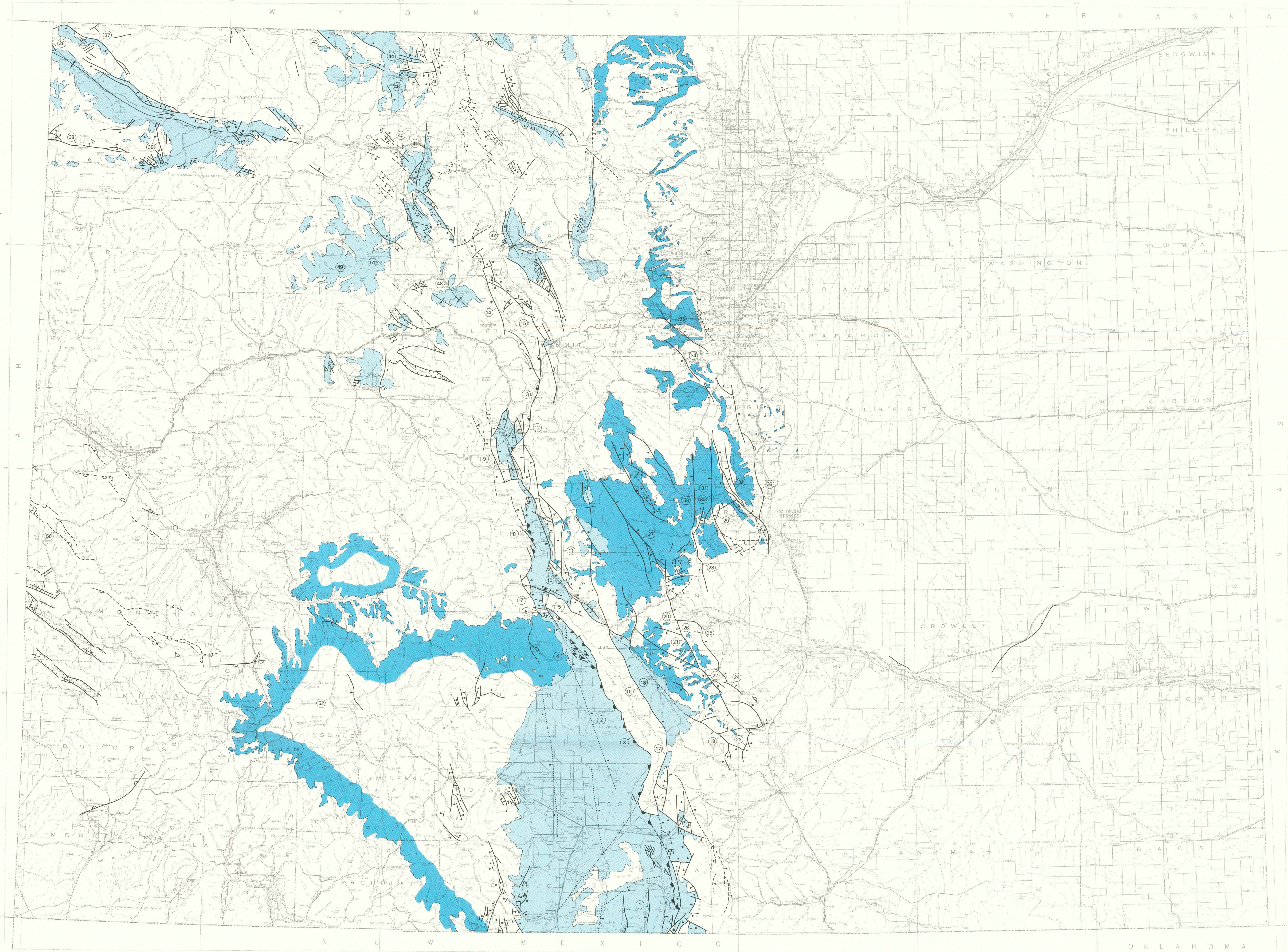
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS INVESTIGATIONS SERIES
MAP I–1566



