GEOLOGIC MAP AND COAL RESOURCES OF THE DEADMAN CANYON QUADRANGLE, CARBON COUNTY, UTAH

By Mark A. Nethercott

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INTRODUCTION

The Deadman Canyon quadrangle is situated in the Book Cliffs Coal field, approximately 16 km (10 miles) northeast of Price, Utah and is defined by the geographic coordinates 39° 37' 30" - 39° 45' latitude and 110° 45' - 110° 52' 30" longitude. The quadrangle encompasses the low, relatively flat forelands south of the Book Cliffs and extends northward across the cliffs into the Emma and Whitmore Park regions.

STRATIGRAPHY

GENERAL

Exposed strata in the Deadman Canyon quadrangle are composed primarily of clastic rocks which range in age from Late Cretaceous to Early Tertiary (plate 1). The oldest exposed formation is the Mancos Shale, which is overlain by the upper Cretaceous Mesaverde Group. Only a partial section of Mancos Shale is found in the area. The Star Point Sandstone, the Blackhawk Formation, and the Price River Formation constitute the Mesaverde Group. Overlying this Group is the North Horn Formation, a time-transgressive unit which straddles the Late Cretaceous and Early Tertiary boundary. The younger Flagstaff Limestone is dated as Paleocene-Eocene age and is the youngest Tertiary formation preserved in the area. Quaternary deposits consist of stream alluvium, slope wash, colluvium, and pediment gravels.

The maximum thickness of the total stratigraphic section in the quadrangle is approximately 1,760 m (5,774 ft). The units from the top of the Mancos Shale to the top of the Flagstaff Limestone thin from west to east across the study area, the most dramatic thinning occurring within the Blackhawk Formation.

CRETACEOUS SYSTEM

Mancos Shale. The total thickness of the Mancos Shale in the Book Cliffs area of Carbon County ranges from 1,432 to 1,539 m (4,698 to 5,049 ft) (Clark, 1928). The exposed thickness of the Mancos Shale, which was measured at Coal Creek, totals nearly 750 m (2,461 ft). The shale, which intertongues with the Star Point Sandstone and the lower Blackhawk Formation, thins toward the west as the sandstone tongues thin toward the east. The lower contacts of the sandstone tongues are gradational, whereas the upper contacts are abrupt. The intertonguing of these two units results in a stratigraphic rise of the upper boundary of the Mancos Shale from west to east, and makes the boundary progressively younger toward the east (Young, 1955, p. 182). Rock units near the boundary between the Mancos and the Blackhawk Formations are assigned an early Campanian age in the western Book Cliffs region (Young, 1955, p. 183).

Calcareous shale, silty shale, siltstone, sandstone and minor lentils of limestone (Young, 1955, p. 182) are dominant rocks in the Mancos. Fresh colors range from medium gray to bluish gray, whereas weathered slopes exhibit blue or brownish gray colors. Localized lentils of siltstone and sandstone, from a few millimeters to several centimeters thick, occur throughout the section. Sandstone beds are commonly bioturbated and fossiliferous (Nethercott, 1983), while resistant sandstone beds form minor cuestas or cap knolls of shale.

The Mancos Shale is believed to have been deposited in a shallow marine environment (Howard, 1966a; Maxfield, 1976). Young (1955), stated that sediments of the Mancos Shale accumulated in a marine environment past the mud-sand transition line, however, most of the mud was probably deposited near shore. The lithology and trace fossils of the study area support these conclusions.

Star Point Sandstone. The Star Point Sandstone occurs in the northern Wasatch Plateau and the western Book Cliffs of central Utah. This formation interfingers with the Mancos Shale and pinches to a feather edge northeast of Wellington, Utah. Two units are involved (Young, 1955, p. 182): the Storrs tongue which pinches out approximately 2 km (1.2 miles) east of Kenilworth, Utah (3.2 km - 2 miles west of the study area); the younger Panther Sandstone which is more persistent and therefore mappable in the

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Deadman Canyon area. The Panther thins across the quadrangle, but does not pinch out until it reaches Fish Creek, several kilometers east of Soldier Creek (Anderson, 1978, p. 17). The maximum thickness of the Panther tongue is 40 m (131 ft) in the Wasatch Plateau, and it ranges in thickness from 5.5 to 24 m (18 to 79 ft) in the Deadman Canyon area.

The Panther tongue can be subdivided into two lithologic units, a basal interbedded siltstone and sandstone and an upper sandstone. Sandstones of the basal unit contain primary dolomite (Sabins, 1962) and are very fine grained with a clay and silt matrix that is rich in organic material (Howard, 1966b, p. 27). The sandstone coarsens upward and becomes finer grained to the east with increasing bed thickness as the units become younger. The fresh color of these sandstones ranges from medium gray to gray brown, weathered surfaces are medium grayish orange. Siltstones weather medium gray and are often heavily bioturbated, which gives the rocks a mottled appearance. Rocks of the lower lithologic unit are thin bedded, ripple marked, and commonly exhibit hummocky bedding.

The upper sandstone lithology consists predominantly of fine-grained sandstone also mottled by bioturbation. Grains are 90% quartz with minor amounts of limonite and disseminated organic material. These units are medium to thick-bedded with horizontal to subhorizontal stratification. At Coal Creek and farther east, calcareous sandstone concretions can be found within the member (Nethercott, 1983).

Body fossils are not common in the Panther tongue. One bivalve (tentatively Inoceramus) was found in the lower 1 m (3.3 ft) of the tongue at Alkali Creek. Trace fossils are abundant, however, and most of the identifiable burrows are located in the upper unit (Howard, 1966c). Fossils collected by Clark and Spieker have been used to date the Star Point as medial Montanan (Campanian) (Young, 1955, p. 182).

The Panther Sandstone in the Deadman Canyon quadrangle represents a transition zone and lower shoreface environment offshore from a delta. The basal interbedded siltstone and sandstone were deposited in the transition zone between the offshore mudstone environment of the Mancos Shale and the lowermost lower shoreface environment of the delta front sheet sands. Rocks of the upper sandstone were deposited in a lower shoreface environment; this is supported by the fact that as the tongue is mapped eastward, away from the Panther delta, the grain size of the Panther Sandstone decreases. The sole marks and hummocky beds within the Panther sandstone suggest that these sediments were deposited offshore by turbidites and/or storm conditions (Nethercott, 1983).

Blackhawk Formation

The Blackhawk Formation is subdivided into the Spring Canyon, Aberdeen, Kenilworth, unnamed lower mudstone, Sunnyside, and unnamed upper mudstone members in the Sunnyside area (Young, 1955; Maberry, 1971). The Aberdeen, Kenilworth, and Sunnyside Members consist mainly of cliff-forming sandstones. The lower and upper mudstone Members are slope forming and contain mudstone, siltstone, sandstone, and the major coal-producing zones.

Maximum thickness of the Blackhawk Formation is approximately 400 m (1,312 ft) near Castlegate, Utah, thinning to 327 m (1,073 ft) at Coal Creek Canyon within the Deadman Canyon quadrangle. Spieker and Reeside (1925, p. 444) dated the formation as medial Montanan (Campanian) based on plant fossils identified by F. H. Knowlton. As with the Star Point Sandstone, the lower Blackhawk Formation is a series of sandstone tongues that interfinger with the Mancos Shale (plate 1).

The contact between the Blackhawk Formation and the Castlegate Sandstone is an angular unconformity in the Wasatch Plateau (Clark, 1928; Spieker, 1931; and Young, 1955). The upper contact becomes disconformable west of the Wasatch Plateau, but this same contact becomes conformable with increasing distance in an easterly direction (Van de Graff, 1969, Osterwald, Maberry, Dunrud, 1981). Generally, the precise Blackhawk-Castlegate contact is not widely exposed due to burial of the slope-forming upper Blackhawk beds by Castlegate debris. The contact, where identified, appears to be conformable in the Deadman Canyon quadrangle. However, an abrupt increase in grain size from the Blackhawk Formation to the Castlegate Sandstone may suggest an unconformity.

Prograding deltas and/or barrier island complexes are considered to represent the environments of deposition of the major cliff-forming sandstone members, whereas terrestrial and transitional environments are represented in the mudstone members (Anderson, 1978; Balsley, 1982). A general strandline orientation of northeast to southwest was calculated by Balsley (1982, p. 61). The Blackhawk Formation represents the final retreat of the Mancos sea from central Utah.

Spring Canyon Member. This member consists of basal sandstone tongues with overlying coal-bearing rocks in the western Book Cliffs (Young, 1955, p. 184), but in the Deadman Canyon area the member is composed of four sandstone tongues separated by tongues of Mancos Shale. All four sandstone units thin from west to east while the Mancos Shale interbeds thin from east to west. The Mancos contacts are gradational at the base of the sandstone tongues and sharp at their tops. Young (1955, p. 184) stated that the upper contact of the Spring Canyon Member is slightly disconformable. The second and fourth sandstone tongues were mapped across the quadrangle, but the first and third tongues lose their identity in the Mancos Shale within the quadrangle (plate 1). The Spring Canyon Sandstones, like the Panther Sandstone, represent distal margins of wave-dominated shore and near-shore deposits (Nethercott, 1983).

The member is predominantly a cliff-forming, fine-grained sandstone that grades laterally to a slope-forming sandy siltstone unit. Local maximum thickness of the

Spring Canyon Member is 46 m (151 ft) near Deadman Canyon and the minimum thickness is 40 m (131 ft) near Soldier Creek. The thickest sandstone tongue is 15 m (49 ft) thick and the thinnest has a maximum thickness of 8 m (26 ft).

Aberdeen Member. The Aberdeen Member consists of one or more sandstone tongues which are often separated by tongues of Mancos-like siltstone and shale. According to Young (1955, p. 184) the Aberdeen Member, from Kenilworth to Coal Creek Canyon, is composed of five littoral sandstone bars. Each tongue eventually grades laterally into Mancos Shale. Six major Aberdeen sandstone bars are found in the Deadman Canyon quadrangle. Thicknesses of the Aberdeen Member range from 45 m (148 ft) at Deadman Canyon to nearly 75 m (246 ft) at Alkali Creek. Individual sandstones reach a maximum thickness of 30 m (98.4 ft) and average about 18 m (59 ft).

The Aberdeen Member is underlain conformably by a tongue of Mancos Shale. The contact was mapped where interbedded siltstone and sandstone became abundant in the lowermost tongue, the base of the lowest sandstone cliff. The upper contact of the Aberdeen Member is sharp and was placed at the top of the uppermost sandstone.

Strata of the Aberdeen Member exhibit upper shoreface, foreshore, distributary channel, and distributary sheet sand environments, in addition to the offshore, transition, and lower shoreface environments (Nethercott, 1983). In general, the Aberdeen Member displays a major regression of the Mancos Sea during Late Cretaceous time.

Kenilworth Member. Maberry (1971, p. 23) defined the Kenilworth Member as consisting of a basal siltstone or shale grading upward into a massive cliff-forming sandstone. The Kenilworth Member is mappable from Helper, Utah eastward to the Beckwith Plateau (Maberry, 1971, p. 23). The maximum thickness of the Kenilworth Member is 44 m (144 ft) at Deadman Canyon. It then thins eastward from Deadman Canyon to Coal Creek but thickens again to the east where it is 42 m (138 ft) thick at the edge of the quadrangle.

Lower contacts of the Kenilworth Member are placed at the top of the uppermost Aberdeen sandstone. This is usually marked by a break from a slope to a near-vertical cliff. The upper contact is mapped at the top of the Kenilworth sandstone.

The Kenilworth Member is composed of a basal slope-forming unit and an overlying thick, cliff-forming sandstone. The lower slope portion changes laterally from siltstone, mudstone, sandstone, and coal at Deadman Canyon to predominantly siltstone east of Coal Creek. Coals include the Castlegate "A" and "B" seams.

Five general depositional environments are represented in the Kenilworth Member in Deadman Canyon. They are prodelta, delta front and beach sands, delta margin paralic swamps, delta plains and lower coastal flood plain (Nethercott, 1983). The prodelta rocks usually form a slope at the base of the massive Kenilworth cliff. The transition, lower and upper shoreface, and foreshore or beach environments are displayed in the massive Kenilworth cliff that is exposed continuously across the quadrangle. Delta margin paralic swamps are represented chiefly by fine-grained fossiliferous, brackish water deposits, and the Castlegate "A" and "B" coals were deposited in the delta plain environment (Balsley, 1982, p. 183). The coastal plain environments in the study area are characterized by lenticular and tabular channel fill sandstones, carbonaceous siltstones, mudstones, and coals.

