Paleontological Inventory and Assessment
Federal Mineral Estates
Northern Portion of the Royal Gorge Resource Area, Central Colorado

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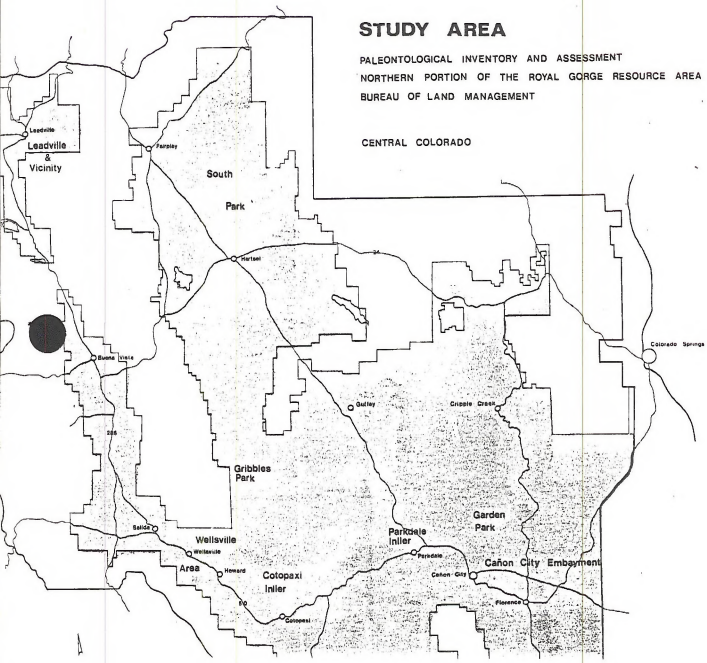

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INTRODUCTION

This report is the result of the Bureau of Land Management (BLM) contract No. CO-050-PP2-39, the purpose of which is to assess the paleontological potential of the Federal Mineral Estates contained within the boundaries of the northern portion of the Royal Gorge Resource Area (see map of study area).

A pre-work conference was held with Mr. Roger Underwood and Mr. Kevin Anderson on May 6, 1982. The order to proceed was issued at this meeting. Work was completed on December 31, 1982.

A previous report, "Paleontological Inventory and Assessment, Northern Portion of the Royal Gorge Resource Area, Central Colorado," submitted by Mr. Dennis W. Fischer on December 20, 1979, covered all BLM lands within the study area. Liberal use of this report was made in the interpretations and assessments of the paleontological potential of the BLM Mineral Estates. It was concluded that the present report could best be utilized as a supplement to Fischer's (1979) report. Therefore, no attempt was made to reproduce complete locality lists, extensive references, or detailed descriptions of geologic units, unless they related directly to BLM Mineral Estates.

Locality files at the United States Geologic Survey (USGS), the University of Colorado Museum (UCM), and the Denver Museum of Natural History (DMNH) were examined, and a literature search was conducted to determine existing localities within the study area. These data are included in their appropriate geographic sections. Mineral estate

localities found by Fischer (1979) were incorporated with these data. In addition, a revised stratigraphic column is included for each geographic section along with a classification and color code for each formation described.

Field work was conducted to determine fossil occurrences at reported localities, to determine new fossil localities, and to define the extent of fossiliferous outcrops as they pertain to adjacent mineral estates.

The present authors, unless otherwise stated, agreed with the basis of classification and recommendations for management proposed by Fischer (1979).

We wish to thank John Hanley and Bob O'Donnell of the United States Geological Survey, and Peter Robinson of the University of Colorado Museum for providing locality information. We also wish to thank Roger Underwood, Kevin Anderson, and Mary Belben for their cooperation and assistance with this report.

Stratigraphic Section for South Park

Period	Formation	Class	Color
Tertiary	Wagontongue	1	Brown
	Antero	1	Brown
	South Park	2	Green
Cretaceous	Laramie	2	Green
	Fox Hills sandstone	2	Green
	Pierre shale	2	Green
	Niobrara	2	Green
	Benton shale	2	Green
	Dakota sandstone	2	Green
Jurassic	Morrison	2	Green
	Garo sandstone	2	Green
Permian-Pennsylvanian	Maroon	1	Dark blue
	Weber	2	Green
Mississippian	Leadville limestone	2	Green
Mississippian-Devonian	Chaffee Group		
	Dyer	2	Green
	Parting	2	Green
Cambrian	Peerless	3	Black
	Sawatch	3	Black
PreCambrian		3	Black

SOUTH PARK AREAS

Quaternary Sediments

Quaternary formations were not formally evaluated in this report due to the rare occurrence of fossils in their sediments in the South Park region. It should be noted, however, that a tooth of Mammuthus cf. columbi was found near Reinecker Ridge, Park County, Colorado (Table 1). In addition, Cook (1931) mentioned mammoths found near Como and South Park, Colorado.

