beds may be hard and tough and may be well indurated and require considerable effort to excavate. Rock fall from cliffs in facies unit four poses a possible slope-stability hazard in some areas.

$TKda_3$ **Facies unit three (Paleocene)—**This facies unit consists of nearly equal amounts of three lithologies: 1) thick and very thick-bedded, massive and cross-bedded, white, tan, and light-gray arkose and pebbly arkose; 2) thin to thick beds of light-green to olive-gray, clay-rich, fine- to medium-grained micaceous and feldspathic sandstone; and 3) thin to thick beds of dark-gray to greenish-gray sandy claystone. In the southeastern part of the Monument quadrangle the unit is 500 to 600 ft thick (Thorson and Madole, 2002). In that quadrangle it thins towards the northwest as it interfingers with facies unit one and facies unit four (Fig. 4).

The very thick-bedded, massive or cross-bedded, light-colored arkose beds in facies unit three resemble those in facies unit one, but are finer grained and generally thinner. Most of the grains in these arkoses are less than 0.5 in. in diameter; a few pebbles are as large as 1.5 in. The lithologies of the coarse grains are much more varied than those in the arkoses of facies unit one, and include grains of quartz, white feldspar, pink feldspar, white granite, pink granite, and small amounts of tan, vuggy dolomite and red, black, or orange-brown chert. A few subrounded to round pebbles of altered volcanic rocks are also included, but these are the least common of all the clast lithologies.

The light-green to olive-gray, clay-rich, fine- to medium-grained micaceous and feldspathic sandstone and the dark-gray to greenish-gray sandy claystone resemble lithologies in the lower part of facies unit two in the Pikeview (Fig. 2) and Elsmere quadrangles (Thorson and others, 2001; Madole and Thorson, 2002). The finer-grained lithologies in unit $TKda_3$ are characterized by greenish colors, which suggests that the facies contains considerable montmorillonitic clay (Varnes and Scott, 1967). Facies three ($TKda_3$) is well exposed in the bed and banks of Kettle Creek in the southwestern corner of the Black Forest quadrangle. Facies unit three may be equivalent to part of the Dawson Arkose and/or Dawson aquifer as used in the Denver area (John Himmelreich, Jr., 2001, oral commun.).

The sandstones and arkoses of facies unit three are generally stable and have good foundation characteristics. The finer-grained, more clay-rich, lithologies should be expected to be less stable and may have high shrink-swell potential.

$TKda_2$ **Facies unit two (Upper Cretaceous to Paleocene)—**Facies unit two does not crop out in the Black Forest quadrangle but is inferred from regional facies relationships to be present in the subsurface. Facies unit two is 400 to 500 ft thick in the Pikeview quadrangle (Fig. 2) and was deposited in the basin-ward part of that quadrangle (Fig. 4). There, unit $TKda_2$ is composed of light-gray to greenish-gray arkosic sandstone and olive-green to brownish-gray, pebbly, andesitic sandstone interbedded with dark-gray to grayish-green, fine-grained micaceous sandstone and sandy claystone. Facies unit two thickens toward the southeast and is more than 1,000 ft thick in the Elsmere quadrangle (Madole and Thorson, 2002). Facies two may be equivalent to the Denver Formation and/or Denver aquifer in the Denver area (J.Himmelreich, Jr., 2001, oral commun.).

$TKda_1$ **Facies unit one (Upper Cretaceous to Paleocene)—**This facies unit is composed of white to light-gray, cross-bedded or massive, very coarse arkosic sandstone, pebbly arkose, or arkosic pebble conglomerate. The facies unit contains local interbeds of thin- to very thin-bedded gray claystone and sandy claystone, or dark-brown to brownish-gray, organic-rich siltstone to coarse sandstone containing abundant plant fragments. Facies unit one comprises a coarse "mountain front" synorogenic deposit of sediments that were eroded from a rapidly uplifting Front Range, transported across an active fault zone along the mountain front, and deposited in the western part of subsiding Denver Basin (Fig. 4). The regional geometry of facies unit one suggests that it should be present in the subsurface of the Black Forest quadrangle as an eastward thinning wedge similar to that mapped at the surface in the Elsmere quadrangle (Madole and Thorson, 2002). Facies one may be equivalent to part of Arapahoe Formation and/or Arapahoe aquifer in the Denver area (J. Himmelreich, Jr., 2001, oral commun.).

