(200)
67rm

UNCLASSIFIED

TEM-915

Subject Category: GEOLOGY AND MINERALOGY

U. S. DEPARTMENT OF THE INTERIOR

A RECONNAISSANCE FOR URANIUM IN CARBONACEOUS ROCKS IN SOUTHWESTERN COLORADO AND PARTS OF NEW MEXICO

By
Elmer H. Baltz, Jr.

This report is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

February 1955

U.S. Geological Survey,
Washington, D. C.

Trace elements memorandum report.

UNITED STATES ATOMIC ENERGY COMMISSION
Technical Information Service, Oak Ridge, Tennessee

UNCLASSIFIED

This report has been reproduced directly from the best available copy.

This report concerns work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

Printed in USA, Price 35 cents. Available from the Office of Technical Services, Department of Commerce, Washington 25, D. C.

AEC, Oak Ridge, Tenn.

CONTENTS

	Page
Abstract	5
Introduction	6
Northern San Juan Basin	8
General description	8
Rocks examined for radioactivity	9
Dakota formation	9
Mesaverde group	9
Fruitland formation	10
Cretaceous and Tertiary sedimentary rocks	11
Cretaceous or Tertiary intrusive rocks	11
Quaternary deposits	12
Mancos-Egnar area	12
General description	12
Rocks examined for radioactivity	13
Burro Canyon formation	13
Dakota formation	13
Norwood-Uravan area	15
General description	15
Rocks examined for radioactivity	16
Hermosa formation	16
Morrison formation	17
Dakota formation	18
Mesaverde formation	20
Cretaceous or Tertiary intrusive rocks	21
Uncompahgre Plateau	22
General description	22
Rocks examined for radioactivity	24
Morrison formation	24
Burro Canyon formation	24
Dakota formation	24
Cretaceous or Tertiary intrusive rocks	26
Cimarron Creek area	26
General description	26
Rocks examined for radioactivity	27
Mesaverde formation	27
San Juan tuff	28
West Elk Mountains	28
General description	28
Rocks examined for radioactivity	30
Dakota formation	30
Mesaverde formation	31
Paonia area	32
General description	32
Rocks examined for radioactivity	33
Mesaverde formation	33
Wasatch formation	34
Palisade area	34
General description	34
Rocks examined for radioactivity	35
Mesaverde group	35

Page

Las Vegas Plateau and Canadian Escarpment in Harding and San Miguel Counties, northeastern New Mexico 35
General description 35
Rocks examined for radioactivity. 36
Chinle formation 36
Morrison formation 39
Purgatoire and Dakota formations 40
Selected bibliography. 40
Appendix 43
Radioactivity measurements and chemical analyses of samples from Colorado and New Mexico

A RECONNAISSANCE FOR URANIUM IN CARBONACEOUS ROCKS IN SOUTHWESTERN COLORADO AND PARTS OF NEW MEXICO

By Elmer H. Baltz, Jr.

ABSTRACT

Coal and carbonaceous shale of the Dakota formation of Cretaceous age were examined for radioactivity in the Colorado Plateau of southwestern Colorado and northwestern New Mexico during the summer of 1953. Older and younger sedimentary rocks and some igneous rocks also were examined, but in less detail. Weak radioactivity was detected at many places but no new deposits of apparent economic importance were discovered. The highest radioactivity of carbonaceous rocks was detected in black shale, siltstone, and sandstone of the Paradox member of the Hermosa formation of Pennsylvanian age. A sample collected from this member at the Bald Eagle prospect in Gypsum Valley, San Miguel County, Colo., contains 0.10 percent uranium.

Carbonaceous rocks were investigated at several localities on the Las Vegas Plateau and the Canadian Escarpment in Harding and San Miguel Counties, northeastern New Mexico. Carbonaceous sandstone and siltstone in the middle sandstone member of the Chinle formation of Triassic age contain uranium at a prospect of the Hunt Oil Company southwest of Sabinoso in northeastern San Miguel County, N. Mex. A channel sample across 3.2 feet of mineralized rocks at this locality contains 0.22 percent uranium. Weak radioactivity was detected at two localities in carbonaceous shale of the Dakota and Purgatoire formations of Cretaceous age.

INTRODUCTION

Carbonaceous rocks of the Colorado Plateau in southwestern Colorado and adjacent parts of northwestern New Mexico were examined for radioactive materials during reconnaissance field work in 1953 as part of a program of exploration for radioactive raw materials undertaken by the U. S. Geological Survey on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission. Fragments of carbonaceous material are conspicuous in most uranium deposits in sandstone in the Colorado Plateau. The uranium content of bedded carbonaceous material such as coals and black shales had not been investigated as possible sources of uranium. The principal rock units examined were the carbonaceous rocks of the Dakota formation of Cretaceous age which crops out over much of the region. Older and younger sedimentary rocks and igneous rocks also were examined. A smaller area in the Las Vegas Plateau of northeastern New Mexico also was examined. Weak radioactivity was detected at many places but no new deposits of economic interest were discovered.

The general areas of investigation in the Colorado Plateau are shown on the index map, figure 1. The localities examined for radioactivity in the Colorado Plateau referred to in the text are shown on the index map, figure 3 (in envelope). Localities examined on the Las Vegas Plateau in northeastern New Mexico are shown on the index map, figure 2.

The writer was assisted during the field work by Richard L. Koogle. Radioactivity measurements and chemical analyses included at the end of the report were made by the Geological Survey Geochemical Laboratories.

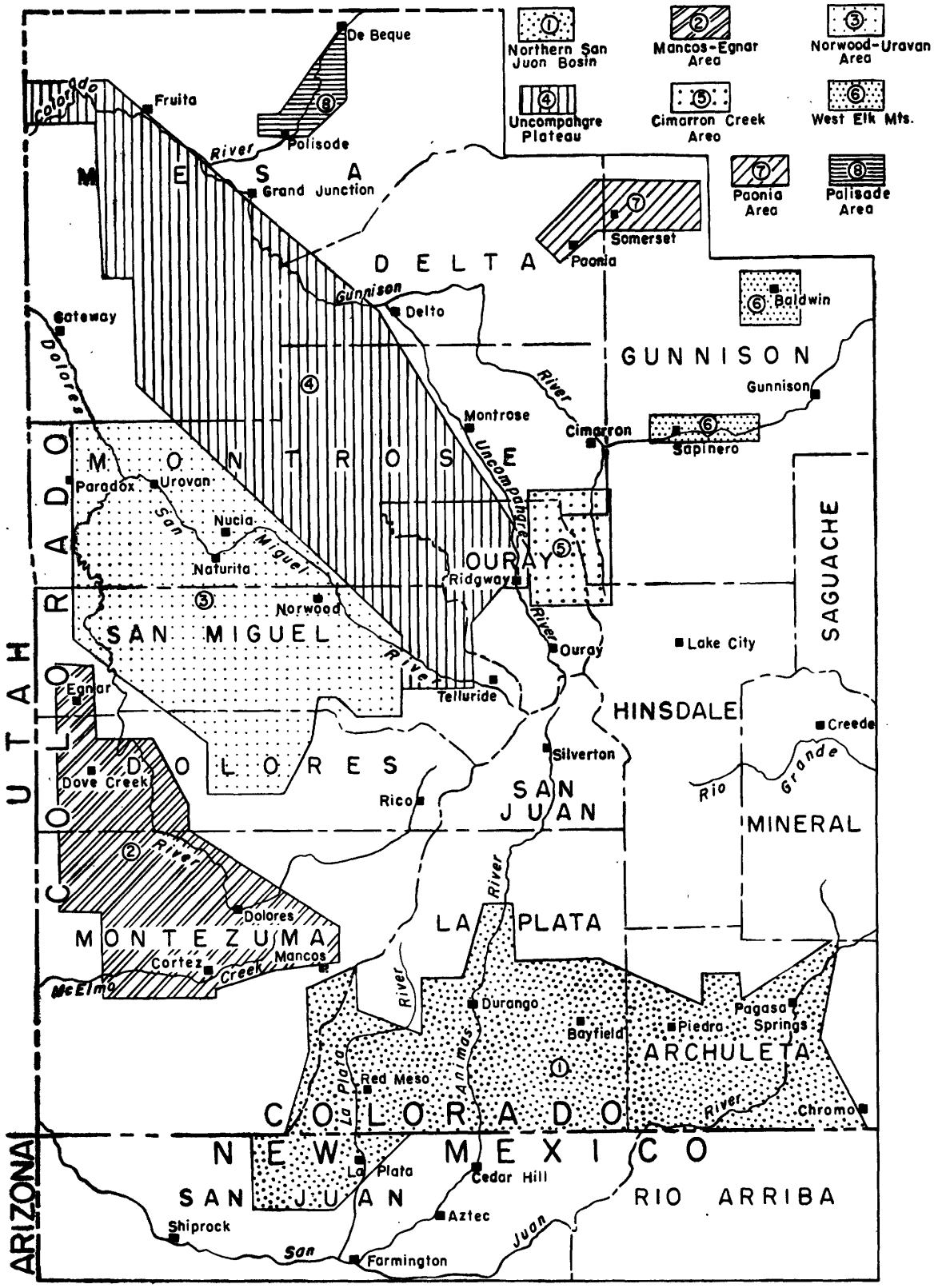

Fig. 1. Index map of southwestern Colorado and northwestern New Mexico showing areas of reconnaissance examination of carbonaceous rocks during 1953.

