The not so Passive Western Canadian Lower Paleozoic Cordilleran Margin – Plate Structure, Rift Basin (Misty Creek Embayment) and Alkalic Volcanism

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The Canadian Cordilleran Late Proterozoic-Paleozoic margin formed as a result of Late Proterozoic rifting. This newly formed margin was Atlantic Type, characterized by deposition of shallow water sandstones and carbonates on the east. However the basinal zone, and parts of the carbonate platform, were punctuated by periods of extension with rifting (Cecile and Norford, 1993, Fig. 1). The rifting was accompanied by widespread occurrences of alkalic volcanism (Goodfellow, Cecile and Leybourne,1995, Fig. 2).

Upper and Lower Crustal Plates

Lister et al., (1991) hypothesized that, on rifting of a continental block, the breakup occurs along listric crustal-scale normal faults. Lister et al. (ibid) proposed five detachment models for this type of breakup. All of them produce a footwall or Lower Plate margin, and a hanging wall or Upper Plate margin. The Lower Paleozoic Canadian Cordillera is proposed to be divided into an Upper Crustal Plate to the south of, and a Lower Crustal Plate to the north of, the Liard Line around 60°N Latitude (Fig. 1, Cecile, Morrow and Williams, 1997). In this model the Liard Line is considered a major transfer fault zone allowing a transition from an upper plate style to the south, to a lower plate style on the north - all on the same margin. In other words the Cordilleran margin was formed by two listric normal faults dipping in different directions on either side of the Liard transfer zone.

The northern Lower Crustal Plate features widespread preservation and complex paleogeography, with discrete basins and depressions, whereas the southern Upper Crustal Plate has limited preservation and by comparison has a simpler paleogeography. In addition there is a marked difference in structural styles and degrees of shortening in northern and southern forelands. The north is characterized by large box folds with thrust faults and 20-30% shortening compared to the south which is thrust dominated and has 40-60% shortening.

The Misty Creek Embayment

The Misty Creek Embayment (MCE, Cecile 1982) is an important basin in the northern Lower Crustal Plate. It is a Lower Paleozoic rift basin with two classic rift “steer head” profiles (Dewey, 1982, White and McKenzie, 1988) with rift fill of late Early Cambrian to middle Late Cambrian (‘Middle Cambrian’ Rift Fill in Fig. 3) and late Early Ordovician to early Late Ordovician age (‘Middle’ Ordovician Rift Fill in Fig. 3, Cecile, Morrow and Williams, 1997). The MCE is typical of the complexity of the northern lower crustal plate. It is bounded to the north and east by the Mackenzie Arch and to the north and west by the Ogilvie Arch. On the southeast it bounded by the Niddery Basin High that separates it from very thin Selwyn Basin chert and argillite (Cecile 2000). It is internally complex with major platform to basin transitions, rapid thickness changes, localized middle Cambrian flysch accumulations, and local thick alkalic basic volcanic accumulations (Fig. 4) with associated diatreme breccias.

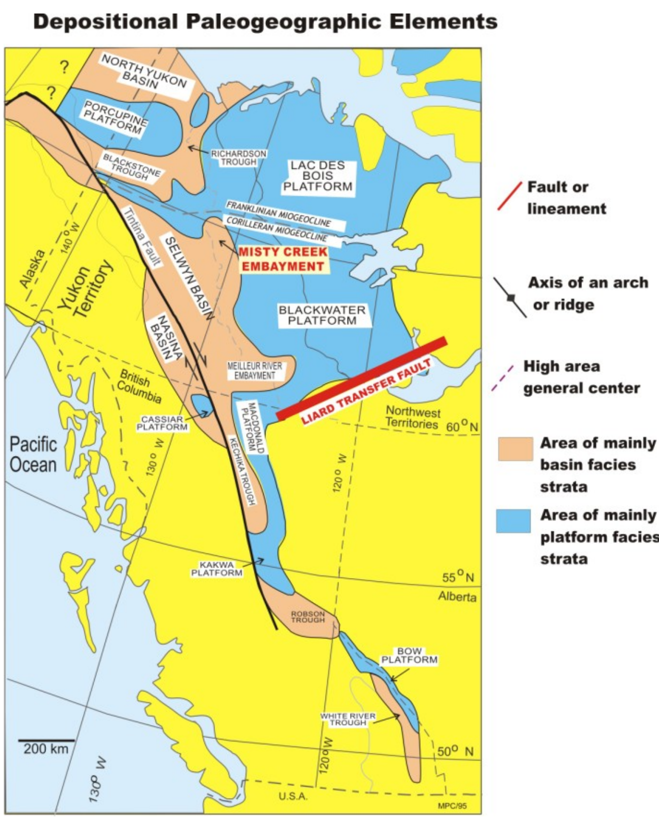


Figure 1. Western Cordilleran Lower Paleozoic. Upper Plate north of Liard Line and Lower Plate to the south (Cecile et al, 1997).