TKdu **Dawson Formation, undivided (Upper Cretaceous to Paleocene)**—shown only on the cross section. Facies units one and facies unit two of the upper Dawson and the lower part of the Dawson Formation (Kda). The lower part of Dawson Formation (Upper Cretaceous) is yellowish-green and greenish-gray to olive-brown sandstone interbedded with grayish-green to dark-green and brown to brownish-gray siltstone and sandy claystone; composed almost exclusively of andesitic debris; about 300 ft thick; does not crop out in the quadrangle.

STRUCTURAL GEOLOGY

The structural geology of the Black Forest quadrangle is not complex. At the surface bedrock units dip gently to the northeast at about 2° to 5° across the quadrangle. Strike and dip symbols are not abundant on the map because of the poor outcrop exposures; those symbols shown are mostly measured from man-made exposures or cut-banks along stream drainages. Measurement of strike and dip in the Dawson Formation is difficult and questionable because of the coarse-grained, lenticular and cross-bedded character of most of the beds. Bedding surfaces and cross-bed orientation from these beds were inclined at deposition, and are unlikely to be representative of the strike and dip of the whole unit. Strike and dip measurements shown on the map were made on thin-bedded, fine-grained strata which were deposited in a horizontal orientation. Projections of the structural geology of the Greenland (Thorson, 2003) and Corral Bluffs (Soister, 1968) quadrangles suggest that the axis of the Denver Basin crosses the Black Forest quadrangle but there are no data available to define that trend.

MINERAL RESOURCES

Sand and gravel are the most significant mineral resources in the Black Forest quadrangle. Lignite coal beds occur in the upper part of the Dawson Formation in other parts of the Denver Basin, but there is no recorded occurrence of these beds in the quadrangle. The Colorado Oil and Gas Conservation Commission has no record of test wells for oil and gas exploration in the Black Forest quadrangle. No metallic or radioactive mineral resources are known in quadrangle.

SAND AND GRAVEL

One permit application for a sand and gravel operation in the Black Forest quadrangle has been filed with the Colorado Department of Natural Resources, Division of Mines and Geology. However, there is no evidence in the field that sand or gravel was ever produced from this proposed pit (Steppler Pit, NW 1/4 SW 1/4 SE 1/4 sec 13, T. 11 N. R. 66 W). Sand and gravel are widely available from surficial deposits derived from the Dawson Formation.

URANIUM

No occurrences of radioactive minerals have been reported from the Black Forest quadrangle, although a small uranium prospect is located in the northwest corner of the Pikeview quadrangle (Burgess claim, NE 1/4 sec. 22, T. 12 S., R. 66 W.; Thorson and others, 2001; Nelson-Moore and others, 1978). This prospect, about 0.5 mi from the southwest corner of the Black Forest quadrangle, occurs in limonite-cemented arkoses of facies unit three of the upper part of the Dawson Formation. Gamma-ray logs from water wells in facies units three and four of the upper Dawson in the Monument quadrangle occasionally have elevated responses (2- to 4-times background) which may indicate small occurrences of low-grade uranium. Small uranium occurrences in the Dawson Formation have been widely encountered as a geological hazard in the northeastern part of the Colorado Springs metropolitan area (John Himmelreich, Jr., written commun., 2002).

REFERENCES CITED

Bassinot, F.C., Labeyrie, L.D., Vincent, E., Quidelleur, X., and Shackleton, N.J., 1994, The astronomical theory of climate and the age of the Brunhes-Matuyama magnetic reversal: Earth and Planetary Science Letters, v. 126, p. 91–108.

Benson, K.P., 1998, Floral diversity and paleoclimate of the latest Cretaceous and early Tertiary deposits, Denver Basin, Colorado, USA: Colorado Springs, Colo., Colorado College, Honors thesis, 178 p.

Benson, K.P., and Johnson, K.J., 1998, Fossil plants of the Late Cretaceous and early Tertiary, Denver Basin, CO, USA [abst.]: Geological Society of America, Abstracts with Programs, v. 30, no. 7, p. A286.

Carroll, C.J., and Crawford, T.A., 2000, Geologic map of the Colorado Springs quadrangle, El Paso County, Colorado: Colorado Geological Survey Open-File Report 00-03, scale 1:24,000.

Crifasi, R.R., 1992, Alluvial architecture of Laramide orogenic sediments, Denver Basin, Colorado: Mountain Geologist, v. 29, p. 19–27.

Emmons, S.F., Cross, Whitman, and Eldridge, G.H., 1896, Geology of the Denver Basin in Colorado: U.S. Geological Survey Monograph 27, 556 p.

