RESULTS OF A PALEONTOLOGICAL SURVEY

NORTH ANTELOPE MINE

CAMPBELL COUNTY, WYOMING

By

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NORTH ANTELOPE COAL COMPANY
Denver, Colorado

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ABSTRACT

A paleontological survey of the North Antelope Mine proposed railroad spur and access road corridors, was undertaken by the Paleontological Section of Western Cultural Resource Management, Inc. on behalf of the North Antelope Coal Company.

The mine is located in the southern part of the Powder River Coal Basin and will extract coal from the basal part of the Wasatch Formation. The survey was undertaken to locate any potentially significant fossils and fossil deposits which might be impacted by mining activities or during construction of the railroad spur and access road.

One of the primary goals of the paleontological survey was to locate unique pockets of concentrated fossilized bone such as those reported elsewhere in the Wasatch Formation in the Powder River Basin. While such pockets were not found, numerous early post-Altithermal bison bones were identified and collected from the Kaycee Terrace sediments along Antelope Creek in the proposed railroad spur.

Other fossil types seen during the survey include numerous leaves and fossilized wood. The leaves usually occur as lignitic impressions in sandstone and as compact masses in shale. The fossil wood often occurs as loci for brown, possibly carcareously cemented concretions in sandstone, or as possibly siliceous compressed logs near the top of coal or in coaly shale. A large, relatively intact log, measuring over six meters long was found at the top of a coal seam in the southern part of the North Antelope Mine.

No fossil vertebrates were found in any exposures of the Wasatch Formation at the North Antelope Mine and the proposed railroad spur and access road corridors, and it is doubtful that any will be found during mining or construction activities. Bison bones, including a partial juvenile skull and a complete adult skull, were found in several arroyos and stream terraces. The abundance of similar remains in and around North Antelope Mine, as well as throughout the Powder River Basin, makes it doubtful that loss of these bones during mining operations will result in a severe loss of scientific data unless the remains are clearly associated with cultural material.

The most abundant fossils found during the paleontological survey and which will be frequently encountered during mining operations and construction of the railroad spur

and access road are leaves. However, because of the widespread distribution of such remains throughout the lower Wasatch Formation and the ease by which large collections can be made, no samples were made. Furthermore, it is doubtful that mining and construction activities will result in loss of information that cannot be obtained from elsewhere in the Powder River Basin. Fossil logs are common in many exposures but these are usually highly fragmentary. Like fossil leaves, these logs can be collected elsewhere in the Powder River Basin and their destruction will not result in a severe loss of data. One log, however, is unique because of its completeness and it is recommended that it be salvaged. Six meters of the log have been uncovered and an unknown length still lies buried.

In summary, mining and construction activities at the North Antelope Mine, railroad spur, and access road should have an insignificant impact on fossil vertebrates in the Wasatch Formation, insignificant impact upon post-Althhermal bison remains, fossil leaves, and fossil logs. It is recommended that only one fossil, a six-meter log, should be salvaged due to its unusual size and state of preservation.

INTRODUCTION

A paleontological field and literature survey for the North Antelope Mine and proposed railroad spur and access road corridors (collectively called the Project) was conducted in May and June, 1981, by the Paleontological section of Western Cultural Resource Management, Inc. (WCRM) on behalf of the North Antelope Coal Company. The survey was conducted in compliance with the Antiquities Act of 1906, the National Environmental Policy Act of 1969, the Archaeological and Historical Data Conservation Act of 1976, the Federal Land Policy Act of 1976, and the Wyoming Department of Environmental Quality regulations.

PROJECT OBJECTIVES

In order to assess the impact that mining and construction activities will have upon fossil material and fossiliferous sites in the Project area, a paleontological survey was conducted in May and June, 1981. Adverse weather and poor access conditions interupted the field survey on numerous occasions during this time.

PROJECT LOCATION

The North Antelope Mine and proposed railroad spur and access road corridors are located about 50 air miles south of Gillette, Campbell County, Wyoming (Map 1).

The North Antelope Mine occupies all or part of the following sections in T41N, R70W:

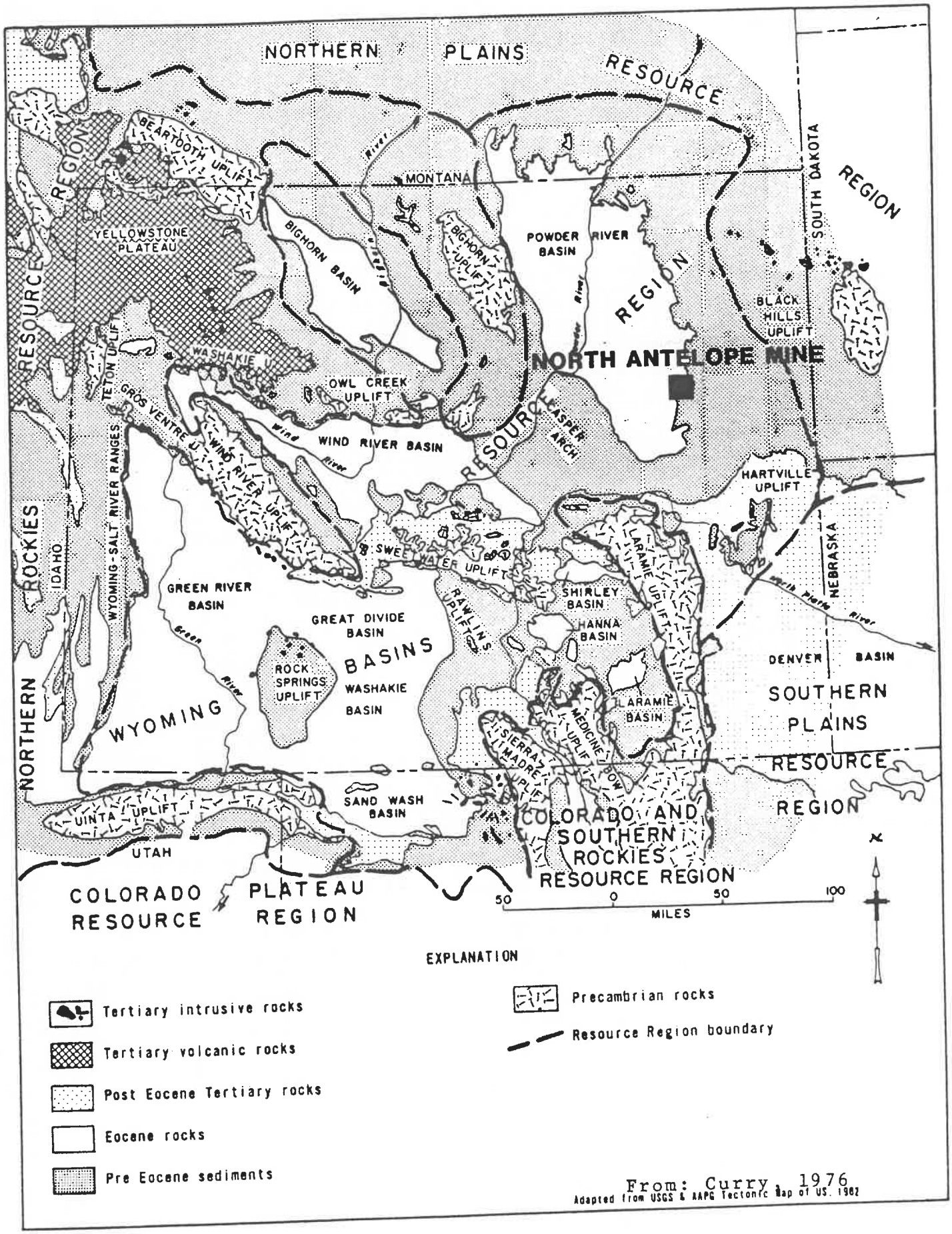
3, 4, 5, 8, 9, 10, 16, 17, 20, 21

The proposed railroad spur corridors occupy all or parts of the following sections in T41N, R70W:

21, 22, 27, 28, 32, 33, 34

The proposed access road corridor occupies all or parts of the following sections:

Sections 2, 10, and 11, T41N, R70W, and
Section 35 in T42N, R70W.

