COLORADO GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES
DENVER, COLORADO

Map of Areas Susceptible to Differential Heave in Expansive, Steeply Dipping Bedrock, City of Colorado Springs, Colorado

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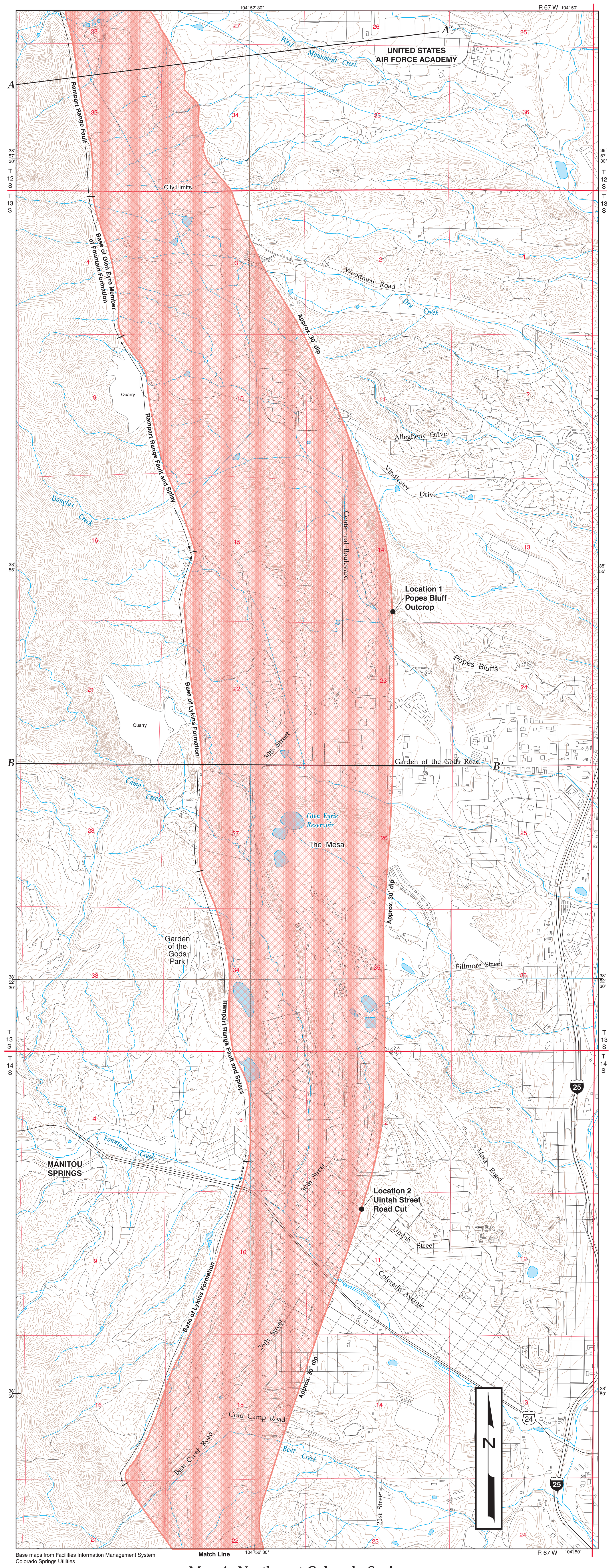
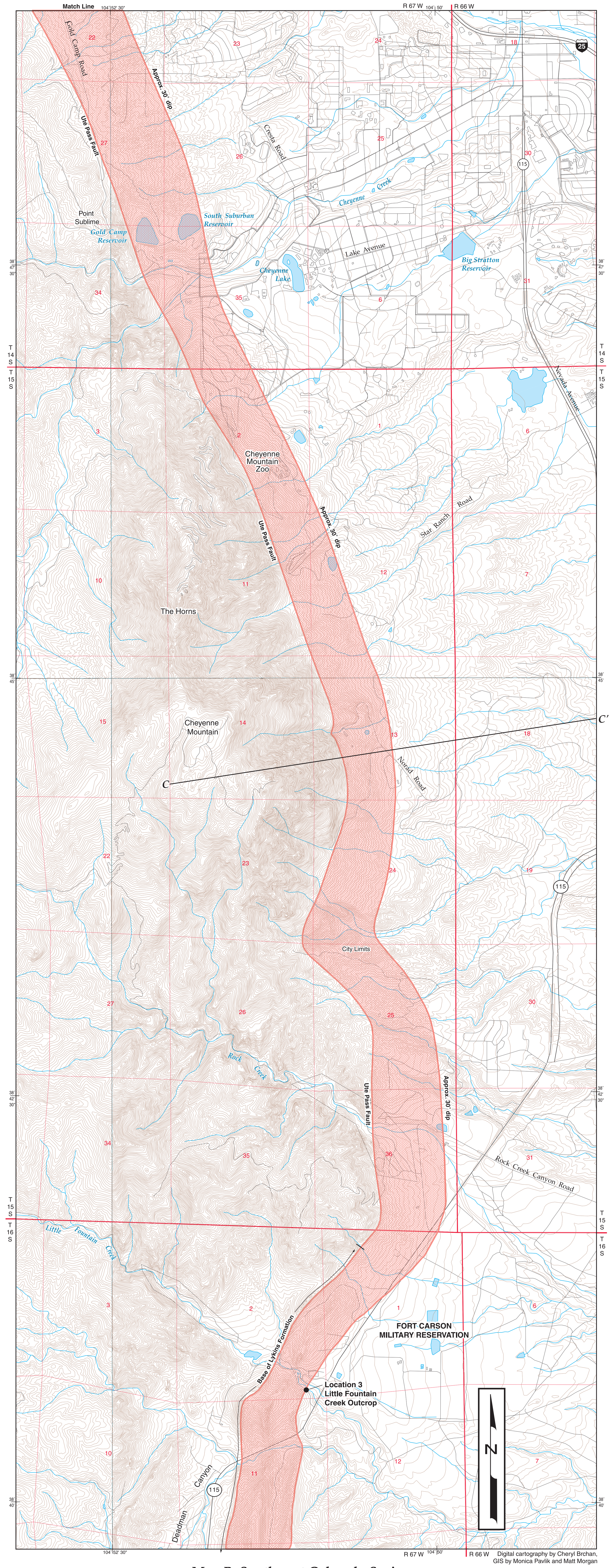
MAP SERIES 32
PLATE 1 OF 1
1999



