

A STUDY OF THE FOSSIL FLORA PRESENT IN A PALEOCENE RIVER SYSTEM,
SOUTHEASTERN MONTANA

Beth L. Williams
Department of Geology
Amherst College
Amherst, MA 01002

Three localities, from a field area 30 mi east of Miles City, MT, were chosen for the study of fossil leaves. More than four hundred individual specimens were collected from specially selected stratigraphic units within the Lebo Member of the Fort Union Formation in southwestern Williston Basin. The purpose of the project was to determine the depositional environments of the unconsolidated sediments and to relate the leaf assemblages to those environments, noting differences in species percentages from one environment to another.

The age of the Lebo is Torrejonian (Early Paleocene). This age is based on turtle bones collected by John Diemer and the leaf fossils collected by myself. J. H. Hutchison (Museum of Paleontology, Berkeley, August, 1987) and L. J. Hickey (Peabody Museum of Natural History, New Haven, February, 1988) independently dated the strata by examining the bone and leaf fossils, respectively. This is the first time Lebo strata in eastern Montana have been dated. In the past the Lebo was assumed to be Torrejonian age. This assumption was based on the age of Ludlow strata 200 miles to the east in North Dakota.

The lithologies of the Lebo units included fine-grained quartz-rich sands, silts, silty muds, clays, carbonaceous shaly mud, and lignitic coal. The clay minerals include smectite, kaolinite, illite, and chlorite (see Hayden report, this volume). Where smectite dominates (in any of the above lithologies except carbonaceous shale and coal), the sediment weathers to a concrete-hard unit, when sandy. It shows popcorn textures, when muddy. Lithification is usually limited to non-extensive nodular layers and clinker. Clinker results from the underground burning of coal that fused the surrounding sediment.

Twenty-two stratigraphic sections were measured and correlated by means of facies associations that define the depositional environments. The scheme for identifying the various environments was developed for Lebo strata in the area by Belt and Rockwell (in press). These depositional environments consist of meandering river systems that carried sediments from a source area located in the vicinity of either the Bighorn Mountains (Wyoming) or the Black Hills (South Dakota) (see Wong report, this volume).

The channel deposits are composed of fine- to medium-grained cross-bedded sand. These deposits are lenticular in sections perpendicular to the flow direction. They are characterized by ripples and cross beds, lateral accretion bedding, and fining-up sequences which are typical of meandering rivers (see Metcalf report, this volume).

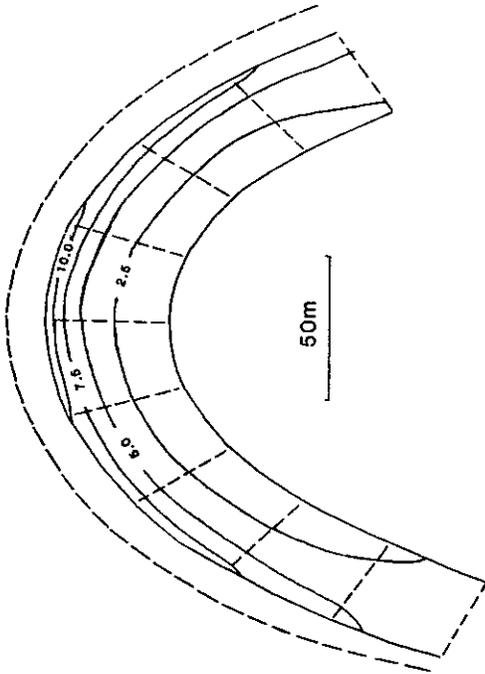
The flood basin adjacent to the river channels is characterized by extensive fine-grained sediment, often rich in organic material, including fossil leaves and roots. These sediments are deposited during flood situations when the river has left its banks and carries fine to very fine clastics in suspension. These become deposited when the flood recedes. Vegetation is drowned by this sediment influx, thus allowing their widespread preservation. Levees along the margins of the river channels form and grow during floods. The river overtops its banks and drops sand and sandy mud at the channel edge, and progressively finer material away from that edge. The sands on the levee are current rippled and commonly penetrated by roots and tree stumps. Levees are only recognizable in the strata where the outcrop exposure will allow observations perpendicular from the channel margin outward into the flood basin, and the above characteristics are noted.