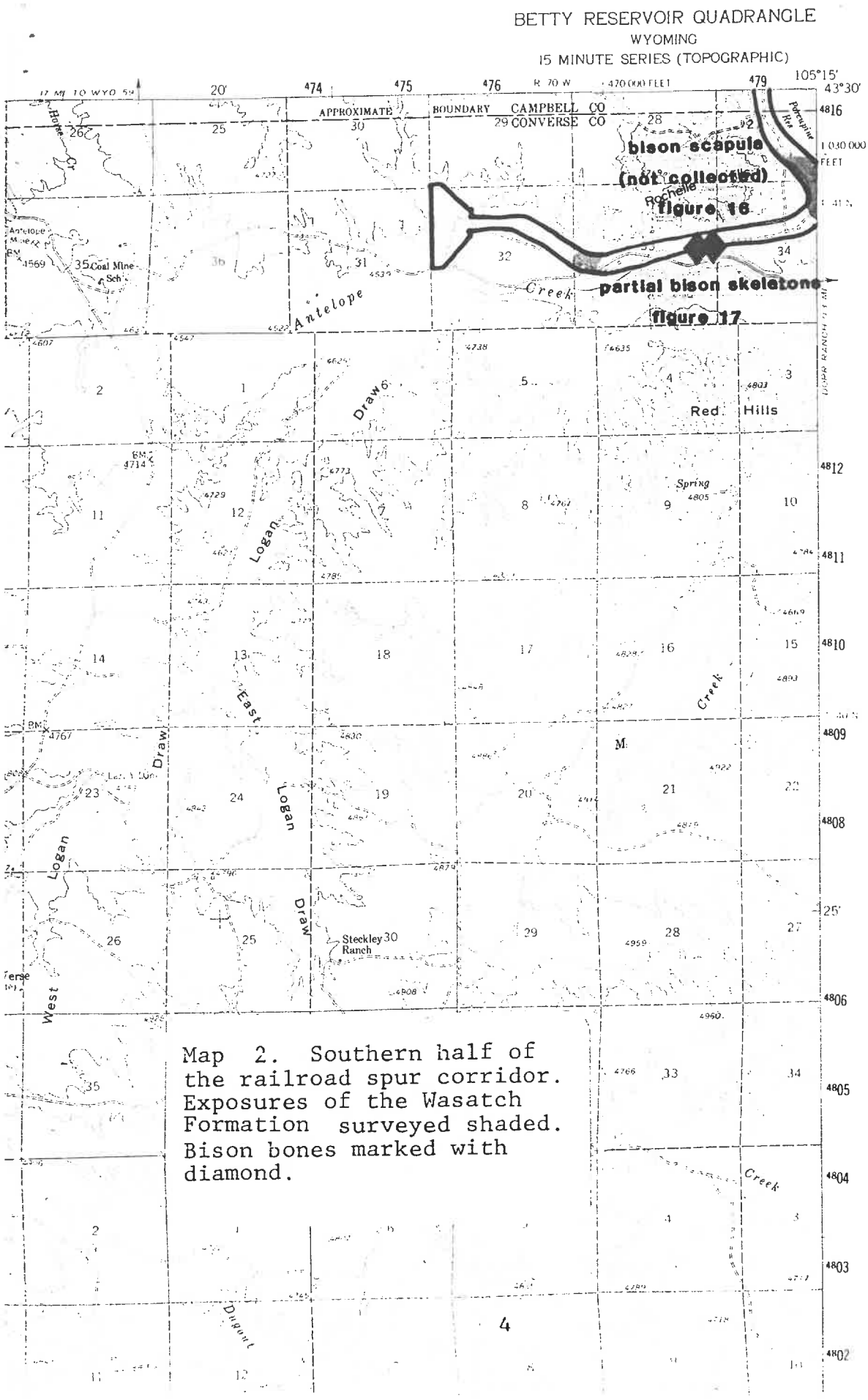


Map 1. Location of the study area.

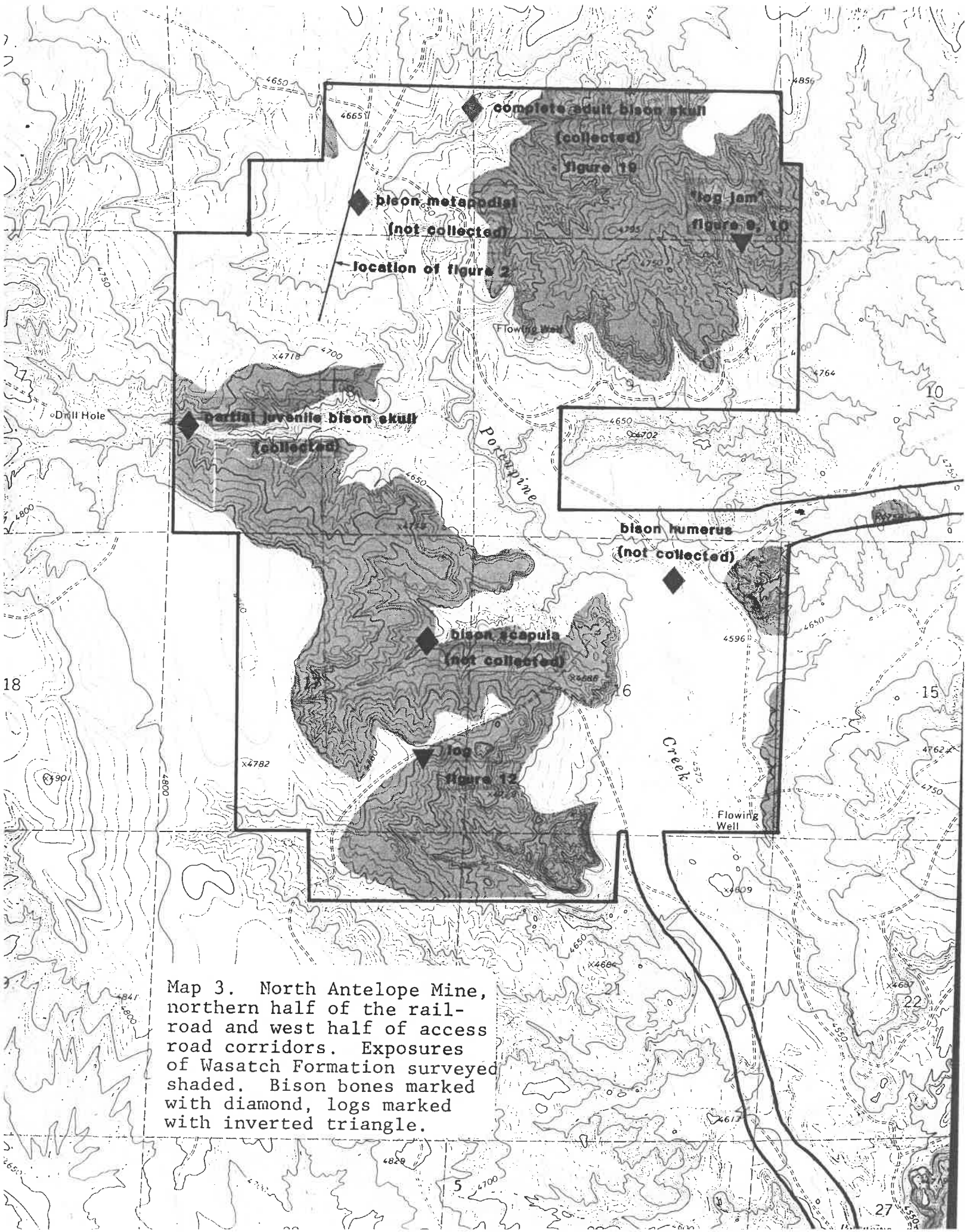
The locations of the mine and railroad spur and access road corridors and exposures surveyed are shown in Maps 2, 3, and 4.

PROJECT ORGANIZATION

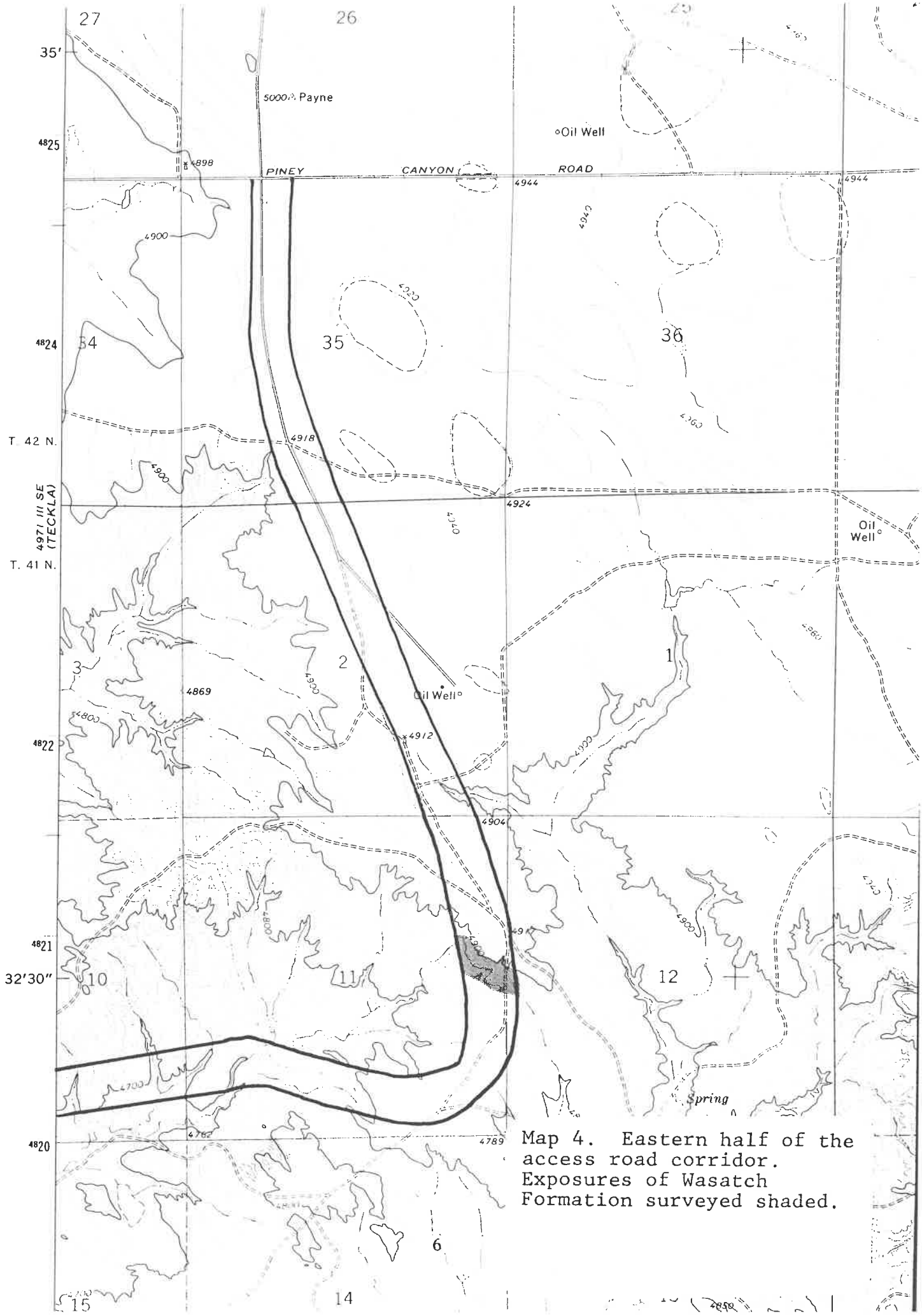
Thomas J. Lennon, Principal Investigator, oversaw all aspects of WCRM's responsibilities to the North Antelope Coal Company. Kenneth Carpenter conducted the field and literature surveys and the writing of the paleontological report. Thomas Lennon reviewed the report, with final typing by Barbara Walker. This survey was conducted under Federal Antiquities Permit Number 81-WY-018. This permit is issued under the authority of the Antiquities Act of 1906 (Public Law 59-209, 34 Stat 225, 16 U.S.C. 432, 433).



