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MAP OF UPPER DEVONIAN AND YOUNGER PALEOZOIC ROCKS, MACKENZIE CORRIDOR

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This map summarizes data on Upper Devonian, Carboniferous and Permian rocks for the Mackenzie Corridor – an area from latitude 60°N to the Arctic coast (but excluding the Mackenzie Delta), from the exposed Precambrian on the east to longitude 136° on the west. Rock types, approximate thickness, and correlation are shown on the inset chart. Sources for field data are shown on the inset index map. Subsurface interpretations are based on my own work south of 65°N, on company well reports and Canadian Stratigraphic Service Ltd. lithologs north of 65°N. Regional summaries of parts of the Corridor area, from a petroleum assessment point of view, are in de Wit et al. (1973), Gilbert (1973), Kunst (1973) and Law (1971). Concepts of depositional history have been discussed and documented by Braman (1981) for the northern area, and by Richards (1983) for Lower Carboniferous strata in the south.

In order to avoid an impossibly cluttered map, the emphasis varies from area to area. In the south, the emphasis is on sub-Cretaceous geology and on facies trends. Isopach maps of various units in this area appear in Belyea (1971) and Williams (1977, 1981). In the Mackenzie Mountains, where most of the pre-Permian strata are of the starved basin facies, the map merely shows distribution of preserved rocks. In the north, the area of highest petroleum potential, drill stem tests and isopachs are shown.

South of the 60th parallel, correlative rocks host large reserves of oil and gas. For example: Upper Devonian Leduc reefs, Nisku and Wabamun carbonates, Mississippian carbonates, and Mississippian and Permian sandstones. This map should help to explain why upper Paleozoic rocks of the Mackenzie Corridor, in contrast to those south of latitude 60°N, offer such a low potential for petroleum. In the Eagle Plains, west of the map area, several small gas fields and one oil field occur in Viséan (Mississippian) clastics.

Some of the more interesting items depicted by the map are listed below.

Southern part of the map

1) Most of the mapped sediments belong to a regressive suite – the waning stages of the Kaskaskia Sequence of Sloss (1963). This is most obvious from column GH of the inset chart (esssentially a west to east cross-section). The various shallow water carbonate units step progressively farther west through time: Twin Falls, Jean Marie, Kakisa, uppermost Kotcho limestone tongue and, lastly, the shallow water facies of the Flett Formation.

2) All mappable facies belts trend north by northwest. This pattern – westward prograding carbonate units over westward dipping clinothems within the clastic facies – is consistent with earlier sedimentation patterns in the Hay River/Twin Falls formations (Williams, 1977) and during the Givetian (Williams, 1986). The sedimentary model assumes a distant source area for the clastic material, delivered, via the Franklinian Trough (Embry and Klovan, 1976), by long shore or long bank currents. This pattern persisted through Devonian and most, if not all, of Carboniferous time.

3) There was a pronounced tectonic sag west of the Liard River; this is best shown on the inset cross-sections. The clastic fill of this sag is a shallowing-upward, coarsening-upward sequence: deep water Besa River shales at the base, with tongues of deep water cherty limestone, siltstone or sandstone, culminating in the shallow water, in part nonmarine Mattson sandstones (see Richards, 1983). Most of the Mattson sands reached this area from the northeast or north; the inferred western source for some of the sandstone (lower inset cross-section) is deduced from the outcrop pattern of lowest Mattson sandstone tongues on the La Biche map (Douglas and Norris, 1959), but this requires further checking in

the field. Although no faults are drawn on the inset cross-sections, the sag could be interpreted as a north-trending graben, or half-graben.

4) The pattern of sub-Cretaceous geology, assuming an erosion surface of low relief, indicates a broad, east-west trending syncline. This feature approximately coincides with what was, in Devonian time, the Tathlina Arch (Belyea, 1971). This is an interesting parallel with the post-Devonian reversal of the Peace River Arch.

