OPEN-FILE REPORT 04-5

Geologic Map of the Castle Rock South Quadrangle, Douglas County, Colorado

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Division of Minerals and Geology
Department of Natural Resources
Denver, Colorado

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Introduction
Geological Setting
Description of Map Units
Structural Geology
Mineral Resources
Water Resources
Geological Hazards
and References Cited

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This mapping project was funded jointly by the Colorado Geological Survey and the U. S. Geological Survey through the National Geologic Mapping Program under STATEMAP agreement No. 03HQAG0095

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FOREWORD

The purpose of Colorado Geological Survey Open File Report 04-5, *Geologic Map of the Castle Rock South Quadrangle, Douglas County, Colorado* is to describe the geologic setting, structural geology, mineral resource potential, water resources, and geologic hazards of this 7.5-minute quadrangle located in central Colorado. Consulting Geologist Jon P. Thorson completed the field work on this project during the summer of 2003.

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, Award number 03HQAG0095, 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.

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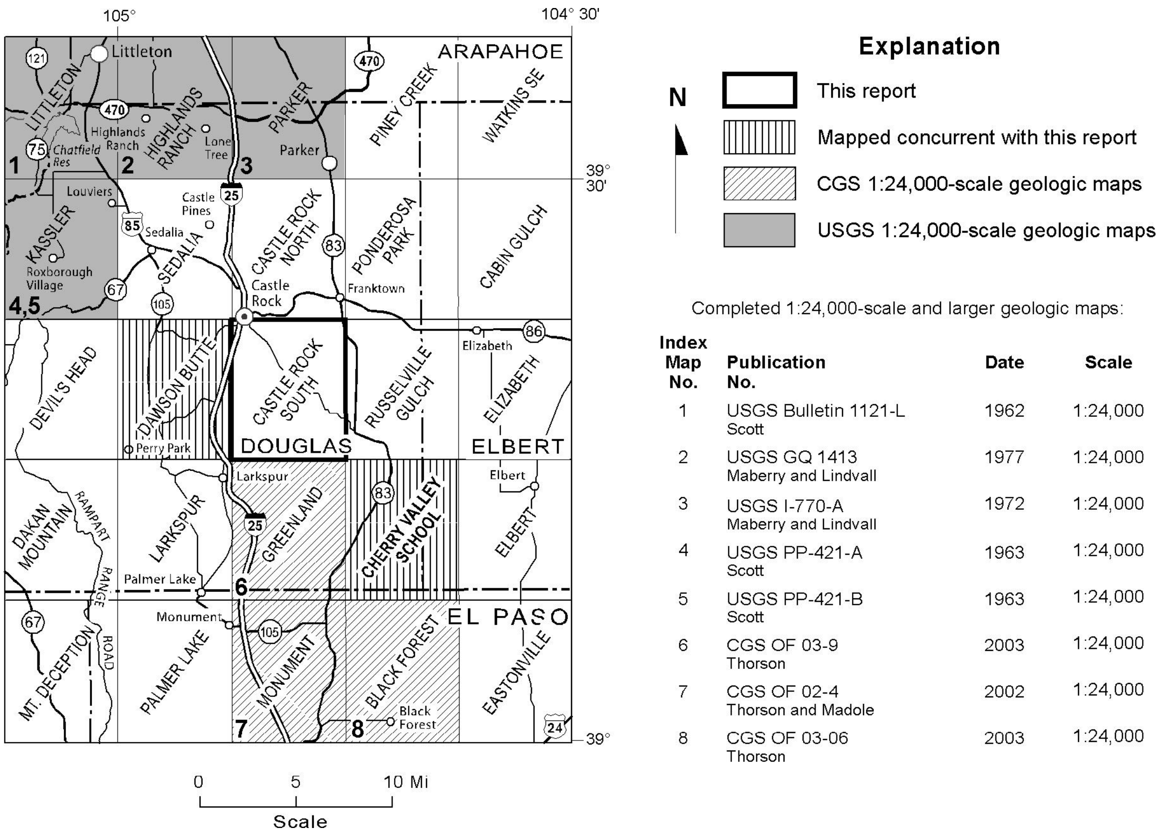
CONTENTS

INTRODUCTION

The Castle Rock South 7.5-minute quadrangle is located immediately south of Castle Rock, Colorado in the southern part of the Colorado Piedmont section of the Great Plains. The quadrangle is located in the Cherry Creek and Plum Creek drainage basins which are tributary to the South Platte River. Geologic mapping of the Castle Rock South quadrangle was undertaken by the Colorado Geological Survey (CGS) as part of the STATEMAP component of the National Cooperative Geologic Mapping Program. 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 1 shows the location of the Castle Rock South quadrangle and the status of geologic mapping of 7.5-minute quadrangles in the Castle Rock area.



