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Structural Evolution of the Eastern Sadlerochit Mountains, Northeastern Brooks Range, Alaska: A Preliminary Report Based on the Summer 1986 Field Season

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This is a preliminary report of findings during the 1986 field season in part of the Mt. Michelson C-2 quadrangle, Arctic National Wildlife Refuge (ANWR), eastern Sadlerochit Mountains, northeastern Brooks Range, Alaska. The data will be the basis for a Master of Science thesis at the University of Alaska. The objective of this study is to contrast changes in the structural style of bedrock deformation across the Sadlerochit Mountains from the coastal plain on the north to Ignek Valley on the south.

Field work addressed three principal questions regarding the structural evolution of the eastern Sadlerochit Mountains:

1) What were the pre-deformational stratigraphic relationships and what are their implications for paleogeography?
2) What is the sequence of deformation and geometry of structures in the field area?
3) What are the implications of the structural style and stratigraphic relationships for the subsurface of the ANWR coastal plain?

A total of six weeks were spent in the area of the eastern and western forks of Marsh Creek. This report presents interpretations which the author currently favors. A variety of other models can be invoked to explain the same field relationships.

The study area is divided into three geographic provinces which coincide with the major structural and stratigraphic provinces (plate 1). The Coastal Plain Province is the portion of the field area from the break in slope at the mountain front north to the northern boundary of the study area. The Marsh Creek Province is bounded on the north by the mountain front and extends south to the headwaters of all the drainages of the east and west forks of Marsh Creek. The Sadlerochit Mountains Province begins in the middle of the Sadlerochit Mountains at the major east-west trending valley north of Mt. Weller and extends across the south flank of the mountains to Ignek Valley.

STRATIGRAPHY OF THE PROVINCES

In order to understand the structural complexities of the area it is necessary to understand the stratigraphic variations between provinces. These variations must be adressed in order to determine original stratigraphic relationships and their implications for paleogeography. To the west at Prudhoe Bay progressively older units underlie a major Lower Cretaceous unconformity (LCu). An unconformity beneath Mississippian rocks (pMu) has a similar geometry, but the amount of section truncated at the unconformity is not as well constrained. Recognizing and establishing the magnitude of truncation by these unconformities, especially the LCu, is central to spatial reconstruction of pre-deformational stratigraphic relationships.

The Sadlerochit Mountains Province contains the most complete stratigraphic sequence and includes all the rock units within the map area. Exposures in the Coastal Plain Province are restricted to Jurassic and younger rocks. Included, in ascending order are: the Kingak Shale, the Kemik Sandstone, the pebble shale unit, and the Colville Group. The same sequence occurs to the south in Ignek Valley. The Marsh Creek Province stratigraphic sequence differs significantly from those of the provinces to either side. Here, the Neruokpuk Formation occurs below the pMu, overlain by the Lisburne Group. The Sadlerochit Group lies below the LCu, overlain by the Kemik Sandstone, and pebble shale unit. The Shublik Formation and Kingak Shale have been eroded below the LCu. The Katakturuk Dolomite is missing beneath the pMu.

The Kingak Shale occurs below the LCu in both the Sadlerochit Mountains Province and the Coastal Plain Province. In the Marsh Creek Province, however, the Ivishak Formation of the Sadlerochit Group occurs below the LCu. If the LCu cuts downsection to the north as the regional pattern to the west suggests, the stratigraphy exposed at the surface within the Coastal Plain Province is allochthonous with respect to the Marsh Creek Province, having been displaced from south of the Marsh Creek Province. Other interpretations are possible for the stratigraphic variations observed between the provinces, this hypothesis seems to fit the field observations best. The Lisburne Group sits unconformably on the Neruokpuk Formation in the Marsh Creek Province. At least two major unconformities apparently cutting down section to the north suggests a major structural high has existed to the north of the present Sadlerochit Mountains since before Misssissippian time.