Map 2. Southern half of the railroad spur corridor. Exposures of the Wasatch Formation surveyed shaded. Bison bones marked with diamond.



Map 3. North Antelope Mine, northern half of the railroad and west half of access road corridors. Exposures of Wasatch Formation surveyed shaded. Bison bones marked with diamond, logs marked with inverted triangle.



Map 4. Eastern half of the access road corridor. Exposures of Wasatch Formation surveyed shaded.

METHODS

The paleontological survey of the Project was conducted in two parts: an initial literature search at the University of Colorado Earth Science Library and Museum, and at the University of Wyoming Geology Library and Museum. The literature search was followed by the field survey.

The literature search revealed that the most common fossils which might be encountered were leaves in the Wasatch Formation (Brown 1962) and bison bones in the stream terraces (Leopold and Miller 1954). Less common and therefore more important fossils from the Wasatch Formation include snails and clams (Taylor 1975) and vertebrates (Delson 1971; Carpenter 1980).

Most of the snails, clams, and vertebrates in the Wasatch Formation are not randomly distributed, but are commonly limited to certain sediments and strata, or are concentrated in small pockets. In order to locate such strata or pockets, it was necessary to conduct the field survey on foot and systematically walk selected outcrops. In order to maximize the total area covered at each exposure, the outcrops were traversed in a zigzag pattern. Outcrops were selected on the basis of areal exposure, with special emphasis on sandstone and blowouts because these have produced fossil vertebrates elsewhere in the Wasatch Formation of the Powder River Basin. Areas of the Wasatch Formation surveyed are shown in Maps 2, 3, and 4.

Bison bones were identified by comparison with modern bison skeletons in the osteology collection of the University of Colorado Museum at Boulder.

GEOLOGICAL SETTING

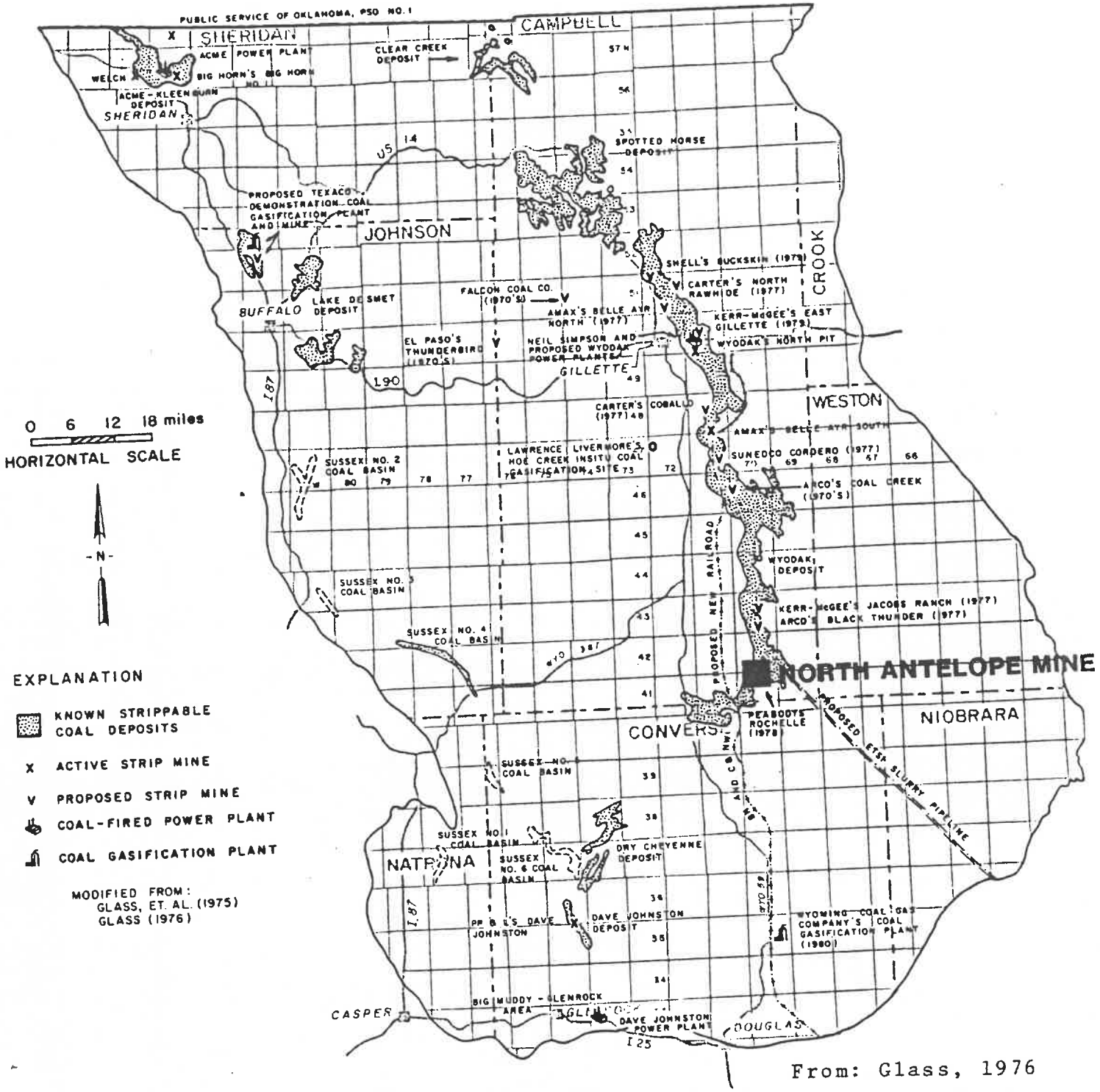
The Project area is in the southern part of the Powder River Coal Basin (Map 5) and will mine coal from the basal Wasatch Formation. The Powder River Coal Basin occupies a structural basin filled with early to middle Tertiary sedimentary rocks with older Cretaceous rocks exposed around the periphery (Map 6). Coal occurs in many of these formations, but are thickest in the Fort Union and Wasatch formations (Glass 1976, 1980). Figure 1 shows the stratigraphic interval of the Wasatch Formation examined during this survey.

Within the Project area, the dominant rocks are of the Lower Eocene Wasatch Formation. Minor amounts of recent alluvium occur as terraces and valley fill. The two most prominent terraces in the Project area are the Kaycee and Lightning terraces of Leopold and Miller (1954). The geomorphic position of these terraces along Porcupine Creek is shown in Figure 2.

Within the Project area the Wasatch Formation is predominantly carbonaceous shales and mudstone (Figure 3), with lesser amounts of coal and sandstone (Figure 4). The sandstone is fine to medium-grained, white to yellow in color. Locally, bright red or orange clinker (scoria) mark areas where burning coal has baked the overlying rocks. The sandstone and clinker locally form an erosionally resistant cap producing an irregular topography (Figure 5). Within the Project area, topographic relief may exceed 280 ft (85 m).