5) Areas where the upper Paleozoic section contains a suitable facies at sufficient depths to offer petroleum potential are fairly small. A Desan-type play (Debolt equivalents lie within the Flett carbonates) exists between longitudes 121°W and 123°W at shallow depths (log section 3). The Jean Marie play (log section 2) occupies part of the same belt. The thick Mattson sandstones (log section 4) are exposed in the large Laramide structures west of 123°W; prospective traps would be limited to structural depressions. The up-dip eroded edge of the Mattson sandstones (a Tattoo-type play) offers some potential; over most of this belt the Paleozoic sands are directly overlain by a porous basal Cretaceous sandstone (Williams, 1978).

The Mackenzie Plain (between the Mackenzie and Franklin Mountains, north to ~64°N)

1) Although thickness data are too sparse to construct a useful isopach map, it would appear that this belt is a northern continuation of the tectonic sag so evident farther south. Isopach maps of several older Paleozoic units show that the Mackenzie Plain has had a long history as a negative tectonic belt (reports in preparation). West of this downwarp, in the Selwyn Basin, the Earn Group (Gordey et al., 1982) is a deep water, starved, shaly facies. The chert conglomerates within this package probably indicate local uplifts, cannibalism of earlier Paleozoic strata and, possibly, some western highlands.

2) A late Frasnian Jean Marie-like limestone is present within the eastern part of the Mackenzie Plain; whether this limestone is a precise correlative of the Jean Marie or of the Kakisa limestone is unknown. The western depositional limit of this limestone follows the same north by northwest trend as do facies belts farther south. The outcrops were described as reef limestones by Douglas and Norris (1961, 1963); they are biostromal, not biohermal, in geometry.

3) There are only two conceivable potential reservoirs: the reefs or the sandstones that occur high in the section; neither display reservoir quality in outcrops.

4) In the plains east of the Franklin Mountains, the basal part of the Fort Simpson shale is all that survived pre-Cretaceous erosion. This section offers no significant petroleum potential.

'he northern area

1) This area, sometimes called the Peel Basin or Peel Plateau, lies within the right-angled reentrant formed by the junction of the Franklinian and Cordilleran geosynclines. The Franklinian Geosyncline ended with the Ellesmerian Orogeny (Late Devonian – Early Carboniferous). The main effects of this Orogeny lie northwest and northeast of the map area, from western Alaska to the Arctic Islands (Douglas, 1970). Within the map area its effects are seen in the pre-Permian lacuna (column A of the inset chart) and in the lobes of coarse clastics, up to pebble sized, in latest Devonian – early Carboniferous fill deposits.

The Cordilleran Geosyncline ended with the Columbian (Late Jurassic to mid-Cretaceous) and Laramide (Late Cretaceous and Tertiary) orogenies. These orogenies influenced the preservation, but not the sedimentary history of upper Paleozoic rocks. The Eskimo Lakes Arch (Young et al., 1976) is a Mesozoic feature; this area was probably strongly negative (an Ellesmerian foredeep) through Devonian and earliest Carboniferous time.

2) The small area with Carboniferous limestone, represented by column D of the inset chart, is representative of a stratigraphic section that occurs in the Eagle Plain, west of the map area. Rocks of this facies do not occur, and probably never were deposited, east of the Richardson Mountains.

3) The isopached unit, which includes the Canol Formation, is a shallowing-upward, coarsening-upward sequence. The deep water, starved-basin Canol shales are succeeded by Imperial shale, silty shale, sandy shale with sandstone turbidites, and, finally, by shallow water marine to nonmarine sandstone. From the study by Braman (1981) it is evident that most of the basin fill prograded into the area from the east or northeast. The youngest part of the fill also received a contribution from rising Ellesmerian highlands northwest of the map area. One of the main depocentres was in the area of the northern Richardson Mountains (see Fig. 16 of Norris, 1985).

