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Fred Peterson and A. R. Kirk

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CORRELATION OF THE CRETACEOUS ROCKS IN THE SAN JUAN, BLACK MESA, KAIPAROWITS AND HENRY BASINS, SOUTHERN COLORADO PLATEAU

FRED PETERSON
and
A. R. KIRK
U.S. Geological Survey
Denver, Colorado

INTRODUCTION

Correlation of the Cretaceous rocks of the Colorado Plateau is difficult, not only because of the scarcity of age diagnostic fossils in many of the formations, but also because of the complex interfingering of the formations and the complex nomenclature that has evolved in each of the major outcrop areas (fig. 1). In order to circumvent these problems as much as possible and still present a comprehensible picture of the interrelationships between the San Juan, Black Mesa, Kaiparowits and Henry basins, we have related the formations in each of these areas to the standard Cretaceous stages that are used in western Europe (figs. 2, 3, 4). By considering the age of the interfingering units with respect to the Cretaceous stages and substages, as well as the major transgressive-regressive cycles in each of the basins, correlation between the various basins can be readily understood.

For this report, we divide the Lower Cretaceous Series into stages and the Upper Cretaceous Series into stages and substages. Present knowledge of the age of Lower Cretaceous formations on the Colorado Plateau is so poor that subdivision of the stages is not warranted for these rocks. For the Upper Cretaceous Series, fossils that indicate ammonite zones have been found at scattered localities in each of the basins, but a time scale divided into zones would imply a greater precision than is possible for most of the rocks. On the other hand, an Upper Cretaceous time scale based solely on stages has subdivisions that are too broad to present a useful picture on the stratigraphic relationships within and between these basins. For this reason, we divided the Upper Cretaceous stages into substages which generally consist of several zones. The boundaries of the substages with respect to the time scale of Obradovich and Cobban (1975) were established with the help of W. A. Cobban and are as follows:

1. The lower Cenomanian substage lacks ammonite faunas in the western interior, and the lower and upper boundaries of the middle Cenomanian substage are placed at the base of the zones of *Calycoceras gilberti* Cobban and Scott and *Dunveganoceras pondi* Hass, respectively.

2. The middle Turonian boundaries are defined by the base of the zones of *Collignoniceras woollgari* (Mantell) and *Prionocyclus macombi* Meek.

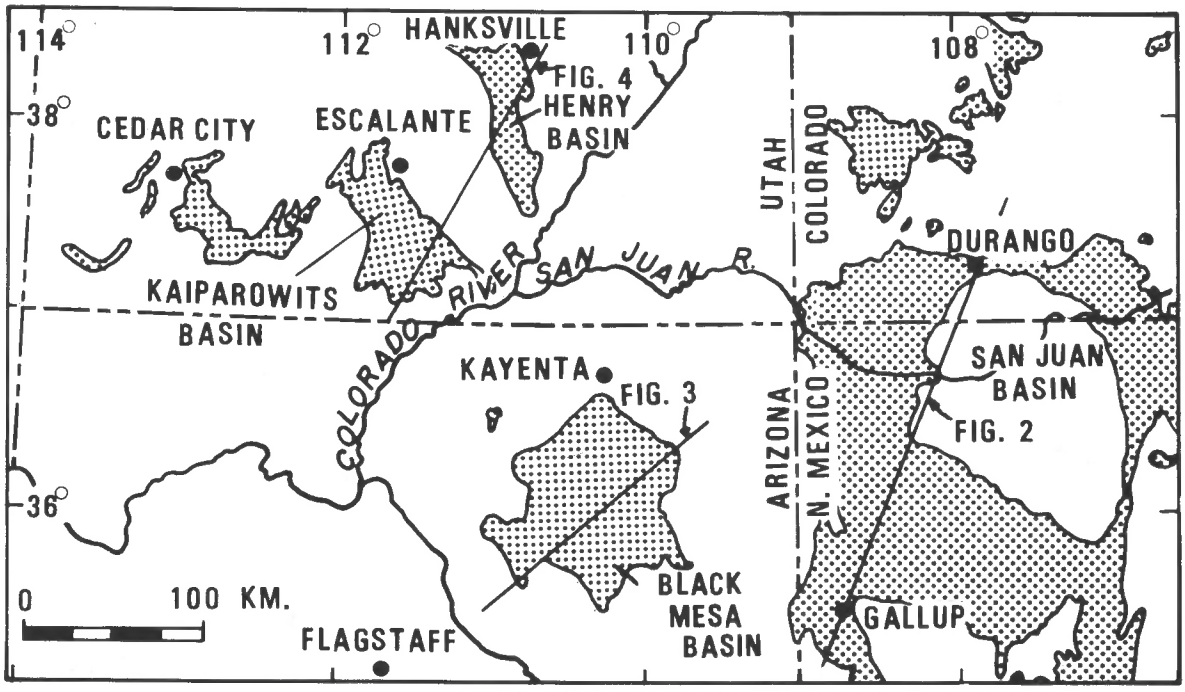


Figure 1. Index map showing major outcrops of Cretaceous rocks (dot pattern) in the southern part of the Colorado Plateau (modified from Fisher and others, 1960, fig. 1).

