UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

SEDIMENTOLOGY AND STRATIGRAPHY OF THE KANAYUT CONGLOMERATE AND ASSOCIATED UNITS, CENTRAL AND EASTERN BROOKS RANGE, ALASKA--REPORT OF 1978 FIELD SEASON

By

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Open-File Report 80-888

1980

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Preliminary report on the sedimentology and stratigraphy
of the Kanayut Conglomerate and associated units,
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ABSTRACT

The Endicott Group of the central and eastern Brooks Range, Alaska, records a major onlap-offlap cycle of Late Devonian to Early Mississippian age (Tailleur and others, 1967). From base to top, the Endicott Group in this area comprises: (1) the Hunt Fork Shale, 1,500 m of deep-marine, fine- to medium-grained sandstone, siltstone, and phyllitic shale of early Late Devonian age; (2) the Kanayut Conglomerate, nearly 2,000 m of mostly nonmarine conglomerate, sandstone, and shale of late Late Devonian and possibly Mississippian age; (3) the Kekiktuk Conglomerate, 100 m of nonmarine granule to cobble conglomerate, sandstone, and coal of Early Mississippian age; (4) the Kayak Shale, 300 m of sandstone, argillaceous limestone, black shale, and red limestone of Early Mississippian age; and (5) the Itkilyariak Formation (a lateral equivalent of the Kayak Shale), 50-300 m of marine shale, calcareous siltstone, quartzite, and limestone. The Hunt Fork Shale is commonly underlain by the Beaucoup Formation, a newly named unit (Dutro and others, 1979), consisting of 300 m of marine sandstone, chert-pebble conglomerate, calcareous siltstone, black shale and reefal limestone of early Late Devonian age. The Beaucoup Formation may represent an earlier onlap-offlap cycle and is not included in the Endicott Group.

Mapping in progress has permitted subdivision of the Kanayut Conglomerate into four regionally persistent members: (a) the basal sandstone member, 560 m

of marine medium-grained sandstone and shale with some interbedded nonmarine conglomerate; (b) the lower shale member, 550 m of nonmarine quartzite, conglomerate, and red shale; (c) the middle conglomerate member, consisting of 450 m of massive nonmarine pebble and cobble conglomerate and quartzite, and (d) the Stuver Member, 400 m of nonmarine conglomerate, sandstone, and shale. The three nonmarine members of the Kanayut are the same as the three members originally described in the type section by Bowsher and Dutro (1957). The dominantly marine sandstone member is new.

Analysis of sedimentary structures, facies relations and measured sections indicates that the deep-marine upper part of the Hunt Fork Shale grades upward into the shallow-marine basal sandstone member of the Kanayut Conglomerate. Analysis of sedimentary structures and depositional cycles in the Kanayut suggests that the lower shale member was deposited by progradation of meandering stream facies over the basal shallow-marine sandstone member, culminating in braided stream deposits of the middle conglomerate member. The successively overlying Stuver Member and basal sandstone and black shale of the Kayak Shale record a major regression of the Kanayut depositional system from meandering-stream to shallow-marine and deep-marine facies, respectively. The entire sequence, therefore, records outbuilding of a major fluvial system into a marine basin during Late Devonian time, and its subsequent burial by an Early Mississippian marine transgression.

Clast size data from the Kanayut Conglomerate indicate that the largest clasts are generally contained in the northern and easternmost outcrops. Paleocurrent data from the fluvial deposits indicate sediment transport toward the southwest.

Conglomerate of the Kanayut depositional system is compositionally very mature, composed primarily of chert with lesser amounts of quartz and quartzite. Chert is more abundant in finer than coarser conglomerate. Clast shape data indicate that chert clasts are smaller and less well rounded than quartzite and vein quartz clasts, probably because chert chips and splinters more easily than quartzite and vein quartz. The Kekiktuk Conglomerate in the eastern Brooks Range is depleted in chert and enriched in vein quartz relative to Kanayut Conglomerate and shows no regular relationship between clast abundance and size. These data suggest that Kekiktuk conglomerates have undergone less abrasion and sorting than Kanayut conglomerates, possibly reflecting closer proximity to the source area.

Sandstones of the Kanayut Conglomerate are also compositionally mature, consisting predominantly of well-sorted and subrounded grains of chert, quartzite, and argillite. Feldspar is rare. The compositional and textural maturity of both sandstone and conglomerate suggest primarily a sedimentary source terrane for the Kanayut depositional system. A likely provenance for at least part of the Kanayut depositional system is the same pre-Carboniferous chert, quartzite, and granitic rocks that presently crop out in the northeastern Brooks Range and the British Mountains.

INTRODUCTION

Purpose and scope

The Kanayut Conglomerate and associated rocks of the Endicott Group (Tailleur and others, 1967) comprise a depositional complex of Late Devonian and Early Mississippian age in the central and eastern Brooks Range of northern Alaska (fig. 1). Regional geologic mapping combined with stratigraphic, sedimentologic and biostratigraphic studies have provided sufficient data to synthesize the paleographic framework of these strata. The Endicott Group contains potential clastic reservoirs both of Devonian age that are regionally extensive in the shallow subsurface of the Brooks Range and Southern Foothills, and of Early Mississipian and possibly Devonian age that are present in isolated basins in the deep subsurface of the Northern Foothills and Coastal Plain. These potential reservoirs underlie parts of the National Petroleum Reserve in Alaska (NPRA).

This preliminary report presents results of work completed in 1978 between the Killik and Itkillik Rivers in the central Brooks Range and near the East Fork of the Chandalar River in the eastern Brooks Range. It also includes stratigraphic information obtained by regional mapping in intervening areas in 1975, 1976 and 1977. The report emphasizes sedimentologic analyses of depositional cycles, paleocurrents, clast size distribution, petrography, and depositional facies. These studies are summarized in a paleogeographic sketch map showing the inferred shape and internal relations of the depositional system in Late Devonian time.

Stratigraphic framework.

The Upper Devonian and Mississippian strata form a major offlap-onlap cycle for which the Upper Devonian Kanayut Conglomerate and the Lower Mississippian Kekiktuk Conglomerate make up the nonmarine middle components of the cycle

Figure 1.--Index map of Alaska showing location of areas described in this report (ruled pattern). British Mountains (Br) and Brooks Range are shown in heavy lines, eastern and central parts of Brooks Range by broken lines. Abbreviations: AV, Arctic Village; AP, Anaktuvuk Pass. Quadrangle names are designated by initial letters: H, Howard Pass; K, Killik River; C, Chandler Lake; P, Philip Smith Mountains; A, Arctic; T, Table Mountain; Am, Ambler River; S, Survey Pass; W, Wiseman; CH, Chandalar; CR, Christian; and CO, Coleen.

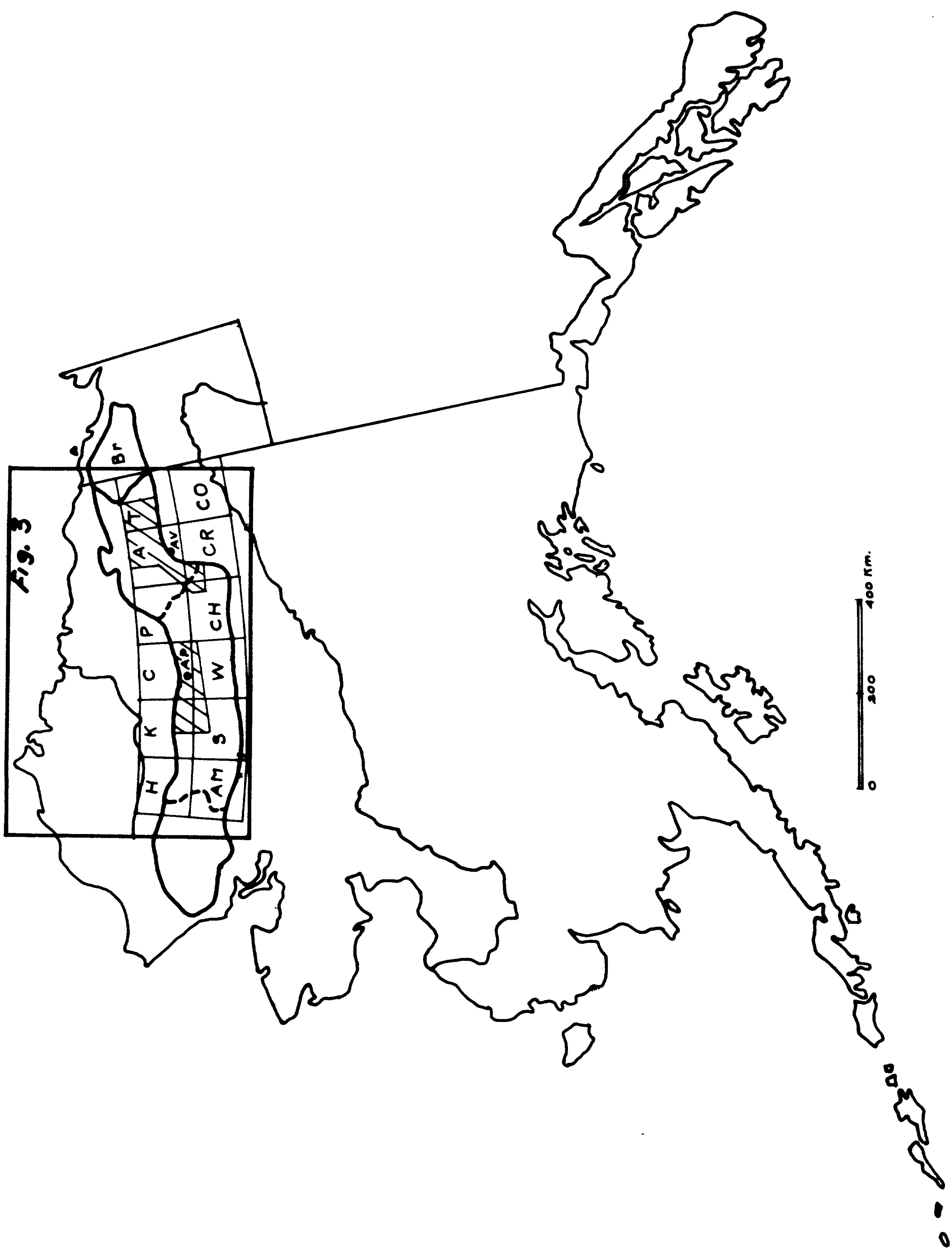


Figure 1

(fig. 2). The Devonian Beaucoup Formation and Hunt Fork Shale comprise the lower marine portion of the cycle and the Mississippian Kayak Shale or its local equivalent, the Itkilyariak Formation, comprise the upper marine portion.

Prior reconnaissance mapping had outlined the general distribution of the formations of the Endicott Group. However, detailed mapping and division of the Kanayut Conglomerate into informal members were limited to areas near Shainin Lake and Anaktuvuk Pass (Bowsher and Dutro, 1957; Porter, 1966). Members of the Kanayut Conglomerate and of the Hunt Fork Shale have now been mapped in the Philip Smith Mountains quadrangle as a result of field work done in 1975-1976 (Brosgé and others, 1979a) and in the region westward to the Killik River valley as a result of field work done in 1977-1978 (Brosgé and others, 1979b).

The Kanayut Conglomerate and Kayak Shale were described by Bowsher and Dutro (1957) in the Shainin Lake area and by Porter (1966) near Anaktuvuk Pass. Bowsher and Dutro described and named the upper three members of the Kanayut, and Porter described the lowest member, which is absent at Shainin Lake. All four members were again described, with the revised names used in this report, in the Philip Smith Mountains area (Brosgé and others, 1979a). The Hunt Fork Shale was defined by Chapman and others (1964), with its type section just west of the Okokmilaga Valley. The Kekiktuk Conglomerate, a basal Carboniferous coarse-grained clastic unit coeval with the lower part of the type Kayak Shale, was named for outcrops west of Lake Peters in the northeastern Brooks Range by Brosgé and others (1962). The Itkilyariak Formation, an Early Mississippian facies equivalent to that part of the Kayak Shale that crops out in the northeastern Brooks Range, was named by Mull and Mangus (1972) for rocks exposed on Itkilyariak Creek in the Sadlerochit Mountains of the northeastern Brooks Range.

Distribution and structure

With the possible exception of some small areas in the northeastern Brooks

Figure 2.--Columnar sections and inferred depositional environments of Endicott Group in the central and northeastern Brooks Range.

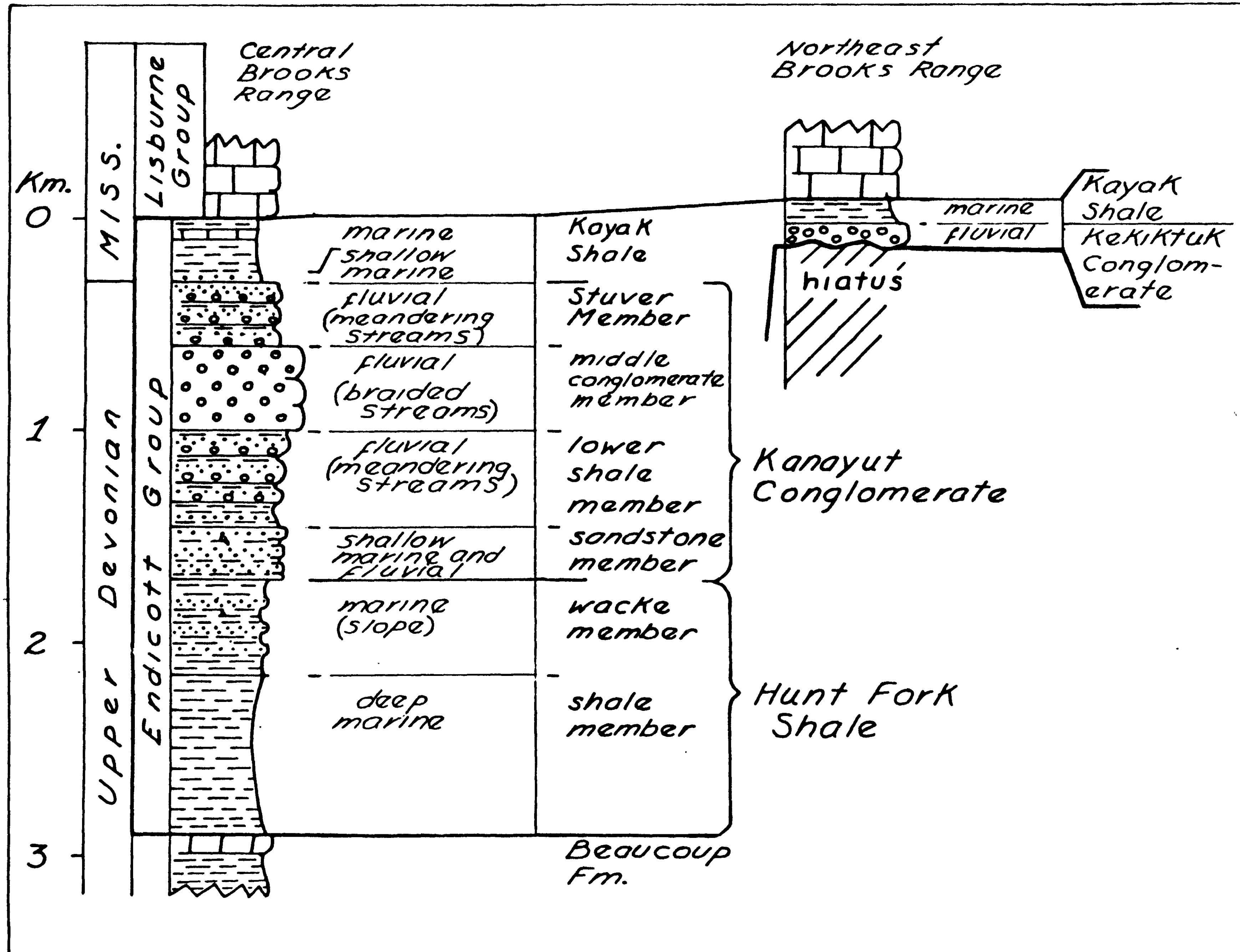

Km.
0
1
2
3
MISS.
Upper Devonian
Lisburne Group
Endicott Group
Central Brooks Range
marine
shallow marine
fluvial (meandering streams)
fluvial (braided streams)
fluvial (meandering streams)
shallow marine and fluvial
marine (slope)
deep marine
Kayak Shale
Stuver Member
middle conglomerate member
lower shale member
sandstone member
wacke member
shale member
Beaucoup Fm.
Kanayut Conglomerate
Hunt Fork Shale
Northeast Brooks Range
marine
fluvial
hiatus
Kayak Shale
Kekiktuk Conglomerate

Figure 2

Range, the outcrop areas of the Upper Devonian clastic rocks, the Beaucoup Formation, Hunt Fork Shale and Kanayut Conglomerate, are different than the outcrop areas of the Mississippian Kekiktuk Conglomerate (fig. 3). The Upper Devonian units are exposed in a band along the 68th parallel but are absent to the north, southwest, and east, where the Lower Mississippian Kekiktuk Conglomerate rests unconformably on pre-Upper Devonian rocks (fig. 3). The overlying Kayak Shale is present throughout the Brooks Range, resting stratigraphically above both the Kanayut and Kekiktuk Conglomerates. In one small area, 50 to 75 km WNW of Arctic Village, both the Kanayut and Kekiktuk are missing, and the Kayak Shale rests directly on the Hunt Fork Shale.