NORTHERN SAN JUAN BASIN [1]

General description

The northern rim of the San Juan Basin in Archuleta County and part of La Plata County, Colo., is marked by a series of arcuate hogback ridges separated by wide valleys. The hogbacks are held up by beds of Upper Cretaceous sandstone, and the valleys are cut on intervening thick shale sequences. The rocks dip steeply southward to form the Hogback monocline which is the structural boundary between the northern San Juan basin and the structural uplift of the San Juan Mountains. Upper Cretaceous strata exposed in the hogbacks are, in ascending order: the Dakota formation, Mancos shale, Mesaverde group, Lewis shale, Pictured Cliffs sandstone, Fruitland formation, and Kirtland shale. Basinward from the Hogback monocline gently southward-dipping Cretaceous beds are overlain by the Animas formation of Cretaceous and Paleocene age, the Nacimiento formation of Paleocene age, and the San Jose (Wasatch) formation of Paleocene and Eocene age.

Southwest of Durango, Colorado (area 1, figure 1) the Hogback monocline trends southwestward and crosses from Colorado into New Mexico along the southeast flank of Barker Creek dome. The northwestern part of the San Juan Basin in southern La Plata and Montezuma Counties, Colo., is a region of dissected plateaus capped by rocks of the Mesaverde group and the Dakota sandstone which dip gently southward.

---

[1] Selected references to published reports describing the geology of each area covered by this report are listed at the end of the report.

Rocks examined for radioactivity

Dakota formation

The Dakota formation is at the surface over a large area north of the Hogback monocline in Archuleta and La Plata Counties, Colo. The Dakota formation at most places consists of a lower member of conglomeratic sandstone, a middle member of carbonaceous shale and siltstone with a few thin lenticular beds of coal, and an upper member of sandstone.

Radioactivity slightly above background was detected in carbonaceous rocks of the Dakota formation at several places. However, at only one locality was the radioactivity high enough to warrant sampling. A sample of carbonaceous shale, 1 foot thick, from the middle shale member at locality 1 (sec. 36, T. 35 N., R. 2 W.) in central Archuleta County (fig. 3) contains 0.001 percent uranium.

Mesaverde group

The Mesaverde group of the northern San Juan Basin consists, in ascending order, of the Point Lookout sandstone, Menefee formation, and Cliff House sandstone.

Coal beds of the Menefee formation were examined along the Hogback between the Florida River and Durango in La Plata County, Colo. East of the Florida River the Menefee wedges out between the overlying Cliff House sandstone and the underlying Point Lookout sandstone. The basal coal of the Menefee formation was examined near the Animas River south of Durango, at the Black Diamond and Morning Star mines (T. 35 N., R. 10 W.) west of Durango, and at the Old Mancos mine (T. 35 N., R. 13 W.) and the Wilden

mine (T. 35 N., R. 12 W.) southeast of Mancos. No radioactivity was detected in Mesaverde rocks in Archuleta, La Plata, or Montezuma Counties and no samples were collected.

At Barker Creek dome in southwestern La Plata County, Colo., and northern San Juan County, N. Mex., the massive Cliff House sandstone that forms the caprock on the dome intertongues with the underlying Menefee formation. Impure coal, carbonaceous shale, and concretionary ironstone of the Menefee tongue were examined on the flanks and on the highest part of the structure. Radioactivity slightly higher than background was detected at several places. At locality 6 (Southern Ute Indian Reservation, projected T. 14 N., R. 14 W.), about 4 miles west of the Southern Union sweetening plant on Barker Creek, a sample of coaly clay shale and impure coal, $1\frac{1}{2}$ feet thick, was collected from the Menefee formation immediately below the Cliff House sandstone. Sample 6 contains 0.002 percent uranium.

Fruitland formation

The coal-bearing Fruitland formation crops out in a narrow band along the Hogback southward from Archuleta County through southern La Plata County, Colo. into northeastern San Juan County, N. Mex. The coal-bearing zone near the base of the Fruitland formation has been an important source of commercial coal. Radioactivity slightly above background was detected in this basal zone near Florida River Gap (T. 35 N., R. 8 W.).

A sample of basal Fruitland coal from a mine at locality 2 (sec. 30, N. T. 34 N., R. 5 W.) near U. S. Highway 160 in Archuleta County contains less than 0.001 percent equivalent uranium.

A sample of Fruitland coal from the tipple of a caved mine at locality 3 (sec. 13, T. 35 N., R. 7 W.) east of Los Pinos River in La Plata County contains 0.001 percent equivalent uranium.

A sample of partly oxidized coaly shale of the Fruitland formation from the dump of a caved mine at locality 5 (sec. 15, T. 32 N., R. 13 W.) east of La Plata River in San Juan County, N. Mex., contains 0.003 percent uranium.

Cretaceous and Tertiary sedimentary rocks

No radioactivity was detected in volcanic sediments of either the McDermott member or the upper member of the Animas formation at the localities examined in southern La Plata County. A two-foot bed of acidic tuff near the base of the San Jose (Wasatch) formation in sec. 19, S. T. 34 N., R. 10 W., in La Plata County, Colo., contains an estimated 0.004 percent equivalent uranium.

Cretaceous or Tertiary intrusive rocks

Two plugs of basaltic rock were examined in Montezuma County, Colo. A sample of dense olivine biotite basalt from a dike projecting from the plug at locality 7 (sec. 24, T. 35 N., R. 14 W.) contains 0.0015 percent uranium. A plug composed of similar rock in T. 33 N., R. 15 W., contains an estimated 0.005 percent equivalent uranium. Radioactivity perceptibility greater than background was not observed in stoped material contained in the igneous rock or in Mesaverde wall rock at either locality.

Quaternary deposits

A hot spring deposit was examined at locality 4 (sec. 25 (?), T. 37 N., R. 9 W.) just west of U. S. Highway 550 at Rancho Encantado, which is 15 miles north of Durango, Colo. The spring issues from the Ouray limestone. A sample (No. 4) of calcareous tufa deposited by the spring contains 0.001 percent uranium.

MANCOS-EGNAR AREA

General description

The Mancos-Egnar area in Montezuma, Dolores, and San Miguel Counties, Colo., is part of the great "Sage Plains", a gently rolling high plateau region deeply incised by several streams. The plateau is capped mainly by sandstone of the Dakota formation but is overlain at several places by thin outliers of Mancos shale. A considerable thickness of Jurassic rocks and some Triassic rocks are exposed in the deep canyon cut by the Dolores River along the northeastern margin of the Mancos-Egnar area. Jurassic rocks are exposed in the canyon of McElmo Creek along the southern margin of the area. Tributaries of both streams have cut through the capping Dakota formation at many places to expose the underlying Burro Canyon formation of Lower Cretaceous age and the Morrison formation of Upper Jurassic age.

The rocks of the region are folded into broad anticlines and synclines which correspond to the rolling topography of the Sage Plains. Ute Mountain, a domal uplift with a laccolithic core, is south of McElmo Creek near the southwestern corner of the area.

Rocks examined for radioactivity

Burro Canyon formation

Beneath the carbonaceous shale, coal, and lenticular sandstone of the Dakota formation is a sequence of purple and green shale, chert and limestone, and heavy-bedded noncarbonaceous conglomeratic sandstone. This sequence of rocks, mapped in earlier reports as part of the Dakota formation, is more properly called the Burro Canyon formation as defined by Stokes and Phoenix (1948). No radioactivity was detected in rocks of the Burro Canyon formation. Near the northeast corner of sec. 35, T. 43 N., R. 19 W., radioactivity about 2 to 3 times greater than the background occurs in moss growing along the contact of the Burro Canyon formation with the underlying Morrison formation.

Dakota formation

The Dakota formation in the Mancos-Egnar area is composed of varying proportions of interbedded carbonaceous shale, coal, and lenticular sandstone. Traces of radioactivity slightly higher than background were detected in carbonaceous rocks of the Dakota formation at many localities in the Mancos-Egnar area. At none of these localities, however, was the radioactivity greater than 2 or 3 times background. Only three samples were collected.

A sample of ferruginous siltstone from the base of the Dakota formation on an erosional outlier at locality 8 (sec. 35, T. 36 N., R. 19 W.), north of McElmo Creek on southwestern Montezuma County contains 0.002 percent equivalent uranium. No radioactivity was detected in impure coal and coaly shale that lie above the base of the Dakota at locality 8 or in the rocks of the underlying Burro Canyon formation and upper part of Morrison formation which also are exposed near locality 8.

Three abandoned and filled coal mines were examined on the west side of Yellowjacket Creek near locality 9 (sec. 34, T. 38 N., T. 17 W.), Montezuma County. A sample of slightly slacked coal from the dump of the mine at locality 9 contains 0.001 percent equivalent uranium. No radioactivity was found at the other mines or in poor exposures of the coal bed, which is in the middle, approximately, of the Dakota formation. The coal bed is estimated to be at least 3 feet thick.

A channel sample of shale was collected at locality 10 ($NE\frac{1}{4}$ sec. 9, T. 39 N., R. 17 W.) on the west side of Narraquinnep Canyon in southwestern Dolores County. The sample was taken from 2 feet of carbonaceous shale about 20 feet below a massive sandstone bed in the Dakota formation which caps the north side of the canyon. Sample 10 contains 0.001 percent equivalent uranium. No radioactivity was detected in beds of the Burro Canyon formation and Morrison formation which are well exposed near locality 10.

NORWOOD-URAVAN AREA

General description

The Norwood-Uravan area in Dolores, San Miguel, and Montrose Counties, Colo. is bounded by the Uncompahgre Plateau on the northeast, the Sage Plains on the southwest, the San Juan Mountains on the southeast, and the La Sal Mountains on the west. The western part of the area is characterized by broad valleys separated by high plateaus that have been deeply incised by the San Miguel and Dolores Rivers and their tributaries. The eastern part of the area is a gently rolling plateau at the foot of the San Juan Mountains.

