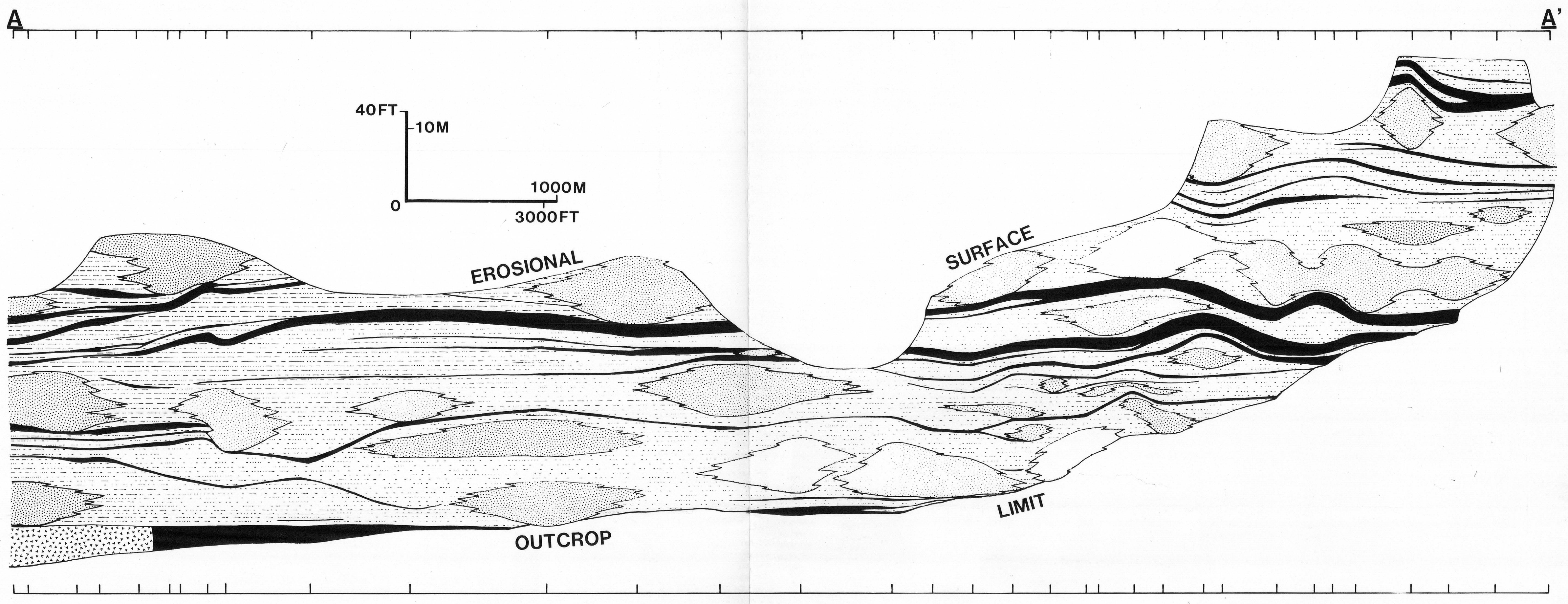
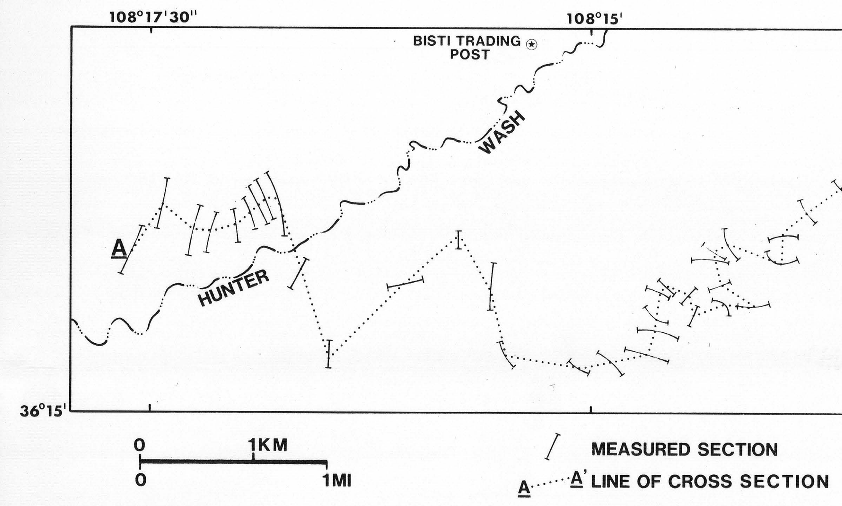
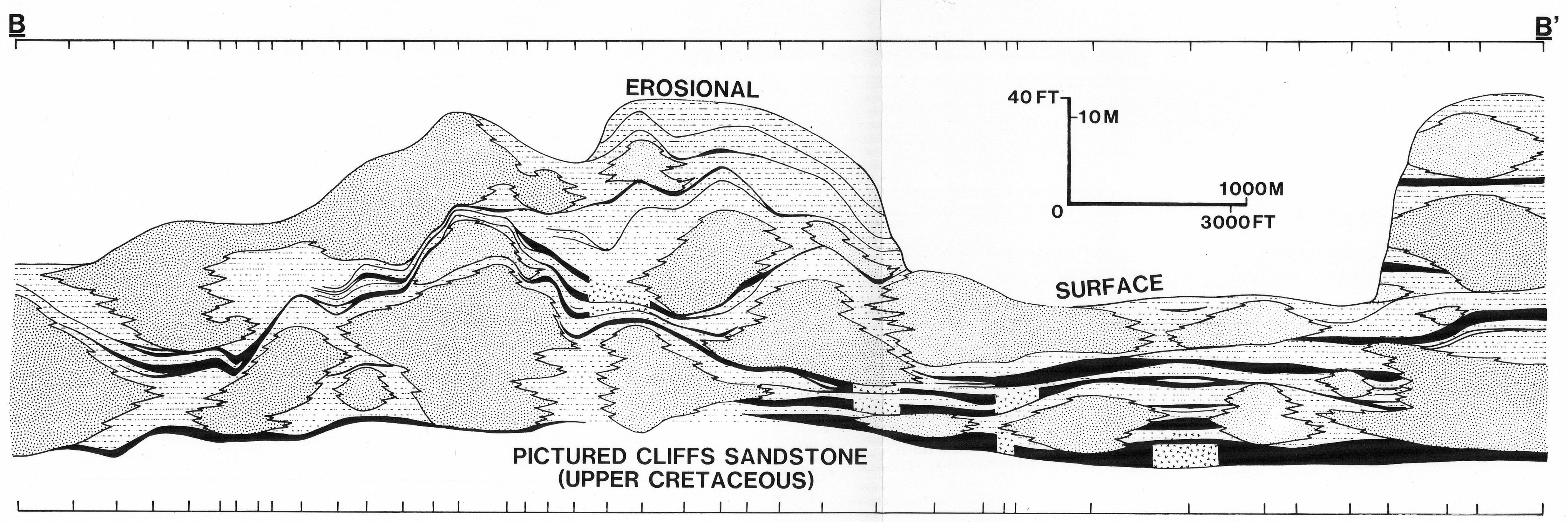