Farnham, T.M. and Kraus, M.J., 2002, The stratigraphic and climatic significance of Paleogene alluvial paleosols in synorogenic strata of the Denver Basin, *in* Johnson, K.R., Raynolds, R.G., and Reynolds, M.L. eds., Paleontology and stratigraphy of Laramide strata in the Denver Basin, The Denver Basin Issue: Rocky Mountain Geology, v. 37, no. 2.

Farrand, W.R., 1990, Origins of Quaternary- Pleistocene-Holocene stratigraphic terminology, *in* Laporte, L.F., ed., Establishment of a geologic framework for paleoanthropology: Geological Society of America Special Paper 242, p. 15-22.

Fenneman, N.M., 1931, Physiography of western United States: New York, McGraw-Hill, 534 p.
Finlay, G.I., 1916, Colorado Springs folio, Colorado: U.S. Geological Survey Geologic Atlas Folio 203.
Folk, R.L., and Ward, W.C., 1957, Brazos River bar; A study in the significance of grain size parameters: Journal of Sedimentary Petrology, v. 27, p. 3–26.
Hilgard, E.W., 1892, A report on the relations of soil to climate: U.S. Department of Agriculture, Weather Bureau Bulletin 3, 59 p.
Imbrie, John, Hays, J.D., Martinson, D.G., McIntyre, A., Mix, A.C., Morley, J.J., Pisias, N.G., Prell, W.L., and Shackleton, N.J., 1984, The orbital theory of Pleistocene climate—Support from a revised chronology of the marine $\delta^{18}O$ record, *in* Berger, A., Imbrie, J., Hayes, J., Kukla, G., and Saltzman, B., eds., Milankovitch and climate: Dordrecht, D. Reidel Publishing, part 1, p. 269–305.
Ingram, R.L., 1989, Grain-size scales, in Dutro, J.T., Jr., Dietrich, R.V., and Foose, R.M., compilers, AGI data sheets-For geology in the field, laboratory, and office (3rd ed.): Alexandria, V., American Geological Institute, sheet 29.1.
Johnson, K.R., and Raynolds, R.G., 2001, Research on paleontological and geological resources of the Denver Basin near Colorado Springs with enphasis on the Jimmy Camp Creek and Corral Bluffs area: Denver, Colo., 2000 Colorado Natural History Small Grants Program, Denver Museum of Nature & Science, unpublished final report.
Kluth, C.F., and Nelson, S.N., 1988, Age of the Dawson Arkose, southwestern Air Force Academy, Colorado, and implications for the uplift history of the Front Range: Mountain Geologist, v. 25, no. 1, p. 29–35.
Lourens, L.J., Antonarakou, A., Hilgen, F.J., van Hoof, A.A.M., Vergnaud-Grazzini, C., and Zachariasse, W.J., 1996, Evaluation of the Plio-Pleistocene astronomical timescale: Paleoceanography, v. 11, p. 391–413.
Maberry, J.O., and Lindvall, R.M., 1972, Geologic map of the Parker quadrangle, Arapahoe and Douglas Counties, Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-770-A, scale 1:24,000.
Maberry, J.O., and Lindvall, R.M., 1977, Geologic map of the Highlands Ranch quadrangle, Arapahoe and Douglas Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-1413, scale 1:24,000.
Madole, R.F., 1991, Colorado Piedmont, *in* Wayne, W.J., ed., Quaternary geology of the Northern Great Plains, *chapter 15 of* Morrison, R. B., ed., Quaternary nonglacial geology—Conterminous United States: Boulder, Colo., Geological Society of America, The Geology of North America, v. K-2, p. 444–445, 456-462.
Madole, R.F., and Streufert, R.K., 2001, Geologic map of the Gibson Gulch quadrangle, Garfield County, Colorado: Colorado Geological Survey Open-File Report 01-2, scale 1:24,000.
Madole, R.F., and Thorson, J.P., 2002, Geologic map of the Elsmere quadrangle, El Paso County, Colorado: Colorado Geological Survey Open-File Report 02-02, scale 1:24,000.
Mcintosh, W.C., and Chapin, C.E., 1994, $^{40}Ar/^{39}Ar$ geochronology of ignimbrites in the Thirtynine Mile volcanic field, Colorado, *in* Evanoff, E., ed., Late Palogene geology and paleoenvironments of central Colorado: Geological Society of America Field Trip Guidebook, p. 23–26.
Mcintosh, W.C., Swisher, C.C., and Chapin, C.E., 1992, Single-crystal laser-fusion $^{40}Ar/^{39}Ar$ sanidine ages of ignimbrites inn the Thirtynine Mile volcanic field, Colorado: [abst.]: Eos, 1992 Spring Meeting Supplement, April 7, 1992.
Morse, D. G., 1979, Paleogeography and tectonic implications of the late Cretaceous to middle Tertiary rocks of the southern Denver Basin, Colorado: Baltimore, Md., Johns Hopkins University, unpublished PhD thesis, 344 p.
Nelson-Moore, J.L., Collins, D.B., and Hornbaker, A.L., 1978, Radioactive mineral occurrences of Colorado: Colorado Geological Survey Bulletin 40, 1054 p.
Nichols, D.J. and Fleming, R.F., 2002, Palynology and palynostratigraphy of Maastrichtian, Paleocene, and Eocene strata in the Denver Basin, Colorado, *in* Johnson, K.R., Raynolds, R.G., and Reynolds, M.L., eds., Paleontology and stratigraphy of Laramide strata in the Denver Basin, The Denver Basin Issue: Rocky Mountain Geology, v. 37 no. 2.
Raynolds, R.G., 1997, Synorogenic and post-orogenic strata in the central Front Range, Colorado, *in* Bolyard, D.W., and Sonnenberg, S.A., eds., Geologic history of the Colorado Front Range: Denver, Colo., Rocky Mountain Association of Geologists, p. 43–48.
Raynolds, R.G., 2001a, Evidence for episodic orogenic activity on the Front Range—Denver Basin Project Spring Science Meeting, Denver, Colorado, May 18. 2001, unpublished conference abstract.
Raynolds, R.G., 2001b, Episodic deposition in the Cretaceous and Paleocene Denver Basin: How tectonics controls the continuity of the stratigraphic record [abst.]: Geological Society of

