Stratigraphy, Sedimentology, and Hydrocarbon Reservoir Potential of the Lower Cretaceous Jackass Mountain Group, Chilko Lake area, British Columbia

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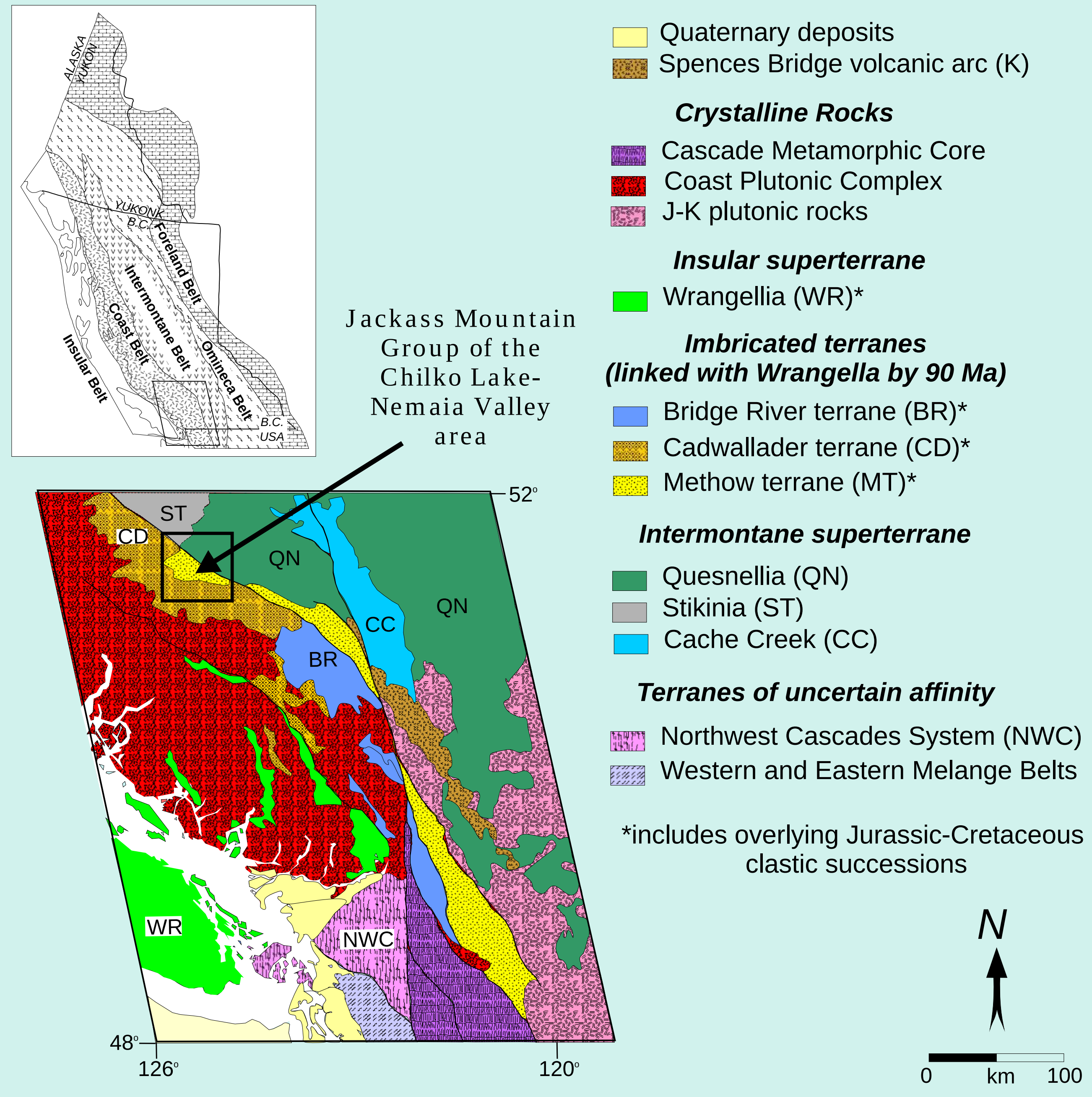
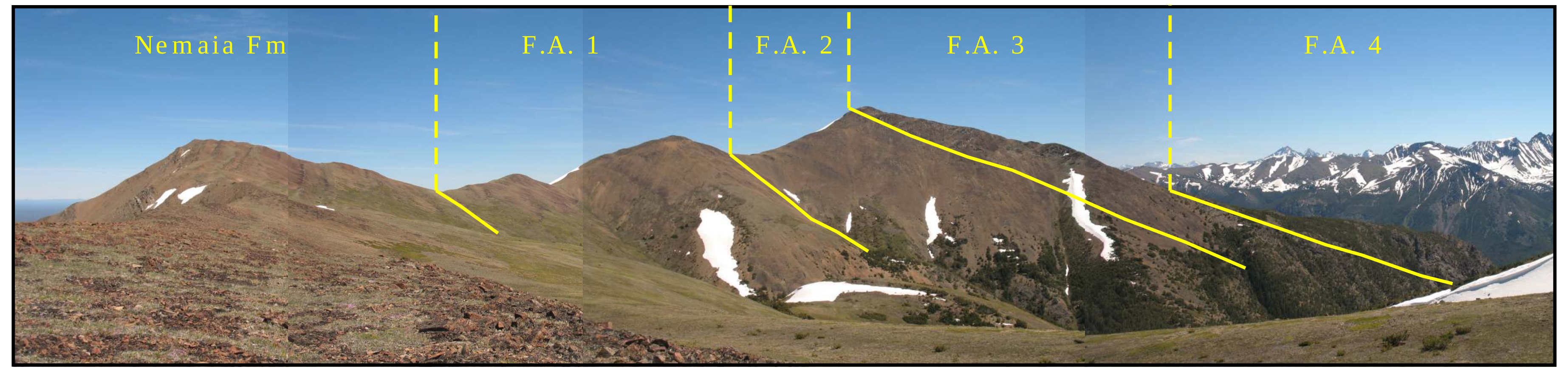
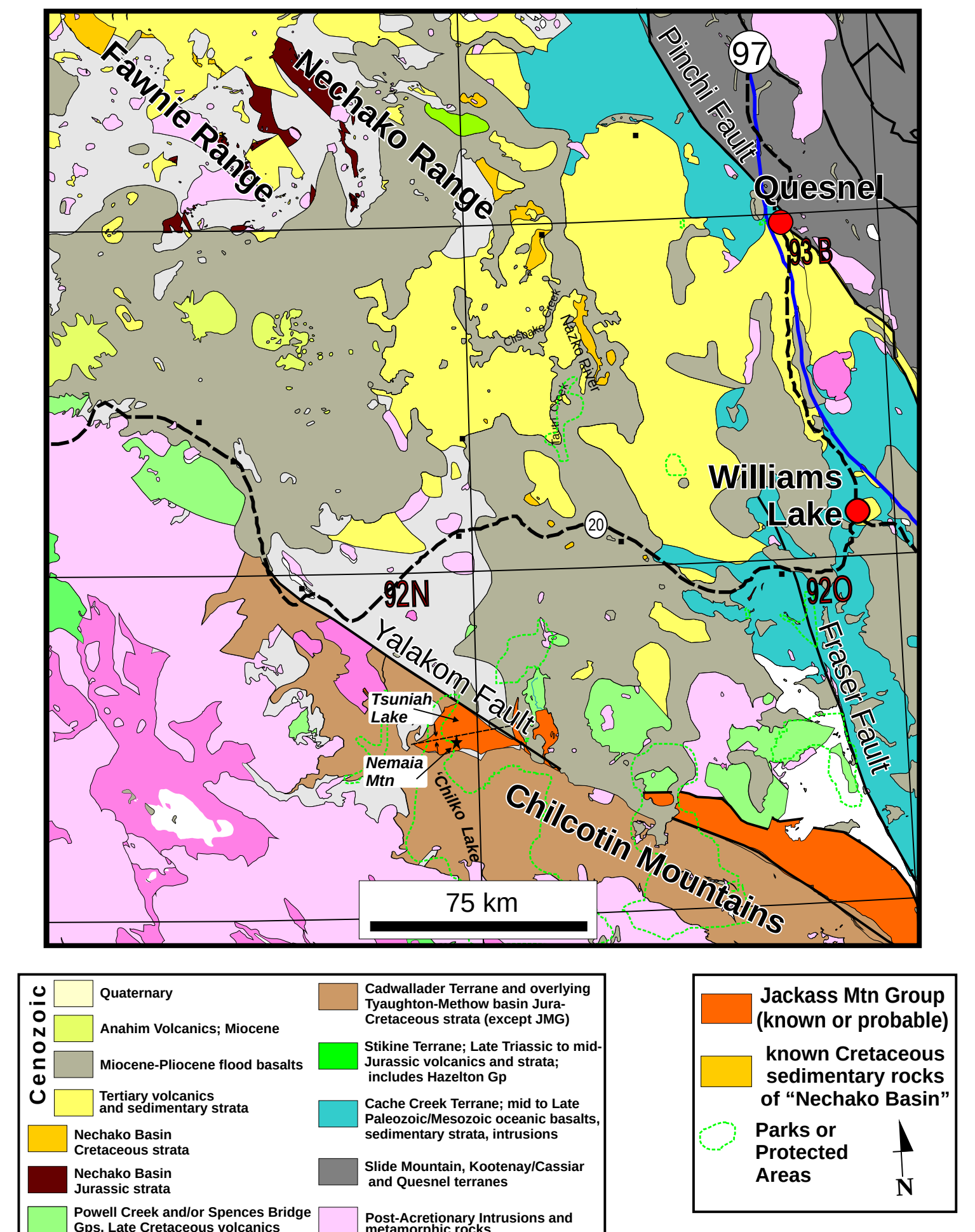
Introduction