STRUCTURAL STYLE OF THE PROVINCES

Jurassic and younger rocks are exposed at the surface in the Coastal Plain Province. Deformation is characterized by a series of imbricated north-vergent thrust faults accompanied by short wavelength folds. The Kemik Sandstone, pebble shale unit, and Kingak Shale occur exclusively within fault slivers. Rocks of the Colville Group do not occur in any of the slivers. If the thrust system is an imbricate fan, all stratigraphic units above the lower thrust would be expected to occur in the slivers. Alternatively, if the structure is a duplex then thrusting would preferentially involve only that portion of the stratigraphic section between the floor and roof thrusts. A floor thrust is interpreted to occur in the Kingak Shale, and a roof thrust is postulated at the base of the Colville Group based on the absence of the Colville Group in the horses. These relationships suggest that the thrust system at the surface in the province may be a duplex structure.

If the LCu cuts downsection to the north within the study area as it does to the west, the greatest amount of truncation would be expected in the northern-most exposures of the LCu. Yet in the Coastal Plain Province, the Kingak Shale underlies the LCu

and hence is apparently out of place with respect to the sequence observed in the Marsh Creek Province. Either the LCu does not simply cut downsection to the north or the the thin sheet of rocks exposed at the surface is a klippe. Because the geometry of the LCu is well-established to the west, the klippe hypothesis is tentatively favored. If there is a klippe within the province, the northern boundary would be where the floor thrust intersects the surface to the north. This probably occurs within the highly deformed shales of the Colville Group and therefore is difficult to recognize as a distinct structure.

The Marsh Creek Province defines a northern topographic salient with respect to the main Sadlerochit Mountains. The structural style is characterized by medium wavelength chevron folds above a major detachment. The detachment ramps northward, from within the pre-Mississippian, to the surface near the northern boundary of the province. The mountain front on the northern side of the province is probably a large fault-bend fold. The southern portion of the province is characterized by spectacular step-like kink folds which are continuous along strike for approximately 10 kilometers. Major structures near the mountain front change significantly along strike as illustrated by the cross sections which accompany the map (plate 1). The thrust sheet which is exposed over most of the province appears to be divided into two parts by a lateral ramp located between the eastern and western drainages of Marsh Creek. In the eastern Marsh Creek area the thrust sheet appears to be underlain by a large duplex. In western Marsh Creek the duplex is not visible. The structure at the mountain front is characterized by a major backthrust which may have formed as a result of displacement along the floor thrust of the duplex to the east. The duplex in the eastern drainage is interpreted as a result of an extra step in the fault surface. The cross-sections imply lateral continuity of the duplex, an interpretation which is no longer favored.

The Sadlerochit Mountains Province is structurally less complex and is essentially one large fold/fault block. It is characterized by a long wavelength asymmetric anticline bounded on the north by a major fault. The fault is postulated as a late stage structure which has segmented a once larger fold/fault block which included the rocks of the Marsh Creek Province. Both folding and faulting are continuous along strike and reflect the character of the major underlying structures which form the Sadlerochit Mountains.

TIMING OF FORMATION OF THE PROVINCES

The structural style and timing of deformation is distinct within each province. The proposed development is a forward deformation sequence starting at the highest stratigraphic levels and involving progressively deeper levels. Deformation began with the formation of the duplex which now sits as a klippe on top of the Coastal Plain Province. There is an overall northeast-southwest trend to the structures. This trend is

truncated by the range front fault bounding the north side of the Marsh Creek Province.

Structures of the Marsh Creek Province were the second to develop. This province is characterized by a weaker northeast-southwest trend which is truncated by the east-west trending fault which defines the northern boundary of the Sadlerochit Mountain Province. Deformation involves detachment from a deeper stratigraphic level within the pre-Mississippian sequence. The entire exposed stratigraphic sequence is involved, in contrast to the klippe where deformation is restricted to Jurassic and younger rocks.

