# Ladyfern, N.E.B.C.: Major Gas Discovery in the Devonian Slave Point Formation

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## ABSTRACT

The Upper Devonian Slave Point Formation in north-central Alberta and British Columbia, Canada is an intermediate depth (2000-3500 m) bioclastic carbonate that holds an estimated 7 TCF gas in place (AEUB/OGC reserve statistics). Along the Hotchkiss Embayment trend [fig. 1] (TWP 90-110 W6) Slave Point oil and gas pools have been found episodically from 1955 to present, however, major field discoveries have been infrequent. **Cranberry** (**595 BCF OGIP)** (TWP 96-4W6) was drilled in 1974, followed by **Hamburg (490 BCF OGIP**) (TWP 96-11W6) in1983. In the last seventeen years 570 Slave Point wells have been drilled in the Hamburg area but similar large hydrocarbon accumulations have remained elusive…until very recently. A field discovery was made in **winter 2000** at **Ladyfern, British Columbia** (Block H-94H1) and early indications suggest that the volume and deliverability of the gas accumulation may surpass all previous finds in the area.

**Apache Canada Limited** (37%), along with farm-in partners Murphy Oil Limited (33%) and Beau Canada (30%), drilled a deeper pool test (2790 m) in the Ladyfern area of northeast British Columbia in February, 2000 at **A97H-94H1** [fig. 2]. The well was completed as a Slave Point gas well with a reservoir pressure of 4400 psi and a deliverability of **100 MMCF/D**. The well has produced 12 BCF of slightly sour gas (5 ppm $H_2S$, 4% $CO_2$) in 9 months with no formation water.

Three additional wells were drilled in 2000 to define the extent and continuity of the reservoir at 4-26-94-13 W6 (producing 7 MMCF/D),10-19-94-12W6 (producing 1.5 MMCF/D) and B17I-94H1 (off bank). Aggressive follow-up drilling programs in 2001 by all Slave Point rights holders in the vicinity have resulted in the licensing of **45 locations** and the drilling of **24 slave point tests**. Apache/Murphy have drilled twelve of the new wells with a 100% success rate. Pressure gradient analysis, geological- and geophysical-data indicate that the Ladyfern Slave Point gas field is areally extensive, up to **100 sq kilometres**, with **gas column greater than 100 m,** proven recoverable reserves of 300 BCF and possible reserves that may approach a **trillion cubic feet of gas in place**.

**Ladyfern Slave Point reservoir rock** is leached, fractured and hydrothermally-dolomitized bioclastic grainstone and packstone. Stromatoporoids and corals are the dominant mega-clasts. Porosity development is directly related to original depositional fabric and is diagenetically enhanced along zones of extensional faulting that parallel and crosscut the carbonate bank [Fig. 2]. The trap is stratigraphic/diagenetic and a seal is provided by tight Slave Point argillaceous limestones and overlying Beaverhill Lake shales. The rocks have a complex

diagenetic history that includes the effects of (1) high energy destructive seafloor processes (2) early syntaxial cementation, stylolitization, compaction, (3) porosity-occluding calcite spar- and dolomite- burial cementation and (4) porosity-creating dissolution, hydrothermal dolomitization, brecciation and fracturing. There are volumetrically minor amounts of pyrobitumen present. Dominant porosity types are dissolution-enhanced intergranular, biomoldic, inter-crystalline, vuggy and fracture. Microporosity locally makes a significant contribution. Aggressive leaching of carbonate by undersaturated fluids passing along argillaceous seams and microfractures has created reservoir rock that is platey, micro-brecciated and locally so porous that it easily crumbles in the hand. Limestone porosity ranges from <1% to 12% ( 5-6% average) with permeabilies from 0.1 to 20 millidarcies. Dolomitic zones, in contrast, have fracture- and vuggy-porosities up to 30% with associated permeabilities measured in hundreds of millidarcies to darcies. Limestone wells (4-26-94-13W6, 10-19-94-12W6) have deliverabilities of 1-20 MMCF/D; dolomitized “monster wells”can produce at rates of 40-100 MMCF/D (A97H-94H1, C6H-94H1).