Lower Mudstone Member. This member has been mapped as the slope interval between the massive Kenilworth Sandstone and the overlying cliff-forming Sunnyside Member (Maberry, 1971, p. 23). The upper contacts are gradational and mapped near the base of the Sunnyside sandstone cliff.

The lower mudstone member consists of mudstone, shale, siltstone, sandstone, and coal. Basal parts of the member contain mostly fine-grained, carbonaceous clastic sediments, mudstone and siltstone that weather medium gray-brown to medium dark gray. This member is often clinkered or oxidized due to burning of the underlying coal seams - the Kenilworth, Gilson, Fish Creek, and Rock Canyon coal zones in ascending order.

Plant fossils, such as Araucaria and Sequoia, occur in some of the sandstones. Dinosaur tracks and logs of trees are found in the sandstone immediately overlying the Gilson seam in the Pinnacle Mine, Deadman Canyon.

Paralic swamp, delta plain, and coastal plain environments are represented in the lower mudstone member of the Blackhawk Formation. Coal of the delta plains environment (Kenilworth coal zone) is generally overlain by shale and mudstone of a paralic swamp environment (Nethercott, 1983).

Sunnyside Member. The Sunnyside Member consists of basal interbedded siltstone and sandstone grading upward to a massive sandstone cliff (Maberry, 1971, p. 27). The upper contact was mapped at the top of the massive Sunnyside sandstones.

Anderson (1978, p. 111) concluded that the Sunnyside Member contains two stacked regressive littoral sandstone tongues in the Pine Canyon quadrangle. The Sunnyside Member reaches its maximum thickness of 19 m (62 ft) in the study area near Deadman Canyon and thins eastward to 17 m (56 ft) near Soldier Creek. Both sandstone tongues illustrate transition, shoreface, and foreshore environments. A thin layer of rocks representing deposition in a restricted marine environment generally occurs between the two regressive sandstones. The Sunnyside Member records the deposition of a prograding delta followed by a local minor transgression and a subsequent progradation of another delta sequence.

Upper Mudstone Member. The coal-bearing rocks above the Sunnyside sandstone constitute the upper mudstone Member (Maberry, 1971, p. 27). The upper contact with the Castlegate Sandstone is possibly unconformable. This upper contact was mapped at the base of the Castlegate cliffs or where coarse-grained, light gray sandstone became dominant in the section. Thickness of the upper mudstone member in the quadrangle ranges from 53 m (174 ft) near

Coal Creek to 80 m (262 ft) at Alkali Creek.

Rocks of the upper mudstone member were deposited almost exclusively in a coastal plain environment, but minor paralic swamp and delta plain deposits are also represented in this member; coal (lower Sunnyside) within this member was probably deposited in a delta plain environment. Rocks of the paralic environment are found above the second Sunnyside littoral sandstone west of Soldier Creek.

Castlegate Sandstone Formation

Where it is exposed, the formation generally forms a cliff above the Blackhawk Formation. The contact with the overlying Price River Formation is conformable and has been placed below the slope-forming interbedded siltstone and sandstone of the lower Price River Member. The Castlegate Sandstone is 123 m (403 ft) thick at the type section in Price River Canyon, and thickens to the northwest where it reaches a maximum thickness of 185 m (607 ft) near Benion Creek (Van de Graff, 1972, p. 569). It is 77 m (253 ft) thick in Deadman Canyon with no marked thickening of the formation within the quadrangle. Spieker and Reeside (1925, p. 446) dated the Castlegate in the Wasatch Plateau as late Montanan.

The predominant lithology is sandstone with minor amounts of interbedded shale and siltstone. Sandstones are medium to coarse grained and composed mostly of quartz with varying amounts of clay minerals, chert, and other lithic fragments. The most common types of cement are silica, calcium carbonate, and some minor iron oxide. Lenticular bedding, trough cross beds, and current ripple marks are visible in the Castlegate Sandstone throughout most of the area.

The Castlegate Sandstone was deposited in a fluvial environment (Van de Graff, 1972). Most of the beds appear as braided stream deposits in the Wasatch Plateau and the western Book Cliffs outcrops. From Deadman Canyon eastward, the sandstone grades from a fluvial sandstone facies to a littoral facies near Green River and Thompson, Utah (Grant Willis, personal communication, 1983).

Price River Formation

In the Deadman Canyon area the Price River Formation has been subdivided into the lower and the upper unnamed members. The lower member is slope forming, and the upper member is composed of two to three main ledges that locally form a single massive cliff. The top of the Price River beds has been mapped at the level of greatest lithologic change between the thicker sandstones of the Price River Member and the variegated mudstone beds of the North Horn Formation (Spieker, 1946). The member is 200 m (656 ft) thick at the type section in Price River Canyon and thins to 125 m (410 ft) in Coal Creek Canyon in the central part of the quadrangle.

Abbott and Liscomb (1956, p. 122) and Cobban and Reeside (1952) have assigned a Campanian to Maastrichtian age to the Price River Member. Spieker (1946) stated that the rocks probably change from late Montanan to early Lancean somewhere in the upper Price River Member.

The Price River Formation represents deposits of fluvial environments in the Deadman Canyon area. Mudstones and other fine grained clastic rocks were deposited on floodplains as overbank deposits during flood stages. Thick sandstones of the member represent a general braided stream environment, although lenticular sandstones associated with the fine grained rocks are probably channel fills of meandering streams on the flood plain.

Lower Price River Member. This member is predominantly mudstone, siltstone, and shale, with interbedded sandstone and minor lenses of coal. Most units are medium gray to medium brownish gray. The sandstones are fine to coarse grained and consist mostly of quartz with varying amounts of feldspar, chert and other lithic fragments. Thicknesses of the member range from 42 m (138 ft) at Deadman Canyon to 50 m (164 ft) at Clearwater Creek.

Upper Price River Member. The upper member consists of sandstone with very minor amounts of shale, coarse to medium grains, and an apparent upward fining trend. Colors range from medium gray brown to medium light gray. Sandstones are medium to thick bedded, and contain lenticular shale beds, cross stratification, and ripple marks. The member is 77 m (253 ft) thick in Coal Creek Canyon.

CRETACEOUS-TERTIARY SYSTEMS

North Horn Formation

The North Horn Formation within the quadrangle ranges from 309 m (1,014 ft) thick at Deadman Canyon to 337 m (1,105 ft) thick west of Soldier Creek Canyon. The formation weathers to a slope which is interrupted by ledges of channel-fill sandstones and limestone. Predominant units are mudstone and shale, with interbedded thin marlstone, limestone, and sandstone. For the purpose of this study, the formation has been divided into two informal members; the lower member which has more interbedded sandstone, coarser grains, and less calcite content, and the upper member which has minor interbedded limestone.

Fossils collected from the formation indicate that it includes Cretaceous and Tertiary rocks (Spieker, 1946, p. 134). The boundary between the two systems is difficult to define, therefore, it is generally agreed that the lower part of the formation is Late Cretaceous and the upper part is Early Paleocene (Nethercott, 1983).

The contact between the North Horn Formation and the overlying Flagstaff Formation is gradational. The contact has been placed immediately below the fossiliferous, relatively clean, blue gray limestones of the Flagstaff Formation.

Lower Member. These strata consist of gray shale and mudstone interbedded with thin beds of grayish orange, medium grained to locally conglomeratic, sandstone. The minor sandstones in this argillaceous member contain quartz, lithic fragments, limonite, and weathered feldspar, and appear to be subarkosic. The major sandstones are medium grained on the average, but range from fine-grained to conglomeratic rocks that contain fine pebble-sized clasts. The upper half of the lower member usually forms a steep slope or cliff below the slope-forming upper member. Maximum thickness of this member is 149 m (489 ft) near Deadman Canyon, and the member thins eastward to 133 m (436 ft) near Soldier Creek.

The lower member was deposited in flood plain environments (Osterwald, Maberry, and Dunrud, 1981, p. 23). Fine-grained rocks were probably deposited as overbank sediments, and the lenticular sandstone beds represent channel fill deposits, probably of meandering streams.

Upper Member. The upper member forms a gentle to moderate slope between the sandstones of the lower unit and the resistant cuesta-capping limestones of the Flagstaff Formation. The maximum thickness of the member is 198 m (649 ft) at Clearwater Creek, and the minimum thickness is 158 m (518 ft) west of Soldier Creek Canyon. This member consists of interbedded mudstone and shale, with minor sandstone and limestone. Mudstone and shale in the lower few meters of the member are pale yellowish orange, and those in the upper parts are variegated and red. The slope-forming argillaceous rocks are covered with float, which consists of sandstone, limestone nodules, and a few oncoids.

Sandstones in the upper member are similar to those in the lower member, but are usually more calcareous. Two or three main sandstone ledges consistently have a basal limestone pebble conglomerate.

Limestone is much more abundant in the upper parts of the section, is usually pale yellowish orange with one or two dark gray beds, and has up to 15 percent sand, silt, and argillaceous material. Fossil bivalves and gastropods are found in some limestone lenses and the beds are less than one meter (3.3 ft) thick.

The upper member accumulated in mixed lacustrine and fluvial environments. The sandstone and mudstone are similar to those found in the lower unit, but the addition of limestone containing fresh water bivalves and gastropods indicates a greater development of lacustrine environments in the upper part. Thus, the environment of deposition is interpreted to have been a low lying inland flood plain with meandering streams and occasional lakes.

TERTIARY SYSTEM

Flagstaff Formation

The Flagstaff Formation is approximately 80 m (262 ft) thick in the western part of Deadman Canyon where it is exposed as a series of three or four limestone ledges forming a striped surface and dip slope between the crest of the Book Cliffs and the base of the Roan Cliffs. In this locality the Flagstaff Formation consists of interbedded mudstone, shale, limestone, and sandstone with gradational contacts between the North Horn and Flagstaff Formations and between the Flagstaff and Colton Formations. The lower contact was mapped at the base of the laterally persistent beds of clean, medium gray, fossiliferous limestone, and the upper contact was mapped at the top of the uppermost persistent limestone, where red mudstone and fluvial sandstones predominate. La Rocque (1960, p. 73) has concluded that the lower member is Middle and Upper Paleocene and the upper member is Lower Eocene.

Mudstone and shale are common in the lower and upper parts of the formation, are usually variegated, red, or green, and form slopes. Ledge- to cliff-forming sandstone occurs in the slope and ranges from pale olive gray to moderate gray-brown. The sandstones are medium to coarse grained, show a fining upward trend, and are composed of quartz, abundant lithic fragments, and clay rip-up clasts. Most of the sandstones are medium to thick bedded and lenticular. Crossbeds and cut-and-fill features are common bedding structures.

The limestones are generally micritic and thin to medium bedded. They weather medium bluish gray to medium dark gray, and form ledges. Freshwater bivalves and gastropods are locally abundant in the limestones (La Rocque, 1960; Osterwald, Maberry, Dunrud, 1981).

The Flagstaff Formation was deposited in a freshwater lake and associated fluvial environments. Ryder, Fouch, and Ellison (1976, p. 499) proposed the term "lake-margin carbonate flat" for a depositional environment that has had extensive nearshore lacustrine carbonate sedimentation and some subaerial exposure. Characteristics of this facies are gray to green calcareous claystone, limestone mud and grain-supported carbonates, and locally abundant channel-form sandstone beds.

QUATERNARY SYSTEM

Alluvium. The alluvium is composed of clay to block-sized clasts that have been eroded from bedrock in the area and deposited in or near stream channels. This material may be dark brown to dark gray where it has been eroded from Mancos beds or reddish brown where it has been eroded from clinkered or weathered sandstones. The material is thin to thick bedded and may exhibit crossbedding locally. Thickness varies but it is not more than 10 m (33 ft) at any point in the quadrangle.

Colluvium. The colluvium is made up of clay to boulder-sized material. Such material is pale yellow orange to medium brown. Clasts are usually poorly sorted and angular to subrounded. Boulders and blocks are massive, attaining diameters of several meters. The colluvium covers slopes at the base of the Book Cliffs and partially covers bedrock on the face of the cliffs.

Slope wash. Areas differentiated as slope wash consist of unconsolidated to poorly consolidated clay to sand-sized particles that have been washed into place by running water not confined to specific stream channels (Witkind, 1979). In the study area they are generally derived from the disintegration of Mancos Shale and exhibit a light to medium gray color. These accumulations are thinly laminated, display crude cross stratification, and generally cover the broad valleys at the base of the gravel-covered Mancos Shale bluffs.