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

Index Map No.	Publication No.	Date	Scale
1	USGS Bulletin 1121-L Scott	1962	1:24,000
2	USGS GQ 1413 Maberry and Lindvall	1977	1:24,000
3	USGS I-770-A Maberry and Lindvall	1972	1:24,000
4	USGS PP-421-A Scott	1963	1:24,000
5	USGS PP-421-B Scott	1963	1:24,000
6	CGS OF 03-9 Thorson	2003	1:24,000
7	CGS OF 02-4 Thorson and Madole	2002	1:24,000
8	CGS OF 03-06 Thorson	2003	1:24,000

Figure 1.

This map is based on prior published and unpublished geologic maps and reports, interpretation of aerial photography, and field mapping in 2003. The aerial photographs used are 1:28,000 scale black and white photographs taken in 1972. The topographic base map for the Castle Rock South quadrangle was published in 1965 and updated by photo inspection in 1994. Consequently, some of the presently existing roads, buildings and other human-made modifications of the landscape are not shown on the base map.

Previous geological mapping in the Castle Rock South area includes the work of Emmons and others (1896) and Richardson (1915). Trimble and Machette (1979) published a 1:100,000 scale regional geologic map of the Front Range urban corridor which includes the Castle Rock South quadrangle. The names and symbols used for geological units in the Castle Rock South quadrangle conform as much as possible to those employed previously on geologic maps of nearby areas prepared by the Colorado Geological Survey (Fig. 1). 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 Castle Rock South 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.

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 reviewed the map and text. Matt Morgan and Jason Wilson of the Colorado Geological Survey were valuable help in converting notes and field mapping on aerial photos into the geological map. George D. VanSlyke, Colorado Division of Water Resources, provided generous access to his department's files of water-well logs. Special thanks go to the landowners and developers who granted permission to enter their property.

GEOLOGICAL SETTING

The Castle Rock South 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.

Most of the exposed bedrock in the Castle Rock South quadrangle is the assemblage of lithologies shown on the geologic map as 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 those 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 of the Dawson 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.

Following the erosion of some of the upper part of the Dawson Formation, the conglomerate of Larkspur Butte (Thorson, 2003b) was deposited in a series of channels and broad valleys occupied by streams which drained the newly rejuvenated mountains. In the western part of the Greenland quadrangle the conglomerate of Larkspur Butte was deposited in narrowly confined, steep-walled stream valleys. These valleys became broader towards the east.

The Wall Mountain Tuff, an ignimbrite or glowing hot volcanic ash flow, was erupted in the late Eocene and poured across the landscape. This ash flow blanketed the eroded surface of the Dawson Formation and the valleys which contained the conglomerate of Larkspur Butte. Because of its great heat the ash compacted into a viscous plastic which flowed for short distances before it cooled into welded tuff. Erosional remnants of the Wall Mountain Tuff overlie the Dawson Formation on the higher buttes in the western part of the Castle Rock South quadrangle. The ash flow ponded in a depression in the east-central part of the quadrangle (sec. 27, T. 8 S., R. 66 W.) where it overlies the conglomerate of Larkspur Butte. The Castle Rock Conglomerate was deposited near the end of the Eocene in paleovalleys on an erosion surface that cuts across the upper Dawson, conglomerate of Larkspur Butte, and Wall Mountain Tuff. One of the Castle Rock paleochannels extends from the southwestern corner to the center of the quadrangle. Deposition of this conglomerate extended over most of the northeastern part of the Castle Rock South quadrangle filling a depression near the center of the Denver Basin.

Since the deposition of the 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.