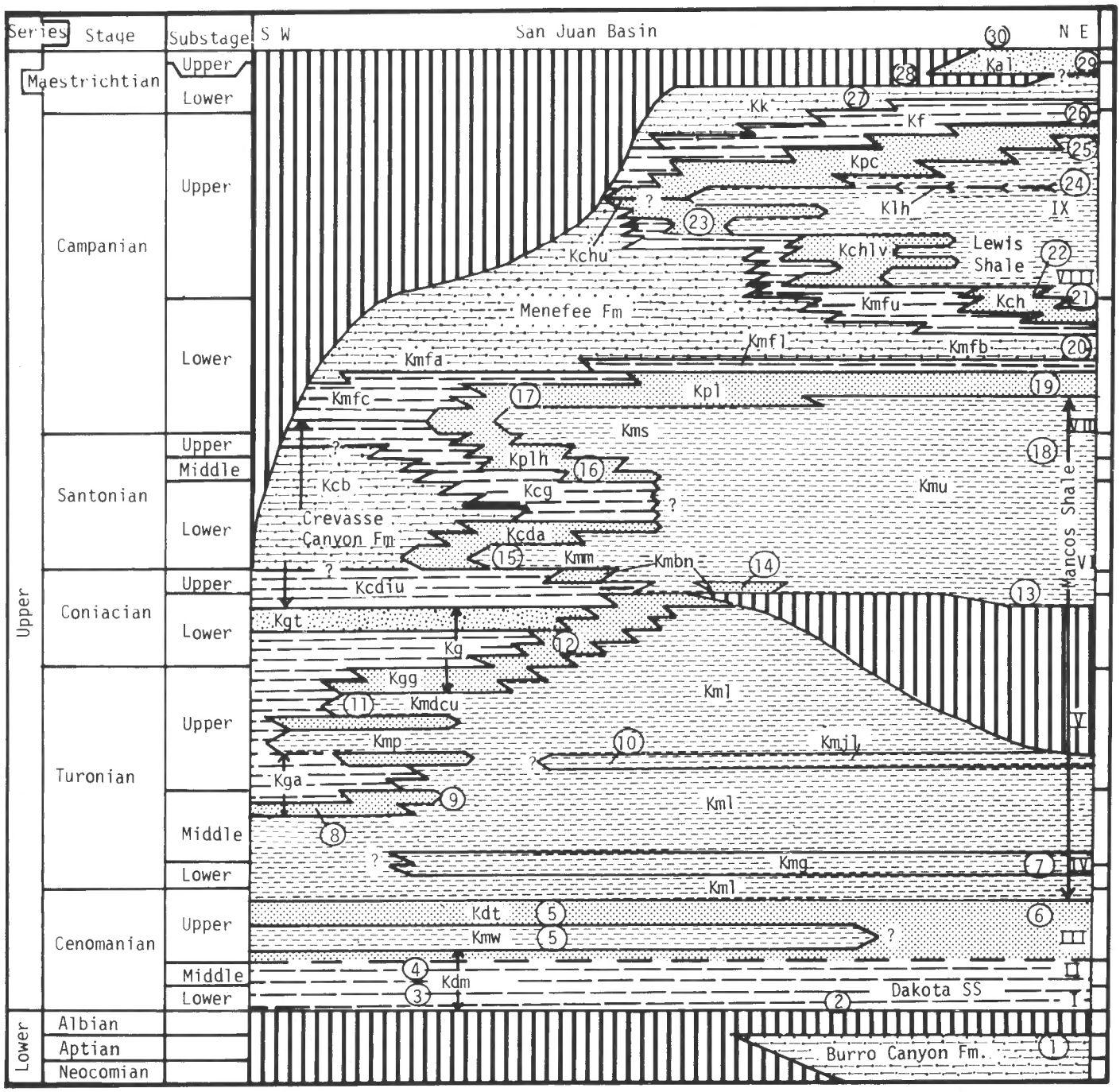


Figure 2. Correlation of Cretaceous rocks along the west side of the San Juan Basin with standard stages of the Cretaceous System. Numbers refer to notes in the Appendix. Roman numerals along right side indicate transition from transgressive to regressive parts of transgressive-regressive cycles described in the text. Not to scale. Units are: Dakota Sandstone: (Kdm) main body; (Kdt) Twowells Sandstone Tongue; Mancos Shale: (Kmw) Whitewater Arroyo Shale Tongue; (Kmg) Greenhorn Limestone Member; (Kmjl) Juana Lopez Member; (Kmp) Pescado Tongue; (Kmdcu) upper part of D-Cross Tongue; (Kmbn) basal Niobrara sandstones; (Kmm) Mulatto Tongue; (Kms) Satan Tongue; (Kml) lower part of Mancos Shale; (Kmu) upper part of Mancos Shale; Gallup Sandstone: (Kga) Atarque Member; (Kg) Gallup Sandstone of type area; (Kgg) Gallego Sandstone Member; (Kgt) Torrivio Sandstone Member of Molenaar (1973, p. 98); Crevasse Canyon Formation: (Kcdiu) Dilco Coal Member; (Kcda) Dalton Sandstone Member; (Kcb) Bartlett Barren Member; (Kcg) Gibson Coal Member; Point Lookout Sandstone: (Kpl) main body; (Kplh) Hosta Tongue; Menefee Formation: (Kmfc) Cleary Coal Member; (Kmfa) Allison Member; (Kmfl) lower coal member; (Kmfb) middle barren member; (Kmfu) upper coal member; Cliff House Sandstone: (Kch) main body; (Kchlv) La Ventana Tongue; (Kchu) upper part (Chacra Sandstone Member of Mesaverde Formation of Dane, 1936, p. 101); other units: (Kpc) Pictured Cliffs Sandstone; (Kf) Fruitland Formation; (Kk) Kirtland Formation; (Kal) lower or Cretaceous part of Animas Formation (includes McDermott Member and lower part of upper member); (Klh) Huerfanito Bentonite Bed of Lewis Shale. **[Editor's note: The unit (Kchu), upper part of Cliff House Sandstone, or Chacra Sandstone of Dane, is the Tsaya Canyon sandstone member of the Cliff House sandstone in the road logs of this field conference. See paper by Fassett elsewhere in this volume.]**

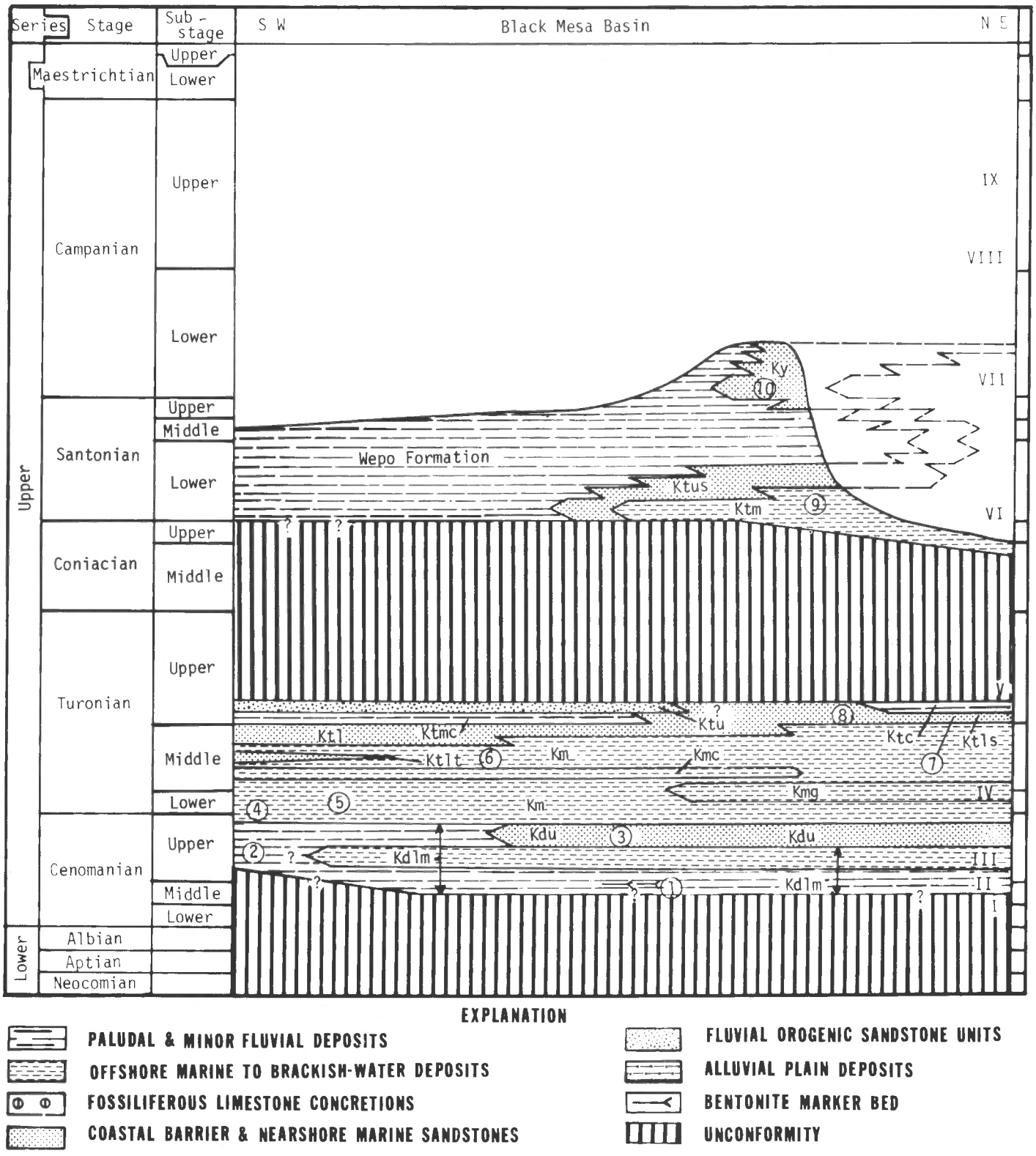


Figure 3. Correlation of Cretaceous rocks in Black Mesa basin with standard stages of the Cretaceous System. Numbers refer to notes in the Appendix. Roman numerals along right side indicate transition from transgressive to regressive parts of transgressive-regressive cycles described in the text. Not to scale. See Figure 2 for explanation of symbols. Units are: Dakota Sandstone: (Kdlm) lower and middle members; (Kdu) upper member; (Km) Mancos Shale: (Kmg) Greenhorn Limestone Member; (Kmc) middle sandy unit; Toreva Formation: (Ktlt) lower tongue; (Ktl) lower sandstone member; (Ktmc) middle carbonaceous member; (Ktu) upper sandstone member; (Ktls) lower sandstone unit; (Ktc) carbonaceous mudstone and coal unit; (Ktm) marine shale tongue; (Ktus) upper sandstone unit; (Ky) Yale Point Sandstone.