Pediment gravels. The pediment gravels consist of pebble to boulder sized clasts with a matrix of sand and silt. Boulders in some gravel deposits are as large as 2 m (6.6 ft) in diameter. Clastic debris was derived from the Book Cliffs bedrock and may contain crude channel deposits and a few lenses of clay material. Thicknesses range from 4 to 15 m (13 to 49 ft), with the thickest and coarsest deposits closest to the Book Cliffs. An undulatory erosional surface under the gravels cuts across the Mancos Shale and the Panther Sandstone. The terrace-like gravel caps rise gently towards the Book Cliff escarpment. A total of five different phases of pediment development and gravel veneer have been mapped in the Deadman Canyon quadrangle (Nethercott, 1983).

STRUCTURAL GEOLOGY

The structure of the Deadman Canyon quadrangle is dominated by the regional northward dip from the San Rafael Swell. Strike trends are roughly parallel to the Book Cliffs escarpment and range from N 90° W at Deadman Canyon to N 84° W near Soldier Creek Canyon (plate 1). Dips range from 4° to 7° toward the north and generally increase slightly from west to east.

Faulting in the quadrangle is minor. No extensive faults were mapped, and those which were observed have only a few meters of displacement.

Spieker (1946, p. 156) stated that monoclinal folds of the Colorado Plateau in Utah (including the San Rafael Swell) were formed before deposition of the Flagstaff Formation. Thinning of the Price River and North Horn sections in the Deadman Canyon quadrangle, when compared with adjacent areas to the east and west, suggest that arching of the San Rafael Swell was contemporaneous with deposition of the Price River and the North Horn sediments.

ECONOMIC GEOLOGY

Coal is the main economic product of the Deadman Canyon quadrangle. Building materials and water resources will be required as exploitation of coal and petroleum continues. The Knight Ideal Mine in Coal Creek Canyon was worked for several years before closing in the early 1970s. Several other mines have operated in Deadman Canyon in the past, but at present the Pinnacle Mine is the only operating one. Three seams have produced most of the coal taken from the mines in the area: the Castlegate "A", the Gilson, and the Lower Sunnyside seams. Oil and gas exploratory wells were drilled in the southern half of the quadrangle near Deadman Canyon and Coal Creek Canyon. Further coal and petroleum development will necessitate upgrading of local roads. An abundant supply of road material is available in the pediment gravels of the area. Local springs and intermittent and perennial streams can supply some of the water needed for resource development.

COAL

Nine coal seams or coal zones have been identified in the Blackhawk Formation of the Deadman Canyon quadrangle of which only three or four are potentially mineable (Clark, 1928, p. 36; AAA Engineering, 1979, p. 5). Coal zones rather than individual seams were mapped because of the lenticularity of the seams, however, the terms "zone" and "seam" are used interchangeably. The main coal-producing zones in the quadrangle occur in the lower part of the Kenilworth Member and the lower and the upper mudstone members of the Blackhawk Formation. Mineable coal seams include the Castlegate "A", Gilson, and Lower Sunnyside zones, and the nonmineable coal zones are the Castlegate "B", Royal Blue, Kenilworth, Fish Creek, Rock Canyon, and Upper Sunnyside zones. Many other thin, lenticular, and unnamed coal seams are present in the quadrangle. The coal zones which were mapped for this study include the Castlegate "A", Castlegate "B", Kenilworth, Gilson, Rock Canyon, and Lower Sunnyside. At present the Gilson and Lower Sunnyside zones are being mined, and plans have been developed to mine the Castlegate "A" seam in Deadman Canyon (Michael Glassen, personal communication, 1983). Thinner seams may be mined or may be targets for in situ coal gasification projects in the future.

Samples from the Gilson seam at the Knight Ideal Mine were analyzed for moisture, volatile matter, fixed carbon, ash, sulfur, and BTU per pound (Doelling, 1972). Statistics for these factors were averaged for the 137 samples taken, yielding a classification of the coal as a high-volatile B bituminous (American Society for Testing and Materials, 1977).

Total reserve tonnage (in short tons) has been estimated at 4,700,000 tons for five minable coal seams (AAA Engineering, 1979, p. 10). The coal zones included in this estimate are the Castlegate "B", Lower Sunnyside, Gilson, Kenilworth, and Castlegate "A" beds, in order of decreasing tonnage. The guidelines which were followed for the tonnage estimation were set by the U. S. Bureau of Mines and the U. S. Geological Survey (1976).

The minable thickness of coal seams with splits was calculated and used for the construction of isopach maps. This thickness was computed by subtracting the thickness of a split in a coal seam from the thinnest coal directly above or below the split. If the split was greater than or equal to the thinner coal, the coal was ignored. If the split was less than the thinner coal, the computed thickness was then added to the other adjacent thicker coal. Thus, in the presence of a split coal, the total minable coal thickness is found by adding the thickness of the best coal seam to that of the calculated thickness of an adjacent thinner seam.

The future coal development in the quadrangle will remain principally subsurface mining, and possibly in situ coal gasification. Surface mining is discouraged by the rugged topography and the large amount of overburden. All areas of unleased Federal coal land in the quadrangle have high development potentials (AAA Engineering, 1979, p. 11). This means that the coal beds are at least 1.5 m (4.9 ft) thick and covered with no more than 1,000 m (3,280 ft) of overburden in a given area.

Castlegate "A" Coal Zone

This coal lies above the Aberdeen member in the basal slope-forming zone of the Kenilworth Member. The Castlegate "A" seam can be mapped from the Deadman Canyon quadrangle westward for approximately 32.2 km (20 miles) (Clark, 1928, p. 30). Most of the thickness information is taken from outcrop measurements. Generally, the Castlegate "A" zone is thicker in the west and the north and thinner in the eastern part of the quadrangle. The coal is lenticular and reaches a maximum thickness of 1.8 m (5.8 ft) immediately west of Straight Canyon. From Straight Canyon eastward, the coal generally thins to zero thickness near Alkali Creek. The average thickness of the coal zone is 1.1 m (3.5 ft). Surficial burning of this zone is restricted to the western part of the quadrangle. The interval between this coal zone and the overlying Castlegate "B" coal zone is 2 to 10 m (7 to 35 ft). Data from measured sections indicate that the floor rock for the seam is sandstone and carbonaceous shale, and the roof rock is sandstone, siltstone, and carbonaceous shale.

Castlegate "B" and Royal Blue Coal Zones

These coals are located between the Castlegate "A" and the Kenilworth coal zones. The seams have been mined in the Helper quadrangle, to the west, and are restricted to the western half of the Deadman Canyon quadrangle. Both coals are thin and lenticular, and only the Castlegate "B" coal zone reaches a mineable thickness in the quadrangle. The average thickness of the Royal Blue zone is 0.3 m (1 ft), and the average thickness of the Castlegate "B" bed is 0.8 m (2.5 ft) (plate 2). The maximum thickness of the Castlegate "B" is 4.0 m (13 ft) in a drill hole in the left fork of Deadman Canyon (plate 2). The roof rock is mainly sandstone and siltstone and the floor rock is siltstone and carbonaceous shale.

Kenilworth Coal Zone

This zone consistently lies within a meter or two of the top of the Kenilworth sandstone. The zone is exposed intermittently across the Deadman Canyon quadrangle and has been mapped for 53 km (33 miles) along the western Book Cliffs and the northern Wasatch Plateau (Clark, 1928, p. 39). It is mined at Kenilworth where it is 6 m (20 ft) thick. The coal zone is lenticular and, therefore, can not be found in some measured sections due to the erosion of the Kenilworth coal swamp by Cretaceous streams, and possibly due to the lack of peat deposition. Average thickness of the seam is 0.7 m (2.3 ft) with a minimum measured thickness of 0.3 m (1 ft) and a maximum thickness of 1 m (3.5 ft). Generally the zone appears to be thickest to the west of Coal Creek and thins to the east (plate 2). Both the roof rocks and the floor rocks are mostly carbonaceous shale and sandstone.

Gilson Coal Zone

The Gilson zone extends from the Helper quadrangle eastward across Deadman and Pine Canyon quadrangles. This seam is considered to be the most important coal zone in the quadrangle (Doelling, 1972), and has been mined extensively in Coal Creek and Deadman Canyons.

The Gilson coal is lenticular within the quadrangle with thicknesses ranging from 3 m (9.9 ft) at Coal Creek to under 1 m (3.3 ft) at several locations (plate 2). The bed is approximately 2 m (6.6 ft) thick in the Deadman Canyon area and thickens to 2.3 m (7.5 ft) to the east. The seam is thinner at the outcrops in the southernmost escarpments of the Book Cliffs (1.3 m - 4.3 ft) and tends to thin considerably in the subsurface to the north (Michael Glassen, personal communication, 1982). A drill hole in the left fork of Deadman Canyon (plate 2) indicates that the Gilson seam thins to only 0.5 m (1.7 ft). Measured sections of the coal outcrops display a seam thickness of 2.3 m (7.5 ft) at Straight Canyon and 1.2 m (4.0 ft) in Hoffman Creek. Outcrop and subsurface mine measurements, in part from Doelling (1972), show that the Gilson coal zone thickens again to a maximum of 3.4 m (11.1 ft) at Coal Creek. Drill holes in Coal Creek Canyon (plate 2) document the thinning of the Gilson zone to the north (1.5 m - 4.9 ft). Subsurface data is lacking east of Coal Creek, but measurements of outcrops suggest that the coal thickness there averages 1 m (3.3 ft).

Splits are a main concern in the Gilson coal. Boney splits and steep pitches of the coal beds make mining difficult and expensive in the Coal Creek area (Doelling, 1972). One main split, averaging 0.2 m (0.7 ft) thick, is recognized in the Deadman-Straight Canyon areas. Roof and floor rocks consist predominantly of sandstone and carbonaceous siltstone.

Fish Creek and Rock Canyon Coal Zones

These coal zones are very thin and lenticular in the Deadman Canyon quadrangle. The belt of rock containing these two coal zones is usually extensively burned, therefore, mapping and measuring the zones was difficult. Clark (1928) traced the Fish Creek Coal from Fish Creek, east of the Deadman Canyon quadrangle, to the west of Soldier Creek Canyon and stated that the coal possibly extends farther west to Coal Creek. Coal in the Fish Creek zone is thin, no more than 1 m (3.3 ft) thick, and usually contains several splits.

The Rock Canyon coal zone has been mapped from Rock Canyon, several kilometers east of the Deadman Canyon quadrangle, to the west side of Coal Creek Canyon (Clark, 1928). Coal in the Rock Canyon zone is thicker than the Fish Creek coal; maximum thickness is nearly 1.5 m (4.9 ft) at Straight Canyon and averages 0.9 m (2.9 ft) between Coal Creek and Deadman Canyon (plate 2). The coal thins between Coal Creek and Soldier Creek, but it thickens again at Soldier Creek where it is presently being mined by the Soldier Creek Coal Company. Generally the roof and the floor rocks of the Rock Canyon coal consist of siltstone and minor sandstone. The Fish Creek coal zone is usually 5 to 15 m (16 to 49 ft) above the Gilson coal zone, and the Rock Canyon coal zone is 5 to 15 m (16 to 49 ft) above the Fish Creek coal zone.

Lower and Upper Sunnyside Coal Zones

The Lower Sunnyside coal zone has been mapped from Sunnyside, Utah across the Deadman Canyon quadrangle and into the Helper quadrangle (Clark, 1928). Coal in the Upper Sunnyside zone in the Deadman Canyon quadrangle is correlated to the upper coal seam mined at Sunnyside, Utah. It is very lenticular and has not been mapped nor extensively measured in the quadrangle. The Lower Sunnyside coal, however, was mapped across the quadrangle by utilizing its prominent position above the Sunnyside sandstone.

The Lower Sunnyside coal is presently mined in Deadman Canyon, where it reaches a maximum thickness of approximately 1.5 m (5 ft). Outcrop measurements show that the Lower Sunnyside bed thins eastward from Coal Creek and develops several major splits (plate 2). Drill data indicate that the coal thickens to over 2 m (6.6 ft) in the left fork of Deadman Canyon, and thins to a little over 1 m (3.3 ft) thick in the subsurface at Coal Creek. The floor rock is composed mainly of sandstone and carbonaceous shales, and the roof rock is primarily siltstone and shale with minor sandstones.

