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GEOLOGIC MAP AND CROSS-SECTIONS: HEADWATERS OF THE KONGAKUT AND AICHILIK RIVERS, DEMARCATION POINT (A-4) AND TABLE MOUNTAIN (D-4) QUADRANGLES, EASTERN BROOKS RANGE, ALASKA

by

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January 1991

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INTRODUCTION

At the headwaters of the Aichilik and Kongakut Rivers, in the northeastern Brooks Range, a major east - plunging anticlinorium exposes the rocks and structures of three distinct structural-stratigraphic domains. Ordovician-Cambrian Romanzof chert and phyllite (informal name) core the anticlinorium (OCcp of Reiser et al., 1980). In the north, Mississippian Kekiktuk Conglomerate unconformably overlies the Romanzof chert and phyllite with angular discordance. In the south, a thick stratigraphic succession consisting of Middle Devonian to Mississippian Ulungarat Formation (Anderson, 1991) and Kekiktuk Conglomerate has been thrust northward over the Romanzof chert and phyllite and its thin overlying cover of Kekiktuk Conglomerate. The anticlinorium and duplexes within younger rocks are the result of Cenozoic - Late Cretaceous deformation which formed the northeastern Brooks Range (Wallace and Hanks, 1990). This report summarizes the preliminary results of a structural study on the southeastern flank of this anticlinorium in the Demarcation Point (A-4) and Table Mountain (D-4) quadrangles. The only previous published work on the area are the reconnaissance - scale maps of Reiser et al. (1980) and Brosge et al. (1976). For this study, detailed mapping at the scale of 1:25,000, analysis of minor structures, and measurement of stratigraphic sections was carried out to characterize the structural geometry and determine lateral variations in the stratigraphy of the field area.

PRELIMINARY FINDINGS

The major structures of the field area are north-vergent folds and thrust faults formed during Late Cretaceous - Cenozoic deformation. The area is divided into three structural-stratigraphic domains based on variation in stratigraphy and structural style (Fig. 1). Shortening is accommodated by a major duplex with a floor thrust at depth in the Romanzof chert and phyllite and a roof thrust in the Kayak Shale (Fig. 2). Northward displacement of a horse in this duplex along the Aichilik Pass thrust has emplaced rocks in the hangingwall (Domain II) north over a partially time-equivalent, but stratigraphically distinct, sequence in the footwall (Domain I). The Mississippian Kayak Shale, which stratigraphically overlies the Kekiktuk Conglomerate, serves as the roof of Domains I and II, and the floor of Domain III. Shortening has been accommodated above the Kayak Shale by the development of short wave-length (100's of meters) folds and associated thrust faults in the Mississippian to Pennsylvanian Lisburne Group and the Permian to Triassic Sadlerochit Group.

The Kayak Shale has served as a major detachment horizon for all three domains. It defines the boundaries between the 3 domains. Detachment folds have formed above the Kayak Shale in Domain III, and it has served as a detachment horizon for imbrication in Domains II and III. Because it is a thick and poorly exposed shale, it is not generally possible to identify specific fault surfaces with in the Kayak Shale. Thus, where faults cut up section to or from flats in the Kayak Shale, the continuation of those faults in the Kayak Shale is not generally illustrated in the Kayak Shale. It is assumed that slip has occurred somewhere in the unit throughout most of the map area. Because of its role as a horizon of slip, the Kayak Shale has been disrupted by minor