The Kekiktuk, Kayak and Itkilyariak Formations have also been penetrated by drill holes north of the Brooks Range. On the Barrow Arch of the Arctic Coast, the Kekiktuk lies unconformably on argillite basement and is overlain by the Kayak Shale or the Itkilyariak Formation in most places. At Inigok Well on the edge of the Umiat Basin, strata thought to be part of the Kekiktuk and Kayak Formations were penetrated below the Lisburne Group at a depth of 17,870 to 20,102 feet (total depth) (5,447 to 6,127 m) (I.L. Tailleur and K. J. Bird, written communications, 1979).

The Upper Devonian part of the Endicott Group is not known for certain to have been reached in the subsurface, but equivalent rocks may be present locally in the deeper parts of the Umiat and Meade Basins as outlined by seismic mapping (Tetra Tech, Inc., 1979). Parts of the Endicott Group may be as thick as 2,800 m in these deeply buried basins. Seismic interpretations (Tetra Tech, Inc., 1979) show a thickness of less than 1,000 m of strata between the Carboniferous (Lisburne)horizon and the argillite basement in most of the area, but as much as 4,000 m in the Umiat Basin. In Inigok test well near the edge of the Umiat Basin, the Lisburne is about 1,200 m thick (I. L. Tailleur and K. J. Bird,

Figure 3.--Index map showing distribution of Kanayut and Kekiktuk Conglomerates and major faults in the eastern and central Brooks Range. Outcrops of the Kanayut Conglomerate are shown by ruled pattern and outcrops of the Kekiktuk Conglomerate nearest to the Kanayut by dotted pattern. Abundant small outcrops of the Kekiktuk farther north in the northeast Brooks Range are omitted; the area near the Arctic coast where the Kekiktuk has been penetrated by wells is outlined by dotted line. Outcrops of conglomerate in the eastern Brooks Range that include both Kekiktuk and possible Kanayut are shown by short dash pattern. Faults that displace the Endicott Group are shown by solid barbed lines. Faults along which younger rocks have been thrust over the Endicott Group at southeast and northwest ends of mapped area are shown by heavy lines with open barbs. Localities mentioned in text are shown by numbered squares: 1, Arctic Village; 2, Anaktuvuk Pass; 3, Howard Pass; 4, location of Section B46 (fig. 4); 5, location of Section B111 (fig. 5); 6, location of Section STU near Shainin Lake (fig. 6); 7, location of Section CHA near Chandler Lake (fig. 7); 8, location of Station B208 (Table 1). Outlines of outcrops are from: Brosgé and Reiser, 1962, 1964, 1965, 1969 and 1971; Brosgé, Reiser, Dutro and Detterman, 1976 and 1979; Brosgé, Reiser, Dutro and Nilsen, 1979; Mayfield and Tailleur, 1978; Mayfield, Tailleur, Mull and Sable, 1978; Nelson and Grybeck, 1980; Reiser, Brosgé, Dutro and Detterman, 1971 and 1974; and from unpublished mapping by I. L. Tailleur in the Howard Pass quadrangle and by the authors and H. N. Reiser in the Arctic and Killik River quadrangles. Information on wells is from K. J. Bird (oral commun., 1979).

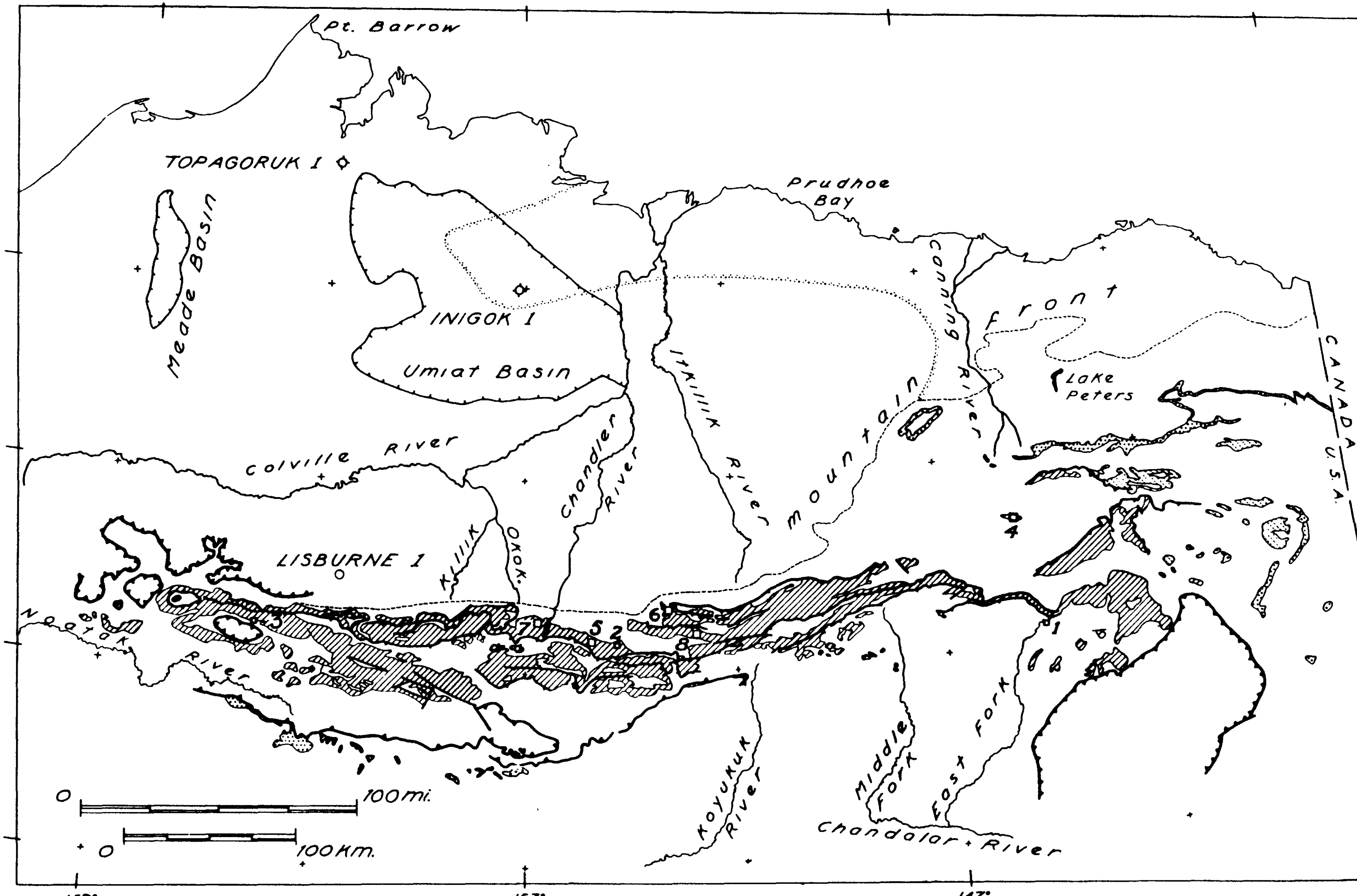

Pt. Barrow
TOPAGORUK 1
Meade Basin
INIGOK 1
Umiat Basin
Prudhoe Bay
Canning River
front
Lake Peters
CANADA
U.S.A.
Colville River
Chandler River
Itkillik River
mountain
Killik
Okok.
LISBURNE 1
Noatak River
Koyukuk River
Middle Fork
East Fork
Chandalar River
0
100 mi.
0
100 KM.
159°
153°
147°
70°
69°
68°
67°
1
2
4
5
6
7
8

Figure 3

written communications, 1980). Assuming it to be this thick throughout the basin, the remaining 2,800 m probably consists of Endicott Group rocks, of which judging from the section in the well, the upper 80 m is Kayak Shale and at least 620 m is Kekiktuk Conglomerate. Part of the remaining 2,100 m in the Umiat Basin may be Devonian rocks, because the interval between basement and a local seismic horizon within the Kekiktuk increases from about 1,000 m at the well to about 2,000 m in the basin, and it is unlikely that the Kekiktuk attains a thickness of 2,000 m. Steeply dipping conglomerate that contains Middle(?) Devonian plants (Collins, 1958) was penetrated in Topogoruk Well No. 1 at the northwest edge of the Umiat Basin.

Most of the Endicott Group in subsurface is only slightly deformed, whereas all outcropping strata are folded and faulted. The thick Devonian rocks of the Endicott Group are broken into large plates that have been thrust northward over each other and over younger rocks. The outcrop trends of the thinner Kekiktuk Conglomerate, however, both in the northeast Brooks Range and in the southwest part of the area shown on figure 3, reflect the orientation of large anticlinoria in the underlying lower Paleozoic and Precambrian rocks. These trends are dominantly east-west, but in Canada bend sharply southward and converge with those of the southern Brooks Range. As a result, the outcrops of basement rocks and the overlying Kekiktuk Conglomerate surround the eastern outcrop limit of the Devonian part of the Endicott Group.

The thick Devonian units of the Endicott Group form a series of stacked thrust plates in the central Brooks Range. The Kanayut Conglomerate in the central Brooks Range forms three thrust plates that are bounded by faults 125 to 450 m long, 15 to 30 km apart, and with local displacements of at least 5 to 15 km. These faults regionally dip southward and obliquely intersect the northern front of the Brooks Range to the west. Where each thrust fault intersects the range front, the thrust plate is folded into a west-plunging anticline and plunges out westward beneath the overlying plate. Most of the faults also die out eastward within the range, becoming overturned anticlines with little or no horizontal displacement. However, the Toyuk Thrust of Porter (1966) extends through most, if not all, of the length of the Kanayut outcrop belt. Because the plates north of the Toyuk Thrust plunge out en echelon to the west, the eastern part of the Toyuk Thrust plate is at the south edge of the belt of Kanayut outcrops, while the western part forms the leading edge of the Kanayut at the front of the Range.

A set of north-dipping thrust faults separates the Upper Devonian clastic rocks in the central Brooks Range from the Kekiktuk Conglomerate to the southwest. These faults may be continuous at depth with the faults that bound the Devonian rocks on the north. Consequently, the entire outcrop of Devonian rocks of the Endicott Group may be a giant klippe (Mull and others, 1976). However, the connection between these faults is presumed to be buried beneath subsequent thrust plates on the west and has not yet been found where it should be exposed around the east end of the presumed klippe (fig. 3).

Acknowledgments

We thank the people of Arctic Village and of Anaktuvuk Pass for much kindness and assistance. We particularly thank Gideon James and Roosevelt Paneak, elected heads of their respective villages in 1978. Helicopter support by Air Logistics, with George Ryan, pilot, and Gene Fowler, mechanic, is gratefully acknowledged. Ernie Viens and Dan Carroll of Wind River Air Service provided additional air support for the project while at Arctic Village.

STRATIGRAPHY

Beaucoup Formation

The Beaucoup Formation, a heterogeneous assemblage of dominantly calcareous rocks about 300 m thick, underlies the Endicott Group in the southeastern and south-central Brooks Range (Dutro and others, 1979). It lies unconformably on Silurian or Middle Devonian strata and is overlain conformably by the Hunt Fork Shale.

At its type locality in the southeastern Philip Smith Mountains quadrangle (Dutro and others, 1979), the Beaucoup contains several depositional cycles, each about 60-80 m thick. A typical cycle is initiated by a basal sandstone, locally including chert-pebble conglomerate, overlain by calcareous siltstone and black shale and capped by a limestone reef. The thickest of the four reef horizons exposed in the type area is about 60 m. The basal Beaucoup in most places is a conglomerate which contains clasts derived from underlying lower and middle Paleozoic terranes. The formation in its lower part also includes about 50 m of black, fine-grained limestone and calcareous shale.

The reef and reef-related facies are fossiliferous, yielding a varied assemblage of Frasnian (early Late Devonian) age. The reefs themselves are built of stromatoporoids, algae and corals, but rugose corals are most abundant in reef-flank and reef-capping facies that are silty, irregularly bedded limestone. Some of the characteristic fossils are: Macgeea, Phillipsastraea, Alveolites, Schizophoria, Nervostrophia, Douvillina, Gypidula, Thomasaria, Warrenella, Atrypa and Spinatrypa.

Hunt Fork Shale

The marine Hunt Fork Shale consists primarily of laminated black shale with graded beds of siltstone and fine-grained sandstone.

The main part of the Hunt Fork Shale consists of as much as 1,000 m of fine-grained gray sandstone, siltstone and black phyllitic shale organized into 15-25-m-thick cycles. Ironstone concretions and phosphatic nodules are common in the black shale portions of the cycles. This part of the Hunt Fork persists throughout the entire area and is commonly present at the bases of major thrust plates where tectonic thickening and thinning and low-rank metamorphism are common.

The upper part of the formation in many places contains packages of medium-bedded, fine- to medium-grained, ferruginous or calcareous lithic wacke and arenite interbedded with grayish-green and black siltstone and shale. This part of the upper Hunt Fork is mapped informally as the "wacke member" (Brosgé and others, 1979). The distribution of the wacke member is sporadic, being thickest and most persistent between upper Alapah Creek and the Itkillik Valley, where it is as thick as 500 m. The wacke member elsewhere is generally thinner and appears to be absent over much of the upper Anaktuvuk drainage basin and between the Chandler and Killik River valleys.

Fossils are present in thin coquinoid, ferruginous limestone or calcareous sandstone beds in the main part of the Hunt Fork, and in conglomerate lenses of shell fragments, ironstone and chert pebbles in the wacke member. These fossiliferous beds probably represent debris flow accumulations of shells transported downslope.

Beds in the main part of the Hunt Fork Shale contain Frasnian (early Late Devonian) invertebrate fossils, including corals, brachiopods, mollusks, algae, and echinoderm debris. Characteristic fossils are: <u>Macgeea</u>, <u>Pachyphyllum</u>, <u>Schizophoria</u>, <u>Nervostrophia</u>, <u>Devonoproductus</u>, <u>Thomasaria</u>, <u>Cyrtospirifer</u>, <u>Atrypa</u>, <u>Spinatrypa</u>, pelecypods, bellerophontid gastropods, several other kinds of gastropods, tentaculitids, and orthoconic cephalopods. Lenses in the wacke member contain Famennian (late Late Devonian) brachiopods.

Kanayut Conglomerate

The Kanayut Conglomerate in the central Brooks Range consists of four members. From bottom to top, these are: the sandstone member, the lower shale member, the middle conglomerate member, and the Stuver Member.

Sandstone member

The sandstone member is a dominantly marine unit distinguished by relatively pure, fine- to medium-grained, calcareous hematitic sandstone in cross-bedded sets of thin platy beds. It is equivalent to the the lower member of Porter (1966). Interbedded shale is mostly red near the Itkillik River in the northeastern part of the region. Elsewhere, the shale is predominantly black or brownish-gray. Conglomerate is rare and is generally a granule- to small-pebble grit where present. Cycles of conglomerate, sandstone, and shale are 2-15 m thick, except in the Itkillik Valley, where conglomerate is most abundant and the cycles may be as thick as 60 m. The distribution of the member is less consistent than that of other Kanayut members, and its thickness varies from 90 to 560 m, thickening in areas where the lower shale member is thin or absent.

Marine fossils occur at many localities in the sandstone member, generally in shaly intervals between sandstone outcrops. The fossils consist of brachiopods, including Cyrtospirifer, gastropods, pelecypods and echinoderm debris of probable mid-Famennian (late Late Devonian) age. Fossils of late Frasnian (early Late Devonian) age were found in one locality in the Philip Smith Mountains quadrangle. Regionally the sandstone member appears to interfinger laterally and vertically with the lower shale member. The lower contact with the upper part of the Hunt Fork Shale is also gradational.

Lower shale member

The lower shale member is the same as the lower member of Bowsher and Dutro (1957), and consists of cycles of conglomerate, sandstone, and shale. The thickness of the cycles decreases from east to west, and the percentage of conglomerate decreases from north to south. Maximum clast size varies little across the region, ranging generally from 3 to 10 cm. The member contains little or no conglomerate in the southern third of the outcrop belt. The amount of shale varies from 50-80% but is most abundant in the lower part. Red shale is typically present in each cycle. The southward replacement of red shale by predominantly gray and black shale takes place approximately at the same latitude as the south edge of the conglomerate in this member. The lower shale member gradationally underlies the middle conglomerate member and overlies the sandstone member.

The lower shale member is present in most of the study area except to the south, where it is missing along the Brooks Range divide between the upper Koyukuk River and the Middle Fork of the Chandalar. It ranges in thickness from an estimated 160 m west of the upper Itkillik Valley, to about 440 m near the type section at Shainin Lake and an estimated 550 m south of Chandler Lake and in the Okokmilaga Valley.