The fault marking the northern boundary of the Sadlerochit Mountains Province is interpreted to be the most recent structure to form but does not have significant throw. The major fold and fault which define the mountain range have a strong east-west regional strike. These structures truncate those of the Marsh Creek Province. If the premise of truncations of pre-existing structural trends is accepted as valid evidence for the sequence of deformation, then the structures of the Sadlerochit Mountains Province would have been brought to the surface as a result of out-of-sequence displacement on this minor splay. The fold/fault block at the surface would then represent a segmented portion of a once larger, continuous fold/fault block.

Fold and thrust belts, in general, evolve by development from the hinterland towards the foreland. As a consequence, thrusts at any given location can be expected to decrease in age with depth. In the Sadlerochit Mountains, the hinterland is to the south and the foreland is towards the north. Prior to its emplacement, the klippe most likely was south of its current position relative to the Marsh Creek Province at the time of deformation. Faulting within the Marsh Creek Province is from deeper stratigraphic levels and is interpreted to be younger than the faulting and folding within the klippe. Hence the sequence of development of formation of the duplex, which later is isolated as a klippe as a result of formation of the Marsh Creek Province, is consistent with the general statement about the spatial and temporal evolution of fold and thrust belts. If the chronology is accepted, the northern fault of the Sadlerochit Mountains Province has developed out of sequence with respect to the structures of the other two provinces in terms of the generalized sequence of development observed in other fold and thrust belts.

IMPLICATIONS FOR THE SUBSURFACE

The study area includes the northernmost exposures of pre-Upper Cretaceous bedrock in the northeastern Brooks Range. It is reasonable to assume the relationships observed at the surface will have implications for those in the subsurface of the coastal plain. The Coastal Plain Province klippe may persist into the subsurface to the north, but is allochthonous with respect to the underlying rocks. The LCu is expected to cut downsection to the

north. The Kemik Sandstone should lie on progressively older rocks farther to the north, ultimately lying on the Neruokpuk Formation. The pre-Mississippian unconformity would not be expected to be a major slip surface beneath the coastal plain because it is not observed as a slip surface anywhere within the field area. Structural styles of any deformation above the LCu would be short wavelength folding and imbricate thrust faulting. Below the LCu, faulting would originate from the basement creating large fault blocks of pre-Mississippian rocks, (as in the Sadlerochit Mountains Province).

Key To Stratigraphic Symbols

Sadlerochit Mountains Province		Marsh Creek Province
Ks	Colville Group	Ks
Kps	pebble shale unit	Kps
Kk	Kemik Sandstone	Kk
	Lower Cretaceous unconformity (LCu)	
Jk	Kingak Shale	
TrS	Shublik Formation	
	Sadlerochit Group	
Tri	Ivishak Formation	Tri
Trk	Kavik Shale	Trk
Pe	Echooka Formation	Pe
	Lisburne Group	
Pw	Wahoo Formation	Pw
Mau	upper Alapah Formation	Mau
Mal	lower Alapah Formation	Mal
	pre-Mississippian unconformity (pMu)	
pCk	Katakturuk Formation	
pCn	Neruokpuk Formation	pCn

GEOLOGIC MAP SYMBOLS

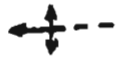
Strike and dip of beds

Strike and dip of beds where stratigraphic top is known

Strike and dip of overturned beds

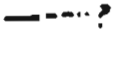
Apparent strike and dip of beds

Horizontal beds

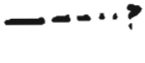


Strike of the axial trace and plunge of the axis of a large anticline; dashed where approximately located

Strike of the axial trace and plunge of the axis of a large syncline; dashed where approximately located



Contact, solid where known, dashed where approximately located, dotted where inferred, queried where questionable



Fault, solid where known, dashed where approximately located, dotted where inferred, queried where questionable

Thrust fault, solid where known, dashed where approximately located, dotted where inferred, queried where questionable

Form lines; trace of bedding

Brecciated zones

steepening of dip across an axis: monoclinal form