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PETROGRAPHY OF UPPER CRETACEOUS AND LOWER TERTIARY SANDSTONES: BEAUFORT-MACKENZIE BASIN

by
Mark D. Myers

Alaska Division of
Geological and Geophysical Surveys

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794 University Avenue, Suite 200
Fairbanks, Alaska 99709-3645

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METHODOLOGY

One hundred and twenty thin sections were cut and examined, and twenty four were selected for quantitative point count analysis. The thin sections were stained for K-feldspar with a sodium colbaltinitrate solution. All thin sections were impregnated with blue epoxy. Each thin section was divided up into four cells of equal area. One hundred detrital grains were counted per cell. The use of seperate cells allows for a comparison to be made between predicted and calculated analytical error and helps to average out operator error during the point counting process (Decker, 1985). Four hundred detrital sand grains were counted on each of the first ten thin sections examined. Three hundred grains per thin section were counted on the remaining fourteen. Cements, matrix, porosity, and authigenic minerals were also counted. A scanning electron microscope (SEM) was used to aid in identification of cements, authigenic minerals, porosity types and diagenetic history.

CLASSIFICATION AND TEXTURE

Representative thin sections from sandstones within the Cuesta Creek and Mudstone Members of the Tent Island Formation, Sandstone and Ministicoog Members of the Moose Channel Formation, and Aklak Member of the Reindeer Formation were point counted. With the exception of three samples from the Sandstone Member of the Moose Channel, all the sandstones are submature to immature chert litharenites. The three Moose Channel samples contain enough plagioclase feldspar that they are classified as feldspathic litharenites.

Grain sizes range from very fine to lower coarse grained sandstone. In order to minimize grain size bias, an attempt was made to point count thin sections of relatively uniform grain sizes. However, due to the fine grained nature and poor sorting of parts of the Tent Island, Moose Channel, and Reindeer formations, the average grain size of individual point counted thin sections varied from lower fine to upper medium sandstone. Whenever possible, medium grained sandstones were point counted. Sandstones ranged from poorly to well sorted.

ROUNDING AND PACKING

The detrital sand grains of all formations are dominantly subangular and range from angular to subrounded. The sandstones examined have extremely close packing of grains. All thin sections contain grains with irregular to straight line contacts, rather than the point to point contacts found in undeformed sediments. Penetration of softer grains by quartz and feldspar grains and fractured grains are common. Deformation, slippage, and rotation of ductile grains are typical. This is often illustrated by argillite, shale, phyllite and micas that which are bent around more resistant grains. Although grain contacts can usually be determined, these liable grains grade into pseudomatrix. Some mutual penetration of quartz, feldspar, volcanic, and chert grains is also present. Good examples of pressure solution between quartz grains were noted. As would be expected, the compaction has significantly reduced primary porosity.

COMPOSITION

QUARTZ

The quartz content of the thin sections studied ranged from a high of 65 percent to a low of 30 percent and averaged 39 percent. Quartz was present both as monocrystalline (straight and undulatory) and polycrystalline (individual crystals greater than .02 mm). Monocrystalline quartz is slightly more common than polycrystalline quartz at 21 and 18 percent respectively. Plutonic, metamorphic, and vein quartz were all common but volcanic quartz was not observed. Within the monocrystalline quartz category, undulatory quartz (>5% undulosity) was twice as common as quartz with straight extinction. For the purposes of this study chert was classified with rock fragments.

FELDSPAR

Feldspar was a relatively minor constituent, making up only 5.5 percent of the detrital grains. The percentage of K-feldspar remained fairly constant throughout the interval examined and averaged 1.5 percent. The K feldspar present was typically weathered, subrounded and was often partially altered to clay. In contrast, much of the plagioclase present was angular, unweathered, and associated with an increased amount of unaltered intermediate volcanics. While the amount of plagioclase present averaged 4 percent, the upper Tent Island (Mudstone Member) and lower Moose Channel (Sandstone Member) contained an average of almost 10 percent with some thin sections containing in excess of 15 percent.