4) The position of the Cretaceous/Paleozoic boundary is uncertain in most wells, highly uncertain in many [the type section of the Tuttle Formation as defined in the subsurface, includes an unknown thickness of Cretaceous section (Pugh, 1983, p. 44)]. In most areas there is no clearly recognizable basal Cretaceous sandstone. Even with palynological control, the boundary is not always clear (see discussion by McGregor <u>in</u> Norford et al., 1970, p. 8).

On the Trail River map the Cretaceous/Paleozoic contact is mapped as a near vertical fault – the Trevor Fault (Norris, 1981d). This cannot be correct. Shell Peel River L-19 (~66°45'N, 135°15'W) and I-21 (~66°10'N, 134°15'W), both of which lie about 10 km east of the alleged fault, encountered Paleozoic rocks at or very near the surface (see well reports, also report by McGregor <u>in</u> Norford et al., 1970, p. 4-7). The Trevor Fault may exist, as mapped; it is not, however, along the Mesozoic/Paleozoic contact.

5) In the southeastern part of the Wind River map (column C of the inset chart) there is a strong unconformity between Devonian and Mississippian beds. This is probably a local phenomenon, unrelated to the Ellesmerian Orogeny. It probably is, rather, a manifestation of a paleoarch that later became the Bonnet Plume Basin (a report on Cretaceous history, in preparation).

6) A search for petroleum in upper Paleozoic rocks of this area must concentrate on finding reservoir sands within the flysch or basinal facies. The sandstones of the eastern, or platform facies are, for the most part, too shallow to offer favorable prospects. Also, along the eastern belt of preserved Imperial Formation the basal Cretaceous sandstone is porous. The fact that this basal Cretaceous sandstone is commonly oil stained or oil saturated (Yorath and Cook, 1981, p. 45) probably indicates that oil has migrated through and escaped from Imperial sandstones. Oil impregnated Imperial sandstones are known in the Norman Wells area (Tassonyi, 1969, p. 147).

The petroleum potential of the flysch facies is difficult to assess. Imperial and Tuttle sandstone units are characteristically poorly sorted, lithic and clay rich. However, the entire section contains a high proportion of organic matter (plant remains) and reservoir beds do exist, albeit rarely. Small gas flows were obtained in the Russell H-23 well (~70°N, 130°W) from two Imperial sands. Between 1965 and 1967 Shell Canada drilled nine shallow tests in the Peel River area (~66°N-67°N, 134°W). Of these, four encountered thin reservoir sands with fair permeabilities (judging from water recoveries), three of the four reservoirs yielded traces of gas.

7) There is as yet no published comprehensive analysis of the thermal maturity of the Imperial Formation. However, a large volume of these sediments must lie within the oil window. From the fact that there is oil at Norman Wells, it can be assumed that the Canol Formation in that general area lies within the oil window. In the well report on Shell Peel River H-37 (~66°35'N, 135°W) it is stated that "...by 8595' the sediments are mature...and by 9000' expulsion should be complete". The base of the Imperial Formation in the well is at 8860' (2700 m). Norris and Cameron (1986) describe an outcrop of bitumen that occurs in the upper part of the Imperial Formation (~67°50'N, 133°45'W). Both the bitumen and host sediments indicate a maturity within the lower part of the oil window. The base of the Imperial in this area lies at a depth of about 1500 m. In the Kugalik N-02 well (~68°30'N, 131°30'W) the Canol shale (881 m) has been heated well beyond the oil window (Gunther and Meijer Drees, 1977).

REFERENCES

Aitken, J.D. and Cook, D.G.

1969: Geology Lac Belot, District of Mackenzie; Geological Survey of Canada, Map 6-1969.

1974a: Geological maps showing bedrock geology of the northern parts of Mount Eduni and Bonnet Plume Lake map area, District of Mackenzie, Northwest Territories, (106 A, B - scale: 1:125,000); Geological Survey of Canada, Open File Report 221.