The Lower Cretaceous Jackass Mountain Group (JMG), near Chilko Lake in south-central British Columbia, is exposed southwest of the dextral Yalakom Fault and has been traditionally considered part of the Jura-Cretaceous Methow-Tyaughton Basin. The JMG in this area is over 2 km thick and unconformably overlies the Middle Jurassic Nemaia Formation and mid- to Upper Jurassic Relay Mountain Group. Preliminary data indicate an age range of Hauterivian to Albian. The rocks are exposed in a major east-northeast-trending synclinorium, which permits detailed examination of the lateral and vertical facies variations within the JMG. Detailed stratigraphic and sedimentologic analysis of JMG strata documents extensive shallow marine deposition, contrary to previous interpretations that described the bulk of the JMG as the deposits of deep submarine fan systems. In the northern limb of the syncline, over half of the strata are interpreted as shelf to shoreface deposits. These strata include extensive, moderately well-sorted sandstone bodies, decimetres thick, with common trough and hummocky cross-stratification, interpreted to represent high energy shoreface environments. Flaser and lenticular bedded facies also suggest that lower energy shoreface environments were widespread. These shallow marine strata are overlain by classic turbidite sequences, suggesting that in this area the basin evolved from shallow marine to outer shelf/slope environments over time. The JMG outcrops in the study area contain many similarities with exposed Cretaceous strata across the Yalakom Fault and 125 km to the southeast; the strata east of the fault dip northward beneath Tertiary basalts which cover subsurface Mesozoic stratigraphy. Assuming correlation with subsurface Lower Cretaceous Nechako Basin strata, the thick and extensive shoreface sandstones of the JMG in the Chilko Lake area provide a new subsurface hydrocarbon target with good reservoir potential, in addition to the previously identified submarine fan sandstone lithofacies. Ongoing geochronologic, geochemical, paleontological, and porosity/permeability analyses will help to constrain basin evolution and reservoir suitability.