The time range for this species of mammoth is Middle Illinoian to Early Holocene. Deposits within this time range could occur in South Park and may contain isolated Pleistocene vertebrates.

These formations were not classified or mapped as they are not easily distinguished in the field, are not well documented, and have produced scant fossil material. Therefore, any fossil vertebrate finds in these deposits would be significant and should be reported to the proper agency.

Wagontongue Formation (Early-Late Miocene)

This formation outcrops in the southern part of South Park, and it is composed of fluviatile siltstones, sands, gravels, and calcareous clays. Vertebrate fossils (Table 1) indicate two faunas, Early and Late Miocene. It is not known if this is the result of discontinuous deposition or lack of paleontological sampling in Middle Miocene beds. The Trump Conglomerate is here considered a facies of the Wagontongue (Scott, 1978). This formation is Class 1 due to the presence of vertebrate fossils.

Antero Formation (Oligocene)

The Wagontongue overlies the Antero Formation which outcrops along the western end of the park, extending north and south from near Fairplay to Gribbles Park, Colorado. The Antero is a series of lacustrine silts, shales, and algal limestones, intertongued by airborne ash and water-laid tuffs with occasional conglomerates and sandstones. At least part of the Antero is thought to be equivalent to the Florissant Formation due to the similarity of their fossils. The formation has produced fossil mammals, insects, gastropods, leaves, seeds, and algae of Class 1 significance.

Lack of visible outcrops makes the Antero and Wagontongue Formations difficult to separate in the field. In addition, both formations are Class 1. Therefore, these formations, as they lie on mineral estates, are both coded brown on the Land Status Maps which accompany this report. Where field observations of outcrops were obscured by soil and vegetation, a somewhat broader boundary was given to adjacent mineral estates.

South Park Formation (Paleocene-Eocene)

This formation is composed of andesite flows, breccia, sandstone, shale, and conglomerates. These beds were formerly designated as the Denver Formation due to paleontologic and lithologic similarities to that formation in the Denver Basin. Fossil plants recovered from the South Park Formation (see Fischer, 1979, Table A) are typical of those from the Denver Formation. However, evidence from DeVoto (1964) indicates that deposition of the South Park Formation was earlier

(Paleocene or Eocene) than, and not contiguous with, the Denver Formation in the Denver Basin. He concluded that the formation should be renamed.

The South Park Formation is considered Class 2.

Cretaceous Formations

All of the Cretaceous Formations in South Park have produced fossils; most are common invertebrates and plants. None have fossils significant enough for a higher classification and are all considered as Class 2.

Morrison and Garo Formations (Jurassic)

The outcrops of the Morrison and Garo Formations are very limited in South Park. The Morrison in South Park has produced some fresh-water gastropods and scraps of fossil vertebrates. Elsewhere the Morrison is well known for its prodigious fauna of dinosaurs. Based on the fossils presently known the Morrison here is designated Class 2.

The Garo, to date, has been unfossiliferous and has a limited extent of outcrops.

The Garo and Morrison Formations were not separated on the Land Status Maps due to the few mineral estates affected.

Maroon Formation (Permian)

The red beds of the Maroon Formation are known to contain a common suite of invertebrates composed predominantly of marine brachiopods. The "Nelson Ranch" locality, approximately four miles southeast of Fairplay, Colorado, is highly unique and significant.

Scudder (1890) described 21 species of Permian insects, and White (1912) reported 25 species of plants from this area. Although the exact locality and horizon are not known, this site is probably on federal mineral estates. The mineral estates of the Maroon Formation adjacent to the "Nelson Ranch" are Class 1 due to the occurrence of rare and significant fossil specimens. The remainder of the Maroon Formation in South Park is designated Class 2 as it has produced only commonly known invertebrate fossils.

Mintern and Belden Formations (Pennsylvanian)

The Mintern and Belden Formations, termed the Weber Formation by Fischer (1979), both contain numerous and well studied fossil invertebrates. These formations are designated as Class 2 in this report.