Plant fragments have been collected from the lower shale member in several places but are mostly indeterminate or nondiagnostic. A single collection of fossil plants from near the base of the member in the Arctic quadrangle about 275 km east of the type area was identified as Devonian (S. H. Mamay, written commun., 1979).

<u>Middle conglomerate member</u>

The middle conglomerate member is best developed in the area surrounding its type section southeast of Shainin Lake (Bowsher and Dutro, 1957) (locality 6, fig. 3). It is also recognizable and mappable eastward into the Philip Smith Mountains quadrangle and westward from Anaktuvuk Pass (locality 2, fig. 3) to the Killik River and beyond.

In its type section, thick and massive beds of pebble and cobble conglomerate characterize the middle conglomerate member. Maximum clast size decreases in a regular fashion from northeast to southwest across the central Brooks Range. The largest clasts, as long as 18 cm in maximum dimension, have been observed in the type section and the area extending about 20 km northeast from it. The maximum clast size decreases south and west of Chandler Lake (locality 7, fig. 3) from about 10 cm to 1-3 cm, and in the upper Killik drainage only a few small pebbles are present.

The thickness of the middle conglomerate member, about 400 m, is remarkably consistent in its main outcrop belt. The thickest estimated section (470 m) is about 32 km WSW of Anaktuvuk Pass and the two thinnest sections (160 m) about 24 km east and about 33 km south of Shainin Lake.

Both the upper and lower contacts of the middle conglomerate member are gradational with overlying and underlying members. No identifiable fossils have been recovered from the middle conglomerate member, although indeterminate plant fragments are found. A Late Devonian age for the middle conglomerate member is assigned on the basis of its stratigraphic position.

Stuver Member

The Stuver Member, named by Bowsher and Dutro (1957), is composed of cycles of conglomerate, sandstone, siltstone, and gray-black or red shale. Hematitic cement is present in some quartzite layers and weathered "tripolitic" chert fragments in some of the conglomerate. Thinning- and fining-upward cycles are most common. Contacts with the underlying middle conglomerate member and overlying Kayak Shale are gradational.

The Stuver Member is mapped from the Middle Fork of the Chandalar River on the east to the vicinity of Howard Pass on the west. It is about 270 m thick at its type section at Shainin Lake (locality 6, fig. 3). In most places it is about 300 m thick, but it varies from a maximum of 400 m about 16 km south of Shainin Lake to less than 100 m in the area of the Okokmilaga and Killik Rivers.

Fossil plants from the coaly shale of the Stuver are mostly indeterminate. However, in the type area the Late Devonian plant Archeopteris has been identified in two collections from the Shainin Lake area (J. M. Schopf, written commun., 1952) and one from Anaktuvuk Pass (Porter, 1966). In addition, probable Early Carboniferous plants are reported in one collection from the Stuver Member between Shainin Lake and Anaktuvuk Pass (S. H. Mamay, written commun., 1979). The Devonian plant collections from the Stuver, together with Devonian plants from the lower shale member, indicate that most of the Kanayuk conglomerate was deposited in Devonian time. The probable Mississippian plants suggest that at least locally fluvial Kanayut deposition continued into the Mississippian, as did the correlative Noatak Sandstone (Dutro, 1953) west of the study area. However, we do not have sufficient evidence at present to redefine the age of the Kanayut.

Kekiktuk Conglomerate

The Kekiktuk Conglomerate, the basal clastic phase of an onlapping Carboniferous sequence, unconformably overlies older Paleozoic and Precambrian rocks in the eastern and south-central Brooks Range and in most of those parts of the Coastal Plain where wells have penetrated to basement. In its type section west of Lake Peters in the northeast Brooks Range, the Kekiktuk is 60 m thick and consists of granule to cobble conglomerate and sandstone, with some shale interbeds. The thickness of the Kekiktuk is rather uniform throughout the eastern Brooks Range, generally less than 100 m. The Kekiktuk is missing locally and the Kayak Shale lies directly on older rocks.

The composition of the Kekiktuk varies considerably from place to place, reflecting a variety of local source areas. Larger clasts are mostly subrounded to rounded chert and quartz, but include at some localities argillite, angular fragments of quartz, and flat slabs of chert from the underlying basement. Quartz-tourmaline cobbles and small grains of cassiterite are common near the pre-Mississippian granite in the northeastern Brooks Range (Reed, 1968).

Although geologic mapping cannot demonstrate continuity throughout northern Alaska, the Kekiktuk has been identified in many wells north of the Brooks Range where it rests unconformably on Ordovician and Silurian argillites (Carter and Laufeld, 1975). The Kekiktuk has also been mapped in the Survey Pass and Ambler River quadrangles in the south-central Brooks Range (Nelson and Grybekc, 1979; Mayfield and Tailleur, 1978), where it lies unconformably on rocks as old as Silurian.

Several collections of fossil plants from the lower part of the Kekiktuk Conglomerate in the northeastern Brooks Range are of Early Mississippian age (S. H. Mamay, written commun., 1970, 1979).

Kayak Shale

The marine Kayak Shale onlaps the predominantly nonmarine Kanayut Conglomerate. In its type area near Shainin Lake in the north-central Brooks Range (locality 6, fig. 3), the Kayak is about 300 m thick and consists of a basal sandstone member 40 m thick, a lower black shale member 180 m thick, an argillaceous limestone member 24 m thick, an upper black shale member 40 m thick and a red limestone member, 5 m thick, at the top. The three lower members are recognized across the entire north-central Brooks Range and their thickness appears to be approximately the same everywhere, although tectonic thickening and thinning of the shale make thickness measurements difficult.

In the central Brooks Range, the sandstone member consists of thin beds of irregularly bedded fine-grained bioturbated sandstone with many trace fossils, including Skolithos, and coaly interbeds containing Early Mississippian plant fossils at several localities. The argillaceous limestone member contains a varied marine assemblage of brachiopods, bryozoans, echinoderms, mollusks, and ostracodes of Early Mississippian (late Kinderhookian) age. These fossils include Penetremites, Platycrinites , fenestrate bryozoans, Rhipidomella, Schuchertella, Leptagonia, Ovatia, small dictyoclostids, Unispirifer, Composita, Brachythyris, Torynifer, Cleiothyridina, Syringothyris, Punctospirifer, and several kinds of pelecypods and gastropods.

In the south-central Brooks Range, the Kayak consists of carbonaceous phyllite interbedded with minor amounts of yellow and orange-weathering limestone that may represent its lower shale and argillaceous limestone members; here the basal sandstone member appears to be absent and the total thickness of the Kayak about 100 m, although it is uncertain because of tectonic deformation (Mayfield and Tailleur, 1978). Brachiopods, corals, conodonts, and foraminifers of Early Mississippian (Kinderhookian and Osagean?) age occur in the limestone beds (Mayfield and Tailleur, 1978; Nelson and Grybeck, 1980).

The Kayak Shale of the eastern Brooks Range is mainly black shale and siltstone with fossiliferous limestone interbeds in its upper part. The Kayak here is generally less than 50 m thick, thinner than elsewhere in the Brooks Range, although accurate thickness measurements are complicated by tectonic thickening and thinning. Lithostrotionoid corals and other megafossils from limestone in the upper part of the Kayak Shale in the eastern Brooks Range indicate an early Late Mississippian (Meramecian) age, equivalent to the middle part of the Lisburne Group of the central Brooks Range.

Itkilyariak Formation

The Itkilyariak Formation consists of interbedded red-weathering limestone, calcareous siltstone, gray shale, thin-bedded quartzite, and minor coal.

It is present either locally above the Kekiktuk Conglomerate or directly on basement rocks in the northeastern Brooks Range and in the subsurface north of the range. It apparently interfingers laterally with the Kayak Shale. Although it crops out in only a few places in the northeast Brooks Range, the Itkilyariak has been identified in many wells from Prudhoe Bay westward to Topogoruk No. 1 (Mull and Mangus, 1972). The Itkilyariak, about 50 m thick in its type section and as much as 300 m thick in some wells, contains Mississippian marine fossils in its upper part.

SEDIMENTARY FACIES

Introduction

The Kanayut Conglomerate and associated units in the central and eastern Brooks Range contain a variety of sedimentary facies deposited in fluvial and marine environments (fig. 2). The upper part of the Hunt Fork Shale records shoaling marine conditions as it grades upward into the shallow-marine deposits of the sandstone member of the Kanayut Conglomerate. The lower shale member of the Kanayut records progradation of fluvial sediments over the basal shallow-marine sandstone, culminating in deposition of the coarser grained fluvial middle conglomerate member of the Kanayut. The successively overlying fluvial Stuver Member, basal shallow-marine sandstone of the Kayak Shale, and shale of the Kayak Shale record major retrogradation of the Kanayut depositional system (fig. 2). Thus, the entire sequence records outbuilding of a major fluvial system, most probably a large delta, out into a marine basin during Late Devonian time.

Earlier episodes of clastic deposition, recorded by conglomerate and sandstone within the Beaucoup Formation and lower Hunt Fork Shale, may or may not be related genetically to the Kanayut onlap-offlap cycle. These depositional events may be related to more local uplifts and restricted sedimentation, but they are not well understood yet.

A later, but certainly related, episode of coarse clastic sedimentation is recorded by the Early Mississippian Kekiktuk Conglomerate. This episode appears to have taken place around the margins of the Kanayut basin after the major progradational-retrogradational cycle had been completed. Differences in clast composition and facies distribution suggest, in a preliminary fashion, that Kekiktuk sedimentation succeeded that of the Kanayut and was restricted to basin margins to the north, east, and south.

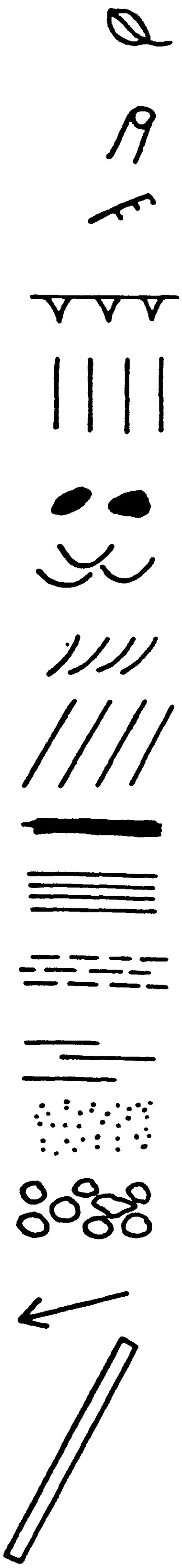
Sedimentary facies of the Kanayut depositional system have been studied by measured sections through the fluvial members of the Kanayut Conglomerate (see fig. 3 for location of sections). Four sections were measured during the 1978 summer field season: (1) 65 km north-northwest of Arctic Village in the middle conglomerate and Stuver members (fig. 4); (2) 16 km west of Anaktuvuk Pass in the lower shale and middle conglomerate members (fig. 5); (3) 45 km east-northeast of Anaktuvuk Pass in the type section of the Stuver Member on the east side of Shainin Lake (fig. 6); and (4) 45 km west-northwest of Anaktuvuk Pass, on a ridge west of Chandler Lake, in the middle conglomerate member (fig. 7). From a sedimentologic viewpoint, outcrops of the Kanayut Conglomerate are generally poor because extensive frost-heaving of resistant blocks of quartzite and conglomerate has produced piles of rubble rather than sections amenable to detailed sedimentologic study.

Deep-marine facies

Shale apparently deposited in low-energy and probable deep-marine (at least below wave base) settings forms a major part of the Hunt Fork Shale and Kayak Shale. These deposits are typically black- or brown-weathering and unfossiliferous except for trace fossils. The shale contains thin turbidite interbeds that increase in abundance upward within the Hunt Fork Shale and downward within the Kayak Shale. These turbidites locally contain, especially in the Hunt Fork Shale, fossil debris and shale rip-up clasts. The thin-bedded turbidites form graded

Figure 4.--Measured section of the middle conglomerate member and Stuver Member of the Kanayut Conglomerate, eastern Brooks Range. See Figure 3 for location of section.

Symbols used in Figures 4 - 7.



Plant Fossils

Burrows

Ripple marks

Mudcracks

Paleosol

Argillite rip-up clasts

Trough crossbeds

Tabular crossbeds

Inclined point-bar sequence

Carbonaceous strata

Shale and siltstone

Thin -bedded sandstone

Bedded sandstone

Massive sandstone

Conglomerate

Compass direction of paleocurrent determination

Megasequence

Figure 4

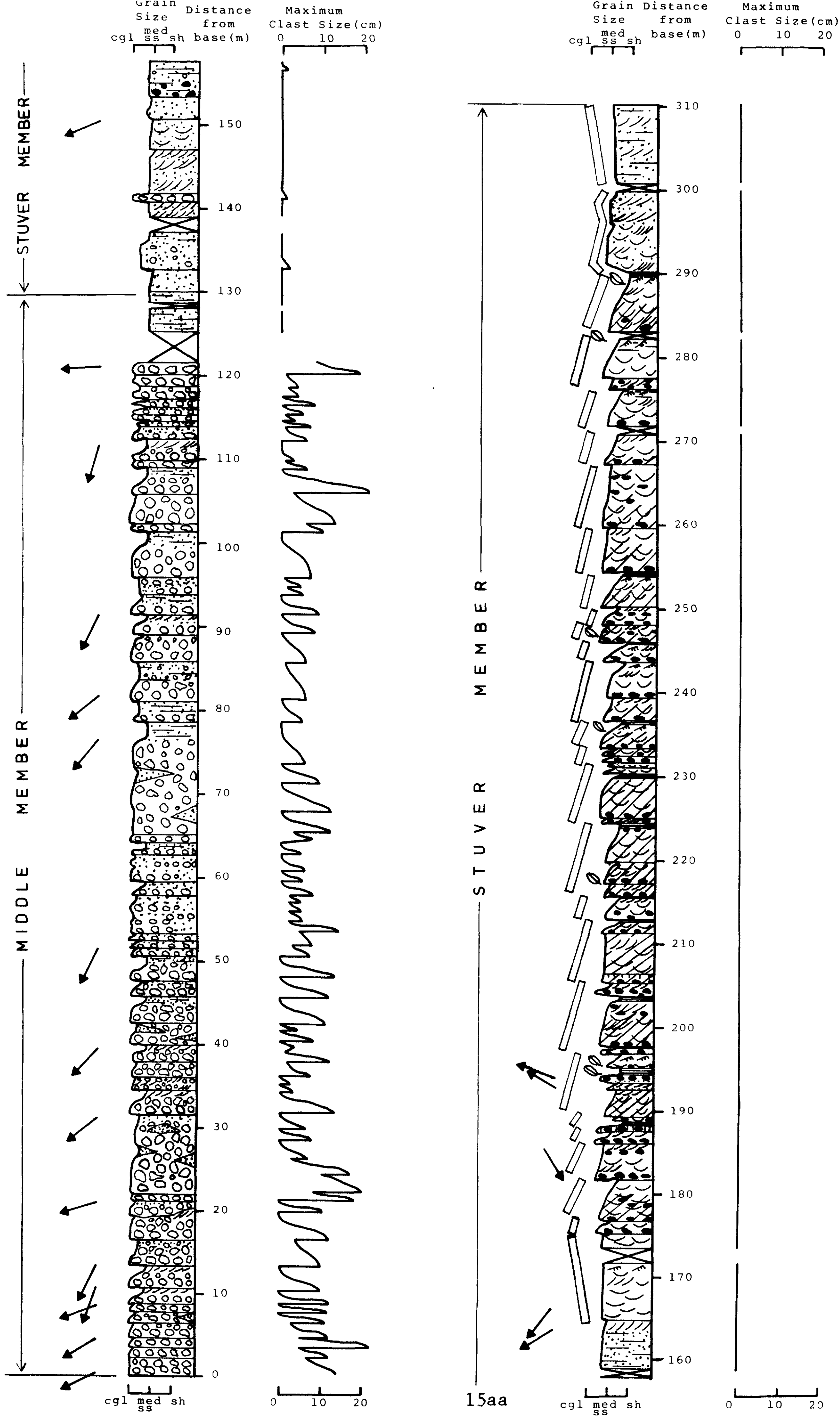

Grain Size
cgl med ss sh
Distance from base(m)
Maximum Clast Size(cm)
0 10 20
STUVER MEMBER
MIDDLE MEMBER
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310

Figure 4

Figure 5.--Measured section of the lower shale member and middle conglomerate member of the Kanayut Conglomerate, central Brooks Range. See Figure 3 for location of section.