Regional Geologic Setting


ALASKA
YUKON
YUKON
B.C.
Foreland Belt
Intermontane Belt
Coast Belt
Omineca Belt
Insular Belt
B.C.
USA
Jackass Mountain Group of the Chilko Lake-Nemaia Valley area
ST
CD
QN
QN
CC
BR
WR
NWC
52°
48°
126°
120°
N
0 km 100
Quaternary deposits
Spences Bridge volcanic arc (K)
Crystalline Rocks
Cascade Metamorphic Core
Coast Plutonic Complex
J-K plutonic rocks
Insular superterrane
Wrangellia (WR)*
Imbricated terranes
(linked with Wrangella by 90 Ma)
Bridge River terrane (BR)*
Cadwallader terrane (CD)*
Methow terrane (MT)*
Intermontane superterrane
Quesnellia (QN)
Stikinia (ST)
Cache Creek (CC)
Terranes of uncertain affinity
Northwest Cascades System (NWC)
Western and Eastern Melange Belts
*includes overlying Jurassic-Cretaceous clastic successions


Nemaia Fm
F.A. 1
F.A. 2
F.A. 3
F.A. 4


Fawnie Range
Nechako Range
Pinchi Fault
97
Quesnel
93B
Williams Lake
20
92N
92O
Yalakom Fault
Fraser Fault
Tsuniah Lake
Nemaia Mtn
Chilko Lake
Chilcotin Mountains
75 km
Cenozoic
Quaternary
Anahim Volcanics; Miocene
Miocene-Pliocene flood basalts
Tertiary volcanics and sedimentary strata
Nechako Basin Cretaceous strata
Nechako Basin Jurassic strata
Powell Creek and/or Spences Bridge Gps, Late Cretaceous volcanics
Gambier Gp; Early Cret. volcanics
Cadwallader Terrane and overlying Tyaughton-Methow basin Jura-Cretaceous strata (except JMG)
Stikine Terrane; Late Triassic to mid-Jurassic volcanics and strata; includes Hazelton Gp
Cache Creek Terrane; mid to Late Paleozoic/Mesozoic oceanic basalts, sedimentary strata, intrusions
Slide Mountain, Kootenay/Cassiar and Quesnel terranes
Post-Acretionary Intrusions and metamorphic rocks
Pre-mid Jurassic Intrusions
Jackass Mtn Group (known or probable)
known Cretaceous sedimentary rocks of "Nechako Basin"
Parks or Protected Areas
N