Mississippian-Cambrian Formations

No mineral estates are present on these outcrops in the South Park region.

Land Status Maps for South Park

NW-23
NW-24
NW-29
NW-30
SW-5
SW-6

Table 1. Additional Localities for South Park.

Locality	Reference	Formation(s) Age	Depository	Fossils
SW¼, sec. 33, T.12S, R.76W	Stark, 1956	?Antero Oligocene		Tooth frag., uintathere or titanothere
Sec. 32, T.14S, R.75W	UCM 82044	Wagontongue U. Miocene or Pliocene	U.C.M.**	Equid jaw, Merychippus, Hypolagus
SE¼, W½, sec. 31, T.14S., R.75W	UCM 77025	Wagontongue U. Miocene or Pliocene	U.C.M.	Camel
NE¼, SE¼, sec. 7, T.14S, R.75W*	USGS	Antero Oligocene	U.S.G.S.	Rhinocerotid & brontothere tooth frags.
NW¼, SW¼, SE¼, sec. 31, T.14S., R75W	USGS	Wagontongue Miocene	U.S.G.S.	Camelid skull frags., cervid, heteromyid skull & mandible
SE¼, SW¼, sec. 14, T.13S., R.76W	USGS	?Antero, ?Wagontongue	U.S.G.S.	Stenomyline camel
SW¼, SE¼, sec. 31, T.14S., R.75W	USGS	Wagontongue U. Miocene	U.S.G.S.	Merychippus cf. paniensis

*Localities on Mineral Estates

**See listing of abbreviations used at the end of the tables

Table 1 continued.

NW¼, SW¼, sec. 8, T.14S., R.75W* and NE¼, SE¼, sec. 7, T.14S., R.75W	USGS	Antero Tallahassee Creek Member	U.S.G.S.	Brontotherid, *Mesohippus*, *Trigonias*, *Agriochoerus* cf. *maximus*
Sec. 33, T.9S., R.76W	USGS	Quaternary Pleistocene	U.S.G.S.	*Mammuthus* cf. *columbi*

Table 2. Localities from Fischer (1979) on Mineral Estates in South Park.

Locality	Reference	Formation(s) Age	Depository	Fossils
Secs. 10 & 22, T.11S., R.78W	Johnson, 1940	Weber Pennsylvanian	C.S.M. U.S.N.M.	New species, algae, stromatolites
SE corner, sec. 25, T.12S., R.76W	Stark, 1949	Maroon Permian		Marine inverts.
"Nelson Ranch, 4 miles SE of Fairplay"	Scudder, 1890, White, 1912	Maroon Permian	U.S.N.M.	Insects, plants
Sec. 11, T.12S., R.74W	Stark et al., 1949	Greenhorn, Carlile, & Benton Cretaceous		Marine inverts.
Sec. 7, T.11S., R.74W	Durden, 1966	Antero Oligocene		Fossil insects

FLORISSANT

Florissant Formation (Oligocene)

The Florissant Formation consists of lava flows, tuffs, gravels, agglomerates, and laminated lacustrine shales. The shales contribute less than one third of the total 150 feet of thickness of this formation. Lithologically and paleontologically the Florissant Formation is similar and, in part, equivalent to the Antero Formation. The lithologic similarities of these formations are due to a degree to the common volcanic source of their sediments.

Prior to 1935 this formation was thought to be of Miocene age. Gazin (1935) identified a fossil mammal from Florissant as the didelphid marsupial Peratherium hunti. This primitive opossum ranged from Lower to Middle Oligocene. Additional fossil mammals found included Mesohippus and fragments of an oreodont, both of which confirm an Oligocene age for Florissant sediments.

Although fossil mammals are rare, over 1,100 species of insects, 140 species of plants, several fish, and spectacular petrified trees have made this one of the most unique fossil localities in the world.

Five of the six known collecting sites are presently within the boundaries of the Florissant National Park which is administered by the U.S. Park Service. The Denver Museum of Natural History has worked a locality in the NE¼ NW¼ sec. 3, T.13S., R.71W. This locality alone has produced a total of 283 plants and over 700 insects.

A systematic list of the flora is summarized by MacGinitie (1953, pp. 15-19). The literature on the insects is extensive but

the majority of the descriptions can be found in Carpenter, Cockerell, Scudder, and Wickham.