CHERT AND CHERTY ARGILLITE

For the purposes of this study, chert was rigidly defined as polycrystalline quartz with crystals less than .02 mm in diameter and with 0-5% argillaceous material. Rock fragments with between 5-70% argillaceous and/or carbonaceous material were classified as cherty argillite. Because of the gradations that exist between chert, cherty argillite, silicified volcanics, and metaquartzite, chert and chert-like grains were often very difficult to categorize. The chert and cherty argillite present appeared to be a mixed assemblage of divitrified (silicified) volcanics, sedimentary chert and to a much lesser extent metachert and metaquartzite. In some cases, chert and cherty argillite grains were found with gradational textural and compositional transitions which made determinig the origin of the grain possible. However it was not possible to distinguish the origin of many chert and cherty argillite grains. Whenever remnants or ghosts of phenocrysts or a felty texture was present the rock fragment was classified as a volcanic rock fragment. Chert plus cherty argillite made up 23 percent of the composition of the rocks studied with cherty argillite being the more abundant.

SEDIMENTARY ROCK FRAGMENTS

All gradations from argillite to shale/ slate were present, with argillite being the most common. Coal and organic detritus, sandstone, and siltstone fragments are a minor constituent in all but two thin sections.

IGNEOUS ROCK FRAGMENTS

Volcanic rock fragments made up about 10 percent of the composition of the interval studied. The volcanic fragments consisted of roughly equal amounts of felsic and intermediate volcanic rock fragments. Only a trace (less than 1 percent) of plutonic rock fragments were present.

METAMORPHIC ROCK FRAGMENTS

Metamorphic rock fragments made up only 6 percent of the total detrital composition. The quartz mica phyllite fragments were the most common with lesser amounts of schist/gneiss and unfoliated metaclastic fragments present.

DIFFERENTIATION OF UNITS BASED ON PETROGRAPHY

Detailed modal analysis indicates that some differentiation of the units studied can be made based on composition. It is interesting, but not surprising, to note that the differentiation of units does not occur at formation boundaries. The compositional variations do however occur at the member level and correspond to significant changes in the depositional system. In turn, these changes in the depositional system can be best related to tectonic events which control uplift history and ultimately provenance.

The following three divisions can be made based on subtle but significant compositional differences in sandstone composition: 1. Cuesta Creek Member, Tent Island Formation 2. Mudstone Member, Tent Island Formation / Sandstone Member of the Moose Channel 3. Ministicoog Member of the Moose Channel/Aklak Member of the Reindeer Formation.

CUESTA CREEK MEMBER

The Cuesta Creek Member contains both the highest percent of total quartz (50 percent) and polycrystalline quartz (33 percent). The Cuesta Creek contains abundant polycrystalline quartz grains with greater than three crystals. The polycrystalline grains display straight contacts between equant interlocking crystals. In addition the Cuesta Creek samples had the highest ratio of undulatory to nonudulatory quartz. Both characteristics are typical of quartz derived from low grade metamorphic rocks. The Cuesta Creek also contained the highest percentage of metamorphic rock fragments of any member studied.

THE MUDSTONE MEMBER OF THE TENT ISLAND AND THE SANDSTONE MEMBER OF THE MOOSE CHANNEL FORMATION

These members can be differentiated from the underlying Cuesta Creek and overlying Ministicoog and Aklak Members by both the amount plagioclase and volcanic rock fragments. While plagioclase was only a relatively minor constituent, averaging of four percent of the detrital grains, the amount present was consistently greater in the upper Tent Island (Mudstone Member) and lower Moose Channel (Sandstone Member) than in either the underlying Cuesta Creek or the overlying Ministicoog and Aklak Members (eight percent vs less than one percent). The amount of K-Feldspar remained relatively constant and made up less than three percent of any sample. The upper Tent Island and lower Moose Channel also contained a much higher percentage of volcanic rock fragments (19%) than either the Cuesta Creek (2%) or the Ministicoog and Aklak Members (4%).

THE AKLAK AND MINISTICOOG MEMBERS

The Aklak and Ministicoog Members contained a much higher percentage of chert + cherty argillite (32%) than the underlying Tent Island and Moose Channel (18%) and Cuesta Creek (14%). The increase in chert and cherty argillite is probably at least partially related to the decrease in volcanic rock fragments from the underlying Mudstone and Sandstone Members. Silicification of volcanic rock fragments and their subsequent transformation into chert and cherty argillite may explain this relationship.

NON-DETRITAL CONSTITUENTS

Cements comprise only 5 percent of the bulk composition of the studied thin sections. Cements consist of calcite, siderite, kaolinite, hemitite, silica, chlorite, illite/smectite (identified by scanning electron microscope), and undifferentiated clay. Carbonate cement was the most abundant and ocurred in several stages.

