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RELATIONSHIP BETWEEN STRATIGRAPHY AND STRUCTURAL GEOMETRY
SOUTHWEST OF BATHTUB RIDGE, NORTHEASTERN BROOKS RANGE, PRELIMINARY RESULTS

By

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INTRODUCTION

In the northeastern Brooks Range southwest of Bathtub Ridge, a major anticlinorium exposes regional angular unconformities of Mississippian and Devonian age. Ordovician-Cambrian chert and phyllite core the anticlinorium. In the north, a Mississippian chert breccia positionally overlies the Ordovician-Cambrian chert and phyllite. In the south, a Middle Devonian clastic sequence has been thrust northward over the chert and phyllite and the Mississippian breccia. The regional anticlinorium and duplexing within structurally higher rocks are the result of Cenozoic-Cretaceous deformation which formed the northeastern Brooks Range. The study area is located on the southeastern flank of this anticlinorium in the Demarcation Point (A-4) and Table Mountain (D-4) quadrangles. Detailed mapping at the scale of 1:25,000, analysis of minor small-scale structures, and measurement of stratigraphic sections was carried out to 1) characterize the structural geometry and 2) determine lateral stratigraphic variations within the field area.

PRELIMINARY FINDINGS

Stratigraphic sequence

The regional anticlinorium is cored by chert and phyllite of inferred Cambrian-Ordovician age (OCcp of Reiser and others, 1980). This age is based on graptolites

from presumably equivalent rocks to the southwest in the Arctic quadrangle (Moore & Churkin, 1984). This unit is the structurally lowest unit in the field area, but forms topographic highs due to its resistance to erosion (figure 1). Massive and bedded cherts occur as lenses in an argillite matrix. Bedding and cleavage dip steeply to the north. The cherts display at least two generations of tight to isoclinal folds with variably east-plunging refolded axes. The folds and associated thrust faults show rotation to north dips prior to development of the pre-Mississippian regional unconformity. The age of these structures is uncertain, but must pre-date deposition of the overlying raspberry breccia (informal name based on color).

A major regional unconformity of pre-Mississippian age truncates the underlying chert and phyllite. The raspberry breccia rests positionally on the unconformity surface and dips gently to the south. The breccia includes gray, white, black, and purple-raspberry colored chert clasts cemented with chert, becomes conglomeratic within one meter of the base, and is positionally overlain by siltstone that commonly contains silicified burrows (measured section, location 88A-58). Plant fossils suggest a Mississippian age. Abrupt lateral changes in thickness are associated with syndepositional high-angle (normal?) faulting of the unconformity surface. During Cenozoic to Cretaceous

deformation, the raspberry breccia and the unconformity surface deformed with the underlying chert and phyllite unit to form a major east-plunging anticlinorium.

The raspberry breccia is structurally overlain on a shale detachment horizon by a fossiliferous, coarsening-up, sequence of Middle Devonian litharenite and chert-pebble conglomerate. Fossils are abundant, but of limited diversity. The fossil assemblage includes trilobites of Givetian age and indicates a shallow marine-inner tidal environment of deposition (Blodgett, oral comm., 1988). Beds in the Middle Devonian sequence dip gently to moderately south, and are concordant with the overlying structural sequence. Abrupt lateral change in thickness of the unit is seen between the measured section at 88A-1 (93 m) and at 88A-54 (370 m). The nature of this lateral change is unclear, but may be due to both lateral variation in depositional thickness and folding. The depositional base of the Middle Devonian sequence is not seen, as the lower contact is everywhere a thrust fault. The nested channels at the top of section 88A-54 and the channels-3 unit overlying 88A-1 bear an uncertain depositional relationship to each other and to the underlying rocks. They may be part of the Middle Devonian clastic sequence or a separate overlying unit of uncertain age.

The structural sequence of units overlying this clastic interval includes: 1. discontinuous black limestone, 2. black shale with laterally discontinuous channels, 3. black shale and siltstone, 4. laterally continuous litharenite and quartz-chert pebble conglomerate, 5. black shale (Kayak Shale?), and 6. Lisburne Limestone (figure 1). Contacts in the interval between the fossiliferous Devonian rocks and the Lisburne Limestone are concordant with bedding, but the ages of the component elements are unknown and structural duplication is possible. This sequence occupies the stratigraphic position of the Endicott Group, but correlation of its elements with those of the Endicott Group is not yet possible.