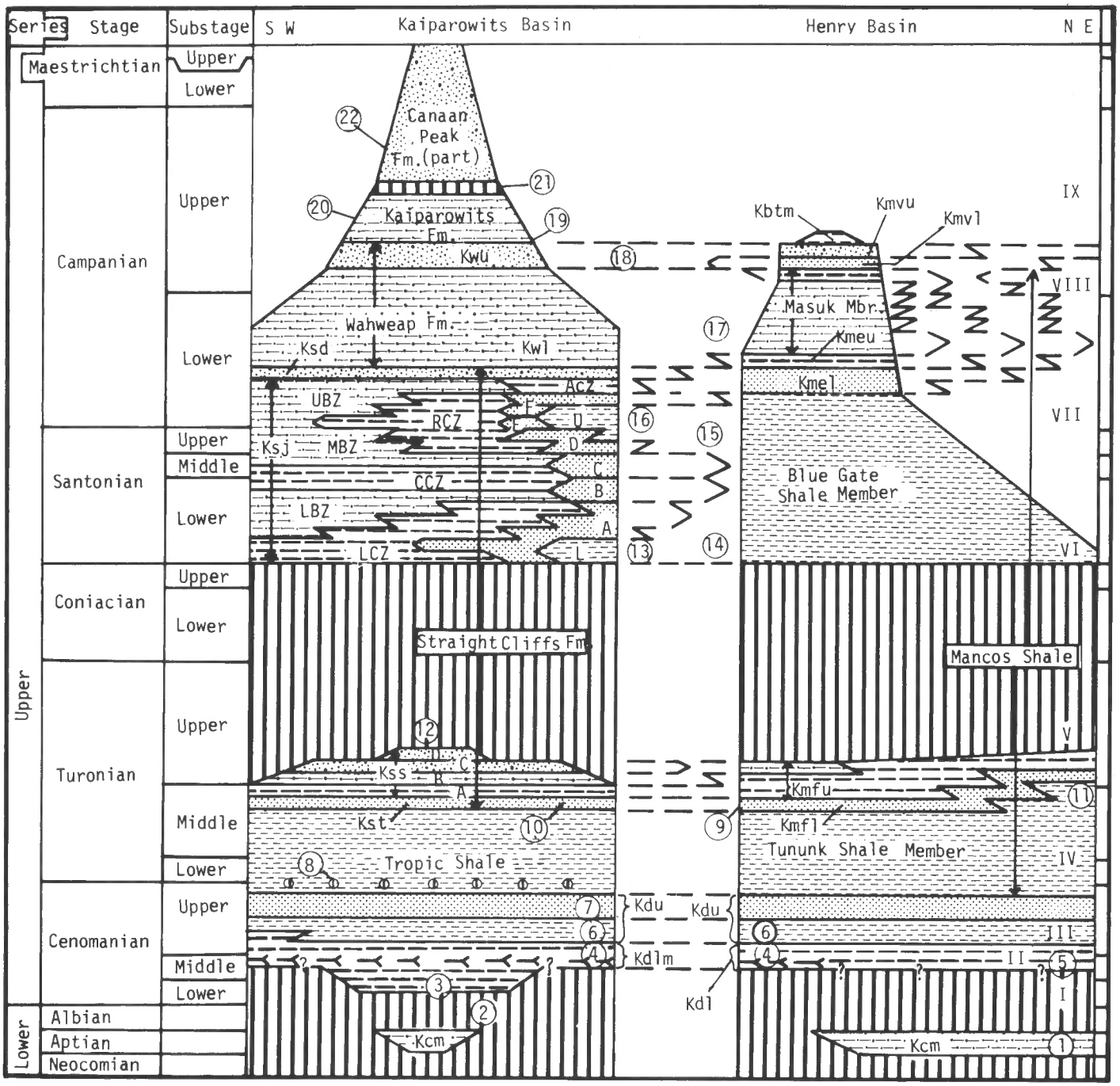


Figure 4. Correlation of Cretaceous rocks in the Kaiparowits and Henry basins with standard stages of the Cretaceous System. Numbers refer to notes in the Appendix. Roman numbers along right side indicate transition from transgressive to regressive parts of transgressive-regressive cycles described in the text. Not to scale. See Figure 2 for explanation of symbols. Units in Kaiparowits basin are: (Kcm) Cedar Mountain Formation; Dakota Formation: (Kdlm) lower and middle members; (Kdu) upper member; Straight Cliffs Formation: (Kst) Tibbet Canyon Member; (Kss) Smoky Hollow Member (letters indicate: (A) coal zone; (B) barren zone; (C) Calico bed; (D) upper unit); (Ksj) John Henry Member (units include: (L) lower marine mudstone tongue; (U) upper marine mudstone tongue, A, B, C, D, E, F and G indicate sandstone marker beds; (LCZ) lower coal zone; (CCZ) Christensen coal zone; (RCZ) Rees coal zone; (ACZ) Alvey coal zone; LBZ, MBZ and UBZ indicate lower, middle and upper barren zones, respectively), (Ksd) Drip Tank Member; Wahweap Formation: (Kwl) lower member; (Kwu) upper sandstone member. Units in Henry basin are: (Kcm) Cedar Mountain Formation; Dakota Sandstone: (Kdl) lower unit; (Kdu) upper unit; Mancos Shale: (Kmfl) lower unit of Ferron Sandstone Member; (Kmfu) upper unit of Ferron Sandstone Member; (Kmel) lower unit of "Emery" Sandstone Member; (Kmeu) upper unit of "Emery" Sandstone Member; "Mesaverde" Formation: (Kmvl) lower part; (Kmvu) upper part; (Kbtm) beds on Tarantula Mesa.

3. The Coniacian stage consists of only two ammonite zones, which are considered the lower and upper substages.

4. The middle Santonian boundaries are placed at the base of the *Clioscaphites vermiformis* (Meek and Hayden) and *Desmoscaphites erdmanni* Cobban zones.

5. The Campanian is a relatively long-ranging stage divided into lower and upper substages, with the boundary at the base of the *Baculites maclearni* Landes zone.

6. All nine ammonite zones listed by Obradovich and Cobban (1975) in the Maestrichtian stage are included in the lower Maestrichtian substage, and the *Triceratops* zone at the top is considered the upper Maestrichtian substage.

LOWER CRETACEOUS SERIES

[Editor's note: Although the authors of this report do not make correlations of individual rock units from one basin to another, the interested reader may make these correlations by making copies of Figures 2, 3 and 4 and placing them side by side, since these figures are all to the same scale.]

Several authors have correlated the Burro Canyon Formation on the east side of the Colorado Plateau with the Cedar Mountain Formation on the west side of the plateau (Cobban and Reeside, 1952; Simmons, 1957) but the available evidence suggests that the Cedar Mountain correlates only with the upper part of the Burro Canyon. No fossils diagnostic of stage have been found in the lower part of the Burro Canyon, but the gradational and intertonguing relationship with the Upper Jurassic Morrison Formation in southwestern Colorado (Ekren and Houser, 1959) indicates that the lower part of the Burro Canyon should be Neocomian in age. (It is not known whether the systemic boundary falls in the Morrison or Burro Canyon in this area.) The Cedar Mountain lies unconformably on the Morrison; and there is no evidence, at present, to suggest a Neocomian age for any part of this formation. Aptian fossils occur in the upper part of the Burro Canyon and in the Cedar Mountain, and Albian fossils have not been reported from either formation. Although age diagnostic fossils are rare in both formations, the available stratigraphic and paleontologic evidence suggests that the Burro Canyon is Neocomian and Aptian in age, the Cedar Mountain is Aptian in age, and only the upper part of the Burro Canyon correlates with the Cedar Mountain (figs. 2, 4).

Lawrence (1965) reported Aptian fossils from the upper-middle part of a unit he called the Dakota Formation in southwestern Utah. To our knowledge, this is the only place in the southern part of the Colorado Plateau where an Early Cretaceous age has been documented for part of the Dakota. This unit probably should be considered Cedar Mountain and Dakota undivided, although Moir (1974) could find no stratigraphic basis for differentiating the two formations in this area. As noted in the Appendix, the evidence from elsewhere in the four basins suggests that the Dakota is entirely Late Cretaceous (Cenomanian) in age. For this reason, the U.S. Geological Survey now considers the Dakota in the San Juan, Black Mesa, Kaiparowits and Henry basins Late Cretaceous in age.