AGE OF FORMATIONS

Dawson Formation - the upper part of the Dawson Formation spans the Cretaceous-Paleogene (K-P) boundary, but the exact location of the time boundary in most of the basin has not been identified. 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 the K-P boundary has been approximately located about 370 feet 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). Fossil leaf localities in the Monument quadrangle (Scotty's Palm, Denver Museum of Nature & Science, DMNH-1204, NE 1/4 SW 1/4 sec. 12, T. 12 S., R. 67 W., Johnson, 2001; and Baptist Road, Denver Museum of Nature &

Science, DMNH-2177, NW 1/4 sec. 35. T. 11 S., R. 67 W., Johnson and Raynolds,1998) are Paleocene in age. Another Paleocene fossil locality is located just north of the quadrangle boundary in NE 1/4, SW 1/4, sec. 2, T. 8 S., R. 67 W, (Ellis and others, 2003). A well-developed paleosol found on Hunt Mountain (Morgan and others, 2004) and in SW 1/4 sec. 23 and NW 1/4 sec. 26, T. 8 S., R. 67 W. may be the regional paleosol traced around the basin by Soister and Tschudy (1978) and proposed to mark the Paleocene-Eocene boundary. This paleosol was used as the boundary between Dawson facies units four and five in the Monument quadrangle (Thorson and Madole, 2002). Recent work on this paleosol has recognized that it separates early Paleocene pollen zone P3 from late Paleocene Pollen zone P6 (Nichols and Fleming,, 2002). Mapping of the Castle Rock South quadrangle has shown that most of the local Dawson Formation lies above this paleosol and is correlated with the Eocene TKda5 facies unit of the Monument quadrangle.

Conglomerate of Larkspur Butte - The conglomerate of Larkspur Butte (Tlc) is a newly recognized unit that underlies the late-Eocene-age Wall Mountain Tuff on Larkspur Butte, and on many of the high buttes in the Greenland (Thorson, 2004b), Black Forest (Thorson, 2003a) and Cherry Valley School (Thorson, 2004) quadrangles. This conglomerate is clearly of Eocene age; it lies between Eocene upper Dawson Formation and late Eocene-age Wall Mountain Tuff. It is of probable late Eocene age because a significant part of the Eocene epoch probably passed during the deposition, alteration, and erosion of the upper Dawson. And, because the conglomerate of Larkspur Butte fills, or partially fills, paleovalleys that were present in the late Eocene and appear to have influenced the deposition of the late Eocene Wall Mountain Tuff.

Wall Mountain Tuff - The ignimbrite eruption which deposited the Wall Mountain Tuff has been considered in the past to be an Oligocene event, for example see Trimble and Machette, 1979. Recent radiometric dates on its eruption are about 36.7 mybp (million years before present; Mcintosh and others, 1992; Mcintosh and Chapin, 1994). However, the age for the end of the Eocene is now recognized to be 33.7 mybp (Remane and others, 2002), so the Wall Mountain Tuff should now be considered to be late Eocene.

Castle Rock Conglomerate - The Castle Rock Conglomerate post-dates the Wall Mountain Tuff since the conglomerate contains clasts of the tuff. The Castle Rock Conglomerate also contains bones of Chadronian (late Eocene) titanotheres (K. R. Johnson, Denver Museum of Nature and Science, written commun., 2002) and so must be late Eocene in age, between 35.7 and 33.7 mybp.

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 highways, railroads, and dams. A special category of this material, rock quarry waste, covers most of the top of the large butte south of the town of Castle Rock in sec. 23 and 24, T. 8 S., R. 67 W. Additional quarry waste dumps are located along the east edge of the Sellers Gulch valley about 3 to 5 miles southeast of town. Thickness generally is between 5 and 50 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 Castle Rock South quadrangle are dominantly 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 (Qt1, Qt2, Qt3) deposits are subround coarse pebbles (less than 1.25 inches) or smaller grains. Occasional larger pebbles and small cobbles (up to about 4 inches) of well rounded light-colored quartz and subangular to subround yellow-brown chert, and rare larger cobbles and small boulders of round to subround dark-pink to light-red Pikes Peak Granite, found in the channel, flood-plain, and terrace deposits can not have been derived from the Dawson. These clasts appear to be recycled from either the older surficial deposits, the conglomerate of Larkspur Butte, or from the Castle Rock Conglomerate. Large cobbles and small boulders of subround Dawson arkose or angular to subangular brownish-gray welded tuff in the alluvial deposits were derived from local sources.

Part of the Castle Rock South quadrangle is mantled by older alluvial deposits of probable Pleistocene age (Qp1, Qp2, Qp3). In many places the upper surface of these older alluvial deposits is preserved as a gently sloping planar surface from which the original base level for the deposit can be interpreted. The relative age of these deposits has been interpreted from the slope, base level, and position in the landscape. These deposits have been grouped together as "older alluvium" since they represent either higher elevations of the present drainage system (Qp1, and Qp2 or deposits which can be related to an older drainage system, Qp3. In either case their form is being modified by erosion over wide areas.