The final facies associated with the meandering river system is the crevasse splay deposit. Whenever the river makes a major breach in the levee, water funnels through the hole and fans out onto the flood plain. These splays form lobes that coarsen-upwards from the fine-grained deposits of the flood plain as they prograde outward from the main channelbelt. Each lobe has one or more channelways that bring the sediment from the breached region to the surface of the lobe. These crevasse channels thus are rippled and cross bedded sands that later become root bioturbated when the lobe is abandoned. The surface of the lobe has ripple-bedded fine-grained sand and mud. The lobe surface can form a region where vegetation can grow.

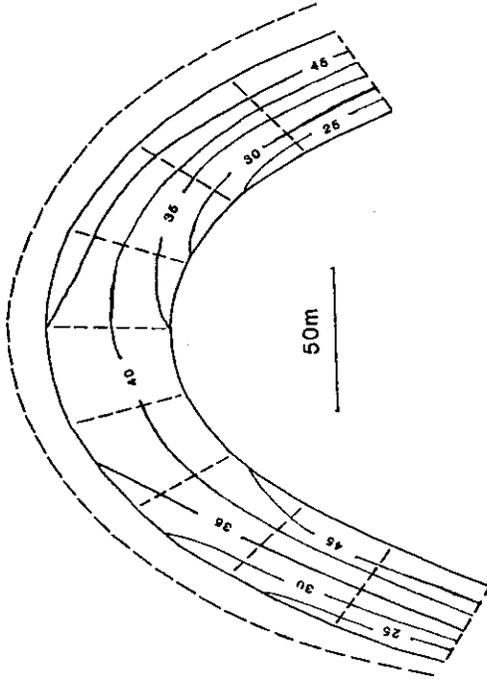
Leaf fossils can be preserved in all of the environments of deposition (Figure 1), but the best preser-

Figure 2

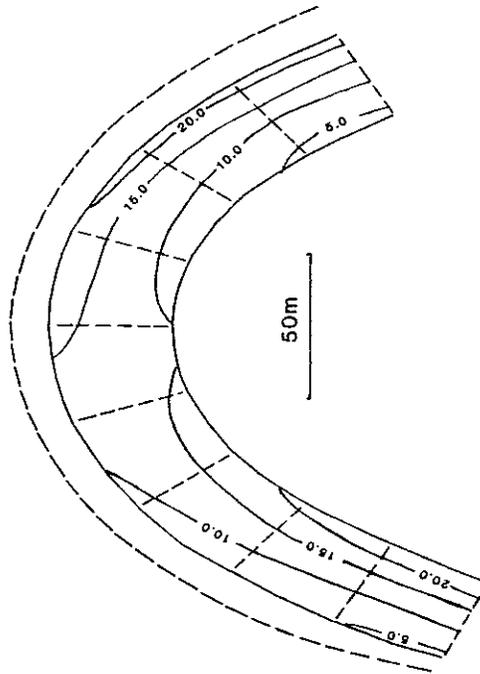
A. CHANNEL 2 DEPTH CONTOURS (m)



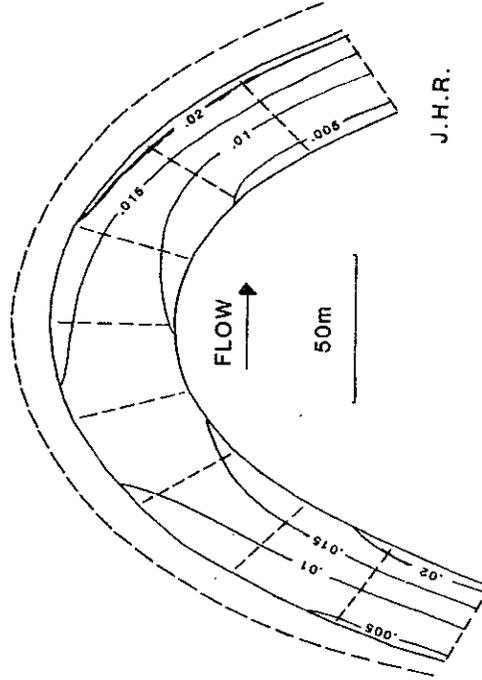
B. CHANNEL 2 VELOCITY CONTOURS (cm/s)