UPPER CRETACEOUS SERIES

During Late Cretaceous time, the present-day Colorado Plateau province lay on the west side of a broad epicontinental seaway that stretched from the Gulf Coast states northward across the interior of the United States and Canada to the Arctic Ocean. In the southern part of the Colorado Plateau province, the shoreline generally trended northwest-southeast and it usually advanced landward (southwest) or retreated seaward (northeast) depending on the rates of regional subsidence and sedimentation. Strata deposited during these advances or retreats of the shoreline can be recognized as transgressive-regressive cyclic sedimentation units by the southwestward-thinning wedges of offshore-marine rocks when viewed in sections oriented perpendicular to the shoreline.

We recognize nine transgressive-regressive cycles in the four basins of the southern Colorado Plateau that are covered by this study (fig. 1). These cycles are designated by Roman numerals, which are shown on the right side of Figures 2, 3 and 4 at the approximate position of the greatest landward advance of the shoreline. Further and more detailed work will undoubtedly reveal more cycles, but the nine recognized here are the ones most useful for regional correlations. Although it does not seem necessary for the transition from transgressive to regressive parts of any particular cycle to occur at the same time in all four basins, the available evidence suggests that this is indeed the case, at least for most of the nine cycles recognized here. However, in terms of the broader relationships throughout the western interior of the United States, the work of Gill and Cobban (1973) amply demonstrated that an advancing shoreline in one region may be retreating in another.

Other systems of numbering transgressive-regressive cycles have been proposed by Weimer (1960) for the entire western interior and by Peterson and Ryder (1975) for the southwestern Part of the Colorado Plateau. Correcting for several miscorrelations in the San Juan Basin part of Weimer's paper, the relation of his cycles to ours, with our cycle numbers in parentheses following Weimer's, is: T-R 1 (IV), T-R 2 (VI and VII), T-R 3 (IX), T-R 4 (not recognized). The relation of Peterson and Ryder's (1975) cycles to ours with our cycle numbers in parentheses, is: 1 (IV), 2 (VI), 3 (VII), 4 (VIII), 5 (upper VIII or lower IX).

Transgressive-Regressive Cycles I and II

Two relatively minor transgressive-regressive cycles in the southeastern part of the San Juan Basin in strata of early and middle Cenomanian age (not shown on Figure 2) are represented in offshore marine rocks by the westward-thinning upper part of the Oak Canyon Member of the Dakota Sandstone (cycle I) and the Clay Mesa Shale Tongue of the Mancos Shale (cycle II; Landis and others, 1973, p. J12, fig. 3). Early Cenomanian palynomorphs were found in the basal beds of the Dakota near Escalante, Utah, in the Kaiparowits basin (fig. 4; Appendix III, note 3), suggesting that the lower and middle members of the Dakota in that area contain strata approximately equivalent to both these cycles in the San Juan Basin.

A bentonite marker bed that is widespread in the Kaiparowits basin (fig. 4; Appendix III, note 4; Peterson, 1969a, p. 25-26) is tentatively correlated with a bentonite bed in the Henry basin (Hunt and others, 1953, p. 77-78) and with another bentonite bed in Black Mesa basin (fig. 3; Appendix II, note 1). This bed may correlate with a marker bentonite bed in the Great Plains region that occurs in the upper-middle Cenomanian zone of *Acanthoceras amphibolum* Morrow. The regressive part of cycle II in the southeastern San Juan Basin includes the same ammonite zone, suggesting correlation of strata from the bentonite marker bed to the base of beds in cycle III in the Black Mesa, Kaiparowits and Henry basins with

the regressive part of cycle II in the San Juan Basin. This correlation also suggests that beds at least as old as middle Cenomanian are present in each of these basins where the bentonite lies near the base of the Dakota.

Transgressive-Regressive Cycle III

Cycle III is the oldest transgressive-regressive cycle that can be recognized in all four basins in the southern part of the Colorado Plateau. In the San Juan Basin it is characterized by the Whitewater Arroyo Shale Tongue of the Mancos Shale (fig. 2), which was deposited at the time of greatest encroachment of the sea during this cycle. Marine to brackish-water mudstone and shale at the top of the middle member and below the upper sandstone member of the Dakota in Black Mesa basin probably correlate with the Whitewater Arroyo Shale Tongue of the Mancos Shale. A similar unit of brackish-water mudstone at the base of the upper member of the Dakota in the Kaiparowits basin and at the base of the upper unit of the Dakota in the Henry basin also correlates with the Whitewater Arroyo. The Whitewater Arroyo and its equivalents grade northward (fig. 2) and south-westward (figs. 3, 4) into marginal-marine or nonmarine beds and into nonmarine strata in the western part of the Kaiparowits basin. This gradation suggests that marine waters of the western interior seaway advanced up a topographic low or shallow trough that extended northwestward from the central and southern parts of the San Juan Basin through the northern part of Black Mesa basin and into the Kaiparowits basin. Southeastward-trending crossbedding resultants in fluvial sandstones of the middle member of the Dakota in the Kaiparowits basin (Peterson, 1969a, p. 159) support this hypothesis.

The Twowells Sandstone Member of the Dakota at the top of cycle III in the San Juan Basin has yielded a characteristic late Cenomanian fauna. A similar fauna has been found in a sandstone bed at the top of the Dakota in the Kaiparowits, Henry and Black Mesa basins, suggesting correlation with the Twowells (figs. 2, 3, 4). This correlation indicates that the Twowells and its correlatives once were part of an extensive marine sandstone bed that covered most of the southern part of the present Colorado Plateau province.

Transgressive-Regressive Cycle IV

The greatest westward and southwestward advance of the western interior seaway across the Colorado Plateau province occurred during cycle IV. Lawrence (1965, p. 81) showed that the maximum advance occurred during deposition of the uppermost Cenomanian zone of *Sciponoceras gracile* (Shumard) and the lower to lower-middle Turonian zone of *Inoceramus labiatus* (Schlotheim) s.l. A thick offshore-marine unit of interbedded mudstone, shale and limestone characterizes this cycle in each of the four basins.

The Calico bed, an informal unit in the Smoky Hollow Member of the Straight Cliffs Formation of the Kaiparowits basin (Peterson, 1969b), and the upper sandstone member of the Toreva Formation in Black Mesa basin (Repenning and Page, 1956) are remnants of a fairly widespread fluvial sandstone bed that apparently was an integral part of the regressive phase of this cycle (figs. 3, 4). Similar widespread fluvial sandstone units occur in younger Cretaceous rocks of the Colorado Plateau, and each of these is associated with a major regression of the strandline. These widespread fluvial sandstone beds were deposited by moderate- to high-energy braided streams, whereas most of the other fluvial sandstone beds were deposited by relatively low-energy meandering streams. This association of relatively high-energy fluvial deposits and regressions of the shoreline suggests that the major regressions were closely related to orogenic pulses in the Cordilleran source region to the west or southwest. Thus, the time of greatest uplift and erosion in the source region, transportation of sediment from it, and maximum retreat of the shoreline coincided with deposition of these fluvial orogenic sandstone (or locally conglomerate) beds. Apparently, the intensity of orogenic movements varied geographically in the Cordilleran source region, because the orogenic fluvial sandstone deposits generally occur in only one or two of the basins. Although we consider these beds to be the result of orogenic pulses in the source areas, it is conceivable that they may have been the result of better integration of the drainage systems.

A thin unit of brown fluvial pebbly sandstones deposited by braided streams and scarce thin carbonaceous mudstone lenses is preserved beneath the unconformity in a small part of the Kaiparowits basin northwest of Escalante, Utah (fig. 4, unit D in Smoky Hollow Member). Present knowledge of the regional significance of these beds is meager, owing to their limited areal extent and lack of age diagnostic fossils. Apparently, this unit was deposited during the waning stage of the orogenic pulse represented chiefly by the underlying Calico bed.

Rapid sedimentation by the streams that deposited the Calico bed and correlative fluvial sandstone beds probably coincided with rapid deposition in, and shallowing of, the western interior seaway. This suggests correlation with the Juana Lopez Member of the Mancos Shale in the San Juan Basin, which is known to be of approximately the same age (figs. 2, 3, 4) and was deposited in shallow shoaling marine waters (Molenaar, 1973, p. 94).

Transgressive-Regressive Cycle V

The greatest landward advance of the seaway during deposition of cycle V is best represented by offshore-marine strata of the Pescado and D-Cross tongues of the Mancos Shale in the San Juan Basin (fig. 2). The Torrivio Sandstone Member of Molenaar (1973, p. 98) in the Gallup Sandstone is another fluvial orogenic sandstone bed that was deposited during the regressive part of this cycle.

