Stratigraphic Analysis of Cretaceous Strata Flanking the Southern Nechako Basin, British Columbia (Parts of NTS 092M, O; 093B): Constraining Basin Architecture and Reservoir Potential[1]

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KEYWORDS: sedimentology, stratigraphy, provenance, Jackass Mountain Group, Nechako, Methow, Cretaceous

INTRODUCTION

The Nechako Basin (Fig 1) 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. Modelling the subsurface distribution of these Cretaceous strata requires detailed stratigraphic analysis of coeval, laterally adjacent strata exposed along the basin margins. The age and general lithological character of strata in the subsurface of the Nechako Basin are broadly known from industry drillholes and examination of isolated outcrops of Cretaceous strata exposed beneath extensive Neogene volcanic cover (reviewed in Ferri and Riddell [2006], also *see* Fig 1 for the location of many of these drillholes). However, regional facies patterns and basin architecture are poorly understood, and even the stratigraphic affinities of subsurface strata are unclear. For example, Hunt (1992) identifies some subsurface strata as possible Jackass Mountain Group, a generally marine succession which is exposed along the southern margins of the Nechako Basin, whereas Hannigan *et al*. (1994) assigns these rocks to the Skeena 'Assemblage' (more commonly termed the Skeena Group), a generally nonmarine succession which is exposed along the northern margins of the Nechako Basin. This confusion illustrates the poorly known nature of the subsurface strata in this region. For a more thorough discussion of stratigraphic problems, *see* Ferri and Riddell (2006).

At the southern end of the Nechako Basin, Lower Cretaceous Jackass Mountain Group (JMG) strata are unconformably overlain by Neogene volcanic rocks (Fig 2). They are generally classified as part of the Methow Basin but are clearly the surface expressions of strata that continue northward into the subsurface beneath the Tertiary rocks, which form most of the exposed strata of the Nechako Basin (Hickson *et al.*, 1994; J.B. Mahoney *et al.*, in progress). The JMG and associated strata include thick (thousands of metres), laterally extensive (tens of kilometres) marine sandstone successions that overlie and interfinger with marine mudstone. However, the three-dimensional architecture of the stratigraphy is very poorly constrained, and therefore the subsurface facies distribution is unknown. Previous studies have interpreted them as the deposits of large submarine fan deposystems (*e.g.*, Kleinspehn, 1982, 1985). However, these previous studies were primarily first order stratigraphic assessments, commonly associated with government regional mapping projects, and preceded a large number of studies that, over the last 15 years, have greatly enhanced the understanding of submarine fan sedimentation models (*e.g.*, Bouma, 2000).

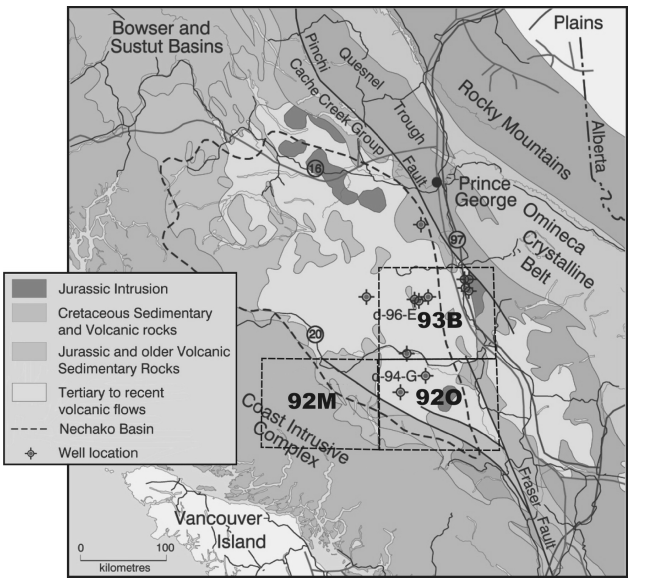

Figure 1. Regional geological location map with boundaries of relevant 1:250 000 map areas, BC (*modified from* BC Ministry of Energy, Mines and Petroleum Resources, 2002).