C. CHANNEL 2 BED SHEAR STRESS CONTOURS (dyn/cm²)



D. CHANNEL 2 GRAIN SIZE DISTRIBUTION (mm)



vation occurs where: (1) the depositional environment is high energy (e.g. channel) where leaves are easily rolled up and/or torn apart. (2) the leaf is quickly buried to remove it from being eaten by insects and by rotting. (3) only a few leaves are buried at a time. Many leaves all at once cause "overprinting" of one leaf on another. The flood basin carbonaceous shales contain the best preserved leaves collected in this study. The crevasse splay deposits yielded a good diversity of species, but had medium to poor preservation because fine textures such as tertiary venation do not hold up in that lithology. The channels had the lowest diversity and poorest preservation.

Twenty-eight morphotypes of fossil leaves were identified. Of these, many have never been illustrated by previous workers (Brown, 1962; Hickey, 1977, 1979, 1980; Johnson, 1982, 1987). These morphotypes were identified to species level using the work of Hickey (1979) and Brown (1962). The most common species found at any locality were of the genera *Platynus*, *Cercidiphyllum*, *Pterocarya* and *Sapindus* (Figure 2). Other genera are also found, and these are still being studied. All four genera were found in the flood basin facies. These four plus *Glyptostrobus* were found in the crevasse lobe facies. The channel contained the poorest preserved and the lowest diversity of fossils; here, *Cercidiphyllum* and *Platynus* were the most common genera. The genus, *Paranymphaea*, is found in two specimens. This genus is diagnostic of Clarkforkian stage. Its presence in this collection is the first time it has been reported from strata as old as Torrejonian (identified by me, supported by Hickey and Johnson).