Strata equivalent to the fifth cycle are not known to be present in the Black Mesa, Kaiparowits and Henry basins or in the northern part of the San Juan Basin. Judging from the age of beds above and below the unconformity in these areas, beds of the fifth cycle were removed by erosion during Coniacian time. The unconformity is generally thought to lie between Carlile and Niobrara age equivalent strata. However, fossil collections listed elsewhere in this report, as well as by King (1974), indicate that the unconformity is entirely within Niobrara age equivalent beds in some places. Molenaar (1974, p. 258) suggested that *"the unconformity probably formed in large part under submarine conditions"* in the San Juan Basin. In most of the Kaiparowits basin, however, it lies between nonmarine beds, and truncation of beds beneath it indicates that uplift and folding of the Kaiparowits basin occurred prior to deposition of strata that lie on the unconformity (Peterson, 1969a, 1969b, p. J8, fig. 5).

Transgressive-Regressive Cycle VI

The maximum advance of the western interior seaway

during the sixth cycle is well represented by offshore marine beds in all four basins. Fossils indicating the lower Santonian zone of *Scaphites depressus* Reeside were reported from the Mulatto Tongue of the Mancos Shale in the San Juan Basin, the marine shale tongue of the Toreva Formation in Black Mesa basin, the lower marine mudstone tongue of the John Henry Member of the Straight Cliffs Formation in the Kaiparowits basin, and the lower part of the Blue Gate Shale Member of the Mancos Shale in the Henry basin. (See notes to figures 2, 3 and 4 in the Appendix.) A widespread fluvial orogenic sandstone bed is not known to be associated with the regressive part of this cycle. However, studies by Peterson (1969a) in the Kaiparowits basin indicated strong southeastward-trending shoreline currents during this time, suggesting that the orogenic source region for much of the nearshore- and offshore-marine sediment probably was northwest of the Kaiparowits basin and that a fluvial orogenic sandstone bed associated with this cycle may be present beneath the Wasatch Plateau of central Utah.

Transgressive-Regressive Cycle VII

Cycle VII is represented by tongues of offshore-marine shale or mudstone in the Satan Tongue of the Mancos Shale in the San Juan Basin and in the upper marine mudstone tongue of the John Henry Member of the Straight Cliffs Formation in the Kaiparowits basin (figs. 2, 4). In Black Mesa basin, interfingering of barrier sandstone beds of the Yale Point Sandstone with paludal beds of the Wepo Formation and the close similarity of these formations to beds in the John Henry Member of the Straight Cliffs Formation in the Kaiparowits basin indicate that the Yale Point was deposited during this transgressive-regressive cycle, as shown diagrammatically in Figure 3. The Drip Tank Member of the Straight Cliffs Formation is present throughout the Kaiparowits basin (fig. 4) and is another thick and fairly widespread fluvial orogenic sandstone bed deposited during the regressive part of this cycle.

Transgressive-Regressive Cycle VIII

The eighth cycle is represented in the San Juan Basin by offshore marine strata in the lower part of the Lewis Shale (fig. 2). Several transgressive-regressive cycles are known in the intertonguing Cliff House Sandstone and Lewis Shale in this area (Fassett, 1977), but the eighth cycle is considered to include only the main body and La Ventana Tongue of the Cliff House and the lower part of the Lewis Shale in the San Juan Basin. This cycle probably falls in the lowermost upper Campanian zones of *Baculites maclearni* Landis and *B. asperiformis* Meek. The greatest advance of the seaway during this cycle is poorly represented in the Henry basin by paludal beds at the top of the Masuk Member of the Mancos Shale and by possible nearshore-marine sandstone beds at the base of the "Mesaverde" Formation (fig. 4; Peterson and Ryder, 1975 p. 182, 184-185). (We follow Peterson and Ryder (1975) in placing quotes around formation or member names that are used incorrectly.) The upper sandstone member of the Wahweap Formation in the Kaiparowits basin, the fluvial upper part of the "Mesaverde" Formation in the Henry basin, and the Castlegate Sandstone in the Book Cliffs and Wasatch Plateau regions constitute another formerly widespread fluvial orogenic sandstone bed that was deposited during the regressive part of this cycle (Peterson and Ryder, 1975, p. 182).

Transgressive-Regressive Cycle IX

The youngest transgressive-regressive cycle in Cretaceous rocks of the southern Colorado Plateau is represented in offshore-marine rocks by the southwestward-thinning tongue of the Lewis Shale in the San Juan Basin (fig. 2), which records the greatest southwestward advance of the seaway during this cycle. The only beds of similar age that are preserved elsewhere in the region of the study are the Kaiparowits Formation and the Cretaceous part of the Canaan Peak Formation in the Kaiparowits basin. As described by Bowers (1972), the Canaan Peak is a fluvial sandstone and conglomerate formation that has yielded Campanian palynomorphs from the lower part and that probably is late Campanian, Maestrichtian, and Paleocene in age. This formation is another fluvial orogenic sandstone and conglomerate unit that apparently was deposited during the regressive part of cycle IX.

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APPENDIX I

Notes on Figure 2, San Juan Basin

1. *Protelliptio douglassi* Stanton and *"Unio" farri* Stanton from the upper part of the Burro Canyon Formation in western Colorado (Simmons, 1957) are considered Aptian in age (Cobban and Reeside, 1952).

2. The fern *Tempskya* sp. was reported from basal beds of the Dakota near here by Strobell (1956). Read and Ash (1961) thought this fossil was restricted to Albian rocks but according to Andrews (1961, p. 117), the genus ranges from the upper part of the Lower Cretaceous to the middle of the Upper Cretaceous and it may extend back to the Upper Jurassic. Thus, *Tempskya* cannot be considered a guide fossil for the Albian Stage.

A sample containing age diagnostic palynomorphs was collected by A. C. Huffman, Jr., from 1 m above the base of the Dakota on the southeast side of Little Shiprock Wash in sec. 6, T. 26 N., R. 20 W., San Juan County, N. Mex. (U.S.G.S. Paleobotany Locality No. D5688). The fossils were identified by R. H. Tschudy (written commun., 1977) who stated "This assemblage, characterized by *Nyssapollenites albertensis* Singh and *Tricolporopollenites* cf. *T. aliquantulus* Hedlund and the absence of more advanced tricolporate or triporate pollen, strongly suggests an early Cenomanian age. The accessory spores and pollen grains are consistent with such a determination."

3. Aptian(?) and Albian palynomorphs were reported from basal Dakota beds farther east by R. H. Tschudy (in Landis and others, 1973, p. J21). Based on new data and re-evaluation of the palynomorphs, Tschudy (oral commun., 1977) stated that this assemblage is "definitely early Cenomanian."

4. A molluscan fauna indicating middle Cenomanian age was found farther east in strata that correlate with the middle and upper parts of the main body of the Dakota Sandstone (Landis and others, 1973, p. J14-J16, J20; Cobban, 1971, p. 12).

5. A molluscan fauna indicates a late Cenomanian age for the Whitewater Arroyo Shale Tongue of the Mancos Shale, the Twowells Sandstone Tongue of the Dakota Sandstone and the lower 6.4-19.2 m of the overlying main body of the Mancos Shale (Landis and others, 1973; W. A. Cobban, oral commun., 1977).

6. The late Cenomanian ammonite, *Metoicoceras defordi* Young, has been recovered from the uppermost beds of the Dakota or the lowermost beds of the Mancos in the Four Corners region (W. A. Cobban, oral commun., 1977). According to Owen (1966), the Whitewater Arroyo Shale Tongue of the Mancos pinches out northward in the Dakota near Toadlena, N. Mex.

7. The Greenhorn contains the lower and middle Turonian guide fossil *Inoceramus labiatus* (Schlotheim) s.l. (Pike, 1947, p. 38, no. 46 and 47; Wanek, 1959, p. 681).

8. The middle Turonian ammonite, *Collignoniceras woollgari* (Mantell), was reported from beds approximately equivalent to the lowest beds of the Atarque Member of the Gallup Sandstone (Molenaar, 1973, p. 94). These fossils were reexamined by W. A. Cobban who says they are juvenile forms of *Prionocyclus hyatti* (Stanton) (C. M. Molenaar, written commun., 1977). *P. hyatti* indicates a slightly younger age but still in the middle Turonian substage.

