Stratigraphic Analysis of Cretaceous Strata flanking the Southern Nechako Basin: Constraining basin Architecture and Reservoir Potential

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Summary

The Jackass Mountain Group (JMG) is a thick (1000's of metres) Lower Cretaceous siliciclastic succession that crops out along the southern margin of the Nechako Basin, a Mesozoic-Tertiary sedimentary basin in the west-central interior of British Columbia considered underexplored for hydrocarbons. A possible correlative to thick subsurface Lower Cretaceous successions known to exist in the subsurface of the Nechako Basin, our detailed analysis of JMG architecture and reservoir potential suggests that the JMG, previously interpreted as dominantly the result of submarine fan deposition, actually comprises a vertically and laterally complex system with non-marine, shallow marine and sub-wavebase fan marine deposits. All deposystems include thick successions with extensive moderate- to well-sorted sandstone facies, potentially high priority targets for hydrocarbon exploration if these surface strata continue to the north into the subsurface of the Nechako Basin.

Introduction

The Nechako Basin is part of the Interior Plateau physiographic region of British Columbia and has been variously defined in terms of extent and age (Ferri and Riddell, 2006). Accurate assessment of the petroleum potential of the Nechako Basin hinges on a comprehensive understanding of the basin architecture developed within Cretaceous strata, which represent the most prospective targets in the subsurface. Modeling the subsurface distribution of these strata requires detailed stratigraphic analysis of coeval, laterally adjacent strata exposed along the basin margins. The age and general lithologic character of strata in the subsurface of the Nechako Basin are broadly known from industry drill holes and examination of isolated outcrops of Cretaceous strata exposed beneath extensive Neogene volcanic cover (reviewed in Ferri and Riddell, 2006). At the southern end of the

Nechako Basin, Lower Cretaceous Jackass Mountain Group (JMG) strata are unconformably overlain by Cenozoic volcanic rocks (Figure 1). The Cretaceous strata are generally classified as part of the Methow or Tyaughton Basins, but are possibly the surface expressions of strata that continue northward into the subsurface of the Nechako Basin.