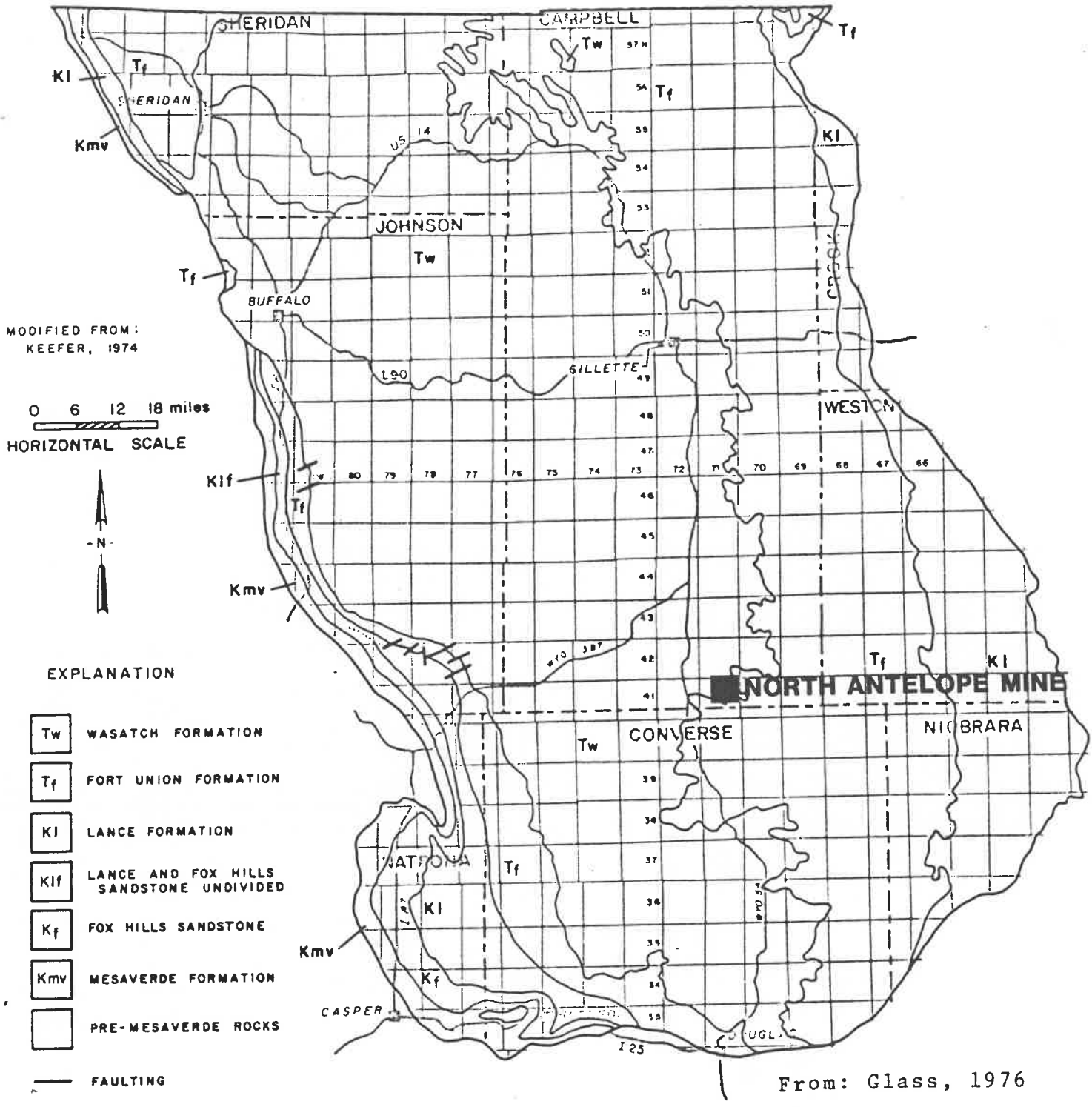
The dominance of overbank sediments and the internal morphology of sandstone bodies indicate that most of the streams flowing through the Project area during the Early Eocene were meandering, with stream flow towards the north and northwest. Seeland (1976) has plotted stream flow direction for the Wasatch Formation permitting him to compile a generalized drainagae map for the Powder River Basin during the Early Eocene (Map 7).

Coal production in the Wasatch Formation was probably in peat-producing swamps developed on the flood plains lateral to river channels (Figure 6). This interpretation is based upon my own observations supplemented by studies by Matson and Pinchock (1975), Weimer (1976), and Obernyer (1976). Ethridge and Jackson (1980) offer an alternative hypothesis where peat accumulates as topographic platforms parallel to the river



From: Glass, 1976

Map 5. Location of the study area in relationship to coal resources and development in the Powder River Coal Basin.



Map 6. Geological map of the Powder River Basin.

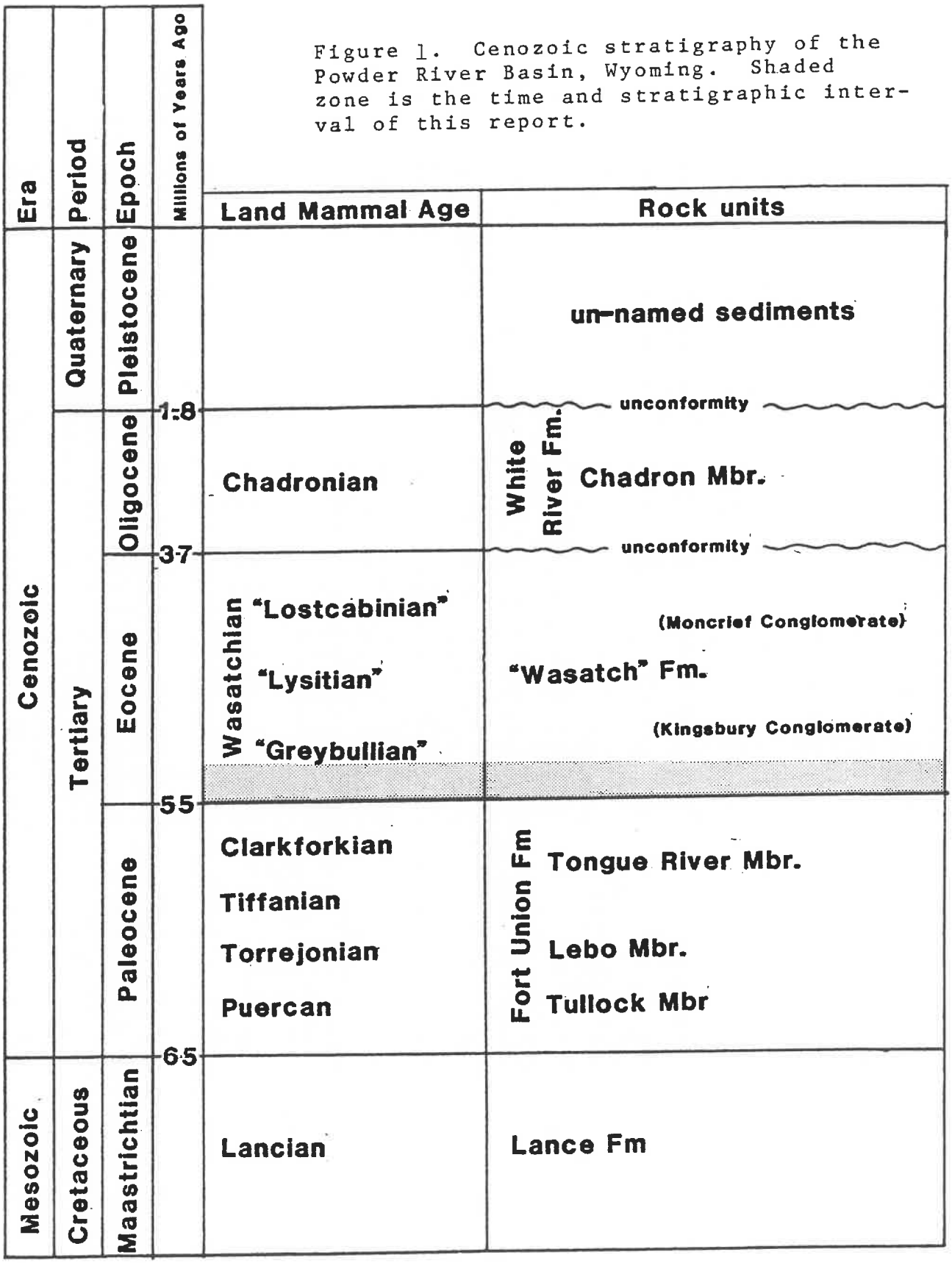


Figure 1. Cenozoic stratigraphy of the Powder River Basin, Wyoming. Shaded zone is the time and stratigraphic interval of this report.

