Geophysical Characterization of Pre-Cenozoic Basement for Hydrocarbon Assessment, Yukon Flats, Alaska

By R.W. Saltus[1] (saltus@usgs.gov), J.D. Phillips[1] (jeff@usgs.gov), R.G. Stanley[2] (rstanley@usgs.gov), A. Till[3] (atill@usgs.gov), and R.L. Morin[2] (morin@usgs.gov)

[1] Denver, Colorado [2] Menlo Park, California, [3] Anchorage, Alaska

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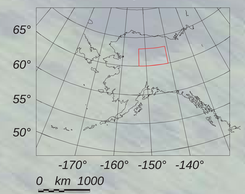
Abstract

The Cenozoic basins of interior Alaska are poorly understood, but may host undiscovered hydrocarbon resources in sufficient quantities to serve remote villages and for possible export. Purported oil seeps and the regional occurrence of potential hydrocarbon source and reservoir rocks fuel an exploration interest in the 46,000 km^2 Yukon Flats basin. Whether hydrocarbon source rocks are present in the pre-Cenozoic basement beneath Yukon Flats is difficult to determine because vegetation and surficial deposits obscure the bedrock geology, only limited seismic data are available, and no deep boreholes have been drilled. Analysis of regional potential field data (aeromagnetics and gravity) is valuable, therefore, for preliminary characterization of basement lithology and structure.

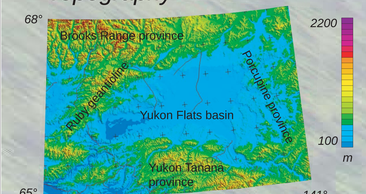
We present our analysis as a red-green-blue composite spectral map consisting of: (1) reduced-to-the-pole magnetics (red), (2) magnetic potential (green), and (3) basement gravity (blue). The color and texture patterns on this composite map highlight domains with common geophysical characteristics and, by inference, lithology. The observed patterns yield the primary conclusion that much of the basin is underlain by Devonian to Jurassic oceanic rocks related to the Angayucham and Tozitna terranes (JDat). These rocks are part of a lithologically diverse assemblage of brittlely deformed, generally low-grade metamorphic rocks of oceanic affinity; such rocks probably have little or no potential for hydrocarbon generation.

The JDat geophysical signature extends from the Tintina fault system northward to the Brooks Range. Along the eastern edge of the basin, JDat appears to overlie moderately dense and non-magnetic Proterozoic(?) and Paleozoic continental margin rocks. The western edge of the JDat in subsurface is difficult to distinguish due to the presence of magnetic granites similar to those exposed in the Ruby geanticline. In the southern portion of the basin, geophysical patterns indicate the possibility of overthrusting of Cenozoic sediments and underlying JDat by Paleozoic and Proterozoic rocks of the Schwatka sequence. These structural hypotheses provide the basis for an overthrust play within the Cenozoic section just south of the basin.

Index map



Topography



GEOLOGIC UNITS

UNITS PRESENT IN MORE THAN ONE PROVINCE

Qu Unconsolidated and poorly consolidated sediments, undivided (Quaternary)
Tb Basalt flows and rare cinder cones (Tertiary)
Tg Granitic rocks (Tertiary)
Ts Clastic sedimentary rocks (Tertiary)
TKs Sedimentary rocks (Tertiary and Cretaceous)
Kg Granitic rocks (Cretaceous)
TRPgt Glenn Shale, lower part, and Tahkandit Limestone, undivided (Triassic and Permian)
JDat Angayucham-Tozitna terrane, undivided (Early Jurassic to Devonian)

BROOKS RANGE PROVINCE

Tv Volcanic rocks (Tertiary)
Kkyu Sedimentary rocks of the Yukon-Koyukuk basin, undivided (Cretaceous)
KDe Sedimentary rocks of the Endicott Mountains allochthon of Moore and others (1994) (Cretaceous to Devonian)
TRPzd Metasedimentary, metavolcanic, and sedimentary rocks of the Doonerak area (Triassic to lower Paleozoic)
Mbu Rocks of Brooks Range sequence of Brosgé and Reiser (2000), undivided, (Mississippian)
Pzvu Sedimentary rocks of the Venetie terrane of Silberling and others (1994), undivided (Paleozoic)
DZs Metamorphosed sedimentary rocks (Devonian to Proterozoic)
PzpCb Metasedimentary and metaigneous rocks of the southern Brooks Range and Ruby geanticline, (Paleozoic and (or) Precambrian)