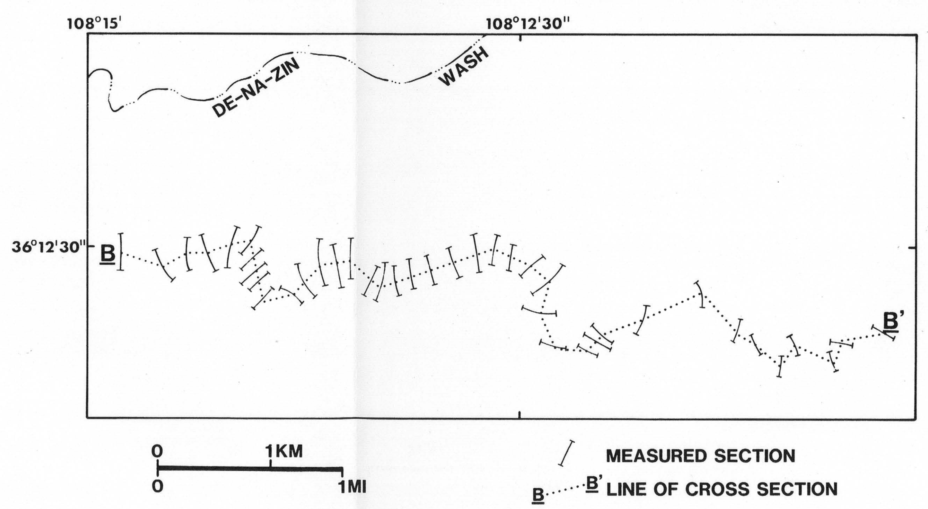
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