The black limestone (bls) includes siliceous sands and is interbedded with black siltstone containing plant fossils. The unit is a massive to cross-bedded ledge and cliff former that appears to grade upward into the overlying unit of black shale with laterally discontinuous litharenite and chert-pebble conglomerate channels (sc). The laterally continuous litharenite and quartz-chert pebble conglomerate of the channels-1 unit (ch-1) are thrust over the black siltstone and shale unit (sh-1) in a possible older over younger relationship. Map units ch-1 and ch-2 are lithologically similar and may reflect structural duplication of the same unit. The black shale of map unit sh-2 (Kayak shale?) shows disharmonic folds and is a detachment horizon for the overlying Lisburne Limestone.- 4 -

Structural geometry

The major structures of the field area are north-vergent folds and thrusts formed during Cenozoic-Cretaceous deformation. Regional shortening is accommodated by a large duplex with a roof thrust in the upper shale (sh-2) and a floor thrust at depth in the pre-Devonian rocks (figure 2 and cross-section A-A'). Northward displacement of a horse in this duplex has emplaced rocks in the hangingwall northward over a partially time-equivalent, but stratigraphically different, sequence in the footwall. The footwall includes the chert and phyllite unit (OCcp) and the raspberry breccia (rb, Mississippian?) whereas the hangingwall includes northward-displaced Middle Devonian (Ds) and possible Endicott-equivalent rocks. The roof sequence directly overlies the footwall north of the hangingwall cut-off. Shortening is accommodated above the upper shale by the development of short wave-length (100's of meters) detachment folds in the Lisburne Limestone.

CONCLUSIONS

Detailed mapping and structural analysis suggests the following preliminary conclusions:

1. Within OCcp multiple generations of structures have been truncated by a regional pre-Mississippian unconformity.

2. The raspberry breccia and OCcp deformed together as a single structural unit during Cenozoic-Cretaceous deformation.

3. The Devonian clastic sequence and the "Endicott-equivalent" rocks form a major south-dipping horse in a duplex thrust system with a) decoupling at depth in OCcp b) a roof-thrust in the Mississippian Kayak Shale, and c) disharmonic folding in the Kayak Shale and short wavelength detachment folds in the Lisburne Limestone to compensate for shortening within the duplex.

4. Northward displacement of the horse has brought a partially time-equivalent, but stratigraphically different, sequence over the footwall.

Acknowledgments

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- Moore, T.E., and Churkin, M., Jr., 1984, Ordovician and Silurian Graptolite discoveries from the Neruokpuk Formation (Sensu Lato), northeastern and central Brooks Range, Alaska in Blodgett, R.B., ed., Paleozoic Geology of Alaska and northwestern Canada newsletter: Alaska Geological Society, no.1, p.21-23.
- Reiser, H.N., Brosge, W.P., Dutro, J.T., Jr., and Detterman, R.L., 1980, Geologic map of the Demarcation Point quadrangle, Alaska: USGS Map I-1133, scale 1:250,000.