**Controls on Reservoir Development** - A basement strike-slip structural regime associated with the Hay River Fault Zone has controlled areal distribution patterns of reservoir facies in the Slave Point formation and directly influenced internal stratigraphy and cyclicity. At Ladyfern, episodic burial reactivation of these faults has resulted in extensive fracturing and created active conduits for hydrothermal fluids which have variably leached, dolomitized and cemented the rock. In areas of maximum extension near fault intersections, intense dissolution, brecciation and hydrothermal dolomitization has resulted in seismically-resolvable collapse synclines at the Muskeg and Slave Point levels. The thickest and best reservoir sections (eg. A97H-94H1) are directly associated with these “collapses”. Increased vertical permeability of the dissolution pipes provide local conduits for fluids to rise and enter stratiform reservoir prone units in the lower Slave Point platform and upper Slave Point bank. Intensity of the secondary diagenetic overprint and associated variability in reservoir quality is directly related to original rock fabric and proximity to the extensional zones.

**The Ladyfern Slave Point gas discovery** is significant in the fact that (1) it confirms the prospectivity and continuity of a reservoir prone grainstone bank along the southwest margin of the Hotchkiss embayment into British Columbia. (2) The lower Slave Point “platform” which is argillaceous, tight and non-productive throughout the region, undergoes a facies change to porous and permeable reservoir facies at Ladyfern. This contributes to a much thicker reservoir section and a considerable increase in marketable reserves per section. (3) The carbonate promontory at Ladyfern was characterized by a broad facies mosaic of grainstone shoals and intershoals, and was extensively crosscut by extensional faults related to the Hay River Fault shear zone. This optimum depositional/diagenetic combination contributes to an areally extensive and extremely productive gas reservoir. (4) At Ladyfern, leached and fractured limestone provides significant gas storage. This diagenetic facies (“limestone

halo" of Reimer and Teare, 1991) is considerably more pervasive than has been documented elsewhere in the Slave Point formation. (5) The Ladyfern discovery confirms the viability of using wrench fault based HTD exploration models championed by Dr. Graham Davies (1993), Dr. Dave Morrow (1995), Jim Reimer and Mark Teare (1991) for prospecting, not only in the Devonian Slave Point Formation, but other carbonate units in the Western Canada Sedimentary Basin and worldwide.

Davies, G.R., 1993, Hydrothermal dolomite (HTD) of western Canada. Genetic and Temporal Linkage between HTD Gas Reservoirs, Mississippi Valley-type (MVT) Pb-Zn Ore Bodies, SEDEX Pb-Zn Deposits, and the Antler (Caribooan) Orogeny. Summary and overview report, prepared for Energy, Mines and Petroleum Resources, Government of the Northwest Territories, unpublished. Graham Davies Geological Consultants Ltd., 94 p.

Morrow, D.W., and Aulstead, K.L., 1995, The Manatoe dolomite – a Cretaceous-Tertiary or a Paleozoic event? Fluid Inclusion and Isotopic Evidence. Bull. Canadian Petroleum Geology, v. 43, no. 3, p. 267-280.

Reimer, J.D., and Teare, M.R., 1991, Reservoir development and resource emplacement in selected Paleozoic carbonates of northeastern British Columbia and northwestern Alberta. Canadian Society of Petroleum Geologists, 1991 Convention, Abstracts, p. 116.