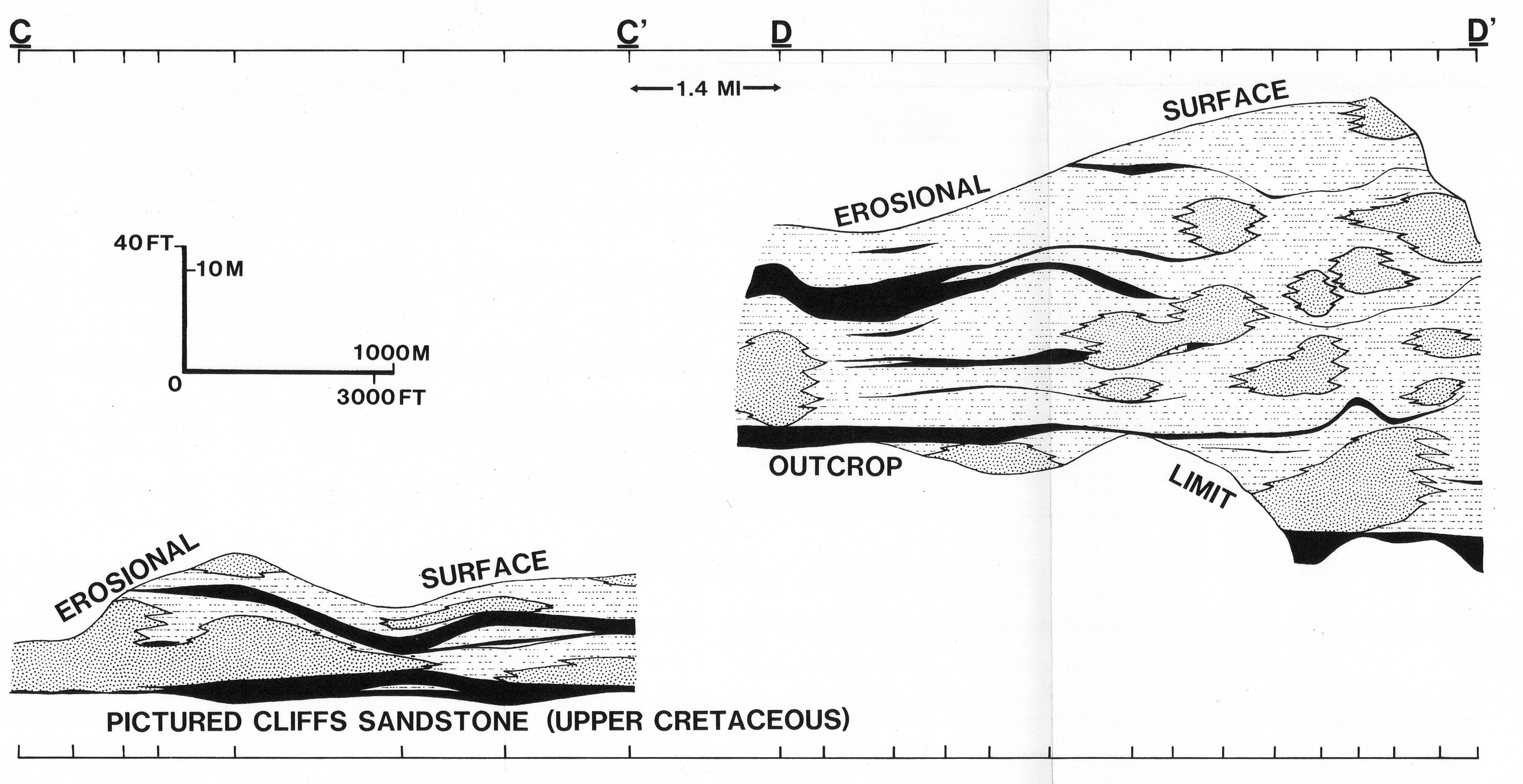
MISCELLANEOUS FIELD STUDIES
MAP MF-1390

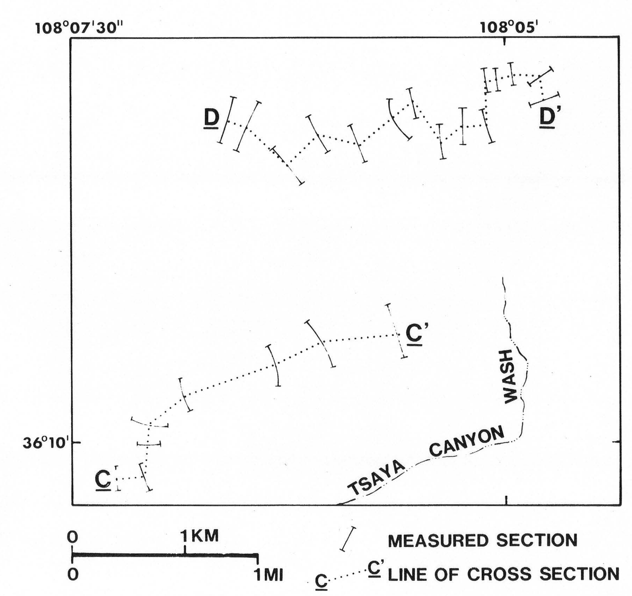


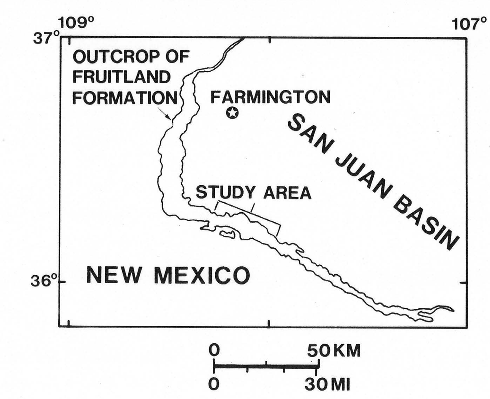


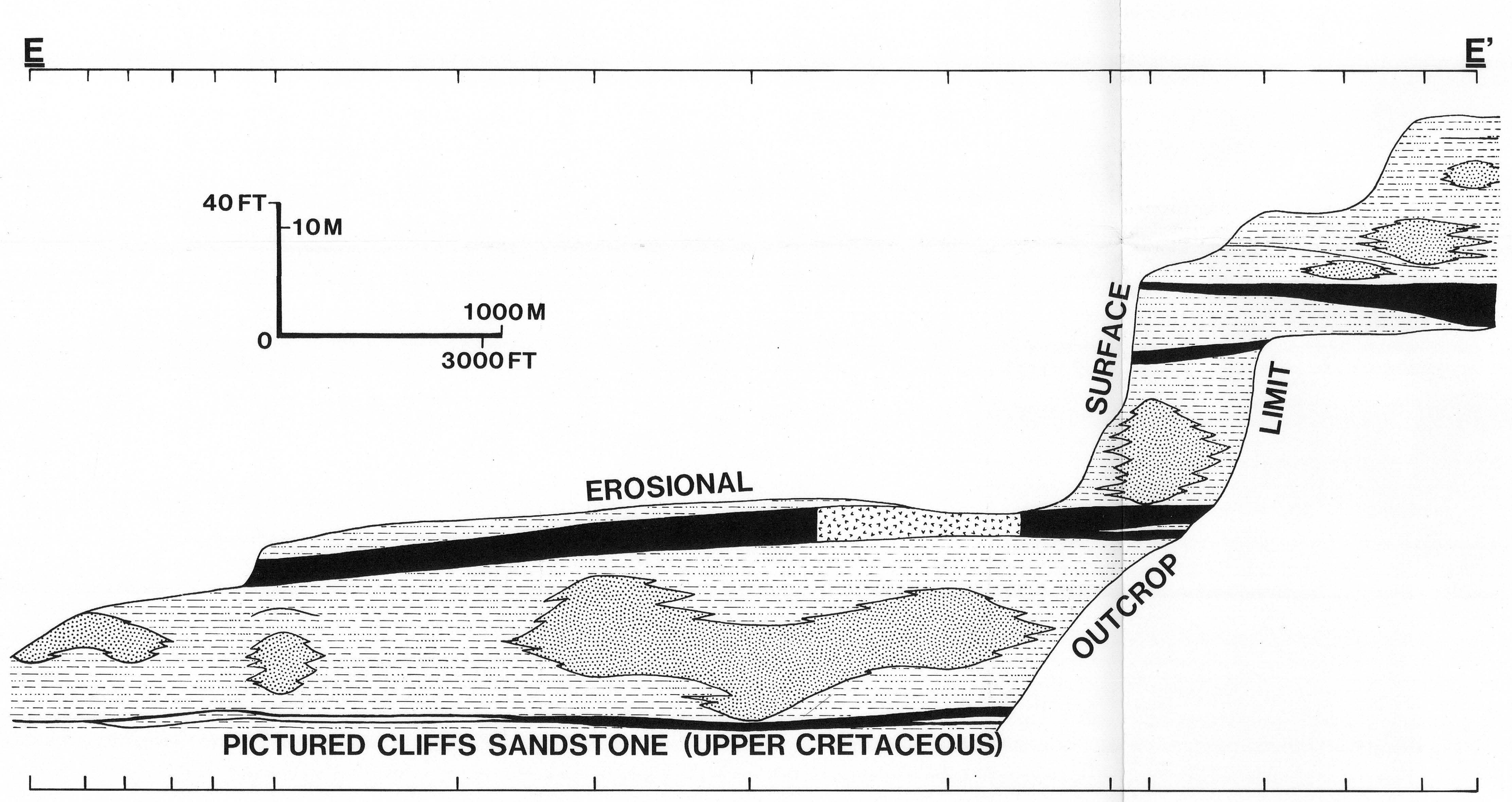


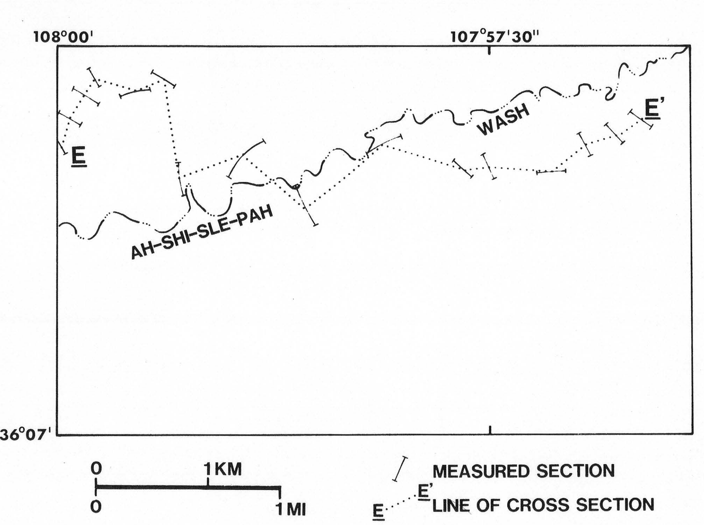












EXPLANATION

- COAL AND CARBONACEOUS SHALE
- SANDSTONE, SILTSTONE, AND SHALE
- CHANNEL SANDSTONE
- CLINKER
- TICK MARKS INDICATE WHERE STRATIGRAPHIC SECTIONS WERE MEASURED

INTRODUCTION

This report illustrates and describes the detailed stratigraphic framework and coal correlation of the Upper Cretaceous Fruitland Formation exposed in isolated badlands and along washes within a 20-mile outcrop belt in the Bisti - Ah-Shi-Sle-Pah area, southwestern San Juan Basin, New Mexico (see index). The stratigraphic framework showing the vertical and lateral distributions of rock types and the lateral continuity of coal beds is illustrated in cross sections. The cross sections were constructed from 112 stratigraphic sections measured at an average distance of 0.4 mi apart. Each section contained key marker beds (sandstone, coal, and tonstein) that were physically traced to adjacent sections. Each measured section was "hung" on multiple marker beds arranged in a geometric best-fit method that accounts for the differential compaction and facies associations of the deposits.