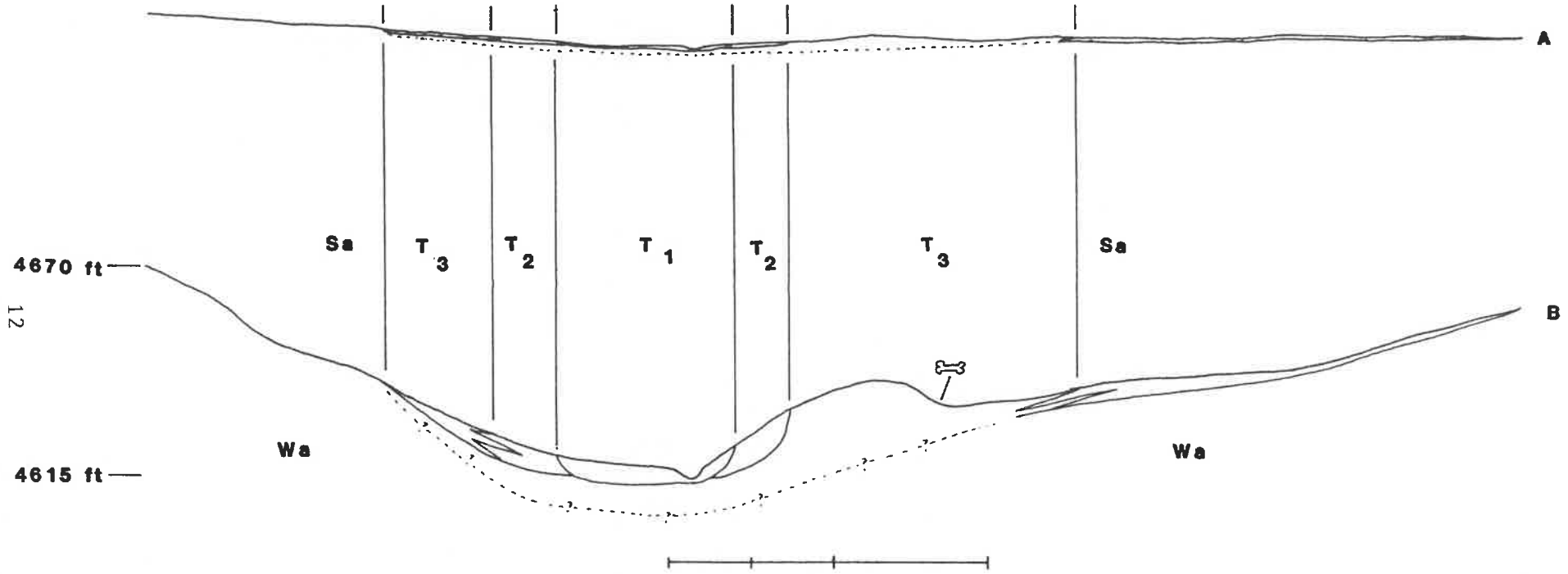


Figure 2. Terrace sequence along Porcupine Creek (see map 3 for exact location). A, terrace sequence without vertical exaggeration. B, same terrace sequence as A, but with x60 exaggeration. SA - Sheetwash and Alluvium; T_1 - Lightning Terrace; T_2 - Moorecroft Terrace; T_3 - Kaycee Terrace; Wa - "Wasatch" Formation. Cross-section made from Surficial Geology Map of North Antelope Mine by Davis, 1980.

Figure 3. Exposures of carbonaceous shales, siltstones, and mudstones. Wasatch Formation, northeastern North Antelope Mine.

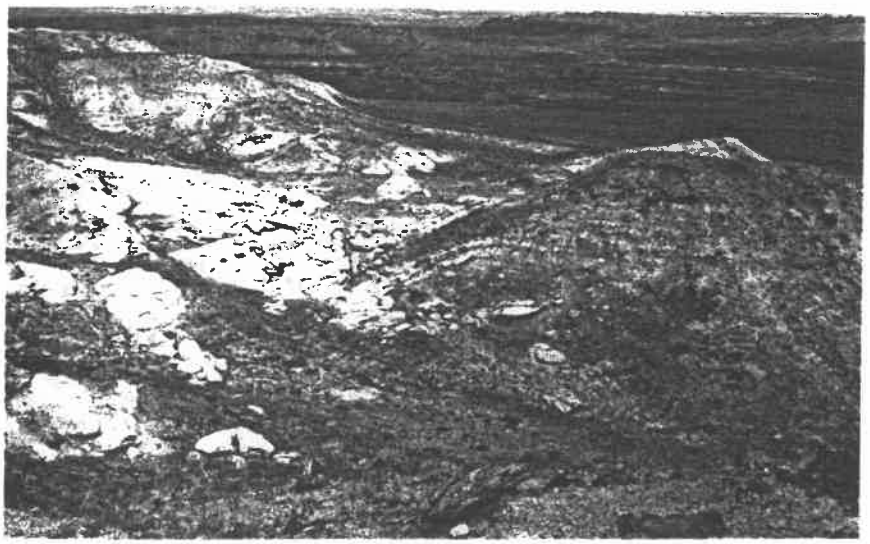


Figure 4. Sandstone outcrop. Wasatch Formation, south-central North Antelope Mine

Figure 5. Irregular topography produced by erosionally resistant sandstone.

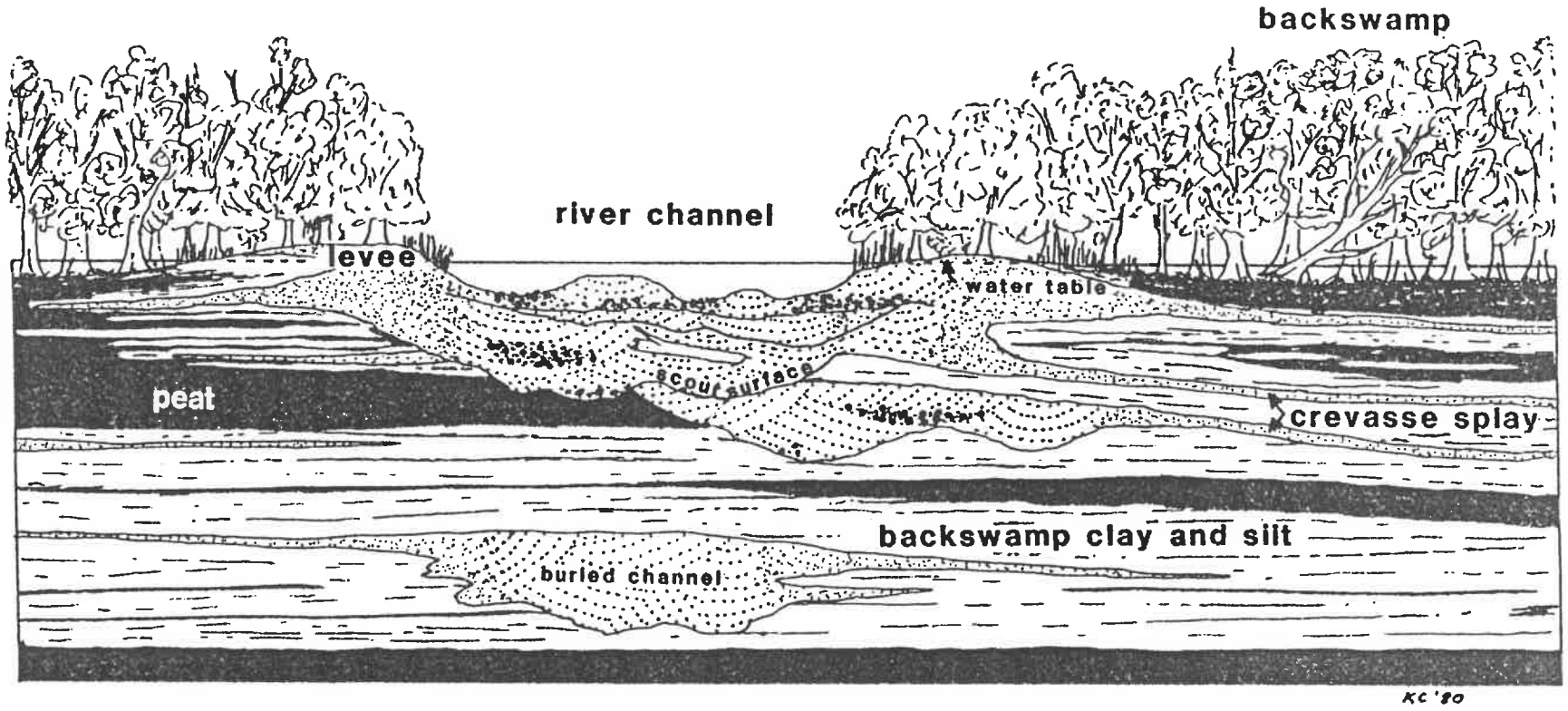


Figure 6. Reconstruction of the depositional environments at the North Antelope Mine during the Early Eocene.

channel, thus restricting any lateral shifting of the channel. Peat accumulation is constant and prevents the river from ever reaching the upper surface of the peat, despite the deposition of sediments in the channel.

The problem with the Ethridge-Jackson model is that many coal seams in the Powder River Basin are not conformably adjacent to river channels as their model requires. Furthermore, their model is based upon an interpretation for peat in a narrow riverine valley and which could not work in an area as broad as the Powder River Basin.

Regardless of the correct model for the origin of the Powder River Basin coal, a balance must be maintained between basin subsidence and sedimentation input in order to produce economically mineable coal (Weimer 1976).

The youngest strata in the Project area are found in the stream terraces developed in the present drainages. These terraces may be viewed as former stream valley floors and may form in response to streams alternatively filling and eroding their valleys. The cause for this change in stream behavior is not fully understood but may be in response to fluctuations in precipitation and ground cover (Leopold and Miller 1954). Since precipitation fluctuations would be expected to occur on a regional scale, Leopold and Miller assumed that many, if not all, of the streams and rivers in an area would show similar and presumably synchronus development of terraces. However, as Albanese (1979) has correctly pointed out, local influences may mask the features used to show the sequence of terrace development and thus make long distance correlations of terraces difficult if not questionable.

It is not certain when terrace development in the Project area began since no radiocarbon dates are available. However, assuming that the terrace sequence in the Project area has been correctly identified (Figure 2), then the oldest terrace is equatable to the Kaycee Terrace of Leopold and Miller (1954), the next oldest with the Moorcroft Terrace, and the youngest with the Lightning Terrace. Leopold and Miller have assigned dates of 4000 to 1500 B.P. for the Kaycee Terrace, 2500 to 1000 BP for the Moorcroft Terrace, and 700 to 600 B.P. for the Lightning Terrace, from dates available for terraces in the Southwest. All but the Lightning Terrace have been shown by radiocarbon dates from various areas in the Powder River Basin to encompass a longer span of time

(Albanese and Wilson 1974) and thus dates cannot be reliably assigned to cultural or fossil material from the terraces in the Project area. Only the Lightning Terrace date as determined by Leopold and Miller corroborates with the radiocarbon dates of Albanese and Wilson (1974).