PORCUPINE PROVINCE

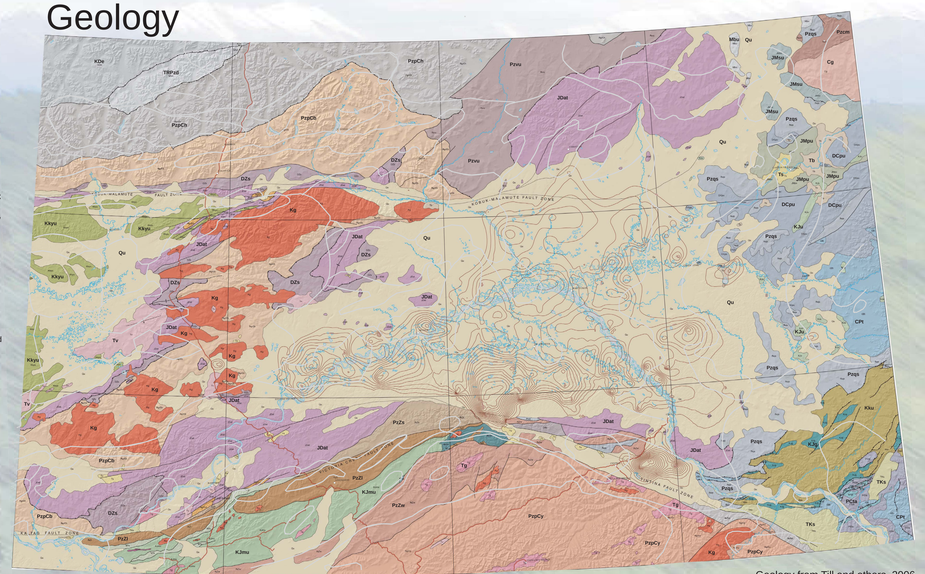
Kku Sedimentary rocks of the Kandik basin, undivided (Cretaceous)
KJg Glenn Shale, upper part (Lower Cretaceous and Jurassic?)
KJu Sedimentary rocks, undifferentiated (Cretaceous? and Jurassic?)
JMsu Strangle Woman Creek sequence of Brosgé and Reiser (1969), undivided (Jurassic to Mississippian)
Cg Granite (Carboniferous)
Pzcm Metamorphic rocks (Paleozoic?)
Pzqs Sedimentary and igneous rocks (Paleozoic)
JMpu Younger strata of the Porcupine River sequence of Brosgé and Reiser (1969), undivided (Jurassic to Mississippian)
DCpu Older strata of the Porcupine River sequence of Brosgé and Reiser (1969), undivided (Devonian to Cambrian)
PCta Sedimentary rocks of the Tatonduk area (Permian to Cambrian)
CPt Sedimentary rocks of the Tindir Group, (Cambrian? and Proterozoic)

YUKON-TANANA PROVINCE

KJmu Sedimentary rocks of the Manley basin, undivided (Cretaceous and Jurassic) –Mzmv Fine-grained sedimentary rocks and tuff (Mesozoic?)
TRPs Sedimentary rocks (Triassic to Early Permian)
MzPza Low-grade metamorphic rocks (Mesozoic? and (or) Paleozoic?)
DSc Metamorphosed sedimentary rocks (Devonian and Silurian)
Pzum Ultramafic rocks (Paleozoic?)
PzZs Sedimentary and igneous rocks corresponding to older parts of the Schwatka - Rampart area sequence of Weber and others (1992) (Paleozoic to Proterozoic)
PzZl Sedimentary and igneous rocks corresponding to the Livengood area sequence of Weber and others (1992) (Paleozoic to Proterozoic)
PzZw Sedimentary and igneous rocks corresponding to the older parts of the Fairbanks-White Mountains area sequence of Weber and others (1992) (Paleozoic to Proterozoic)
PzpCy Metamorphic rocks of the Yukon-Tanana Upland, undivided (Paleozoic to Precambrian?)