1974b: Carcajou Canyon map area (96 D), District of Mackenzie, Northwest Territories; Geological Survey of Canada, Paper 74-13.

Aitken, J.D., Cook, D.G., and Yorath, C.J.

1982: Upper Ramparts River (106 G) and Sans Sault Rapids (106 H), map areas, District of Mackenzie; Geological Survey of Canada, Memoir 388, with Maps 1452A and 1453A.

Balkwill, H.R.

1971: Reconnaissance geology, southern Great Bear Plain, District of Mackenzie; Geological Survey of Canada, Paper 71-11, 47 p.

Balkwill, H.R. and Yorath, C.J.
1970a: Brock River map area, District of Mackenzie; Geological Survey of Canada, Paper 70-32, 25 p.

1970b: Simpson Lake map area, District of Mackenzie (97 B); Geological Survey of Canada, Paper 69-10.

Bassett, H.G.
1961: Devonian stratigraphy, central Mackenzie River region, Northwest Territories, Canada; in Geology of the Arctic, G.O. Raasch (ed.); Alberta Society of Petroleum Geology and University of Toronto Press, v. 1, p. 481-495.

Belyea, H.R.
1971: Middle Devonian tectonic history of the Tathlina Uplift, southern District of Mackenzie and northern Alberta, Canada; Geological Survey of Canada, Paper 70-14.

Blusson, S.L.
1971: Sekwi map area, Yukon Territory and District of Mackenzie; Geological Survey of Canada, Paper 71-22.

Braman, D.R.
1981: Upper Devonian – Lower Carboniferous miospore biostratigraphy of the Imperial Formation, District of Mackenzie; unpublished Ph.D. thesis, University of Calgary, 377 p.

Cecile, M.P.
1982: The Lower Paleozoic Misty Creek Embayment, Selwyn Basin, Yukon and Northwest Territories; Geological Survey of Canada, Bulletin 335.

Chi, B.I. and Hills, L.V.
1973: Stratigraphic and paleoenvironmental significance of Upper Devonian megaspores, type section of the Imperial Formation, Northwest Territories, Canada; in Proceedings of the Symposium on the Geology of the Canadian Arctic, p. 241-257.

Cook, D.G. and Aitken, J.D.
1969: Geology Fort Good Hope, District of Mackenzie; Geological Survey of Canada, Map 4-1969.

1969: Erly Lake, District of Mackenzie (97 A); Geological Survey of Canada, Map 5-1969.

1971: Geology, Colville Lake map area and part of Coppermine map area, Northwest Territories; Geological Survey of Canada, Paper 70-12.

1974: Geology of Norman Wells (96 E) and Mahony Lake (96 F) map areas, District of Mackenzie, Northwest Territories; Geological Survey of Canada, Open File 304.

Cook, D.G. and Aitken, J.D.
1975: Ontaratue River (106 J), Travaillant Lake (106 O) and Canot Lake (106 P) map areas, District of Mackenzie, Northwest Territories; Geological Survey of Canada, Paper 74-17.

1976: Geological maps of Blackwater Lake (96 B) and Fort Norman (96 C), District of Mackenzie; Geological Survey of Canada, Open File Report 402.

de Wit, R., Gronberg, E.C., Richards, W.B., and Richmond, W.O.
1973: Tathlina Area, District of Mackenzie; in The Future Petroleum Provinces of Canada, R.G. McCrossan (ed.); Canadian Society of Petroleum Geologists, Memoir 1, p. 187-212.

Douglas, R.J.W.
1959: Great Slave and Trout River map area, Northwest Territories; Geological Survey of Canada; Paper 58-11, Maps 1370A and 1371A.

Douglas, R.J.W. (editor)
1970: Geology and economic minerals Canada; Geological Survey of Canada, Economic Geology Report no. 1.

Douglas, R.J.W. and Norris, A.W.
1960: Horn River map area, Northwest Territories; Geological Survey of Canada, Paper 59-11, Map 1372A.