Bison bones are common in the terrace sediments of the Project area, especially the Kaycee Terrace in the railroad spur (see Survey Results). These bones could be used to obtain a radiocarbon date for these sediments; however, because of the lack of associated cultural material, these dates would have little meaning beyond their immediate vicinity.

The terrace sequence as determined by Leopold and Miller (1954) for the Powder River Basin is presented in Figure 7 to assist in the interpretation of Figure 2. Figure 8 shows an example of a terrace deposit in the Project area.

Figure 7. Schematic representation of the topographic and stratigraphic relationships of alluvial sediments in the Powder River Basin (taken from Leopold and Miller (1974:194).

Figure 8. Sediments of the Kaycee Terrace, north bank of Antelope Creek, railroad spur corridor.

SURVEY RESULTS

Exposures of the Wasatch Formation in the Project area are good, with most of the exposures developed around the rim of drainages and on the sides of drainage divides (Map 3). The best and most extensive exposures are carbonaceous shales and mudstones representing flood plain and backswamp facies, in Sections 4 and 9, T41N, R70W, and sandstone interbedded in carbonaceous shales; and mudstone and coal, representing a complex system of channel, near-channel, floodplain, and backswamp facies in Sections 16 and 17, T41N, R70W. Examples of these two major areas are shown in Figures 3 and 4 respectively.

Fossil material in the Wasatch Formation seen during this survey was predominately of plants and consists of leaves, logs, and indeterminate debris. Leaf impressions are extremely common in carbonaceous shales, where they form dense mats. Leaf impressions are also common in sandstone; however, are usually limited to zones or layers and may represent times of nondeposition by the streams.

Logs are commonly seen in both carbonaceous shale and sandstone, although in neither are they as common as leaves. A "log-jam," consisting of at least six logs, was seen in a sandstone outcrop in Section 4 (Figure 9; Map 3). Elsewhere, the logs occur as isolated and fragmented specimens (Figures 10 and 11). One exception is a log, of which 21 feet (six meters) is exposed (Figures 12 and 13). The log was found at the top of a coal seam and has been flattened by the overlying sediments (Figure 14).

Fossil vertebrates have been reported from the Wasatch Formation of the Powder River basin by Delson (1971) and Carpenter (1980). Most, but not all, of these fossils were located in blowouts where they accumulate as lag deposits after the wind has winnowed out the finer-grained sedements. For this reason, a considerable amount of time was spent examining blowouts in the Project area, expecially on the south slope of a ridge in Sections 16 and 17, T41N, R70W (Figure 15). In addition, numerous anthills were examined because the western harvester ant, Pogonomyrmex occidentalis, often adds fossilized bones and teeth to their mounds. Hatcher (1896) working in the Lance Formation on the eastern rim of the Powder River Basin, reports collection of over 300

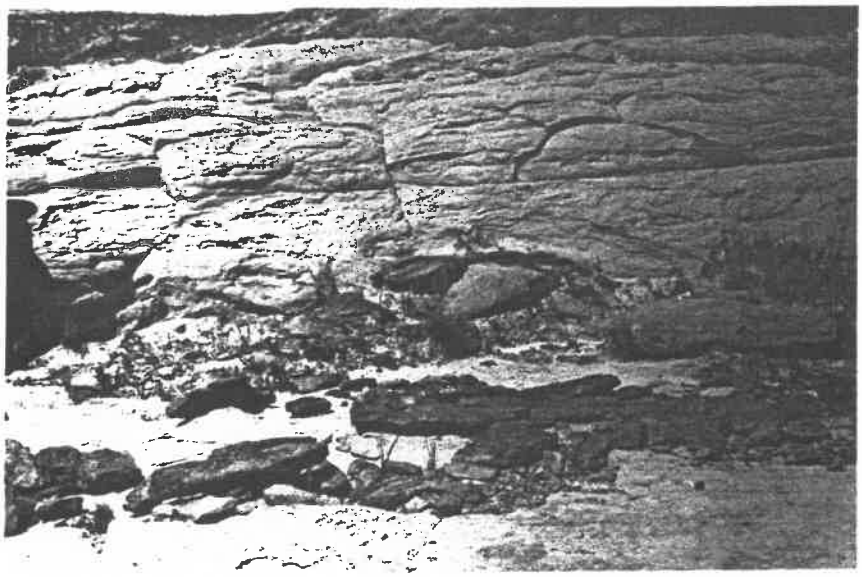


Figure 9. A "log-jam" in a channel sandstone.

Figure 10. Fragmented log at the top of a lignitic shale.

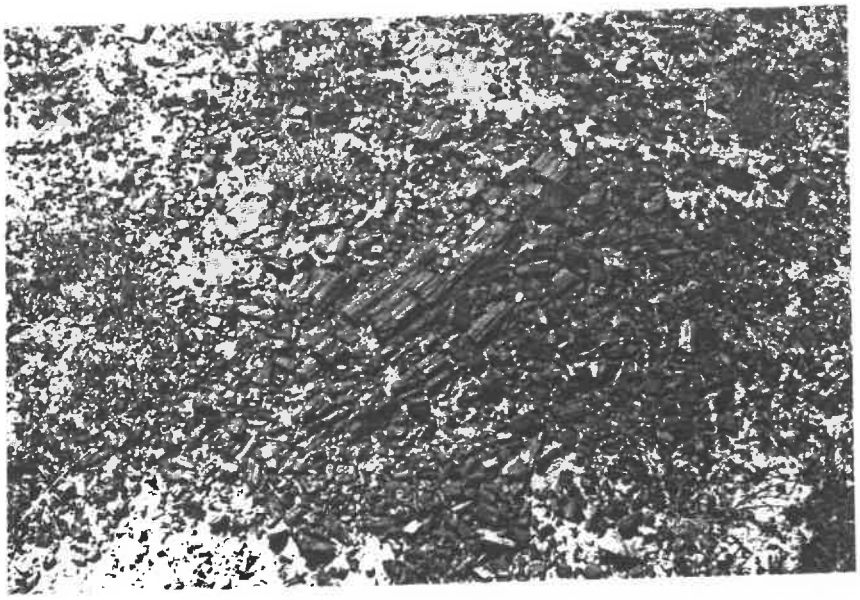


Figure 11. Very fragmented log eroding from sandstone.

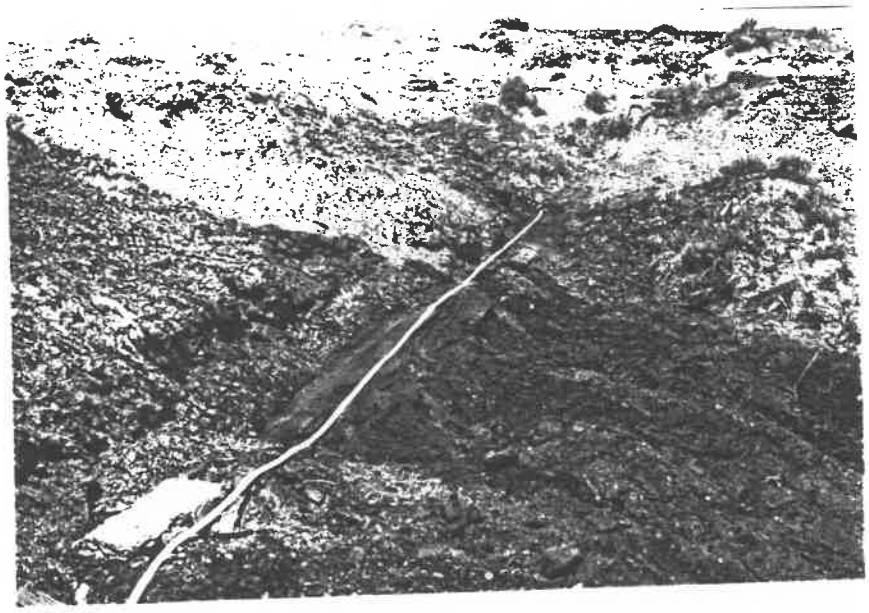


Figure 12. A 21-foot (six meter) fossil log eroding out near the top of a coal.

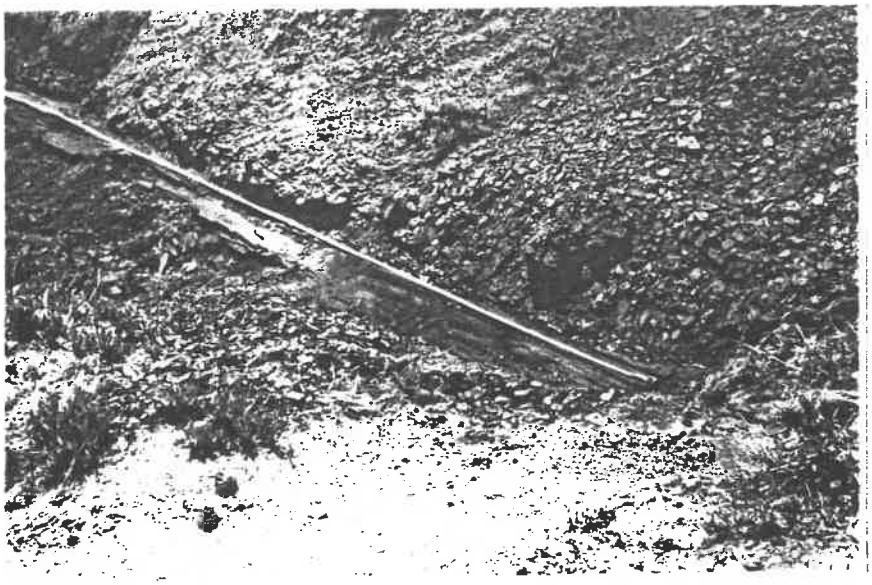


Figure 13. The fossil log shown in Figure 12 still covered by overburden.