Pennsylvanian rocks are exposed in Gypsum Valley and Paradox Valley. Permian, Triassic, and Jurassic rocks are present in the deep canyons in the western part of the area and in the canyons of the San Miguel River and some of its tributaries in the northeastern part of the area. Jurassic rocks are the surface rocks over much of the western part of the area. Many of the higher mesas are capped by resistant beds of the Burro Canyon formation. In the eastern and central parts of the area the Dakota formation is the surface formation over most of the plateau and also crops out along the edges of the valley of Disappointment Creek and Dry Creek and on the high mesas north of the San Miguel River. Mancos shale also is preserved in the same areas. Mesaverde rocks are present on Klondike Ridge, North Mountain, and South Mountain in the southeastern part of the area. Remnants of the Lewis shale also are present on North Mountain and South Mountain.

The dominant structural features in the western part of the area are three large northwest-trending faulted anticlines separated by broad synclines. The anticlines and synclines are, from south to north, Dolores anticline, Disappointment syncline, Gypsum Valley anticline, Dry Creek Basin syncline, Paradox anticline, and the Nucla syncline, which lies adjacent to the Uncompahgre uplift. The axes of these folds generally parallel the axis of the Uncompahgre uplift. The anticlines plunge southeastward and die out so that the eastern part of the Norwood-Uravan area is a gently warped plateau. To the west the folds are obscured by the more recent laccolithic structure of the La Sal Mountains. The anticlines are believed to have been formed by upward flowage of evaporite rocks of the Paradox member of the Hermosa formation (Stokes and Phoenix, 1948). The central parts of the Gypsum Valley and Paradox anticlines have collapsed forming long fault valleys parallel to the axes of the folds.

Rocks examined for radioactivity

Hermosa formation

Bituminous shale, sandstone, siltstone, and gypsum in the Paradox member of the Hermosa formation of Pennsylvanian age crop out on the northeastern side of Gypsum Valley in San Miguel County. Several small hills composed of highly contorted and fractured Paradox beds were examined in sec. 33, T. 44 N., R. 16 W. north of Colorado Highway 80. A sample of black shale and siltstone from locality 15 (SW$\frac{1}{4}$ sec. 33, T. 44 N., R. 16 W.) contains 0.007 percent uranium, but no radioactivity was detected at other localities in this vicinity.

A grab sample of black shale, siltstone, and very fine-grained sandstone of the Paradox member from locality 14 (NE¼ sec. 25, T. 44 N., R. 17 W.) in a prospect a short distance west of the main workings of the Bald Eagle prospect contains 0.10 percent uranium. Stains and small irregular masses of yellow uranium minerals occur in brecciated beds near the middle of the narrow outcrop band of the Paradox member. Field counter readings indicate a mineralized band at least 20 feet wide. The rocks are highly contorted and fractured but generally have vertical dips. The Paradox beds occur as a sliver several hundred feet wide faulted against Jurassic rocks of the San Raphael group to the north and against rocks of the Morrison formation to the south.

Morrison formation

The Salt Wash and Brushy Basin members of the Morrison formation were examined for radioactivity at a few localities in the Norwood-Uravan area. Radioactivity was detected only at locality 11 (SE¼ sec. 29, T. 43 N., R. 12 W.) in a road cut on the east side of McCullack Creek Canyon, a tributary of Beaver Creek in eastern San Miguel County. A selected sample from the middle of a 5 foot bed of carbonaceous siltstone in the upper part of the Brushy Basin member contains 0.0027 percent uranium. The carbonaceous siltstone is overlain by approximately 80 feet of greenish-gray siltstone, shale, and thin sandstone beds to the base of the Burro Canyon formation. Immediately below the carbonaceous siltstone is 5 feet of quartzitic sandstone. The rocks are concealed on both sides of the road cut.

Dakota formation

The Dakota formation and the Mancos shale are preserved in Disappointment, Dry Creek Basin, and Nucla synclines, but they have been removed by erosion from the intervening anticlines. The Dakota formation caps most of the plateau in the eastern part of the area. The Dakota formation in the Norwood-Uravan area consists of lenticular sandstone, siltstone, carbonaceous shale, and coal. The thickest and best coal is in the vicinity of Norwood in San Miguel County, and near Naturita and Nucla in Montrose County, where several mines produce coal for local use. Elsewhere the coal is absent or is thin and generally very impure. Carbonaceous or coaly shale is common in the Dakota formation throughout most of the region. Only weak traces of radioactivity were detected in the areas which contain commercial coal.

A sample of impure coal from locality 19 (sec. 31, T. 47 N., R. 15 W.) on the north bank of Tuttle Draw northwest of Nucla in Montrose County contains 0.001 percent equivalent uranium. The sample was collected from the upper 8 inches of a 4-foot bed of coal near the middle of the Dakota formation. This coal bed is mined on the south side of Tuttle Draw. No radioactivity was detected in coal, sandstone, and shale that lie above and below the sampled interval at locality 19, and no radioactive rocks were found at other localities in this area.

A coal bed 9½ feet thick was examined at the portal of the Naturita mine of the Vanadium Corporation of America at locality 17 (sec. 14, T. 46 N., R. 16 W.). The mine is on the north side of the San Miguel River northwest of Naturita in Montrose County. No radioactivity was detected in the lower 5½ feet of the bed. A channel sample from the upper 4 feet

of impure coal which contains 4 siltstone partings, each about 5 inches thick, contains 0.001 percent equivalent uranium.

A coal mine was examined in sec. 17, T. 45 N., R. 13 W., about 2 miles northwest of Norwood near Colorado Highway 252. The bed in the Dakota formation which is being mined at the present time is about 3 feet thick and is composed of clean, lustrous bituminous coal. No radioactivity was detected in the mine or in nearby outcrops, and no samples were collected.

Weak radioactivity was detected in carbonaceous shale of the Dakota formation at several localities in the Norwood-Uravan area, but rocks at only 4 of these localities were sufficiently radioactive to be sampled. At locality 13 ($NE\frac{1}{4}$ sec. 3, T. 43 N., R. 16 W.) in San Miguel County northeastward-dipping beds of the Dakota formation are exposed north of Colorado Highway 80 on the north flank of the Gypsum Valley anticline. The Blackie prospect pit at locality 13 is in carbonaceous shale, siltstone, and sandstone beneath a thick ledge-forming bed of sandstone. A grab sample of carbonaceous shale from the prospect contains 0.002 percent equivalent uranium.

Coal and coaly shale of the Dakota formation were examined in the vicinity of Dry Creek Gap west of Naturita in T. 46 N., R. 16 W. Here the Dakota is preserved in down-dropped fault blocks in the axial portion of the Paradox anticline on the northeast limb of the fold. At locality 18 ($SW\frac{1}{4}$ sec. 22, T. 46 N., R. 16 W.) a trace of radioactivity was detected in a 5 foot bed of coaly shale which lies approximately 40 feet stratigraphically below the top of the Dakota formation. Sample 18 contains 0.002 percent equivalent uranium.

Traces of radioactivity were detected in several beds of coaly shale near the middle of the Dakota formation east of Naturita in a road cut along Colorado Highway 145. The Dakota formation is about 50 feet thick at locality 16 (sec. 22, T. 46 N., R. 16 W.) and contains many thin beds of carbonaceous shale and coaly shale. Sample 16 from a 1-foot bed of coaly shale that crops out about 4 feet above the level of the highway contains 0.001 percent uranium.

At locality 21 ($NE\frac{1}{4}$ sec. 35, T. 48 N., R. 16 W.) north of Tabequache Creek a channel sample of carbonaceous silty clay shale, 2 feet thick, from a bed just below the highest preserved part of the Dakota formation contains 0.002 percent equivalent uranium. The shale bed is about 100 feet above the base of the Dakota formation and is at the top of a 50 foot sequence of carbonaceous shale, thin siltstone and sandstone, and thin, impure coal. No radioactivity was found in rocks below the sampled bed. Locality 21 is near the northern edge of the Dakota formation preserved on the northeast limb of the Nucla syncline. The mesas north of this locality are capped by sandstone of the Burro Canyon formation. No abnormal radioactivity was observed in carbonaceous rocks in the Dakota formation at other localities along the northeast limb of the Nucla syncline or on the high mesas in the axial part of the syncline in the vicinity of Uravan.

Mesaverde formation

Rocks of the Mesaverde formation are preserved as erosional remnants on Klondike Ridge, North Mountain, and South Mountain in the southeastern part of the area. The three formations of the typical Mesaverde group preserved about 30 miles to the south have not been differentiated in this

area. Consequently, these rocks are referred to the Mesaverde formation following the usage of Stokes and Phoenix (1948). Mesaverde strata are overlain by remnants of the Lewis shale several hundred feet thick on North Mountain and by a thin veneer of Lewis shale on South Mountain. The Mesaverde formation wedges out to the northeast by lateral transition of upper beds into the Lewis shale, and lateral transition of lower beds into the Mancos shale. These stratigraphic relationships may be observed in the canyon of Disappointment Creek. At Ryman Creek on South Mountain the Mesaverde is composed of massive sandstone estimated to be 350 feet thick. On Colorado Highway 147 near the San Miguel-Dolores County line east of North Mountain and on the northwest slope of Lone Cone Mountain, the Mesaverde formation is represented by thin sandstone, siltstone, and interbedded shale 20 to 30 feet thick. This wedge-out of the Mesaverde has not been reported previously in the literature. A few thin beds of coal are present in the sandstone beds of the Mesaverde formation at Ryman Creek on South Mountain, but the coal beds pinch out to the northeast. No radioactivity was detected in them.