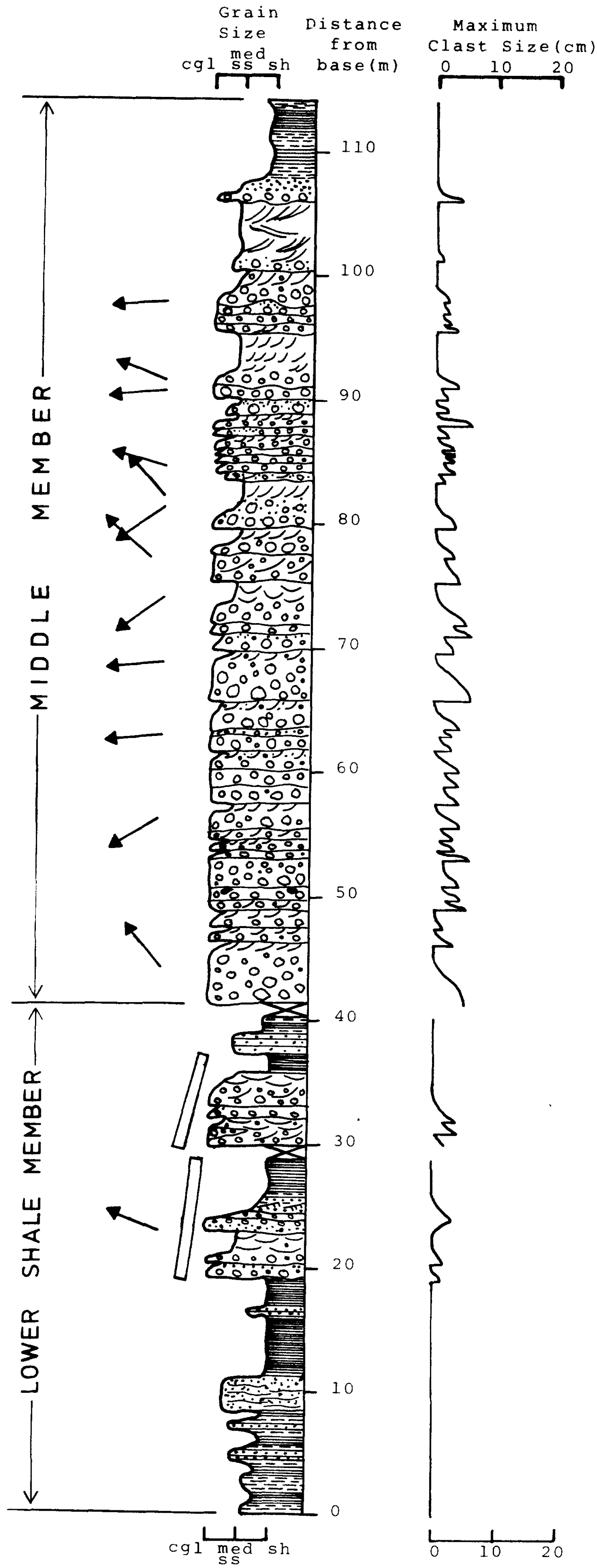

Grain Size
cgl
med ss
sh
Distance from base(m)
Maximum Clast Size(cm)
0 10 20
110
100
90
80
70
60
50
40
30
20
10
0
MIDDLE MEMBER
LOWER SHALE MEMBER

Figure 5

Figure 6.--Measured type section of the Stuver Member of the Kanayut Conglomerate at Shainin Lake, central Brooks Range. See Figure 3 for location of section.

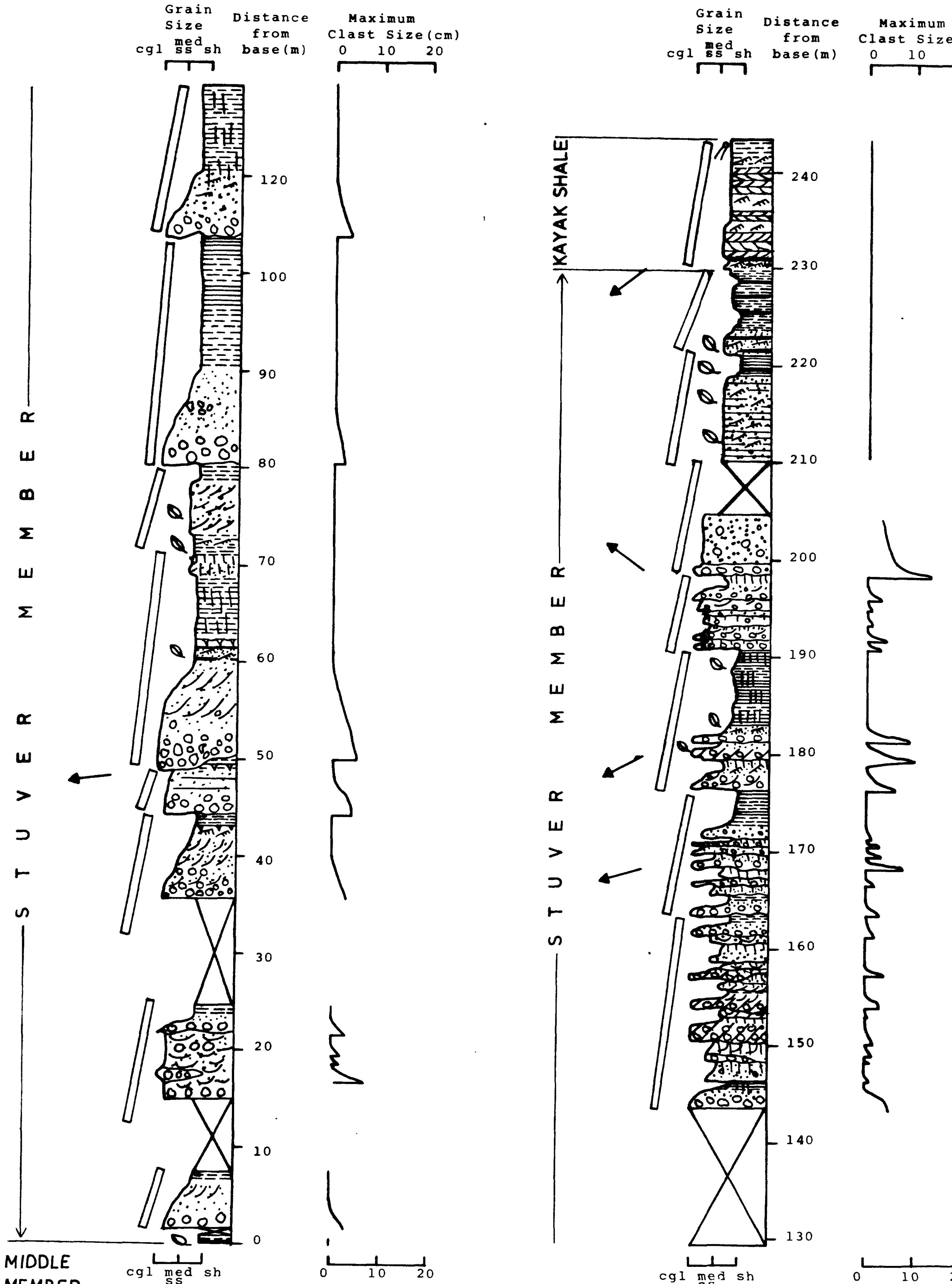

Grain Size
cgl med ss sh
Distance from base (m)
Maximum Clast Size (cm)
0 10 20
0
10
20
30
40
50
60
70
80
90
100
120
STUVER MEMBER
MIDDLE MEMBER
KAYAK SHALE
130
140
150
160
170
180
190
200
210
220
230
240

Figure 6

Figure 7.--Measured section of the middle conglomerate member of the Kanayut Conglomerate near Chandler Lake, central Brooks Range. See Figure 3 for location of section.

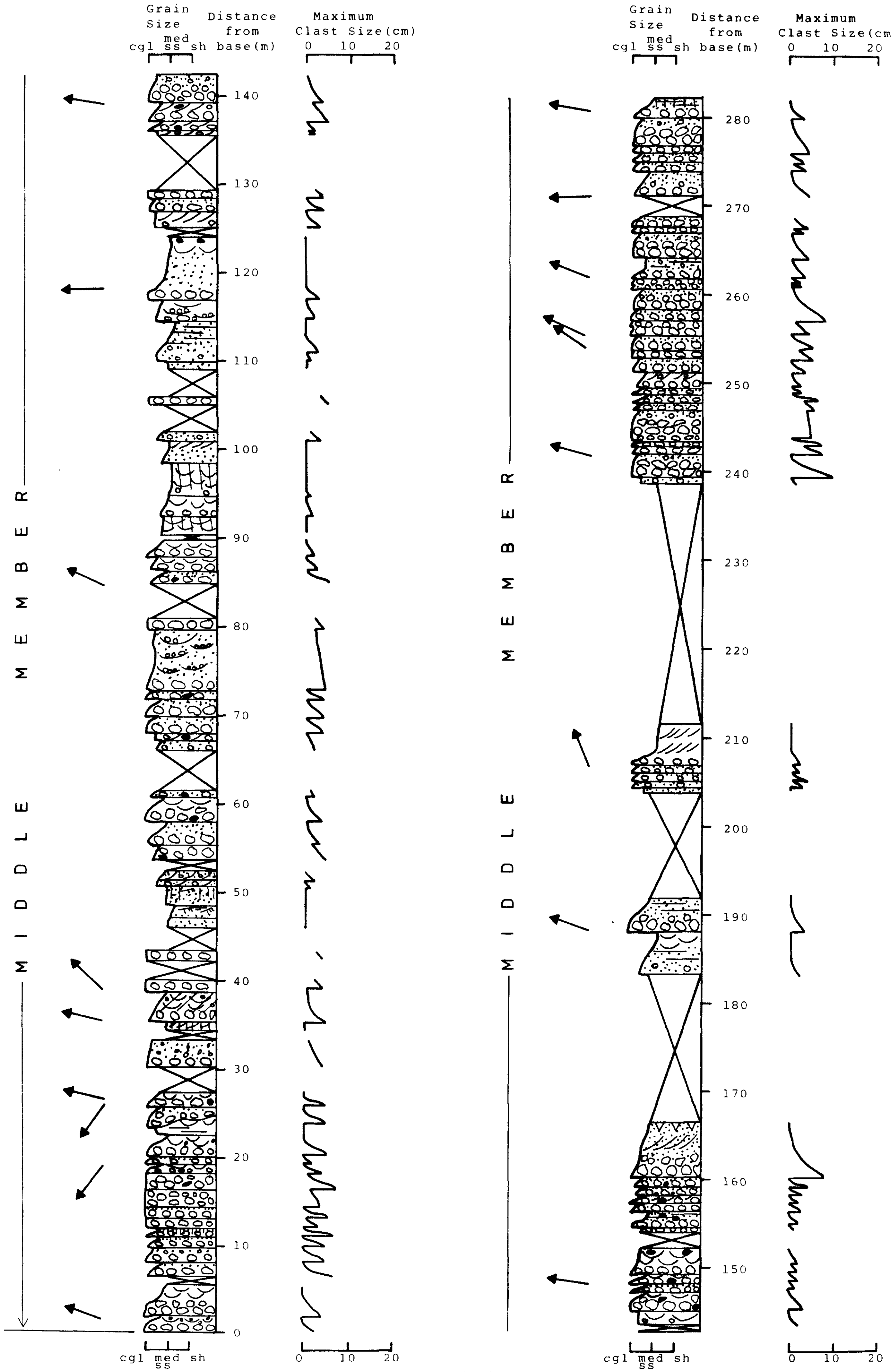

Grain Size
cgl med ss sh
Distance from base (m)
Maximum Clast Size (cm)
0 10 20
MIDDLE MEMBER
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280

Figure 7

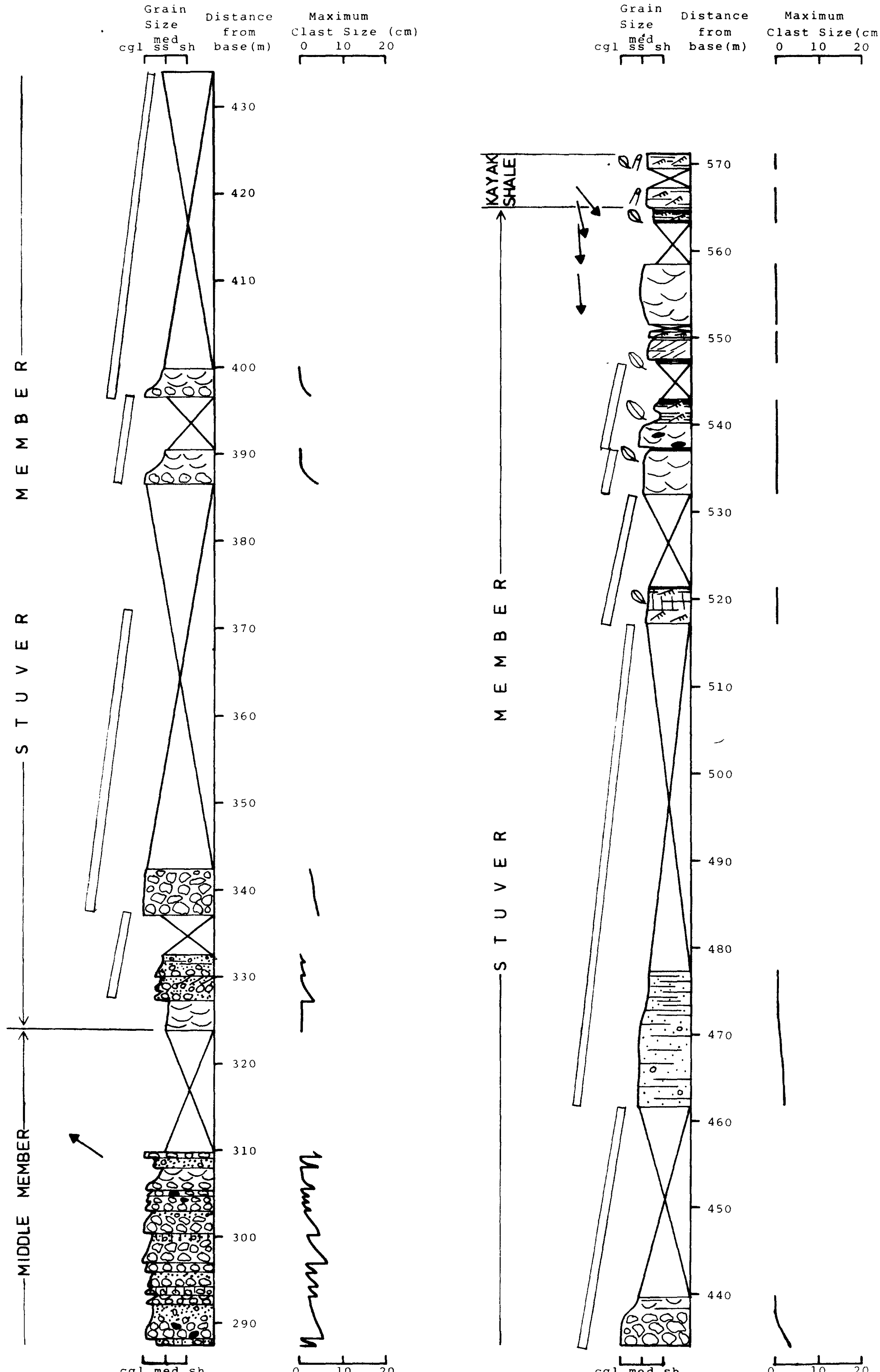


Figure 7 continued

beds, generally less than 5 cm thick, that may contain parallel-stratification or small-scale cross-stratification; however, they are commonly structureless internally, reflecting vertical settling from storm-generated overflows or interflows within the water column rather than bottom-flowing turbidity currents. The thin-bedded turbidites have a random vertical distribution and do not form thinning- or thickening-upward megasequences or cycles. Thicker beds of sandstone, probably of turbidite origin, crop out in the "wacke" member of the Hunt Fork Shale, but their lateral and vertical distribution is poorly known because of a general lack of good outcrops.

Shallow-marine facies

Shallow-marine sandstone characterizes the sandstone member at the base of the Kanayut Conglomerate and the sandstone member at the base of the Kayak Shale. These sandstone units are locally fossiliferous, containing assemblages characteristic of shelf, intertidal, lagoonal, and marginal-marine environments. The sandstone strata, deposited as a variety of depositional bodies, most typically form thickening- and coarsening-upward cycles, especially in the sandstone member of the Kanayut Conglomerate. Intertidal deposits form a major component of the basal sandstone member of the Kayak Shale. They contain numerous reactivation surfaces, flaser bedding, herringbone cross-strata, cross-stratified transverse bars, and well-sorted sandstone.

The characteristic thickening-upward cycles record progradation of the delta over marine slope and shelf deposits. Although the geometry of these deposits has not been ascertained, the vertical sections resemble those of channel-mouth bars described from many modern deltas. The cycles typically contain strata that consist of shale and thinly interbedded cross-stratified fine-grained sandstone at the base, coarser grained sandstone containing thicker sets of trough cross-strata in the middle, and numerous erosion surfaces associated with medium- to large-scale cross-strata at the top. The cycles are typically abruptly overlain by shale or siltstone.

