ILLUSTRATION 8

9230-V2-1P

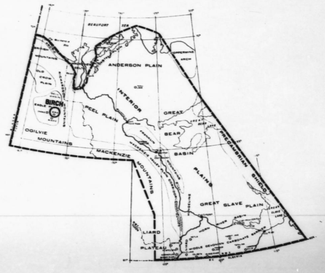
GEOLOGY
OF THE
SOCONY MOBIL WESTERN MINERALS BIRCH YT B-34 GAS DISCOVERY

SOUTHEASTERN EAGLE PLAIN
YUKON TERRITORY

DISCOVERY DATE · 1965

PREPARED BY
VEEZAY GEODATA (1977) LIMITED PARTNERSHIP
CALGARY, ALBERTA
1982

REGIONAL LOCATION MAP



1982 MACKENZIE BASIN CANADA LANDS EXPLORATION PROGRAM

SURFACE AREAL GEOLOGY AND STRUCTURAL INTERPRETATION MAP OF THE BIRCH ANTICLINE IN THE SOUTHEASTERN EAGLE PLAIN

SCALE : 1:50,000

LEGEND

UPPER AND LOWER CRETACEOUS	Ka	Sand, shale fm [Kb — base of upper sandstone unit; Ka — base of Cretaceous strata]
LOWER CRETACEOUS	Kb	Bluebird sandstone, arg., sbr.,sh.
LOWER PERMIAN	Pj	Jungle Creek Fm; sh., ss., ls.
PENNSYLVANIAN	Pu	Unnamed Fm; ls

GEOLOGIC SYMBOLS

Faults, fold axes and contacts are dashed where their position is indefinite, queried where existence and extent are doubtful. Colour coded by Earth-ordinate module.

- Bedding exposure horizontal on air photographs
- Dip of bedding, in degrees, air photos horizontal
- Photographic dip of 7° or less
- Dip group 1, 7° to 3°
- Dip group 2, 3° to 10°
- Dip group 3, 10° to 45°
- Dip group 4, 45° to 65°
- Dip group 5, 65° to nearly vertical
- Bedding appears nearly vertical on air photographs
- Overturned bedding
- General dip of beds being subordinate folds
- Top known on geologic evidence
- Top unknown
- Strike and dip interpreted from geomorphic evidence
- Possible dip slope
- Strike and dip measured, stage or bedding, interpreted from photographs (Photo-estimated)
- Field observed information
- Field observed published or open file information
- Field observed dip from outcrop or open file source
- Dip measured photogrammetrically
- Closure (inclined, vertical)
- Contact
- Apparent unconformable contact
- Key bed
- Stratigraphic break
- Equivalent formations
- Correlative key beds
- Gulvay area
- Fracture or joint
- Distinctive alignment, possible structural significance
- High-angle fault ; & denotes upthrown side
- Strike-slip fault showing direction of relative movement
- Dip-slip fault showing direction of relative movement
- Thrust fault, triangles on upthrown block, barbs on hanging wall, dashed where inferred
- Anticline, arrow shows plunge, dashed where inferred
- Axis of anticline opposite to outside with fault trace
- Axis of syncline opposite to outside with fault trace
- Overturned terrace
- Monocline
- Prominent scarp, steep slope or escarpment ridge
- Dike (D) or sill (S)
- Glacial striation showing direction of ice movement
- Facies and/or nonsimilarity change
- Depth based on data from nearby drill or level of Middle Devonian carbonate

STRUCTURAL CONTOUR SYMBOLS

- Outline of detailed structural contour area.
- 1852 Dip direction of meters from base hole information.
- Stratigraphic thickness in meters measured photogrammetrically.
- Structure dipping direction calculated or meters and derived from structural elevation contours. Dip is in degrees. Structural control points at base hole, geologic contacts below datum have been projected to datum plane, structure contours derived photogrammetrically.
- 1000 Structure contour in meters derived where relevant.
- Dip measured photogrammetrically.