REFERENCES CITED

Decker, J., 1985, Sandstone Model Analysis Procedure: Version 2: Alaska Division of Geological and Geophysical Surveys Public-data File 85-3a, 42p.

FIGURE 1

LOCATION OF CANADIAN STUDY AREA

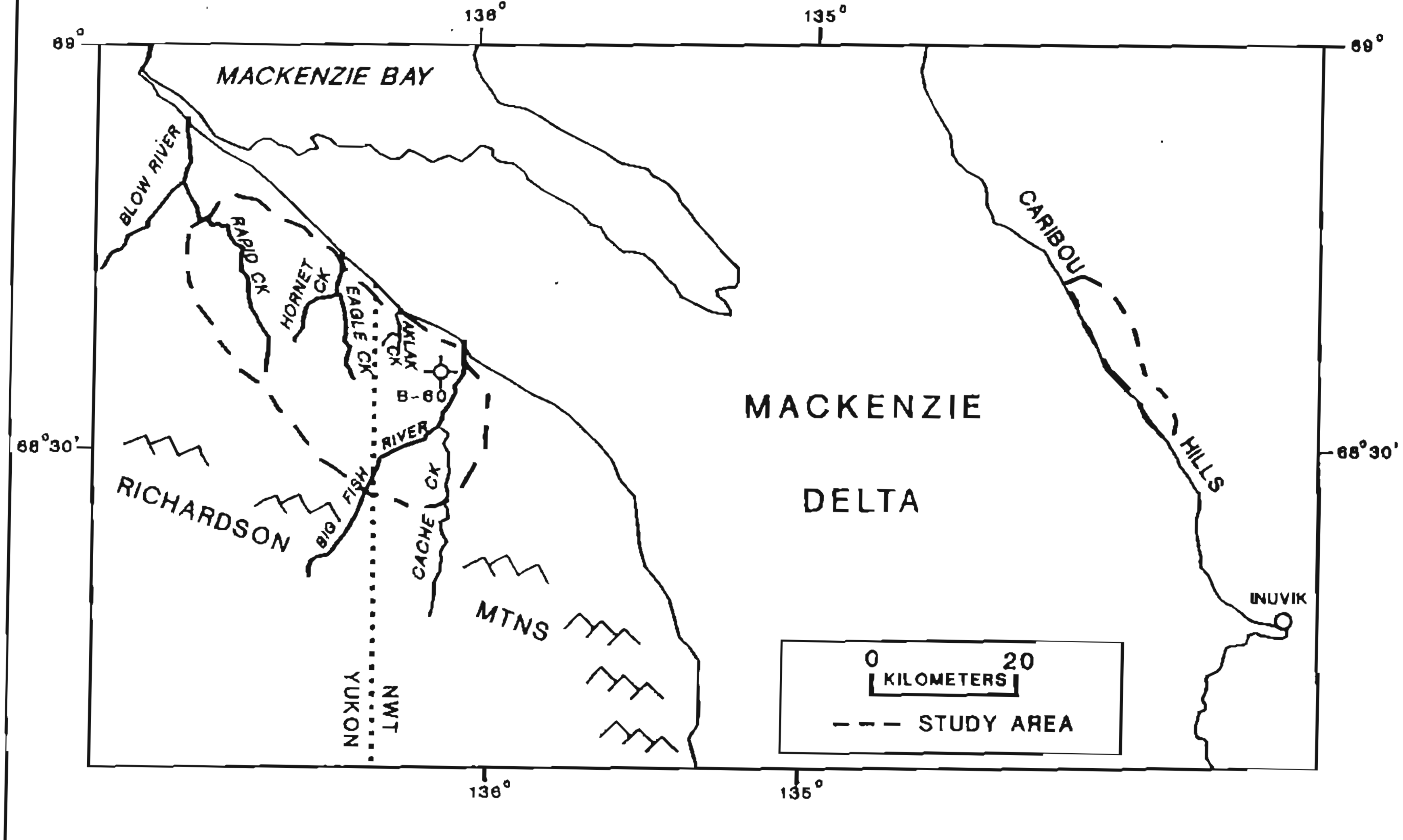


FIGURE 2