Other bodies of shallow-marine sandstone, characterized throughout by medium- to large-scale cross-strata that have consistent orientations, may represent offshore bars or spits that formed on the margins of the delta. Variable paleocurrents generally present within the shallow-marine sandstone bodies reflect currents generated by waves, winds, tides, and longshore drift.

Meandering stream facies

The lower shale and Stuver members of the Kanayut Conglomerate are interpreted to have been deposited by meandering streams on a flood plain. The members consist of a series of thinning- and fining-upward cycles similar to those described from many modern meandering rivers. Detailed analyses of the cycles may permit future determinations of the sizes of the rivers, their discharges, and temporal or geographical variability of the streams within the depositional basin.

The cycles characteristically commence at their base with erosional truncation of underlying shale or paleosols by thick beds of conglomerate or sandstone. The amount of downcutting observed varies from a few centimeters to as much as 5 m; if seen on a large enough scale, each fluvial cycle probably downcuts approximately the thickness of the individual cycle, inasmuch as the cycle is a preserved record of filling of the individual river channel. The basal beds typically consist of massive or crudely parallel-stratified conglomerate or conglomeratic sandstone containing abundant rip-up clasts of shale, siltstone, and paleosol material.

Overlying the basal conglomeratic beds are parallel-stratified beds of sandstone in turn overlain by trough-cross-stratified beds of sandstone. Trough amplitudes gradually decrease upward in the cycles concomitantly with decreasing grain size of the sandstone. The trough axes have variable attitudes, but generally plunge toward the southwest. These deposits represent fill of the channel by transverse and longitudinal bars that migrate downchannel as the stream channel gradually shifts and migrates laterally by the meander process.

The upper part of the cycles consists of thinly bedded current-ripple-marked fine-grained sandstone with thin shale interbeds. These ripple-marked sandstones contain abundant mica, clay, and carbonaceous material. Climbing ripples are locally common in these deposits, as well as plant fossils and root impressions. These thin beds of sandstone are interpreted to be levees deposited on the inner parts of meander loops by overbanking processes during flood stages.

The uppermost part of the cycles consists of interchannel and floodplain shale and siltstone containing prominent local paleosols. The shale varies from reddish brown to black in color, probably depending upon the amount of exposure to the atmosphere. Red shale probably was deposited chiefly on higher ground of the flood plain and black shale in lower, swampy areas. Many cycles contain red shale directly over the sandy levee facies, succeeded upward by black shale. Both red and black shale contain abundant fossil plant debris, much of it *in situ*. Mudcracks, raindrop imprints, and features that might represent burrows but are more likely root casts from plants are common.

A characteristic feature of the cycles is long inclined surfaces that cut across the vertical sequence. These surfaces are thought to be the original inclined surfaces of the inner parts of meander loops or point-bar surfaces. The point-bar surfaces are recognizable only in well-exposed and wide outcrops, but are especially well displayed in the measured section of the Stuver Member north of Arctic Village (fig. 4).

The lower shale member locally contains very thick sections of reddish-brown shale, particularly in the eastern Brooks Range. These deposits may represent large floodplain areas traversed by few if any river channels. In these areas, shale deposited by major floods probably accumulated to substantial thicknesses.

Cycles of sandstone not characterized by fining- and thinning-upward trends accumulated in parts of the meandering stream facies. These bodies of sandstone are locally channelized, sometimes form symmetrical vertical cycles, and characteristically contain abundant rip-up clasts and fragments of levee and interchannel sediments. These deposits may have been formed by crevasse-splays in which channels broke through their levees and deposited sediment into interchannel and floodplain areas, typically during large floods or when meander loops were captured.

Braided stream facies

The middle conglomerate member of the Kanayut Conglomerate consists of interbedded conglomerate and sandstone thought to have been deposited by braided streams. The characteristic feature of these deposits is the vertical stacking of fining-upward couplets of conglomerate and sandstone, with the erosional base of each conglomerate bed truncating the underlying sandstone. In some sections, conglomerate rests on conglomerate to form amalgamated beds, with sandstone absent either as a result of nondeposition or erosion.

The conglomerate-sandstone couplets are thought to represent deposition of various kinds of bars within a braided stream complex. Sandstone is deposited on the flanks, tops, and downstream edges of gravel bars as thin but wide lens-shaped bodies characterized generally by parallel stratification, low-angle trough cross stratification, or very low-angle inclined tabular cross stratification. The sandstone probably accumulated during waning stages of floods and on the protected downstream margins of bars.

The largest conglomerate clasts are found in the middle conglomerate member. The conglomerate is typically well imbricated and characterized by a closed framework. Long axes are oriented parallel to flow and have proven to be useful paleocurrent indicators for the middle conglomerate member. Paleosols, levee deposits, shale, and siltstone are rarely present.

In the eastern Brooks Range, the braided stream facies of the middle conglomerate member of the Kanayut Conglomerate may grade laterally into distal alluvial fan facies. However, the lack of well-defined radial paleocurrent patterns and readily recognizable alluvial fan facies such as debris-flow deposits permits only speculative inference of the existence of fan deposits at present.

CLAST SIZE AND SHAPE

Clast size

The maximum dimension of the ten largest conglomerate clasts was measured at each station where conglomerate was observed in order to determine patterns of clast dispersal. The mean size of the ten largest clasts was plotted for 28 stations in the Kanayut Conglomerate and Kekiktuk Conglomerate (fig. 8). The data are not geographically well dispersed, being concentrated around the villages of Arctic Village and Anaktuvuk Pass, so that east-west and north-south changes are difficult to ascertain. In addition, at many stations only a portion of the entire stratigraphic thickness of a member or of the formation was examined, so that many plots represent the mean only for a limited stratigraphic thickness of the unit. Nevertheless, several useful conclusions can be derived from the limited data.

The Kanayut Conglomerate generally contains larger clasts in northern and eastern outcrops. The middle conglomerate member generally contains the largest clasts and we collected more data from it than from other members. The north-to-south decrease in clast size in the middle conglomerate member east of Anaktuvuk Pass is readily observed (fig. 8). In addition, the maximum clast size in the middle conglomerate member decreases sharply west of Anaktuvuk Pass. The largest mean clast size for the middle conglomerate member in the Arctic Village area was noted in the northeasternmost outcrop. The largest mean clast size in the

Figure 8.--Map showing distribution of mean size of ten largest conglomerate clasts in the Kanayut and Kekiktuk Conglomerates.

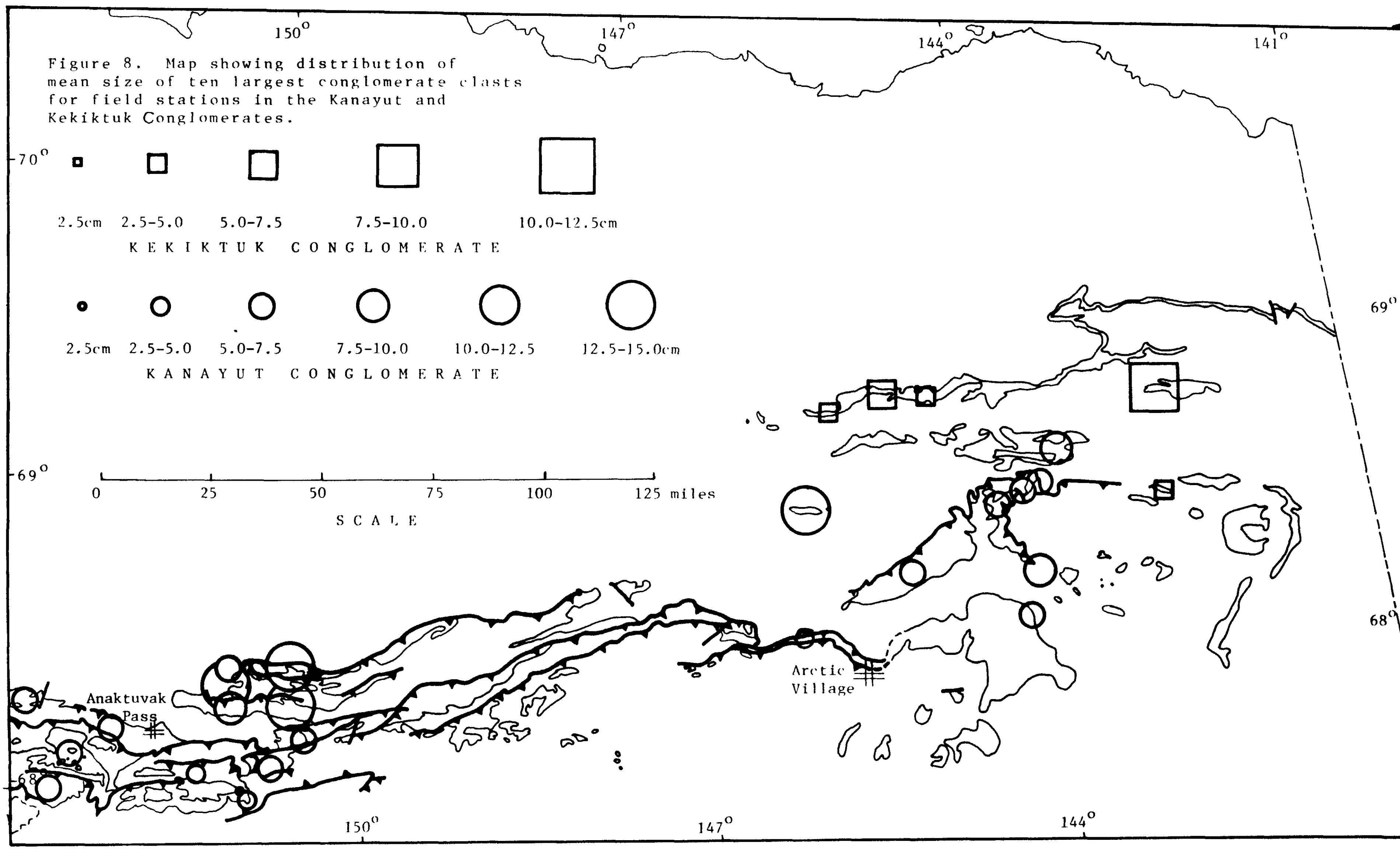


Figure 8. Map showing distribution of mean size of ten largest conglomerate clasts for field stations in the Kanayut and Kekiktuk Conglomerates.

Figure 8

lower shale member of the Kanayut Conglomerate was noted in the southeasternmost observed outcrop, strongly suggesting possible derivation of this conglomerate from the east-southeast. The map distribution of maximum clast sizes must be cautiously interpreted with regard to paleogeography because of the presence of at least three major thrust faults within the outcrop belt and the lack of well-defined marker beds for regional correlation.

In order to determine whether clasts of different lithology tended to preferentially fall into certain size groups, a total of 327 randomly selected clasts was measured and counted at a well-exposed outcrop of the middle conglomerate member of the Kanayut Conglomerate east of Anaktuvuk Pass (table 1). The data indicate that chert pebbles are smaller, vein quartz pebbles intermediate, and quartzite and quartzite conglomerate pebbles larger in size within the same conglomerate. This relationship probably reflects in part hardness and durability of clasts during transport. The softer and more easily chipped and broken chert clasts probably break down to finer sizes more easily and rapidly than the harder and more durable quartzite and quartzite conglomerate clasts, with vein quartz clasts intermediate in breakability. This relationship of clast size to lithology suggests that finer conglomerates should be more chert-rich. Distal conglomerates, those transported the greatest distances, should also be chert-rich because the larger more durable clasts would have been deposited in more proximal areas. However, the original state of weathering and jointing of the rocks in the source region may also have contributed to the size differences; the chert clasts initially supplied to the depositional basin may have been smaller than quartzite and quartzite conglomerate clasts because of thinner bedding, more closely spaced joints, and susceptibility to physical weathering.

Data from the Beaucoup Formation and Kekiktuk Conglomerate are inconclusive. An insufficient number of outcrops of conglomerate from both units were observed to discern any general patterns of fining or coarsening of the conglomerate.

A related study of maximum clast sizes, but of only vein quartz clasts from the Kanayut and Kekiktuk Conglomerates by Donovan and Tailleur (1975), indicates that clasts in the Kanayut decrease in size from north to south and that clast size in the Kekiktuk decreased from east to west.

Clast shape

Detailed information about roundness and sphericity of various clast types was obtained at a well-exposed conglomerate outcrop of the middle conglomerate member of the Kanayut Conglomerate about 50 km east of Anaktuvuk Pass (table 1). The roundness and sphericity (actually, circularity, because clasts could not be removed from the matrix to determine their three-dimensional characteristics) of 50 clasts each of black chert, gray chert, vein quartz, quartzite, and quartzite conglomerate were determined using visual comparative charts of Krumbein and Sloss (1963).

The data show that Kanayut clasts in general are moderately to well rounded and have a moderate to high circularity when viewed on a bedding surface. However, the individual clast types vary considerably in their characteristics. Chert clasts are the least well rounded, vein quartz clasts have intermediate values of roundness, and quartzite and quartzite conglomerate clasts have the highest roundness values. These roundness values are partly a function of the greater tendency of chert to chip and splinter during transport than quartzite and quartzite conglomerate. Breaking of chert clasts continually produces more angular clasts during transport, whereas the more durable quartzite and quartzite conglomerate clasts tend to gradually round without breaking. Vein quartz clasts are intermediate in character, tending to break more than the quartzite

Table 1. Mean size, roundness and sphericity of various clasts in the middle conglomerate member of the Kanayut Conglomerate at field station B208 in the central Brooks Range. See figure 3 for location.

Clast type	Average clast length (in cm) (327 clasts total)	Average roundness (250 clasts total)	Average sphericity (250 clasts total)
Black chert -------	1.67	5.82	6.48
Gray chert --------	2.15	7.02	6.74
White chert -------	1.62	--	--
Vein quartz -------	2.32	7.40	5.98
Quartzite ---------	3.65	8.68	7.48
Quartzite --------- conglomerate.	5.40	8.26	6.94

and quartzite conglomerate clasts but less than the chert clasts. The roundness values are probably also a function of size, the larger clasts being better rounded; this relation has been demonstrated in numerous studies of modern gravel and ancient conglomerate.

Sphericity values are less easy to explain, with all clasts having roughly similar average values. Vein quartz has the lowest sphericity, chert an intermediate value, and quartzite and quartzite conglomerate the highest values. The tendency of chert and vein quartz to chip and splinter more readily may explain their lower values of sphericity, but there is not a sufficient spread in the data to substantiate this conclusion.

PETROGRAPHY

Conglomerate

The clast compositions of conglomerate from the Kanayut Conglomerate, Kekiktuk Conglomerate, and Beaucoup Formation were determined by counting in the field. Thirty-eight pebble counts of one hundred randomly selected clasts larger than 1 centimeter in diameter were made at 29 separate locations (table 2). Five counts were made from the Beaucoup Formation, 4 from the Kekiktuk Conglomerate, and 5, 19 and 5 from the lower shale, middle conglomerate, and Stuver members,respectively, of the Kanayut Conglomerate. The size of the longest axis of the largest clast from each pebble count was also noted.

The conglomerates, in general, are characterized by a high chert content and lesser amounts of quartz and quartzite. They are compositionally very mature, as indicated by a plot of the data on a ternary diagram with quartzose, nonquartzose clastic, and carbonate clasts as poles (fig. 9A). This diagram, designed to display compositional maturity, visually shows that all of the conglomerates contain more than 75 percent chert + vein quartz + quartzite and only one sample (from the Beaucoup Formation) contains less than 90 percent of these constituents. Thus, the Kanayut, Kekiktuk and Beaucoup conglomerates

Figure 9.--Ternary diagrams showing clast content from pebble counts of the Kanayut Conglomerate, Kekiktuk Conglomerate, and conglomerate from the Beaucoup Formation. A, Mature clast (chert, vein quartz and quartzite)--immature clast (argillite, siltstone, and sandstone)--carbonate clast plot. B, Quartzite--vein quartz--chert plot.