SCHEMATIC STRUCTURAL SEQUENCE OF LITHOLOGIC UNITS SOUTHWEST OF BATHTUB RIDGE

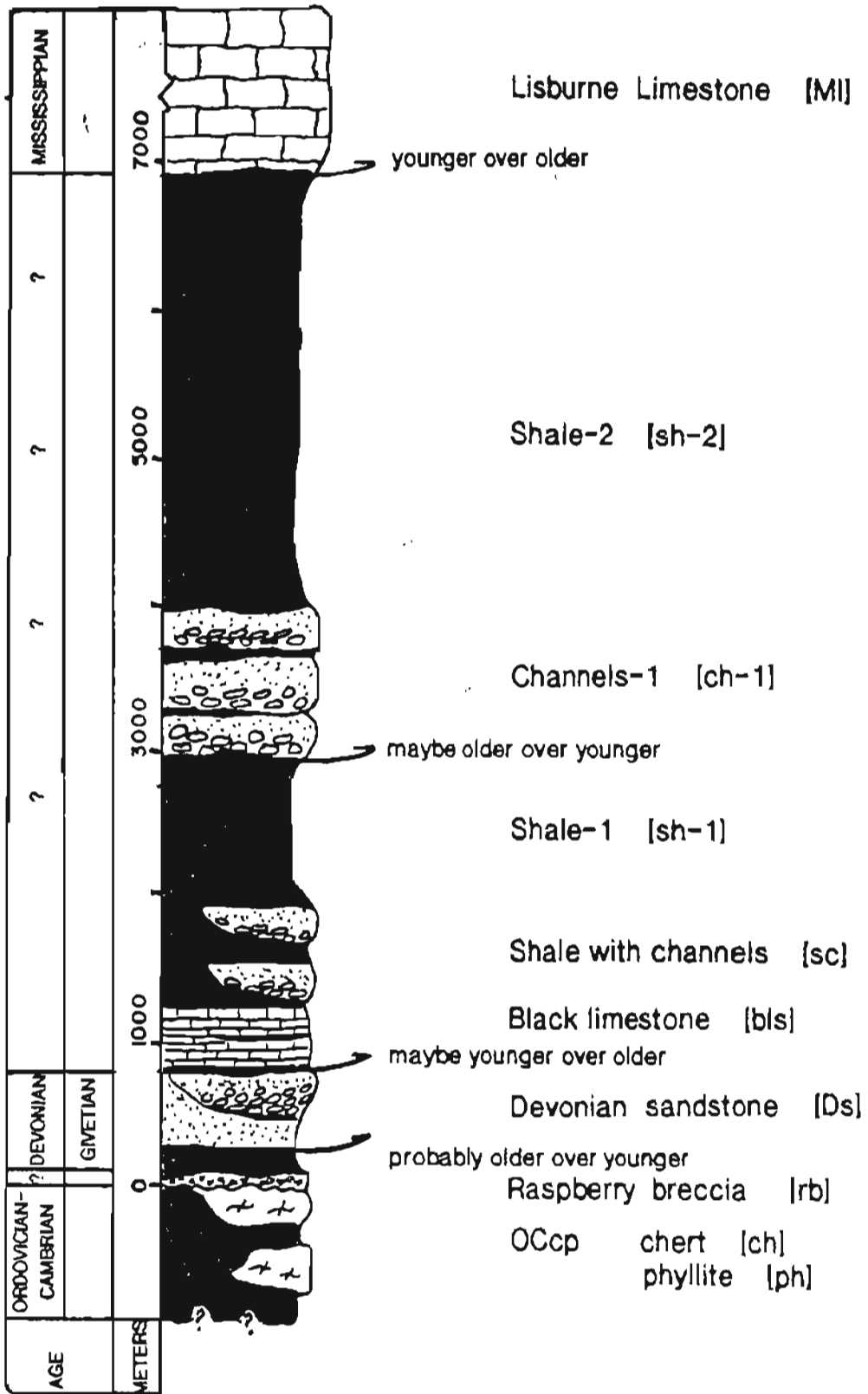


Figure 1. Schematic structural sequence of lithologic units southwest of Bathtub Ridge along line of cross-section A - A'. Contacts in the interval between the Devonian rocks and the Lisburne Limestone are concordant with bedding, but the ages of the component elements are unknown and structural duplication is possible. This sequence occupies the stratigraphic position of the Endicott Group, but correlation of its elements with those of the Endicott Group is not yet possible. See description of map units.