CARTOGRAPHIC SYMBOLS

- Linear stream segment, interpreted as strike controlled
- Meandering stream segment, interpreted as structurally controlled
- Strike and dip interpreted from geomorphic evidence
- Anticline and syncline based on geomorphic evidence. Arrow indicates direction of plunge
- Geologic contacts, faults, fold axes, contact or geomorphic lineaments, dashed where inferred, queried where doubtful
- E - Radial drainage domains
- A - Annular drainage domains
- P - Photogenic fault domains
- DD - Radial-linear drainage domains
- T - Transgressive domains
- ? - very well defined by geomorphic evidence
- ?? - well defined by geomorphic evidence
- ??? - interpreted solely by geomorphic evidence
- 1000 Drainage density domains, a numerical change in the nature and density of drainage of 10 units when one-third structural contour interval is crossed
- Trend of geomorphic anomalies which may reflect or individual features
- Glacial lineation
- Crest of well-defined ridge or hogback. Arrow indicates direction of dip direction.
- Glacial striation

WELL SYMBOLS

- Location or drilling
- Dry and abandoned
- Oil well
- Gas well
- Oil and gas well
- Capped gas well
- Capped oil well
- Suspended well

WELL INFORMATION AS OF SEPTEMBER 30, 1982

STRUCTURAL GEOLOGY
of the
BIRCH ANTICLINE
in the
SOUTHEASTERN EAGLE PLAIN

Structure of the Eagle Plain, an intermontane structural basin, is dominated by a complex assemblage of anticlines, synclines, broad, elongate, gentle folds defined by dips ranging from less than 1° to 10°. Some westerly trending structures are also present as well as local faults. These structures are expressed at the surface in sandstone and shale of Cretaceous age preserved in the Eagle Plain basin and in the Upper Devonian carbonate platform. Although faults are of relatively minor importance at the surface in the southeastern Eagle Plain, Graham (1976) points out that anticlines in the Eagle Plain are frequently associated with thrust faults at depth.

The Birch anticline is a west-northwesterly to westerly trending, closed fold defined by dips in Upper Cretaceous strata ranging from 1° to 10°. The fold is 15 km long and approximately 3 km wide. The fold is about 8 km wide between flanking synclines. The anticline is double-plunging from a point 500 m south of the Socony Mobil W.M. Birch YT B-34 well. It dies out to the west in gently dipping Upper Cretaceous strata and is terminated and/or offset on the south-east by a complex system of faults. Structure to the north, approximately 3 km southeast of the Birch B-34 well.

The accompanying Structural Contour Map of the Birch anticline attempts to portray the configuration of structure quantitatively at depth by means of structural contours. Surface structural data in the immediate vicinity of the Birch anticline was supplemented by gammaritically using a Kern PG 2 stereoplotter and projected to the top of a thick sandstone unit at the top of a Hart River basinal sandstone (Chance sandstone equivalent) of Mississippian age. Thus, the map shows the form, shape, size and magnitude of the structure. The Birch anticline is characterized by a low-relief, broad areal and structural extension of approximately 20 m. The area of structural closure covers approximately 2420 ha (5930 acres).

The anticline displays considerable asymmetry as shown on the accompanying structural cross section, with the south limb not only dipping more steeply but also extending to a deeper structural level at the adjacent synclines than the north limb. The Socony Mobil W.M. Birch YT B-34 well penetrated the crest of the anticline approximately 500 m north of the apex of closure.

Seismic data and interpretation reveal a closed anticline at the top of the Devonian carbonate whose structural configuration conforms to a considerable extent with surface geology. This geophysical evidence, in conjunction with the known presence of a surface anticline strongly suggests a closed structure at the level of the Hart River Formation (Chance sandstone equivalent) which yielded gas during a drillstem test.

STRATIGRAPHIC SUMMARY
of the
HART RIVER FORMATION
in the
SOUTHERN EAGLE PLAIN

The Hart River Formation in the southern Eagle Plain is comprised of three members. These are: 1. a basal unit of limestone and associated clastics; 2. a major clastic interval (the Chance Sandstone Member and equivalents); 3. an upper limestone unit. The type section is on the north bank of the Peel River at lat. 62° 53' N., long. 138° 34' W., about 14k km east of its confluence with the Hart River. Graham (1974) has proposed a formal stratigraphy for the Hart River Formation mainly in the Upper Mississippian. The uppermost part is probably lowermost Pennsylvanian in age (Member 4 Yatacheenne, 1971; Graham, 1974); it is conformably underlain by Mississippian shale with minor siltstone and sandstone comprising Unit 1 of Member 4 Yatacheenne (1971). The formation is unconformably overlain by Cretaceous clastics. The Hart River Formation (1971) as "unnamed Pennsylvanian and Mississippian shale and siltstone" of Graham (1974). However, north of the sub-Cretaceous erosional limit of cover of the Hart River Formation by overlying Pennsylvanian strata, the Hart River Formation is unconformably overlain directly by Cretaceous clastics.