Base maps from Facilities Information Management System, Colorado Springs Utilities

Map A: Northwest Colorado Springs



Digital cartography by Cheryl Brchan, GIS by Monica Pavlik and Matt Morgan

Map B: Southwest Colorado Springs

SCALE 1:24,000

DISCUSSION

Introduction

Heaving bedrock hazards exist under certain geologic conditions in the western part of the City of Colorado Springs. Accordingly, landowners, developers, homebuilders, homeowner's associations, special districts, utility providers, and the City of Colorado Springs should consider the potential for this geologic hazard during all phases of property development. This includes site exploration and evaluation, facilities design, construction quality control, and longer-term maintenance. In May 1996, the City of Colorado Springs enacted a geologic hazard ordinance that requires the identification and mitigation of several types of natural hazards (City of Colorado Springs, 1996). This ordinance includes heaving bedrock hazards associated with expansive, steeply dipping bedrock.

This map shows the general area of expansive, steeply dipping bedrock in the vicinity of Colorado Springs. Engineered facilities in this area may be subjected to destructive, differential ground heave if expansive layers of bedrock are encountered at shallow depth. Actual heaving bedrock hazards vary considerably within the hazard area. This map does not show areas where thick, surficial-soil deposits may cover the bedrock, significantly reducing the heaving potential. Additionally, it does not distinguish between formations that have high, moderate, or low swell potentials. The hazard-area boundaries are approximate, and have been delineated based on the best-available geologic information. The accuracy of these bound-aries should not be considered to exceed the accuracy of the map scale of 1:24,000.

Heaving Bedrock Geological Hazard

Residential and commercial structures, roads, and utilities have been significantly damaged along Colorado's Front Range piedmont by heaving bedrock. This geologic hazard occurs where the ground is underlain at shallow depth by steeply dipping beds of expansive claystone. In such areas, uneven ground deformations occur when the bedrock is exposed to excess moisture, usually after grading and construction. Differential heave takes place where the bedrock layers have different swell potentials, or where pre-existing shear surfaces are re-activated along fractures. The resulting, elongate heave features may grow as large as 2 feet high, several tens of feet wide, and several hundreds of feet long.

Damage caused by heaving bedrock typically is first seen within 10 years after development of raw land. However, the ground deformation may continue for years or even decades. The resulting damage may be more destructive than damage caused by flat-lying expansive soils and bedrock. Since the early 1970s, this geologic hazard is responsible for tens of millions of dollars in excess maintenance costs to local governments and Colorado taxpayers and homeowners.