The youngest of these older alluvial deposits, Qp1, has surfaces which mimic the present drainage system but represent material deposited during a higher base level of the drainage than present. Qp2 is intermediate in position in the landscape between Qp1 and Qp3. The position of the oldest alluvial deposits, Qp3, at higher elevation positions in the landscape than Qp2, suggests that these deposits may be the remnants of older drainage systems which flowed northeastward and mantled much of the area in the Pleistocene. In some places the lower elevation edges of the older deposit, Qp3 grades imperceptibly into the upper part of Qp2; in others Qp3 was clearly deposited at a higher elevation than Qp2, and is therefore older.

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 Qt1. 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.

Qt1 **Terrace alluvium one (Holocene and late Pleistocene) —** Pale-brown and brown to 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 5-10 ft higher than some of the larger streams, but is only about 3-5 ft higher than the smaller streams of the area. Infrequent large floods may inundate Qt1 in places. The unit may correspond to the Piney Creek Alluvium of Maberry and Lindvall (1972). Thickness is estimated to be 5-35 ft.

Qt2 **Terrace alluvium two (late Pleistocene) —** Very pale-brown to dark 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) and the Broadway Alluvium of Maberry and Lindvall (1972). The upper surface of the unit is typically 10-20 ft higher than the larger streams.   Thickness is 5-20 ft.

Qt3 **Terrace alluvium three (late middle Pleistocene) —** Chiefly pale-brown to light 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 20-40 ft higher than the drainages. The unit may correspond to Louviers Alluvium of Maberry and Lindvall (1972). 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. These alluvium-filled valley heads are not exhumed or deeply incised. The unit probably includes sediment that is correlative with units Qa, Qt1, and possible Qt2. Estimated thickness is 3-10 ft.

Qsw **Sheetwash (Holocene and late Pleistocene) —** Typically, light grayish-brown, pale-brown, to brown, extremely poorly sorted sand, silty and clayey sand, and minor amounts of gravel including some cobbles and small boulders. Unit consists chiefly of material transported on moderate slopes by sheet flow but also includes some sediment delivered by runoff in rills and minor gullies.   The abundance of sand-size grains and pebbles in this unit make it a gruss-like deposit. The unit has been largely derived from disintegration of the Dawson, but a smaller amount may have been derived from the older alluvial deposits. Estimated thickness is 3-20 ft.

Qaf **Alluvial-fan deposits (Holocene and late Pleistocene) -** Typically, light grayish-brown, pale-brown, to brown very poorly sorted sand, silt, and minor gravel deposited by ephemeral tributary streams on fans at the edges of valley floors. The unit is composed of material that is essentially the same as the sheet-wash deposits (Qsw), and was probably largely deposited by sheet-flow processes, although it may contain also some material transported by debris flow and mud flow processes. The geomorphic form of these alluvial fan deposits allows them to be mapped separately. Estimated thickness is 3-20 ft.

Qp1 **Older alluvium one (late Pleistocene) —** Chiefly light-brown to reddish-brown, extremely poorly sorted sand and coarse gravel, which, in places, includes boulders as well as pebbles and cobbles. The unit may have cobbly and bouldery layers with angular to subround fragments of Wall Mountain Tuff and subrounded clasts of Dawson arkose. Unit Qp1 is poorly exposed in places; estimated thickness may be a great as 30 ft.

The slope of the Qp1 older alluvium deposits, and of the upper surface where preserved, indicates that this is the youngest of the older alluvial deposits. Gently sloping surfaces that appear to be the original depositional surface can be seen in many areas. The slope of these surfaces, toward a drainage in approximately the same position as the present drainage but representing a higher base level, acknowledges the presence of an older drainage system that resembled the present drainage system. The older alluvial deposits that are older than Qp1 indicate drainages that have less similarities to the present system.

Qp2 **Older alluvium two (middle Pleistocene) —** Light-brown to light reddish-brown, poorly-sorted sand and coarse gravel which includes cobbles and boulders as well as pebbles as remnants of older alluvial deposits along the sides of major valleys in the quadrangle. The upper surfaces of these deposits are being reshaped by erosion. Unit may correlate with the Slocum Alluvium of Maberry and Lindvall (1972). Estimated thickness is 5-75 ft.