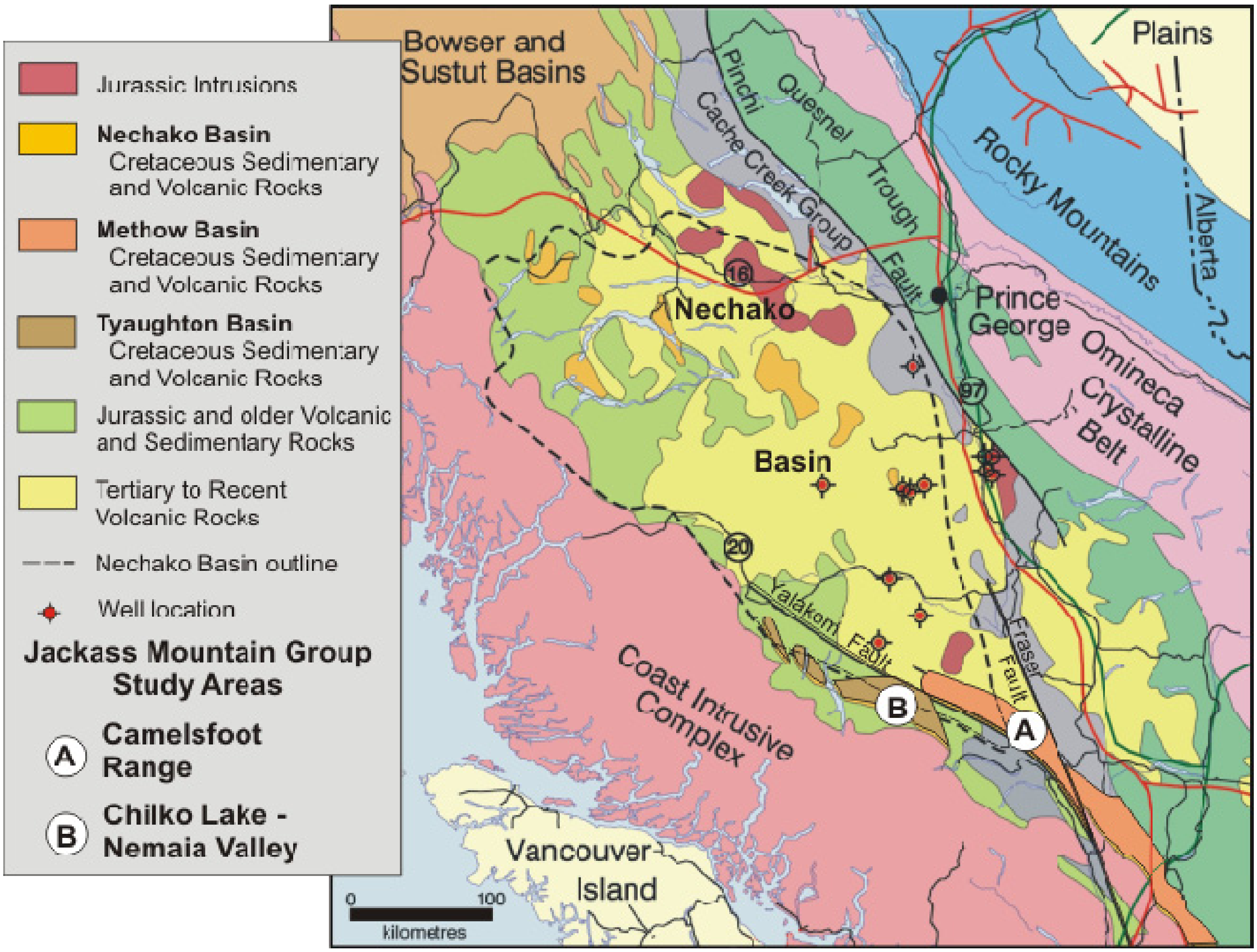

Figure 1: Regional location of main basins and study areas.

The JMG and associated strata include thick (>1000 m), laterally extensive (>10 km) sandstone successions that overlie and interfinger with mudstones. Previous studies have interpreted them as the deposits of large submarine fan deposystems (Kleinspehn, 1982, 1985), although Schiarizza et al. (1997) identified some areas of nonmarine strata, which they considered to be part of the JMG. Our emphasis on the Jackass Mountain Group reflects our hypothesis that this unit is probably the best candidate for major reservoir systems in the subsurface of the Nechako Basin. We suggest that JMG strata represent the closest surface analogue and most likely direct correlative to the "Skeena Assemblage" of the subsurface, which has been interpreted by Hannigan et al. (1994) to contain "the most significant petroleum plays in this assessment."

Study Details

Our study concentrates on two areas of well exposed JMG along the southern margin of the Nechako Basin (localities A and B on Figure 1). In the Camelsfoot Range (locality A). the JMG be subdivided into three major facies associations, which roughly correspond to southern, central, and northern geographic areas. In the south, directly northeast of the Yalakom Fault, the thick succession includes massive sandstones that were deposited as sediment gravity flows (mostly turbidites) in a sub-wavebase, marine environment. In the central portion of the study area, the interbedded turbiditic sandstones and siltstones were most likely deposited near or within the migrating lobes of an active submarine fan system. However, common wave reworking of the upper parts of many turbidites indicates that depth was typically above storm wavebase, suggesting a relatively shallow shelf environment, possibly transitional to a marginal marine shoreline regime. It is considered likely that these shallow shelf turbidites comprise distal (e.g. pro-deltaic) deposits of river-dominated delta or fan delta systems, rather than as parts of deeper water submarine fan systems. The facies exposed in the north Camelsfoot Range are indicative of nonmarine fluvial, floodplain, and possible lacustrine environments.