Heaving bedrock is recognized and regulated in other areas along the Front Range Urban Corridor. Jefferson County has delineated a hazard area called the Designated Dipping Bedrock Area (Jefferson County, 1995). Douglas County has delineated a hazard area called the Dipping Bedrock Overlay District (see Noe and Dodson, 1999). Both counties require detailed geologic investigations and the use of special mitigative designs where zones of potentially heaving bedrock are identified.

Considerations For Proposed and Existing Development

Heaving bedrock is difficult to predict using conventional site exploration methods. Detailed investigations are recommended to assess site specific conditions including geologic structure and swell potential of the bedrock, and the type and thickness of surficial soil deposits. Such investigations require trenching and detailed geologic assessments in addition to drill holes. Field personnel should consider any beds of expansive bedrock that dip more steeply than 30 degrees from horizontal as having a potential for heaving bedrock hazards. Failure to recognize or consider these conditions may result in improper or incomplete hazard mitigation.

Existing damage due to heaving bedrock in the City of Colorado Springs is generally concentrated along certain zones of dipping bedrock. The affected areas were developed before special investigations and mitigative designs were employed. The extent and magnitude of damage is quite variable. In some cases, damaged structures are located next to others that have no damage. When purchasing an existing structure located within the shaded area on this map, the buyer should have a qualified engineer evaluate whether the building is structurally sound. Similarly, utility providers and other organizations with maintenance responsibility should be aware of this geologic hazard and its associated risks. There is a potential for higher maintenance costs associated with utilities and public improvements if the condition is not identified and mitigative designs implemented in initial construction.

Geology and Boundaries

The dipping bedrock hazard area within the City of Colorado Springs is underlain by sedimentary formations of Pennsylvanian through Cretaceous age (see Stratigraphic Column, below).

The western boundary of the hazard area is mapped at the base of the western-most, steeply dipping zone of expansive bedrock. This includes the base of the Lykins Formation and the Glen Eyrie Shale Member at the base of the Fountain Formation. The traces of the Ute Pass and Rampart Range Faults (or, in some locations, splays associated with these faults) are used as the western boundary where these basal contacts are missing due to faulting.

The eastern boundary of the hazard area corresponds to the trace of the axis of a monoclinal fold, which separates the moderately to steeply dipping bedrock to the west from the more gently dipping bedrock to the east. This decrease in dip occurs over a relatively short distance, about 50 to 300 feet, due to folding of the bedrock layers (see Stratigraphic Cross-Sections A–A', B–B', and C–C', below). This fold can be observed at an outcrop at the base of Popes Bluff (Location 1 on Map A), at a road cut on Uintah Street near 27th Street (Location 2 on Map A), and in an outcrop along Little Fountain Creek (Location 3 on Map B). Because this eastern boundary is based on limited exposures and evidence, it should be considered approximate.

Acknowledgements

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EXPLANATION

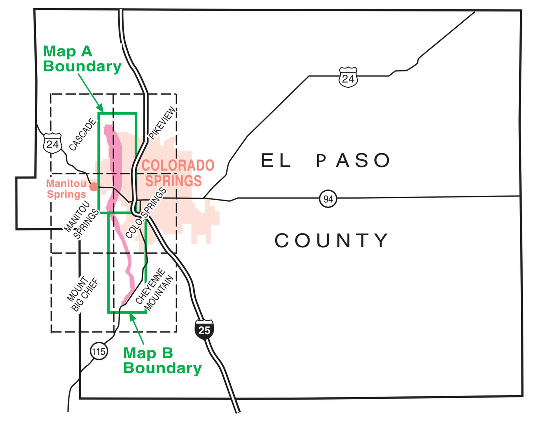
Area underlain by dipping bedrock

Area boundary (approximate)