The Fruitland Formation, which is as much as 500 ft thick, was described by Fassett and Hinds (1971) as consisting of interbedded sandstone, siltstone, shale, carbonaceous shale, carbonaceous sandstone and siltstone, and thin, brackish-water, pelecypod-bearing limestone. However, in the study area, the Fruitland Formation averages 240 ft in thickness and consists mainly of sandstones, siltstones, shales, carbonaceous shales, and coals.

LITHOLOGY

The lithology and lithogenetic interpretation of the Fruitland Formation in the study area were described in detail by Erpenbeck (1979).

Sandstone: Sandstone comprises as much as 60 percent of the Fruitland detrital rocks in the study area. The color ranges from buff in weathered outcrops to light gray in fresh outcrops. The sandstone is very fine to coarse grained and ranges from a few inches to 65 ft thick. Genetically, the sandstone consists of channel and crevasse-splay types. These sandstone types were distinguished by the nature of the basal contact, vertical sequence of grain size, and internal structures. The channel sandstones show erosional bases and fining-upward sequences ranging from coarse to fine grained. The internal structures consist mainly of festoon and planar crossbeds, and some convolute and ripple laminations. The crevasse-splay sandstones show either gradational or sharp basal contacts and coarsening-upward sequences ranging from very fine to medium grained. The internal structures comprise mainly asymmetrical and climbing ripple laminations and some small-scale (as much as 4 in. thick) cross laminations. The crevasse-splay sandstones are distributed mainly lateral to channel sandstones; however, the channel sandstones locally cut out the crevasse-splay sandstones. The channel sandstones, which average 40 ft in thickness, range from 600 ft to 1.2 mi in lateral extent. The crevasse-splay sandstones, which average 4 ft in thickness, range from a few feet to 122 ft in lateral extent.

Siltstone: Siltstone ranges from light gray to dark gray and consists of very fine to coarse silt grains; many of the laminations are defined by "coffee grounds" that are composed of finely macerated plant fragments. The siltstone commonly contains narrow, smooth-walled, vertical burrows, stem and leaf impressions, and rarely tree trunks and tree stumps in growth position. Root mottlings are common biogenic bioturbations. This rock type vertically and laterally grades into the sandstones and shales. The siltstone and shale commonly contain ironstones that occur as siderite, limonite, and hematite deposits. These deposits, which are from a few inches to 2 ft thick, range from nodules to lenses; the latter deposits are laterally traceable for as much as 100 ft. Some of the nodule-shaped deposits show septarian features in which associated fissures were filled with barite. Some of these deposits contain stem and leaf fragments, and root marks.

Shale: Shale ranges in color from very dark gray to gray and is composed of clay-size grains. This rock type is commonly nonbedded; however, numerous beds show parallel and subparallel laminations that are marked by "coffee grounds". Root marks commonly destroyed these internal structures of the shale. Burrows, similar in form to those of the siltstone, also usually disturbed the bedding of this rock type. In two localities, fossils (brackish-water pelecypods and carapaces of turtles) were found imbedded in silty shales.

Carbonaceous shale: Carbonaceous shale is reddish brown in weathered outcrops and very dark gray to black in fresh outcrops. It consists of equal amounts of clay-size particles and very finely divided plant fragments, as well as macroscopically identifiable plant leaves, stems, and seeds. Petrified tree trunks are also common plant fossil remains. Carbonaceous shales are commonly interbedded with or laterally grade into coal beds.