OIL AND NATURAL GAS

Several wells have been drilled in the southern half of the quadrangle in search for oil and natural gas. The main targets were the Ferron and Emery Sandstones. One well drilled near Deadman Canyon in 1956 had a show of gas, however, subsequent drilling in that area (Price no. 3 well, NE 1/4, NW 1/4, Sec. 19, T 13 S, R 11 E and Price no. 5 well, NW 1/4, SW 1/4, Sec. 20, T 13 S, R 11 E) yielded only dry holes. Two additional exploratory wells were also drilled in the Mancos Shale near Coal Creek (Coal Creek no. 1, SE 1/4, SE 1/4, Sec. 18, T 13 S, R 11 E, and Coal Creek no. 2, SW 1/4, SW 1/4, Sec. 10, T 13 S, R 11 E), but neither of these wells were productive.

Homoclinal dips and unfaulted sections produced no known petroleum traps in the quadrangle. However, interfingering of the sandstones in the lower Blackhawk and the marine shales of the upper Mancos Shale could create stratigraphic traps for petroleum in areas to the north.

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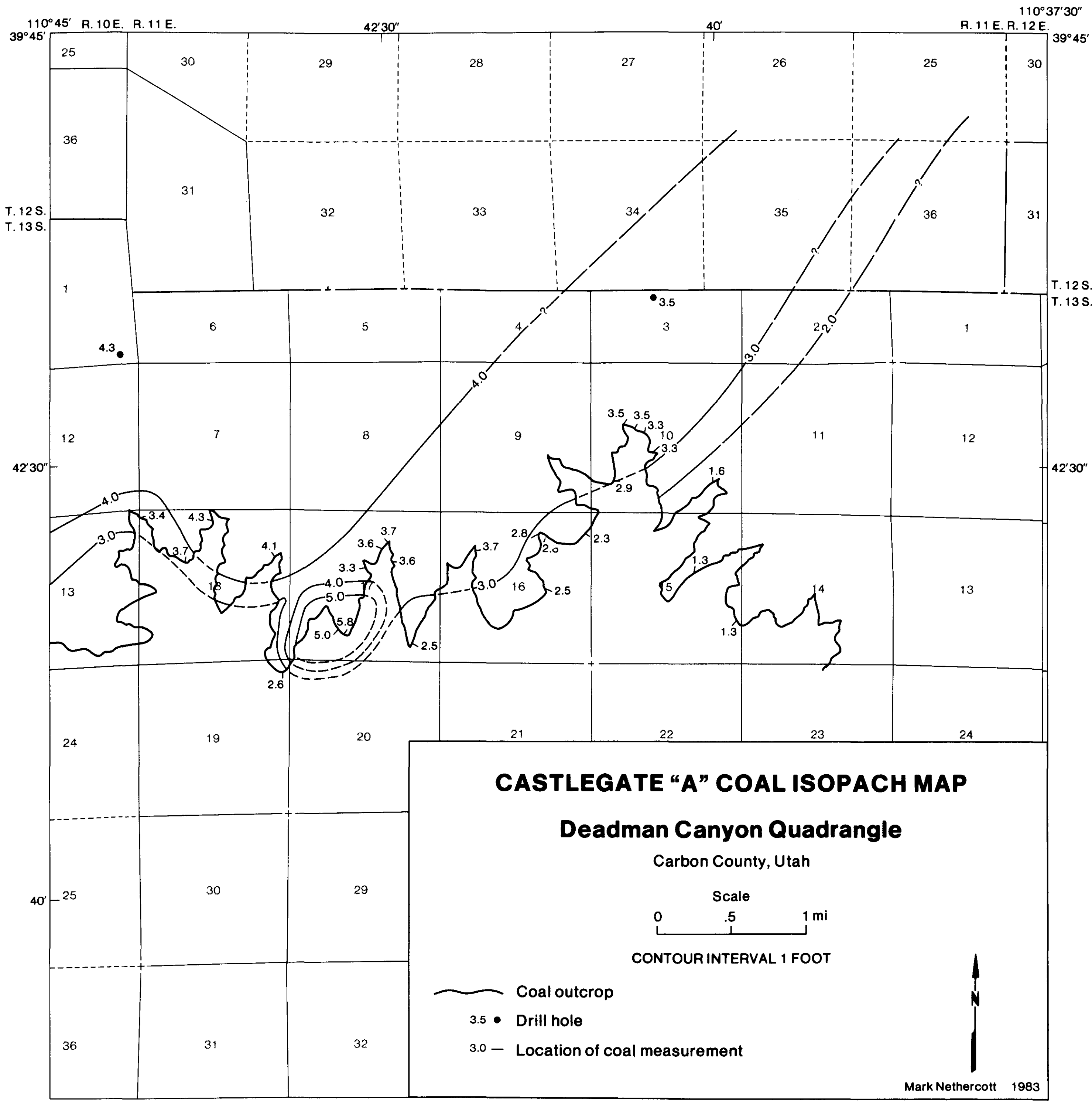
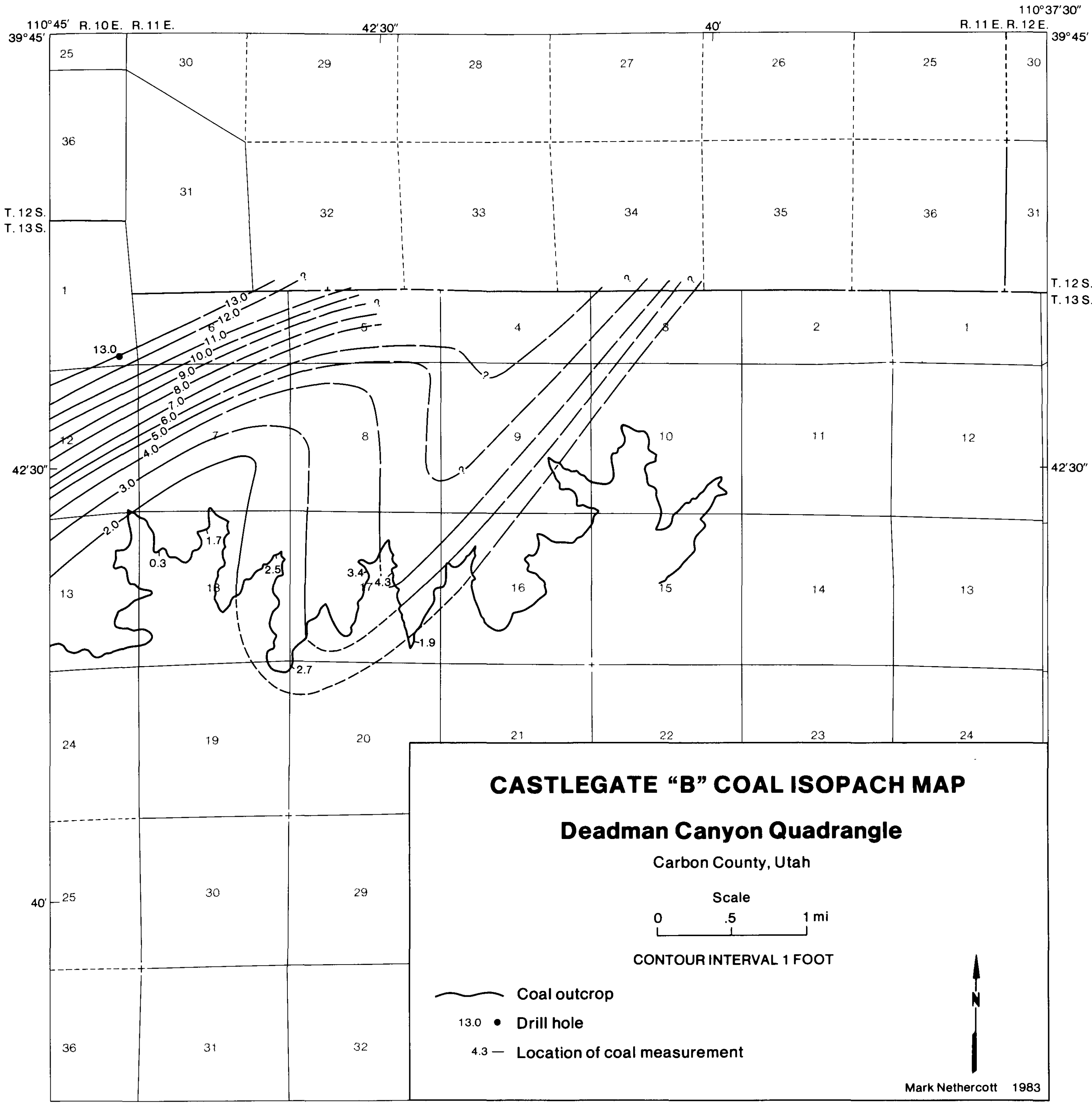
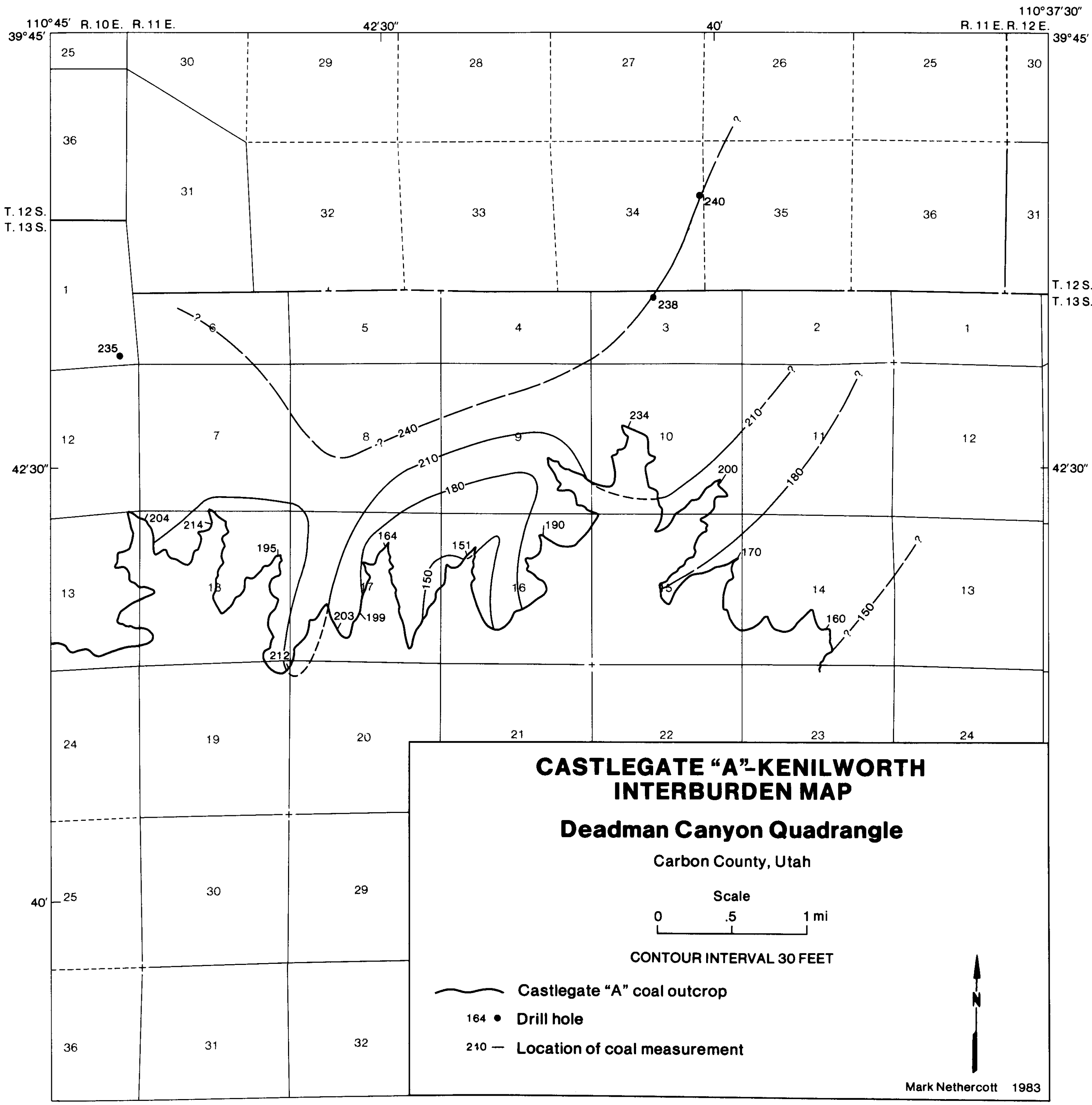
APPENDIX