Cretaceous or Tertiary intrusive rocks

Basic igneous rocks occur as concordant and discordant sills in the Disappointment syncline in T. 42 and 43 N., R. 16 W., and T. 42 N., R. 15 W., San Miguel and Dolores Counties. These rocks were intruded into the Mancos shale in the central part of the syncline and into the Dakota formation on the northeastern and southwestern limbs of the syncline. The rocks that enclose the sills have been baked and slightly altered for a few feet from the contacts. No radioactivity was found in the igneous rocks or the altered sediments at any of the localities examined.

The highest parts of North Mountain and South Mountain in the southeastern part of the area are capped by a gently westward-dipping layer of light brownish-gray porphyritic igneous rock, about 30 feet thick, which is monzonitic in composition. Vertical jointing and horizontal sheeting of the rock are pronounced. The monzonitic rock probably is a remnant of a sill injected into the Lewis shale and probably is related to the intrusive stock of Lone Cone Mountain. The overlying shale has been eroded leaving the sill as a caprock which protects the shale beneath. A sample from the sill at the highest point on North Mountain (locality 12, sec. 10, T. 42 N., R. 14 W.) contains 0.002 percent equivalent uranium. The contact of the sill with the underlying Lewis shale could not be examined because it is covered by soil and vegetation.

UNCOMPAHGRE PLATEAU

General description

The Uncompahgre Plateau is a mountain range more than 80 miles in length and as much as 30 miles wide which extends northwestward from the San Juan Mountains of Colorado into eastern Utah. The highest part of the Plateau is the central part north of Nucla where the crest is nearly 10,000 feet above sea level. The southwestern slope of the Plateau descends abruptly to the flat-topped mesas north of the San Miguel and Dolores Rivers. The long northeastern slope descends gently to Grand Valley and the valleys of the Uncompahgre and Gunnison Rivers.

Precambrian crystalline rocks are exposed in Unaweep Canyon and other deep canyons near the northwestern end of the Plateau, along the southwestern side of the Plateau north of Uravan and Nucla, and in Escalante River canyon on the northeastern slope. Triassic rocks resting on the basement rocks are exposed in the same areas. Jurassic rocks of the Glen Canyon and San Raphael groups and the Morrison formation are the surface rocks throughout most of the Uncompahgre Plateau northwest of Unaweep Canyon. San Raphael and Morrison rocks also are exposed along the southwest-facing escarpment of the Plateau near the center of the uplift and in some of the deep canyons that cut the northeast slope. Resistant beds in the Burro Canyon formation cap most of the southeastern half of the Plateau. Carbonaceous rocks of the Dakota formation crop out at lower altitudes on the northwestern, northeastern, and southeastern flanks, and along part of the southwestern flank of the Plateau. Outliers of the Dakota occur at several places on the higher parts of the Plateau. Mancos shale is exposed in a nearly continuous outcrop band around the northwestern, northeastern, and southeastern margins of the Plateau.

The Uncompahgre Plateau is an asymmetrical anticlinal uplift. The structural axis which is generally the same as the topographic crest trends N. 35° W. The southwestern limb of the uplift dips steeply into the Nucla syncline and is broken in places by high angle faults. The northeastern limb dips gently to the northeast into the Piceance basin except west of Grand Junction where it passes into a sharp monoclinal fold.

Rocks examined for radioactivity

Morrison formation

The oldest rocks that were examined for radioactivity on the Uncompahgre Plateau are those of the Morrison formation. Rocks of the Salt Wash and Brushy Basin members of the Morrison were examined at a few localities along both sides of the Plateau. No abnormal radioactivity was detected at any of the localities examined.

Burro Canyon formation

A small amount of radioactivity occurs in copper-bearing sandstone in the lower part of the Burro Canyon formation at the abandoned workings of the Kopper King mine. The mine is located at locality 22 (sec. 20, T. 48 N., R. 14 W.) north of Tabeguache Creek in western Montrose County. Azurite and malachite occur in fossil wood and as interstitial material in arkosic conglomeratic sandstone exposed in the caved prospect. A sample of copper-bearing conglomeratic sandstone collected in the prospect contains less than 0.001 percent equivalent uranium.

No radioactivity was found in rocks of the Burro Canyon formation elsewhere in the Uncompahgre Plateau.

Dakota formation

Radioactivity above background was detected in rocks of the Dakota formation at three localities on the Uncompahgre Plateau.

Carbonaceous beds in the Dakota formation are exposed in a large landslide scar at locality 20 (sec. 28, T. 47 N., R. 12 W.) near the crest of the Uncompahgre Plateau in Montrose County. Conglomeratic sandstone of the Burro Canyon formation is exposed at the base of the scar. The sandstone is overlain by approximately 50 feet of carbonaceous to coaly shale, siltstone, and thin beds of sandstone of the Dakota formation. Above the scar the Dakota rocks are concealed by thick brush and timber. Sample 20 from 2 feet of dark gray to black carbonaceous siltstone about 45 feet above the base of the Dakota formation contains 0.002 percent equivalent uranium.

A channel sample of carbonaceous clay shale and thin siltstone was collected from the middle of the Dakota formation at locality 28 (sec. 27, T. 51 N., R. 13 W.) on the northeast flank of the Uncompahgre Plateau in Montrose County. The sample was taken from the upper 2 feet of a sequence of carbonaceous shale and siltstone, 4 feet thick, exposed in a small prospect near the Delta-Nucla road southwest of Delta. Sample 28 contains 0.002 percent equivalent uranium.

Radioactivity as much as 2 to 4 times background was found near the top of an outlier of the Dakota formation on a prominent hill at locality 37 (sec. 14 (?), T. 11 S., R. 102 W.) in Mesa County. An airline beacon is located at the top of the hill. Sample 37 is from 2 feet of coaly shale and siltstone, just below a thick sandstone which caps the hill. The sample contains 0.005 percent uranium. Dakota rocks in this part of the Plateau occur south of locality 37 between Glade Park and Unaweep Canyon. No radioactivity was detected in poorly exposed rocks examined at several places south of Glade Park.

Cretaceous or Tertiary intrusive rocks

Dikes and sills of intermediate to basic igneous rocks are present in the vicinity of Ridgway near the southeastern end of the Uncompahgre Plateau. The igneous rocks have been intruded into the Dakota formation and Mancos shale. No radioactivity was detected in either the intrusive rocks or in the rocks they intrude.

CIMARRON CREEK AREA

General description

The Cimarron Creek area is in Ouray and Gunnison Counties in the northwestern part of the San Juan Mountains. Cimarron Creek, a tributary of the Gunnison River, flows northward in a deep valley between Trident Mesa at the east and Cimarron Ridge at the west. West of Cimarron Ridge the land slopes irregularly into the valley of the Uncompahgre River.

The Uncompahgre River and Cimarron Creek have cut deep canyons in the Mancos shale. Above the Mancos shale are coal-bearing beds that have been assigned to the Mesaverde formation but which are probably younger than the typical Mesaverde rocks as indicated by the Mesaverde wedge-out in eastern San Miguel and Dolores Counties. Above these so-called Mesaverde rocks are thin irregularly distributed remnants of nonvolcanic conglomerate which may represent the Telluride conglomerate of Oligocene (?) age. Trident Mesa and Cimarron Ridge are capped by remnants of the San Juan tuff of middle Tertiary age. Quaternary glacial deposits are present on terraces and as valley fill.

Rocks in the area dip gently to the north and northwest from the San Juan uplift toward the Gunnison uplift and the Piceance basin.

Rocks examined for radioactivity

Mesaverde formation

Coal of the Mesaverde formation was examined at mines on both east and west sides of Cimarron Ridge. Two samples of coal were collected on the east side from a mine at locality 27 (sec. 25 (?), T. 47 N., R. 7 W.) which is in southeastern Montrose County. The coal bed is 18 feet thick and lies about 150 feet above the base of the Mesaverde formation. Rocks above the coal bed are covered by soil and vegetation to the base of the San Juan tuff. The lower 7.3 feet of the coal bed is being mined at present. A channel sample, 27a, from the lower 7.3 feet of coal collected at a point 15 feet inside the mine contains less than 0.001 percent equivalent uranium. Sample 27b collected from the top of the 18 foot coal bed beneath a thick sandstone contains 0.001 percent equivalent uranium.

An abandoned and filled mine in the Mesaverde formation was examined on the west side of Cimarron Ridge. It is located on the trail to Lou Creek Pass in sec. 26 (?), T. 46 N., R. 7 W. No radioactivity was detected in coal on the dumps or in coal at several poor exposures of the bed, and no samples were collected.

San Juan tuff

The San Juan tuff was examined near the north end of Cimarron Ridge in sec. 9, T. 47 N., R. 7 W.; east of Jackson Guard Station in sec. 2 (?), T. 46 N., R. 6 W.; and near High Park Lake in sec. 35, T. 47 N., R. 7 W. A representative sample of tuff and volcanic breccia was collected from large landslide blocks near the base of the San Juan tuff at locality 25 which is on the north shore of High Park Lake in Gunnison County. The sample contains 0.0001 percent uranium. Water sample no. 24 was collected from High Park Lake which is fed by springs that issue from the base of the San Juan tuff. The sample contains less than 0.001 parts per million uranium.