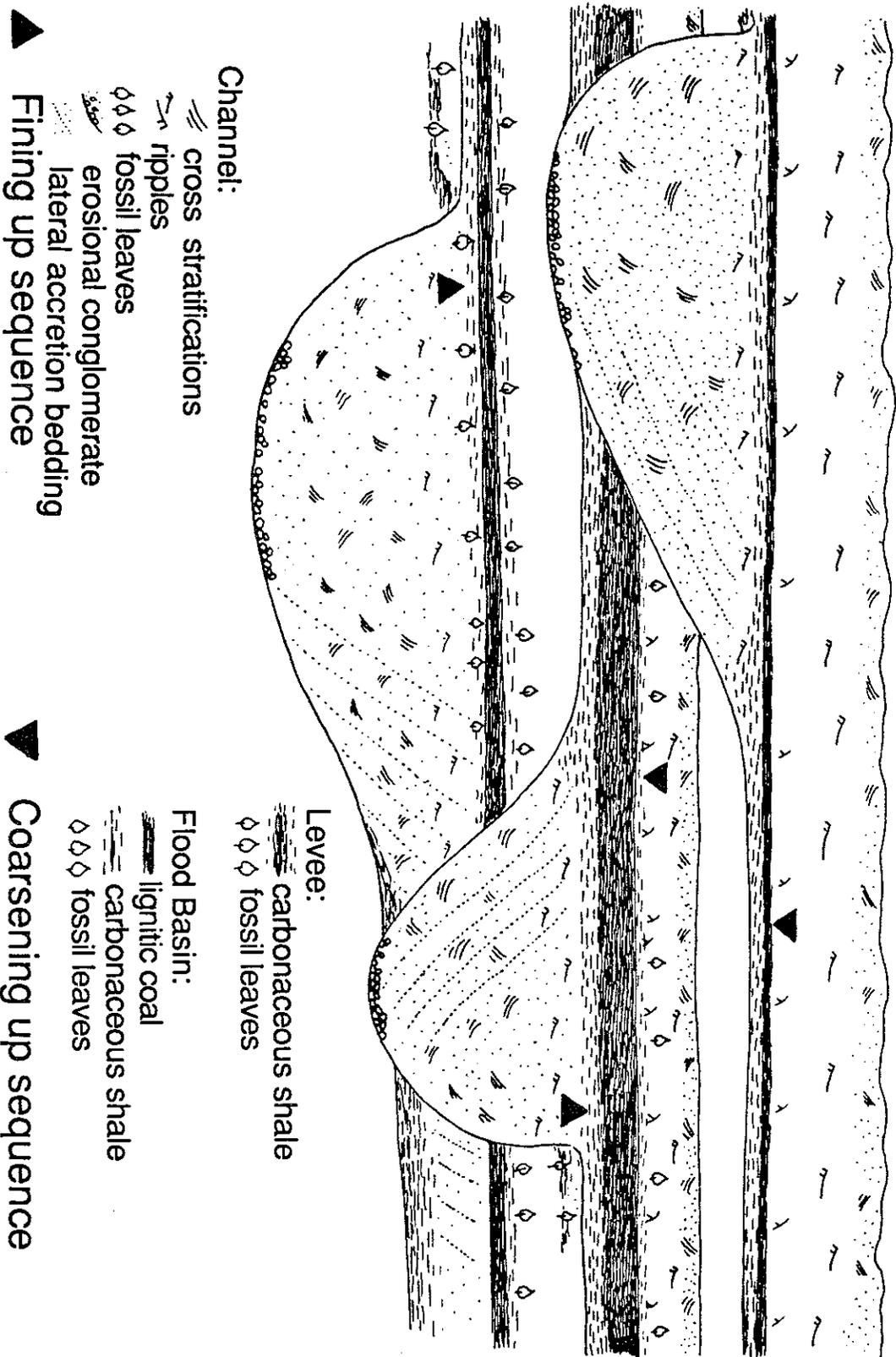
According to Wolf (1979), it is possible to deduce the paleoclimate by means of examining the relative size and the nature of the leaf margin within the floral assemblage. The percentage and proportion of the entire-margined to the dentate-margined leaves, and the size and the texture of the leaves, indicates the mean annual temperature and hence the climate at the site of deposition. Although this work is in progress, the data seems to point to a humid, temperate to subtropical climate similar to that of the coastal plain of the southeastern United States today. This is similar to conclusions reached by Kirk Johnson (1982) for older Puercan-aged strata 200 miles to the east in southwestern North Dakota.

REFERENCES

- Belt, E. S., and Rockwell, B. W., *in press*, Lower Paleocene fluvial deposits, western Williston Basin, Montana: *in*, M.A. Sholes and S. M. Vuke-Foster, editors, Stratigraphy and Sedimentology of coal-bearing Early Paleocene deposits from eastern Montana, Montana Bureau of Mines and Geology, Special Publications.
- Brown, R. W., 1962, Paleocene flora of the Rocky Mountains and Great Plains: U.S. Geological Survey, Memoir 375, 119 pages and 69 plates.
- Hickey, L. J., 1977, Stratigraphy and paleobotany of the Golden Valley Formation (Early Tertiary) of western North Dakota: Geological Society of America, Memoir 150, 181 pages and 55 plates.
- Hickey, L. J., 1979, A revised classification of the architecture of dicotyledonous leaves: *in*, C. R. Metcalfe, and L. Chalk, editors, Anatomy of the dicotyledons, second edition, volume I, Systematic anatomy of leaf and stem, with a brief history of the subject: Clarendon Press, Oxford, 39 p.
- Hickey, L. J., 1980, Paleocene stratigraphy and flora of the Clark's Fork Basin: *in*, P.D. Gingerich, editor, Early Cenozoic paleontology and stratigraphy of the Bighorn Basin, Wyoming, University of Michigan, Papers on Paleontology 24, p. 33-49.
- Johnson, K. R., 1982, The sedimentology and paleobotany of some lower Ludlow strata, Fort Union Formation (Paleocene), Slope County, North Dakota: unpublished honors thesis, Amherst College, Amherst, MA, 159 pp.
- Johnson, K. R., 1987, Fossil leaf and palynomorph changes associated with an iridium anomaly at the Cretaceous-Tertiary boundary in North Dakota: Geological Society of America, Abstracts with Programs, v. 19, n. 7, p. 718.
- Wolf, J. A., 1979, Temperature parameters of humid to mesic forests of eastern Asia and relation to forests of other regions of the northern hemisphere and Australasia: U.S. Geological Survey, Professional Paper 1106, 37 p.