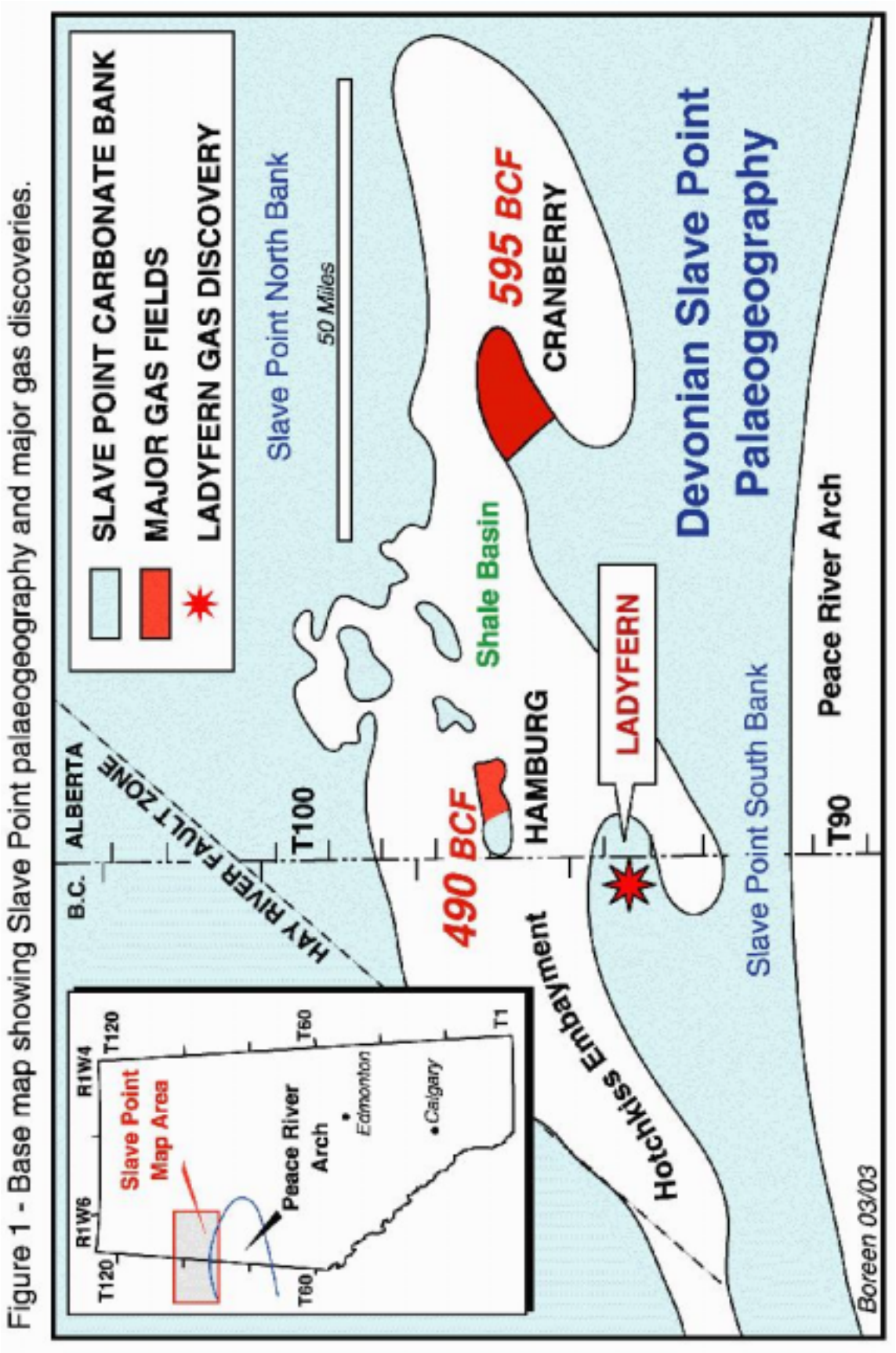


Figure 1 - Base map showing Slave Point palaeogeography and major gas discoveries.