Base from U.S. Geological Survey
State base map 1:500,000, 1968
Revised 1980

SCALE 1:1 000 000

25 0 25 50 75 MILES

25 0 25 50 75 100 125 KILOMETERS

DESCRIPTION OF MAP UNITS

Miocene and younger rocks deposited in structural basins. Includes Alamosa, Santa Fe, Los Pinos, Dry Union, Wagontongue, Troublesome, North Park, and Browns Park Formations and younger alluvial, eolian, and glacial deposits. Excludes Arikaree and Ogallala Formations on the eastern plains and other rocks not associated with major structural basins. Consists primarily of basin-fill sediments, but includes interbedded volcanics. These rocks were deposited mostly in structural basins associated with Miocene and younger faulting and(or) down-warping. Modified from Tweto (1978, 1979b)

Late Eocene erosion surface. In areas shown, the surface is either preserved beneath thick volcanic rocks, or forms the present land surface, where it is slightly eroded and locally covered by thin sedimentary rocks. The late Eocene erosion surface is best known in central Colorado, east of the Upper Arkansas and San Luis Valleys, where it was originally a surface of low relief sloping gently to the east and southeast (Epis and Chapin, 1975; Scott, 1975); in these areas, it is now extensively preserved at or near the land surface with remnants of its former cover of Oligocene and Miocene volcanics and Miocene alluvium. The surface is less well known west of the San Luis and Upper Arkansas Valleys, but is probably present beneath the Oligocene volcanics of the San Juan and West Elk Mountains, with a possible residual high in the Needles Mountains (Epis and Chapin, 1975). Extent of the erosion surface east of the Upper Arkansas and San Luis Valleys, including overlying Oligocene volcanics and Miocene alluvium modified from Scott (in press) and Tweto (1979b). Surface beneath the base of Oligocene volcanics west of the Upper Arkansas and San Luis Valleys from Tweto (1979b). Enclosed blank areas indicate that the surface is not exposed in the interiors of the San Juan and West Elk Mountains; dotted line indicates concealed or inferred outcrop of the surface

EXPLANATION OF MAP SYMBOLS

Contact or unit boundary—Dotted where concealed

Faults showing late Cenozoic movement—Dashed where age of movement is inferred; dotted where concealed beneath valley fill. Inferred Neogene faults are identified primarily by stratigraphic and(or) structural relations and association with other faults or structures of known Neogene age. Inferred Quaternary faults are identified primarily by geomorphic features, such as fault-line scarps and drainage anomalies, and association with other faults or structures of known Quaternary age. Concealed faults are known mostly from geophysical and(or) well-log data. Latest known movements on all faults are normal; symbols are on downthrown side and indicate age of most recent known movement (see below). Lack of symbol indicates movement direction not known. Small circles indicate Quaternary faults too small to show at map scale. Many faults shown are reactivated older features

Age symbols:

Latest documented movement is Holocene (less than 10,000 yr)

Latest documented movement is late Pleistocene (about 10,000 to 150,000 yr)

Latest documented movement is middle to early Pleistocene (about 0.15 to 1.8 m.y.) or Pleistocene undifferentiated

Latest documented movement is Neogene (about 2.0 to 24 m.y.)

Many faults, especially those designated as Neogene, may have moved at a later time than indicated, but documentation of such movement is impossible because of a lack of diagnostic younger deposits or because of severe erosion of fault-scarp morphology

Faults associated with salt structures—In the Eagle Valley evaporite basin, Kirkham and Rogers (1981) cite evidence of displaced Quaternary landslide and pediment deposits. In the anticlinal valleys of the Paradox Basin, geomorphic relations suggest relatively recent movement on faults, possibly as young as Holocene (Kirkham and Rogers, 1981), but only one locality where Quaternary deposits are displaced (along Dry Creek, south of Paradox Valley) is known

Neogene synclines—Mostly associated with fault-bound Neogene depositional basins

(40) **Locations where magnitude and average rate of late Cenozoic faulting can be estimated**—Numbers correspond to Table 1

(50) **Locations from which other important late Cenozoic tectonic data are known**—Numbers correspond to Table 1

INTRODUCTION

This map draws heavily on previous compilations of late Cenozoic tectonics in Colorado, but differs from these studies in several ways. It attempts to show, in addition to faults, all available data pertaining to Miocene and younger tectonism in Colorado. The late Eocene erosion surface is also represented because of the structural datum that it provides. Miocene sediments that fill structural basins are shown, along with synclines associated with some of the basins. Total displacements and average rates of displacement since the end of the Oligocene are shown, as are the few localities where total absolute uplift has been estimated (table 1). A scale of 1:1,000,000 has been used both for convenience and for compatibility with similar maps being prepared for nearby states. Earlier syntheses used in the present compilation include Epis and Chapin (1975), Izett (1975), Larson and others (1975), Lipman and Mehnert (1975), Scott (1975), and Taylor (1975). Other pertinent general references include Tweto (1978) and Trimble (1980). Map compilations by Witkind (1976), Tweto (1978), and particularly Kirkham and Rogers (1981) were especially valuable sources.