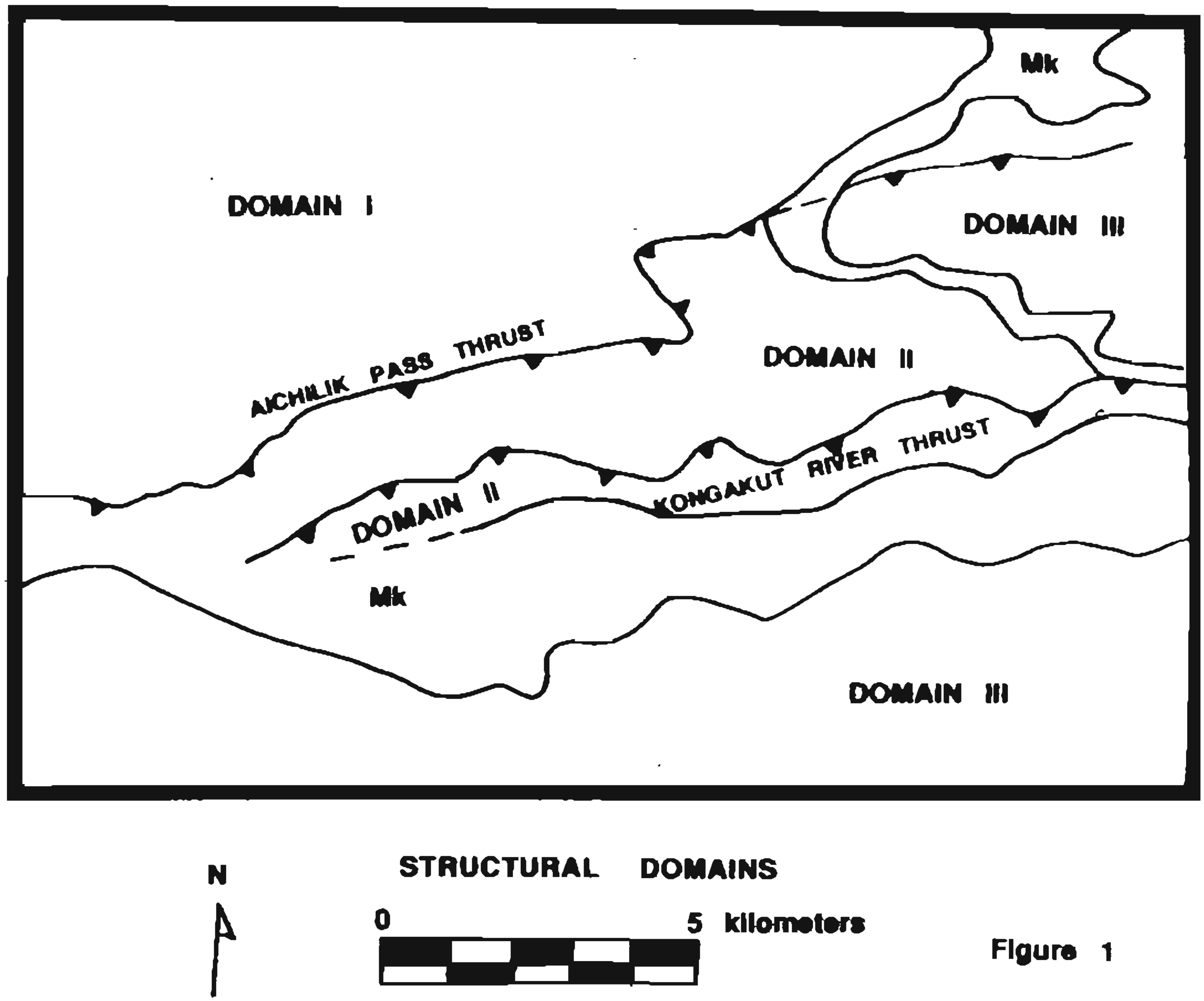
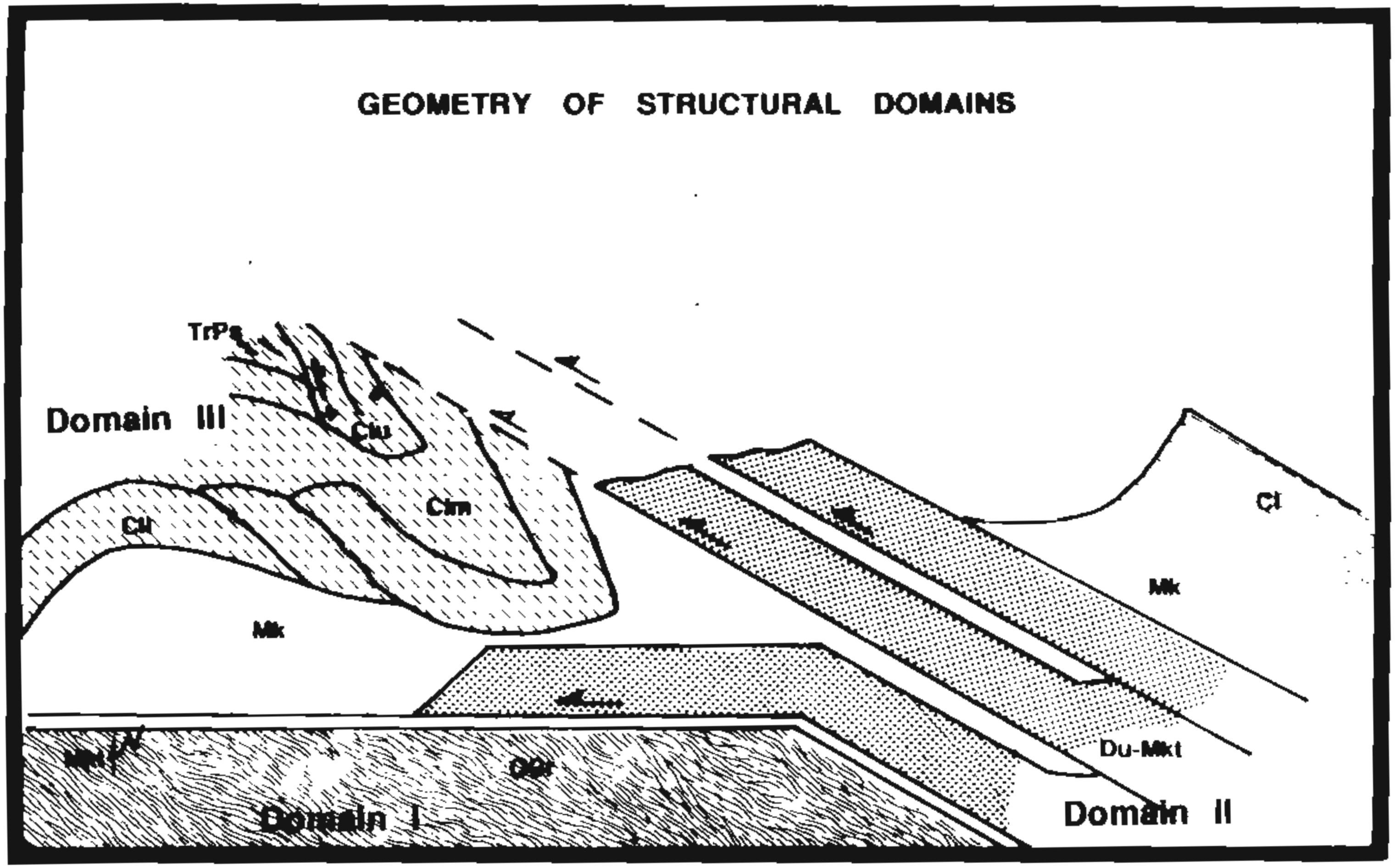