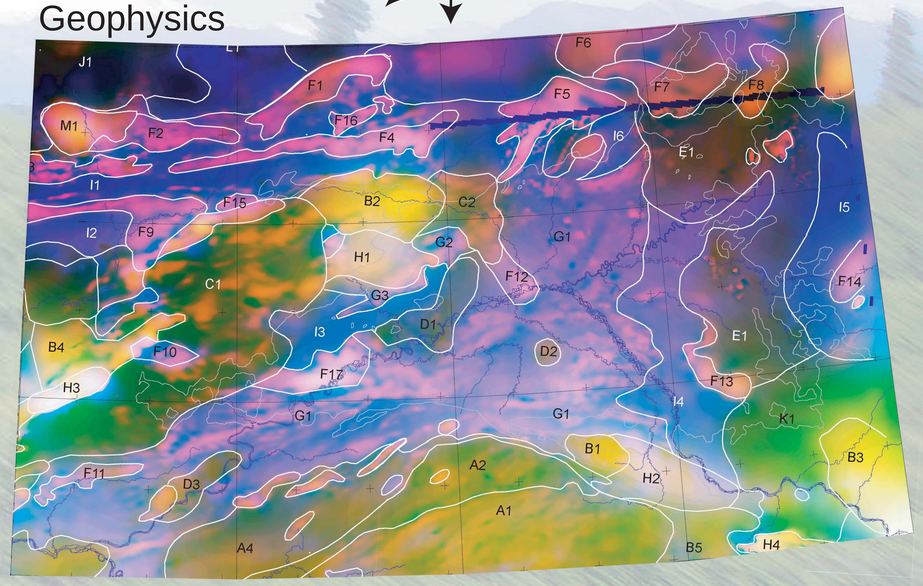
See Till and others (2006) for complete geologic unit descriptions

Geology

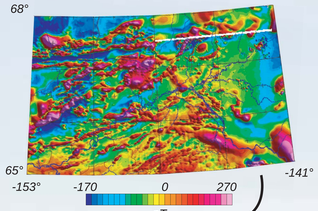


Geology from Till and others, 2006

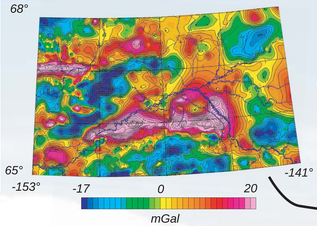
Geophysics



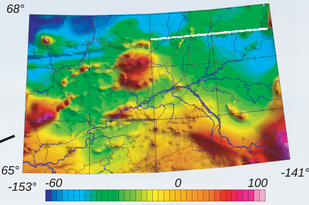
Reduced-to-pole Aeromagnetics



Basement Gravity

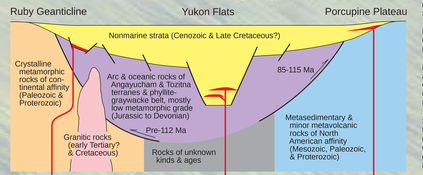


Magnetic Potential



0 km 100

Yukon Flats schematic geology



Yukon Flats Geophysical Domains

Label	Description	Geological Association	Geophysical Interpretation	Risk*
A1	Mottled yellow-green, NE-SW grain	Yukon-Tanana terrane (**PzpCy**)	Gravity lows reflect pervasive felsic plutonism, mag highs reflect metamorphic minerals and grain.	M
A2	More dark green than A1, NE-SW grain	White Mountain terrane (**PzZw**)	Similar to A1 except less pluton volume and more subdued magnetic grain.	M
A3	More blotchy than A1, less grain	Yukon-Tanana terrane (off of map area to south)	Similar to A1 except less pluton volume and blotchy magnetic grain.	M
A4	Colors more subdued than A1, no grain	Manley and Livengood terranes (**KJmu**)	Overall felsic character, no magnetic grain.	M
B1	Uniform yellow	Crooked Creek (Tintina trough) basin (**Qu**)	Cenozoic basin.	M
B2	Mostly yellow, boundaries indistinct	Mixed, incl. granite, quaternary, Schist belt, (**Kg**, **Qu**, **PzpCb**)	Voluminous felsic plutons.	H
B3	Yellow, gradational boundary to green (K1)	Tatonduk terrane, Kandik, Glen Shale, Tert. Sedx, Porcupine (**Kku**, **KJg**, **PCta**, **TrPs**)	Thick Kandik sediments – Tatonduk terrane (NA affinity).	M
B4	Yellow with green strands	Quaternary cover, Tertiary volcanics (**Qu**, **Tv**, **Kkyu**)	Thick Cenozic sediments and/or felsic plutons.	M
B5	Faded yellow & blue	Granite, YTT (**Kg**, **PzpCy**)	Felsic plutons	M
C1	Mottled orange pattern on green background	Schist belt, granite (**PzpCb**, **Kg**)	Schist belt (green field) with extensive felsic zerrusion (orange blotches).	M