Following the close of the Laramide orogeny in Eocene time, Colorado and surrounding areas experienced a period of tectonic quiescence, during which erosion reduced much of the area to an undulating surface of low relief. This late Eocene erosion surface was later buried by voluminous volcanic rocks from the San Juan, West Elk, Thirtynine Mile, and other volcanic centers in Oligocene and Miocene time, but was apparently little disturbed by tectonic deformation until near the end of the Oligocene. Just before the beginning of Miocene time, Colorado abruptly entered a period of major uplift and normal faulting. The late Eocene erosion surface and its Oligocene volcanic cover were disrupted by faulting and the Rio Grande rift and associated structural basins began to form and fill with sediments. Uplift apparently accelerated in late Miocene and Pliocene time, resulting in an episode of intense canyon cutting in the mountains and a change from aggradation to incision along streams on the eastern plains. Tectonic deformation extended into Quaternary time, and Holocene faulting in the Rio Grande rift suggests that this late Cenozoic period of uplift and faulting continues to the present. Most of the faults that have moved in late Cenozoic time have had long previous histories of repeated movement, but Colorado's major late Cenozoic structural system, the Rio Grande rift, began to form less than about 28 m.y. ago.

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TABLE 1.—Locations where rates of late Cenozoic tectonic movement can be calculated.

Number	Feature	Location	Displacement (m)	Time (m.y.)	Rate (m/m.y.)	Reference
1	fault	west side, San Pedro Mesa	100	3.5	29	Kirkham and Rogers (1981)
2	fault	east side, San Luis Valley horst	5000	38	132	Tweto (1978)
3	Sangre de Cristo fault	San Luis Valley	7000	38	184	Tweto (1978)
4	fault	west side, northern San Luis Valley	760	38	20	Kirkham and Rogers (1981)
5	fault	north side, Poncha Pass block	3500–3700 1200	26 5	135–142 240	Tweto (1978) Epis and others (1976)
6	fault	Poncha Pass	1100	26	42	Knepper (1976)
7	fault	Poncha Pass	1850–2750	26	71–106	Knepper (1976)
8	Sawatch Range fault	Buena Vista	3050	26	117	Tweto (1978)
9	Sawatch Range fault	Leadville	2300–2400	26	88–92	Tweto (1978)
10	Dead Horse fault	Mosquito Range	125	35	4	Knepper (1976)
11	fault	west side, southern Mosquito Range	600	35	17	Epis and Chapin (1978) Knepper (1976)
12	Mosquito fault	Leadville	1000	26	38	Tweto (1979a)
13	Mosquito fault	Climax	2740	30	91	Tweto (1978)
14	Gore Fault	Gore Range	350	20–24	14–17	Tweto (1979a)
15	Frontal (Blue River) fault	Gore Range	1220	26	47	Kirkham and Rogers (1981)
16	Alvarado fault	Wet Mountain Valley	3800 3000	38 26	100 115	Tweto (1979a) Taylor (1975)
17	Alvarado fault	Huerfano Valley	5800	38	153	Tweto (1979a)
18	Westcliffe fault	Wet Mountain Valley	2900	38	76	Tweto (1979a)
19	Westcliffe fault	Huerfano Valley	4850	38	128	Tweto (1979a)
20	Ilse Fault	Tanner Peak	500	28	18	Taylor (1975)
21	Ilse Fault	Locke Park	370	28	13	Taylor (1975)
22	Ilse Fault	Wixon Divide	370	28	13	Taylor (1975)
23	Wet Mountain fault	east side, Wet Mountains	1000	28	36	Tweto (1979a)
24	Wet Mountain fault	Tanner Peak	1130	28	40	Taylor (1975)
25	Wet Mountain fault	south of Canon City	1080	29	37	Scott (1975)
26	faults	southeast of Greenhorn Peak	1500	28	54	Taylor (1975)
27	Currant Creek fault	Currant Creek	400	29	14	Taylor (1975)
28	Oil Creek fault zone	Fourmile Creek	450	34	13	Taylor (1975) Epis and Chapin (1975) Epis and others (1976)
29	faults	northwest of Pike's Peak	1000	28	36	Epis and Chapin (1975)
30	Oil Creek fault zone	Divide	300	28	11	Epis and others (1976)
31	fault	Florissant	125–150	28	4–5	Epis and others (1976)
32	Ute Pass fault zone	east of Divide	370	28	13	Epis and Chapin (1975) Taylor (1975)
33	Rampart Range fault	north of Colorado Springs	450	28	16	Tweto (1979a) Scott (1970) Epis and Chapin (1975)
34	Kennedy Gulch fault	Conifer	300	28	11	Scott (1975)
35	Floyd Hill fault	Floyd Hill	600	28	22	Scott (1975)
36	Beaver Creek fault	Beaver Creek	460	10	46	Izett (1975)
37	Sparks Ranch and related faults	Talamantes Creek	200	10	20	Izett (1975)
38	Yampa fault	Yampa	120–1200	10	12–120	Izett (1975)
39	Cross Mountain fault	Cross Mountain	150	10	15	Kirkham and Rogers (1981)
40	fault	Sand Mountain	600	10	60	Izett (1975)
41	Streamboat Springs fault	Steamboat Springs	300	10	30	Izett (1975)
42	Antelope Pass fault	Antelope Pass	100	10	10	Izett (1975)
43	Slater Creek fault zone	Slater Creek	300	10	30	Kirkham and Rogers (1981)
44	Kimg Solomon fault	Hahn's Peak	180–610	10	18–61	Kirkham and Rogers (1981)
45	Grouse Mountain fault	Hahn's Peak	150	10	15	Kirkham and Rogers (1981)
46	Steamboat Lake fault	Steamboat Lake	53	10	5	Kirkham and Rogers (1981)
47	fault	Independence Mountain	122	10	12	Kirkham and Rogers (1981)