America Abstracts with Programs, v. 33, no. 6, p. A197.

Raynolds, R.G., 2002, Upper Cretaceous and Tertiary stratigraphy of the Denver Basin, Colorado, *in* Johnson, K.R., Raynolds, R.G., and Reynolds, M.L., eds., Paleontology and stratigraphy of Laramide strata in the Denver Basin, The Denver Basin Issue: Rocky Mountain Geology, v. 37 no. 2.

Remane, J., Faure-Muret, A. and Odin, G.S., 2002, International Stratigraphiic Chart: International Union of Geological Sciences and UNESCO Commission on the Geological Map of the World.

Richardson, G.B., 1912, The Monument Creek Group: Geological Society America Bulletin, v. 23, p. 257–276.

Richardson, G. B., 1915, Castle Rock folio, Colorado, U.S. Geological Survey Geologic Atlas Folio 198, 19 p.

Robson, S.G., 1987, Bedrock aquifers in the Denver Basin, Colorado—A quantitative water-resources appraisal: U.S. Geological Survey Professional Paper 1257, 73 p., includes map at scale 1:500,000.

Robson, S.G., 1989, Alluvial and bedrock aquifers of the Denver basin—eastern Colorado's dual ground-water resource: U.S. Geological Survey Water-Supply Paper 2302, 40 p.

Rowley, P.D., Himmelreich, J.W., Jr., and Kupfer, D.H., 2002, Geological map of the Cheyenne Mountain quadrangle, El Paso County, Colorado: Colorado Geological Survey Open-file Report 02-05, scale 1:24,000,

Scott, G.R., 1962, Geology of the Littleton quadrangle, Jefferson, Douglas, and Arapahoe Counties, Colorado: U. S. Geological Survey Bulletin 1121-L, 53 p., includes map at scale 1:24,000.

Scott, G.R., 1963, Bedrock geology of the Kassler quadrangle, Colorado: U.S. Geological Survey Professional Paper 421-B, p. 71–125, includes map at scale 1:24,000.

Scott, G.R., and Wobus, R.A., 1973, Reconnaissance geologic map of Colorado Springs and vicinity, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-482, scale 1:62,500.

Soister, P. E., 1968, Geologic map of the Corral Bluffs quadrangle, El Paso County, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-783, scale 1:24,000.

Soister, P.E., and Tschudy, R.H., 1978, Eocene rocks in the Denver Basin, *in* Pruit, J.D., and Coffin, P.E., eds., Energy resources of the Denver Basin: Denver, Colo., Rocky Mountain Association of Geologists, 29th Annual Field Symposium Guidebook, p. 231–235.

Tauxe, Lisa, Deino, A.D., Behrensmeyer, A.K., and Potts, R., 1992, Pinning down the Brunhes/Matuyama and upper Jaramillo boundaries-A reconciliation of orbital and isotopic time scales: Earth and Planetary Science Letters, v. 109, p. 561–572.