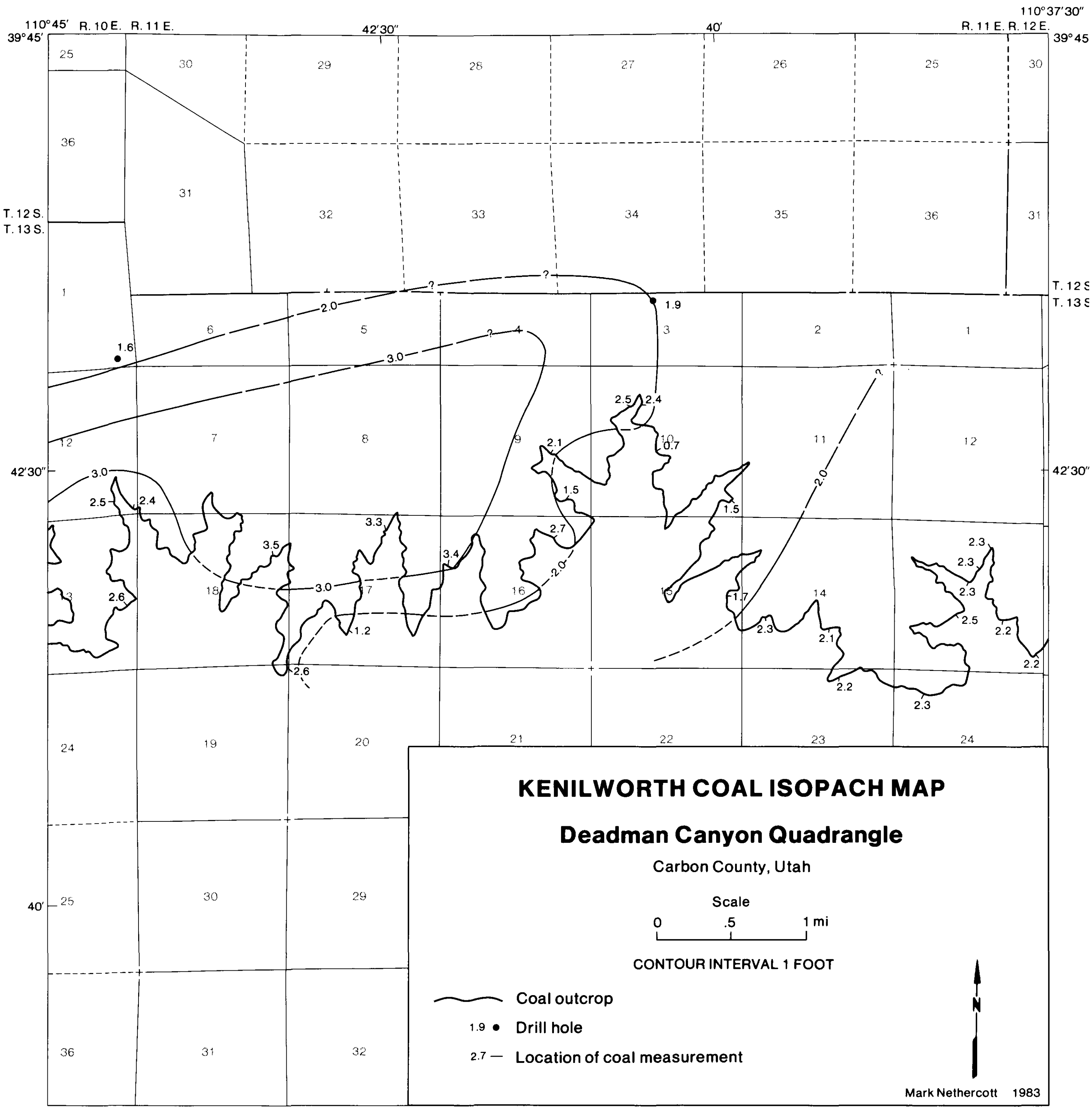
CASTLEGATE "A" COAL ISOPACH MAP
Deadman Canyon Quadrangle
Carbon County, Utah
Scale
0 .5 1 mi
CONTOUR INTERVAL 1 FOOT
Coal outcrop
3.5 • Drill hole
3.0 — Location of coal measurement
Mark Nethercott 1983



CASTLEGATE "B" COAL ISOPACH MAP
Deadman Canyon Quadrangle
Carbon County, Utah
Scale
0 .5 1 mi
CONTOUR INTERVAL 1 FOOT
Coal outcrop
13.0 • Drill hole
4.3 — Location of coal measurement
N
Mark Nethercott 1983
110°45'
R. 10 E.
R. 11 E.
42'30"
40'
110°37'30"
R. 11 E.
R. 12 E.
39°45'
T. 12 S.
T. 13 S.
42'30"
40'



CASTLEGATE "A"-KENILWORTH
INTERBURDEN MAP
Deadman Canyon Quadrangle
Carbon County, Utah
Scale
0 .5 1 mi
CONTOUR INTERVAL 30 FEET
Castlegate "A" coal outcrop
164 • Drill hole
210 — Location of coal measurement
N
Mark Nethercott 1983
110°45′
R. 10 E.
R. 11 E.
42′30″
40′
110°37′30″
R. 11 E. R. 12 E.
39°45′
T. 12 S.
T. 13 S.
42′30″
40′
240
238
235
234
210
200
180
170
160
150
204
214
195
164
151
190
212
203
199



