Liard Basin and Trout Plain:  
Tectonic Evolution and Petroleum Potential, NWT

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Recent discoveries and industry interest in the Liard Basin and Trout Plain north of 60°E has prompted a re-appraisal of public domain reflection seismic in these areas. Although most of this seismic was acquired before 1980, few interpretations have been published. Publicly available company reports (NEB) and previously published compilations of hydrocarbon pools contain interpretations of selected seismic lines. However, very few of these lines have been used in the construction of published regional structural cross-sections across this region and there is no published comprehensive interpretation using the available regional seismic in conjunction with well data.

Figure 1 shows the available seismic database (National Energy Board) for the Northwest Territories part of the Liard Basin and the Trout Plain. The active cooperation of several companies has made it possible to reprocess a number of lines to their full record length. This permitted interpretation of structures affecting the Precambrian and that may have influenced structural development of the overlying Phanerozoic succession.

The dominant structural feature of this region is the Bovie Structure. The Bovie Structure is a multiphase feature that developed in response to at least two structural events separated by a considerable time interval. The earlier event was the development of a westward-verging high angle contractile reverse fault, the Bovie Fault, which extends upwards from the Proterozoic through to the Upper Devonian Kotcho Formation (Figure 2). Higher in the sequence (Banff Formation) this early event is manifested as a narrow west-dipping monocline. The second structural event was Laramide compression in Early Tertiary time that generated a thin-skinned eastward-verging thrust with a decollement horizon near the top of the Banff Formation. This thrust, the Bovie Thrust Fault, appears to have been deflected upwards where it encountered the deeper, west-facing Bovie monocline, causing the development of a shallow thrust-front anticline.

The northern limit of the Bovie Fault and Bovie-related structures from surface mapping is about 60°40' (Figure 1). However, aeromagnetic data (first and second derivative total magnetic field maps) indicate that the Bovie Fault continues northward in the subsurface to about 61° north latitude.

The deeper Bovie Fault separates the Liard Basin from the Interior Plain (i.e. Trout Plain) as shown by the considerable vertical throw on the top of the Carboniferous westward across the Bovie Fault into Liard Basin (Figure 1). Paleozoic units thicken westward towards the axis of Liard Basin and some like
the Mattson and Fantasque formations are almost entirely contained within the basin. Burial histories indicate that Paleozoic strata in Liard Basin are thermally overmature with respect to oil generation. Triassic strata (Toad and Grayling formations) are also almost entirely contained within the basin (Figure 2). Little is known about the hydrocarbon potential of these units in the subsurface of Liard Basin. However, the recent discovery of significant gas reserves in the Mattson Formation at the Paramount et al. Liard F-36 (Figure 1) strongly indicates the existence of gas in Mattson deltaic and shoreface sandstones in other parts of this basin. Whereas gas in the Mattson appears to occupy primary porosity, other more brittle silicified units such as the Fantasque (Figure 2) may have developed significant fracture porosity for potential gas reservoirs during burial and deformation.

High-angle westward-verging reverse Bovie-related faults of Paleozoic age underlie parts of the western side of the Arrowhead Salient and may have played a role in determining the western limit of this paleogeographic feature. There are also many small normal faults that developed during this mid-to-late Paleozoic deformation.

East of Bovie lies the Slave Point shelf edge with numerous shelf edge gas pools. A typical platform shelf-edge reef gas pool discovered by Shell Canada along the subsurface Slave Point edge occurs at the Netla C-07 well, which penetrated the Slave Point slightly eastward of the shelf edge and slightly below the highest point of Slave Point carbonates. There are several other possible Slave Point shelf edges inboard of the Netla C-07 well that may be equally prospective for gas in a northward continuation of the prolific shelf-edge gas fields of northeast British Columbia. Multiple shelf edges may be seen in seismic along most parts of the Slave Point shelf in the Trout Plain along the Arrowhead Salient and Cordova Embayment of the Presqu'ile Barrier. The recently completed Nahanni gas discovery at Paramount et al. Bovie C-76/C-76A at the western edge of the Arrowhead Salient is an example of this type of play.

Many of these shelf edge buildups along the Slave Point edge and shelf interior buildups are located above basement structures or paleotopography along the pre-Devonian Tathlina High. These structures may have played a role in the localization of Slave Point buildups. Gas-filled porosity in the Slave Point appears to be secondary, rather than primary in silicified and fractured limestones (e.g. Netla C-07) or in dolomitized Slave Point limestone along the west side of the Cordova Embayment (e.g. Island River M-41). Seismic has also imaged untested carbonate buildups in the Jean Marie Formation.

Seismic maps of various Phanerozoic surfaces such as the base of the Phanerozoic and the top of Middle-Lower Devonian carbonates display trends that reflect the influence of northeast-trending structures in Trout Plain, such as the Rabbit Lake and Trout Lake fault zones. Intersections of these faults with porous Slave Point and Keg River shelf margin carbonates may be favourable for
the occurrence of more massive and reservoir-enhancing developments of Presqu'île Dolomite. It is not known if these fault zones extend southwestward into Liard Basin, or whether they intersect or are intersected by Bovie Fault.

The K-29 and M-25 wells are major gas discoveries in Manetoe hydrothermal dolomite in the Arnica, Headless and Nahanni formations (Figure 1). The extensive vertical extent of hydrothermal dolomite developed in these gas wells and in the previously discovered Pointed Mountain, Kotanelee and Beaver River fields may be related in part to the steep slope of the top of the Proterozoic from the region of the Bovie Structure westward into the central part of Liard Basin. Hydrothermal dolomitizing fluids may have circulated through a greater depth range in this region than along the shallower east and west sides of the basin.
Liard Basin is bounded by the Bovie Fault to the East and by the edge of Cordilleran Deformation to the west. Contours are on the top of Carboniferous (metres).

Figure 1. A. Seismic data publicly available only in the territories is shown along with recent gas discoveries in Liard Basin and Trout Plain. B. An overview of Liard Basin and the Slave Point shelf platform east of Bovie Fault. A thick upper Paleozoic and Mesozoic succession fills Liard Basin.
Figure 2. A stratigraphic chart along an east-west transect westward across the Interior Plain north of 60° into Liard Basin. Major gas discoveries occur in the Manetoe Dolomite of the Liard Basin, in the Presqu’ile Dolomite of the Slave Point, in sandstone of the Mattson Formation and in basal Cretaceous sandstone. The Bovie Fault, active in Late Devonian time, separates the much thicker Paleozoic succession of Liard Basin from a thinner Paleozoic section east of Bovie.