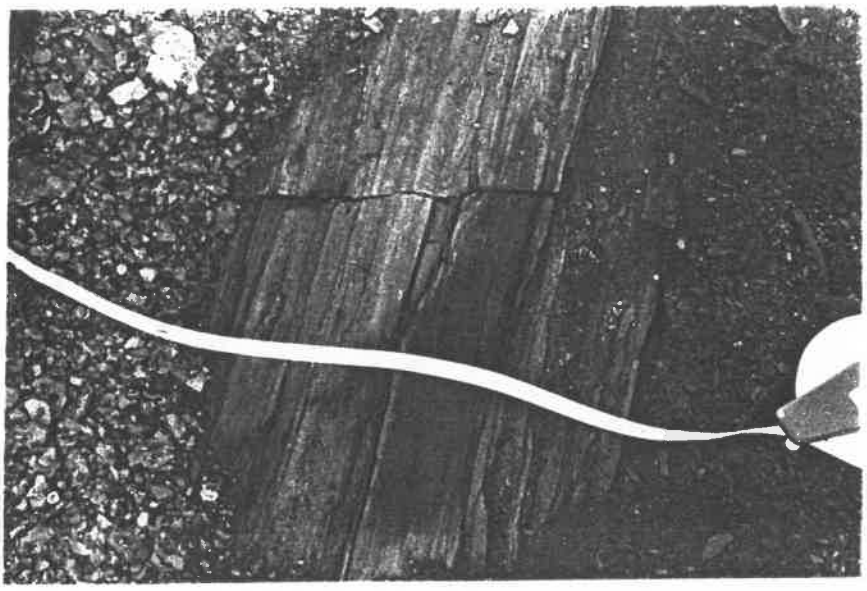


Figure 14. Close-up of the fossil log shown in Figure 13.

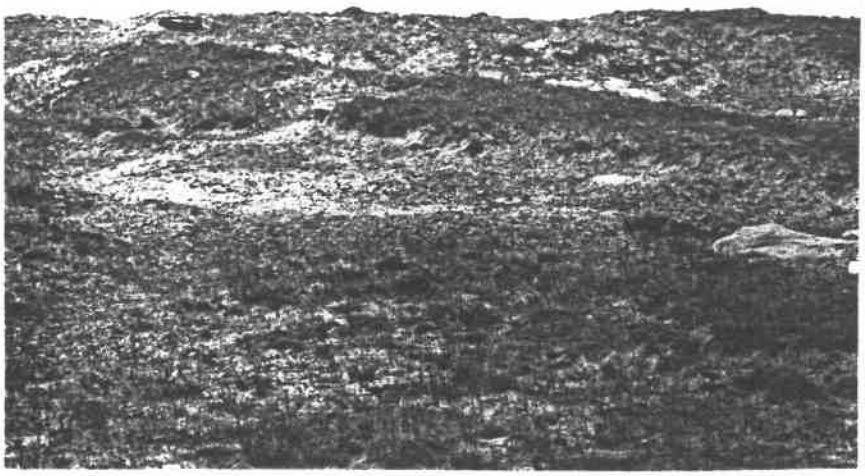


Figure 15. One of several blowouts in the southern part of North Antelope Mine that was systematically crawled for small rodent-sized bones.

Figure 16. A bison scapula uncovered in the Kaycee Terrace in the railroad spur corridor.

teeth and jaws of fossil mammals from one anthill alone. Results of this careful searching in blowouts and anthills was disappointing as not one fragment of fossilized bone was found.

The only bone remains identified in the Project area were bison. Most of these were found in terrace deposits and in valley fill (Figures 16 and 17). A partial skeleton was recovered from the upper part of the Kaycee Terrace in the railroad spur corridor (Figure 18, Map 2) and parts of another nearby (Figures 16 and 17). The BLM obtained a complete skull of Bison bison (Figure 19) from the base of a terrace in the north-central part of the mine (Figure 20, Map 3). This skull was transferred to WCRM on May 6, 1981. A fragment of a juvenile skull with one horn was also obtained from terrace sediments in Roger's Draw (Map 3).

Both of the bison skulls are referred to as Bison bison bison because of the inferred age of the sediments from which the skulls were collected and because of insignificant differences in measurements of the adult skull and those of Bison bison bison from the osteology collection of the University of Colorado Museum (Figure 21 with Table 1).

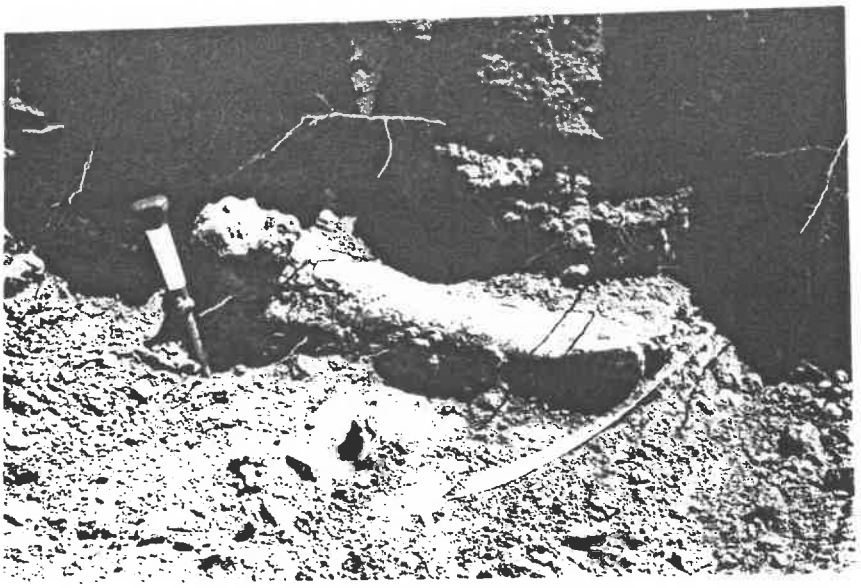


Figure 17. Tibia and rib fragments of a bison from the same area shown in Figure 16.

Figure 18. Site where a partial bison skeleton was removed from a Kaycee Terrace in the railroad spur.

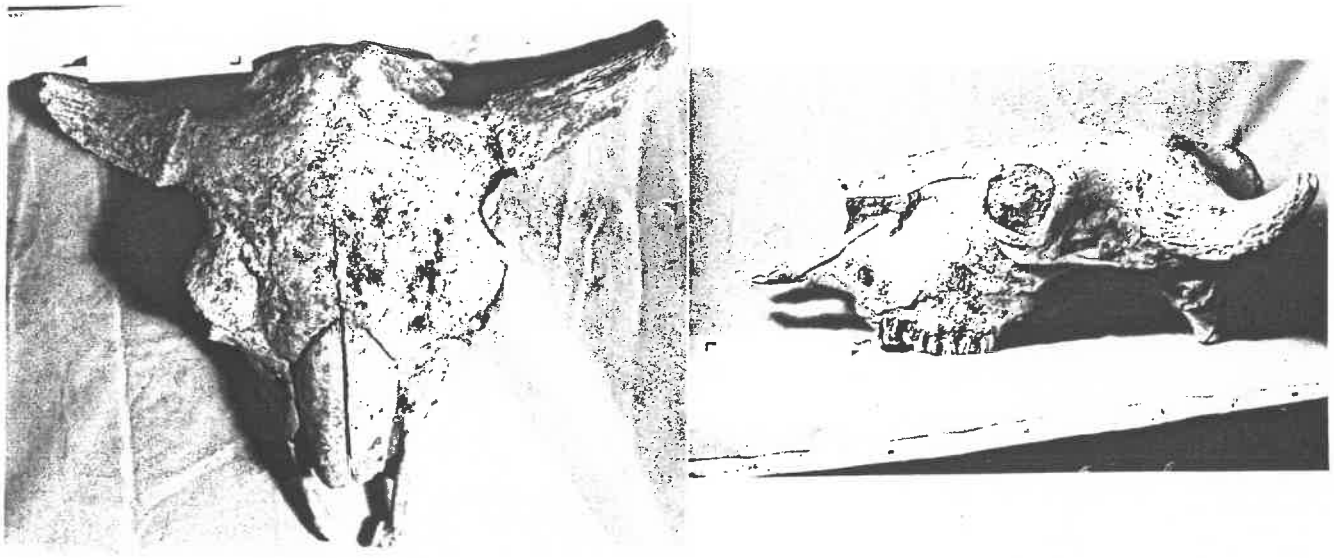


Figure 19. A complete bison skull from North Antelope Mine.