*Risk denotes relative confidence in geophysical interpretation

C2	Pattern more faded than C1	Schist belt, Quaternary cover, (**PzpCb**, **Qu**)	Thin schist belt over Tozitna.	M
D1	Diffuse yellow-green stain over blue sky background	Entirely covered by Yukon Flats basin Quaternary (**Qu**)	Cenozoic sediments or felsic plutons over Tozitna.	M
D2	Small yellow stain	Ditto (**Qu**)	Felsic pluton intruded into Tozitna?	M
D3	Yellow stain	Quat cover and Angayucham-Tozitna (**Qu**, **JDat**)	Cenozoic sediments or felsic pluton.	M
E1	Diffuse prune color with a few scattered RTP highs	Quat cover, Angayucham-Tozitna, and Porcupine (**Qu**, **JDat**, **DCpu**)	Thick, low-density, mostly non-magnetic crustal section. No Angayucham-Tozitna.	H
F1	Bright pink	Hammond terrane (**PzpCb**)	Mafic belt	L
F2	ditto	Ditto (**PzpCb**)	Mafic belt	L
F3	ditto	Schist belt (**PzpCb**)	Mafic belt	L
F4	ditto	Ditto (**PzpCb**)	Mafic belt	L
F5	ditto	Angayucham-Tozitna (**JDat**)	Mafic belt	L
F6	ditto	Ditto (**JDat**)	Mafic belt	L
F7	ditto	Angayucham-Tozitna (**JDat**)	Mafic belt	L
F8	ditto	Ditto (**JDat**)	Mafic belt	L
F9	ditto	Angayucham-Tozitna and cover rocks (**JDat**, **Qu**)	Mafic belt	L
F10	ditto	Ditto (**JDat**, **Qu**)	Mafic belt	L
F11	Faded pink	Quaternary cover (**Qu**)	Mafic belt	L
F12	ditto	Ditto (**Qu**)	Mafic belt	L
F13	ditto	Ditto (**Qu**)	Mafic belt	L
F14	ditto	Porcupine (**DCpu**, **Gb**)	Mafic belt	L
F15	Bright pink	Angayucham-Tozitna (**JDat**)	Mafic belt	L
F16	ditto	Schist belt (**PzpCb**)	Mafic belt	L
F17	Faded pink	Quaternary cover (**Qu**)	Mafic belt	L
G1	Blue sky with light pink clouds	Angayucham-Tozitna, Quaternary cover (**JDat**, **Qu**)	Angayucham-Tozitna basement	L
G2	Ditto	Quaternary cover (**Qu**)	Angayucham-Tozitna basement	L
G3	Ditto	Quaternary cover (**Qu**)	Angayucham-Tozitna basement	L
H1	Uniform light pink/white	Quaternary cover (**Qu**)	Mafic intrusion	H
H2	Mostly light pink/white with blue fringes	Quaternary cover (**Qu**)	Mafic intrusion	M
H3	Bright white	Quaternary cover (**Qu**)	Mafic intrusion	H
H4	White with yellow tint	Yukon-Tanana, Porcupine, Tertiary seds (**PzpCy**, **Kg**, **Ts**)	Mafic intrusion	M
I1	Blue with minor pink strands	Phyllite belt, Angayucham-Tozitna (**Pzpg**, **JDat**)	Dense, non-magnetic basement. Limestone, marble, argillite, possible.	M
I2	Pure blue	Yukon-Koyukuk (**Kkyu**)	Dense, non-magnetic basement. Limestone, marble, argillite, possible.	M
I3	Light blue	Quaternary cover, Angayucham-Tozitna (**Qu**, **JDat**)	Dense, non-magnetic basement. Non-magnetic Angayucham-Tozitna or Limestone, marble, argillite, etc.	M
I4	Light blue, hazy pink zones	Quaternary cover (**Qu**)	Dense, non-magnetic basement. Limestone, marble, argillite, possible.	M
I5	Blue, one faint pink zone	Porcupine (**DCpu**, **Gb**)	Dense, non-magnetic basement. Limestone, marble, argillite, possible.	M
I6	Blue	Quaternary cover (**Qu**)	Dense, non-magnetic basement. Limestone, marble, argillite, possible.	M
J1	Mottled black	Endicott Mountains, North Slope, Hammond (**KDe**, **TrPzd**, **PzpCb**)	Low density, non-magnetic basement.	L
J2	Mottled black	Ditto (**KDe**, **TrPzd**, **PzpCb**)	Low density, non-magnetic basement.	L
K1	Uniform green/yellow	Kandik – Tatonduk terrane (**Kku**, **Pzqs**)	Thick sedimentary section	M
L1	Blue with some black	Endicott Mountains, North Slope, Hammond (**TrPzd**, **PzpCb**)	Dense, non-magnetic basement.	L
M1	Pink/orange	Hammond terrane (**PzpCb**)	Thick mafic belt/intrusion	M

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