Assuming that the JMG study area in the Camelsfoot Range is all part of the same structural block, these three major facies associations likely represent both lateral and vertical changes in basin depositional patterns over time. The southern submarine fan sandstones may represent the base of a relative marine regression, whereas the central facies of shallow marine turbidites may reflect either progressive shallowing of the basin over time or a time-equivalent, but more proximal marine facies in the northern part of the study area. The nonmarine succession represents either a more proximal part of the basin or a progressive shallowing of JMG deposition over time. The current lack of age control on the non-marine unit and possibility of structural separation from the other facies makes either interpretation feasible at this stage of the study.

A similar detailed stratigraphic study of JMG and related strata is underway in the Chilko Lake – Nemaia Valley area (locality B on Figure 1). 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 (Schiarizzi et al., 2002). 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 documents extensive shallow marine deposition, contrary to previous interpretations that described the bulk of the JMG as the deposits of deep-water submarine fan systems. In the northern limb of the syncline, over half of the strata are interpreted as shelf to shoreface deposits. These 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 Cretaceous strata exposed across the Yalakom Fault and 125 km to the southeast in the Camelsfoot Range. We interpret these areas to have been near contiguous depositional systems during formation.

Conclusions

The presence in the Jackass Mountain Group of extensive and extremely thick facies intervals interpreted to represent shallow marine and non-marine environments is surprising, given that the prinicpal previous study of the JMG interpreted it as dominated by submarine fan deposits that accumulated in relatively deep-water (sub-wavebase) environments (Kleinspehn, 1982, 1985). In the Camelsfoot Range, sub-wavebase submarine fan facies are present as a thick succession immediately northeast of the Yalakom Fault. However, the JMG in large areas of the northern Camelsfoot Range comprises non-marine fluvial and possibly lacustrine successions. In addition, the central Camelsfoot Range contains extensive exposures of sandstone-mudstone turbidites, but with common reworking of the tops of these turbidites by wave processes, indicating a relatively shallow marine environment of deposition. The implication is that a continuous, nonmarine to marine succession is preserved in this area, which possibly spans Barremian to Albian-Cenomanian time. The presence of thick and moderately well-sorted cross-stratified fluvial sandstone in the northern Camelsfoot Range provides a new potential hydrocarbon reservoir system, which may have had better original porosity and permeability characteristics than the less well-sorted massive sandstone turbidites common to the southern Camelsfoot Range.

Detailed work in the Chilco Lake - Nemaia Valley study area also suggests that much of the JMG in this area lacks submarine fan turbidites. Thick successions of marine sandstones with swaley and, locally, hummocky and trough cross-stratification indicate shallow and relatively high-energy nearshore environments of deposition, as do associated heterolithic sandstone-mudstone packages containing wave and combined-flow ripple types. These shallow marine intervals appear to be more common in the northern and lower parts of the JMG succession in this area and change upward and southward to massive sandstone beds and interbedded mudstone successions that are more typical of deeper marine submarine fan systems, although the extent and thickness of these facies do not appear to be great. The presence of thick successions of shallow marine (shoreface or delta front) facies which include extensive decimetre-thick intervals of well-sorted sandstone is an important discovery. If these strata continue into the subsurface to the north, they may represent priority targets to test as a hydrocarbon reservoir system.

The presence of significant thicknesses of shallow marine and terrestrial units within the JMG also increases support for correlation of this unit with similar subsurface Lower Cretaceous strata of the Nechako Basin. Shallow marine sandstones in particular are likely to serve as well-sorted and laterally extensive units with sufficient porosity and permeability to act as high volume reservoir units for significant hydrocarbon accumulation. As well, this correlation expands greatly the extent of potential source rocks for the subsurface strata. Mud-rich source rocks of the Tyaughton and Methow basins include the extensive Ladner Group and Relay Mountain Group units. Both of these extensive units are current objects of study for source rock potential, both as part of this project and ongoing projects described in Ferri and Riddell (2006).

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