The Hart River thickens southward rapidly (82 m/km) from a sub-Cretaceous erosional edge, which trends easterly in the subsurface across Eagle Plain, to a maximum thickness of approximately 1000 m near the Hart Phanne C-18 well. The formation thins basinward to the south. From its maximum thickness on the shelf edge it thins rapidly (45 m/km) southward on the slope, and gently (less than 8 m/km) in the basinal facies. The Hart River Formation sequence thins to the north from its maximum thickness near the shelf edge to a zero edge at the sub-Cretaceous erosion and to the south depositionally down the slope into the basinal facies as portrayed on the stratigraphic map and cross section.

In apparent Devonian time fine clastics were deposited relatively uniformly upon the Middle Devonian carbonates in the Eagle Plain Basin. The deposits were thin and fine grained in the shallow water shelf area and thicker to the south. This clastic deposition continued uninterrupted into the lowermost Mississippian (Unit 1) time except on the northern "proto-shelf" where coarse clastic (sacrious the "Vision sandstone") took place at the top of the Devonian.

Following this, in the Visean stage, Hart River Formation carbonate deposition commenced. In the northern portion of the basin on the Unit 1 "proto-shelf" a thin veneer of carbonate and clastic sediments (Unit 2 Yatacheenne) were also being deposited concurrently on the Unit 1 "proto-slope", and thinning to the south they accumulated in shelf, slope, and basinal environments.

Light colored, cherty crinoidal limestone with minor siltstone and sandstone beds are typical of the shelf facies Hart River Formation. On the slope and into the basin the amount of limestone is gradually replaced by calcareous shale and bituminous limestone.

In mid-Hart River time, a major clastic influx (the Chance Sandstone Member) took place. Graham and Yatacheenne (1971) suggest that the Chance Member was deposited as a shelf delta complex. Contemporaneously, Hart River basinal sandstones were being deposited to the south.

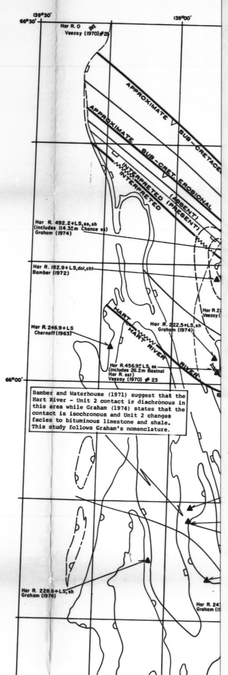
The shelf facies Chance sandstone is characteristically conglomeratic in part, with light to dark brown sub-rounded chert clasts in a light brown-gray very fine to coarse quartz and chert grain matrix. Minor associated medium dark gray to black carbonaceous shale and coal, and medium dark gray and light to medium brown calcitic limestones are also present. The shelf facies forms the oil and gas reservoir rock in the three Chance wells: Chance #1 (M-08), Chance D-02, and Chance J-12. On the adjacent slope and basin, basinal Hart River sandstones were deposited overall with the Chance sandstone. These sandstones are dark gray to black, very fine grained, quartz and chert, although much thicker and less continuous laterally, than of the shelf basinal sandstones, which are possibly turbiditic in origin, is the reservoir rock in the Birch B-34 suspended gas well.

The distribution of the Chance sandstone and its basinal equivalents are shown on the accompanying stratigraphic map. In the northeastern part of the map area the Chance sandstone thickens rapidly (35 m/km) from its northern erosional edge to a maximum thickness of 100 m in the vicinity of the Chance #1 well. The Chance #1 well. The Chance sandstone thins to the south towards their feather edge where they change facies to shales and limestones. The provenance of the sediments was from the north with the chert and quartz components being derived from underlying Middle Devonian carbonates and Precambrian quartzites. In the southeastern part of the map area, in the central part of the map area, the Chance sandstone and basinal Hart River sandstones appear to have undergone a facies change to shale and limestone based on sparse well control. Lack of subsurface data precludes mapping of net sandstone in the south-central map area where basinal Hart River sandstones could be present.