9. The seaward pinchout of the Atarque Member probably correlates with the Semilla Sandstone Member of the Mancos Shale in the southeastern part of the San Juan Basin (Molenaar, 1973, p. 94). The Semilla contains fossils indicating the middle Turonian zone of *Prionocyclus hyatti* (Stanton) according to Dane, Kauffman and Cobban (1968, p. F9).

10. Fossils indicating the late Turonian zones of *Prionocyclus macombi* Meek, *Prionocyclus wyomingensis wyomingensis* Meek, and *Scaphites whitfieldi* Cobban have been found in the Juana Lopez (Dane and others, 1966). Lamb (1968, p. 833) found that the Juana Lopez is partly truncated by basal Niobrara beds near the mound.

11. *Prionocyclus reesidei* Sidwell, reported by Dane, Wanek and Reeside (1957, p. 193-194), indicates the upper Turonian zone of *Scaphites nigricollensis* Cobban (Cobban and Reeside, 1952). The *P. reesidei* is a single questionable specimen; it could be *P. wyomingensis wyomingensis* Meek which is two zones older but still in the upper Turonian substage (W. A. Cobban, written commun., 1977). Molenaar (1974, p. 252-257) considers the Pescado Tongue equivalent to the lower part of the D-Cross Tongue farther east.

12. *Inoceramus erectus* Meek was collected by Molenaar (1973, p. 100) from the Gallego Sandstone Member of the Gallup in the southeastern San Juan Basin. The fossil indicates that at least part of the Gallego falls in the lower part of the lower Coniacian zone of *Scaphites preventricosus* Cobban. The Gallup Sandstone was included in the Mesaverde Group by Beaumont, Dane and Sears (1956).

13. Fossils indicating the lower Coniacian zone of *Scaphites preventricosus* Cobban have been found in strata that lie on the unconformity. These include *Inoceramus deformis* Meek in the southwestern part of the basin (Dane, 1960, p. 53) and *I. erectus* Meek found by C. M. Molenaar (written commun., 1977) in the southeastern part of the basin and identified by W. A. Cobban (Molenaar collection No. M125A/68, collected 10.5 m above the base of the Mulatto Tongue of the Mancos in sec. 27, T. 12 N., R. 2 W., Sandoval County, N. Mex.). The early Coniacian ammonite *Barroisiceras* sp. collected by D. L. Wyant (in Dane, 1960, p. 52) in the southeastern San Juan Basin was originally reported from the upper part of the Gallego Sandstone Member. However, according to Molenaar (1973, p. 100) it came from a sandstone bed that lies on the unconformity and was not from the Gallego.

14. Scattered marine sandstone lenses lying on the unconformity or at the base of the Mulatto Tongue are known by several names in different areas including: Tocito Sandstone lentil of the Mancos Shale (Reeside, 1924, p. 9, "Stray" sandstone (Sears and others, 1941, p. 113), Borrego Pass lentil of the Crevasse Canyon Formation (Correa, 1970), Cooper Arroyo Sandstone Member of the Mancos Shale (Landis and Dane, 1967, p. 7-8), and basal Niobrara sandstone (Pentilla, 1964; McCubbin, 1969). We follow Molenaar (1973, p. 100-102) in using the name basal Niobrara sandstone because it applies to all of these isolated sandstone lenses, although we realize that there are slightly older Niobrara age equivalent beds in the San Juan Basin (King, 1974). Dane (1960, p. 53) reported *Inoceramus* (*Volviceramus*) *involutus* Sowerby from one of these sandstones on the west side of the basin. This fossil suggests the upper Coniacian zone of *Scaphites ventricosus* Meek and Hayden in the time-scale of Obradovich and Cobban (1975).

15. *Inoceramus* cf. *I. stantoni* Sokolow was collected from the Mulatto Tongue of J. F. Robertson in 1973. The fossil came from a sandstone bed 1.5 m thick and about 13.7 m below the top of the tongue in the SW¼ SW¼ sec. 26, T. 16 N., R. 13 W., McKinley County, N. Mex. (U.S.G.S. Mesozoic locality D887). According to W. A. Cobban (written commun., 1973), who identified the fossil, it seems best assigned to the lower Santonian zone of *Scaphites depressus* Reeside. Studies by Tschudy (1976) show a zonation based on palynomorphs in nonmarine Coniacian and Santonian rocks in this part of the basin. The Crevasse Canyon Formation was included in the Mesaverde Group by Beaumont, Dane and Sears (1956).

16. *Texanites texanus* (Roemer), found by Sabins and Bonham (1960), indicates the middle Santonian zone of *Clioscaphites vermiformis* (Meek and Hayden).

17. *Inoceramus* (*Sphenoceramus*) *patootensiformis* Seitz was found by J. F. Robertson in 1974 from the lower part of the Point Lookout Sandstone. The collection (U.S.G.S. Mesozoic locality D9198) came from the SW¼ NE¼ sec. 17, T. 16 N., R. 12 W., McKinley County, N. Mex. The fossil was identified by W. A. Cobban who stated (written commun., 1974) that it "occurs elsewhere in the western interior region in the upper Santonian zones of *Desmoscaphites erdmanni* Cobban and *D. bassleri* Reeside and in the lower Campanian zone of *Scaphites hippocrepis* (DeKay)." Considering the presence of *Scaphites hippocrepis* (DeKay) in approximately equivalent beds of the upper Mancos farther north (see following note), the Point Lookout as well as the Satan Tongue probably fall in the zone of *S. hippocrepis* (Gill and Cobban, 1966, pl. 4).

18. The early Campanian ammonites *Scaphites hippocrepis* (DeKay) and *Scaphites leei* Reeside occur in the upper 244 m of the Mancos Shale in southwestern Colorado (Reeside, 1927, p. 6, locality 10429; Cobban, 1969, p. 2-6, localities 78-82; 1973, p. 148-150).

19. *Baculites aquilaensis* Reeside, indicating the lower Campanian zone of *Scaphites hippocrepis* (DeKay), was recovered from float blocks of Point Lookout Sandstone by Cobban (1973, p. 150). *Scaphites leei* Reeside, which also indicate the *S. hippocrepis* zone, is reported from beds that probably are the Point Lookout Sandstone in the southeastern part of the basin (Cobban, 1969, p. 5, loc. 81).

20. The Menefee Formation probably spans the lower Campanian zones of *Baculites* sp. (smooth), Baculites sp. (weakly ribbed), and *B. obtusus* Meek in the Mesa Verde area according to Cobban (1973, p. 150-151) and Gill and Cobban (1966, pl. 4).

21. The uppermost lower Campanian fossil *Baculites* cf. *B. obtusus* Meek was found about 61 m above the base of the Lewis Shale in the southeastern part of the San Juan Basin (Cobban and others, 1974, p. 279). Considering the northwest trend of strandlines in the San Juan Basin, these fossils suggest that the lowest beds of the Lewis and part or all of the Cliff House Sandstone in the northeasternmost part of the basin are of the same age.

22. The lowermost upper Campanian fossil *Baculites maclearni* Landis occurs in the Cliff House Sandstone of southwestern Colorado (Cobban, 1973, p. 150) and in the lower part of the Lewis Shale east of the San Juan Basin (Landis and others, 1974, p. 236).

23. The upper Campanian ammonite *Baculites perplexus* Cobban was reported from this part of the Cliff House Sandstone by Siemers and King (1974, p. 268). Subdivision of the Cliff House Sandstone into three units as shown is based on studies by Dane (1936), Hollenshead and Pritchard (1961), O'Sullivan and others (1972, p. E48-E49), and Fasset (1977).

24. The Huerfanito Bentonite Bed of the Lewis Shale is in the lower part of the zone of *Baculities scotti* Cobban (Cobban, 1973, p. 150-151), Based on subsurface studies, J. E. Fassett (oral commun., 1974) thinks the southwesternmost pinchout of the Lewis is stratigraphically a little bit lower than the bentonite, perhaps in the zone of *Baculites gregoryensis* Cobban.

25. Molluscs suggesting the upper Campanian zone of *Baculites compressus* Say were reported by Cobban, Landis and Dane (1974, p. 281) from the uppermost part of the Lewis Shale in the northeastern part of the San Juan Basin.