Douglas, R.J.W. and Norris, D.K.
1959: Fort Liard and La Biche map area, Northwest Territories and Yukon; Geological Survey of Canada, Paper 59-6, Maps 1379A and 1380A.

1960: Virginia Falls and Sibbeston Lake map areas, Northwest Territories; Geological Survey of Canada, Paper 60-19, Maps 1377A and 1378A.

1961: Camsell Bend and Root River map area, District of Mackenzie, Northwest Territories; Geological Survey of Canada, Paper 61-13, Maps 1375A and 1376A.

1963: Dahadinni and Wrigley map areas, District of Mackenzie, Northwest Territories; Geological Survey of Canada, Paper 62-33, Maps 1373A and 1374A.

Embry, A.F. and Klovan, J.E.
1976: The Middle-Upper Devonian clastic wedge of the Franklinian geosyncline; Bulletin of Canadian Petroleum Geology, v. 24, p. 485-639.

Gabrielse, H. and Blusson, S.L.
1969: Geology of Coal River map area, Yukon Territory and District of Mackenzie; Geological Survey of Canada, Paper 68-38.

Gabrielse, H., Blusson, S.L., and Roddick, J.A.
1973: Geology of Flat River, Glacier Lake and Wrigley Lake map areas, District of Mackenzie and Yukon Territory; Geological Survey of Canada, Memoir 366, Parts I and II.

nnie, K.W.
1963: An interpretation of turbidites whose sole markings show multiple directional trends; Journal of Geology, v. 71, no. 4, p. 525-527.

ɔert, D.L.F.
1973: Anderson, Horton, Northern Great Bear and Mackenzie Plains, Northwest Territories; in The future petroleum provinces of Canada, R.G. McCrossan (ed.); Canadian Society of Petroleum Geologists, Memoir 1, p. 213-244.

ʼdey, S.P., Abbott, J.G., and Orchard, M.J.
1982: Devono-Mississippian (Earn Group) and younger strata in east-central Yukon; in Current Research, Part B, Geological Survey of Canada, Paper 82-1B, p. 93-100.

ɛen, L.G.
1972: Geology of Nash Creek, Larsen Creek, and Dawson map areas, Yukon Territory; Geological Survey of Canada, Memoir 364.

nther, P.R. and Meijer Drees, N.C.
1977: Devonian coal in the subsurface of Great Slave Plain: a guide to exploration for oil and gas; in Report of Activities, Part A, Geological Survey of Canada, Paper 77-1A, p. 147-150.

ls, L.V. and Braman, D.R.
1978: Sedimentary structures of the Imperial Formation, Northwest Canada; in Display Summaries, Canadian Society of Petroleum Geologists - Core and Field Sample Conference 1978, A.F. Embry (ed.); Canadian Society of Petroleum Geologists, p. 35-37.

nst, H.
1973: The Peel Plateau; in The future petroleum provinces of Canada, R.G. McCrossan (ed.); Canadian Society of Petroleum Geologists, Memoir 1, p. 213-244.

w, J.
1971: Regional Devonian geology and oil and gas possibilities upper Mackenzie River area; Bulletin of Canadian Petroleum Geology, v. 19, no. 2, p. 437-486.

ırford, B.S., Braun, W.K., Chamney, T.P., Fritz, W.H., McGregor, D.C., Norris, A.W., ʼdder, A.E.H., and Uyeno, T.T.
1970: Biostratigraphic determination of fossils from the subsurface of the Yukon Territory and Districts of Mackenzie and Franklin; Geological Survey of Canada, Paper 70-15.

ɔrris, A.W.
1985: Stratigraphy of Devon outcrop belts in northern Yukon Territory and northwestern District of Mackenzie (Operation Porcupine area); Geological Survey of Canada, Memoir 410.

Iorris, D.K.
1981a: Geology, Aklavik, District of Mackenzie; Geological Survey of Canada, Map 1517A, scale 1:250 000.