The Chance Sandstone and the basinal Hart River sandstone equivalents are a combination of bottomset (distal) deltaic, slope and basinal turbidite deposits. They are highly prospective for both oil and gas exploration. Also, potentially prospective are fractured Hart River limestones beneath the Chance sandstone, as shown by gas shows in Chance #1 from 1535 m to 1560 m.

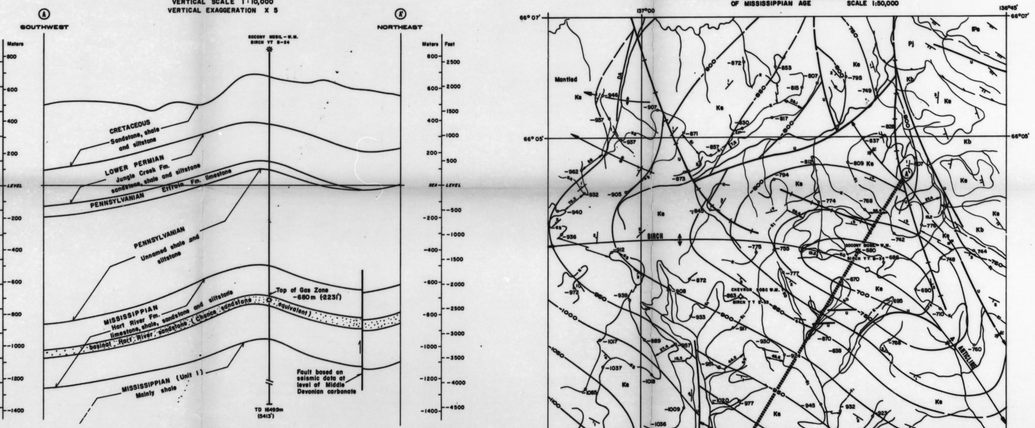
The reservoir in the Birch B-34 suspended gas well is a basinal Hart River sandstone which is stratigraphically equivalent to the Chance shelf Chance sandstone. Due to its nature, such a reservoir could be bounded by an up dip pinch out and a facies change to shale and siltstone. Hydrocarbon source beds can be attributed to associated clastics and carbonates of the Hart River Formation.

Based on the stratigraphic basin the prospective areas for Hart River exploration are along the Hart River shelf where the Chance sandstone is well developed as shown by the stratigraphic map and along the slope and in the Hart River basin at the base of the slope where basinal Hart River sandstones accumulated.



STRUCTURAL CROSS SECTION
DRAWN ACROSS BIRCH ANTICLINE

HORIZONTAL SCALE 1:50,000
VERTICAL SCALE 1:10,000
VERTICAL EXAGGERATION X 5



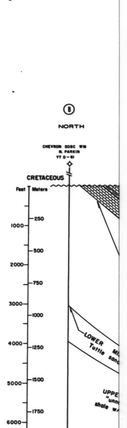
STRUCTURAL CONTOUR MAP OF THE BIRCH ANTICLINE

CONTOUR INTERVAL : 50 METERS

STRUCTURAL DATUM : (TOP OF A HART RIVER BASINAL SANDSTONE (CHANCE SANDSTONE EQUIVALENT) OF MISSISSIPPIAN AGE

SCALE 1:50,000

Surface structural data compiled photogrammetrically using a Kern PG 2 stereoplotter



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RESERVOIR DATA

HYDROCARBON BEARING SECTION: Basinal Hart River sandstone of Mississippian age.

RESERVOIR ROCK: Fine to coarse-grained partially conglomeratic sandstone.

TRAP TYPE: Basinal, Westerly trending, broad, gentle, closed anticline displaying approximately 75 m of structural closure at the Hart River Formation level covering 2,400 ha.

POTENTIALLY PRODUCTIVE INTERVAL: 4,000+' (1224.7m-1828.5m)

WET GAS PAY THICKNESS: - Calculated: 7.6 m
- Published: 6.3 m (Graham, 1974)

POROSITY: - Calculated: 15% - 20% (average 18%) based on log and sample examination.