Another water sample was collected at locality 26 (sec. 26, T. 47 N., R. 7 W.) from a small stream about 3/4 of a mile north of High Park Lake. The stream is fed by springs which flow from the base of the San Juan tuff. Sample 26 contains 0.001 parts per million uranium.

Water sample 23 was collected from a small lake at the base of the San Juan tuff below Lou Creek Pass west of Cimarron Ridge in Ouray County (locality 23, sec. 24, T. 46 N., R. 7 W.). This water sample contains less than 0.001 parts per million uranium.

WEST ELK MOUNTAINS

General description

The West Elk Mountains are north of the Gunnison River and southeast of Grand Mesa in western Gunnison County.

Along the southern edge of the West Elk Mountains, in the Gunnison uplift, the Black Canyon of the Gunnison River has been cut into pre-Cambrian metamorphic rocks. The Entrada and Morrison formations of Jurassic age crop out along the rim of the canyon. Beds of resistant sandstone in the Dakota formation form prominent ledges above the Morrison formation, and the lower part of the Mancos shale is exposed at many places, particularly in the large canyons north of the Gunnison River. In the northern part of the Elk Mountains coal-bearing beds of the Mesaverde formation are present. Remnants of the Chio Creek conglomerate and the Wasatch formation of early Tertiary age overlie the Mesaverde formation. The southern two-thirds of the West Elk Mountains is capped by thick deposits of volcanic detritus, which have been called the West Elk breccia. The areas of outcrop of the San Juan tuff and West Elk breccia are separated only by the canyon of the Gunnison River and the formations undoubtedly are correlative. Remnants of basalt flows of the Potosi series (Miocene) overlie the West Elk breccia on the high mesas north of the Gunnison River. The sedimentary rocks in the northern part of the mountains contain large laccolithic bodies of quartz monzonite porphyry (Lee, 1912, p. 53).

The West Elk Mountains are on the southeastern edge of the Piceance Basin. In the southwestern part of the area the rocks dip northward and northeastward from the Gunnison uplift. Farther to the east the rocks dip northward on the north flank of the San Juan uplift. In the northern part of the West Elk Mountains the northward dip of the rocks into the Piceance Basin is interrupted locally by folding and faulting related to the intrusion of the laccolithic bodies.

Rocks examined for radioactivity

Two areas in the West Elk Mountains were examined for radioactivity (fig. 1). One is located on the north side of the Gunnison River between Sapinero and Cebolla, and the other is located near Baldwin in the northeastern part of the mountains.

Dakota formation

The Dakota formation north of the Gunnison River is composed of thick conglomeratic sandstone and interbedded shale. No coal was observed and no radioactivity was detected in the Dakota formation in this area. The formation is well exposed at locality 29 (sec. 28, T. 49 N., R. 3 W.) in an erosional scar north of U. S. Highway 50 just east of Cebolla. Here the Dakota is overlain by about 30 feet of Mancos shale which, in turn, is overlain unconformably by the West Elk breccia. Sample 29 was collected from a 3-foot bed of gray silty clay shale, about 30 feet below the top of the Dakota formation. Much limonite is present along fractures and bedding planes in the Mancos shale and the Dakota formation. The limonite was apparently leached down from the overlying volcanic rocks. Sample 29 contains 0.001 percent equivalent uranium.

Weak radioactivity was detected in a filled prospect about 300 feet east of locality 29. The prospect is in sandstone of the Morrison formation just below the bench formed by the Dakota formation. The source of the radioactivity was not found in the bedrock.

Mesaverde formation

Marine sandstone and coal-bearing beds above the Mancos shale in the West Elk Mountains are referred to the Mesaverde formation following the usage of Lee (1912).

Coal beds in the Mesaverde formation were examined north of Gunnison in the northeastern part of the West Elk Mountains. At New mine (locality 30 in sec. 10 (?), T. 15 S., R. 86 W.) east of Carbon Creek the coal and the enclosing sediments have been slightly metamorphosed by the igneous intrusions at Mount Carbon and Mount Wheatstone north of the mine. The bed that is being mined ranges from 4½ feet to 9 feet in thickness. Sample 30 is a representative sample of fresh coal collected from the tipple and contains 0.0001 percent uranium.

A 7 foot channel sample was collected from the main coal bed of the Old Baldwin mine at locality 31 (sec. 8, T. 15 S., R. 86 W.) west of Carbon Creek. The sample was collected at a point about three-eighths of a mile inside the east air tunnel. The coal is hard and lustrous and contains no rock partings at this point. Sample 31 contains 0.0002 percent uranium. Mining operation in Old Baldwin mine at present consists mainly of mining the old pillars.

A water sample was collected from an abandoned entry at locality 32 (sec. 25, T. 14 S., R. 87 W.) 3 miles north of Baldwin on the east side of Ohio Creek. A tunnel has been driven into massive sandstone of the Mesaverde formation which dips 45° westward from the Mount Carbon laccolith. A good stream of water flows out of the tunnel and the mine is nearly filled with water impounded by beaver dams built at the portal and within the tunnel. Water sample 32 contains less than 0.001 parts per

million uranium. According to Lee (1912, p. 148) the tunnel cuts three coal beds, the middle bed of which is 3 feet 6 inches thick and contains coal of coking quality. No radioactivity was detected in coal on the dump or in coke remaining near the old coking ovens at this locality.

PAONIA AREA

General description

The Paonia area is located in eastern Delta County and northwestern Gunnison County. The North Fork of the Gunnison River crosses the middle of the area in a deep valley that separates Grand Mesa on the north from the mesas and the laccolithic peaks of the West Elk Mountains on the south.

The Mancos shale crops out west of Somerset on the steep slopes of the mesas that rise on either side of the valley of the North Fork. The coal-bearing Mesaverde formation is extensively exposed in the cliffs on both sides of the North Fork valley and in the bottom of the valley east of Somerset. The highest parts of the mesas south of the North Fork are capped by the Ohio Creek conglomerate and the overlying Wasatch formation. The Wasatch formation and the overlying Green River formation (Eocene) are preserved on Grand Mesa which is capped by late Tertiary or Quaternary basalt flows.

Sedimentary rocks of the Paonia area dip generally northward at about 10° into the Piceance basin. Locally, the beds are steeply tilted near the laccolith masses south of the North Fork.

Rocks examined for radioactivity

Mesaverde formation

Coal beds in the Mesaverde formation were examined at three mines in the Paonia area. No radioactivity was detected near the portal of the Farmers mine (SW¼ sec. 17, T. 13 S., R. 91 W.); the Bear mine (SW¼ sec. 9, T. 13 S., R. 90 W.); and the Hawksnest No. 2 mine (NE¼ sec. 11, T. 13 S., R. 90 W.).

A sample of carbonaceous shale was collected at locality 34 (NE¼ sec. 8, T. 13 S., R. 89 W.) in an erosional scar on Colorado Highway 135, about 300 feet west of the junction of Colorado Highways 135 and 133. The sample is from the upper one foot of a 6-foot bed of carbonaceous shale which is overlain by a massive sandstone in the Mesaverde formation; it contains 0.0001 percent uranium.

A grab sample was collected from oxidized sandstone, shale, and coal at locality 35 (SW¼ sec. 11, T. 13 S., R. 90 W.) about three-quarters of a mile west of the Hawksnest mine on Colorado Highway 135. Sample 35 contains 0.002 percent equivalent uranium.

A trace of radioactivity was detected in clinkers from the Bowie power plant at locality 36 (NE¼ sec. 15, T. 13 S., R. 91 W.) about one-quarter of a mile east of Bowie on Colorado Highway 135. Coal for the plant is mined in the Bowie mine near locality 36. Sample 36 taken from clinkers at the power plant contains 0.002 percent equivalent uranium.

Wasatch formation

Rocks in the lower part of the Wasatch formation were examined near locality 33 (sec. 6, T. 13 S., R. 88 W.) on Colorado Highway 135. No radioactivity was detected. A water sample (no. 33) collected from a small spring which issues from rocks near the base of the Wasatch formation near locality 33 contains 0.001 parts per million uranium.

PALISADE AREA

General description

The Palisade area lies between Palisade and De Beque in northern Mesa County. Here the deep steep-walled canyon of the Colorado River cut into gently dipping sedimentary beds separates Grand Mesa and Battlement Mesa on the southeast from the Book Cliffs and Roan Cliffs on the northwest. The Colorado River leaves the canyon in the vicinity of Palisade and enters Grand Valley.

Grand Valley is underlain by Mancos shale which also is exposed in the steep lower slopes of the Book Cliffs and Grand Mesa. Rocks of the overlying Mesaverde group form prominent cliffs and benches in the Book Cliffs and the Grand Mesa. The Mesaverde, in turn, is overlain by the Wasatch and Green River formations.

Rocks examined for radioactivity

Mesaverde group

The Palisade mine and an unnamed mine about three-quarters of a mile to the east were examined in T. 11 S., R. 98 W., north of Palisade. Both are in the Palisade coal bed of the Mount Garfield formation of the Mesaverde group (Erdmann, 1934, p. 110). No radioactivity was found at either locality and no samples were collected. No radioactivity was detected in stratigraphically higher rocks of the Mesaverde group in this vicinity.

Carbonaceous shale and sandstone of the Hunter Canyon formation (Erdmann, 1934, p. 33) of the Mesaverde group were examined for radioactivity along U. S. Highway 6-50 between Cameo and De Beque and in the canyon of Plateau Creek. No radioactivity was detected and no samples were collected.