LOCATION MAP FOR POINT COUNTED SANDSTONES

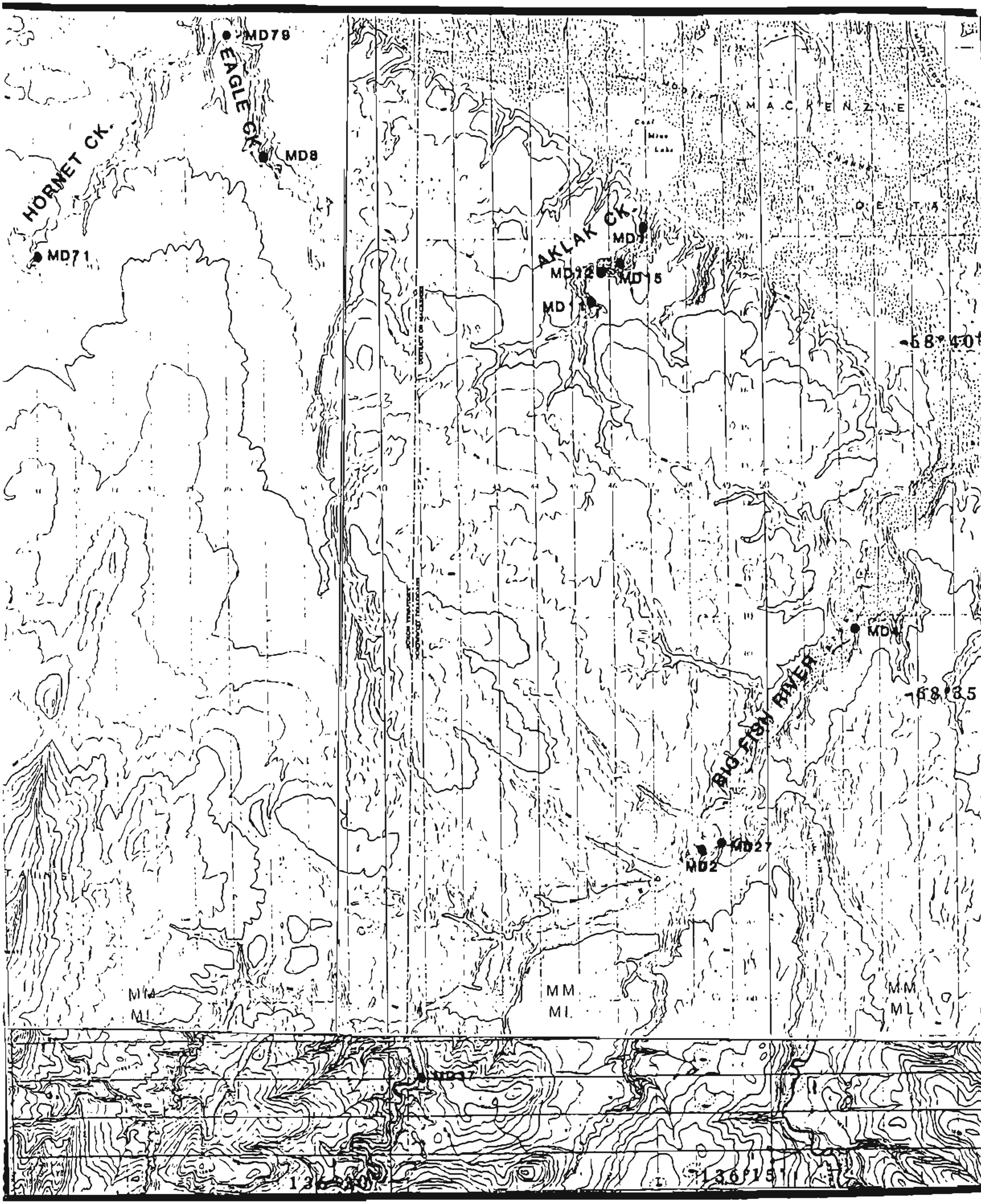
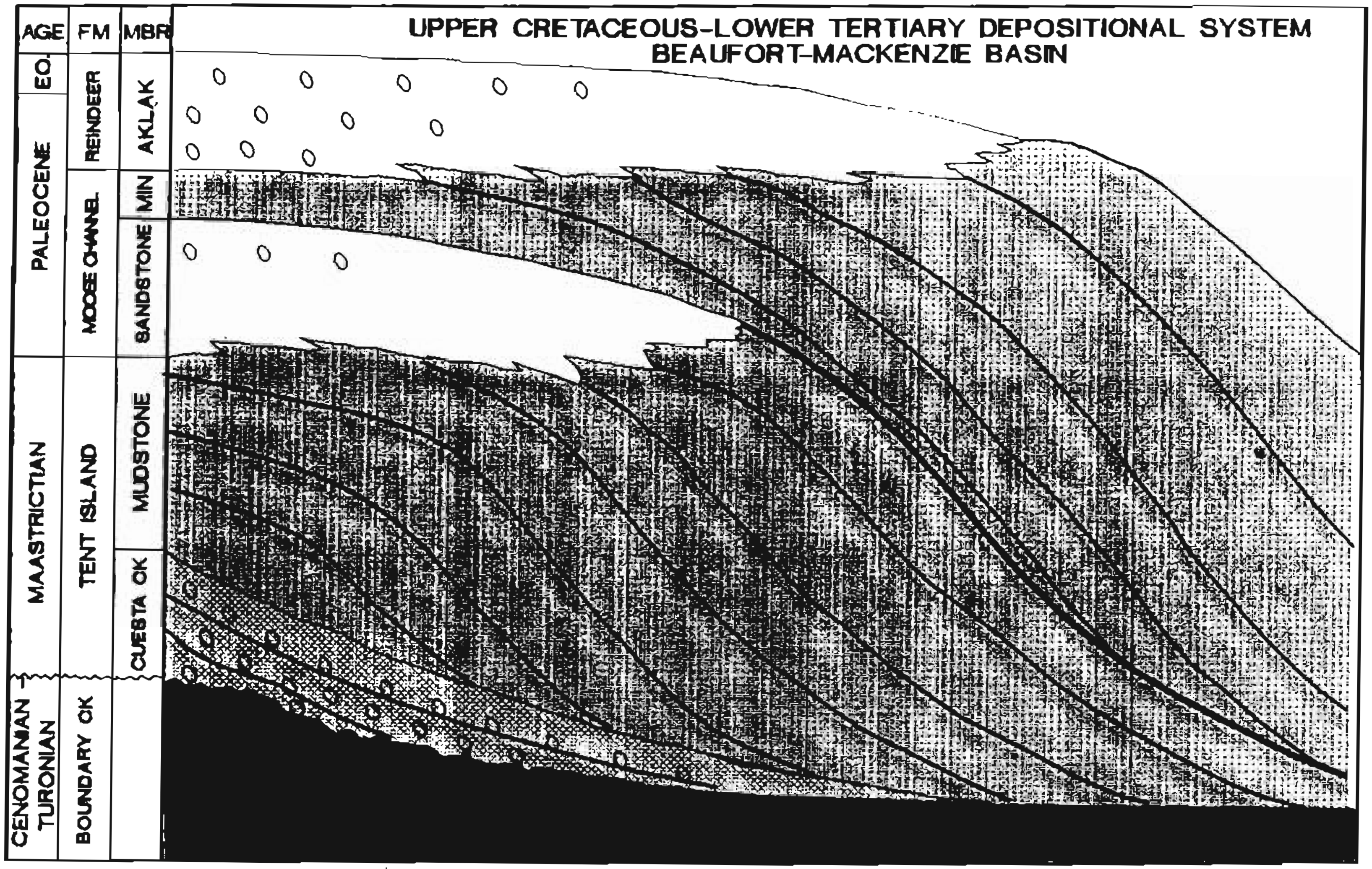