26. The youngest beds of the Fruitland Formation at the Gasbuggy site in the middle of the San Juan Basin probably correlate with part or all of the interval that includes the zones of *Baculites jenseni* Cobban, *B. eliasi* Cobban, and *B. baculus* Meek and Hayden according to R. H. Tschudy (oral commun., 1977). These zones are now considered early Maestrichtian in age, although at the time of his original work (Tschudy, 1973), they were considered latest Campanian.

27. About 90 km north of the San Juan Basin, the upper part of the Kirtland is considered Maestrichtian in age on the basis of pollen (Dickinson and others, 1968).

28. A regional unconformity apparently is present throughout most of the San Juan Basin, but the exact stratigraphic position of it is the subject of considerable debate (Baltz and others, 1966; Clemens, 1973; Fassett, 1973, 1974; Fassett and Hinds, 1971; Powell, 1973). The unconformity apparently corresponds to the unconformity within Maestrichtian age rocks on the north side of the San Juan Mountains (Dickinson and others, 1968). Zapp (1949), Barnes (1953), Barnes, Baltz and Hayes (1954), and Hayes and Zapp (1955) only found evidence of local unconformities between the Kirtland and Animas formations along the north side of the San Juan Basin, and they concluded that, for the most part, deposition at the boundary of these formations was continuous and only locally interrupted. On the other hand, J. E. Fassett (oral commun., 1977) suggests that the unconformity is present throughout the basin but was not recognized by previous workers in the northern part of the basin.

29. The lower part of the Animas Formation (including the McDermott Member and the lowermost beds of the upper member) probably is the same age as, or slightly younger than, the Cimarron Ridge Formation farther north which has been dated as latest early Maestrichtian in age by pollen and radiometric methods (66-67 m.y.; Dickinson and others, 1968). The close age relationship is based on volcanic

pebbles in the lower part of the Animas that were derived from a source area farther north (Barnes and others, 1954), presumably from volcanics in or associated with the Cimarron Ridge Formation.

30. Zapp (1949), Barnes (1953), and Barnes, Baltz and Hayes (1954) concluded that no unconformity is present between the Cretaceous and Tertiary parts of the Animas Formation. J. E. Fassett (oral commun., 1977) disagrees; he believes an unconformity marks the Cretaceous-Tertiary boundary throughout the basin but that it has not been properly recognized by previous workers.

The Ojo Alamo Sandstone (Brown, 1910) is not included here because it was restricted by Baltz, Ash and Anderson (1966) and placed in the Paleocene Series. Powell (1973, p. 119) and J. E. Fassett (oral commun., 1977) found dinosaur bones in the Ojo Alamo, suggesting that at least part of it is Cretaceous in age, and Anderson (1960, p. 9-10) found a suite of palynomorphs that was not diagnostic but suggested a Tertiary age.

Recent magnetostratigraphic studies by Butler and others (1977) indicate that the Cretaceous-Tertiary boundary as defined by marine invertebrate fossils in Italy is slightly older (by about 0.5-1.5 million years) than the same boundary as defined by vertebrate fossils in the San Juan Basin. The data provided by these authors suggests that the systemic boundary based on marine fossils in Italy falls in the upper part of the Kirtland Formation and that the dinosaur fossils recovered from the uppermost part of the Kirtland and the overlying Ojo Alamo Sandstone actually are earliest Paleocene in age.

APPENDIX II

Notes on Figure 3, Black Mesa Basin

1. A thin bentonite bed was found in the lower part of the Dakota near Cow Springs Trading Post on the northwest side of the basin and is thought to correlate with the bentonite marker bed in the lower part of the Dakota of the Kaiparowits basin and with the bentonite marker bed in the middle Cenomanian zone of *Acanthoceras amphibolum* Morrow of the Great Plains region (Cobban and Scott, 1972, p. 16; Hattin, 1965, p. 33-38).

2. A Cenomanian assemblage of spores and pollen was reported from the lower and middle members of the Dakota by Agasie (1969) and Romans (1975).

3. A late Cenomanian pelecypod *Pycnodonte newberryi* (Stanton) was reported by Repenning and Page (1956, p. 262) from a thin marine shale bed in the middle member of the Dakota. This pelecypod was also reported in the upper sandstone member by the same authors.

4. Hazenbush (1973, p. 59-64) found the ostracode *Cythereis eaglefordensis* Alexander in the lowermost beds of the Mancos Shale at several localities in the region. According to Hazel (1969), this fossil indicates a latest Cenomanian age.

5. Important ammonites of late Cenomanian age that have been recovered from the lower beds of the Mancos Shale in Black Mesa include *Sciponoceras gracile* (Shumard), *Metoicoceras whitei* (Mantell), *Calycoceras naviculare* (Mantell), and *Desmoceras* (*Moremanoceras*) *scotti* (Moreman). These were reported by Reeside and Baker (1929, p. 34), Repenning and Page (1956, p. 267-268), and Cobban (1971, p. 7; 1975) who also included lists of many other fossils in the Mancos.

6. The early middle Turonian index fossil *Collignoniceras woollgari* (Mantell) is reported from the middle sandy unit of the Mancos and upwards into beds of the Mancos that lie above the lower tongue of the Toreva Formation (Repenning and Page, 1956, p. 263, 268).

7. *Inoceramus dimidius* White was found in the basal beds of the Toreva Formation by Repenning and Page (1956, p. 268). This pelecypod indicates the lower upper Turonian zone of *Scaphites warreni* Meek and Hayden in Cobban and Reeside (1952) or the zone of *Prionocyclus macombi* Meek in Obradovich and Cobban (1975).

8. A nonmarine unit consisting of carbonaceous mudstone, coal and fluvial sandstones is present in the upper 28.5 m of the unit that Beaumont and Dixon (1965, pl. 2, sec. 19) called the lower sandstone of the Toreva Formation.

9. The pelecypods *Inoceramus deformis* Meek and *I. stantoni* Sokolow were reported from the marine shale tongue of the Toreva by Reeside and Baker (1929, p. 34; see also Repenning and Page, 1956, p. 275-276). These indicate, respectively, the lower Coniacian zone of *Scaphites preventricosus* Cobban and the lower Santonian zone of *Scaphites depressus* Reeside (Scott and Cobban, 1964; Obradovich and Cobban, 1975; W. A. Cobban, oral commun., 1975).

10. Reeside and Baker (1929, p. 36) reported the lower Santonian guide fossil *Inoceramus stantoni* Sokolow from a collection made earlier by Gregory (U.S. Geol. Survey loc. 11642) that was thought to have come from the Yale Point Sandstone (Repenning and Page, 1956, p. 279). We disagree with the stratigraphic position ascribed to this fossil because that would make the Yale Point considerably out of place with respect to the major transgressive-regressive cycles that are well documented in the southern part of the Colorado Plateau, and because the presence of this fossil in the Yale Point would make the lower Santonian zone of *Scaphites depressus* Reeside range through a stratigraphic interval of at least 120 m, which is considerably more than is known elsewhere.

APPENDIX III

Notes on Figure 4, Kaiparowits and Henry Basins

1. The Cedar Mountain Formation is unfossiliferous in the Kaiparowits and Henry basins, and the age is based on fossils found farther north at the north end of the San Rafael swell. In that area, an Aptian age is indicated by the pelecypod *Eupera onestae* McLearn (Katich, 1951; Cobban and Reeside, 1952) and the charophyte *Clavator harrisi* Peck (Stokes, 1952; Peck, 1957, p. 14-15). The uppermost beds of the Cedar Mountain could be Albian in age but fossils diagnostic of that stage have not been found in it.

2. Recent work by Fred Peterson indicates that the Dakota truncates the Cedar Mountain Formation near Escalante, Utah (in this area the Cedar Mountain was mapped with the Morrison Formation by Stephens (1973)). The erosion interval occurred during latest Albian and(or) earliest Cenomanian time based on the age of the Cedar Mountain in the San Rafael swell and the age of the Dakota near Escalante.