LAS VEGAS PLATEAU AND CANADIAN ESCARPMENT IN HARDING AND SAN MIGUEL COUNTIES, NORTHEASTERN NEW MEXICO

General description

The Las Vegas Plateau is a broad gently rolling plain which is deeply incised by the Canadian, Mora, and Gallinas Rivers. The Plateau extends from the Sangre de Cristo Mountains on the west to a steep southeastward-facing erosional escarpment, known as the Canadian Escarpment, on the southeast.

Upper Triassic rocks of the Santa Rosa sandstone and Chinle formation of the Dockum group are exposed along the edge of the Las Vegas Plateau and in the deep canyons. Above the Triassic rocks are the Entrada sandstone, the Wanakah formation, and the Morrison formation, all of late Jurassic age. The Morrison formation is overlain by the Purgatoire formation of early Cretaceous age, which consists of massive sandstone and carbonaceous shale. The Las Vegas Plateau is capped by resistant beds of the Dakota sandstone and by thin outliers of the Graneros shale, Greenhorn limestone, and Carlile shale members of the Benton formation of Cretaceous age. Remnants of the Ogallala formation of late Tertiary age overlie these older strata and form the surface of the eastern part of the Plateau. Quaternary basalt flows are present in the canyons of the Mora and Canadian Rivers. The sedimentary rocks of the region are relatively flat-lying. All localities that were examined for radioactivity in this area are shown on figure 2.

Rocks examined for radioactivity

Chinle formation

The Chinle formation consists of a lower shale member, a middle sandstone member, and an upper shale member. A prospect in the middle sandstone member was examined at locality 40 which is about 3 miles southwest of Sabinoso in northeastern San Miguel County. The prospect is on a claim of the Hunt Oil Company in sec. 30 (?), T. 17 N., R. 24 E., about 2 miles west of the Canadian River. It is located on the north side of the ridge north of New Mexico Highway 65 in a saddle between a small Morrison-capped hill to the east and a large Dakota-capped mesa to the west.

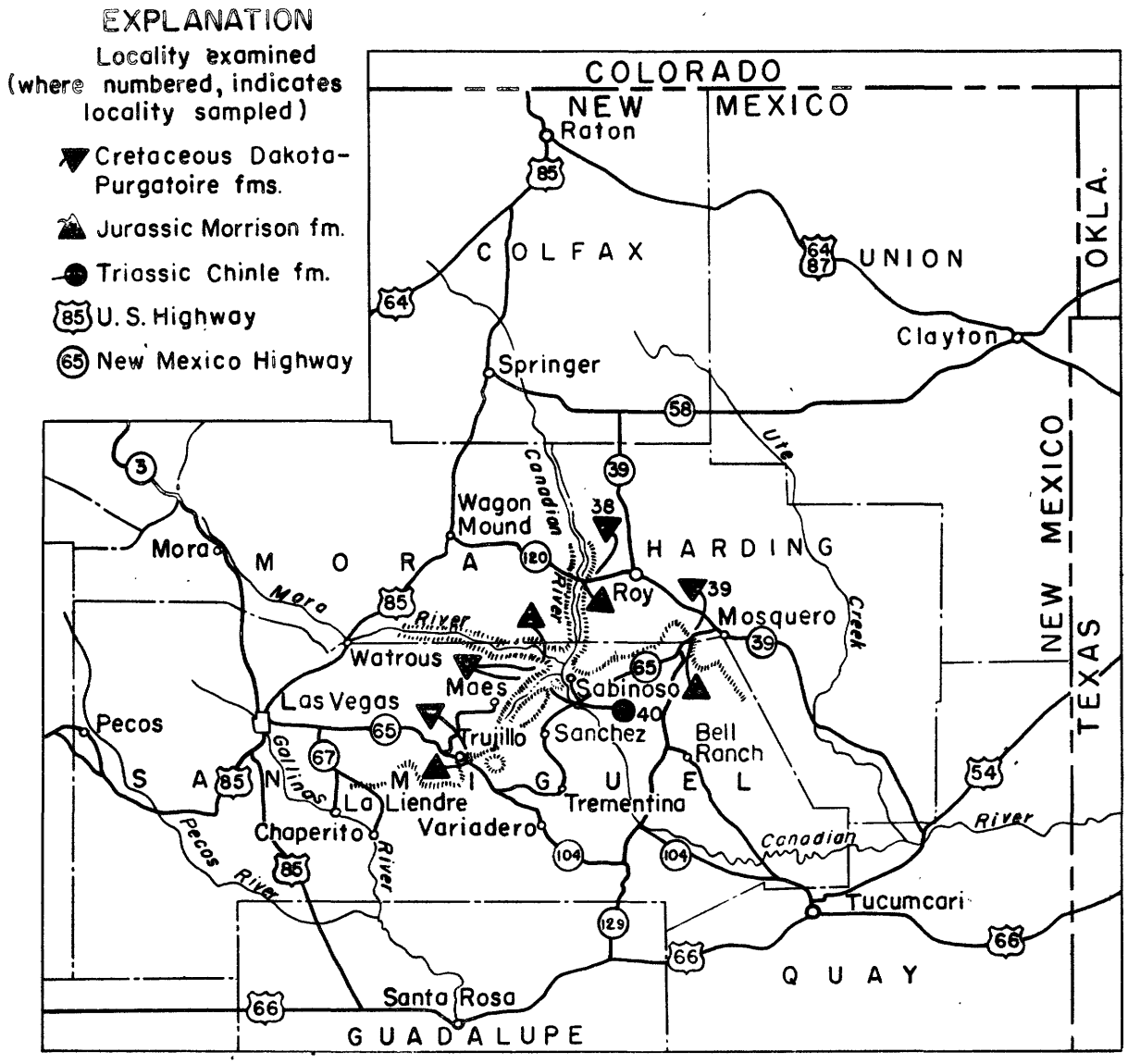

Fig. 2 Index map of part of northeastern New Mexico showing localities examined for radioactivity in 1953.

The following section of rocks in the middle sandstone member of the Chinle formation was measured at locality 40.

Top - near the middle of the Chinle formation

Unit		Thickness in Feet
1.	Sandstone, light gray to light brown, thin- to medium-bedded with interbedded limestone pebble conglomerate. At the top is a thick-bedded sandstone which forms the top of the bench in the saddle.	25+
2.	Sandstone, light gray, very fine- to medium-grained, massive, ledge-forming. Composed of white, green, pink quartz, some chert, and highly weathered feldspar. Fractures at the base of the sandstone are coated with yellow uranium minerals.	10
3.	Siltstone and fine-grained sandstone, light gray, greenish-gray, dark gray, very thin- to medium-bedded, irregular-bedded and cross-bedded. This unit appears to be fill in a small channel. Many small carbonized logs, limbs, and twigs occur in the sandstone. Yellow uranium minerals and dark stains of vanadium minerals occur in carbonaceous material along bedding planes and in lenses of green argillaceous siltstone. Malachite also is present with carbonaceous material on bedding planes. Small joints and fractures are coated with yellow uranium minerals. A channel sample (40a) across unit 3 contains 0.22 percent uranium. A selected sample (40b) from the middle 8 inches of unit 3 contains 0.88 percent uranium.	3.2

Unit		Thickness in Feet
4.	Sandstone, light-brown weathering, very fine- to medium-grained, massive-bedded, finely laminated. Angular to subangular, white, green, and pink quartz and chert fragments are the principal mineral constituents. The sandstone is arkosic and highly argillaceous. Field counter readings 2 to 3 times background were observed near the top of the unit.	10+

Base - slightly below the middle of the Chinle formation.

The lateral extent of the deposit was not determined because of poor exposures.

The Chinle formation crops out continuously along the Canadian Escarpment between the Pecos River in San Miguel County and Ute Creek in Harding County. In view of the presence of a considerable amount of uranium at the Hunt prospect, reconnaissance examination of the Triassic rocks in this region may be advisable.

Morrison formation

The Morrison formation was examined at the localities shown on figure 2. Traces of radioactivity were detected at the contact of the Morrison formation with the overlying Purgatoire formation about 1 mile southeast of Trujillo near New Mexico Highway 65 in San Miguel County, but no sample was collected. No radioactivity was found at the other localities where the rocks were examined.

Purgatoire and Dakota formations

Exposures of carbonaceous shale in the Purgatoire and Dakota formations were examined at several localities and two samples were collected. A trace of radioactivity was detected at locality 38 (T. 20 N., R. 25 E.) in outcrops of carbonaceous shale along New Mexico Highway 120 about 1½ miles east of the Canadian River in Harding County. Sample 38 from this locality contains 0.001 percent uranium.

Radioactivity was detected in carbonaceous shale beneath the thick Dakota sandstone at locality 39 (T. 18 N., R. 27 E.) near New Mexico Highway 65 about 6 miles west of Mosquero in Harding County. Sample 39 which was collected near the edge of the Escarpment contains 0.001 percent equivalent uranium.

No radioactivity was detected at the other localities where Purgatoire and Dakota rocks were examined.

SELECTED BIBLIOGRAPHY

Northern San Juan Basin

Barnes, Harley, 1953, Geology of the Ignacio area, Ignacio and Pagosa Springs quadrangles, La Plata and Archuleta Counties, Colorado: U. S. Geol. Survey Oil and Gas Invest. Map OM 138.

Barnes, Harley, Baltz, E. H., and Hayes, P. T., 1954, Geology and fuel resources of the Red Mesa area, La Plata and Montezuma Counties, Colorado: U. S. Geol. Survey Oil and Gas Invest. Map OM 149.

Hayes, P. T., and Zapp, A. D., 1955, Geology and fuel resources of the Upper Cretaceous rocks of the Barker Dome-Fruitland area, San Juan County, New Mexico: U. S. Geol. Survey Oil and Gas Invest. Map OM 144, sheets 1 and 2.