The few mineral estates in the vicinity and within the limits of the Florissant Formation are designated Class 1, and shown in brown on Land Status Maps SW-6 and NW-30.

LEADVILLE AND VICINITY

There are no existing mineral estates on fossil bearing formations in this region. A Class 3 designation is given to this area.

Stratigraphic Section for Wellsville, Howard, Cotopaxi Inlier, Gribbles Park, and Salida

Period	Formation	Class	Color
Tertiary	Dry Union	1	Red
Permian-Pennsylvanian	Sangre de Cristo	1	Dark blue
	Minturn	2	Green
	Belden	2	Green
Mississippian	Leadville	2	Green
Devonian	Chaffee Group		
	Dyer dolomite	1	Purple
	Parting quartzite	1	Purple
Ordovician	Fremont	2	Green
	Harding sandstone	2	Green
	Manitou	2	Green
PreCambrian		3	Black

WELLSVILLE, HOWARD, AND VICINITY

Dry Union Formation (Miocene-Pliocene)

The Dry Union Formation outcrops from near Wellsville and runs north to Buena Vista. It is composed of fluvial sands, silts, clays, and conglomerates. Vertebrate fossils from Upper Miocene to Pliocene age have been collected (Table 3). Although vertebrate fossils are scarce and fragmented, the Dry Union Formation is given a Class 1 rating.

Sangre de Cristo Formation (Pennsylvanian-Permian)

The Sangre de Cristo Formation within the study area is considered Class 1 based on the vertebrate fauna described by Vaughn (1969, 1972). A comprehensive list is given in Fischer (1979, Table 16). There is one mineral estate located approximately 2 miles east of Howard and north of Highway 50.

Parting Formation - Chaffee Group (Devonian)

The Parting Formation is designated Class 1 based on two significant localities containing disarticulated remains of Devonian fish. Of the two localities only the Gribbles Park area has mineral estates which would be affected. The specimens are from along Gribbles Creek, T.51N., R.11E. in Fremont County, Colorado. A complete list is given in Fischer (1979, Table 13). Adjacent mineral estates within the Parting Formation are designated as Class 1 and are shown in purple.

In summary, of the three Class 1 formations the majority of the mineral estates are within the Dry Union Formation. Although the vertebrate fossils from this formation are relatively scarce and

of a fragmentary nature, they are significant from a stratigraphic standpoint in that they refine the Miocene-Pliocene boundary within the formation. Any subsurface activity on these estates should be monitored.

Regarding the remaining two formations, the Sangre de Cristo and the Chaffee Group, few mineral estates are within or adjacent to these areas, and the impact of mining or quarry activities would be reduced. The remaining fossil bearing formations in this region contain less significant fossils and are designated Class 2.

Land Status Maps for Wellsville and Adjacent Areas

SW-5
SW-6
SW-12

Table 3. Additional Localities for Wellsville and Adjacent Areas.

Locality	Reference	Formation(s) Age	Depository	Fossils
CW¼, SE¼, NW¼, sec. 35, T.50N., R.8E	USGS	Dry Union L. Pliocene	U.S.G.S.	?Pliohippus tibia, ?Megatylopus postcrania
NE¼, SW¼, sec. 7, T.49N, R.9E	USGS	Dry Union L. Pliocene	U.S.G.S.	Neohipparion sp. teeth
		Pliocene	U.S.G.S.	Hipparion cf. occidentale
		?Pliocene		Hypolagus, equid molar
		Miocene		Merychippus teeth
NW¼, NW¼, sec. 16, T.49N., R.8E	USGS	Dry Union U. Miocene		Camelid
NE¼, SE¼, sec. 12, T.49N., R.9E	USGS	Dry Union Pliocene	U.S.G.S.	Neohipparion teeth, camelid, ?Plioceros sp.
SW¼, NW¼, sec. 7, T.49N., R.9E	USGS	Dry Union Pliocene	U.S.G.S.	Neohipparion sp., Teleoceras sp., Prosthenops cf. serus, ?Aphelops, Hipparion sp.

Table 3 continued.