SCHEMATIC CROSS SECTION
SOUTHWEST OF BATHUB RIDGE

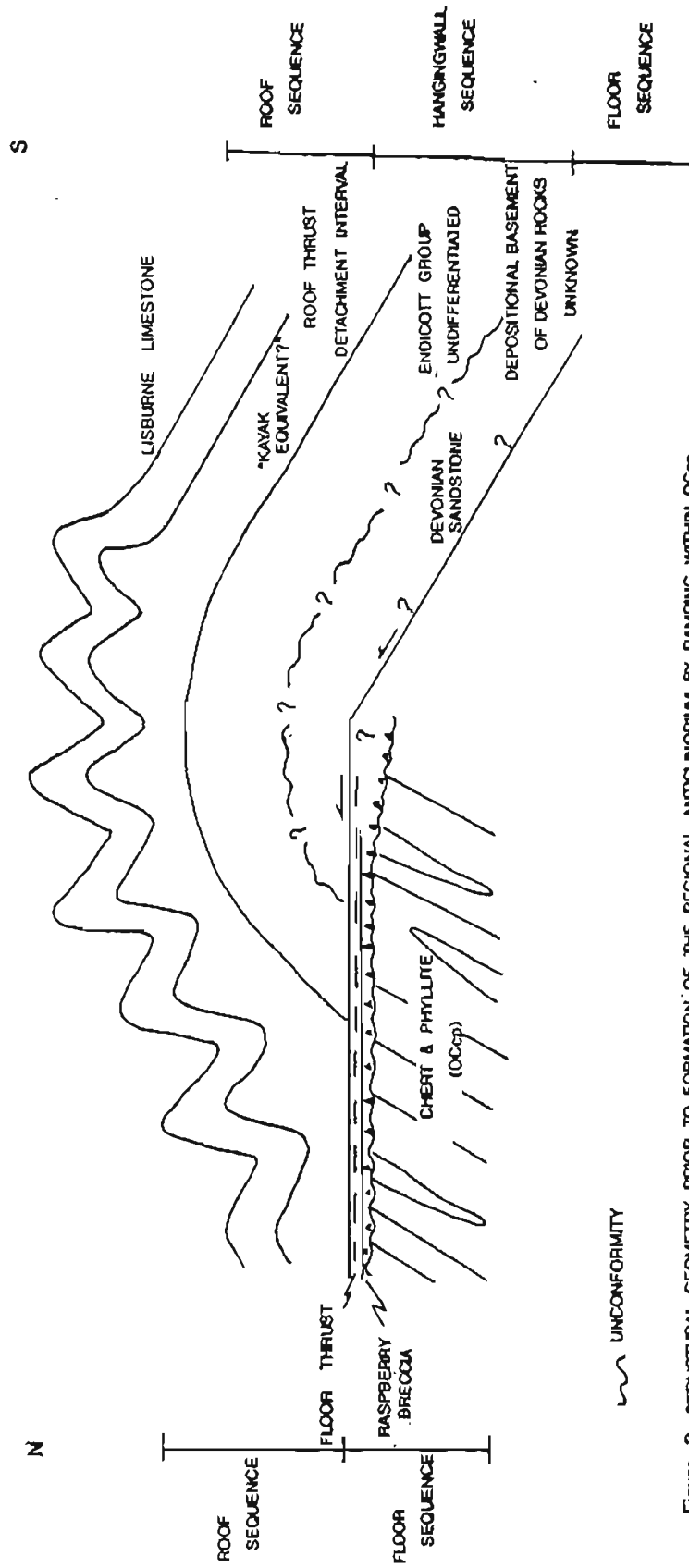


Figure 2. STRUCTURAL GEOMETRY PRIOR TO FORMATION OF THE REGIONAL ANTICLINORIUM BY RAMPING WITHIN OCCP.

ANDERSON, 1989

STRATIGRAPHIC COLUMN SYMBOLS



Limestone



Shale, mudstone, phyllite



Siltstone



Sandstone



Conglomerate



Breccia



Tectonite



Channels



Ripples



Cross bedding



Fossils




Thrust fault



Unconformity

DEVONIAN SANDSTONE

AGE	METERS	GRAPHIC COLUMN	DESCRIPTION
		Location 88A-1 Sec. 16, T.5 S., T.37 E., Demarcation Point quadrangle, Alaska	
		1 of 1	
G I V E T I A N	90		<p>Litharenite, weathers maroon; very fine-grained; thin bedded; fossils: ledge former</p> <p>Interbedded siltstone and thin-beds of fossiliferous limestone; weathers dark gray, maroon, orange-yellow; small scale cross-beds; cleavage generally disrupts original sedimentary structures; 0.5 m high ledge weathering from slope</p> <p>Litharenite, weathers gray to rusty-red and maroon; interbedded medium-to fine-grained, unit fines upward; fine rubble on dip slope of more resistant lower channels</p> <p>Litharenite, medium-grained with black lithics; medium- to massive-bedded; top 3 m has beds 2-4 cm thick; low angle cross-beds, ripples; fossils; channels; low cliff former</p> <p>Litharenite, weathers rusty-orange; lower 60 cm; beds 3-4 cm thick; middle: massive beds; top: beds 1-4 cm thick; resistant ledges in steep slope</p> <p>Litharenite with chert grit, weathers light gray to rusty-orange; medium- to coarse-grained; poorly sorted; small scale cross-beds, ripples, channels; beds 2-4 cm thick; cubic holes after pyrite; hematite spots common; cliff former, overlain by shale, weathers black-gray</p> <p>Litharenite, medium gray; weathers rusty-orange to maroon, very fine- to fine-grained; cross-bedded, thin-bedded; in places bioturbated; sharp, irregular contact at base; channel(?) geometry</p> <p>Shale, medium gray, weathers from covered interval</p> <p>Litharenite, gray, weathers rusty orange and maroon, 0.5 to 2 cm thick beds, cross-bedding, ripples; "floating" brachiopods; 2 cm thick fossiliferous bed at top; 60 cm thick ledge former in steep slope</p> <p>Shale, weathers steel gray; fissile; infrequent siltstone beds, 0.5 cm thick outcrop in steep slope</p> <p>Siltstone, calcareous; weathers rusty-orange; medium bedded; 80 cm thick ledge in steep slope</p> <p>Shale, calcareous, dark gray, weathers gray and orange-brown; resistant; laterally discontinuous beds 3 - 22 cm thick; fine laminated; irregular base as if deposited on soft substrate</p> <p>Mudstone, weathers to green-gray clay; forms steep slope</p> <p>Soil cover with shale chips; brown, weathers red-brown to gray; soil development greater than 20 cm; abundant Lingulid brachiopod fossils; saddle marking contact with OMcC</p> <p>Base of section covered. Base of measured section placed at north edge of saddle at beginning of red-brown weathering zone.</p>
	70		
	50		
	30		
	10		
	0		