THIS STUDY

The intent of the three-year study is to conduct a regional analysis of lateral and vertical variations in Early Cretaceous stratigraphic character along the southern margin of the Nechako Basin, which will be integrated with

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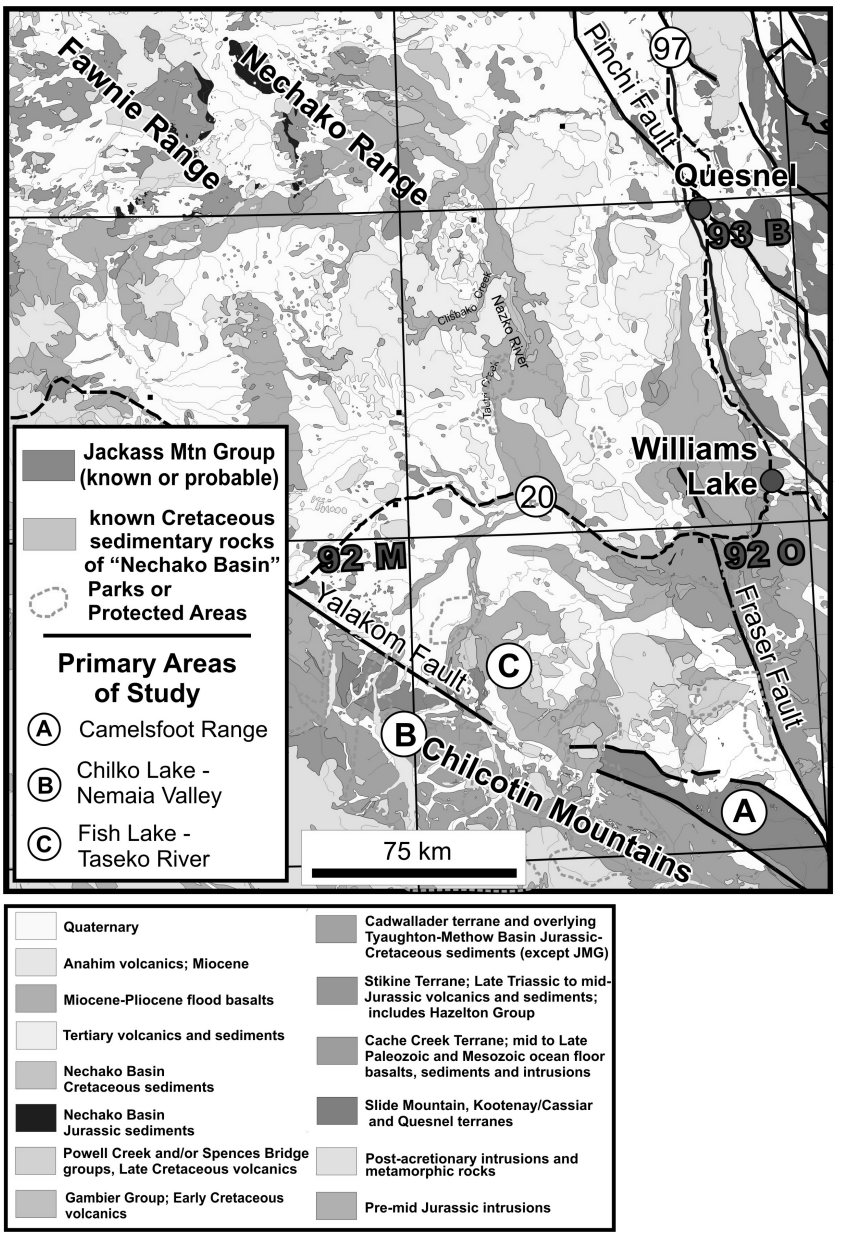