CARTOON CROSS SECTION

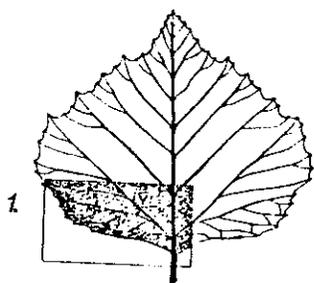
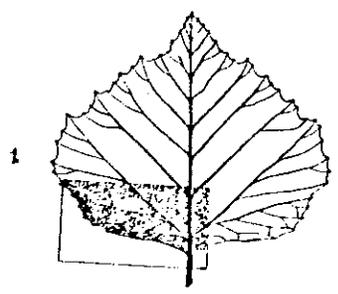
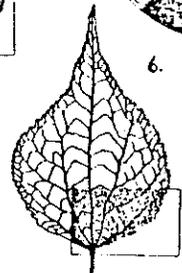
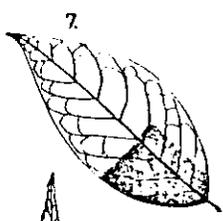
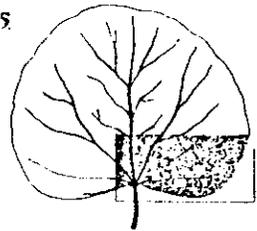
Figure 1



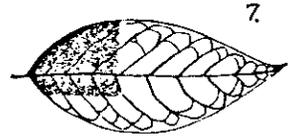
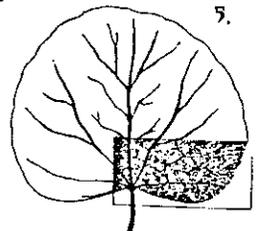
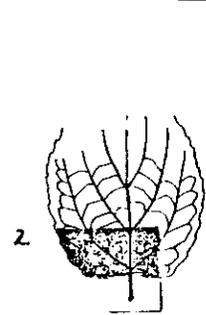
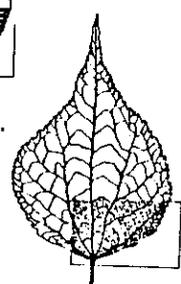
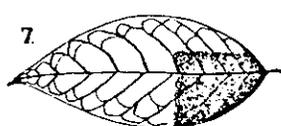
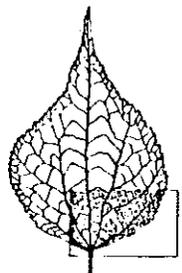
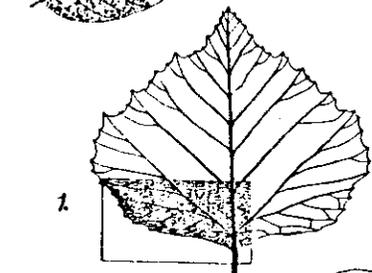
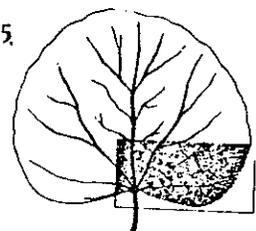
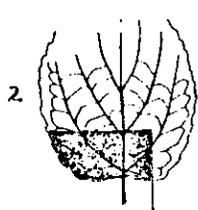
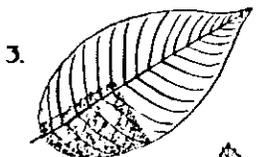
channel

Figure 2

levee/flood basin



crevasse splay



- 1. *Platynus reynoldsi*
- 2. *Platynus nobilis*
- 3. *Pterocarya*
- 4. *Glyptostrobus*
- 5. "*Cocculus*" *flabella*
- 6. *Cercidiphyllum arcticum*
- 7. *Sapindus affinus*