Center W edge, SW¼, NE¼, sec. 35, T.50N., R.8E	USGS	Dry Union L. Pliocene	U.S.G.S.	Mylagaulus hatcheri, Mylagaulus sp. Teleoceras?, Neohipparion, Megatylopus
SE corner, SW¼, NE¼, sec. 35, T.50N., R.8E	USGS	Dry Union L. Pliocene	U.S.G.S.	Megatylopus?, rodent
NW¼, NW¼, sec. 34, T.50N., R.8E	USGS	Dry Union U. Pliocene	U.S.G.S.	Plioceros sp., Mylagaulus sp.
Sec. 16, T.49N., R.9E.	USGS	Dry Union U. Miocene	U.S.G.S.	Merychippus, Merychyus

Stratigraphic Section for Canon City

Period	Formation	Class	Color
Tertiary			
Paleocene	Poison Canyon	2	Green
	Raton	2	Green
U. Cretaceous	Raton	2	Green
	Vermejo	2	Green
	Trinidad sandstone	2	Green
	Laramie	2	Green
	Fox Hills	2	Green
	Pierre shale	2	Green
	Niobrara	2	Green
	Carlile shale	2	Green
	Greenhorn limestone	2	Green
	Graneros shale	2	Green
L. Cretaceous	Dakota sandstone	2	Green
	Purgatoire	2	Green
Jurassic	Morrison	1	Orange
	Ralston Creek	2	Green
	Entrada sandstone	2	Green
Permian	Lykins	2	Green
	Lyons sandstone	2	Green
Permian-Pennsylvanian	Fountain	2	Green
Ordovician	Freemont limestone	1	Purple
	Harding sandstone	1	Purple
	Manitou limestone	2	Green
Cambrian	Peerless dolomite	3	Black
	Sawatch sandstone	3	Black
PreCambrian		3	Black

CANON CITY EMBAYMENT, GARDEN PARK, AND PARKDALE INLIER

Quaternary Formations

Alluvial terraces are present along the Arkansas River and Oil Creek near Canon City. They range in age from Middle Pleistocene, or Nebraskan Glaciation, to Late Holocene. No mineral estates are present in this area. However, for future planning it should be added that the terraces contain occasional vertebrate remains.

Dr. G. E. Lewis (1970) reported Bison latifrons from a gravel pit along Oil Creek in the SW¼, NE¼, sec. 26, T.18S., R.70W. Bison latifrons was large in size and had extremely long horn cores. It was common and widespread during the Sangamonian and survived until about 100,000 years before the present.

A significant Pleistocene vertebrate fossil was also found in an abandoned gravel pit in the SW¼, sec. 4, T.19S., R.70W. The deciduous premolar of an early proboscidian has been identified by Madden and Lindsey (in press) as Stegomastodon cf. mirificus. This species was extant during the Middle Pleistocene, either the Afton or the Yarmouth Interglacial, 1,400,000 - 700,000 years before the present. The specimen is in the vertebrate paleontology collection of the Denver Museum of Natural History.

Poison Canyon and Raton Formations (Upper Cretaceous-Paleocene)

The Poison Canyon Formation is a medium-grained sandstone with a basal conglomerate of Precambrian clasts. Total thickness of the formation is 500 - 1,000 feet. The Raton is a cliff-forming sandstone with thin lignite banding. It is 500 feet thick. No recorded fossil

localities were found in the literature. However, given the nature of the sediments, some pollen and plant material is probably present. No mineral estates are present in these formations.

Cretaceous Formations

All these formations are fossiliferous in the Canon City region and designated as Class 2.

Morrison Formation (Jurassic)

The Morrison Formation in Garden Park north of Canon City is well known for it unique and abundant dinosaur remains. A complete list of species was given by Fischer (1979, Table 17). It should also be noted that the first Jurassic mammals found in Colorado were collected from Marsh Quarry 1, and are from two distinct orders of early mammals:

Order Pantotheria

Keptolestes coloradensis

Order Docodonta

Docodon sp. (Simpson, 1929, p. 146)

These finds are of greater importance from a research standpoint than the predominant dinosaur remains; there is much yet to be learned about the earliest mammal ancestors.

The Denver Museum of Natural History is currently excavating a Camarasaurus in the Garden Park area. In addition to this dinosaur, vertebrae and limb bones of a small theropod, and a small reptilian jaw belonging to the primitive Order Rhynchocephalia have been collected. Sphenodon, an extant Rhynchocephalian, is found in New Zealand.

The Morrison Formation in this vicinity also contains a diverse fauna of fresh-water molluscs (Yen, 1952). The dinosaurs, mammals, and other fossils from the Garden Park area result in a Class 1 designation for the Morrison Formation.