Mk
DOMAIN I
DOMAIN III
AICHILIK PASS THRUST
DOMAIN II
KONGAKUT RIVER THRUST
DOMAIN II
Mk
DOMAIN III
N
STRUCTURAL DOMAINS
0
5 kilometers

Figure 1



Domain I OCr, Mkt-1
Domain II Du, Mkt-2
Domain III Cl (Cll, Clm, Clu), TrPs

Not to scale

Figure 2

folding and faulting. It probably has been structurally thickened in most places, so its true depositional thickness is uncertain

DOMAIN I

In the northwestern part of the map area, the regional anticlinorium is cored by Ordovician-Cambrian Romanzof chert and phyllite. The thin Mississippian Kekiktuk Conglomerate is less than 30 meters thick and depositionally overlies the chert and phyllite with angular discordance. This stratigraphic succession forms the footwall of the Aichilik Pass thrust and is defined as Domain I.

The Romanzof chert and phyllite is of inferred Ordovician-Cambrian age (Reiser et al., 1980). This age assignment is supported by graptolites from presumably equivalent rocks along strike to the southwest in the Arctic quadrangle (Moore and Churkin, 1984). This is the structurally lowest unit in the field area, but forms topographic highs due to its resistance to erosion. The massive and bedded cherts occur as lenses in the phyllite matrix. Lenses or groups of lenses define mappable linear features that extend for kilometers in an east-west orientation. Individual chert lenses crop out on a scale of 100's of meters and are laterally discontinuous. Bedding and cleavage in the cherts are steep to subvertical. The cherts display at least two generations of tight to isoclinal folds with variably plunging refolded axes. The axial surfaces of the folds and associated thrust faults were rotated to steep dips prior to development of the overlying regional unconformity.