Reeside, J. B., Jr., 1924, Upper Cretaceous and Tertiary formations of the western part of the San Juan Basin, Colorado and New Mexico: U. S. Geol. Survey Prof. Paper 134.

Wood, C. H., Jr., Kelley, V. C., and MacAlpin, A. J., 1948, Geology of southern Archuleta County, Colorado: U. S. Geol. Survey Oil and Gas Invest. Prelim. Map 81.

Zapp, A. D., 1949, Geology and coal resources of the Durango area, La Plata and Montezuma Counties, Colorado: U. S. Geol. Survey Oil and Gas Invest. Prelim. Map 109, sheets 1 and 2.

Mancos-Egnar area

Finley, E. A., 1951, Geology of Dove Creek area, Dolores and Montezuma Counties, Colorado: U. S. Geol. Survey Oil and Gas Invest. Map OM 120.

Norwood-Uravan area

Fischer, R. P., 1942, Vanadium deposits of Colorado and Utah: U. S. Geol. Survey Bull. 936-P.

Fischer, R. P., and Hilpert, L. S., 1952, Geology of the Uravan mineral belt: U. S. Geol. Survey Bull. 988-A.

Stokes, W. L., and Fischer, R. P., 1945, Geologic map of the Gateway area, Mesa County, Colorado, and the adjoining part of Grand County, Utah: U. S. Geol. Survey Strategic Minerals Invest. Prelim. Map.

Stokes, W. L., and Phoenix, D. A., 1948, Geology of the Egnar-Gypsum Valley area, San Miguel and Montrose Counties, Colorado: U. S. Geol. Survey Oil and Gas Invest. Prelim. Map 93.

Cimarron Creek area

Atwood, W. W., and Mather, K. F., 1932, Physiography and Quaternary geology of the San Juan Mountains, Colorado: U. S. Geol. Survey Prof. Paper 166.

West Elk Mountains

Lee, W. T., 1912, Coal fields of Grand Mesa and the West Elk Mountains, Colorado: U. S. Geol. Survey Bull. 510.

Paonia area

Johnson, V. H., 1948, Geology of the Paonia coal field, Delta and Gunnison Counties, Colorado: U. S. Geol. Survey Prelim. Coal Map.

Palisade area

Erdmann, C. E., 1934, The Book Cliffs coal field in Garfield and Mesa Counties, Colorado: U. S. Geol. Survey Bull. 851.

Las Vegas Plateau and Canadian Escarpment
Northeastern New Mexico

Griggs, R. L., and Hendrickson, G. E., 1951, Geology and ground-water resources of San Miguel County, New Mexico: New Mexico Bur. Mines and Mineral Resources Ground-Water Report 2.

Northrop, S. A., Sullwold, H. H., MacAlpin, A. J., and Rogers, C. P., 1946, Geologic maps of the Las Vegas basin and of the foothills of the Sangre de Cristo Mountains, San Miguel and Mora Counties, New Mexico: U. S. Geol. Survey Oil and Gas Invest. Prelim. Map 54.

APPENDIX

RADIOACTIVITY MEASUREMENTS AND CHEMICAL ANALYSES OF SAMPLES FROM COLORADO AND NEW MEXICO[1]

[1] Radioactivity determinations and chemical analyses of samples were made by the Geological Survey Geochemical Laboratories. Analyzed by S. Furman, W. Mountjoy, J. Meadows, and J. Wilson.

Radioactivity measurements and chemical analyses of samples from Colorado and New Mexico

Sample and locality number[1]	Laboratory serial number	Location	Equivalent uranium (percent)	Uranium (percent)	Description
		Northern San Juan Basin			
1	D-98354	Sec. 36, T. 35 N., R. 2 W., Archuleta County, Colo.	0.004	0.001	Grab sample of carbonaceous clay shale, 1 foot thick, from the middle shale member of the Dakota formation.
2	D-98355	Sec. 30, N. T. 34 N., R. 5 W., Archuleta County, Colo.	<.001	---	Sample of coal from the tipple of a mine in the basal coal of the Fruitland formation.
3	D-98356	Sec. 13, T. 35 N., R. 7 W., La Plata County, Colo.	.001	---	Coal from the tipple of a caved mine in the basal coal of the Fruitland formation.
4	D-98357	Sec. 25 (?), T. 37 N., R. 9 W., La Plata County, Colo.	.004	.001	Selected sample of calcareous tufa from a hot spring deposit. The spring issues from the Ouray limestone.
5	D-98352	Sec. 15, T. 32 N., R. 13 W., San Juan County, N. Mex.	.003	.003	Oxidized coaly shale from the dump of a caved mine in the basal coal of the Fruitland formation.
6	D-98353	T. 14 N., R. 14 W., San Juan County, N. Mex. On cliffs 4 miles west of Barker Creek.	.003	.002	Grab sample of coaly shale and impure coal, 1½ feet thick, from the top of the Menefee formation.

[1] Sample localities shown on fig. 3.

Radioactivity measurements and chemical analyses of samples from Colorado and New Mexico.--Continued.

Sample and locality number	Laboratory serial number	Location	Equivalent uranium (percent)	Uranium	Description
		Northern San Juan Basin (Continued)			
7	D-98358	Sec. 24, T. 35 N., R. 14 W., Montezuma County, Colo.	0.006	0.0015	Grab sample of olivine biotite basalt from a dike in the Mancos shale and Point Lookout sandstone.
		Mancos-Egnar area			
8	D-98359	Sec. 35, T. 36 N., R. 19 W., Montezuma County, Colo.	.002	---	Selected sample of ferruginous siltstone associated with coaly shale at base of the Dakota formation.
9	D-98360	Sec. 34, T. 38 N., R. 17 W., Montezuma County, Colo.	.001	---	Coal from the dump of a caved mine in the Dakota formation.
10	D-98361	Sec. 9, T. 39 N., R. 17 W., Dolores County, Colo.	.001	---	Channel sample, 2 feet thick, of coaly shale from the middle of the Dakota formation.
		Norwood-Uravan area			
11	D-98372	Sec. 29, T. 43 N., R. 12 W., San Miguel County, Colo.	.004	.0027	Selected sample of carbonaceous siltstone from the middle of a 5-foot bed in the Brushy Basin member of the Morrison formation.
12	D-98367	Sec. 10, T. 42 N., R. 14 W., San Miguel County, Colo.	.002	---	Light-colored igneous rock from a sill in the Lewis shale at the top of North Mountain.

Radioactivity measurements and chemical analyses of samples from Colorado and New Mexico.--Continued.

Sample and locality number	Laboratory serial number	Location	Equivalent uranium (percent)	Uranium (percent)	Description
		Norwood-Uravan area (Continued)			
13	D-98362	Sec. 3, T. 43 N., R. 16 W., San Miguel County, Colo.	0.002	---	Grab sample of carbonaceous shale from the Blackie prospect in the Dakota formation.
14	D-98389	Sec. 24, T. 44 N., R. 17 W., San Miguel County, Colo.	.073	0.10	Grab sample of gray-black siltstone, sandstone and shale of the Paradox member of the Hermosa formation collected at the Bald Eagle prospect.
15	D-98388	Sec. 33, T. 44 N., R. 16 W., San Miguel County, Colo.	.006	.007	Grab sample of black shale and siltstone of the Paradox member of the Hermosa formation.
16	D-98366	Sec. 22, T. 46 N., R. 16 W., Montrose County, Colo.	.003	.001	Grab sample of coaly shale, 1 foot thick, from the middle of the Dakota formation.
17	D-98370	Sec. 14, T. 46 N., R. 16 W., Montrose County, Colo.	.001	---	Channel sample of the upper 4 feet of a 9½ foot coal bed in the Dakota formation at the Naturita mine of the Vanadium Corporation of America.
18	D-98365	Sec. 22, T. 46 N., R. 16 W., Montrose County, Colo.	.002	---	Channel sample of 5 feet of impure coal of the Dakota formation.

Radioactivity measurements and chemical analyses of samples from Colorado and New Mexico.--Continued.

Sample and locality number	Laboratory serial number	Location	Equivalent uranium (Percent)	Uranium (Percent)	Description
		Norwood-Uravan area (Continued)			
19	D-98368	Sec. 31, T. 47 N., R. 15 W., Montrose County, Colo.	0.001	---	Selected sample of the upper 8 inches of an impure coal bed 4 feet thick in the middle of the Dakota formation.
21	D-98369	Sec. 35, T. 48 N., R. 16 W., Montrose County, Colo.	.002	---	Channel sample of carbonaceous silty clay shale from the upper 2 feet of a 50-foot interval of carbonaceous shale, siltstone, and thin sandstone in the middle of the Dakota formation.
		Uncompahgre Plateau			
20	D-98373	Sec. 28, T. 47 N., R. 12 W., Montrose County, Colo.	.002	---	Channel sample of carbonaceous siltstone 2 feet thick, about 45 feet above the base of the Dakota formation.
22	D-98371	Sec. 20, T. 48 N., R. 14 W., Montrose County, Colo.	<.001	---	Selected sample of copper-bearing conglomeratic sandstone of the Burro Canyon formation from the Kopper King mine.
28	D-98363	Sec. 27, T. 51 N., R. 13 W., Montrose County, Colo.	.002	---	Channel sample of the upper 2 feet of a 4-foot bed of carbonaceous clay shale, and thin siltstone of the Dakota formation in a small prospect.

Radioactivity measurements and chemical analyses of samples from Colorado and New Mexico.--Continued.