Qp3 **Older alluvium four (early ? to middle ? Pleistocene)** This deposit is composed of light-brown sand and fine gravel that appears to be derived from the Dawson Formation, plus cobbles and small boulders of Dawson arkose, and cobbles of Wall Mountain Tuff. Qp3 is the highest alluvial deposit in the Castle Rock South quadrangle and therefore, probably the oldest. The highest parts of this unit in the southern part of the quadrangle are located at elevations above 7200 ft. Qp3 slopes generally toward the north. Unit is about 45 to 60 ft thick.

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 Castle Rock South 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 upper 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, Wall Mountain Tuff, and Castle Rock

Conglomerate. 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.

Colluvium generally accumulates on or near the base of steep slopes below buttes and cliffs capped by Wall Mountain Tuff and Castle Rock Conglomerate. Notable exceptions are the circular clusters of small hills in S1/2 sec. 14 and N edge sec. 23, T. 8 S., R. 67 W. (just south of the town of Castle Rock) and NW1/4 sec. 30, T. 9 S., R. 66 W. (in Sellers Gulch valley). Careful examination of the colluvium covering these hills reveals that the colluvium is thin and rests on underlying hills of Dawson Formation facies unit five (TKda5). It seems reasonable to conclude that these clusters of colluvium-covered hills are the remnants of now-eroded buttes that previously had colluvium flanks and conglomerate and tuff caprocks.

BEDROCK DEPOSITS

Tcr **Castle Rock Conglomerate (late Eocene)** - The Castle Rock Conglomerate is a pebble, cobble, and boulder arkosic conglomerate composed dominantly of subround to round fragments of pink and gray granite and quartz with subordinate amounts of gneissic metamorphic rocks, quartzite, red sandstone, and chert. The distinguishing characteristic of this unit is the presence of angular to subangular cobble to boulder-size clasts of gray, brownish-gray, maroon, or lavender-gray welded tuff which have been eroded from deposits of the Wall Mountain Tuff. The Castle Rock Conglomerate was deposited on an erosion surface cut across the top of the upper Dawson Formation, conglomerate of Larkspur Butte, and Wall Mountain Tuff. In the southeastern part of the quadrangle the Castle Rock Conglomerate was deposited in a paleochannel at a lower elevation than Wall Mountain Tuff, but in the northeastern part of the quadrangle this unit overlies the Wall Mountain Tuff. 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, Denver Museum of Nature and Science, written commun. 2002).

Twm **Wall Mountain Tuff (late Eocene)** - The Wall Mountain Tuff is a moderately to densely welded tuff of rhyolitic composition (Izett and others, 1969; Epis and Chapin, 1974). It is generally light- to medium-brown when fresh but is occasionally medium-gray in a few of the more densely welded outcrops. On weathering is may be light-brown, lavender, pink , reddish-brown, or maroon. The fine-grained groundmass usually contains small phenocrysts of biotite and sanidine, and occasionally near the base may contain quartz grains and small arkose fragments ripped up from the underlying strata. The Wall Mountain Tuff was emplaced in the Castle Rock South quadrangle as an ash-flow that was hot enough that the ash compacted and welded into a viscous plastic after emplacement. In places the welded ash flowed and developed flow-banding before cooling and solidifying. The Wall Mountain Tuff has been dated as about 36.7 million years in age by McIntosh and others, 1992; McIntosh and Chapin, 1994. The ash was erupted from the Thirtynine Mile volcanic field (Epis and Chapin, 1974).

In the Castle Rock South quadrangle the Wall Mountain Tuff is up to about 60 feet thick. On most outcrops the welded tuff is fractured horizontally into hackly plates generally about 4 to 8 inches thick. It caps many of the higher buttes in the southwestern part of the quadrangle as a flat or very gently sloping deposit resting on the Dawson Formation. In the northwestern part of the quadrangle the welded tuff once capped the prominent flat-topped butte on the south edge of the town of Castle Rock (sec. 23 and 24, T. 8 S., R. 67 W.) before it was largely removed by quarrying for building stone. Here, and near the eastern edge of the quadrangle (sec. 27, 34, and 35, T. 8 S., R. 66 W.), the Wall Mountain Tuff was deposited across older stream channels partially filled with the conglomerate of Larkspur Butte.