A major regional unconformity truncates the underlying Romanzof Chert and phyllite. The Mississippian Kekiktuk Conglomerate rests depositionally on the unconformity surface and is thin to laterally discontinuous. Lateral facies and thickness changes indicate that deposition of the Mississippian clastic succession was controlled by relief on the unconformity. This ancient topographic relief may have been influenced by syndepositional high-angle faulting as suggested by local faults that cut across the unconformity into the Kekiktuk Conglomerate. In this area the Kekiktuk Conglomerate is a breccia with clasts displaying the colors of the underlying chert.

The Kekiktuk Conglomerate has remained attached to the underlying Romanzof chert and phyllite at the unconformity surface so that the two units have deformed as a single structural unit (Domain I) during Brookian deformation. Shortening was accommodated by the displacement of large horses in a duplex with a floor thrust at depth and a roof thrust in the Kayak shale. The unconformity and overlying Kekiktuk Conglomerate define the geometry of the upper surfaces of the horses.

DOMAIN II

Domain II is exposed in the hangingwall of the Aichilik Pass thrust and comprises a partially time equivalent but different stratigraphic succession than in Domain I. The succession consists of interbedded terrigenous clastic rocks. It includes the Ulungarat Formation (Middle Devonian and younger? (Anderson, 1991)) and the Kekiktuk Conglomerate (Mississippian). The lower member of the Ulungarat Formation contains shallow marine invertebrate fossils of Eifelian age (Blodgett, pers. comm., 1991). The age of the two overlying nonmarine members is bracketed between Middle Devonian and Mississippian. The top of the Ulungarat Formation is an erosional unconformity on which the Kekiktuk Conglomerate was deposited with low-angle discordance. This stratigraphic succession is as much as 550 meters thick.

Domain II includes a phosphatic, oncolitic black limestone rhythmically interbedded with black shale (bls). Its contact with other units of the domain is concordant to slightly discordant, but the stratigraphic position of this unit is unclear. The unit structurally(?) overlies both Kayak Shale and Kekiktuk Conglomerate. The base may be a fault or an unconformity. The black limestone is overlain by Kayak Shale and fault (?) emplaced Kekiktuk Conglomerate. The age of the unit is poorly constrained as Late Devonian or Early Mississippian based on plant fossils (S. Mamay, pers. comm., 1989).

The rocks of Domain II have shortened by northward displacement of south-dipping horses in a duplex with a floor thrust in the lower Ulungarat Formation and a roof thrust in the Kayak Shale. The lowest horse is composed of the thickest stratigraphic sequence, including the Ulungarat Formation, and is thrust northward directly onto strata of Domain I on the Aichilik Pass thrust. Farther south, another major thrust, the Kongakut River thrust (Wallace et al., 1989), also brings rocks of the Ulungarat Formation to the surface. The Kongakut River thrust has apparently cut across the roof thrust forming a footwall syncline in the Lisburne Group of Domain III. However, the thrust truncation of the Lisburne Group has been eroded in the study area and is inferred from the exposed structural geometry. Numerous smaller-displacement imbricate faults also are present in the domain. In a number of places in the domain, thrust faults appear to cut up-section laterally, in what are interpreted to be lateral ramps to a flat in the Kayak Shale. As stated above, there are insufficient field criteria to allow these Kayak-on-Kayak thrusts to be mapped.

DOMAIN III

Short-wavelength (100's meters) folds above a detachment horizon in the Kayak shale characterize Domain III, which consists of the Lisburne Group and the unconformably overlying Sadlerochit Group. The Lisburne Group is divided into three units which show abrupt lateral changes in thickness and organization. Each of the three (Clu, Clm, Cll) has deformed as a separate structural unit within Domain III. The lowest unit (Cll) is a cliff-forming bioclastic limestone that in places shows pervasive replacement by black chert. It is depositionally absent from the southern part of the map area. Cll has behaved as a structurally competent unit. It is present in the footwall syncline of the Kongakut River thrust, where shortening was accommodated before folding by displacement of horses in a duplex with a floor thrust in the Kayak shale and a roof thrust in Clm. In the northern part of the map area, Cll forms local spectacular fault-bend folds, fault-propagation folds, and detachment folds. The thick, relatively incompetent Clm forms a detachment horizon between Cll and Clu. Thinner competent beds within Clm form disharmonic detachment folds. Clu is a thick, competent unit that has generally shortened by folding above Clm. In the structurally highest eastern part of the map area, Clu and the Sadlerochit Group have shortened by thrust duplication.