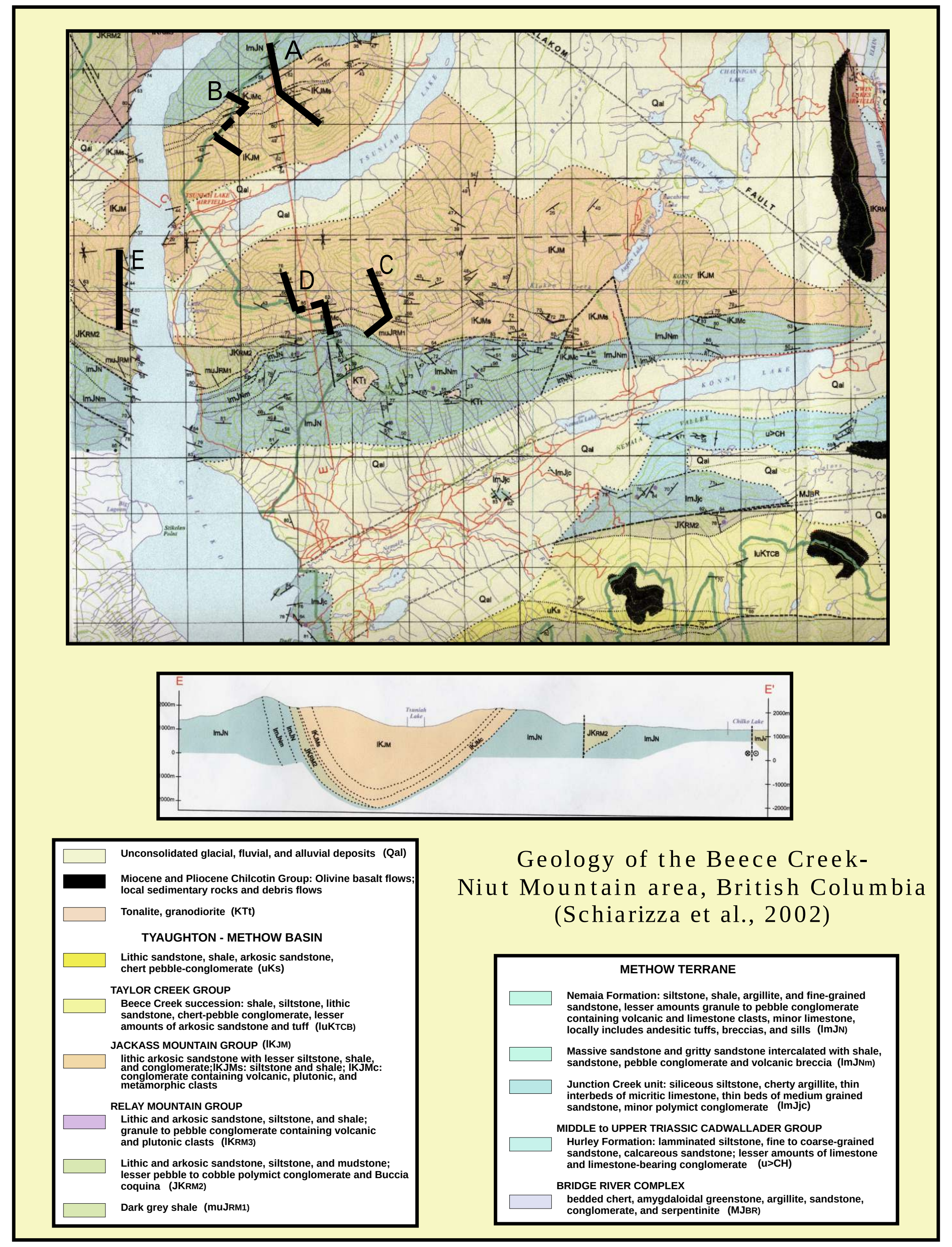
(from Mustard et al., 2008, modified after Ferri and Riddell, 2006 and Riddell, 2006)

Regional Tectonic Setting

The JMG has been traditionally considered to be part of the Methow-Tyaughton Basin. This Mesozoic Basin has been generally considered as part of an overlap assemblage, linking the western edge of the Intermontane Belt (most importantly Cache Creek, Bridge River, Stikinia, and Quesnellia terranes) with the eastern edge of the Insular Belt (most importantly the Wrangellia Terrane) (Kleinspehn, 1982)(Figure to the left). The JMG represents most of the Early Cretaceous sedimentation within this basin and is thought to have formed in a forearc setting (Kleinspehn, 1982,1985; Garver, 1992,1995). The JMG in the Chilko Lake area is located to the south-southwest of the Nechako Basin and is offset ~150±25 km by the Yalakom Fault (Kleinspehn, 1985; Schiarizza and Riddell, 1997).