KENILWORTH COAL ISOPACH MAP

Deadman Canyon Quadrangle

Carbon County, Utah

Scale

0 .5 1 mi

CONTOUR INTERVAL 1 FOOT

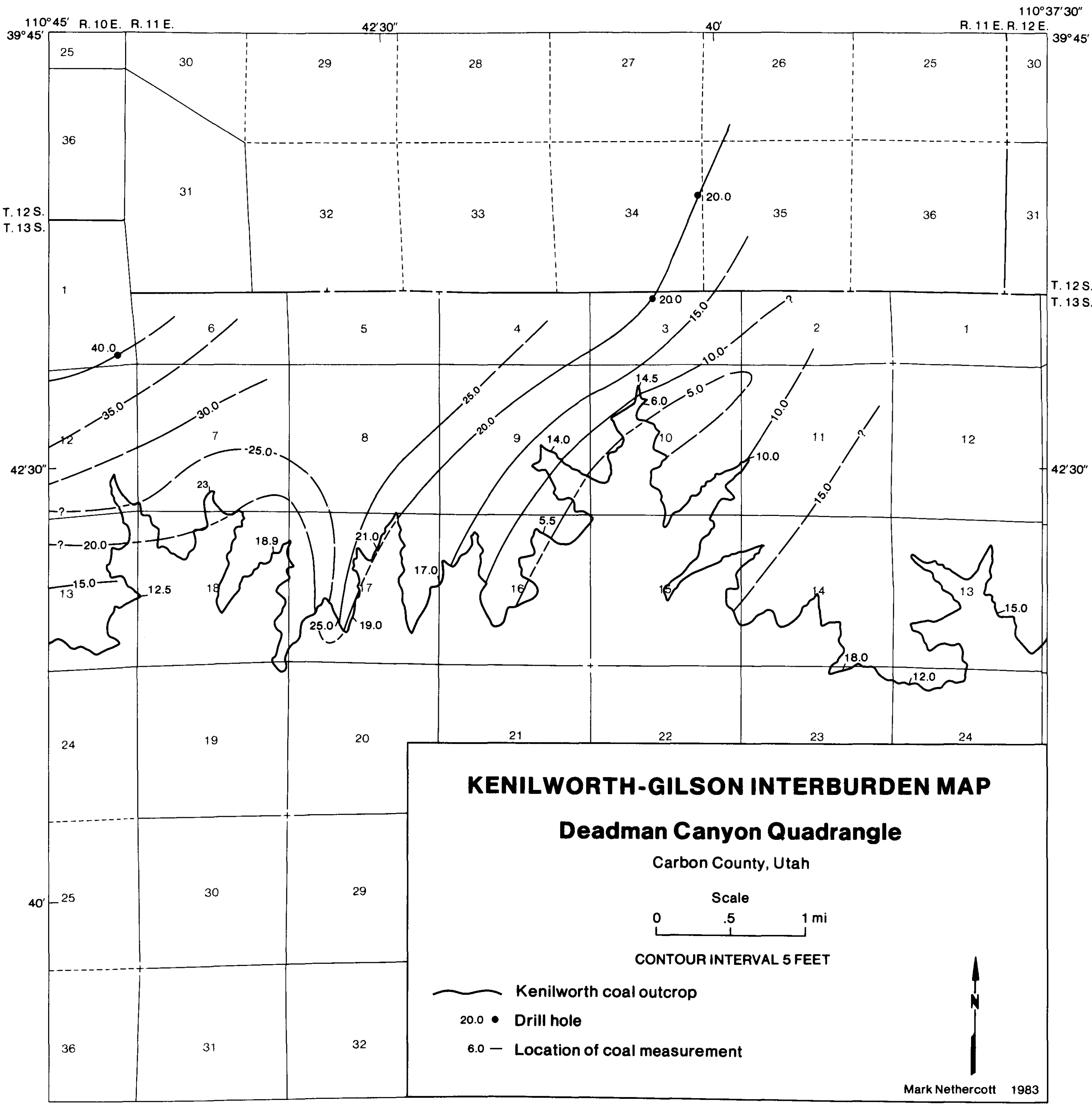
Coal outcrop

1.9 ● Drill hole

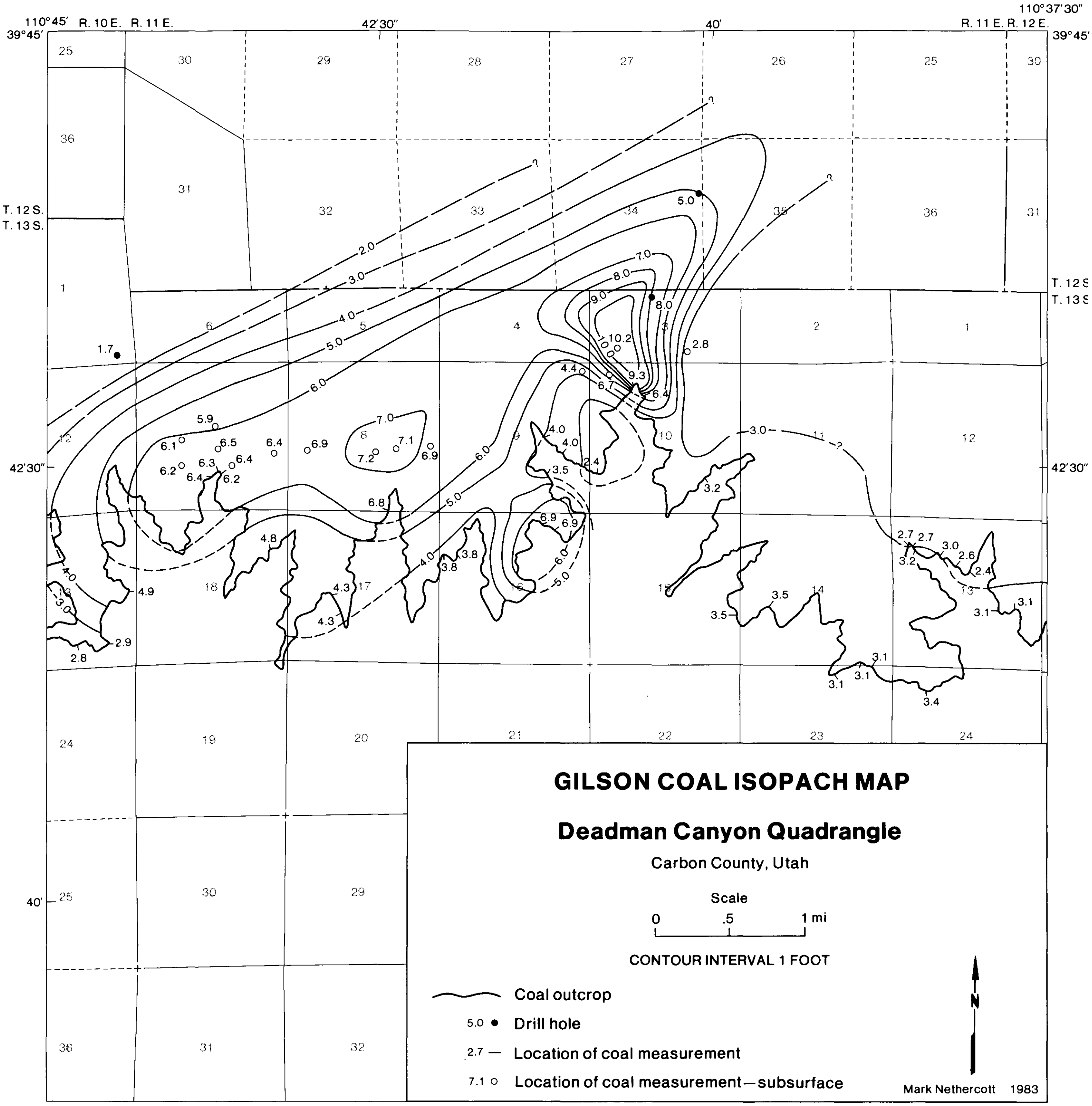
2.7 — Location of coal measurement

N

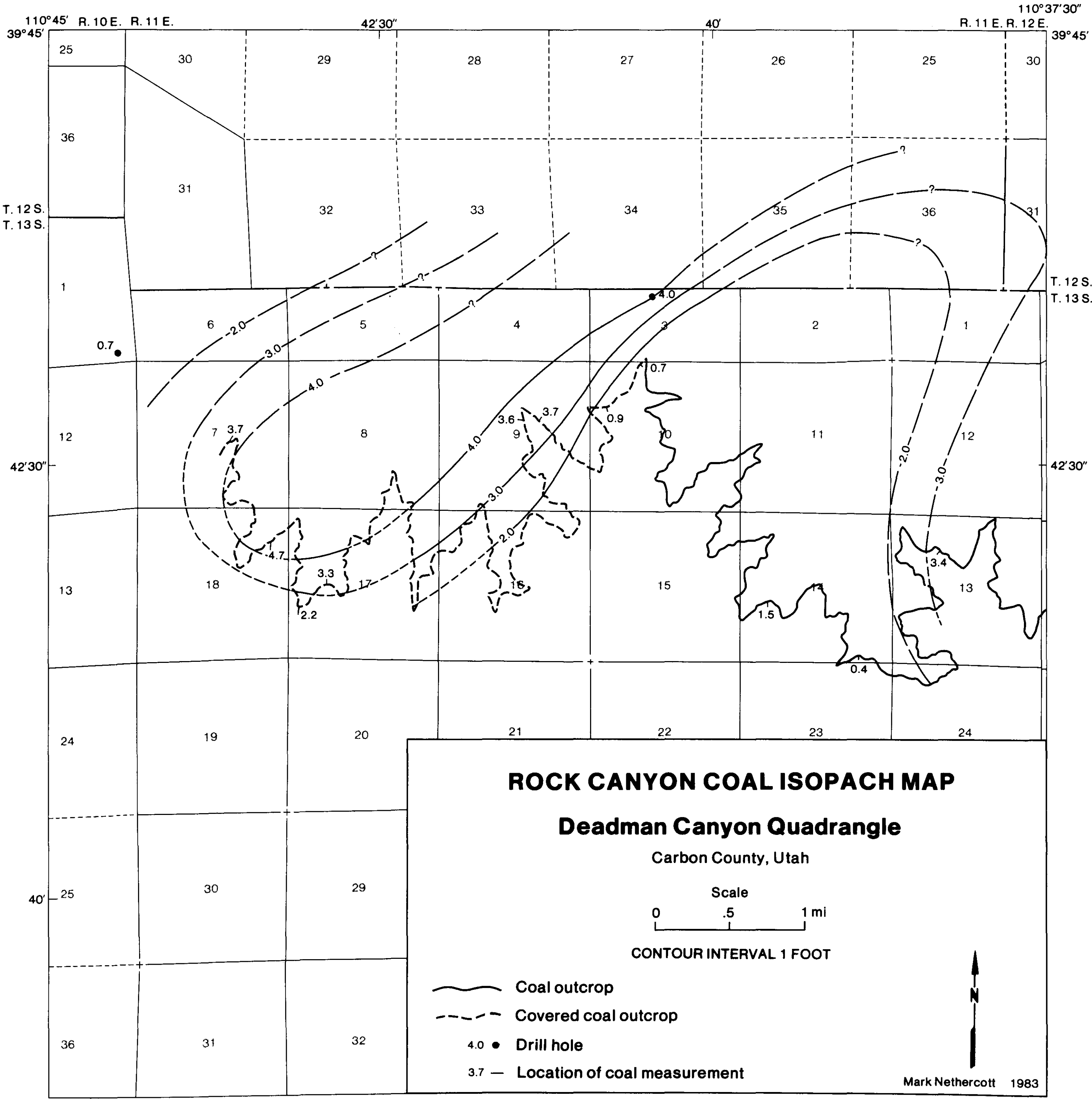
Mark Nethercott 1983

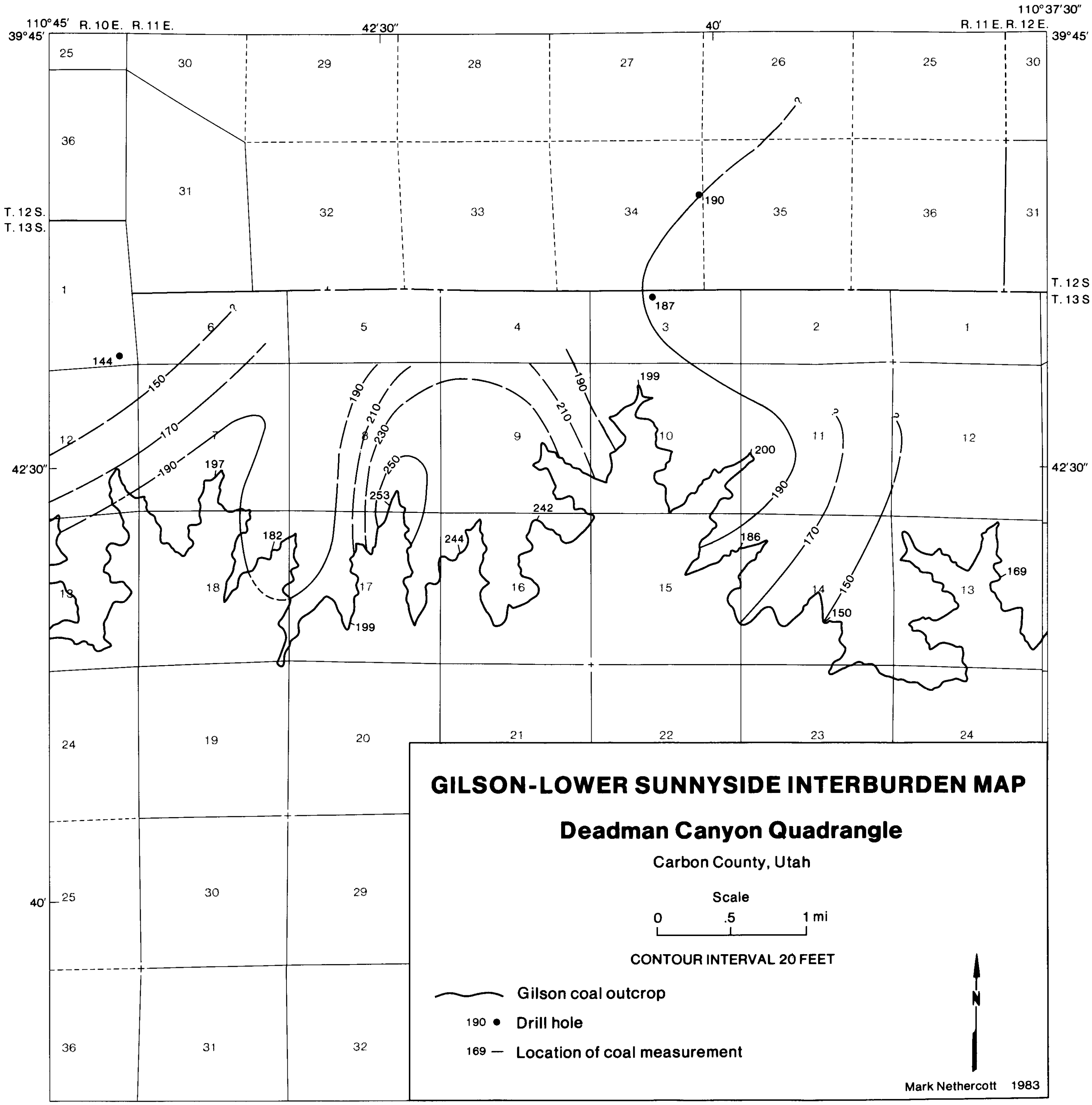


KENILWORTH-GILSON INTERBURDEN MAP
Deadman Canyon Quadrangle
Carbon County, Utah
Scale
0 .5 1 mi
CONTOUR INTERVAL 5 FEET
Kenilworth coal outcrop
20.0 • Drill hole
6.0 — Location of coal measurement
Mark Nethercott 1983
110°45′
R. 10 E.
R. 11 E.
42′30″
40′
110°37′30″
R. 11 E.
R. 12 E.
39°45′
T. 12 S.
T. 13 S.



GILSON COAL ISOPACH MAP
Deadman Canyon Quadrangle
Carbon County, Utah
Scale
0 .5 1 mi
CONTOUR INTERVAL 1 FOOT
Coal outcrop
5.0 • Drill hole
2.7 — Location of coal measurement
7.1 o Location of coal measurement—subsurface
Mark Nethercott 1983
110°45'
R. 10 E. R. 11 E.
42'30"
40'
110°37'30"
R. 11 E. R. 12 E.
39°45'
T. 12 S.
T. 13 S.
42'30"
40'


ROCK CANYON COAL ISOPACH MAP
Deadman Canyon Quadrangle
Carbon County, Utah
Scale
0 .5 1 mi
CONTOUR INTERVAL 1 FOOT
Coal outcrop
Covered coal outcrop
4.0 ● Drill hole
3.7 — Location of coal measurement
Mark Nethercott 1983
110°45'
R. 10 E.
R. 11 E.
42'30"
40'
110°37'30"
R. 11 E.
R. 12 E.
39°45'
T. 12 S.
T. 13 S.
42'30"
40'
2.0
3.0
4.0
0.7
3.7
3.6
0.9
4.7
3.3
2.2
1.5
0.4
3.4