Thorson, J. P., 2003, Geologic map of the Greenland quadrangle, Douglas and El Paso Counties, Colorado: Colorado Geological Survey Open-File Report 03-0x, scale 1:24,000

Thorson, J. P., Carroll, C. J., and Morgan, M. L., 2001, Geologic map of the Pikeview quadrangle, El Paso County, Colorado: Colorado Geological Survey Open-File Report 01-03, scale 1:24,000.

Thorson, J. P., and Madole, R. F. 2002, Geologic map of the Monument quadrangle, El Paso County, Colorado: Colorado Geological Survey Open-File Report 02-04, scale 1:24,000.

Trimble, D.E., and Machette, M.N., 1979a, Geological map of the Colorado Springs-Castle Rock area, Front Range urban corridor, Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-857-F, scale 1:100,000.

Trimble, D.E., and Machette, M.N., 1979b, Geologic map of the greater Denver area, Front Range urban corridor, Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-856-H, scale 1:100,000.

Van Devender, T.R., Thompson, R.S., and Betancourt, J.L., 1987, Vegetation history of the deserts of southwestern North America—The nature and timing of the late Wisconsin-Holocene transition, *in* Ruddiman, W.F., and Wright, H.E., Jr., eds., North America and adjacent oceans during the last deglaciation: Boulder, Colo., Geological Society of America, The Geology of North America, v. K-3, p. 323–352.

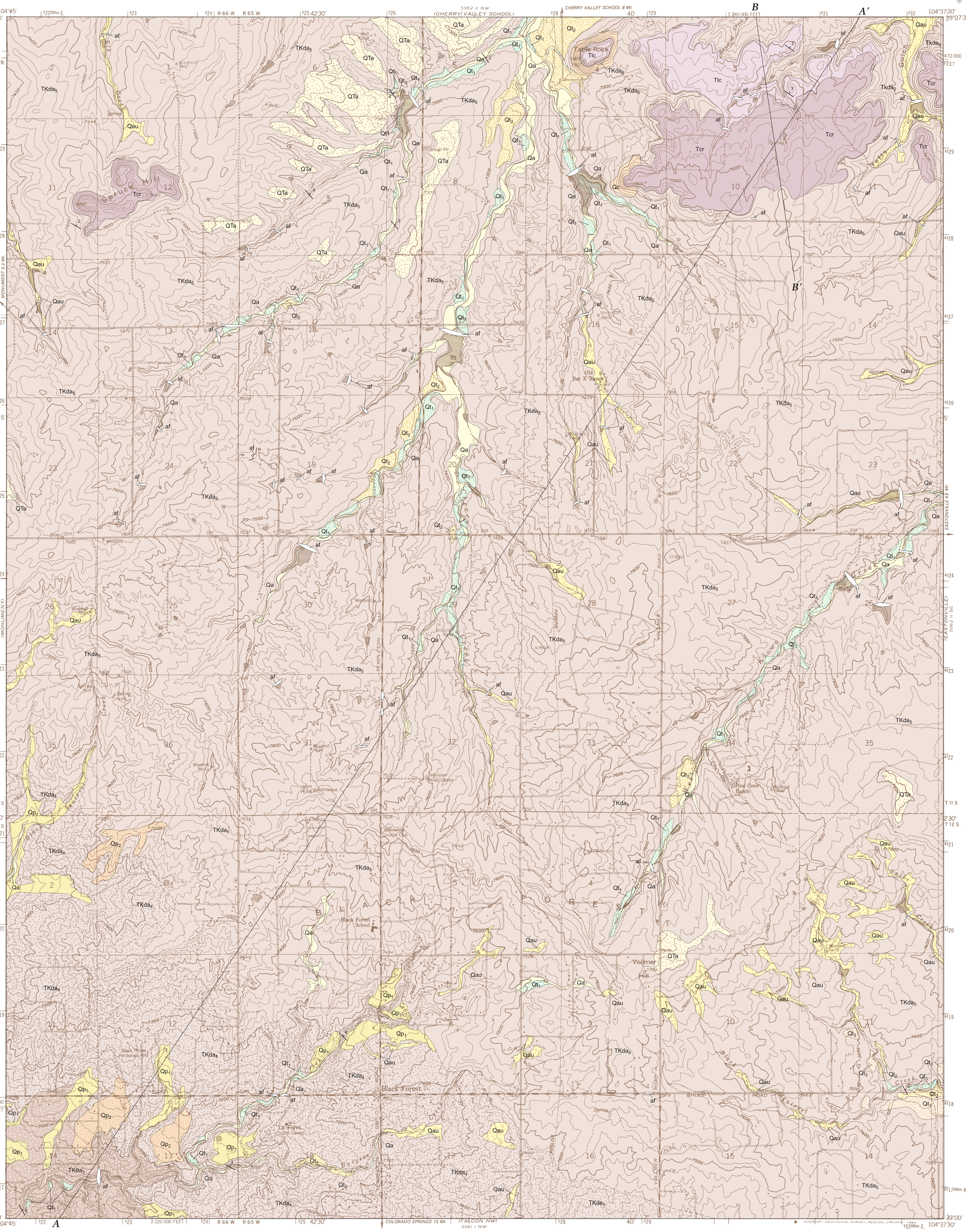
Varnes, D.J., and Scott, G.R., 1967, General and engineering geology of the United States Air Force Academy site, Colorado, with a section on ground water by W.E.D. Cardwell and E.D. Jenkins: U.S. Geological Survey Professional Paper 551, 93 p.