Coal: Coal deposits in the Fruitland Formation are subbituminous and range in heat value from 6,700 to 13,700 Btu. Chemical analyses of core samples of the coal deposits in the Bisti Trading Post and De-Na-Zin areas are found in Wilson and Jentgen (1980). In the study area, coal beds range from a few inches to 12 ft in thickness and have a lateral continuity of as much as 3.5 mi along the cross sections. Some of the coal beds have been traced considerably farther in the subsurface by Jentgen and Fassett (1977) and Wilson and Jentgen (1980). Splitting and merging, common characteristics of the coal beds, are often caused by channel and crevasse-splay sandstones. A few coal beds contain tonsteins that were used for correlation.

STRATIGRAPHIC FRAMEWORK AND COAL CORRELATION

The stratigraphic framework and coal correlation of coal beds of the Fruitland Formation in the study area are shown in cross sections A-A', B-B', C-C', D-D', and E-E'. Cross section A-A' shows the vertical and lateral variation of the rock types of the Fruitland Formation in the Bisti Trading Post area (fig. 2). More than 50 percent of the Fruitland Formation in this area is composed of interbedded sandstone, siltstone, and shale. Forty percent of the formation consists of channel sandstone, and less than 10 percent is composed of coal and carbonaceous shale. The interbedded sandstone, siltstone, and shale that underlie, overlie, and laterally grade into the channel sandstones represent overbank and crevasse-splay deposits. The channel sandstones, which are generally laterally extensive in the upper part of the interval, indicate well-developed, meandering channel systems. In addition, the en echelon arrangement of the channel sandstones suggests autocyclic shifts of the channel systems. These channel systems probably formed as distributaries in a delta-plain environment described by Erpenbeck (1979), Erpenbeck and Flores (1979), and Flores (1980). The vertical distribution of the coal beds, as illustrated in cross section A-A', can be divided into zones according to their thickness and persistent characteristics. The thick and laterally persistent coal beds occur in three distinct zones: lower, middle, and upper. The lower coal zone contains the thickest bed; the middle and upper coal zones consist of moderately thick beds that are split laterally. The coal beds between these coal zones are generally thin, laterally discontinuous, and commonly split and merged. These thin coal beds were probably deposited in interdistributary-bay backswamps and the zones of thick coal beds accumulated in backswamps of abandoned distributary-channel ridges and interdistributary environment.

Cross section B-B', constructed from outcrops exposed south of the De-Na-Zin Wash (fig. 3), shows vertical and lateral variations of the rock types similar to those shown in cross section A-A'. However, in this area, the proportion of the channel sandstones is high and they make up 60 percent of the detrital rocks of the Fruitland Formation. The interbedded sandstone, siltstone, and shale, which represent overbank and crevasse-splay deposits, are well developed marginally as well as directly below and above the channel sandstones. As in the Bisti Trading Post area, the channel sandstones in the upper part of the interval have wide lateral extent. This characteristic, as well as their offset arrangement and abundance, suggests that the channel sandstones developed on a delta plain, perhaps in an environment geographically related to that of the Bisti Trading Post area. However, unlike the coal beds of the Bisti Trading Post area, the coal beds of the De-Na-Zin Wash area are not as well vertically segregated into distinct thin or thick zones of coal beds. As shown in cross section B-B', the thick coal beds are distributed mainly in the lower part of the interval and abruptly change into thin coal beds that split and are juxtaposed against vertically stacked channel sandstones. Because of the environment of deposition, there is difficulty in tracing the thick coal beds across the extent of the cross section; for example, prolonged accumulation of peat in a backswamp was prevented from spreading laterally by frequent shifting and cut and fill of adjacent distributary channels. This subenvironment of the delta plain probably developed active distributary-channel sedimentation through time in contrast to the Bisti delta-plain subenvironment that formed episodic abandonment of distributary channels, allowing a more stable condition for accumulation of peat in backswamps. This difference in subenvironments played a significant role in the distribution and correlation of the coal beds in the Bisti Trading Post and De-Na-Zin areas.