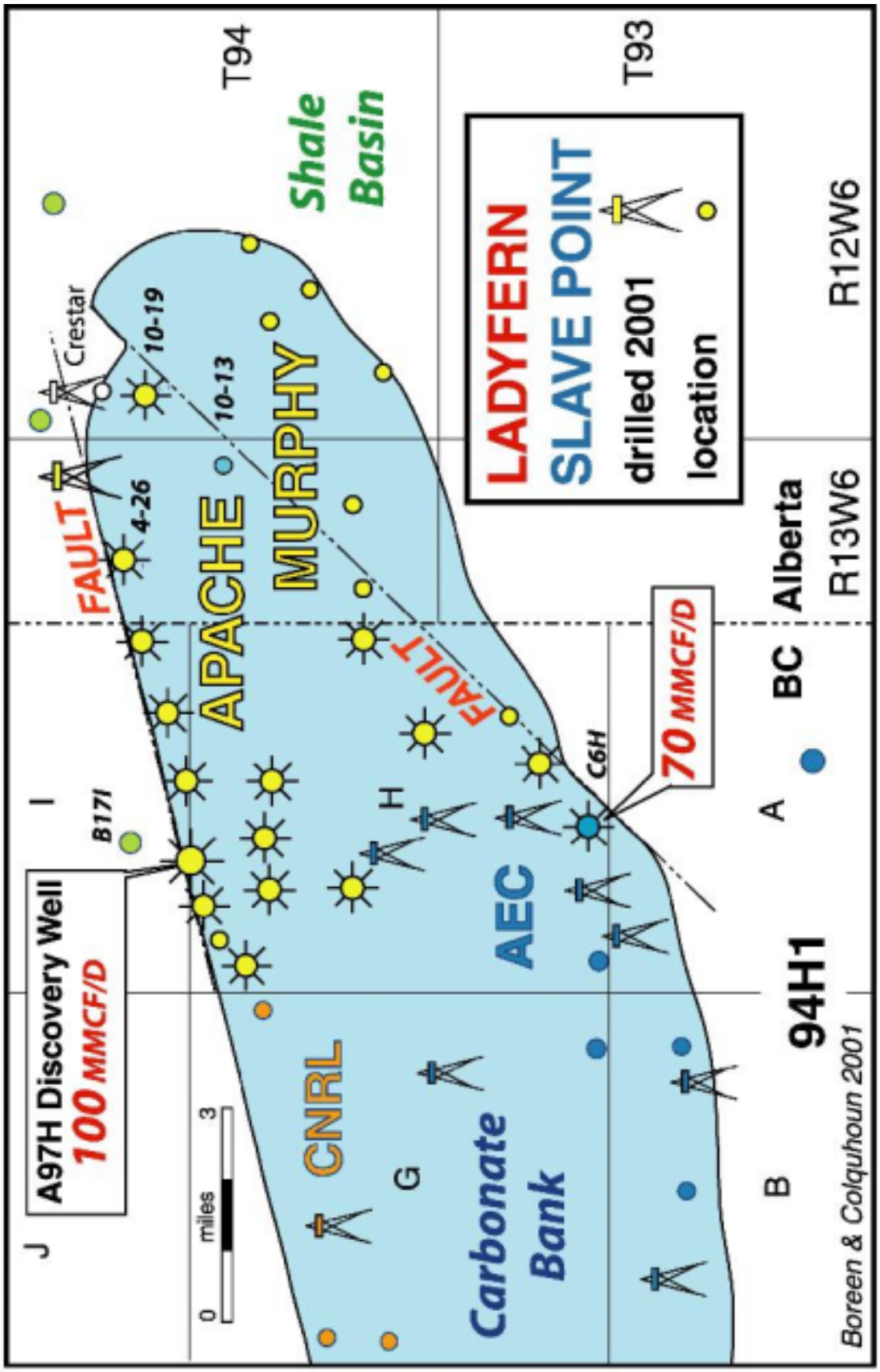


Figure 2 - Ladyfern Slave Point gas field showing recent drilling activity.