FIGURE 3



UPPER CRETACEOUS-LOWER TERTIARY DEPOSITIONAL SYSTEM
BEAUFORT-MACKENZIE BASIN
AGE
FM
MBR
EO.
PALEOCENE
MAASTRICTIAN
CENOMANIAN - TURONIAN
REINDEER
MOOSE CHANNEL
TENT ISLAND
BOUNDARY CK
AKLAK
MIN
SANDSTONE
MUDSTONE
CUESTA CK

FIGURE 4

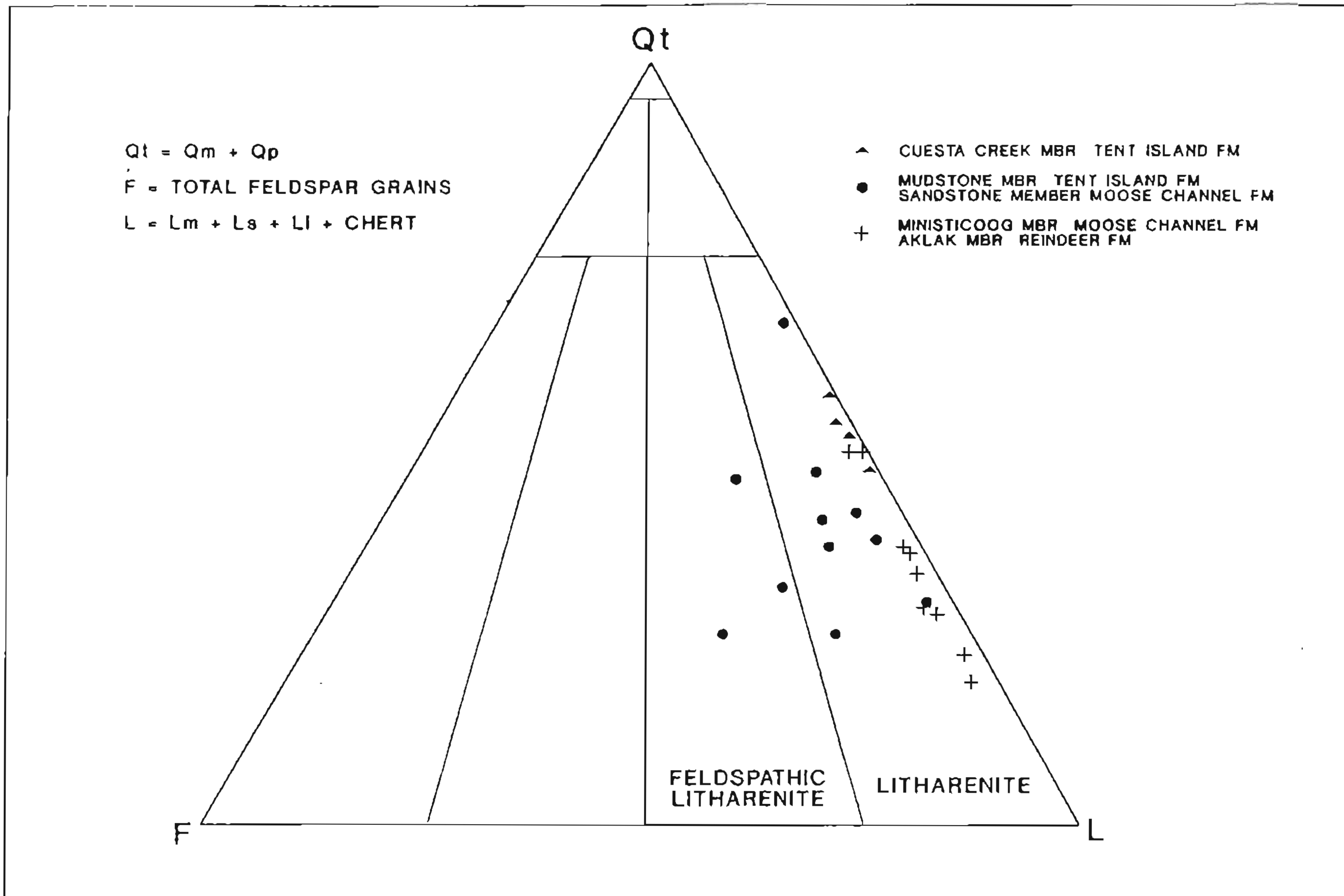
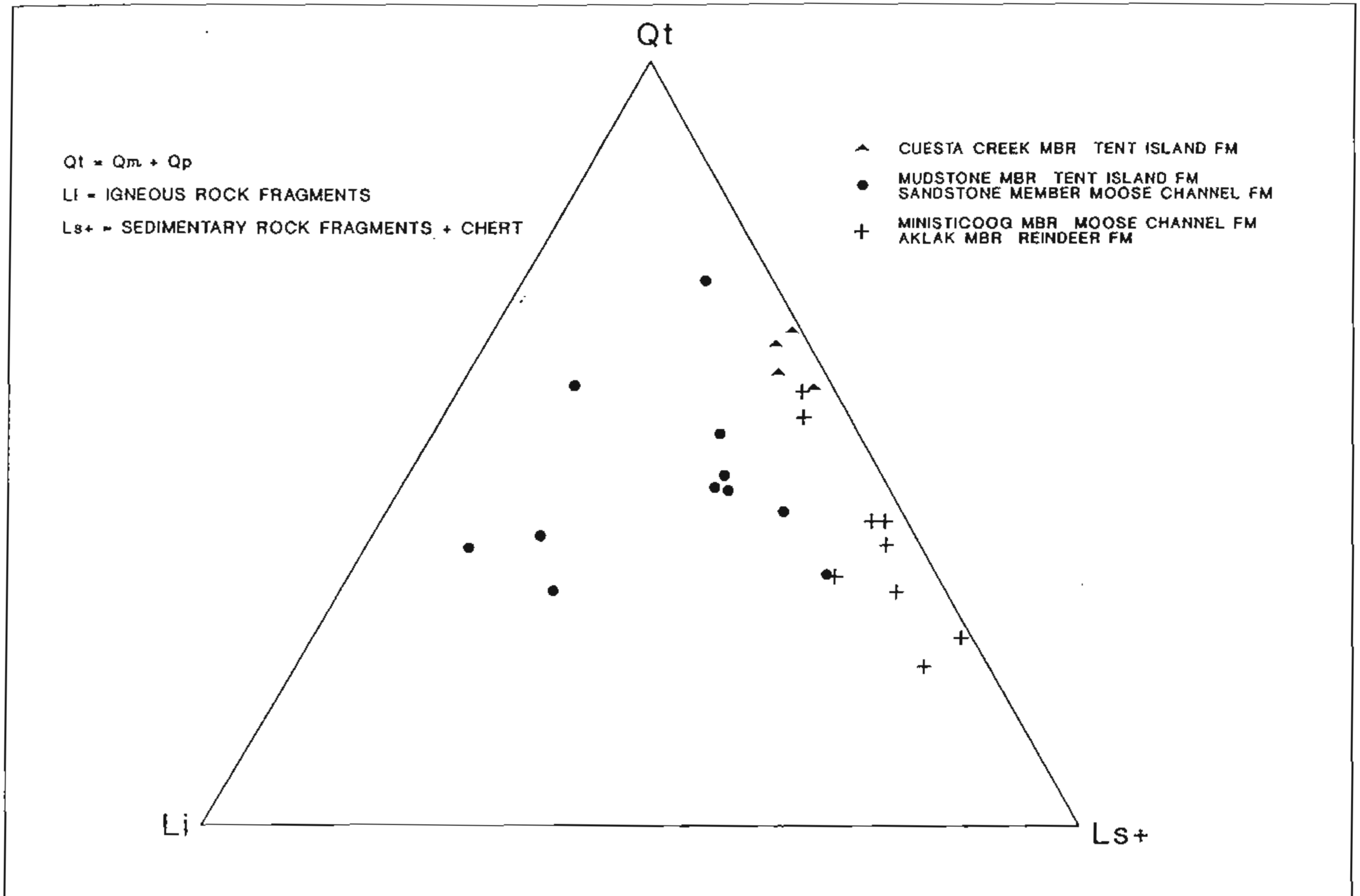