Figure 2. Regional geological framework and location of major areas of study, BC (*modified from* Ferri and Riddell, 2006; Riddell, 2006).

analysis of the isolated exposures within the basin to provide constraints on temporal and spatial variations in the subsurface. This study builds on earlier studies, but with more detailed sedimentology and stratigraphic analysis, petrological analysis (with porosity/permeability estimates), provenance studies (detrital mica and zircon, Nd analysis of fine-grained units, geochemistry of conglomerate clasts), biostratigraphic studies and hydrocarbon reservoir rock potential. The emphasis on the Jackass Mountain Group reflects the authors' contention that this is probably the best candidate for a major reservoir system in the subsurface of the Nechako Basin. This study suggests that the JMG are the closest surface analogue and most likely directly correlative to the Skeena 'Assemblage' of the subsurface, which is interpreted by Hannigan *et al.* (1994) to contain "the most significant petroleum plays in this assessment".

Field reconnaissance examination in late August 2006 identified the main focus areas for detailed analysis of Lower Cretaceous sedimentary successions in the southern part of the Nechako Basin and along its southern margins. Two MSc students will conduct thesis research as part of this project. One MSc investigation will include detailed examinations of well exposed sections of the JMG in the Camelsfoot Range (Fig 2, locality A). The JMG is well exposed on several ridges in this area (Fig 3) and volumetrically the most significant unit in the central and eastern Camelsfoot Range (Hickson *et al*., 1994; Schiarizza *et al*., 1997; J.B. Mahoney *et al*., in progress). It forms the central part of an approximately 150 km long, southward-tapering wedge of mainly medium to coarse-grained sandstone and polymictic conglomerate exposed between the Yalakom and Fraser fault systems. It is part of a broad, asymmetric synclinorium; the base of the unit is exposed in steeply dipping beds on the western limb, east of the Yalakom River, and the upper part is exposed in moderately west-dipping beds in the eastern limb. Multiple stratigraphic sections will be measured with detailed examination of the facies associations and architecture on the ridges between section locations. Extensive sampling of rock types keyed to stratigraphic position will facilitate detailed petrological, organic maturation, and porosity/permeability analyses (done mostly in conjunction with ongoing regional studies of these parameters by F. Ferri of the BC Geological Survey as outlined in Ferri and Riddell [2006]). Traditional sedimentological measurements (paleocurrents, facies types and descriptions, conglomerate clast compositions, stratigraphic thickness variations and cyclicity and other sedimentological parameters) will be supplemented with sampling for isotopic provenance studies. It is hoped that new fossil localities will add to biostratigraphic information available for these units.

A second MSc student will conduct a similar detailed stratigraphic study of JMG and related strata in the Chilko Lake – Nemaia Valley area (Fig 2, locality B). JMG and other Jurassic and Cretaceous sedimentary successions are well exposed in this area, especially on Nemaia Mountain and surrounding ridges (Fig 4; Schiarizza *et al*., 2002). These strata occur immediately southwest of the Yalakom fault and traditionally are considered part of the Tyaughton Basin, which Garver (1992) described as a sub-basin separate from the Methow Basin, with different sedimentation patterns and source areas. However, restoration of the approximately 115 km of dextral offset on the Yalakom fault restores the JMG of the Camelsfoot Range directly adjacent