Other Data

48 State Bridge syncline. Structural relief is about 600 m resulting from deformation occurring after about 10 m.y. (Larson and others, 1975). These data yield an average rate of subsidence of about 60 m/m.y.

49 White River uplift. This Laramide structure has been reactivated as a broad upwarp cut by minor faulting, probably within the last 10 m.y. (Larson and others, 1975). Basal Browns Park gravels on the uplift now occur 460 m higher than their source in the Park Range (Kucera, 1962), and 9–14 m.y.-old basalt flows in the Flat Tops occur 600 m higher than similar rocks to the east (Larson and others, 1975).

50 Southwest flank of the Uncompahgre Plateau. Differential uplift of the Uncompahgre Plateau of 580–640 m has occurred along this faulted monocline since mid-Pliocene time (Cater, 1966). Assuming an age of 3.5 m.y., these data result in an uplift rate of about 166–183 m/m.y.

51 Derby Peak fauna. This fauna is estimated to have lived at about 1830 m, and now occurs at 3660 m (Larson, 1968). Age of the deposit is about 10–13 m.y. (Larson and others, 1975). The younger age limit yields an average uplift rate of about 183 m/m.y.

52 Creede flora. This flora is estimated to have been deposited at about 1500–1800 m (Leopold and McGinitie, 1972). It now occurs at about 2600–2700 m in deposits dated at 24.6 m.y. (Steven and Eaton, 1975). These data yield an uplift of about 800–1200 m, and an average uplift rate of about 33–49 m/m.y.

53 Florissant flora and fauna. Present altitude about 2865 m; depositional altitude about 915 m or less (McGinitie, 1953); age about 34 m.y. (Epis and Chapin, 1975). These data yield an uplift of about 1950 m and an average uplift rate of about 57 m/m.y. Other nearby fault blocks have been uplifted substantially more (see map).

MAP SHOWING TECTONIC FEATURES OF LATE CENOZOIC ORIGIN IN COLORADO

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1985

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