RASPBERRY BRECCIA & DEVONIAN SANDSTONE

Location 88A-58
 Sec. 7, T.5 S., R.38 E., Demarcation Point quadrangle, Alaska

UNIT	AGE	METERS	GRAPHIC COLUMN	DESCRIPTION
DEVONIAN SANDSTONE	GIVETIAN	80 60 40		<p>Mudstone with rare fine-grained, calcareous, fossiliferous beds (6-10 cm thick); in upper part: interbedded fine-grained litharenite. Mudstone weathers to green-gray clay; contains Lingulid fossils; Sandstone weathers dark gray and rusty-orange; forms steep slope.</p>
TECTONITE	?	20		<p>Raspberry breccia -- black, gray, and raspberry colored chert clasts; in places coal fragments; in places breccia and mudstone finely interbedded with plant fossils on both surfaces; deposited with angular unconformity on OCcp; abrupt lateral changes in thickness. The raspberry breccia fines upward to a 0.5 m thick bed of dark gray fine-grained sandstone to siltstone; local silicified burrows; overlain by dark gray siltstone with plant fossils and detrital white mica; a zone of quartz-rich tectonite is overlain by a dark gray to black shale with tan-colored ironstone concretionary beds and slaty cleavage; north vergent folds; a detachment surface for the overlying Ds.</p>
RASPBERRY BRECCIA	?	0		

DEVONIAN SANDSTONE

UNIT	AGE	METERS	GRAPHIC COLUMN	DESCRIPTION
Location 88A-58 Sec. 7, T.5 S., R.38 E., Demarcation Point quadrangle, Alaska				2. of 5
DEVONIAN SANDSTONE	GIVETIAN	160		Cyclic sequence of coarse grained litharenite overlain by fine-grained sandstone to siltstone; weathers maroon; massive to small scale cross-beds, in places calcareous, fossiliferous; overlain by normal bedded siltstone; coarse-grained sandstone has hematite spots; medium bedded; cliff former.
		140		Base is a coarse- to medium-grained litharenite; ripples with black mud drapes, small channels to 5 cm deep. Interbedded litharenite, coarse- to fine-grained, and siltstone; infrequent black chert pebbles to 3 cm; weathers maroon and rusty-orange; fossiliferous beds; cross-bedding, channels, thick bedded; massive ledge to cliff former. Minor structural disruption, but no indication of duplication of section.
		120		Litharenite, medium-grained, interbedded with thin bedded, fine-grained sandstone to siltstone; weathers gray; beds 2-10 cm thick; small scale cross-beds, symmetrical ripples, fossils (brachiopods?); near top: sandstone channel, medium- to coarse-grained litharenite with black chert grit; cross-beds; molds of fossil with large ribs; 1 m thick bed; forms steep slopes.
		100		