In general, the structure of Domain III is characterized by detachment folds formed above the Kayak Shale. The shale generally appears to be structurally thickened in the cores of anticlines. Thrust faults commonly have formed by break-through of the detachment folds, forming overturned footwall synclines and hangingwall anticlines. Thrust-truncation of existing folds has led to the formation of relationships that commonly are considered anomalous in thrust-faulted terrains, such as younger-over-older thrust faults and apparent discrepancies in sense of offset. Complications to this overall pattern have resulted from differences in structural behavior, in the different structural stratigraphic units, during detachment folding and thrust propagation and displacement.

CONCLUSIONS

Detailed mapping and structural analysis suggest the following preliminary conclusions:

1. Within the Ordovician-Cambrian Romanzof chert and phyllites multiple generations of structures have been truncated by a regional pre-Middle Devonian to pre-Mississippian unconformity.

2. Where the Kekiktuk Conglomerate was deposited directly on the erosional surface of the Romanzof chert and phyllite (Domain I), the two deformed as a single structural unit during Brookian shortening.

3. In the south, a stratigraphic succession consisting of Middle Devonian to Mississippian clastic rocks (Domain II) forms south-dipping horses in a duplex thrust system with a floor thrust at the base of the Ulungarat Formation and a roof thrust in the Mississippian Kayak Shale.

4. Disharmonic folding in the Kayak Shale and short wave-length folds and thrust faults in the Lisburne Group (Domain III) accommodate shortening above the duplex.

5. The Lisburne Group and Sadlerochit Group of Domain III record a two-phase deformation sequence, probably progressive, in which detachment folds have been truncated by thrust faults.

6. The Middle Devonian through Triassic stratigraphic succession records only Brookian deformation.

Acknowledgments

This research was supported by research grants to the Tectonics and Sedimentation Research Group, University of Alaska Fairbanks. Sponsors include ARCO Alaska, ARCO Research, BP Exploration (Alaska), Chevron, Elf Aquitaine, Exxon, Japan National Oil Corp., Mobil, Murphy, Phillips, Shell, Texaco, and UNOCAL. Additional grants to the author from the American Association of Petroleum Geologists, Alaska Geological Society, Amoco Production Company, Geological Society of America (1988), Geological Society of America John Dillon Research Award (1989), Geist Fund of the University of Alaska Fairbanks Museum, and Sigma Xi are gratefully acknowledged. I thank Robert B. Blodgett (USGS) for identification of Devonian invertebrate fossils, Robert Spicer (University of Oxford) and Sergius Mamay (USGS) for identification of plant fossils, Gerhard Hahn for identification of Mississippian trilobites, Anita Harris (USGS) for identification of conodonts, and Professor J. Nageak (University of Alaska Fairbanks) for help with the Inupiaq Eskimo language. Special thanks to U.S. Fish and Wildlife Service for allowing the project to purchase helicopter time and to Joe Clor, Tom Osterkamp, and David Stirling for their cheerful assistance in the field. A sincere thanks to Wesley K. Wallace and Charles G. Mull for their guidance in this study.