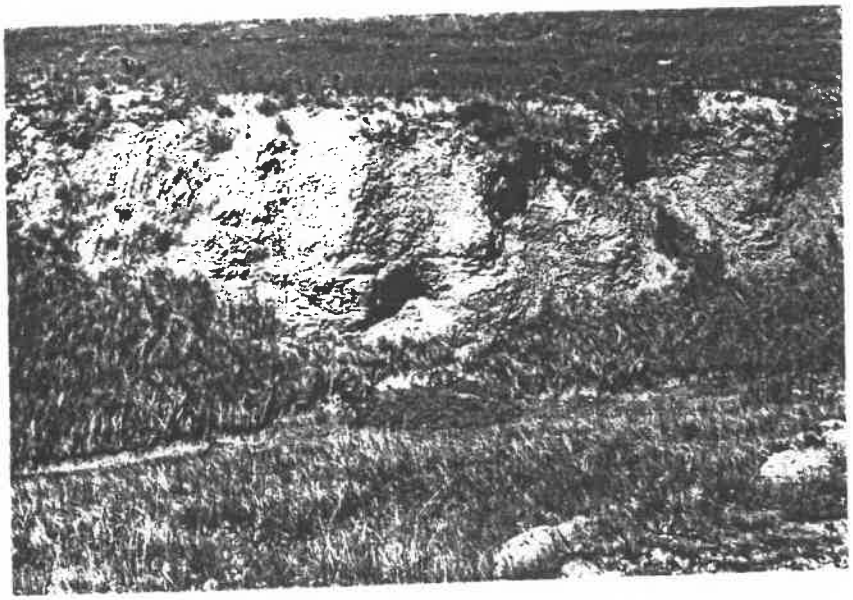


Figure 20. Location of bison skull shown in Figure 19. Excavation pit at the base of the terrace.

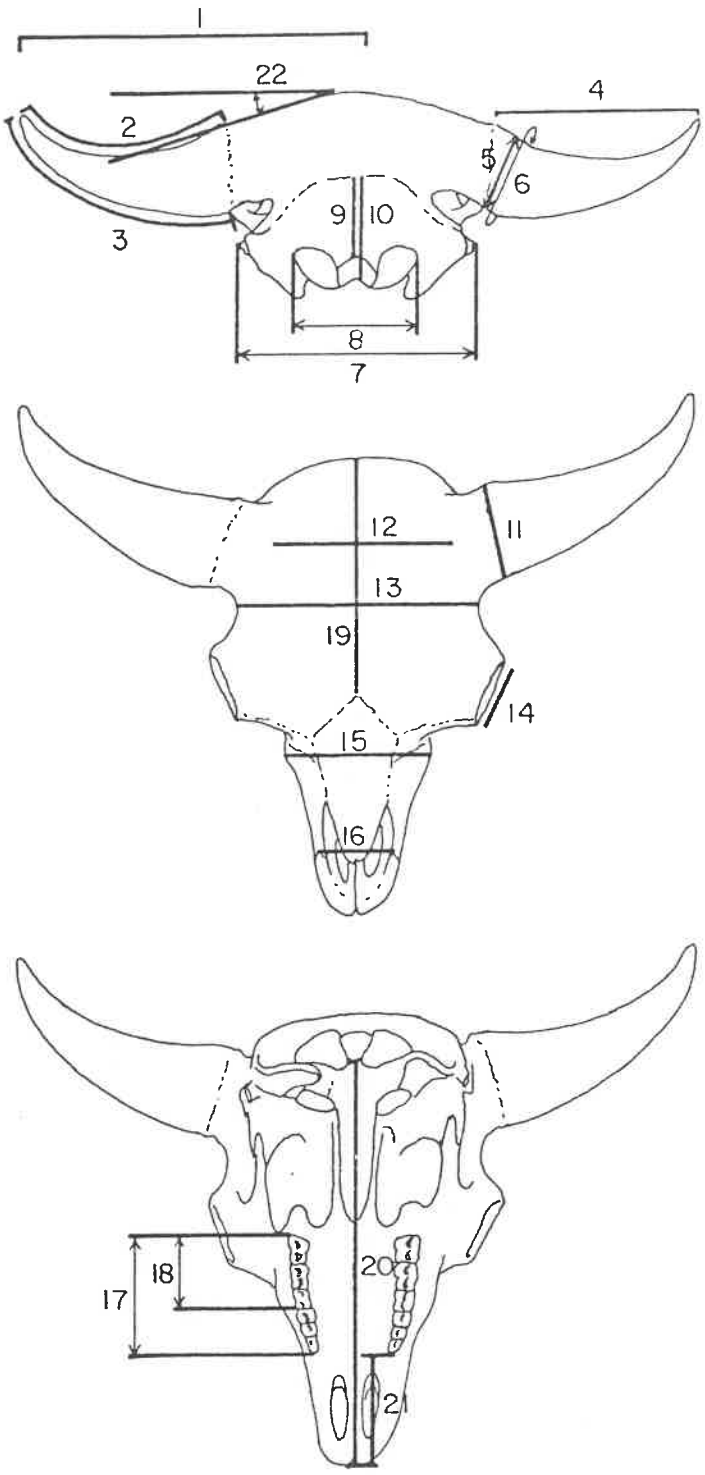


Figure 21. Location for the measurements listed on Table 1 for bison skulls.

Table 1. Comparative Measurements for Modern and Subrecent Bison Skulls

	North Antelope Mine Skulls		University of Colorado Museum
No	Adult	Juvenile	Skull 4983
1*	31.5	28.2	
2	21.4	35.4	
3	24.3	12.5	27
4	19	16	18.2
5	24.6	24.8	
6	7.57	7.9	
7	26.3	14.2	25
8	16.0**	12.1**	
9	10	11.4	
10	13.6	15	
11	8.6	8.8	
12	22**	21.5**	
13	27**	26**	
14	7.8	6.8	
15	20.2**	18.8**	
16	13	11.5	
17	14.6	15	
18	9	9	
19	26	24	
20	47	49.3	
21	13.1	14.5	
22	35^{o}	50^{o}**	18^{o}

* See Figure 21 for location of measurements; all measurements are in centimeters.
**Approximate measurement

CONCLUSIONS AND RECOMMENDATIONS

The most abundant fossils in the Project area are leaves which usually occur as impressions in sandstone and as compact masses in carbonaceous shales. These leaves will be frequently encountered during mining and construction activities in the Project area; however, because of the widespread distribution of these leaves in and around the Project area as well as elsewhere in the basal Wasatch Formation, no collections were made. It is doubtful that mining and construction activities will result in a several and irreplaceable loss of information about the Early Eocene flora in the Powder River Basin.

Fossil logs were also frequently encountered, although most were short fragmentary specimens. One log over six meters long was found at one locality, and owing to its unusual completeness it is recommended that it be salvaged. Overburden is not thick and the log can be salvaged with minimal difficulty. The log may be turned over to the Historical Museum in Gillette for display or possibly put on display at the Administrative Office at the North Antelope Mine. If the latter course is decided on, then arrangements should be made for a transfer of the log once mining operations are terminated.

Bison bones were the only vertebrates found during this survey. Unless there was a considerable portion of a skeleton or unless the material was a skull, the bones were left in the field. It is possible that some of the bones collected, especially the two partial skeletons, have cultural processing marks. These will be discussed in Volume I of this report. There may be additional bison material buried in the Project area, but in all probability the bones will be of the modern bison species and so of little paleontological interest.

One of the primary goals of the paleontological survey was to locate fossil vertebrates in the Wasatch Formation as have been reported by Delson (1971) and Carpenter (1980). Their total absence at the North Antelope Mine was puzzling until a comparison was made of the sediments in the Project area with those of fossil sites of Delson and Carpenter. One of the most distinctive differences was the absence of coal and the near absence of carbonaceous shale at Delson's and Carpenter's localities. The flood plain

sediments are mostly tan to yellow, with some red bands near Delson's localities. This is in sharp contrast to the flood plain sediments in the Project area which are predominantly shales and coal.

The sediments at Delson's and Carpenter's localities are interpreted as well-drained swamps and soils with high Eh (oxidizing environment) where groundwater rarely became acidic. This type of environment is conducive for fossilization of bone.

In the Project area, the dominance of carbonaceous shale, the abundance of plant debris and coal, and the presence of pyrite nodules indicate low Eh (reducing). This is interpreted as poorly drained swamps and water-logged soils. In such a moist environment, subaerial decomposition of leaf litter can lower soil and water pH to as low as 2.8. These low pH levels are the result of acid formation, especially carbonic and sulfuric. In such an environment, bone is decalcified as has been documented for Iron Age human bodies recovered from peat bogs in northern Europe. The best example is the Damendorf Man of whom only the skin and leather belt and shoe is preserved; the entire skeleton having been removed by decalcification (Glob 1971). Erye (1964) reports that many of these bogs have a pH below 4.

It might be argued that the coal swamps of the basal Wasatch were inhospitable to vertebrate life, as indicated by the absence of vertebrate fossils. That this is not true is shown by the report of two small fragments of bone from an anthill just above the contact of the Wasatch and Fort Union formations immediately north of the North Antelope Mine (Eaton 1979). Therefore, it would appear that vertebrate life did exist in the the Project area during the Early Eocene, but that the bones were destroyed by the low pH of the swamps. This makes any bone recovered from the basal Wasatch Formation important because this will permit an analysis and reconstruction of the coal vertebrate community. However, it is doubtful that any significant concentrations of Early Eocene vertebrates will be encountered during mining and construction activities since careful surveying of blowouts and anthills failed to produce any bones.

In summary, mining and construction activities should not be impeded at the North Antelope Mine, nor in the railroad spur and access road corridors by important fossils and fossiliferous deposits. There is, however, a fossil log which, because of its completeness, should be salvaged prior to mining activities.

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