GILSON-LOWER SUNNYSIDE INTERBURDEN MAP

Deadman Canyon Quadrangle

Carbon County, Utah

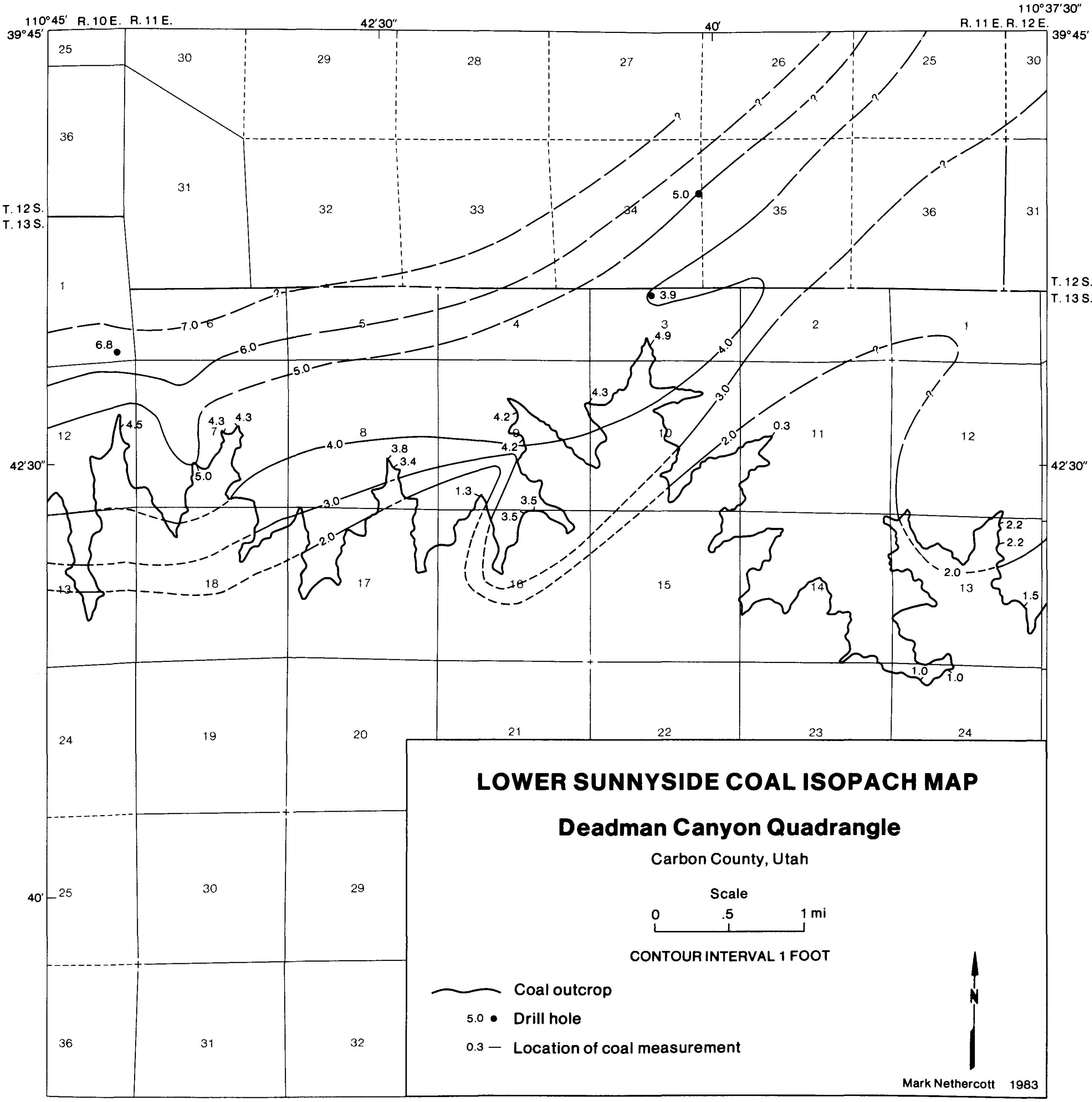
CONTOUR INTERVAL 20 FEET

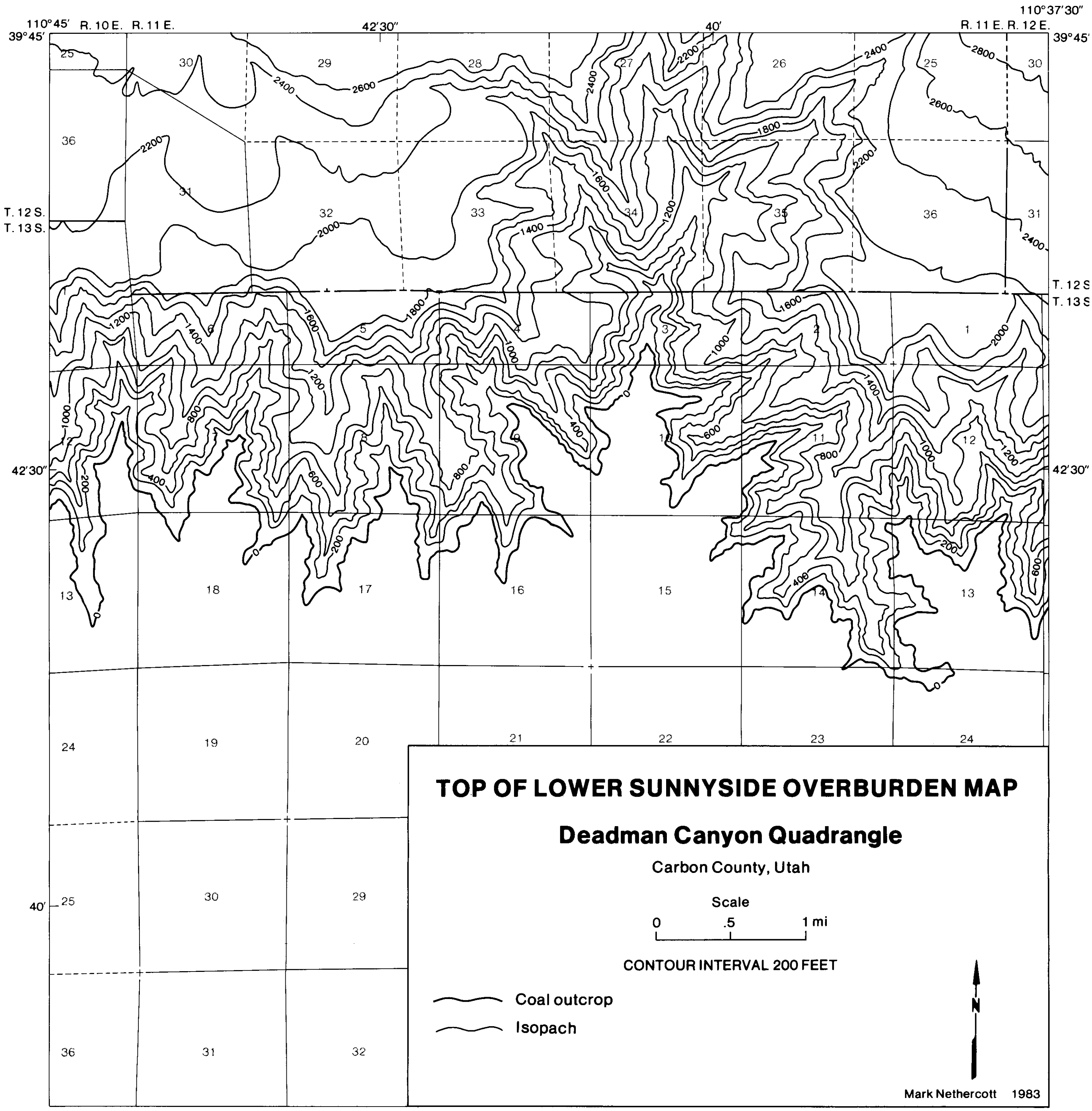
Gilson coal outcrop

190 • Drill hole

169 — Location of coal measurement

Mark Nethercott 1983


LOWER SUNNYSIDE COAL ISOPACH MAP
Deadman Canyon Quadrangle
Carbon County, Utah
Scale
0 .5 1 mi
CONTOUR INTERVAL 1 FOOT
Coal outcrop
5.0 • Drill hole
0.3 — Location of coal measurement
Mark Nethercott 1983
110°45′
R. 10 E.
R. 11 E.
42′30″
40′
110°37′30″
R. 11 E.
R. 12 E.
39°45′
T. 12 S.
T. 13 S.
42′30″
40′



TOP OF LOWER SUNNYSIDE OVERBURDEN MAP

Deadman Canyon Quadrangle

Carbon County, Utah

Scale

0 .5 1 mi

CONTOUR INTERVAL 200 FEET

Mark Nethercott 1983

UTAH GEOLOGICAL AND MINERAL SURVEY

606 Black Hawk Way
Salt Lake City, Utah 84108-1280

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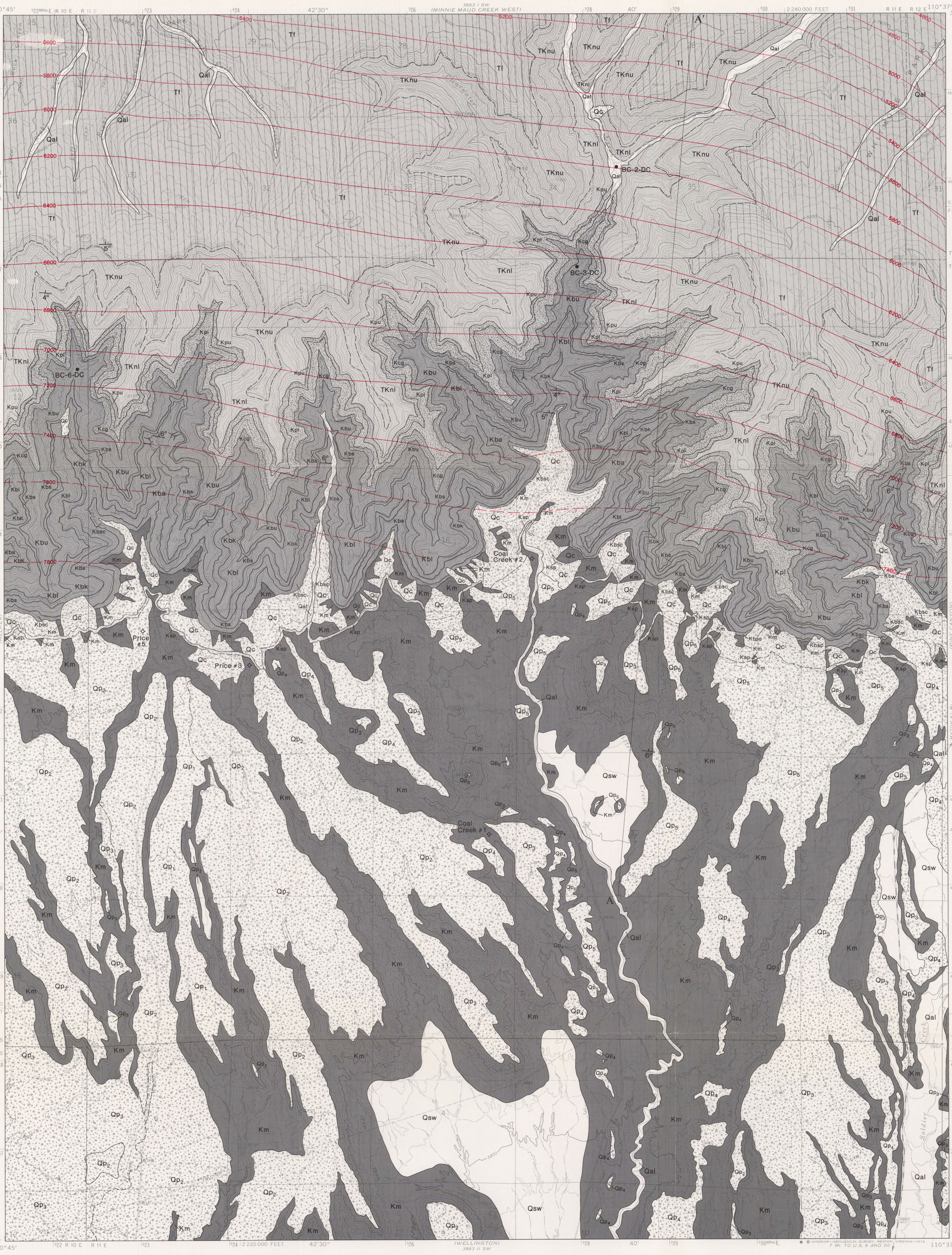

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SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

UTM GRID AND 1972 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

QUADRANGLE LOCATION

SYSTEM	SERIES	FORMATION	SYMBOL	LITHOLOGY	THICKNESS meters (feet)	DESCRIPTION
QUATERNARY		Unconsolidated deposits	Qp		0-25 (0-75)	alluvium, colluvium, slopewash, pediment gravels
TERTIARY	Eocene	Flagstaff Formation	Tf		86 (280)	fluvial, lacustrine, mudstone, shale, sandstone, limestone, yellow-orange, medium to dark gray
TERTIARY ? CRETACEOUS	Paleocene ? Danian ? Maastrichtian	North Horn Formation	TKnh		320 (1040)	fluvial, lacustrine, mudstone, shale, siltstone, sandstone, limestone, minor conglomerate, variegated yellow-orange, gray-orange
CRETACEOUS	Maastrichtian	Price River Formation	Kpr		83 (270)	fluvial, sandstone, siltstone, shale, medium gray to gray-brown
CRETACEOUS	Campanian	Castlegate Sandstone	Kcg		77 (250)	fluvial, sandstone, minor shale, medium gray-brown
CRETACEOUS	Campanian	Blackhawk Formation	Kb	S R G K Cg	225 (900)	littoral, fluvial, sandstone, shale, mudstone, coal, pale yellow-orange and light gray
CRETACEOUS	Campanian	Mancos Shale (tongue)	Km		40 (120)	shale, siltstone, medium gray
CRETACEOUS	Campanian	Spring Canyon Member	Kb		40 (120)	marine, siltstone, shale, minor sandstone
CRETACEOUS	Campanian	Mancos Shale (tongue)	Km		106 (345)	marine, shale, siltstone, medium gray
CRETACEOUS	Campanian	Star Point Sandstone	Ksp		5-25(16-80)	sandstone, siltstone
CRETACEOUS	Campanian	Mancos Shale	Km		1540 (5000)	marine, shale, siltstone, minor sandstone, medium gray and brown-gray