A —— A' Line of cross section

COLORADO COUNTY INDEX

7.5-MINUTE QUADRANGLE INDEX

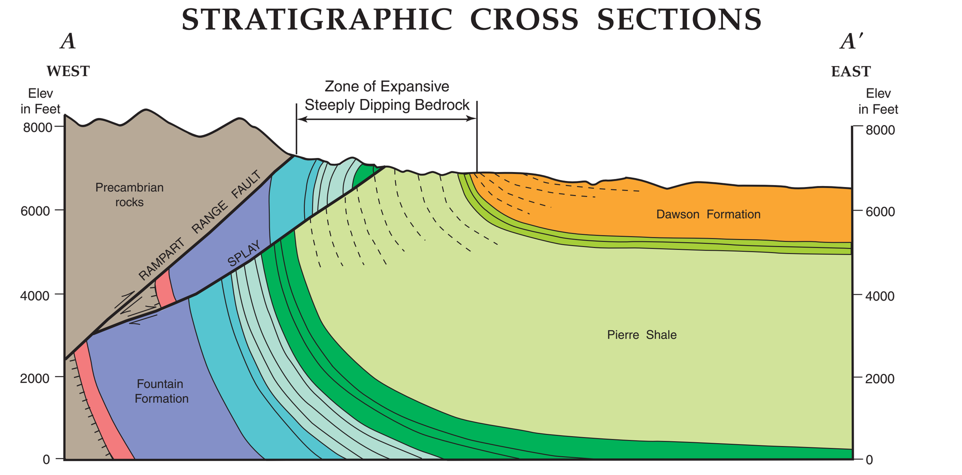


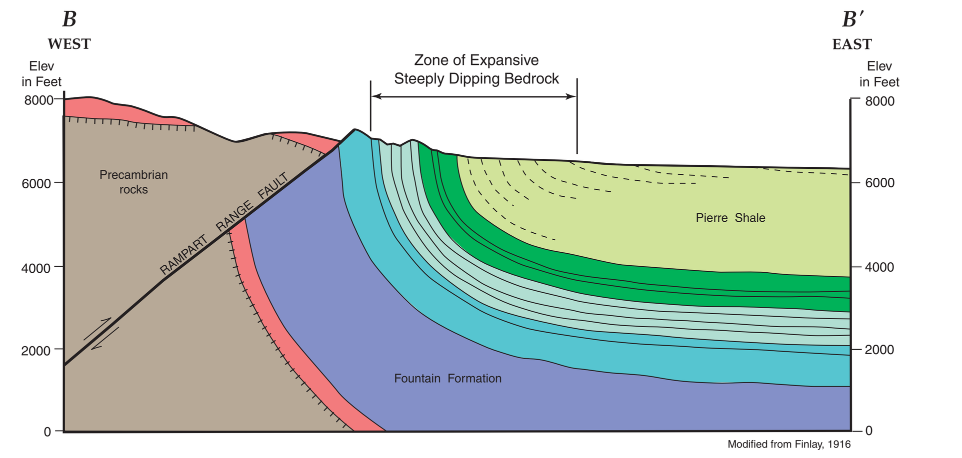
STRATIGRAPHIC COLUMN

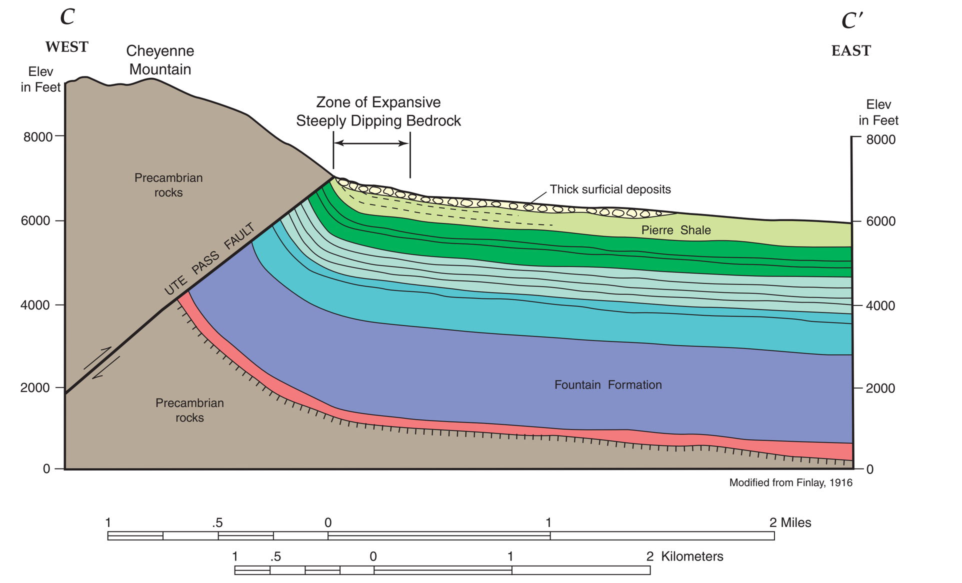
Stratigraphic Column	Age	Formation	Member or Informal Unit	Lithology (listed from most to least common)	Thickness (feet)
	CENOZOIC Tertiary	Dawson Formation	Upper part of formation	Sandstone, siltstone, claystone	1,800
	MESOZOIC (Jurassic, Cretaceous)	Dawson Formation	Lower part of formation	Sandstone, siltstone, claystone	200
		Laramie Formation		Sandstone, claystone, siltstone, coal	250
		Fox Hills Sandstone		Sandstone, siltstone, claystone	250
		Pierre Shale	Upper transition zone	Siltstone, sandstone, claystone	590
			Main part of formation	Claystone, siltstone, sandstone, limestone	3,150–4,800
		Niobrara Formation	Smoky Hill Shale	Siltstone, claystone, limestone, chalk	530
			Fort Hays Limestone	Limestone	30–40
		Carlile Shale Greenhorn Limestone Graneros Shale		Claystone, siltstone, limestone, sandstone	300
		Dakota Sandstone Purgatoire Formation		Sandstone, siltstone, claystone	400
		Morrison Formation		Claystone, siltstone, sandstone, limestone	225
		Ralston Cr Fm		Sandstone, siltstone, gypsum, limestone	20
	PALEOZOIC (Pennsylvanian, Permain, Triassic)	Lykins Formation		Siltstone, sandstone, claystone, limestone, gypsum	180
		Lyons Sandstone		Sandstone, congomerate	700–800
		Fountain Formation	Main part of formation	Conglomerate, sandstone, siltstone, claystone	4,300
			Glen Eyrie Shale	Claystone, sandstone, siltstone	100
	PALEO-ZOIC		Older Paleozoic rocks	Limestone, sandstone, dolomite	445
	PRECAM-BRIAN		Precambrian rocks	Granite, gneiss	—