Tlc **Conglomerate of Larkspur Butte (late ? Eocene) -** The conglomerate of Larkspur Butte is a brown, pinkish-brown, or pink arkosic conglomerate dominantly composed of pebbles and cobbles of pink granite or pink feldspar in a coarse sand-size to small-pebble matrix composed of quartz and pink feldspar. Clasts of gray or white quartz are common; less abundant are clasts of gneissic metamorphic rocks, quartzite, red sandstone, and chert; clasts are subround to round. Clasts of eroded Dawson Formation arkose are common near the base of the unit. The conglomerate of Larkspur Butte rests on an erosional unconformity on the top of the Dawson Formation that has up to 50 to 60 feet of relief where well exposed on Larkspur Butte in the Greenland quadrangle (Thorson, 2003b). Similar channel-edge geometry relationships can be interpreted from poor exposures on the prominent flat-topped butte on the south edge of the town of Castle Rock (sec. 23 and 24, T. 8 S., R. 67 W.) and in sec. 34, T. 8 S., R. 66 W.

The conglomerate of Larkspur Butte is distinguished from the underlying Dawson by its coarser grain size, pinkish color tones, dominance of pink granite and unbleached pink feldspar grains, and lack of clay in the matrix material. 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 of the macroscopic 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 similar in appearance to the Castle Rock Conglomerate although the latter generally lacks pink tones and is light-gray in color. The principal distinguishing characteristic is the fragments of Wall Mountain Tuff in the Castle Rock Conglomerate. In the absence of tuff fragments, the two late-Eocene conglomerates may be very hard to distinguish.

Dawson Formation (Upper Cretaceous to Eocene) - The Dawson Formation is divided into upper and lower parts in the Colorado Springs area (Thorson and others, 2001, Thorson and Madole, 2002). The lower part is entirely Upper Cretaceous in age and composed almost exclusively of andesitic debris. 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 (TKda1), facies unit two (TKda2), facies unit three (TKda3), facies unit four (TKda4), and facies unit five (TKda5). 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.
Only facies unit four (TKda4), and facies unit five (TKda5) are present in the Castle Rock South quadrangle.

Logs and samples from the Dawson in the abandoned petroleum test well in the Greenland quadrangle (sec 17, T. 10 S., R. 66 W. (F.G. Holl et al., #1 Greenland Cattle Co.), plus the thickness of Dawson exposed on the adjacent buttes above the collar of the well, indicates that the Dawson Formation is about 2750 feet thick.

TKda5 **Facies unit five (early to middle ? Eocene)**
The TKda5 unit is dominated by very thick-bedded to massive, cross-bedded, light-colored arkoses, pebbly arkoses, and arkosic pebble conglomerate, but also 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 often thin or medium bedded; wavy bedding and ripple cross-laminations are common in the finner-grained parts. Facies unit five also contains massive structureless beds interpreted to be mudflows. Occasionally unit TKda5 contains thin, poorly developed, red, pink, and yellow-brown oxidized zones interbedded with, or developed within, the thick arkoses. Some of these oxidized zones have preserved mottling, burrows, and root structures which indicate their origin as paleosols; others are probably just the result of oxidation by groundwater. TKda5 is at least 400 ft thick in the quadrangle; the base is exposed on Hunt Mountain (sec. 22, T. 9 S., R. 67 W.), but the top of the unit has been removed by erosion.

TKda5 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 can be well indurated and may require considerable effort to excavate. The clay content of the finer grained parts of the facies unit suggest that soils developed from the Dawson may have high swell factors. Rock fall from cliffs in facies unit five poses a possible slope-stability hazard in some areas. Facies unit five appears to be equivalent to the Dawson Arkose and/or Dawson aquifer in the Denver area (George VanSlyke, 2001, oral commun.).

TKda4 **Facies unit four (Paleocene)** - This facies unit of the upper part of the Dawson Formation is similar to facies unit five (TKda5) in the Castle Rock South quadrangle. Facies unit four is dominated by beds of white to light-tan, fine- to medium-grained, feldspathic cross-bedded friable sandstone but also contains very thick bedded to massive, cross-bedded, light-colored arkose, pebbly arkose. The sandstones are poorly sorted, have high clay contents, and are commonly thin or medium bedded; wavy bedding and ripple cross-laminations are also common. Only the upper part of facies unit four (about 250 feet) is exposed in the quadrangle.