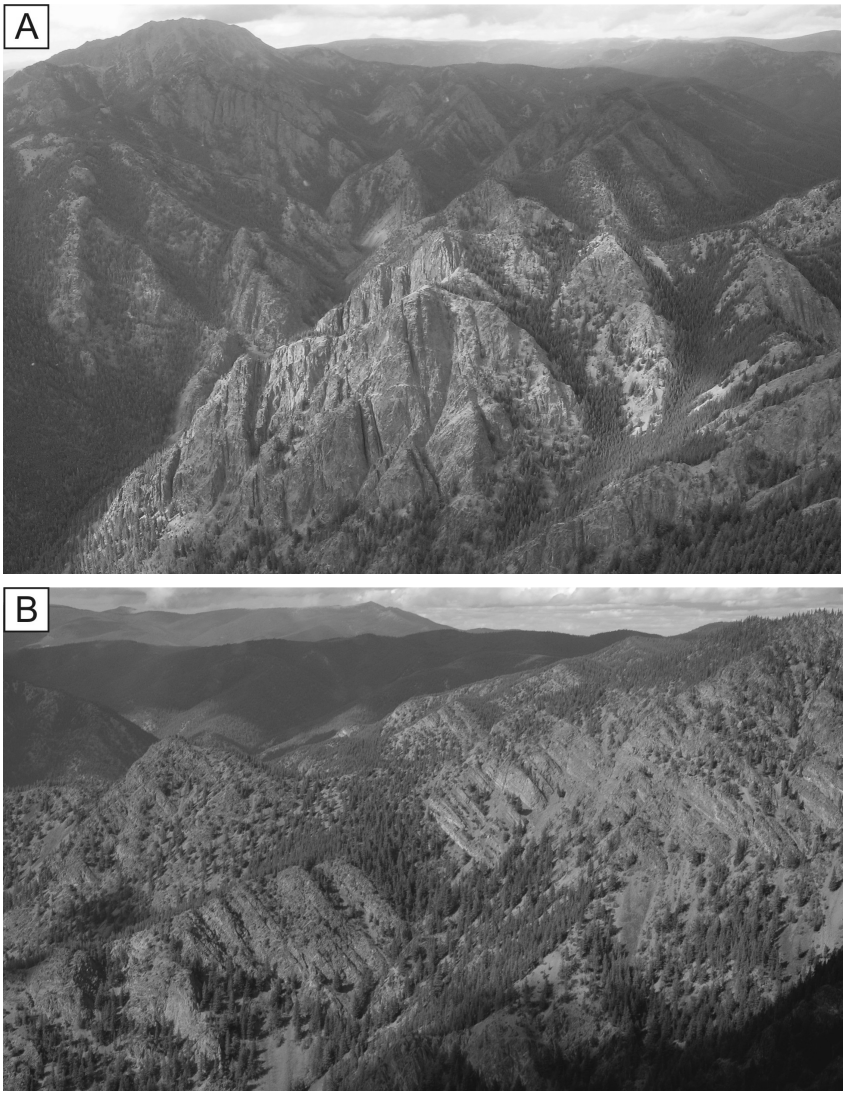

Figure 3. Exposures of Jackass Mountain Group in the Camelsfoot Range, BC: A) looking northwest toward Yalakom Mountain (upper left of photo), showing several kilometre thick successions dominated by thick-bedded sandstone turbidites, B) looking east from Yalakom Mountain area at eastern Camelsfoot Range ridges showing extensive sandstone and mudstone submarine fan facies associations of the steeply south-dipping Jackass Mountain Group (JMG) strata.

to the Chilko Lake – Nemaia Valley exposures, suggesting original depositional continuity. Detailed stratigraphy and provenance analysis of Cretaceous strata in both areas will document lateral and vertical depositional patterns and source regions, which will permit evaluation of the sub-basin hypothesis of Garver (1991) and provide new and more detailed information to constrain the nature of the JMG along the southern margin of the Nechako Basin.

In addition to the detailed MSc project studies, the authors have begun a regional study of these Cretaceous strata. Examination of Lower Cretaceous strata in well exposed areas (potentially all identified areas of Cretaceous strata on Fig 2) will permit regional evaluation of lateral variations in the stratigraphic successions. Paleocurrent and provenance data will be collected, including systematic sampling for isotope geochemistry, conglomerate clast geochemistry, and sandstone petrology. Detailed stratigraphic sections will be integrated with sections provided by the MSc projects to provide a regional stratigraphic framework. For example, locality C (Fig 2) is the site of several different areas of known lower Cretaceous sedimentary rock exposures. Regional mapping projects have included descriptions of these exposures, the most detailed descriptions were by Schiarizza and Riddell (1997), who refer to these strata by various locality names (Chaunigan Lake, Vick Lake, Fish Lake, Elkin Creek). Much of these strata have been tentatively correlated with either Relay Mountain Group or JMG strata, both by Schiarizza and Riddell (1997) and Schiarizza *et al*. (2002) and on the new Geological Survey of Canada geology map for map area