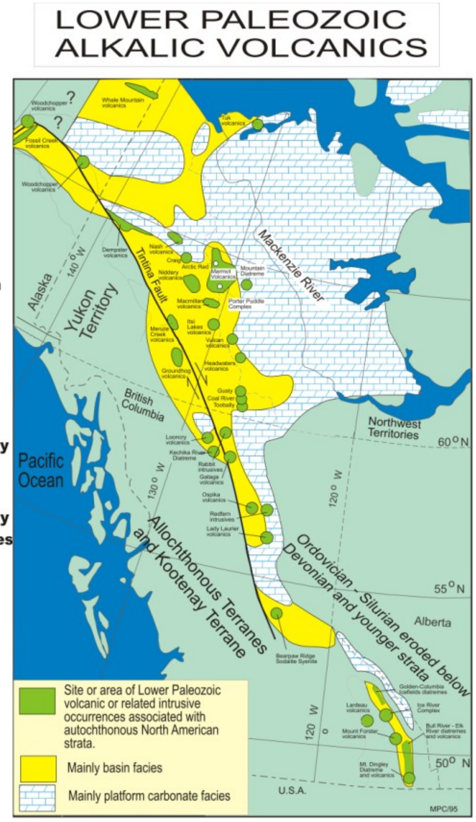
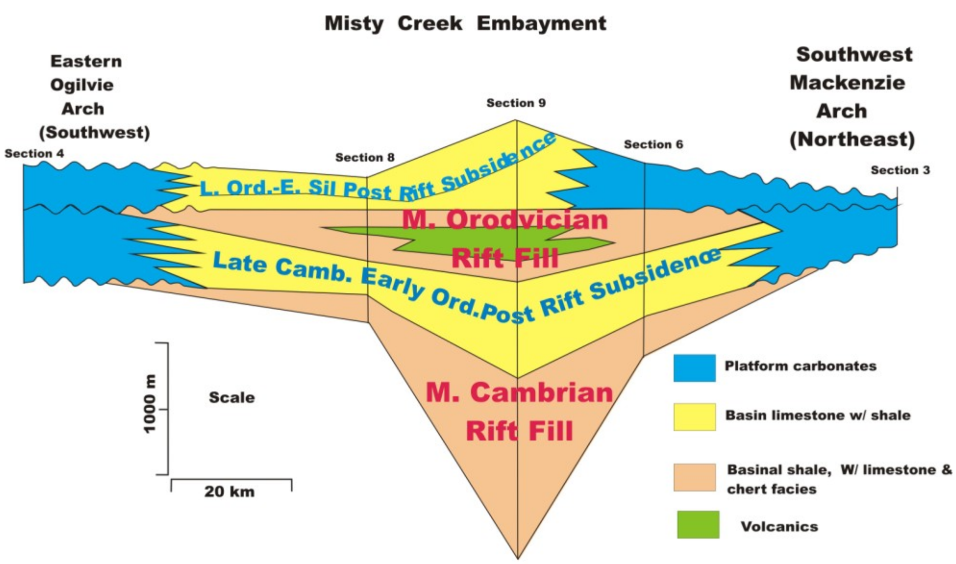


Figure 2. Lower Paleozoic Alkalic Volcanic Occurrences. (Goodfellow et al,1995)



Southwest to northeast cross section through Misty Creek Embayment (Cecile, 1982). This cross section shows the classic profiles of two rift 'steer faces' (Dewey, 1982; White and McKenzie, 1988).

Figure 3. “Steer Head” profiles of the Misty Creek Embayment (Cecile et al, 1997).

Alkalic Volcanics

In the Canadian Cordillera volcanic rocks are only locally volumetrically significant, but centers of volcanism are found scattered throughout basin facies areas, and at least in two cases, interstratified with platform-edge carbonates (Fig. 2). The southeastern MCE also features a major Middle Ordovician to Early Devonian alkalic volcanic complex known as the Porter Puddle Complex (Fig. 4). Volcanics south of Ogilvie Arch are alkalic and ultrapotassic with biotite-phlogopite phenocrysts, sandine, augite and Ba-feldspar. The Porter Puddle Complex (Fig. 4) in the MCE, as well as volcanics in the adjacent Selwyn Basin, are potassic basinites (Goodfellow, Cecile and Leybourne 1995). To illustrate how common occurrences of Lower Paleozoic volcanism are, Norford and Cecile (1994) discovered that volcanic rocks thought to be Late Silurian or Devonian in age were actually interstratified with the Cambro-Ordovician McKay Group and the platformal Beaverfoot Formation in the Southern Cordillera. The volcanics they examined were part of a local volcanic center, with thick local accumulations, including volcanic breccia.