Qt
Qt = Qm + Qp
F = TOTAL FELDSPAR GRAINS
L = Lm + Ls + Ll + CHERT
CUESTA CREEK MBR TENT ISLAND FM
MUDSTONE MBR TENT ISLAND FM
SANDSTONE MEMBER MOOSE CHANNEL FM
MINISTICOOG MBR MOOSE CHANNEL FM
AKLAK MBR REINDEER FM
FELDSPATHIC LITHARENITE
LITHARENITE
F
L

FIGURE 5



Qt
Qt = Qm + Qp
Li = IGNEOUS ROCK FRAGMENTS
Ls+ = SEDIMENTARY ROCK FRAGMENTS + CHERT
CUESTA CREEK MBR TENT ISLAND FM
MUDSTONE MBR TENT ISLAND FM
SANDSTONE MEMBER MOOSE CHANNEL FM
MINISTICOOG MBR MOOSE CHANNEL FM
AKLAK MBR REINDEER FM
Li
Ls+

FIGURE 6

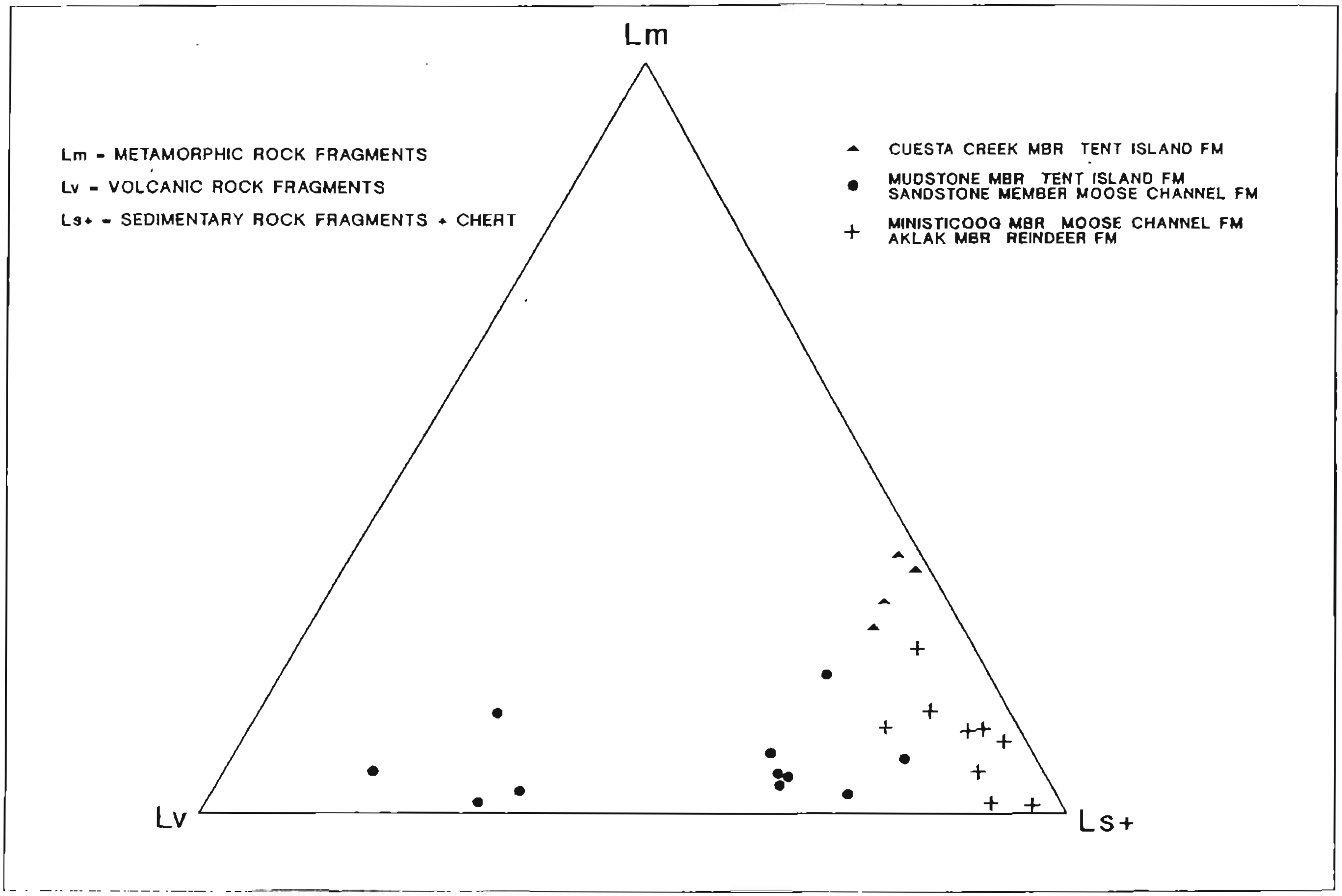

Lm
Lm - METAMORPHIC ROCK FRAGMENTS
Lv - VOLCANIC ROCK FRAGMENTS
Ls+ - SEDIMENTARY ROCK FRAGMENTS + CHERT
CUESTA CREEK MBR TENT ISLAND FM
MUDSTONE MBR TENT ISLAND FM
SANDSTONE MEMBER MOOSE CHANNEL FM
MINISTICOOG MBR MOOSE CHANNEL FM
AKLAK MBR REINDEER FM
Lv
Ls+

FIGURE 7

COMPOSITIONAL VARIATION BY MEMBER