DRILLSTEM TEST MAXIMUM FLOW RATE: 180 x 10^3 m^3/d (5.5 mmcf/d)

ESTIMATED RESERVES: 1.47x 10^9 m^3 (51.9 BCF) Based on one well.

GAS CHARACTERISTICS: (Volume Percentage)

Nitrogen	0.82	Isobutane	0.25
Carbon Dioxide	1.91	N. Butane	0.51
Hydrogen Sulphide	0.00	Isopentane	0.14
Helium	0.04	N. Pentane	0.14
Ethane	6.61	Hexanes	0.10
Propane	2.39	Heptanes+	0.15
		Total -	100.004

Gross J/m^3 @ 15.6° C and 101.0 kPa = 4.12 x 10^7 J/m^3
Gross BTU/cu.ft. @ 60° F and 14.65 p.s.i.a. = 1107
Specific Gravity 0.606 (calculated), 0.602 (actual)

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PROJ. NO. 9230-V2-1P
LINE NO. MA

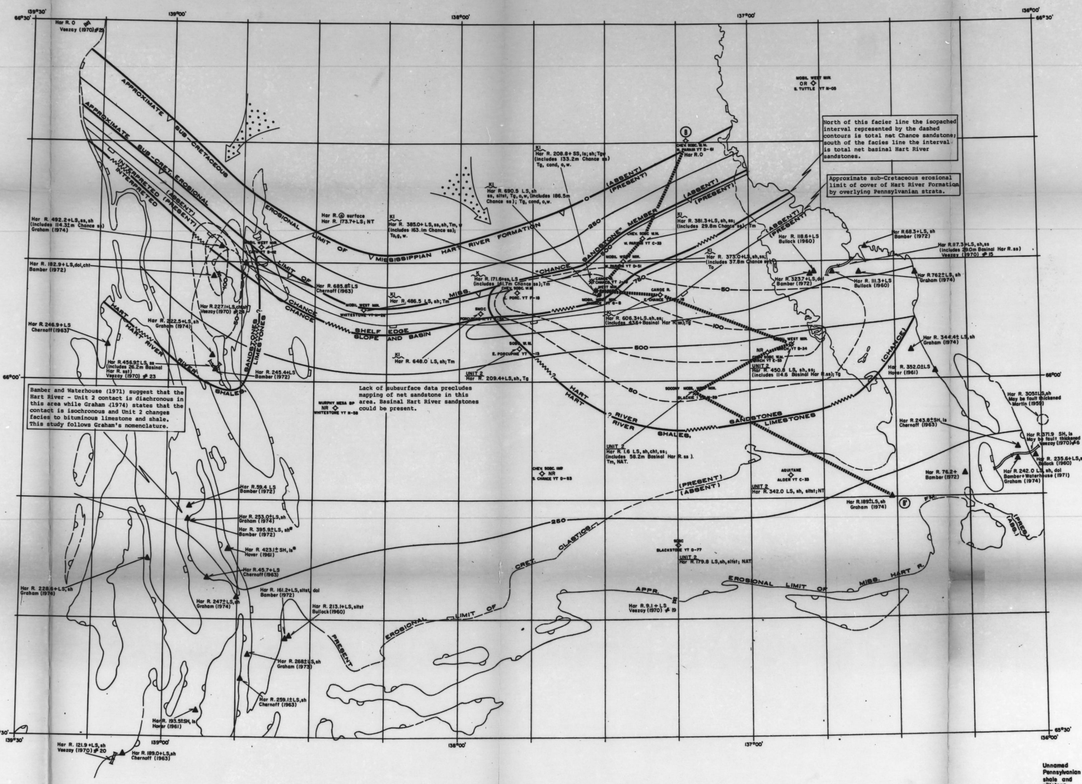
PART NO. 1 OF 2
R.R. 10X

STRATIGRAPHIC MAP OF THE HART RIVER FORMATION OF MISSISSIPPIAN AGE SOUTHERN EAGLE PLAIN

TOTAL FORMATION ISOPACH INTERVAL · 250 METERS (SOLID CONTOURS) CHANCE SANDSTONE (=TOTAL NET BASINAL SANDSTONE) ISOPACH INTERVAL · 50 METERS (DASHED CONTOURS)

SCALE · 1: 250,000

This map shows the interpreted thickness, distribution, lithology and significant stratigraphic changes prior to Laramide deformation and subsequent erosion.