EXPLANATION

QUATERNARY
- Qal — Alluvium
- Qc — Colluvium
- Qp — Shown in cross section only
- Qsw — Slope wash
- Qp_{1-5} — Pediment gravels (5 levels)

UNCONFORMITY

TERTIARY
- Tf — Flagstaff Limestone

TERTIARY / CRETACEOUS — North Horn Formation
- TKnh — Shown in cross section only
- TKnu — upper member
- TKnl — lower member

CRETACEOUS — Price River Formation
- Kpr — Shown in cross section only
- Kpu — upper member
- Kpl — lower member

- Kcg — Castlegate Sandstone

Blackhawk Formation
- Kb — Shown in cross section only
- Kbu — upper mudstone member
- Kbs — Sunnyside Member
- Kbl — lower mudstone member
- Kbk — Kenilworth Member
- Kba — Aberdeen Member
- Kbsc — Spring Canyon Member

- Ksp — Star Point Sandstone

Mancos Shale
- Km — Undifferentiated

SYMBOLS

Contact
Dashed where inferred

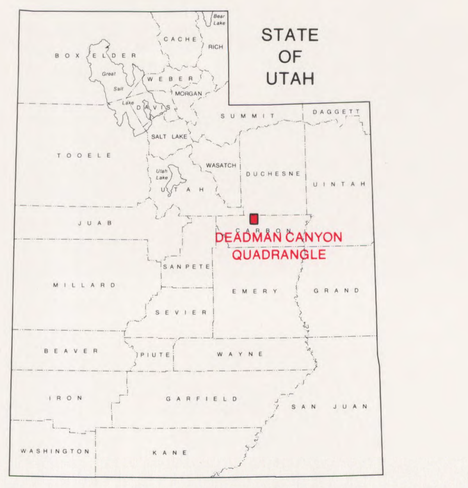
Mine Portal

Structure Contour
Dashed where inferred
Drawn at the top of the Sunnyside Coal
contour interval 200 ft

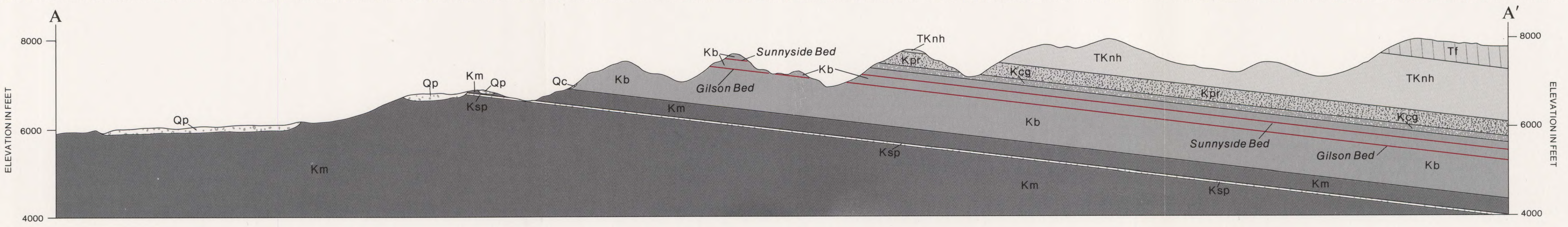
Drill hole (Petroleum)

Drill hole (Coal)

Dip and Strike



LOCATION MAP



MAP 76

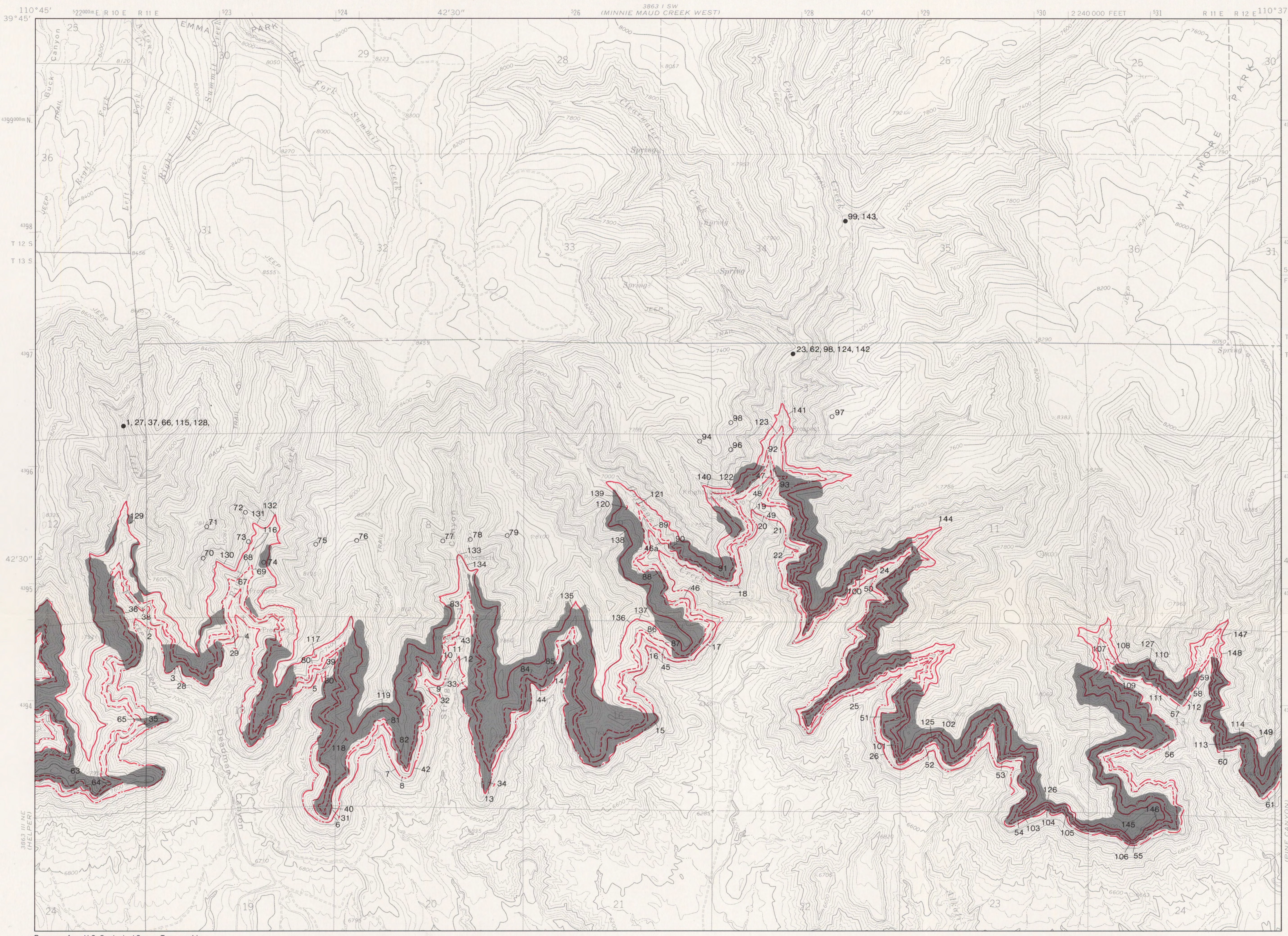
GEOLOGIC MAP AND COAL RESOURCES OF DEADMAN CANYON QUADRANGLE, CARBON COUNTY, UTAH

1985

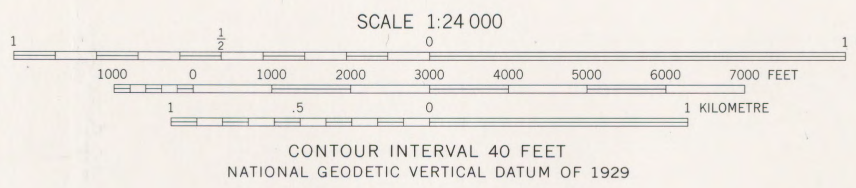
By Mark A. Nethercott

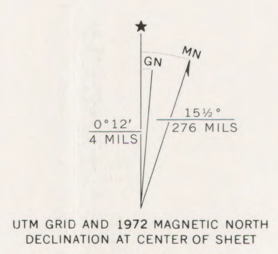
Klaus D. Gurgel, Cartographic Editor
Jessie S. Roy, Patricia H. Speranza, Cartographers

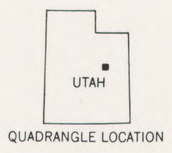
COAL OUTCROP AND SECTION MAP OF DEADMAN CANYON QUADRANGLE, CARBON COUNTY, UTAH



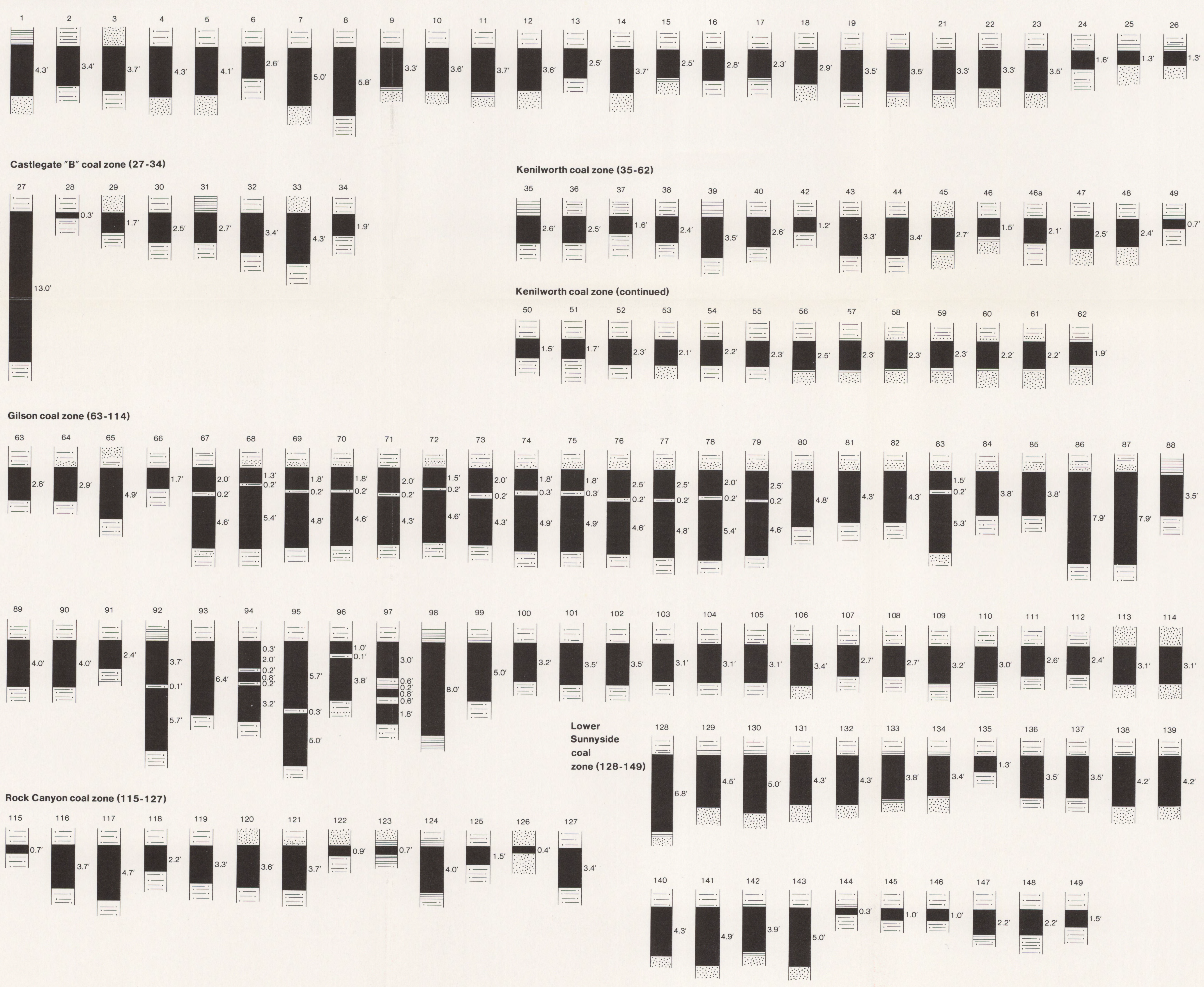
Base map from U.S. Geological Survey Topographic quadrangle: Deadman Canyon, Utah 1972.







MEASURED SECTIONS



EXPLANATION