PROVENANCE IMPLICATIONS OF SAND COMPOSITION FROM LEBO AND LOWER
TONGUE RIVER MEMBERS, FORT UNION FORMATION (PALEOCENE),
SOUTHWESTERN WILLISTON BASIN

Bonnie Wong
Department of Geology
Carleton College
Northfield, MN 55057

Introduction:

Sand composition of the Lebo and lower Tongue River Members (both Paleocene) was studied from a site north of Route 12, 25 miles east of Miles City. These data were compared with sands of the Lebo Member (Paleocene) and Hell Creek Formation (Late Cretaceous) south of Route 12 (Sloan, 1988), and also with strata of Lebo age in North Dakota where sand composition from the Ludlow and Tongue River Members has been studied by Velbel (1988a, 1988b). These three areas were analysed in my senior thesis (Wong, 1988) to decide whether tectonic setting (model of Dickinson and Suczek, 1979) or climate (model of Suttner, Basu, and Mack, 1981) most influenced sand composition.

This paper is more speculative. The regional implications of the differences in provenance of the stratigraphic units in the three study areas is examined because compositional changes ought to indicate the time when unroofing of plutonic and metamorphic rocks occurred. Previous literature shows the initiation of block mountains in the younger part of the Early Paleocene (Torrejonian). Once formed, they are thought to continue to be actively uplifted through the remainder of the Paleocene (RMAG, 1972, Figure 53, p. 227 and Figure 3, p. 237; Cherven and Jacob, 1985, figs 25 and 25B-H). The Bighorn Mountains and Black Hills are the nearest block mountains to the study area, and are therefore likely contenders sand sources, although other, more distant sources are possible. Neither the Bighorns nor the Black Hills were thought to have contributed sediment during the latest Cretaceous or the earliest part of the Paleocene (Puercan). Evidence in this paper implies that there was a pulse of the the Laramide Orogeny earlier (latest Maestrichtian) than previously thought, but that pulse died down and was renewed again after the Tiffanian stage.

The stratigraphic units studied are primarily the Lebo Member (Montana) and the Ludlow Member (North Dakota). The Tongue River Member which overlies both these units in the two states was also studied. All three members are Paleocene in age; upper Ludlow is the same age as Lebo and the boundary between the Lebo or Ludlow and the overlying Tongue River Member is reputedly a time-line throughout the western Williston Basin (Bluemle et al., 1981). The stratigraphic units reported here are of thus comparable age so that changes in sand composition should reflect some influence of source-area changes.

Results:

Both the Lebo and Tongue River Members consist of fine- to very fine-grained unconsolidated sand, mud, carbonaceous shale and lignitic coal. The Lebo Member locally shows medium-grained sand within channelbelt deposits. Lebo Member is characterized by smectite-dominated clay minerals that occur in the muds and as matrix in the sands (see Hayden report, this volume). Tongue River Member has essentially no smectite clay (Belt et al., 1985; Belt and Rockwell, in press). Thus the sands from the early Paleocene strata in the district are solidified by smectite (Lebo case) or are entirely friable (Tongue River case) due to the dominance of kaolinite and illite.

Considering both Lebo and Tongue River Members of Montana together, point counts revealed a predominant composition of mono- and polycrystalline quartz (40-50 lithic fragments (45-55 cases of embayed volcanic quartz, quartz with recycled overgrowths, and brown chert. Both weathered and fresh feldspars are seen; varieties include microcline and perthite. Potassium feldspar is dominant over plagioclase. Major lithic fragments consist of limeclasts, shale-siltstone fragments, and quartz-mica aggregates. Minor lithic constituents include quartz-mica tectonites, mica, volcanic lithics, and indeterminate lithic fragments. Trace constituents include polycrystalline mica (metamorphic lithic?) and glauconite.

All constituents were plotted on various Dickinson-style ternary diagrams (Dickinson and Suczek, 1979; Dickinson et al., 1983). Figure 1 indicates some of these plots. They clearly show differences between the two formations in the three areas.

The constituents studied suggest significant contributions from extrabasinal sources, including Meso-