Cross sections C-C' and D-D', constructed from exposures in the Pretty Rock area (fig. 4), show a significant difference in the amount of channel sandstones and associated fine detritus, and in the vertical distribution of the coal beds compared to those in cross sections A-A'and B-B'. Cross sections C-C' and D-D' show a very low proportion (25 percent) of channel sandstones and abundant (60 percent) interbedded sandstone, siltstone, and shale. In addition, the channel sandstones are relatively thin and laterally narrow. The coal beds thin rapidly laterally and are difficult to correlate along the extent of the cross sections. Although the coal beds are thick in the lower part of the intervals, Erpenbeck (1979) observed that more than half of their thickness is carbonaceous shale. These characteristics of the channel sandstones and coal beds suggest deposition in a back-barrier environment, probably geographically contemporaneous to the delta plain formed in the Bisti and De-Na-Zi areas. The mixing of flocculated clays brought into the marshes by tidal currents with in situ organic matter, led to significant accumulation of carbonaceous shale interbedded with coal.

Cross section E-E', constructed from exposures along the Ah-Shi-Sle-Pah Wash (fig. 5), shows vertical and lateral variations of rock types similar to those in cross sections C-C' and D-D'. However, the channel sandstones are the least common rock type and the interbedded sandstone, siltstone, and shale sequence makes up most of the formation. The channel sandstones are isolated from one another, suggesting development in either widely dispersed or rarely formed channel systems. As in cross sections C-C' and D-D', the coal beds in this area have thick interbeds of carbonaceous shale (Erpenbeck, 1979); however, they are more persistent laterally and thus they are less difficult to correlate along the extent of the cross section. The abundance of fine detritus, isolated occurrence of channel sandstones, and abundance of carbonaceous shale interbeds in the coals suggest a back-barrier depositional environment; this milieu, perhaps, is a southeast extension of the same environment formed in the Pretty Rock area.

SUMMARY

In summary, the five cross sections show continuous stratigraphic variations of the rock types in areas where the Fruitland Formation is continuously exposed. Correlation of the coal beds is easy in some parts of the area but difficult in other parts. Correlation of the coal beds depends on recognition of the environment of deposition of the detrital rocks that were deposited in laterally contemporaneous delta-plain and back-barrier environments. The rapid lateral variation of the coal beds and associated detrital rocks cause difficulty in correlations of these deposits between cross sections.

REFERENCES CITED

Erpenbeck, M. F, 1979, Stratigraphic relationships and depositional environments of the Upper Cretaceous Pictured Cliffs Sandstone and Fruitland Formation, southwestern San Juan Basin, New Mexico: Lubbock, Texas, Texas Tech University unpublished M.S. thesis, 78 p.

Erpenbeck, M. F., and Flores, R. M., 1979, Stratigraphy and depositional environments of the Upper Cretaceous Pictured Cliffs Sandstone and Fruitland Formation in the southwestern San Juan Basin, New Mexico [abs.]: Geological Society of America Abstracts with Programs, v. 11, no. 6, p. 271.

Fassett, J. E., and Hinds, J. S., 1971, Geology and fuel resources of the Fruitland Formation and Kirkland Shale of the San Juan Basin, New Mexico and Colorado: U.S. Geological Survey Professional Paper 676, 76 p.

Flores, R. M., 1980, Comparison of depositional models of Tertiary and Upper Cretaceous coal-bearing rocks in some Western Interior basins of the United States, in Carter, L. M., ed., Proceedings of the fourth symposium on the geology of Rocky Mountain coal: Colorado Geological Survey Research Series 10, p. 17-20.

Jentgen, R. W., and Fassett, J. E., 1977, Sundance-Bisti-Star Lake 1976 drilling in McKinley and San Juan counties, northwestern New Mexico: U.S. Geological Survey Open-File Report 77-369, 80 p.

Wilson, R. W., and Jentgen, R. W., 1980, Coal test drilling for the De-Na-Zin Bisti area, San Juan County, New Mexico: U.S. Geological Survey Open-File Report 80-1289, 109 p.

STRATIGRAPHIC FRAMEWORK AND COAL CORRELATION OF THE UPPER CRETACEOUS FRUITLAND FORMATION, BISTI - AH-SHI-SLE-PAH AREA, SAN JUAN BASIN, NEW MEXICO

By

Romeo M. Flores and Michael F. Erpenbeck

1982

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1982

For sale by Branch of Distribution, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225