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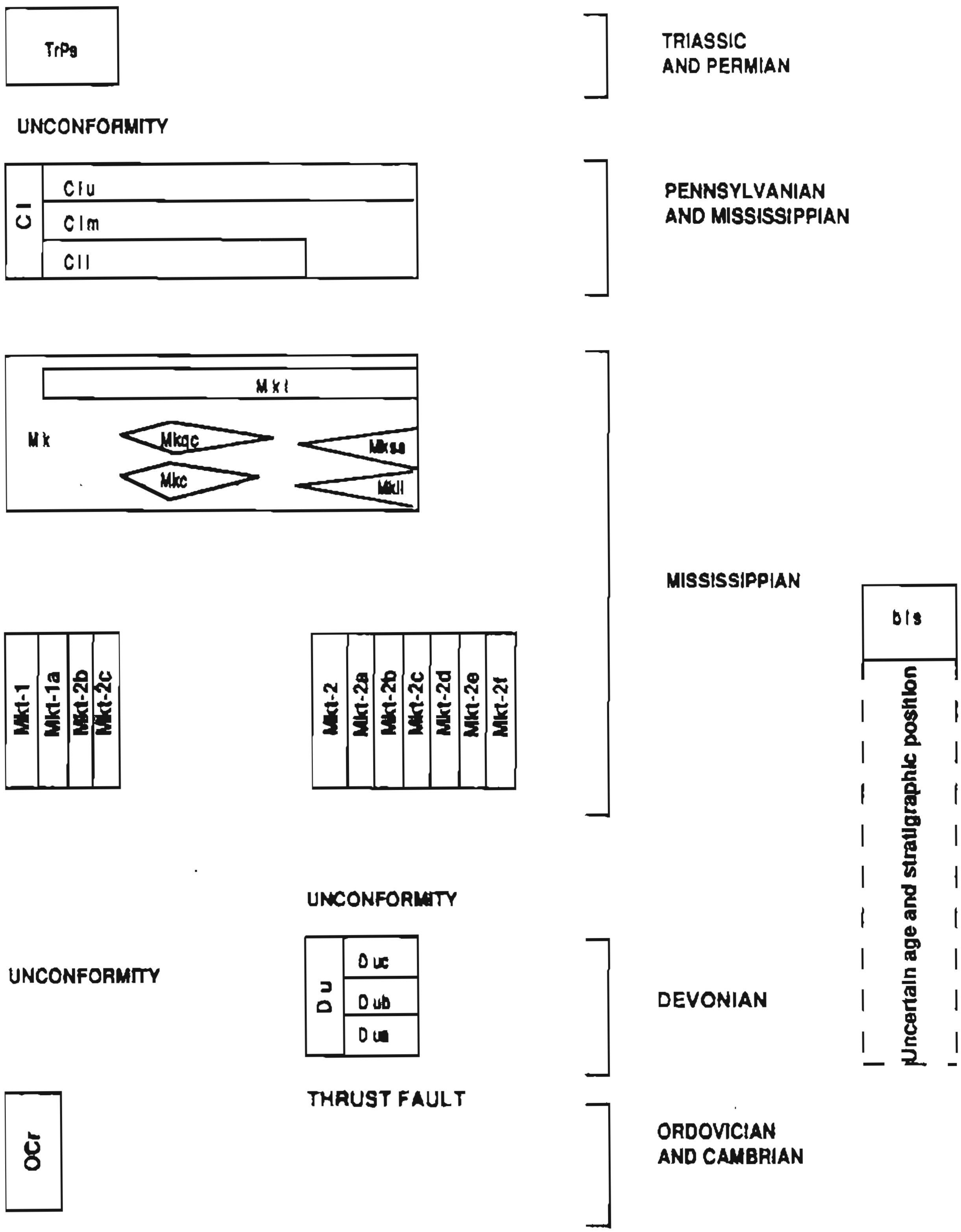
CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

TrPs Sadlerochit Group, undivided

Ivishak Formation - Thin regularly bedded, medium-grained sandstone with ripple cross-lamination. Weathers reddish-brown. Underlain by dark gray silty shale with minor thin limy beds. Early Triassic age. (Reiser & others, 1980). Echooka Formation - Medium-grained, thin- to medium-bedded fossiliferous sandstone. Permian age (Reiser & others, 1980).

Cl Lisburne Group

Bioclastic limestone and micrite divided into three units which show abrupt changes in thickness and organization. Forms short-wavelength (100's meters) folds above a detachment horizon in Mk. Forms cliffs. Late Mississippian to Early Pennsylvanian age (Reiser & others, 1980).

Clu Fine-grained limestone, weathers light gray to yellowish cream. Forms high cliffs.

Clm Bioclastic limestone. Weathers gray to very dark gray. Forms ledges and slopes. Has acted as a detachment horizon where Cll is present. Commonly structurally thickened.

Cll Bioclastic limestone, in places pervasively replaced by black chert. Weathers medium-gray to black. Forms steep cliffs. Depositionally absent from southern part of map area.

Mk Kayak Shale, undivided

Shale, steel gray to black; very finely fissile; in places phyllitic; in places siltstone with abundant plant fossils; carbonaceous; forms low passes and valleys beneath the Lisburne Group limestones; forms steep loose slopes where structurally overlain by Mkt and Du; structurally thickened; important detachment horizon. Mississippian age.

Mkl Thickening-upward intervals of thin-bedded bioclastic limestone in fissile, calcareous black mudstone and siltstone. Crinoid and brachiopod hash common; ironstone concretions with pyrite centers. Commonly forms disharmonic folds below Cl. Present throughout the map area. Generally mapped as part of Mk.

Mkqc Quartz pebble conglomerate, 1 cm diameter rounded pebbles, white to light-gray matrix. Plant fossils. Abrupt lower and upper contacts with black shale (Mk). Present only in the western part of the map area. Forms ledges, 2 to 5 m thick.