APPROXIMATE WEST CONTAINED EROSIONAL LIMIT OF MISSISSIPPIAN HART RIVER FORMATION
APPROXIMATE EAST CONTAINED EROSIONAL LIMIT OF MISSISSIPPIAN HART RIVER FORMATION
EROSIONAL LIMIT OF CRETACEOUS
EROSIONAL LIMIT OF MISS. HART R.
SHELF SLOPE AND BASIN
SHALES
SANDSTONES
LIMESTONES
HART RIVER
Bamber and Waterhouse (1971) suggest that the Hart River - Unit 2 contact is diachronous in this area while Graham (1974) states that the contact is synchronous and Unit 2 changes facies to bituminous limestone and shale. This study follows Graham's nomenclature.
Lack of subsurface data precludes mapping of net sandstone in this area. Basinal Hart River sandstones could be present.
North of this facies line the isopachs interval represented by the dashed contours is total net Chance sandstone; south of the facies line the interval is total net basinal Hart River sandstones.
Approximate sub-Cretaceous erosional limit of cover of Hart River Formation by overlying Pennsylvanian strata.
Hor R. 0 surface Vassay (1970) P 23
Hor R. 73.7+L5; NT
Hor R. 208.8+ SS,ls,sh,Tp; Includes 93.2m Chance ss) Tp, cong, o,v.
Hor R. 690.5 L,S,sh; ss, sltst; Tp, o,v; Includes 186.0m Chance ss); Tp, cong, o,v.
Hor R. 385.0+ L,S,ss,sh,Tp, o; Includes 93.1m Chance ss); Tp,o,v.
Hor R. 381.3+L,S,sh,ss; Includes 23.6m Chance ss); Tp
Hor R. 375.0+L,sh,ss; Includes 37.0m Chance ss); Tp
Hor R. 608.5+L,S,sh,ss; Includes 246+Basinal Hor R. ss); Tp
Hor R. 650.0 L,S, sh,ss; Includes 0+L S Basinal Hor R. ss); Tp
Hor R. 342.0 L,S, sh, sltst; NAT
Hor R. 14 L,S, sh,sltst; Includes 94.2m Basinal Hor R. ss); Tn, NAT.
Hor R. 342.0+L,S,sh,sltst; Hor R. 0 surface Vassay (1970) P 20
Hor R. (2)3+L,S,sh Vassay (1970) P 20
Hor R. 289.1+L,S,sh Charnoff (1963)
Hor R. 289.1+L,S,sh Graham (1974)
Hor R. 213.1+L,S,sltst Bufalo (1963)
Hor R. 161.2+L,S,sltst; dol Bamber (1972)
Hor R. 423.1+ SH,sh Vassay (1962)
Hor R. 45.7+L,S Charnoff (1963)
Hor R. 0+L,S Bamber (1972)
Hor R. 0 L,S Graham (1974)
Hor R. 593.9+L,S, sltst Bamber (1972)
Hor R. 247.1+L,S Graham (1974)
Hor R. 228.6+L,S,ss Graham (1974)
Hor R. 266.9+L,S Charnoff (1963)
Hor R. 492.2+L,S,ss,sh Graham (1974)
Hor R. 182.9+L,S,dol,sltst Bamber (1972)
Hor R. 227.0+L Bamber (1972)
Hor R. 267.5+L,S,sh Vassay (1974)
Hor R. 245.4+L,S Bamber (1972)
Hor R. 0 L,S Graham (1974)
Hor R. 0 surface Hor R. 73.7+L,S; NT
Hor R. 685.6+L,S Charnoff (1963)
Hor R. 5.496.5 L,S, sh; Tn
Hor R. 648.0 L,S, sh; Tn
Hor R. 209.6+L,S,sh; Tp
Hor R. 0+L,S,ss,sh Graham (1974)
Hor R. 0 L,S,ss,sh Graham (1974)
Hor R. 0 L,S,ss,sh Graham (1974)
Hor R. 0