DEVONIAN SANDSTONE

Location 88A-58
 Sec. 7, T.5 S., R.38 E., Demarcation Point quadrangle, Alaska

3 of 5

UNIT	AGE	METERS	GRAPHIC COLUMN	DESCRIPTION
DEVONIAN SANDSTONE	GIVETIAN	<div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 10px;">280</div> <div style="margin-bottom: 10px;">240</div> <div style="margin-bottom: 10px;">220</div> <div style="margin-bottom: 10px;">200</div> <div style="margin-bottom: 10px;">180</div> </div>		<p>Sequence of fining-up channels in an overall coarsening-up sequence. Weathers gray to rusty-orange; base of channels marked by poorly sorted chert pebbles, subangular black chert, subrounded white and gray chert; matrix is coarse-to medium-grained litharenite; channels fine upwards to litharenite, coarse- to fine-grained, cross-bedding; sandstone beds 10 - 50 cms thick; thick bedded; cliff former.</p>

DEVONIAN SANDSTONE

Location 88A-58
 Sec. 7, T.5 S., R.38 E., Demarcation Point quadrangle, Alaska

4 of 5

UNIT	AGE	METERS	GRAPHIC COLUMN	DESCRIPTION
DEVONIAN SANDSTONE ?	GIVETIAN ?	<div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 10px;">340</div> <div style="margin-bottom: 10px;">320</div> <div style="margin-bottom: 10px;">300</div> <div style="margin-bottom: 10px;">280</div> </div>		<p>Chert pebble conglomerate with coarse-grained sandstone matrix; weathers gray and dark rusty-orange; subangular black chert clasts, subrounded gray and white chert clasts, rare raspberry colored chert clasts at 210 m level, clasts to 8 cm., poorly sorted; nested channels are laterally discontinuous; cliff former.</p>

DEVONIAN SANDSTONE

Location 88A-58
 Sec. 7, T.5 S., R.38 E., Demarcation Point quadrangle, Alaska

5 of 5

UNIT

AGE

METERS

GRAPHIC COLUMN

DESCRIPTION

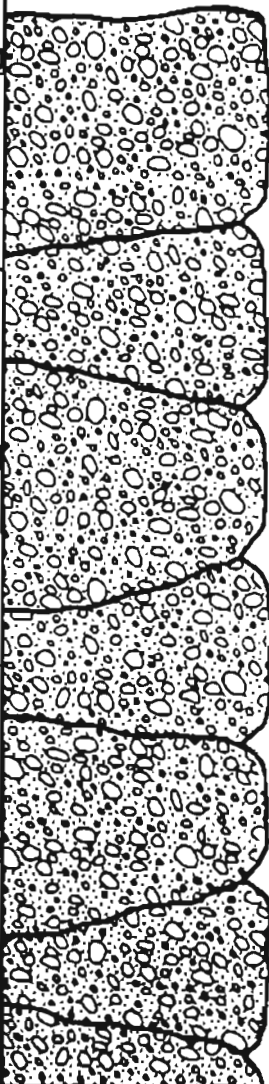
DEVONIAN SANDSTONE ?

GIVETIAN ?

400

380

360



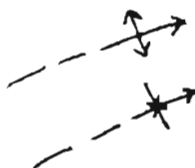
GEOLOGIC MAP SYMBOLS



Strike and dip of beds



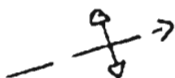
Contact; dashed where approximately located, dotted where inferred



Anticline (top) and syncline, showing trace of axial surface and plunge of axis; dashed where approximately located



Overtuned syncline, showing trace of axial surface; dashed where approximately located



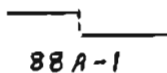
Crest of anticlinorium, approximately located



Thrust fault; dashed where approximately located, dotted where inferred, barbs on upper plate. Solid barbs indicate older-over-younger relationship, open barbs indicate younger-over-older relationship, alternating closed and open barbs indicate unknown age relationship. (Note: Also used to delineate a map unit which acts as a detachment horizon)



Line of cross section



Line of measured section with location number

DESCRIPTION OF MAP UNITS

Contacts in the interval between the Devonian rocks and the Lisburne Limestone are concordant with bedding, but the ages of the component elements are unknown and structural duplication is possible. This sequence occupies the stratigraphic position of the Endicott Group, but correlation of its elements with those of the Endicott Group is not yet possible.

M1 Mississippian Lisburne Limestone, undivided

Limestone, bioclastic, with beds of black chert to 8 cm thick, weathers gray; thin beds of black lime mud.