Mkss Medium- to coarse-grained quartz sandstone. Amalgamated beds; low-angle trough cross-beds; rare preservation of shale interbeds, some coal; base is abrupt and irregular on underlying black shale (Mk).

Overlain by black mudstone (Mk). Outcrops in the southeastern part of the map area. Less than 15 meters thick.

Mkc Dense, fine-grained, silicified crinoidal limestone; weathers dark black, limonitic, with interbedded dark gray shale; silicified fossils include large crinoid stems, corals, and trilobites. Abrupt, flat upper & lower contacts with black shale (Mk). Outcrops as 18 m thick laterally discontinuous unit and as loose debris on structurally thickened Mk in the southwestern part of the map area. Middle Mississippian(?) trilobites.

Mkll Limestone, alternating micrite and black shale with episodic storm beds of crinoid hash. Storm beds become dominant upwards. Ripple cross-laminations; large crinoid stems; some black chert nodules. Overlies 33 m of black shale and is overlain by more black shale (Mk). With underlaying black shale, depositionally overlies Mkt-2 in the southern part of the map area. Less than 50 meters thick.

Mkt <u>Kekiktuk Conglomerate, undivided</u>

Divided into two sequences, Mkt-1 and Mkt-2. To the north, Mkt-1 is thin with deposition controlled by local topography on the unconformity surface above unit OCr. Mkt-2 is thicker and exposed in the southern part of the map area. Mississippian age (Reiser & others, 1980).

Mkt-1

Quartz-chert breccia to pebble conglomerate deposited with angular unconformity on OCr. Abrupt lateral changes in thickness. Easily mistaken for massive chert of OCr, thus is difficult to distinguish.

Mkt-1a Quartz - chert pebble conglomerate and sandstone, locally calcareous, fines upward; plant fossils. Deposition controlled by topography on underlying angular unconformity that overlies Cambrian Ordovician chert and phyllite (OCr). Abruptly discontinuous laterally. Overlain by the Kayak Shale. Exposed as steep ledges at base of Mk talus slopes near headwaters of the Aichilik River. Less than 15 m thick.

Mkt-1b Fining-upward intervals of quartz to black chert pebble conglomerate. Quartz 60%, chert 40%. Distinctive 1 cm round quartz pebbles. Upper 5 m grades into light gray sandstone. Overlain by black siltstone (Mk) with abundant plant fossils. Approximately 20 m thick.

Mkt-1c Chert breccia of black, gray, white, and raspberry color. Angular to subangular basal clasts to 1 cm; in places coal fragments; poorly sorted with average clasts from 5 cm to medium-grained sandstone, largest clast to 60 cm; white to gray chert cement. Abrupt lateral changes in thickness; deposited with angular unconformity on OCr and OCt. Generally less than 30m thick. As mapped, includes overlying siltstone with abundant plant fossils (Mk)

Mkt-2

Quartz - chert pebble conglomerate, sandstone, and siltstone deposited with low-angle discordance on Du; in some places, lower contact is a thrust fault over Mk. Fining-upward intervals in an overall fining-upward succession that is overlain by Mk on an abruptly gradational contact. Generally 40 to 130 m thick.

Mkt-2a Fining-upward intervals of coarse-grained quartz arenite to fine-grained sandstone and siltstone. Quartz arenite commonly contains cubic voids from leached outpyrite. Some channel geometry, tabular cross-beds, ripple cross-lamination, plant fossils. Lower contact is thrust fault over Mk. More than 50 meters thick.

Mkt-2b Quartz-chert granule to pebble conglomerate, sandstone and siltstone in series of fining-upward intervals. Trough cross-stratified sandstone, ripple cross-laminated fine-grained sandstone; plant fossils, mud cracks. Deposited on thick Du; gradationally overlain by Mk. 125 m thick.

Mkt-2c Chert-quartz pebble to cobble conglomerate. Unit fines upward from massive conglomerate to interbedded medium-grained quartzite and shale. The quartz and chert conglomerate includes white, gray, lavender and less common black chert pebbles and cobbles up to 17 cm in size. The matrix is light gray to lavender-gray, becoming light gray to white quartzite near the top of the interval. Channelized; plant fossils, worm burrows, and long wave-length, low-amplitude ripples along upper contact. Deposited with low-angle discordance on erosional surface of Du. Abruptly gradational upper contact with Mk. Massive ledge former; 40 m thick.