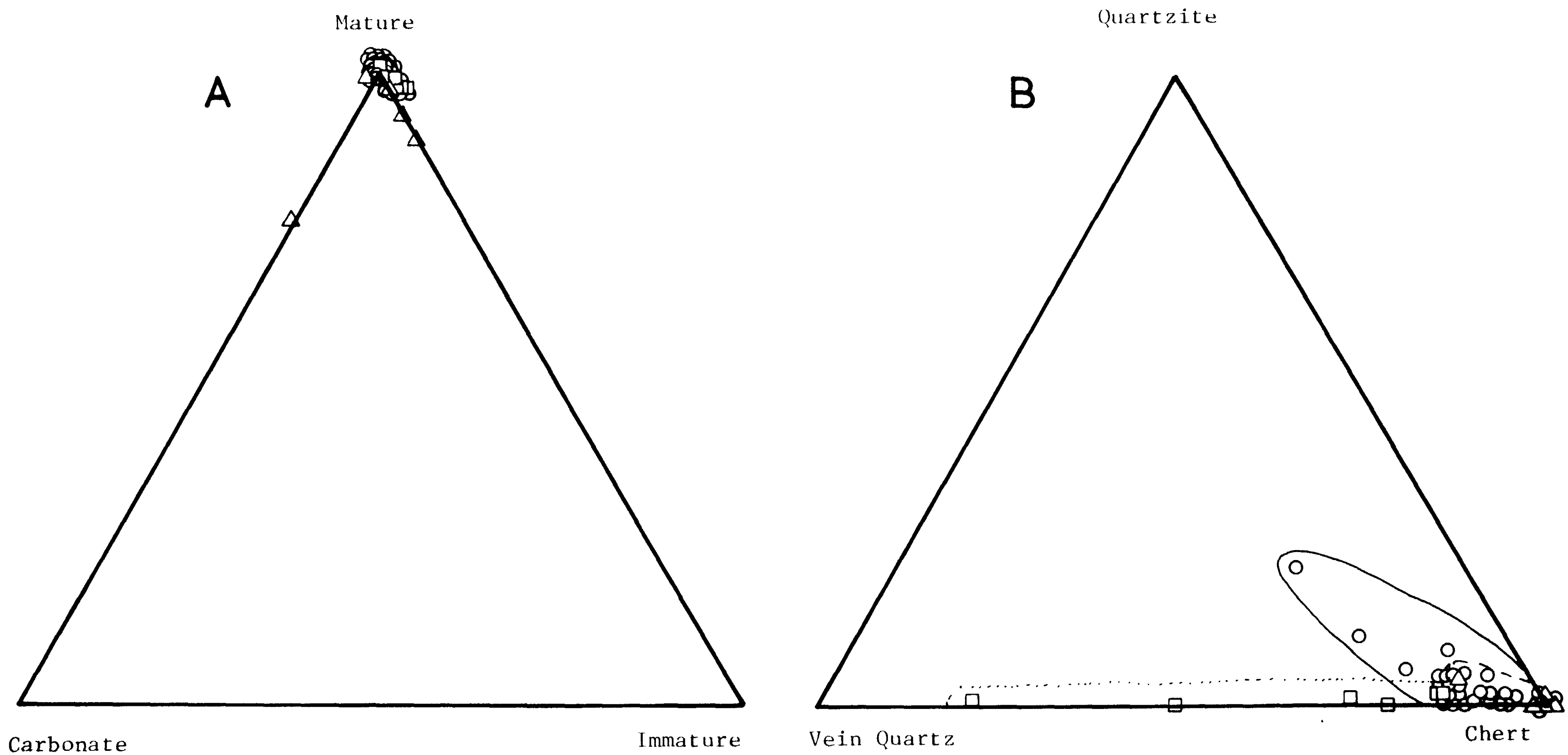


Figure 9. Ternary diagrams showing clast content from pebble counts of the Kanayut Conglomerate, Kekiktuk Conglomerate, and conglomerate from the Beaucoup Formation. A. Mature clast (chert, vein quartz and quartzite) - immature clast (argillite, siltstone and sandstone) - carbonate clast plot. B. Quartzite - vein quartz - chert plot.

Symbols: △ -- Beaucoup Formation; ○ -- Kanayut Conglomerate; □ -- Kekiktuk Conglomerate

Table 2.--Maximum clast size and percentage of each clast type from pebble counts of the Kanayut Conglomerate, Beaucoup Formation, and Kekiktuk Conglomerate.

are compositionally very mature. This maturity can result from a compositionally mature provenance, extensive chemical weathering, or extreme physical abrasion during transport.

To discern compositional differences between the stratigraphic units, data were plotted on a ternary diagram with vein quartz, chert, and quartzite as the poles (fig. 9B). Pebble counts from the Kanayut Conglomerate and Beaucoup Formation cluster near the chert pole and contain minor amounts of vein quartz and quartzite. In contrast, those from the Kekiktuk Conglomerate are richer in vein quartz and depleted in chert clasts; they plot in the middle part of the quartz-chert join and define a separate field from that of the Kanayut and Beaucoup conglomerates. This distinction suggests either different provenances or different weathering and abrasion histories.

When the abundance of each clast type is plotted against the maximum clast size (as a measure of coarseness of the conglomerate), the enrichment of Kekiktuk conglomerate in vein quartz and its depletion in chert relative to Kanayut and Beaucoup conglomerates is readily apparent, although the different fields overlap slightly at their extreme ends (figs. 10A,B). The percentage of chert and quartz in the Kekiktuk is also more variable, with both clast types ranging in abundance from 20 to 80 percent. Despite the lack of pebble counts from the coarser beds of the Kekiktuk Conglomerate, the data suggest that, at least with respect to chert and vein quartz clasts, sorting of clasts by composition has been less efficient in the Kekiktuk Conglomerate.

In contrast, clast abundances in the Kanayut Conglomerate exhibit a regular relationship with clast size. The percentage of vein quartz and quartzite clasts increases with increasing clast size, whereas the abundance of chert decreases proportionately with increasing clast size. In the Beaucoup Formation,

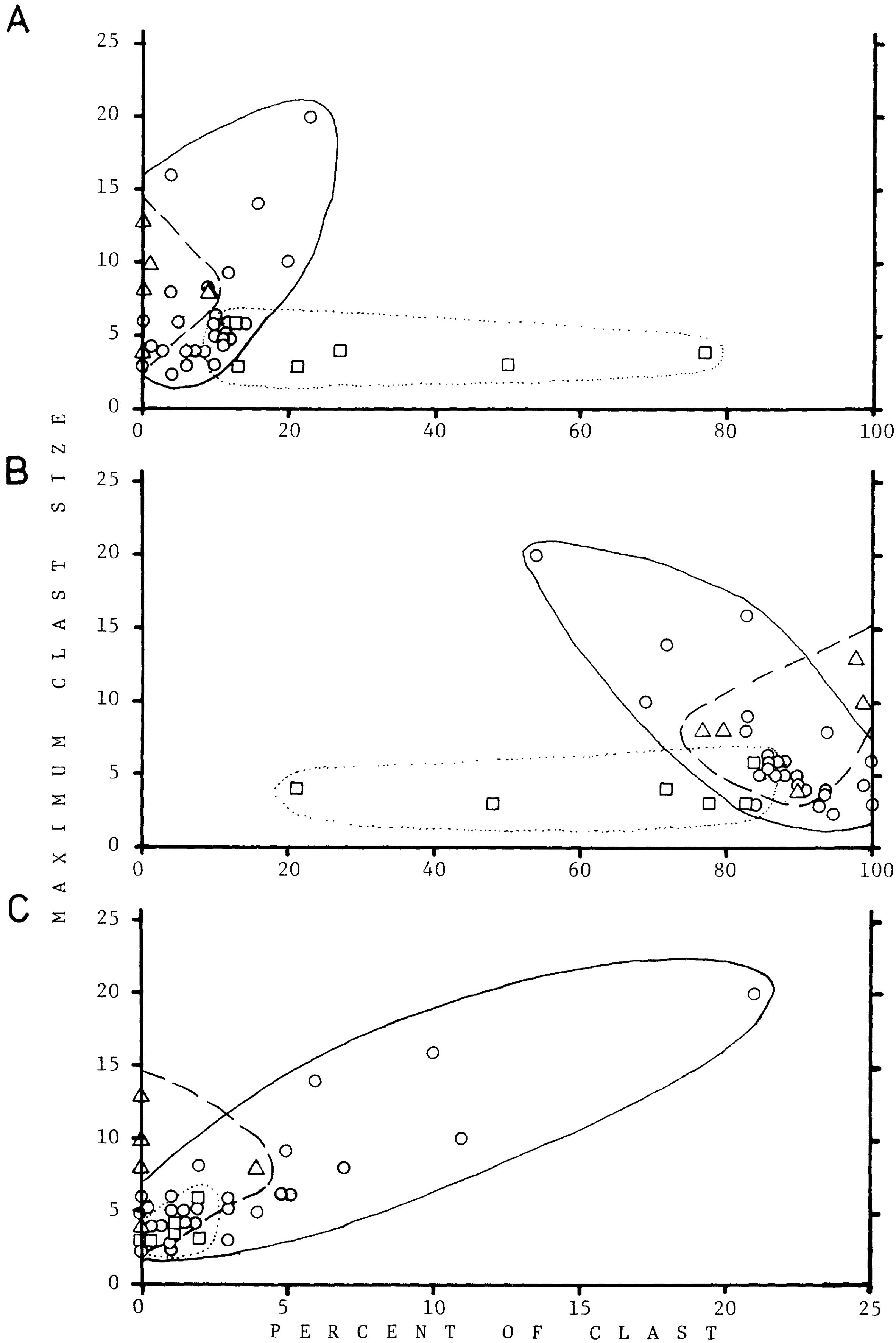


Figure 10. Plots of maximum clast size versus percentage of clast lithology from pebble counts of the Kanayut Conglomerate, Kekiktuk Conglomerate and conglomerate from the Beaucoup Formation. A, Vein quartz. B, Chert. C, Quartzite.

Symbols: (△)-- Beaucoup Formation; ○-- Kanayut Conglomerate; □ -- Kekiktuk Conglomerate however, chert abundance appears to increase with increasing clast size because there is a slightly larger percentage of argillite and carbonate clasts in the finer conglomerate. The same sorting process therefore operates in the Beaucoup Formation, except that softer carbonate and argillite clasts are concentrated in finer conglomerate relative to chert, which predominates in the coarser conglomerate.

Pebble counts from the different fluvial members of the Kanayut Conglomerate have also been plotted on pebble-type abundance vs. maximum clast size diagrams (figs. 11A,B,C). Although the conglomerates of the Kanayut Conglomerate are clearly similar compositionally, these diagrams demonstrate that, for conglomerates with the same clast size, the middle conglomerate member is generally enriched slightly in vein quartz and quartzite and depleted in chert relative to the lower shale member and Stuver Member. Sorting of clast types according to coarseness of the conglomerate, as discussed above, cannot explain this relationship. Instead, these data show that the middle conglomerate member is compositionally more mature than the upper and lower members.

The pebble count data were also plotted geographically in order to aid in determination of sediment dispersal patterns. Although distribution maps for each pebble type were plotted for each formation and member, no significant compositional trends were detected. Conglomerate of such high compositional maturity probably has variations in clast abundance of only 10-15 percent or less, and these variations were not apparently significant. The scarcity of pebble count data from units other than the middle member of the Kanayut and a geographic clustering of sampled localities north of Arctic Village and near Anaktuvuk Pass further limited interpretation of the data.

Sandstone

Thin sections of 37 sandstone samples of the Kanayut Conglomerate and

Figure 11.--Plots of maximum clast size versus percentage of clast lithology from pebble counts of the lower shale, middle conglomerate and Stuver Members of the Kanayut Conglomerate. A, Vein quartz. B, Chert. C, Quartzite.

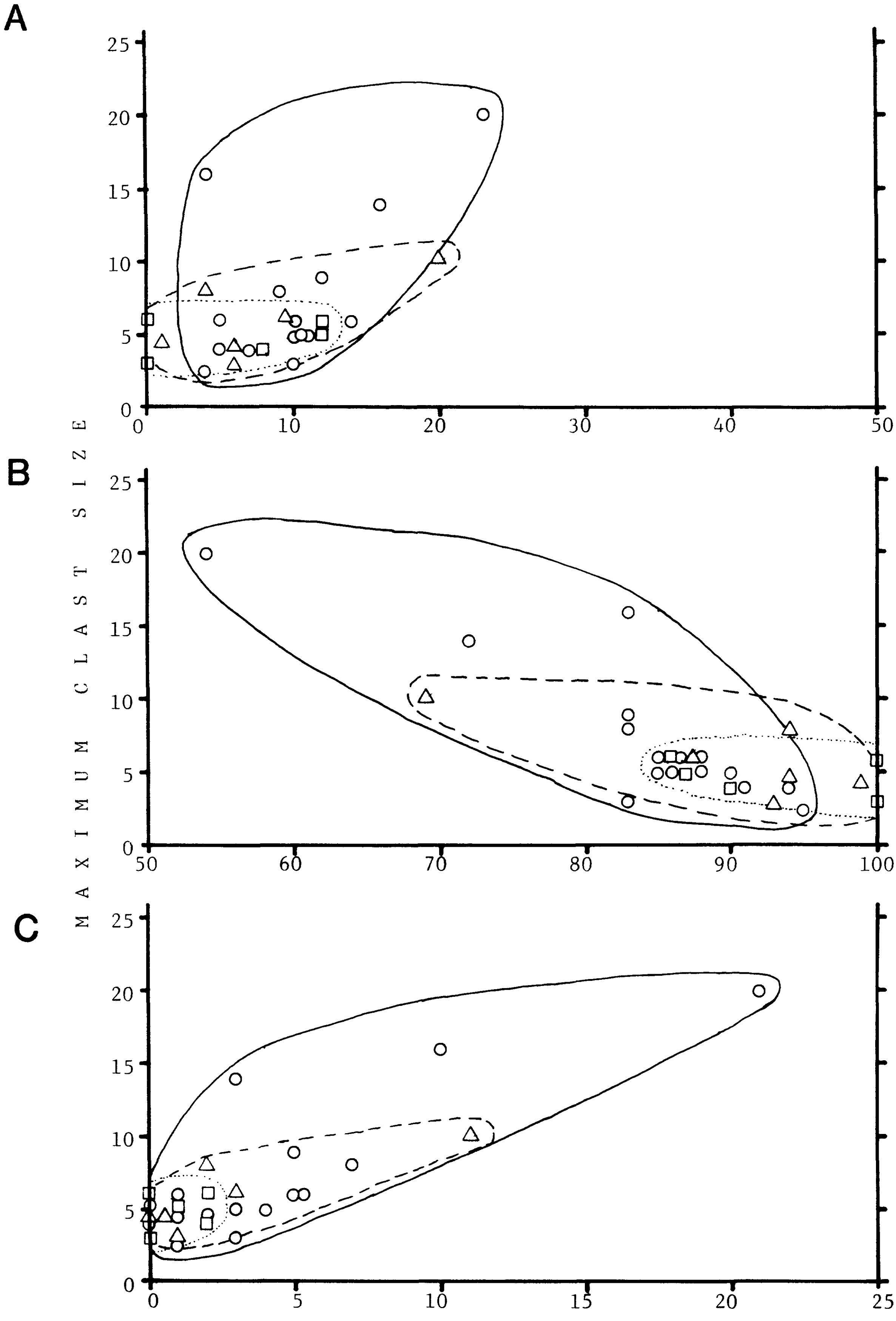


Figure 11. Plots of maximum clast size versus percentage of clast lithology from pebble counts of the lower shale, middle, and Stuver members of the Kanayut Conglomerate. A, Vein quartz. B, Chert. C, Quartzite.

Symbols: △ -- Lower shale member; ○ -- Middle conglomerate member; □ -- Stuver member

Kayak Shale were examined for compositional and textural relations. All of the studied samples are from the measured sections 16 km west of Anaktuvuk Pass and at Shainin Lake (figs. 5 and 6). The sandstone compositions were determined by visual estimation of the constituent grain types, using terminology of Dickinson (1970).

The sandstone samples are composed mainly of chert and quartz with subordinate amounts of argillite, granitic and/or gneissic, quartz and quartzite rock fragments (table 3). Feldspar is generally absent or present only in small quantities. Minor constituents include quartz-mica tectonite (metamorphic) rock fragments, biotite, muscovite, opaque iron minerals, tourmaline, and rarely, volcanic rock fragments. Heavy minerals were not separated or studied in detail.

Samples of medium-grained sandstone plot very near the Qm + Qp pole on an (Qm + Qp)--F--R diagram, illustrating the compositional maturity of the sandstone of the Kanayut (fig. 12A). On a Qm--F--(R + Qp) diagram, the data are displaced toward the rock-fragment pole from the midpoint of the Qm - (R + Qp) join, showing that the sandstone is rich in rock framents, primarily chert (fig. 12B). These two diagrams suggest that there is little compositional difference among fluvial sandstone of the lower shale, middle conglomerate, and Stuver Members of the Kanayut Conglomerate, although data from the lower shale member are minimal.

The framework is tightly compacted and many samples have a fabric defined by parallel orientation of elongate grains. Most quartz grains are fractured and polygonized, indicating extensive postdepositional deformation.

The cement is dominated by overgrowths of silica on quartz grains and generally less abundant but relatively coarse phyllosilicates which have grown interstitially. Other cement includes local authigenic hematite as poikilitopic

Figure 12.--Ternary diagrams showing sandstone composition from thin-section estimates of medium-grain sandstone of the lower shale, middle conglomerate and Stuver members of the Kanayut Conglomerate. A, polycrystalline and monocrystalline quartz (vein quartz, chert and quartzite)-feldspar-lithic fragment plot. B, monocrystalline quartz (vein quartz)-feldspar-lithic fragment and polycrystalline quartz (chert and quartzite) plot. Only plots of medium-grained sandstone are shown.

Symbols: □ --Stuver Member; ○ --Middle conglomerate member;
△ --Lower shale member.