Pennsylvanian-Permian Formations

The Pennsylvanian and Permian series within the study area has not produced documented fossils. The same, and equivalent formations elsewhere, have produced plants and common marine invertebrates. The probability of recovering fossils is low but not impossible. Any fossils found may be significant, therefore, these formations are, for the present, considered Class 2.

Harding Sandstone (Ordovician)

Of particular interest in the Canon City vicinity is the Middle Ordovician Harding Sandstone Formation. The small polygonal armor plates of the earliest known vertebrates, the Ostracoderms, are found in abundance in this vicinity. The type locality, as described by Walcott (1892) is a few miles west of Canon City. The locality known as the Indian Springs Ranch, northeast of the city, has produced the most complete Ostracoderm fish yet discovered. The Harding also has received acclaim for its conodonts, arthropod trackways, and other invertebrates. Three of the localities containing conodonts (Sweet, 1955) are on mineral estates (Table 4). The Harding Formation is designated as Class 1 based on its fossils and the historical interest in the sediments.

Fremont Formation (Ordovician)

The Fremont Formation, which overlies the Harding and is generally exposed in the same areas, contains abundant marine invertebrates

dominated by ammonites. It is considered in this report, and in that of Fischer (1979), to be Class 1 as a result of the lack of study given to its fauna. It should be noted, however, that the Fremont is not as important as the Morrison and Harding Formations in the Canon City vicinity. It could as well be Class 2 providing any fossils discovered were protected for future study.

Manitou Limestone (Ordovician)

The Manitou Limestone has a limited outcrop, and few fossils have been recovered in this vicinity. Elsewhere it contains a well documented fauna of marine invertebrates. It has been designated as Class 2.

In summary, the entire study area contains a wide spectrum of geologic formations which span the large section of geologic time from the Ordovician to the Tertiary. The outcrops are confined primarily to the flanks of uplifts, anticlines, and faults, and within the major basins adjacent to the mountains. In many areas the outcrops are obscured by soil and vegetation.

In addition to the more critical Class 1 formations, almost all of the remaining sediments contain or could be expected to contain some fossils. Although most of these Class 2 formations have fossil faunas and floras that have been adequately studied and documented, any major quarry operation or other such land disturbance could expose new collecting areas. There is a high potential for these activities to result in new additions to the fauna and flora of certain formations, or increase the number of individuals of a given genera and/or species.

Increased numbers of individuals can provide material for population studies or excellent exhibit specimens. Although the common fossils are well known to the scientific community, they may be of value as study specimens for schools and colleges, or the localities can be designated as public collecting areas.

Keeping this in mind and considering the large number of fossil bearing formations within the study area, it is recommended that any large scale mining activities or other distrubances in these Class 2 formations be periodically monitored by qualified personnel for fossil content.

Land Status Maps for Canon City and Vicinity

SE-1
SE-6
SW-6
SW-12
NE-21

Table 4. Additional Localities for Canon City.

Locality	Reference	Formation(s) Age	Depository	Fossils
Sec. 26, T.17S., R.70W	DMNH 462 & 759	Morrison Jurassic	D.M.N.H.	Diplodocus sp. partial skeleton
"Garden Park" T.17S., R.70W	DMNH 1483	Morrison Jurassic	D.M.N.H.	Stegosaurus stenops complete skeleton
SW¼, SW¼, sec. 20. T.17S., R.71W	USGS	Morrison Jurassic	D.M.N.H.	Allosaurus sp.
"Chandler Coal Mine"	DMNH 1497 & 1186	Vermejo Cretaceous	D.M.N.H.	Dinosaur tracks

Table 5. Localities from Fischer (1979) on Mineral Estates for Canon City.

Locality	Reference	Formation(s) Age	Depository	Fossils
Sec. 13, T.18S., R.71W	Sweet, 1955	Harding Ordovician	I.S.U.	Conodonts
Sec. 10, T.16S., R.67W	Sweet, 1955	Harding Ordovician	I.S.U.	Conodonts
SE¼, sec. 33, T.17S., R.69W	Frederickson, & Pollard, 1952	Harding Ordovician	U.O.G.M.	Toernquista sp.

Abbreviations Used in Tables

1.	C.S.M.	Colorado School of Mines
2.	D.M.N.H.	Denver Museum of Natural History
3.	I.S.U.	Iowa State University
4.	U.C.M.	University of Colorado Museum
5.	U.O.G.M.	University of Oklahoma Geological Museum
6.	U.S.G.S.	United States Geological Survey
7.	U.S.N.M.	United States National Museum

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