In the Monument quadrangle (Thorson and Madole, 2002), and on Dawson Butte in the Dawson Butte quadrangle (Morgan and others, 2004) 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). A paleosol believed to be the same was found on the western flank of Hunt Mountain (NW 1/4, sec. 22, T. 9 S., R. 66 W., about 2000 feet west of the west edge of the Castle Rock South quadrangle) and in sec. 23 and 24, T. 8 S., T. 66 W. 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.

TKdu **Dawson Formation, undivided (Upper Cretaceous to Eocene) -** undivided Dawson Formation possibly including facies units one through facies unit three of the upper Dawson plus the exposed facies units four and five; shown undivided on cross section on the geologic map.

STRUCTURAL GEOLOGY

The structural geology of the Castle Rock South quadrangle is not complex. Most of the Dawson strata are flat lying although a few very gentle northeast dips were found. Strike and dip symbols are not abundant on the map because of poor outcrop exposures. 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 more likely deposited in a horizontal orientation.

MINERAL RESOURCES

Sand, gravel, and stone are the most significant potential mineral resources in the Castle Rock South quadrangle. A test well for oil and gas reported no shows and was abandoned. No metallic or radioactive mineral resources are known in the quadrangle.

SAND AND GRAVEL

Sand and gravel are widely available in the quadrangle from surficial deposits derived mostly from erosion of the Dawson Formation, but there is little indication that these resources are currently being exploited from the quadrangle. The gravel pit shown on the map in sec. 20, T. 8 S., R. 66 W. appears to be inactive. The gravel pit shown on the map in sec. 32, T. 8 S., R. 66 W. have been closed, recontoured, and revegetated.

BUILDING STONE

The Wall Mountain Tuff has been extensively quarried for building stone in the Castle Rock area for over a century. The oldest quarry sites appear to be those along the east side of the Sellers Gulch valley in sec. 19, 29, and 30, T. 8 S., R. 66 W. These quarries, although abandoned, are still open; the sites and waste piles are only partially overgrown with vegetation. More recently, most of the tuff has been quarried off of the top of the prominent flat-topped butte just south of the town of Castle Rock (sec. 23 and 24, T. 8 S., R. 67 W.); these quarries have been closed and partially revegetated. Quarries are presently in operation in SE 1/4 sec. 29, T. 8 S., R. 66 W. producing facing and building stone, and in SE 1/4 sec. 28 and SW 1/4 sec., T. 8 S., R. 66 W. producing crushed stone and landscape rock. In many other locations in the quadrangle the Wall Mountain Tuff has been tested for potential quarry sites but these sites have not had significant production.

OIL AND GAS

The Colorado Oil and Gas Commission has completion records for one petroleum test well drilled in the Castle Rock South quadrangle. In 1971, the Clark Canadian Exploration Company drilled the Seidensticker #1. well in NE 1/4 SE 1/4 sec. 32, T. 8 S., R. 66 W. and evaluated the Dakota Group sandstone beds. This well terminated in the Skull Creek Shale at 9669 ft, had no shows of oil or gas, and was plugged and abandoned. The nearest oil production is about 30 miles northeast of the quadrangle, north of Kiowa in Elbert County.

WATER RESOURCES

Water resources in the Castle Rock South quadrangle are contained either in shallow groundwater aquifers in surficial alluvial deposits along the major stream drainages, largely the terrace deposits Qt1, Qt2, and Qt3, or in deeper groundwater aquifers of the Denver Basin (Robson, 1987, 1989) This basin contains four major aquifers; the Dawson, Denver, Arapahoe and Laramie-Fox Hills; listed from the top down. Drill depths anticipated to completely test the four deep aquifers in the Castle Rock South quadrangle are approximately 1000, 2000, 2500, and 3000 ft., respectively (Robson, 1987).

GEOLOGIC HAZARDS

Several geologic processes may effect planning and ultimate development within those portions of the Castle Rock South quadrangle likely to be developed. In some of the steeper slope areas, particularly below some of the steep cliffs in the southern part of the quadrangle, the potential for debris flows, and rock falls present significant threats to developed structures. Slope instability and swelling soils problems associated with the more clay-rich portions of the Dawson Formation are potential problems where this unit is exposed. Over most of the quadrangle flooding probably represents the greatest geological threat however. Most of the quadrangle is broad open slopes with thin to moderate density grassland cover which offers little impediment to runoff. This area is subjected to occasional short but intense periods of torrential rain associated with summer thunderstorms. Flooding following these storms can be dramatic and dangerous.

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