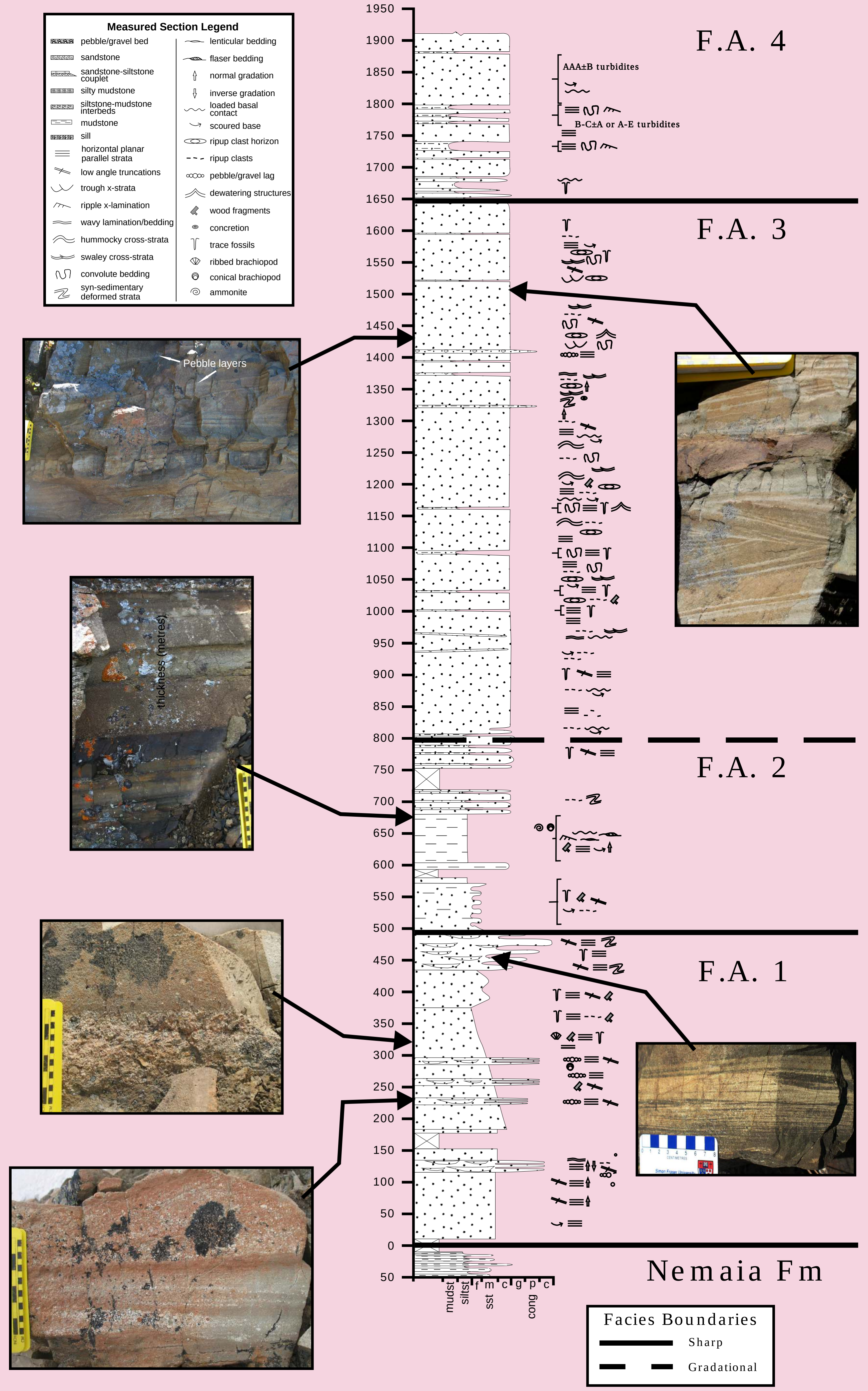
Measured Section A (above):

Section A was completed during the summer of 2007 and can be broken in to four distinct facies associations that range from offshore/shelf to upper shoreface environments. Three more sections (B, C, D) are in progress and will be completed during the 2008 field season. Preliminary observations suggest that the southern sections (C & D) may represent more distal environments within the basin. Section E will tentatively be completed in 2008.