Wobus, R.A., and Scott, G.R., 1977a, Reconnaissance geologic map of the Woodland Park quadrangle, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-842, scale 1:24,000.

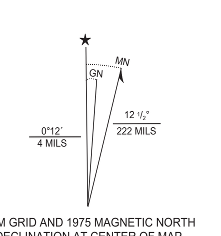
Wobus, R.A., and Scott, G.R., 1977b, Reconnaissance geologic map of the Cascade quadrangle, El Paso County, Colorado: U.S. Geological Survey Open-File Report 77-138, scale 1:24,000.

COLORADO GEOLOGICAL SURVEY
DIVISION OF MINERALS AND GEOLOGY
DEPARTMENT OF NATURAL RESOURCES
DENVER, COLORADO

OPEN FILE MAP 03-06
GEOLOGIC MAP OF THE BLACK FOREST
QUADRANGLE, EL PASO COUNTY, COLORADO
Booklet accompanies map
DOI: https://doi.org/10.58783/cgs.of0306.mxso5099

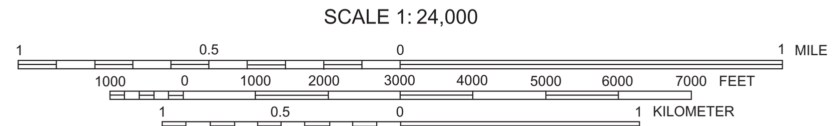


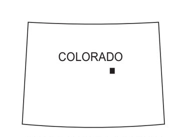
Base from U.S. Geological Survey, 1975
Polyconic projection, 1927 North American Datum
10,000-foot grid based on Colorado coordinate system, central zone
1,000-meter Universal Transverse Mercator grid ticks, zone 13