Sample and locality number	Laboratory serial number	Location	Equivalent uranium (percent)	Uranium (percent)	Description
		Uncompahgre Plateau (Continued)			
37	D-98364	Sec. 14 (?), T. 11 S., R. 102 W., Mesa County, Colo.	0.006	0.005	Channel sample of coaly shale and siltstone, 2 feet thick, in the Dakota formation.
		Cimarron Creek area			
23	D-98379	Sec. 24, T. 46 N., R. 7 W., Ouray County, Colo.	---	<.001 (Parts per million)	Water sample from small lake at the base of Lou Creek Pass. The lake is fed by streams which issue from the San Juan tuff.
24	D-98377	Sec. 35, T. 47 N., R. 7 W., Gunnison County, Colo.	---	<.001 (Parts per million)	Water sample from High Park Lake. The lake is fed by springs which issue from the San Juan tuff.
25	D-98376	Sec. 35, T. 47 N., R. 7 W., Gunnison County, Colo.	.002	.0001	Selected sample of volcanic breccia and tuff of the San Juan tuff collected from landslide blocks at the east base of Cimarron Ridge.
26	D-98378	Sec. 26, T. 47 N., R. 7 W., Gunnison County, Colo.	---	.001 (Parts per million)	Water sample from a stream 3/4 miles north of High Park Lake. The stream is fed by springs which issue from the San Juan tuff.

Radioactivity measurements and chemical analyses of samples from Colorado and New Mexico.--Continued.

Sample and locality number	Laboratory serial number	Location	Equivalent uranium (percent)	Uranium (percent)	Description
		Cimarron Creek area (Continued)			
27a	D-98374	Sec. 25 (?), T. 47 N., R. 7 W., Montrose County, Colo.	<0.001	---	Channel sample of the lower 7.3 feet of an 18-foot coal bed of the Mesaverde formation in a mine east of Cimarron Ridge.
27b	D-98375	Sec. 25, T. 47 N., R. 7 W., Montrose County, Colo.	.001	---	Selected sample of coal from the top of the 18-foot bed at locality 27.
		West Elk Mountains			
29	D-98380	Sec. 28, T. 49 N., R. 3 W., Gunnison County, Colo.	.001	---	Channel sample of gray silty clay shale, 3 feet thick, about 30 feet below the top of the Dakota formation.
30	D-98381	Sec. 10 (?), T. 15 S., R. 86 W., Gunnison County, Colo.	<.001	0.0001	Selected sample of coal of the Mesaverde formation from the tipple of the New Mine.
31	D-98382	Sec. 8, T. 15 S., R. 86 W., Gunnison County, Colo.	<.001	.0002	Channel sample of a 7-foot coal bed of the Mesaverde formation collected 3/8 mile in from the portal of the east air tunnel of the Old Baldwin mine.

Radioactivity measurements and chemical analyses of samples from Colorado and New Mexico.--Continued.

Sample and locality number	Laboratory serial number	Location	Equivalent uranium (percent)	Uranium (percent)	Description
		West Elk Mountains (Continued)			
32	D-98385	Sec. 25, T. 14 S., R. 87 W., Gunnison County, Colo.	---	<0.001 (Parts per million)	Water sample from abandoned mine in the Mesaverde formation east of Ohio Creek. The tunnel is half filled with water impounded by beaver dams.
		Paonia area			
33	D-98384	Sec. 6, T. 13 S., R. 88 W., Gunnison County, Colo.	---	.001 (Parts per million)	Water sample from a small spring which issues from the highest part of the Mesaverde formation or the base of the Wasatch formation.
34	D-98386	Sec. 8, T. 13 S., R. 89 W., Gunnison County, Colo.	0.003	.0001	Selected sample of the upper 1 foot of a 6-foot bed of carbonaceous clay shale of the Mesaverde formation.
35	D-98387	Sec. 11, T. 13 S., R. 90 W., Gunnison County, Colo.	.002	---	Grab sample from the base of a 12-foot bed of oxidized shale, sandstone, and coal of the Mesaverde formation.
36	D-98383	Sec. 15, T. 13 S., R. 91 W., Delta County, Colo.	.002	---	Selected sample of ash and clinker from the Bowie power plant. Coal for the power plant is mined from the Mesaverde formation at the Bowie mine.

Radioactivity measurements and chemical analyses of samples from Colorado and New Mexico.[1]--Continued.

Sample and locality number	Laboratory serial number	Location	Equivalent uranium (percent)	Uranium (percent)	Description
		Las Vegas Plateau and Canadian Escarpment			
38	D-98347	T. 20 N., R. 25 E., Harding County, N. Mex. Approximately 1½ miles east of Canadian River on N. Mex. Highway 120.	0.001	---	Grab sample of dark gray-black highly carbonaceous shale of the Dakota formation.
39	D-98348	T. 18 N., R. 27 E., Harding County, N. Mex. Edge of the Canadian Escarpment, approximately 6 miles west of Mosquero on N. Mex. Highway 65.	.001	---	Grab sample of gray carbonaceous siltstone from the Dakota formation.
40a	D-98350	Sec. 30 (?), T. 17 N., R. 24 E., San Miguel County, N. Mex.	.21	0.22	Channel sample, 3.2 feet thick, of light-dark gray siltstone and fine-grained carbonaceous sandstone from the middle sandstone member of the Chinle formation at the Hunt Oil Co. prospect.
40b	D-98351	Sec. 30 (?), T. 17 N., R. 24 E., San Miguel County, N. Mex.	.66	.88	Selected sample of light-dark gray and green siltstone from the middle of the above unit of the Chinle formation at the Hunt Oil Co. prospect.

[1] Sample localities shown on fig. 2.

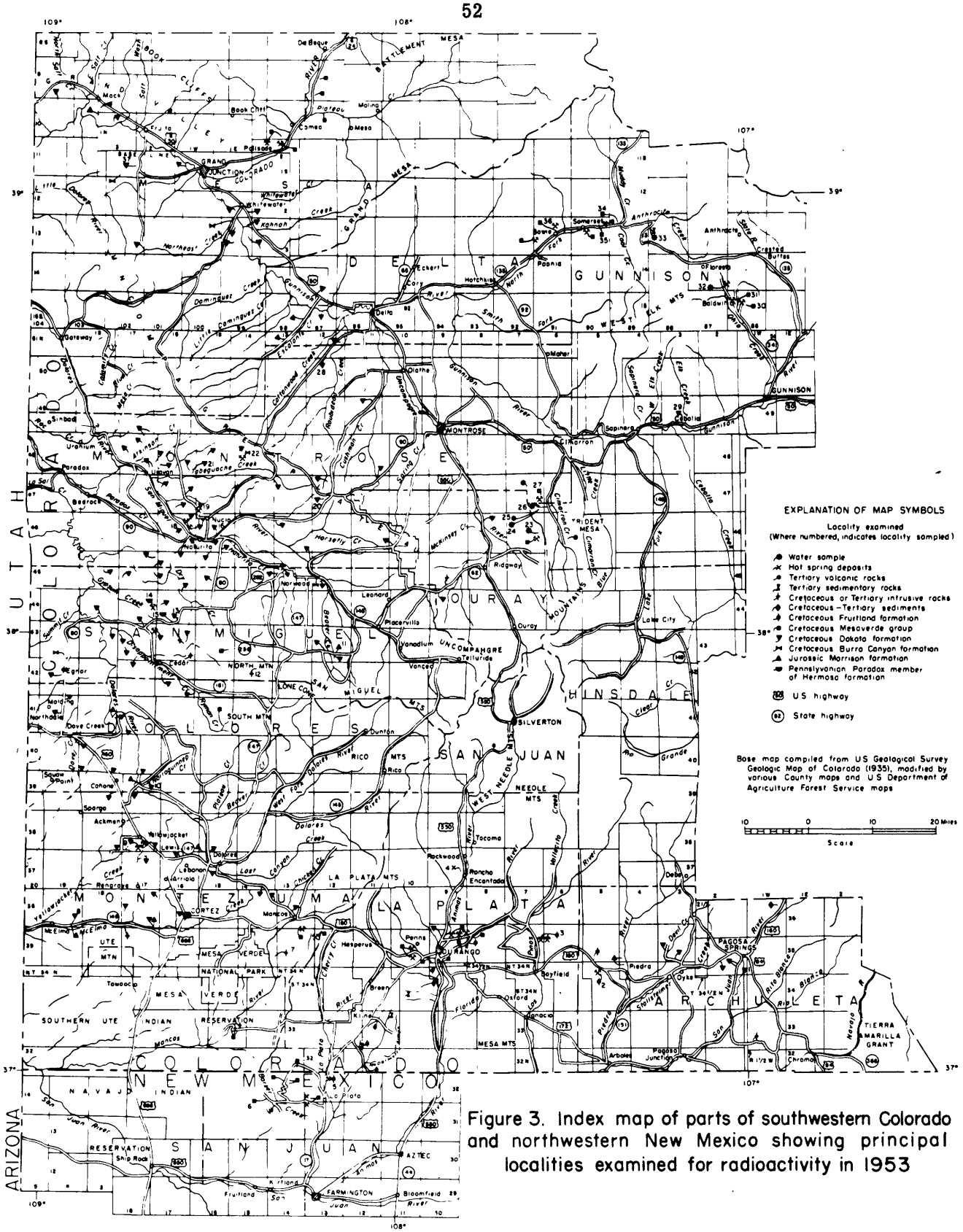

Figure 3. Index map of parts of southwestern Colorado and northwestern New Mexico showing principal localities examined for radioactivity in 1953