1981b: Geology, Fort McPherson, District of Mackenzie; Geological Survey of Canada, Map 1520A, scale 1:250 000.

1981c: Geology, Arctic Red River, District of Mackenzie; Geological Survey of Canada, Map 1521A, scale 1:250 000.

1981d: Geology, Trail River, Yukon-Northwest Territories; Geological Survey of Canada, Map 1524A, scale 1:250 000.

1981e: Geology, Martin House, Yukon-Northwest Territories; Geological Survey of Canada, Map 1525A, scale 1:250 000.

1982a: Geology, Wind River, Yukon Territory; Geological Survey of Canada, Map 1528A, scale 1:250 000.

1982b: Geology, Snake River, Yukon Territory-District of Mackenzie; Geological Survey of Canada, Map 1529A, scale 1:250 000.

Norris, D.K. and Cameron, A.R.
1986: An occurrence of bitumen in the Interior Platform near Rengleng River, District of Mackenzie; in Current Research, Part A, Geological Survey of Canada, Paper 86-1A, p. 645-648.

Pugh, D.C.
1983: Pre-Mesozoic geology in the subsurface of Peel River map area, Yukon Territory and District of Mackenzie; Geological Survey of Canada, Memoir 401.

Richards, B.C.
1983: Uppermost Devonian and Lower Carboniferous stratigraphy, sedimentation and diagenesis, southwestern District of Mackenzie and southeastern Yukon Territory; unpublished Ph.D. thesis, University of Kansas.

Sloss, L.L.
1963: Sequences in the cratonic interior of North America; Geological Society of America, Bulletin, v. 74, no. 2, p. 93-113.

Tassonyi, E.J.
1969: Subsurface geology, lower Mackenzie River and Anderson River area, District of Mackenzie; Geological Survey of Canada, Paper 68-25.

Williams, G.K.
1977: The Hay River Formation and its relationship to adjacent Formations, Slave River map area, Northwest Territories; Geological Survey of Canada, Paper 75-12.

1978: An update of subsurface information, Cretaceous rocks, Trout Lake area, southern Northwest Territories: Scientific and Technical Notes; in Current Research, Part A, Geological Survey of Canada, Paper 78-1A, p. 545-553.

Williams, G.K.
1981: Subsurface geological maps, southern Northwest Territories (NTS 85, 95); Geological Survey of Canada, Open File 762.

1986: Middle Devonian Facies Map, Mackenzie Corridor; Geological Survey of Canada, Open File .

Yorath, C.J. and Balkwill, H.R.
1969: Geology, Crossley Lakes, District of Mackenzie; Geological Survey of Canada, Map 8-1969.

1970: Stanton map area, Northwest Territories (107 D); Geological Survey of Canada, Paper 69-9.

Yorath, C.J., Balkwill, H.R., and Klassen, R.W.
1969: Geology of the eastern part of the Northern Interior and Arctic Coastal Plains, Northwest Territories; Geological Survey of Canada, Paper 68-27.

1975: Franklin Bay (97 C) and Malloch Hill (97 F) map areas, District of Mackenzie; Geological Survey of Canada, Paper 74-36.

Yorath, C.J. and Cook, D.G.
1981: The Cretaceous and Tertiary stratigraphy and paleontology, northern Interior Plains, District of Mackenzie; Geological Survey of Canada, Memoir 398.

Young, F.G., Myhr, D.W., and Yorath, C.J.
1976: Geology of the Beaufort-Mackenzie Basin; Geological Survey of Canada, Paper 76-11.

List of Illustrations

Map of upper Paleozoic sediments, Mackenzie Corridor, scale ~1:1,270,000.

Log section 1, Upper Devonian formations, near 60°, 119°.

Log section 2, Upper Devonian formations, near 60°, 122°.

Log section 3, Flett Formation, near 60°, 123°.

Log section 4, Flett to Mattson transition, near 60°, 124°.