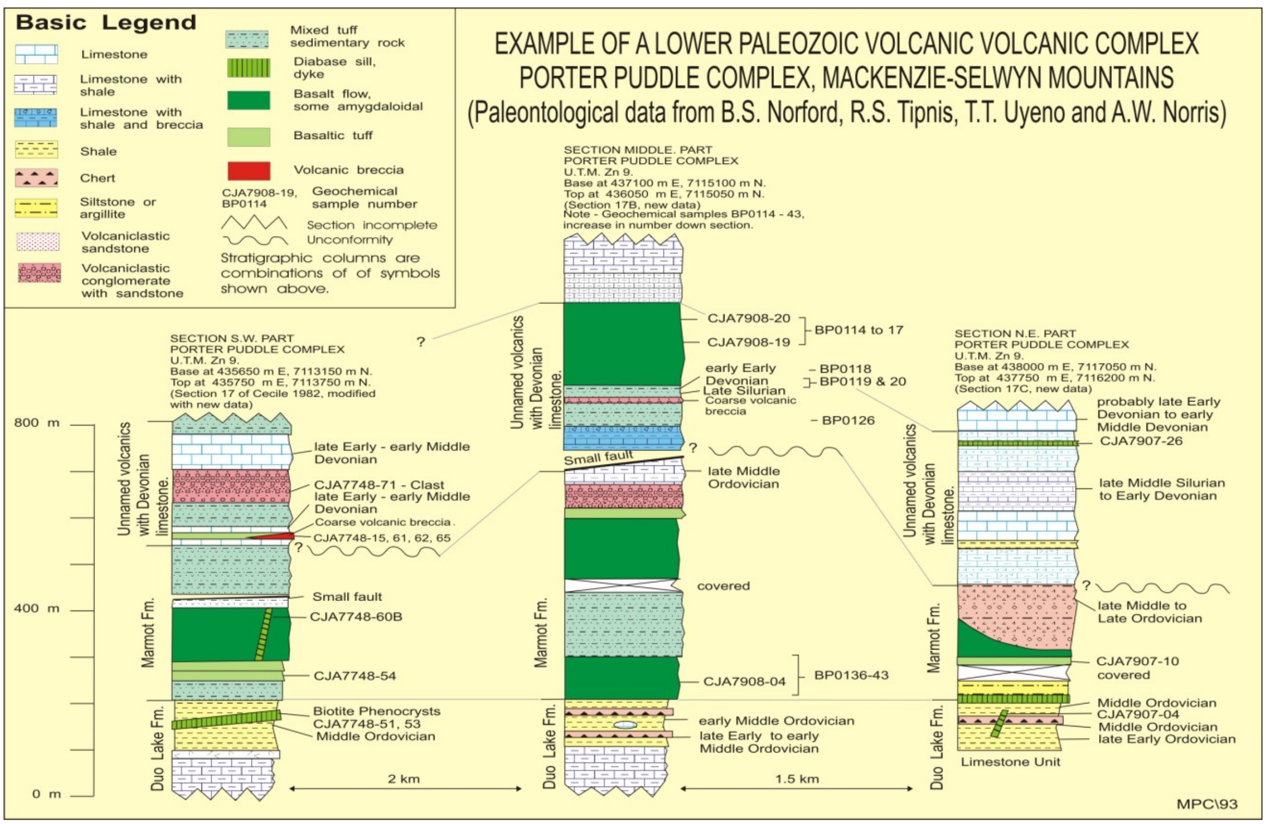


Figure 4 Porter Puddle Volcanic Compex, Misty Creek Embayment (M.P. Cecile,unpublished)

Economic Potential

A history of active rifting along the Canadian Cordilleran Late Proterozoic-Paleozoic margin and associated volcanism greatly increase the potential of these areas for hydrothermal metal deposits and stratiform base metal deposits. Given the northern area is proposed to sit on a lower crust margin, is widely preserved and has a complex paleogeography, enhances its prospectivity. In the subsurface of the northern interior plains the presence of Lower Paleozoic rifts increases the oil and gas prospectivity of that area.

Conclusions

In conclusion the Canadian Cordilleran Late Proterozoic-Paleozoic margin, although characterized by deposition of shallow water sandstones and carbonates on the east, had quite and active history of rifting and volcanism in adjacent deep water basins and platform margins. In addition the basinal zone, and parts of the carbonate platform, were punctuated by periods of extension with rifting. This margin can be divided into a northern Lower Crustal Plate with complex paleogeography, widespread preservation, large scale folding and 20-30% shortening, and a southern upper plate with relatively simpler paleogeography, narrow preservation, and dominated by thrusting and 40-60% shortening. This history and rifting and volcanism enhances the mineral prospectivity of these strata, and in the Northern Interior Plains the oil and gas potential.

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