NOT TO SCALE

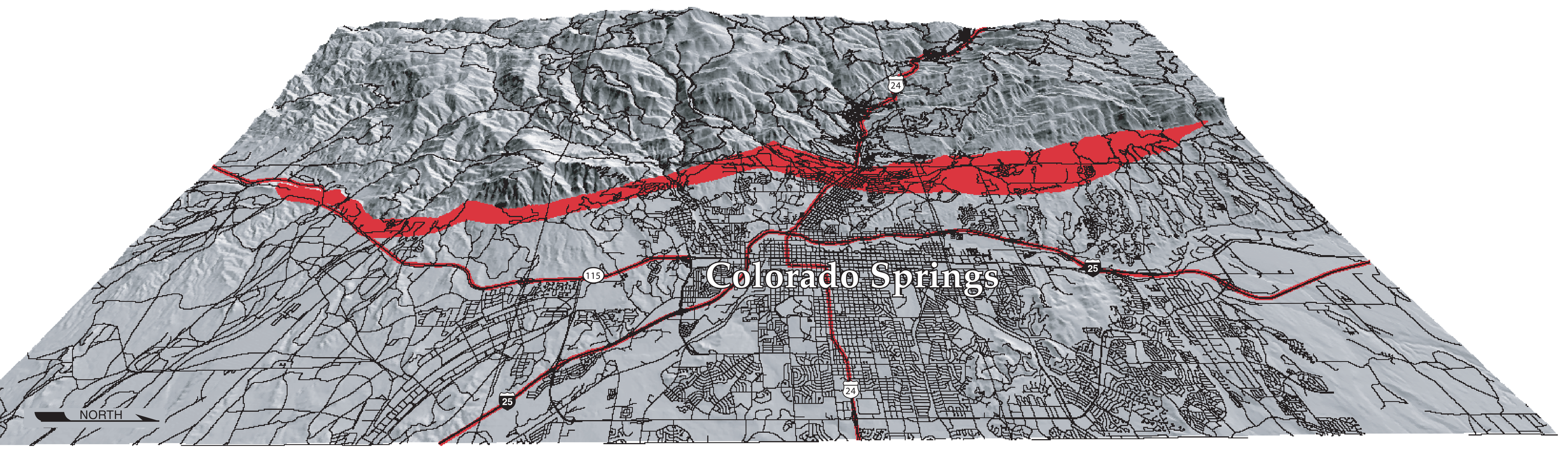
STRATIGRAPHIC CROSS SECTIONS







SHADED-RELIEF MAP OF COLORADO SPRINGS AND AREA UNDERLAIN BY EXPANSIVE, STEEPLY DIPPING BEDROCK (Oblique View from the East)



State of Colorado, Bill Owens, Governor
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