3. Spores and pollen were obtained from samples of the basal meter of the Dakota Formation near Escalante, Utah. The collection (U.S.G.S. Paleobotany locality D4771) came from the NE¼ SW¼ sec. 13, T. 34 S., R. 2 E., Garfield County, Utah. The fossils included: *Retitricolpites georgensis* Brenner, *R. prosimilis* Norris, *Psilatricolpites parvulus* (Groot and Penny) Norris, and *Nyssapollenites albertensis* Singh. According to R. H. Tschudy (oral commun., 1977) who identified them, the fossils suggest an early Cenomanian age. This age is compatible with that determined by May and Traverse (1973) for the Dakota farther west in the Bryce Canyon National Park.

4. A thin, widespread bentonite marker bed is present in the lower part of the middle member of the Dakota throughout most of the Kaiparowits basin (Peterson, 1969a; Peterson and Barnum, 1973) and, locally, at the base of the lower unit of the Dakota in the Henry basin (Hunt and others, 1953, p. 77-78). This marker probably correlates with a widespread bentonite marker bed of the Great Plains region that is in the middle Cenomanian zone of *Acanthoceras amphibolum* Morrow (Cobban and Scott, 1972, p. 16; Hattin, 1965, p. 33-38). The marker bentonite of the Great Plains has been traced by Haun (1959) "with reasonable certainty to western Colorado," and this tentative correlation with it suggests that the bentonite originally extended west over much of the Colorado Plateau province.

5. Age diagnostic fossils have not been found in the lower unit of the Dakota in the Henry basin, but a Cenomanian flora was reported from the Dakota farther north near Elgin and Woodside, Utah (Richardson, 1909, p. 14; Fisher and others, 1960, p. 25).

6. The upper member of the Dakota in the Kaiparowits basin contains a mudstone unit at the base that has yielded a brackish-water fauna including *Flemingostrea prudentia* (White), *Pycnodonte newberryi* (Stanton), and *Exogyra levis* Stephenson (Peterson, 1969a), which indicate a late Cenomanian age (Cobban and Reeside, 1952; W. A. Cobban, oral commun., 1975). The same fossils have been found in a mudstone unit in the lower part of the upper unit of the Dakota in the Henry basin (Peterson and Ryder, 1975, p. 171).

7. The upper member of the Dakota contains a sandstone bed at the top that has yielded *Metoicoceras defordi* Young (Peterson, 1969a) which indicates the upper Cenomanian zone of *Dunveganoceras albertense* (Warren) according to W. A. Cobban (oral commun., 1977). The uppermost Cenomanian index fossils *Sciponoceras gracile* (Shumard) and *Cythereis eaglefordensis* Alexander (Hazel, 1969) occur in fossiliferous limestone concretions near the base of the Tropic Shale (Hazel, 1969, p. D155-D156; Peterson, 1969a, p. 41-45).

8. Younger beds in the Tropic contain *Mytiloides mytiloides* Mantell (formerly *Inoceramus labiatus* (Schlotheim) and *Collignoniceras woollgari* (Mantell) which indicate an early and middle Turonian age (Peterson, 1969a, p. 46-47). The uppermost beds of the Tropic in the northeastern part of the region lack age diagnostic fossils, but are included in the middle Turonian zone of *Prionocyclus hyatti* (Stanton)

because they interfinger with the Tibbet Canyon Member of the Straight Cliffs Formation which contains guide fossils indicating that zone.

9. *Inoceramus howelli* White, which indicates the middle Turonian zone of *Prionocyclus hyatti* (Stanton), and *Inoceramus* cf. *I. cuvieri* Sowerby, which ranges no higher than the upper Turonian zone of *P. macombi* Meek according to W. A. Cobban (oral commun., 1975), were found in the Ferron Sandstone Member (Peterson and Ryder, 1975, p. 176).

10. *Inoceramus howelli* White has been collected from the Tibbet Canyon Member at several localities in the Kaiparowits basin (Peterson, 1969a, 1969b); it indicates the middle Turonian zone of *Prionocyclus hyatti* (Stanton) according to W. A. Cobban (written commun., 1975).

11. Juvenile *Prionocyclus* that resemble *P. hyatti* (Stanton) and *P. macombi* Meek were reported from the top of the Tununk Shale Member; they suggest that the upper part of the Tununk and overlying Ferron Sandstone Member may be as young as early late Turonian (Peterson and Ryder, 1975, p. 172).

12. About 15 m of unfossiliferous fluvial sandstone and scarce carbonaceous mudstone beds are present above the Calico bed at the top of the Smoky Hollow Member but beneath the unconformity in a small area northwest of Escalante, Utah. Presumably these beds are only slightly younger than the Calico bed of the Smoky Hollow Member.

13. *Inoceramus stantoni* Sokolow and *Protexanites shoshonensis* (Meek) were found in the lower marine mudstone tongue, and *Inoceramus* (*Volviceramus*) *involutus* Sowerby was found in the overlying A sandstone bed of the John Henry Member by Peterson (1969b, p. J13-J14). According to Scott and Cobban (1964, p. L15) and W. A. Cobban (oral commun., 1966), *I. stantoni* and *P. shoshonensis* indicate the lower Santonian zone of *Scaphites depressus* Reeside; the upper limit of the range of *I. involutus* is in the same zone.

14. *Inoceramus kleini* Mueller, now known to be *Inoceramus stantoni* Sokolow, occurs in the lower beds of the Blue Gate Shale Member (Peterson and Ryder, 1975, p. 177) and indicates the lower Santonian zone of *Scaphites depressus* Reeside according to W. A. Cobban (oral commun., 1975).

15. Fossils indicating the middle and upper Santonian zones of *Clioscaphites vermiformis* (Meek and Hayden) and *Desmoscaphites bassleri* Reeside occur in the middle part of the Blue Gate Shale Member and indicate that this part of the Blue Gate correlates with the middle part of the John Henry Member of the Straight Cliffs in the Kaiparowits basin (Peterson and Ryder, 1975, p. 177, 182).

16. The ammonite *Desmoscaphites*? sp. was recovered from a float block that probably came from the base of the upper marine mudstone tongue of the John Henry Member of the Straight Cliffs Formation at U.S.G.S. Mesozoic locality D8880 (SE¼ NE¼ sec. 22, T. 39 S., R. 6 E., Kane County, Utah). According to W. A. Cobban (written commun., 1973), the ammonite suggests a late Santonian age. The following pelecypods were recovered from a bed 5.6 m above the base of the lower marine mudstone tongue: *Inoceramus* (*Sphenoceramus*) sp. and *I.* (*Endocostea*) cf. *I. balticus* Bohm. (Peterson, 1969a, p. 83-84). According to W. A. Cobban (written commun., 1968) these fossils suggest a low position in the lower Campanian zone of *Scaphites hippocrepis* (DeKay).

17. Samples taken 24.1 m above the base of the Masuk Member contained palynomorphs that suggest an early Campanian age according to R. H. Tschudy (written commun., 1970; Peterson and Ryder, 1975, p. 179). Peterson and Ryder (1975, p. 175) showed that the Masuk is largely, if not entirely, nonmarine.

18. Peterson and Ryder (1975, p. 182, 185) correlate the upper sandstone member of the Wahweap Formation in the Kaiparowits basin and the Mesaverde Formation of the Henry basin with the Castlegate Sandstone in the Book Cliffs region farther north which falls in the lower upper Campanian zone of *Baculites asperiformis* Meek.

19. Gregory (1951, p. 40) reported an unconformity at the base of the Kaiparowits Formation but recent work by Bowers (1973, 1975) and H. D. Zeller (oral commun., 1976) indicates that the basal contact of the Kaiparowits is conformable and gradational.

20. Campanian palynomorphs were found in the upper part of the Kaiparowits Formation (Bowers, 1972, p. B19-B20). Considering the position of the Kaiparowits Formation above the Wahweap Formation, the youngest beds of which are considered early late Campanian in age, the entire Kaiparowits must be late Campanian in age. A younger age determination by Lohrengel (1969) is considered incorrect.

21. An unconformity at the base of the Canaan Peak Formation was reported by Bowers (1972, p. B11; 1973; 1975).

22. Campanian palynomorphs were reported from the lower 65 m of the Canaan Peak Formation by Bowers (1972, p. B18-B20). No Maestrichtian fossils have been found in overlying beds of the Canaan Peak, but Bowers (1972, p. B20) includes the upper part in the Tertiary so a Maestrichtian age for the middle part of the Canaan Peak is inferred.