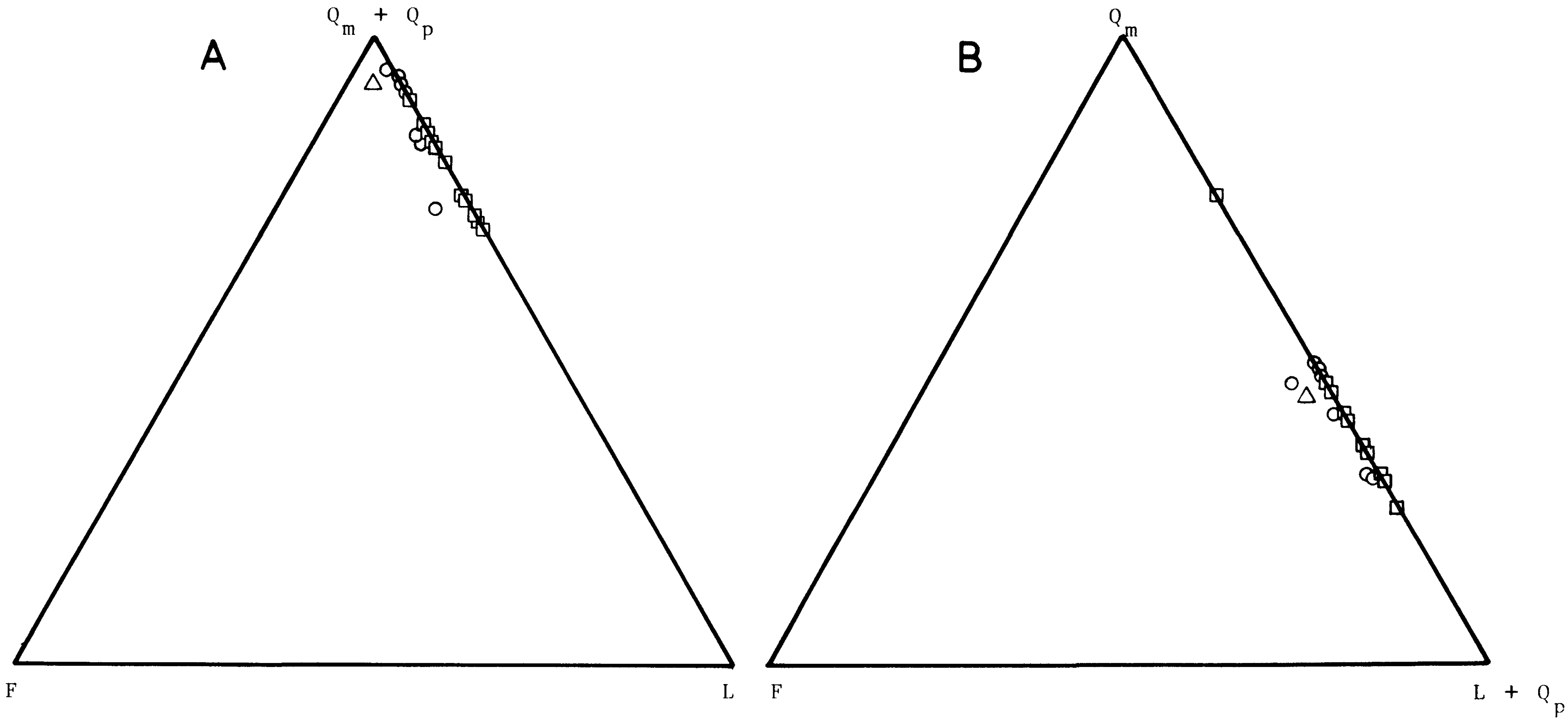


Figure 12. Ternary diagrams showing sandstone composition from thin section estimates of medium-grain sandstone of the lower shale, middle and Stuver members of the Kanayut Conglomerate. A, polycrystaline and monocrystalline quartz (vein quartz, chert and quartzite) -feldspar-lithic fragment plot. B, monocrystalline quartz (vein quartz)-feldspar-lithic fragment and polycrystalline quartz (chert and quartzite) plot.

Symbols: □ -- Stuver member; ○ -- Middle conglomerate member: △ -- Lower shale member.

Table 3.--List of thin-section estimates of sandstone composition of the lower shale, middle conglomerate, and Stuver Members of the Kanayut Conglomerate and the basal sandstone of the Kayak Shale.

Table 3.--List of thin-section estimates of composition of sandstone samples from the lower shale, middle conglomerate and Stuver members of the Kanayut Conglomerate and the basal sandstone of the Kayak Shale

[Abbreviations: Zr = zircon; To = tourmaline; chl = chlorite; ep = epidote; op = opaque minerals; sph = sphene, gt = garnet.]

		Framework grains equal 100 percent											Interstitial constituents (percent of total rock)			
Sample number	Grain size	Quartz	Plag	K-spar	Chert	Argil-lite	Quartzite and granitic rock	Mica tectonite	Vol-canic rock	Musco-vite	Bio-tite	Other	Silica over-growth	Phyllo-silicate	Hematite	Car-bonate
							Kayak Shale									
78 STU-14	Fine ss.	70	0	0	15	5	5	1	2	1	0	Zr, To.	13	2	5	0
78 STU-15	Fine ss.	65	0	0	15	10	5	2	1	1	1	Zr, To.	12	5	3	0
78 STU-16	V. fine ss.	50	0	0	20	20	2	5	0	2	0	Zr, To., sph, op.	13	5	2	0
78 STU-17	V. fine ss.	55	0	0	20	20	2	5	0	2	0	Zr, To, chl.	5	10	5	5
78 STU-18	Fine ss.	55	0	0	25	15	5	1	1	2	<1	Sph.	12	8	3	2
							Kanayut Conglomerate, Stuver member									
78 STU-1	Med. ss.	35	0	0	50	0	10	3	0	1	<1	To, ep, op.	10	3	3	0
78 STU-2	Med.-crs. ss.	40	0	0	40	5	15	0	0	<1	0	Op.	10	7	3	0
78 STU-3	Fine-med. ss.	45	0	0	30	1	10	10	0	2	0	To, op.	6	6	5	0
78 STU-4	Crs.-gran ss.	35	0	0	40	5	15	5	0	1	0	Ep, op	10	10	5	0
78 STU-6	Fine ss.	40	0	0	30	15	10	3	0	<1	1	To	12	4	1	0
78 STU-7	Med.-crs. ss.	40	0	0	50	2	5	0	0	0	0	To, ep.	15	5	1	0
78 STU-8	Med.-pbl. ss.	35	0	0	35	20	10	0	1	0	0	To.	1	5	5	0
78 STU-9	Fine-crs. ss.	30	0	0	45	20	5	0	0	0	0	To.	0	4	4	0
78 STU-10	Med. ss.	30	0	0	40	20	10	0	<1	0	0	To. op.	0	5	0	0
78 STU-11	Med. ss.	25	0	0	50	20	5	0	<1	1	0		0	5	0	0
78 STU-12	Med. ss.	75	0	0	10	10	5	0	0	0	0	To., op.	15	0	5	0
78 STU-13	Crs. sltst.	75	0	0	5	5	5	0	0	5	2	Op.	0	0	0	0
78 CHA-8	Fine ss.	45	0	0	40	10	3	1	0	1	<1	Op.	15	4	1	0
78 CHA-9	Fine ss.	45	0	0	35	10	5	1	5	1	1	Op, To.	10	5	0	0
78 CHA-10	Med.-crs ss.	45	0	0	40	10	5	0	0	0	0		13	1	1	0
78 CHA-11	Fine ss.	60	0	0	25	10	5	1	0	1	0		0	0	50	0
78 CHA-12	Fine ss.	50	0	0	25	15	3	1	0	2	<1	Op., To., Zr.	12	5	3	0
78 CHA-13	Med. ss.	55	0	0	30	10	5	<1	0	1	0	Op., To., Zr.	17	2	1	0
78 CHA-14	Fine ss.	45	0	0	40	10	3	1	0	1	<1	Op.	15	4	1	0
							Kanayut Conglomerate, middle conglomerate member									
78 ABe 111-4	Med ss.	45	4	1	28	15	10	2	<1	0	1	Chl.	14	3	0	3
78 ABe 111-5	Fine ss.	45	7	1	20	20	5	2	<1	1	1	Op.	14	2	2	0
78 CHA-1	Med. ss.	30	1	0	55	10	5	0	<1	<1	<1		11	2	1	1
78 CHA-2	Med. ss.	30	<1	0	55	10	5	1	1	0	<1		13	2	0	0
78 CHA-3	Fine ss.	35	1	0	45	10	5	1	0	2	0		0	0	0	40
78 CHA-4	Med. ss.	40	<1	0	45	8	5	1	1	1	0		11	3	1	0
78 CHA-5	Med. ss.	45	0	0	45	5	5	0	0	0	0		13	1	1	0
78 CHA-6	Med. ss.	45	0	0	45	5	5	5	0	<1	0		13	2	5	0
78 CHA-7	Med. ss.	45	0	0	45	5	5	<1	0	<1	0	Ep, gt, op	13	2	<1	0
							Kanayut Conglomerate, lower shale member									
78 ABe 111-1	Fine ss.	35	6	2	30	20	5	2	<1	1	1	To.	5	10	0	0
78 ABe 111-2	Med.-crs. ss.	43	3	1	40	7	5	1	0	0	0	To.	3	10	3	2
78 ABe 111-3	Fine ss.	37	4	0	30	20	5	1	0	1	2	Chl., To.	5	8	2	0

grains and lenticular concretions up to 1 cm in length, and calcite, which has partly replaced detrital grains and silica cement in several samples. The combination of good sorting and little primary matrix shows that the sandstone is texturally mature.

The measured porosities of seven samples from the sandstone member of the Kanayut ranged from 1.3 percent to 6.5 percent and averaged 3.2 percent. Permeability of these rocks ranged from .002 md to 0.17 md and averaged 0.006 md.

Sandstone of the Kanayut Conglomerate was probably derived mainly from a recycled sedimentary provenance, as suggested by the textural and compositional maturity. Subordinate volcanic and metamorphic lithic fragments, however, suggest that volcanic and metamorphic terranes provided some detritus to the Kanayut Conglomerate.

Summary

The conglomerate and sandstone compositional data, which indicate roughly equivalent abundances of the same suite of clasts and sand grains, argue against important differences in the provenance of the various formations and members. Differences such as the higher abundance of vein quartz in the Kekiktuk Conglomerate and the slightly higher compositional maturity of the middle conglomerate member relative to the lower shale member and Stuver Member of the Kanayut Conglomerate are minor and their distinction requires very careful examination of grain and pebble abundances.

The sandstone and conglomerate data show that the various units are compositionally very mature. The presence of immature grains and clasts of argillite, carbonate, volcanic rock fragments and micas suggests that mechanical and weathering processes are not the primary cause of this maturity; rather, the maturity probably was inherited from the source rocks. However, much of the compositional variation between the different sandstones and conglomerates

Figure 13. Paleocurrent map for the Kanayut Conglomerate in the central and eastern Brooks Range.

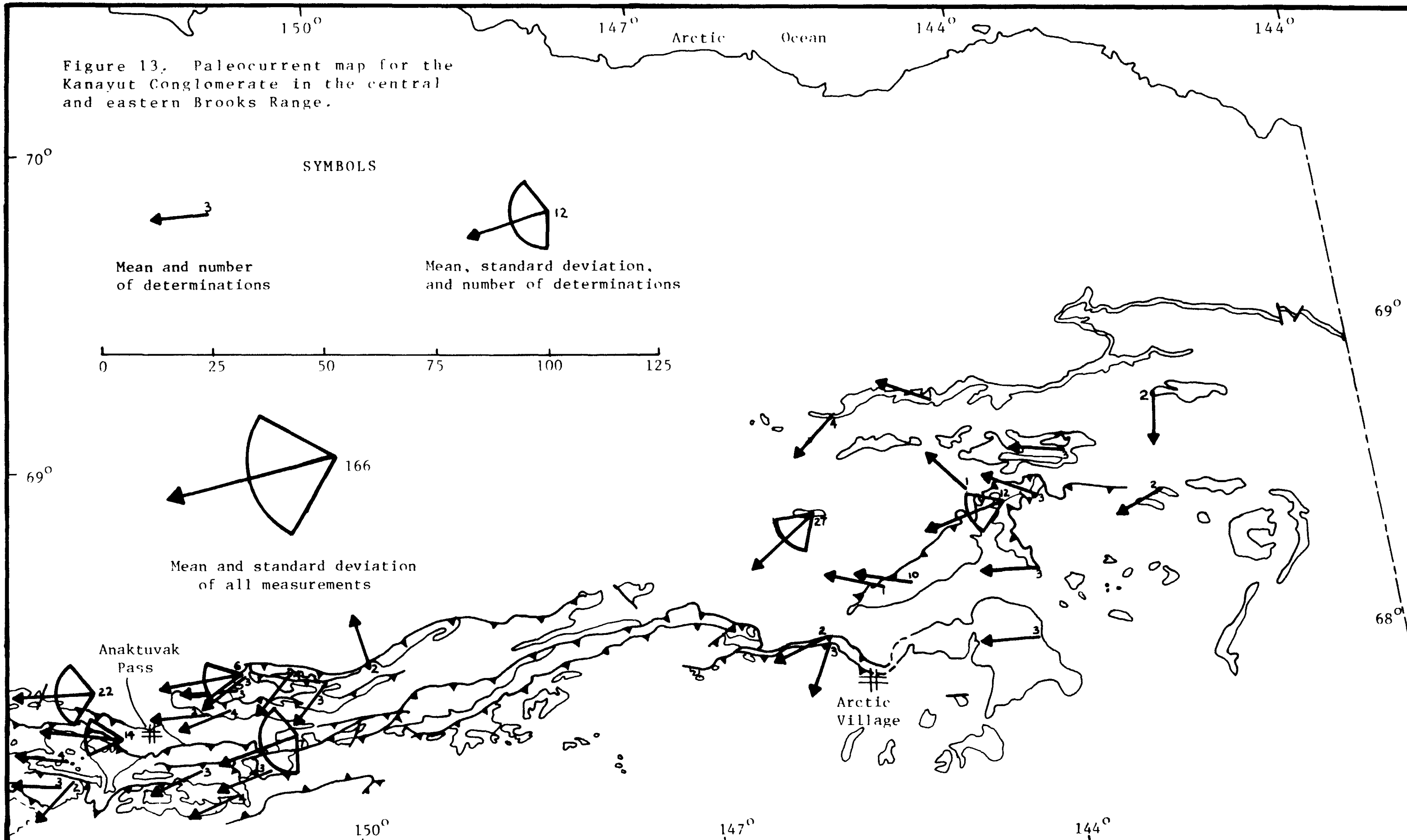


Figure 13. Paleocurrent map for the Kanayut Conglomerate in the central and eastern Brooks Range.

can be ascribed to either weathering or abrasion effects. The slightly lower compositional maturity of Kekiktuk conglomerates may be explained by closer proximity to source area, yielding less mechanical reworking and degradation of the less durable clasts. The slightly higher compositional maturity of the middle conglomerate member of the Kanayut Conglomerate may reflect greater mechanical reworking from transport of clasts.

The predominance of chert, quartz, quartzite and argillite clasts and grains suggests that the provenance of these Devonian-Mississippian strata is mainly a sedimentary terrane. The good sorting and subrounding of sand grains and near-absence of feldspar in all units support this interpretation and argue that the source terrane itself consisted of sedimentary rocks. The presence of phyllitic, gneissic and micaceous tectonite rock fragments in the sandstones suggests that the sedimentary provenance may have been partly metamorphosed. Scarce volcanic rock fragments and locally abundant carbonate clasts suggest that these rock types were also exposed in the source area, at least in small quantities.

PALEOCURRENTS

A total of 166 paleocurrent measurements were made at 35 locations; 158 from conglomerate and sandstone of the fluvial lower shale, middle conglomerate, and Stuver members of the Kanayut Conglomerate (fig. 13) and eight from the Kayak Shale. Sedimentary features measured included conglomerate clast long-axis orientation (96 determinations), medium-scale tabular and cross-strata (57 determinations), primary current lineation (7 determinations), ripple markings (5 determinations) and pebble trains (1 determination). Restorations of paleocurrent directions to the horizontal were done manually on a stereonet. Computer-calculated vector means and standard deviations were determined for seven locations at which more than four paleocurrent measurements

Figure 14. Summary rose diagram for 166 paleocurrent measurements from the Kanayut Conglomerate in the central and eastern Brooks Range.