UTM GRID AND 1975 MAGNETIC NORTH DECLINATION AT CENTER OF MAP DIAGRAM IS APPROXIMATE

SCALE 1: 24,000

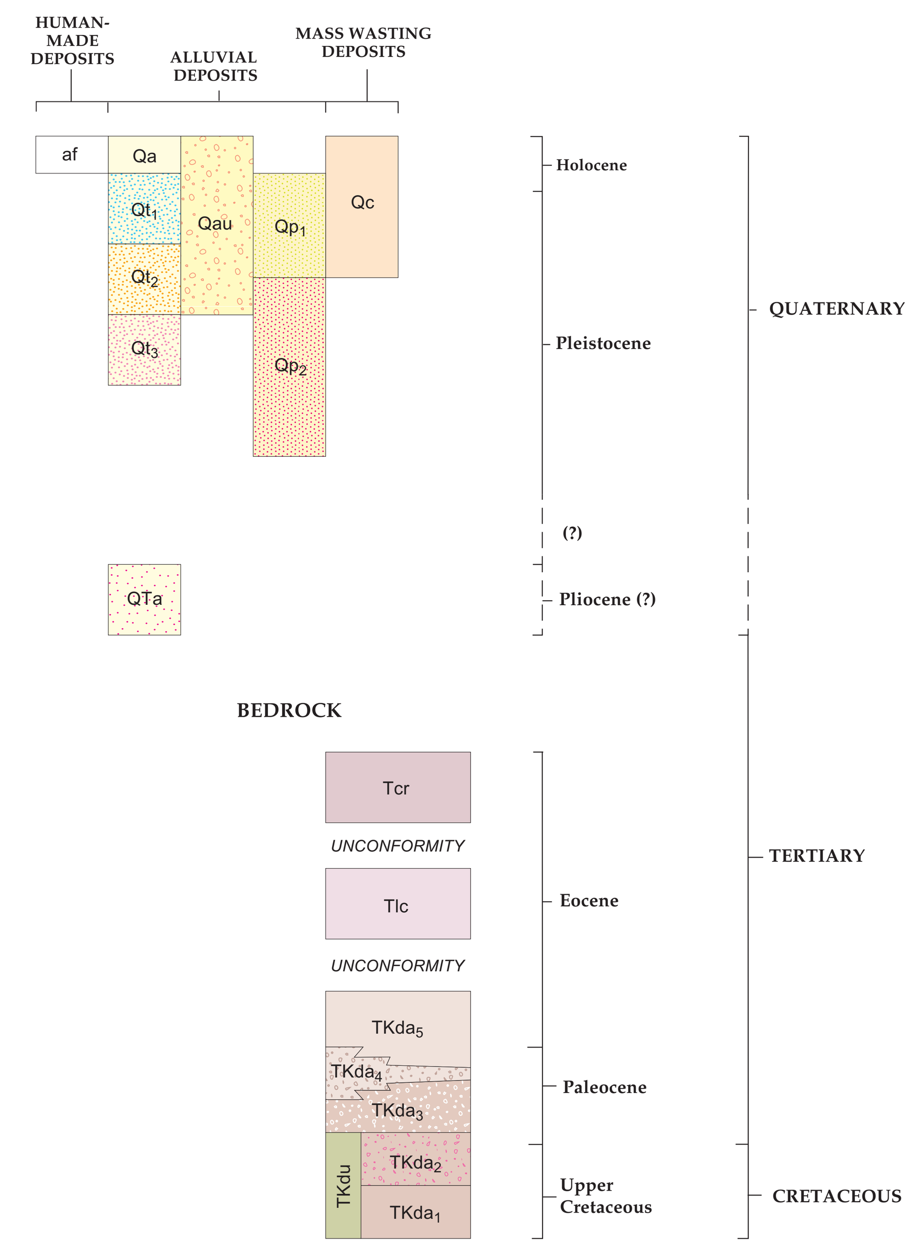




QUADRANGLE LOCATION

Geology mapped in 2002
Cartography by Jason Wilson

CORRELATION OF MAP UNITS



MAP UNITS

The complete description of map units and references are in the accompanying booklet.

SURFICIAL DEPOSITS

HUMAN-MADE DEPOSITS

af	**Artificial fill (late Holocene)**

ALLUVIAL DEPOSITS

Qa	**Channel and flood-plain alluvium (late Holocene)**
Qt_1	**Terrace alluvium one (Holocene and late Pleistocene)**
Qt_2	**Terrace alluvium two (late middle Pleistocene)**
Qt_3	**Terrace alluvium three (late middle Pleistocene)**
Qau	**Alluvium, undivided (Holocene and Pleistocene)**
Qp_1	**Younger piedmont-slope alluvium (Holocene and late Pleistocene)**
Qp_2	**Middle piedmont-slope alluvium (middle Pleistocene)**
QTa	**Alluvium of Palmer Divide (early? Pleistocene or Pliocene?)**

MASS-WASTING DEPOSITS

Qc	**Colluvium (Holocene and late Pleistocene)**

BEDROCK DEPOSITS

Tcr	**Castle Rock Conglomerate (late Eocene)**
Tlc	**Conglomerate of Larkspur Butte (late Eocene)**

Dawson Formation (Upper Cretaceous to Eocene)

Upper part of the Dawson Formation (Upper Cretaceous to Eocene)

$TKda_5$	**Facies unit five (early to middle? Eocene)**
$TKda_4$	**Facies unit four (Paleocene)**
$TKda_3$	**Facies unit three (Paleocene)**
$TKda_2$	**Facies unit two (Upper Cretaceous to Paleocene)**—Not shown on map or cross section
$TKda_1$	**Facies unit one (Upper Cretaceous to Paleocene)**—Not shown on map or cross section
TKdu	**Dawson Formation, undivided (Upper Cretaceous to Paleocene)**—Shown only on cross section