A
B
C
D
E
E
E'
Unconsolidated glacial, fluvial, and alluvial deposits (Qal)
Miocene and Pliocene Chilcotin Group: Olivine basalt flows; local sedimentary rocks and debris flows
Tonalite, granodiorite (KTt)
TYAUGHTON - METHOW BASIN
Lithic sandstone, shale, arkosic sandstone, chert pebble-conglomerate (uKs)
TAYLOR CREEK GROUP
Beece Creek succession: shale, siltstone, lithic sandstone, chert-pebble conglomerate, lesser amounts of arkosic sandstone and tuff (luKTCB)
JACKASS MOUNTAIN GROUP (lKJM)
lithic arkosic sandstone with lesser siltstone, shale, and conglomerate;lKJMs: siltstone and shale; lKJMc: conglomerate containing volcanic, plutonic, and metamorphic clasts
RELAY MOUNTAIN GROUP
Lithic and arkosic sandstone, siltstone, and shale; granule to pebble conglomerate containing volcanic and plutonic clasts (lKRM3)
Lithic and arkosic sandstone, siltstone, and mudstone; lesser pebble to cobble polymict conglomerate and Buccia coquina (JKRM2)
Dark grey shale (muJRM1)
METHOW TERRANE
Nemaia Formation: siltstone, shale, argillite, and fine-grained sandstone, lesser amounts granule to pebble conglomerate containing volcanic and limestone clasts, minor limestone, locally includes andesitic tuffs, breccias, and sills (lmJN)
Massive sandstone and gritty sandstone intercalated with shale, sandstone, pebble conglomerate and volcanic breccia (lmJNm)
Junction Creek unit: siliceous siltstone, cherty argillite, thin interbeds of micritic limestone, thin beds of medium grained sandstone, minor polymict conglomerate (lmJjc)
MIDDLE to UPPER TRIASSIC CADWALLADER GROUP
Hurley Formation: lamminated siltstone, fine to coarse-grained sandstone, calcareous sandstone; lesser amounts of limestone and limestone-bearing conglomerate (u>CH)
BRIDGE RIVER COMPLEX
bedded chert, amygdaloidal greenstone, argillite, sandstone, conglomerate, and serpentinite (MJBR)

Geology of the Beece Creek-Niut Mountain area, British Columbia (Schiarizza et al., 2002)

Measured Stratigraphic Section A
Northern Limb of the Tsuniah Lake Syncline


Measured Section Legend
pebble/gravel bed
sandstone
sandstone-siltstone couplet
silty mudstone
siltstone-mudstone interbeds
mudstone
sill
horizontal planar parallel strata
low angle truncations
trough x-strata
ripple x-lamination
wavy lamination/bedding
hummocky cross-strata
swaley cross-strata
convolute bedding
syn-sedimentary deformed strata
lenticular bedding
flaser bedding
normal gradation
inverse gradation
loaded basal contact
scoured base
ripup clast horizon
ripup clasts
pebble/gravel lag
dewatering structures
wood fragments
concretion
trace fossils
ribbed brachiopod
conical brachiopod
ammonite
Pebble layers
thickness (metres)
1950
1900
1850
1800
1750
1700
1650
1600
1550
1500
1450
1400
1350
1300
1250
1200
1150
1100
1050
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
50
AAA±B turbidites
B-C±A or A-E turbidites
F.A. 4
F.A. 3
F.A. 2
F.A. 1
Nemaia Fm
mudst
siltst
f
m
c
sst
g
p
c
cong
Facies Boundaries
Sharp
Gradational

Preliminary Interpretations

F.A. 1 is interpreted to be a high energy storm-dominated middle shoreface setting undergoing an overall transgression. F.A. 2 represents a transgression or a decrease in energy into a lower shoreface to upper offshore environment where tempestites are still being deposited, but fairweather deposition dominates. The shift back into the storm dominated deposits of F.A. 3 requires a gradational regression to the upper shoreface, where trough cross strata can be formed. The abrupt change to fine grained sediments and graded sands may represent a rapid transgression to an offshore/shelf environment where sediment is deposited within a submarine fan complex. This interpretation varies greatly from previous interpretations that claimed that the JMG was dominated by deep water submarine fan complex deposition (Kleinspehn, 1982; 1985).

Facies Association 4

The base of this facies association consists of 20 m of mudstone with abundant bioturbation and planar laminated muds. There is a sharp contact between these muds and the underlying sands of F.A. 3. This fine grained section is overlain by medium to thick bedded, normally graded, sandstone beds that are occasionally topped by planar strata. The sands are overlain by convolute to ripple- cross laminated siltstones that are periodically overlain by planar laminated silt or mudstones. The base of the sandstone beds are typically loaded and scour into the underlying muds.

Facies Association 3

This facies association is characterised by green-blue, thick-bedded sandstone interbedded with silty mudstone intervals that range in size from 5 cm to 5 m, but are on average 20 cm thick. The sandstone displays planar stratification that grades into hummocky, swaley and lesser trough cross strata. Gravel stringers and lenses are common in the middle of the section where these sedimentary structures are abundant. The sandstones beds scour into the mudstone layers and frequently contain rip ups (1 cm to 2 m). The mudstone is characterised by convolute bedding and occasional bioturbation that increases away from the middle of the section. Dewatering structures and loaded bases are extremely common between the sandstone/mudstone bedding contacts.