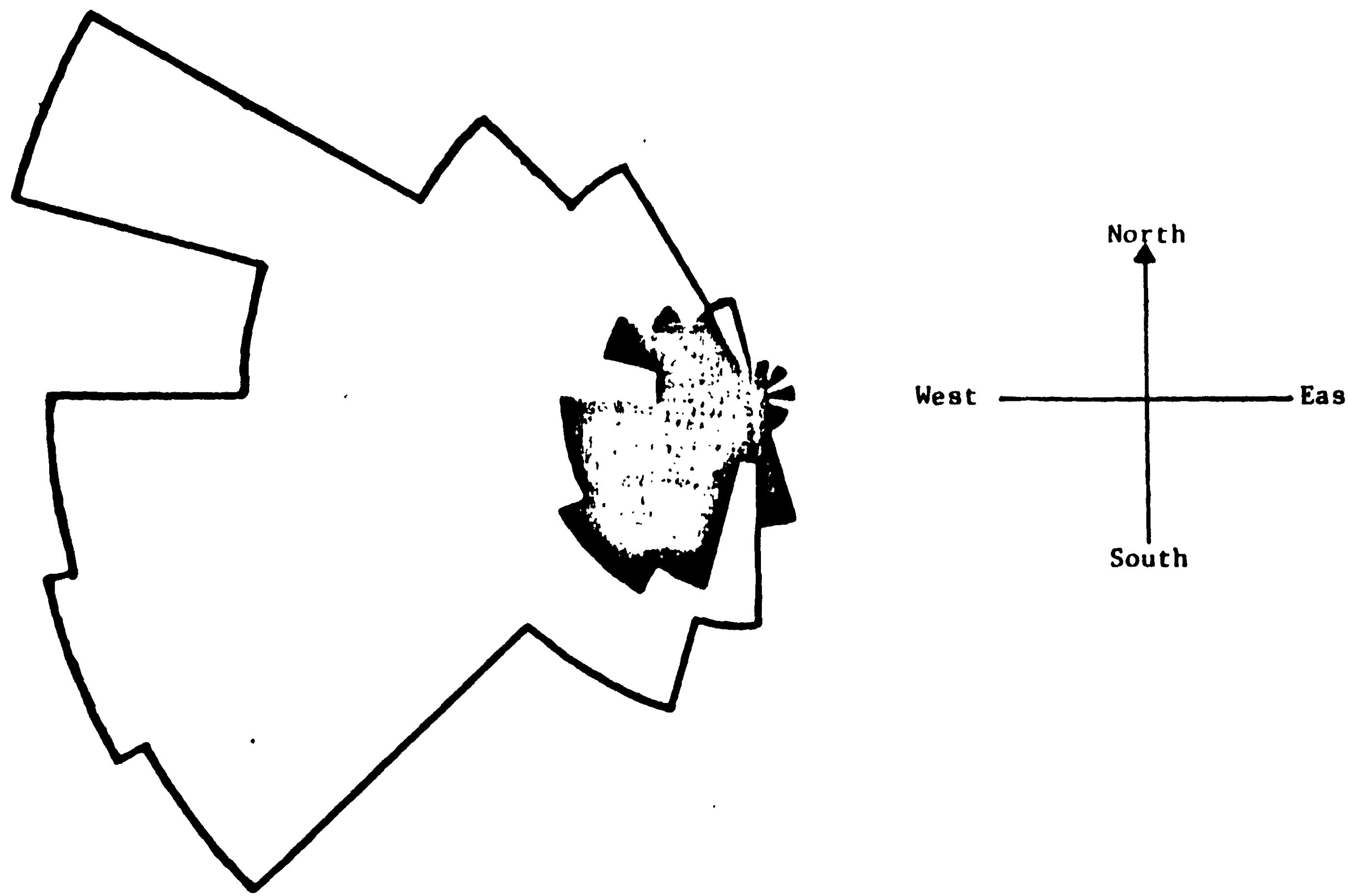


Figure 14. Summary rose diagram for 166 paleocurrent measurements from the Kanayut Conglomerate in the central and eastern Brooks Range. Filled area represents measurements giving direction and sense; clear area represents measurements giving sense but not direction.

were made and also for the total number of Kanayut paleocurrent measurements. Bidirectional features such as primary current lineation were assigned a westerly or southerly sense because of the preponderance of undirectional indicators with that orientation. Measurements were analyzed without regard to stratigraphic position within the Kanayut Conglomerate.

Figure 14 summarizes by rose diagram all paleocurrents from the Kanayut Conglomerate. Undirectional indicators show a southwest transport of sediment and bidirectional indicators (those giving sense of transport only) a west to southwest transport. The azimuthal vector mean and standard deviation of all measurements from the Kanayut is 258 ± 45°. Vector means and standard deviations for locations having more than four measurements range from 248 ± 11° to 278 ± 12°, showing that the data are consistent between locations. Two measurements of trough cross-strata from the marine sandstone member of the Kanayut Conglomerate indicate sediment transport directions of 337° and 360°.

These data indicate that fluvial sediment transport of the Kanayut Conglomerate was toward the west or west-southwest. Donovan and Tailleur (1975) previously determined southerly directions of transport for the Kanayut Conglomerate.

Five scattered paleocurrents measured from cross-strata in the Kekiktuk Conglomerate in the northeastern Brooks Range indicate sediment transport ranging from 191° to 300°, with a mean of 243°. This direction is similar to that of the Kanayut Conglomerate, but is probably not significant statistically.

Three paleocurrents measured from current ripple markings in the shallow-marine or intertidal lower sandstone of the Kayak Shale near Chandler Lake indicate southeastward sediment transport. The mean direction is 163° and range 142° - 178°, but this amount of data is not statistically significant.

PALEOGEOGRAPHY AND TECTONICS

The Kanayut Conglomerate and related rocks reflect westward and southwestward growth of a prograding delta in late Late Devonian time. A reasonable partial source of clasts of the Kanayut is the Precambrian and lower Paleozoic terrane exposed in the cores of the large anticlinoria of the northeastern Brooks Range and British Mountains. The main clast types can be matched with rocks found in these anticlinoria. Several siliceous and cherty pre-Carboniferous formations could have provided the abundant chert in conglomerates of the several members of the Kanayut (Reiser and others, 1978). Quartz clasts could have been derived from the Neruokpuk Formation, the Devonian and Ordovician granites of the Romanzof Mountains, the early Paleozoic granites of the Table Mountain and Coleen quadrangles and the northern Yukon, and the ubiquitous quartz veins that are found throughout pre-Carboniferous terranes. Quartzite clasts could have been derived from Cambrian sandstone units or Precambrian and lower Paleozoic quartzites. Red and green argillite clasts could have been derived from the Cambrian and Ordovician chert and phyllite, Precambrian argillite and limestone, and similar red and green argillite of uncertain pre-Carboniferous age. Several schistose units, including the Neruokpuk Formation, could have been the source of the minor amounts of schist in the conglomerates.

Many stratigraphic sections can be used to demonstrate the general nature of the offlap-onlap cycle that was initiated early in Late Devonian time. The cycle culminated in the extension of the Kanayut delta at least as far westward as the longitude of Howard Pass and ended with onlap of the marine Kayak Shale in the early Carboniferous.

Shallow-marine strata of the Beaucoup Formation, including basal conglomerate and reef limestone, unconformably overlie Middle Devonian and Silurian rocks and grade upward into the deeper marine Hunt Fork Shale. The wacke member of the Hunt Fork Shale reflects shallowing marine conditions and prodelta sedi-

Figure 15.--Paleogeographic sketch map of the delta comprising the Kanayut Conglomerate at the time of maximum Late Devonian progradation and before later tectonic dislocations. Location of the delta with respect to present geography is correct only for the exposed southern half. B, Barrow; AP, Anaktuvuk Pass; AV, Arctic Village; FY, Fort Yukon; K, Kotzebue.

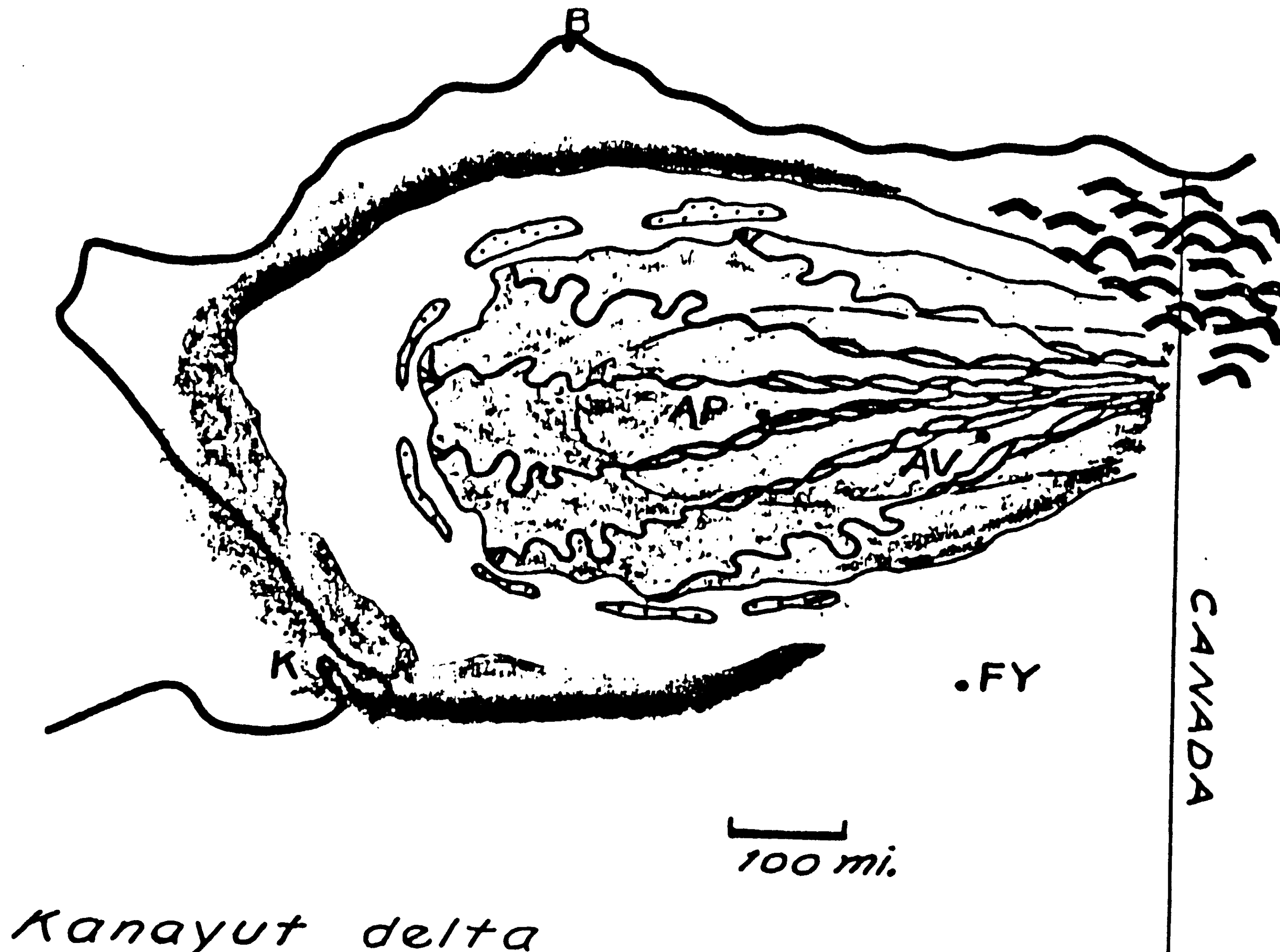


Figure 15

mentation. It grades upward and laterally into marine sandstone of the sandstone member of the Kanayut Conglomerate. This sandstone was probably deposited as a complex of river mouth and offshore bars. The three main members of the Kanayut comprise a symmetrical nonmarine cycle with the lower shale and Stuver members reflecting meandering stream conditions and the middle conglomerate member braided stream and possibly alluvial fan conditions. The inferred paleogeography for the deltaic complex, although difficult to represent because only its central, southern and western portions are preserved in outcrop, is shown on figure 15.

Published speculative plate-tectonic reconstructions place the delta of the Kanayut conglomerate much farther north than its present position. Tailleur's (1969a, 1969b) hypothesis infers a post-Mississippian counterclockwise rotation of northern Alaska away from the Canadian Arctic Islands about a pole of rotation located near the modern Mackenzie delta. In this model, the Upper Devonian Kanayut delta would display northward transport from a northeast-trending axial highland now represented in part by the Barrow Arch. Dutro (in press) has alternatively suggested that northern Alaska has been displaced laterally from the eastern Arctic, with the Fenno-Scandian shield the ultimate source for the Kanayut delta. This reconstruction places northern Alaska in an early Paleozoic foldbelt that includes Novaya Zemlya, Spitsbergen and northeast Greenland. Other hypotheses are certainly possible, but much more evidence from the Arctic Basin itself is needed before a coherent paleotectonic story can be written.

SUMMARY

Regional geologic mapping shows that the Upper Devonian Kanayut Conglomerate consists of a basal marine sandstone member and three successive fluvial members. It presently crops out over a distance of at least 450 km along strike and about 50 km across strike in at least three major thrust plates. Detailed studies were

made of the Kanayut in the eastern part of this belt near Arctic Village and in the western part near Anaktuvuk Pass in order to describe and define these members.

Sedimentary features suggest that the marine basal sandstone member was probably deposited as channel mouth bars and offshore bars and spits. The overlying lower shale member is inferred to have been deposited by meandering streams over a large floodplain area. The middle conglomerate member, which contains the coarsest conglomerate and little or no shale, was probably deposited by braided streams, and in the northeast possibly as alluvial fans. The uppermost Stuver Member is inferred to have been deposited by meandering streams. It is overlain by intertidal and shallow-marine sandstone of the lower part of the Kayak Shale.

The orientations of crossbeds, current lineations, ripple marks and long axes of pebbles in the three fluvial members of the Kanayut consistently indicate current transport toward the west and southwest in the two areas that were studied. The clast size of the conglomerate, as indicated by the mean size of the largest pebbles, decreases westward and southward in the area near Anaktuvuk Pass. In the area near Arctic Village the clast size also decreases generally westward. However, no persistent decrease in clast size across the whole region from east to west is indicated, because no data were collected from the central half of the region and because the area of largest known clasts (up to 18 cm) is in the western study area near Anaktuvuk Pass. Additional data will be required to more clearly define regional fining trends.

The composition of the large clasts in the Kanayut Conglomerate varies little from place to place or member to member. In most of the conglomerates examined, about 80-95 percent of the pebbles are chert, about 5-15 percent quartz, and 1-5 percent quartzite. Pebbles of argillite and other rock fragments are rare. With increasing pebble size, the percentage of quartz and quartzite pebbles increases and chert decreases. The middle conglomerate member not only contains the coarsest conglomerate but also contains slightly more quartz at each size grade than do the two other fluvial members.

The pebbles in the Kanayut are moderate- to well-rounded and have moderate to high spericity. The quartzite pebbles have the highest roundness and sphericity and chert pebbles the lowest roundness.

The sandstone in the fluvial members of the Kanayut is well-sorted and is composed mostly of subrounded grains that have been tightly compacted, aligned and fractured. The composition ranges from 25-75 percent quartz, 5-55 percent chert, 7-31 percent mica and rock fragments, and 0-8 percent feldspar. Sandstone samples from the three fluvial members differ little in composition, although the highest percentages of feldspar and mica are present in the lower shale and Stuver members.

Cement and matrix in thin section commonly form 15-29 percent of the rock and consist mostly of silica overgrowths with lesser amounts of recrystallized phyllosilicates and minor amounts of authigenic hematite. Calcite has partly replaced detrital grains and silica cement in several samples.

The Kekiktuk Conglomerate, in a few places examined, contains a significantly greater percentage of quartz pebbles than the Kanayut Conglomerate. It also contains highly variable proportions of quartz and chert, ranging from 21-77 percent quartz and 21-79 percent chert.

The facies sequence in the Hunt Fork Shale and Kanayut Conglomerate suggests that the Kanayut comprises the marginal marine and fluvial parts of a prograding delta system. The consistent westward and southwestward direction of paleocurrents in the fluvial deposits, together with the southwestward decrease of grain size in the western part of these deposits, may imply an eastern or northeastern source. Judging from the abundance of chert, quartz and quartzite clasts in the Kanayut, the source terrane was probably composed mostly of slightly metamorphosed sedimentary rocks. The high roundness and sphericity of the clasts and their compositional maturity indicate that the source terrane may also have included older conglomerates, from which the Kanayut clasts were recycled.

A reasonable source area for at least part of the Kanayut Conglomerate is the terrane of Precambrian and lower Paleozoic rocks now exposed in the Brooks Range and British Mountains to the northeast of the Kanayut outcrop. This source would be equally consistent with the counter-clockwise rotation of northern Alaska envisioned in the reconstruction of Tailleur (1969a, b) or the westward translation by lateral faulting of northern Alaska and Yukon proposed by Dutro (in press).

The Lower Mississippian Kekiktuk Conglomerate seems to have been derived from local sources on the periphery of the area presently underlain by the Kanayut Conglomerate. Local sources are indicated by both the extremely variable ratio of quartz to chert clasts and by a few occurrences of identifiable fragments of local basement rocks in the conglomerate. The stratigraphic and paleogeographic relations between the Kanayut and Kekiktuk Conglomerates are not clear yet because their outcrop areas are mutually exclusive, and the Kanayut is wholly allochthonous, the Kekiktuk generally autochthonous.

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