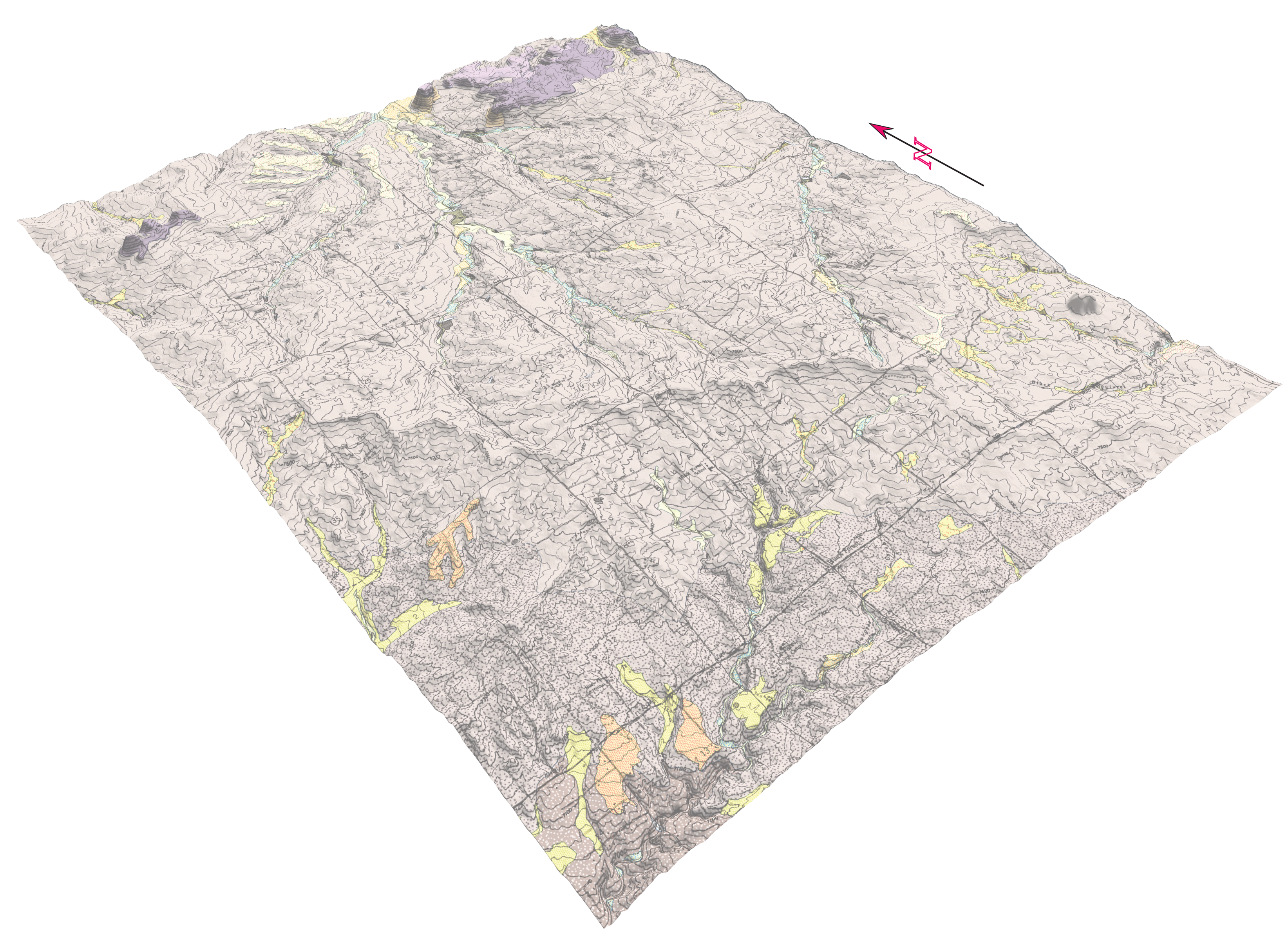
MAP SYMBOLS

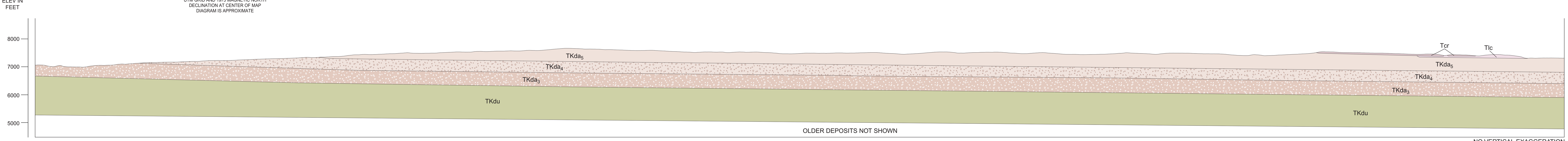
Contact—Dashed where approximately located

Strike and dip of inclined beds—Angle of dip shown in degrees

A —— A′ **Alignment of cross sections; B–B′, Figure 6 in booklet**

SHADED RELIEF MAP OF THE BLACK FOREST QUADRANGLE WITH GEOLOGY OVERLAY; OBLIQUE VIEW LOOKING NORTHEAST





GEOLOGIC MAP OF THE BLACK FOREST QUADRANGLE, EL PASO COUNTY, COLORADO

By Jon P. Thorson

2003