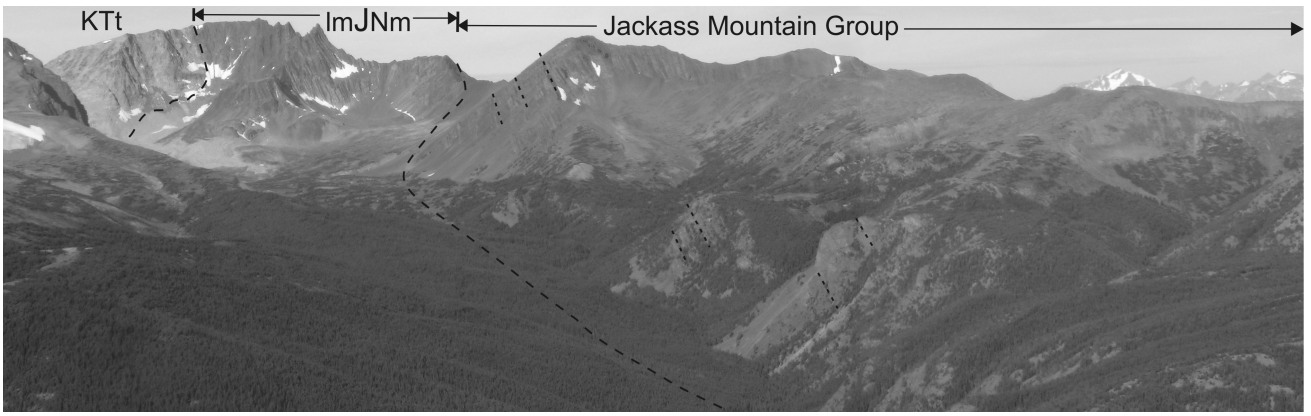

Figure 4. Looking west at Nemaia Range ridges, showing extensive steeply northeast-dipping Jackass Mountain Group (JMG) strata, unconformably overlying Jurassic strata informally named Nemaia formation by Schiarizza (2002, labelled ImJNm on photo). KTt is an unnamed and undated pluton, probably Cretaceous or Tertiary (Schiarizza, 2002). Dashed lines within JMG indicate the general dip of strata, with tops to the northeast.

092O (J.B. Mahoney *et al*., in progress). As part of this project, these areas will be re-examined and evaluated for their relationship to other Cretaceous units and their role in overall basin development.

SUMMARY

Detailed lateral and vertical stratigraphic studies will provide a basis for assessment of the stratigraphy, sedimentology, provenance and potential reservoir suitability of the Jackass Mountain Group and associated Cretaceous strata of the southern Nechako Basin. These focused studies, combined with regional examinations of Cretaceous strata in this area, will allow the development of a model of basin evolution during the Early Cretaceous in terms of large-scale depositional systems and patterns of sedimentation, which in turn will allow prediction of the types of sedimentation and thus stratigraphy that should occur in subsurface areas of the southern Nechako Basin. Ultimately this new data will permit evaluation of previous models of the Nechako and related Methow, Tyaughton (and possibly Skeena) basins during the Cretaceous, both in terms of temporal variations in tectonic controls on basin evolution and evidence for the importance and extent, if any, of separate sub-basins. An understanding of these critical stratigraphic relationships and a more detailed understanding of the sedimentology and basin deposystems during the Early Cretaceous are fundamental to the success of hydrocarbon exploration in the Nechako Basin.

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