Mkt-2d . Quartz-chert pebble to cobble conglomerate; black, gray, and lavender colored chert. 15 m thick massive channels are overlain by fining-upward intervals of quartz-chert pebbles to medium-grained sandstone. 10 to 20% pebbles to 1 cm. Weathers light-gray. Lower contact is a fault truncating unit bls. Massive basal channels outcrop as steep resistant ledge whereas overlying finer-grained deposits generally form talus on the dip slope. Greater than 20 meters thick.

Mkt-2e Quartz-chert pebble conglomerate; 60-70 % subangular-subrounded quartz pebbles. Black, gray, and white colored chert pebbles, poorly sorted. Interval fines upward to medium-grained sandstone with thin basal pebble beds. Plant fossils. Up to 20 meters thick. Forms laterally discontinuous cliff.

Mkt-2f Quartz-chert pebble to cobble conglomerate and sandstone. Distinctive well-rounded quartz cobbles to 15 cm. Chert is black, gray, and lavender color; channels, trough cross-beds. Lower contact is a thrust fault, upper contact is abruptly gradational with Mk. Forms cliff in southwestern part of the map area. Approximately 100 m thick.

Bls Black limestone

Phosphatic, oncolitic black limestone rhymatically interbedded with black shale. Base and top interbedded with black shale containing plant fossils. Episodic chert-quartz clastic beds are cross-bedded and ripple cross-laminated. Relationship to Mkt and Mk is uncertain. The unit overlies both Mk and Mkt. Base may be a thrust fault or an unconformity. Age is poorly constrained as Late Devonian or Early Mississippian. May be as much as 100 m thick.

Du Ulungarat Formation (new name)

Overall thickening- and coarsening-upward sequence from marine mudstone, limestone, and sandstone to nommarine meandering and braided fluvial deposits. Lower contact is a thrust fault, depositional basement unknown. The formation is unconformably overlain by the Mississippian Kekikktuk Conglomerate at a low-angle unconformity. The formation consists of three informal members. The lowermost member (Unit A) is Middle Devonian (Eifelian). The upper two members are bracketed between the Eifelian age of Unit A and the Mississippian age of the unconformably overlying Mkt. The upper two members are laterally discontinuous due to erosion prior to deposition of Mkt.

Duc Unit C

Chert granule to pebble conglomerate and sandstone. Thick succession of large-scale conglomeratic channel-fills that coarsen and thicken upsection. Original depositional relationship with Dub is unclear. Forms steep cliff. As much as 110 meters thick.

Dub Unit B

Chert pebble conglomerate, sandstone, and siltstone in multiple, upward-fining sandstone channel-fills with intervening siltstone beds. Plant fossils, mudcracks, root casts. The top of the assemblage is an interval of intensely bioturbated red and gray-green siltstone. Forms steep ledges. As much as 100 meters thick.

Dua Unit A

Upward-thickening and -coarsening succession of shale, siltstone, and sandstone that contains a shallow-marine invertebrate fauna of Middle Devonian (Eifelian) age. Assemblage is dominated by thin, amalgamated sandstone beds. Commonly bioturbated; thin, fossiliferous calcareous beds occur near the base. Forms ragged weathering steep slopes. 160 meters thick.

OCr Romanzof chert and phyllite (informal name)

Structurally complex mixture of lenticular chert bodies (OCrc) in matrix of phyllite (OCrp). Original depositional relationship between chert and phyllite is unclear. Base of unit not exposed in map area: Chert and phyllite structurally duplicated by folds and imbricate thrust faults. Thickness unknown, but very thick. Forms high mountains in northwest part of map area. Assigned an Ordovician - Cambrian age

OCrc (chert unit)

Chert, massive- to medium-bedded; black, mottled gray, white, and less common raspberry color; includes black ribbon chert showing pinch and swell; tight to isoclinal folds and refolded folds. Chert crops out as thick resistant lenticular intervals (up to100's of meters thick) in a matrix of dark gray phyllite (OCrp) Because of resistance to erosion, it defines long linear outcrops.

OCrp (phyllite unit)

Dark gray phyllite showing strong cleavage; forms matrix around rocks of chert unit (OCrc); base of unit not seen; original depositional relationship between chert and phyllite unclear. Ordovician - Cambrian age (Reiser and others, 1980; Moore and Churkin, 1984).