Facies Association 2

This facies association contains two distinct members:

F.A. 2a: The lower member is characterised by alternating beds (thin ~ 5cm) of planar parallel laminated sandy siltstone and a nondescript, black, recessive siltstone to mudstone. The sandy siltstone contains scour marks, wood fragments and rip up clasts of black mudstone. Bioturbation is abundant, but not diverse.

F.A. 2b: The upper member consists of interbedded black shale, siltstone, and sandstone beds. Shale is the dominant lithology and contains sporadic ammonite and conical bivalve fossils. The siltstone displays planar parallel laminations, current ripple laminations, wavy and flaser bedding. Thin bedded (2-6 cm) beds of normally graded sandstone scour into the shale and siltstone beds. Thicker (<1.5 m) beds of sandstone containing large mud rip up clasts are also interbedded marking a gradational change into F.A. 3.

Facies Association 1

This facies association is characterised by a homogeneous grey blue to bluish green, medium grained, well sorted sandstone (sublithic feldspathic arenite) that weathers to a tan-green to brown colour. Bedding is medium to thick (>7 cm) and displays abundant normally graded beds, planar parallel lamination and rare low angle truncations. Gravel lenses (10 cm x ~20 cm) and beds (<30 cm) occur interbedded with the sandstone in some intervals and display poorly sorted, local inverse gradation (grade from matrix to clast supported), sharp basal contacts, and planar stratification. Clast-supported conglomeratic lenses (1.5 m x 4 m) that have sharp basal and upper contacts are also present. Wood fragments, burrowing, and conical and ribbed bivalves are present. Soft sediment deformation is rare.

References
Ferri, F. and Riddell, J. (2006) The Nechako Basin project: new insights from the southern Nechako Basin. In: Summary of Activities 2006, BC Ministry of Energy, Mines and Petroleum Resources, URL <http://www.em.gov.bc.ca/subwebs/oilandgas/pub/reports/summary2006.htm>, [November 2007], 89–124.
Riddell, J.M., compiler (2006) Geology of the southern Nechako basin, NTS 92N, 92O, 93B, 93C, 93F, 93G; BC Ministry of Energy, Mines and Petroleum Resources, Petroleum Geology Map 2006-1, scale 1:400 000.
Kleinspehn, K.L. (1982) Cretaceous sedimentation and tectonics, Tyaughton-Methow basin, southwestern British Columbia. In: Canadian Journal of Earth Sciences, 22, 154-174.
Kleinspehn, K.L. (1985) Cretaceous sedimentation and tectonics, Tyaughton-Methow basin, southwestern British Columbia. In: Ph.D. thesis, Princeton University, 184 p.
Schiarizza, P., and Riddell, J. (1997) Geology of the Tatlayoko Lake – Beece Creek area. In: Interior Plateau Geoscience Project: Summary of Geological, Geochemical and Geophysical Studies; BC Ministry of Energy, Mines and Petroleum Resources, Paper 1997-2 and Geological Survey of Canada Open File 3448, 63-101.
Schiarizza, P., Gaba, R.G., Glover, J.K., Garver, J.I., and Umhoefer, P.J. (1997) Geology and mineral occurrences of the Taseko-Bridge River area; BC Ministry of Energy Mines and Petroleum Resources Bulletin, 100, 291 p.
Schiarizza, P., Riddell, J., Gaba, R.G., Melville, D.M., Umhoefer, P.J., Robinson, M.J., Jennings B.K. and Hick, D. (2002) Geology of the Beece Creek–Nuit Mountain area, B.C.(NTS 92N/8, 9, 10; 92O/5, 6, 12); BC Ministry of Energy, Mines and Petroleum Resources, Geoscience Map 2002-3, scale 1:50 000.144. In: Geoscience BC Summary of Activities 2007.