Changes northward from a south-dipping homocline to short-wavelength (100's meters) folds above a

detachment horizon in ch-2; cliff-former;

Mississippian age.

sh-2 Shale-2

Shale, steel gray, weathers gray to maroon and green; very finely fissile; in places phyllitic; carbonaceous; forms low passes and valleys beneath M1; structurally thickened, detachment horizon; probably equivalent to Kayak Shale.

cr Crinoid Unit

Arenite, dense, fine-grained, quartzose; weathers dark black, limonitic, with interbedded dark gray shale; silicified fossils include abundant large crinoid stems, corals, and trilobites. Deforms as short-wave (10's of meters) length chevron folds above a thin black shale.

ch-3 Channels-3

Litharenite, medium- to coarse-grained with subangular chert grit; weathers gray to maroon; covered by black lichens; cross-bedding, channelized; depositionally overlies maroon-weathering Ds with possible discordance.

ch-2 Channels-2

Litharenite and quartz-chert pebble conglomerate; white, gray, and black chert clasts; gray, weathers gray, covered by black lichens; cross-bedded, channelized; lower and upper contacts covered; cliff former.

ch-1 Channels-1

Quartz-chert pebble conglomerate, fine- to medium-grained litharenite with interbedded siltstone and mudstone; light gray, weathers dark gray to rusty-orange; covered by black lichens; medium bedded; fining-up channels; ripples, small-scale cross-beds, base of channels show load structures; lower contact is a thrust fault, upper contact covered; cliff former.

sh-1 Shale-1

Shale to siltstone, black; detrital white mica; small scale cross-beds in siltstone; forms very steep slopes beneath cap rocks of ch-1. Structurally disrupted by both folding and faulting. May be gradational with sc below.

Ds Devonian Sandstone

Overall thickening and coarsening-upward sequence of mudstone at the base through bedded litharenites to prominent channel-fill in upper part. Mudstone, fissile, weathers green-gray; Litharenite, gray to maroon, weathers gray to maroon, covered by black lichens; fine- to coarse-grained, thin-to medium-bedded; cross-bedding; siltstone beds with filled burrows; thin, fossiliferous calcareous beds; laterally discontinuous channels: chert-pebble conglomerate; matrix of coarse-to-medium grained litharenite; cross-bedded; shallow marine fossils; Givetian age. Lower contact is a fault, depositional basement unknown.

rb Raspberry Breccia

Breccia of black, gray, and raspberry colored chert clasts; angular to subangular basal clasts to 1 cm along unconformity surface; in places coal fragments; poorly sorted with average clasts from 5 cm to medium-sandstone, largest clast to 60 cm; white to gray chert cement; fining up cycles of approximately 0.5 m; usually massive bedded; in places breccia and mudstone finely interbedded with plant fossils on both surfaces; clasts become subrounded and increase in size over a short distance; deposited with angular unconformity on OCcp; abrupt lateral changes in thickness. Easily mistaken for a massive chert, thus is difficult to distinguish from OCcp.

sc Shale with channels

Channels are cut into and are laterally discontinuous in black shale; plant fossils, coal, some magnetite. Chert-pebble conglomerate, medium- to fine-grained litharenite with very fine-grained sandstone interbeds; pebbles of black, gray, and white chert with black chert most common; one channel fines to a clean white sandstone; upper channels include interbedded black sandstone and siltstone; Crops out as high, resistant ledges at base of sh-1. Contacts appear to be gradational with bls and sh-1.

bls Black Limestone

Limestone, black to gray, weathers gray; medium-bedded; becomes sandy toward the top including chert clasts; massive to cross-bedded, ripples, graded bedding; fossils; base and top interbedded with black shale containing plant fossils; lower contact with Ds is a fault, upper contact appears to be gradational with sc; ledge and cliff former.

The raspberry breccia (rb) fines upward to a 0.5 m thick bed of dark gray fine-grained sandstone to siltstone; in places siltstone contains silicified burrows; overlain by dark gray siltstone with plant fossils and detrital white mica; a zone of quartz-rich tectonite is overlain by a dark gray to black shale with tan-colored ironstone concretionary beds and slaty cleavage; north vergent folds; a detachment surface for the overlying Ds.

OCcp Ordovician - Cambrian chert and phyllite

Chert, massive to medium bedded; black, mottled gray, white, and less common raspberry color; includes black ribbon chert showing pinch and swell of beds interbedded with black argillite. Chert crops out as large, resistant lenses in matrix of dark gray phyllite showing strong cleavage; tight to isoclinal folds; base of unit not seen; Ordovician - Cambrian age (Reiser and others, 1980).

ch chert

ph phyllite