Preliminary Report on the Geology of the St. Patricks Channel Salt Deposit (NTS 11K/02), Victoria County, Cape Breton Island, Nova Scotia

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Introduction

The St. Patricks Channel area is situated approximately 15 km southwest of Baddeck, Victoria County, in central Cape Breton (Figs. 1 and 2). The geology in the vicinity was mapped and described by Kelley (1967), including the Whycocomagh and Baddeck map areas (NTS 11F/14 and 11K/02), and by Weeks (1955) in the Grand Narrows area (NTS 11F/15). The area is also included in recent mapping of NTS area 11K/02 by Lynch and Lafrance (1996).

Although there is a long history of investigation of the indicators of salt deposits in the area (Boehner, 1986), including salt springs and seeps described in Cole (1930) and Hayes (1931), it was not until 1981 that salt was defined in exploration drilling at MacIvers (McIvor) Point by Chevron (1982). Trace salt was known from the deeper parts of the Canadian Gypsum Company Little Narrows gypsum quarries where it occurs in association with anhydrite near the gypsum to anhydrite transition zone (Holleman, 1976).

Geology

Salt was intersected by Chevron (1982) in drillhole R1/R1W at MacIvers (McIvor) Point, located near the centre of a substantial Bouguer gravity low anomaly in the St. Patricks Channel area 25 km northeast of the Orangedale salt deposit (Figs. 1, 2 and 3). This exploration was part of an extensive potash exploration program by Chevron that focused on the Malagawatch salt deposit, located approximately 20 km to the south. Due to drilling difficulties, the drillhole required the drilling of an overlapping ‘wedge’ interval in the lower parts to get to the final depth (e.g. R1 and R1W). The salt-bearing section was intersected from 395.7 to 1174 m (1301-3853 ft.). The drillhole deviation from vertical is substantial, with 21 to 24 degrees reported near the bottom of the hole (no azimuth direction was reported). Note that bedding dips reported from the core sections are based upon measurements with respect to the horizontal core angle and not to the core axis. True dips of the strata, therefore, may be more or less depending upon the amount of hole deviation from vertical and the azimuth direction of deviation (unknown) with respect to the bedding dip direction(s).

In summary, drillhole R1/R1W intersected an upright and relatively continuous and complete section of the C Subzone (Major Cycle 3) and B Subzone (Major Cycle 2) of the Windsor Group from 22.5 m to 395.7 m (Fig. 3). This section occurs entirely within the salt dissolution zone and consequently none of the original salt is preserved. The drilling intersected an antiformal fold axis at 490 m within the uppermost part of the main salt of Major Cycle 1. The lowermost section of Major Cycle 2 was intersected in a major synform from 577.9 m to 828 m. An attenuated section of the main salt was intersected from 828 m to 1169 m and the hole was stopped in the basal anhydrite of Major Cycle 1 at 1185.7 m.

The drilled section contains the following units and structures in descending order (Fig. 3). The lower part of the Upper Windsor (Major Cycle 3) was intersected in the cored interval from 22.5 m to the base of the Herbert River Limestone Member at approximately 180 m. Bedding dips in this right-way-up section are at approximately 30 to 40°.
degrees. A relatively complete section of the Middle Windsor (B Subzone - Major Cycle 2) was then intersected to a depth of 395.7 m. The ‘Triplet Marker’ section described by Cook and Giles (2001) in the middle part of the Major Cycle 2 section of the Orangedale salt deposit is interpreted to occur in R1/R1W at a depth of 294.4 to 311.2 m. Bedding dips in this right-way-up section are approximately 20 to 30 degrees. Similar to the Malagawatch and Orangedale deposits (Giles, 2001 and Cook and Giles, 2001), all the salt strata were removed by dissolution in the near-surface environment (typically at depths above 400 m). Salt typically dominates Major Cycle 2 (530 m thick and 55% salt) and is abundant in Major Cycles 3 to 5 (470 m thick and 36% salt).

The uppermost part of the main salt section in Major Cycle 1, with a large component of mudrock as interbeds and inclusions, was intersected from 395.7 m to 577.9 m. An antiform fold axis is located at an approximate depth of 490 m, where the section is repeated in the overturned fold limb. A thin carnallite potash unit within the generally muddy and dark-colored salt section defines this fold repeat. Bedding dips in this fold-repeated section of Major Cycle 1 are approximately 20 to 30 degrees.

The overturned fold limb continues down from the base of the overturned Major Cycle 2 at 577.9 m to a major synformal fold axis at a depth of approximately 773 m. This major synformal
structure repeats the lower part of Major Cycle 2. Two related minor antiformal folds at approximate depths of 697 m and 828 m symmetrically repeat a thin interval of anhydrite and salt units of the middle Windsor (B Subzone - Major Cycle 2) in a ‘M’ shaped fold. The upright lower fold limb continues down from 828 m to the base of Major Cycle 2 at approximately 1008 m. Bedding dips in this large, overturned fold structure in Major Cycle 2 between 577.9 m and 1008 m are approximately 30 to 50 degrees. The moderate to low-angle bedding dips indicate that the fold structures (limbs and fold axial planes) intersected in R1/R1W are also probably low angle, and approximately recumbent and isoclinal. This would be consistent with folds mapped in the Little Narrows gypsum quarries by Wilson and Sharpe (1994). The fold vergence direction for R1/R1W has been assumed to be congruent with folds in the quarries, with axial planes generally dipping to the northwest (Fig. 3).

A relatively thin interval of structurally disturbed salt and mudstone/salt breccia of the Major Cycle 1 main salt was intersected at 1008 m to 1169 m, and the basal anhydrite of Major Cycle 1 was intersected from 1169 m to the total depth of the hole at 1185.7 m. The stratigraphic thickness of the main salt typically exceeds 200 m and may be up to 300 m (Boularderie salt deposit, Boehner, 1986). Much of this thickness is inferred to be absent in R1/R1W due to structural removal and attenuation thinning due to the deformation associated with the decollement fault detachment zone at the top of the basal anhydrite of Major Cycle 1. Bedding dips in this multiple folded section are approximately 15 to 20 degrees.
Figure 3. Stratigraphic and structural cross-section, St. Patricks Channel salt deposit, Inverness County (see Fig. 2 for location of line A - A₁).
The contact zone of the folded Major Cycle 2 section and attenuated main salt of Major Cycle 1 is inferred to be a major decollment zone (Fig. 3) that extends up dip to the southeast into the equally disturbed (folded, faulted and hydrated) evaporite section that is currently mined for gypsum by CGC Little Narrows Gypsum at Little Narrows (Wilson and Sharpe, 1994). The structural attenuation or shear faulting in this detachment zone has been previously described by Boehner (1992) and Giles and Lynch (Ainslie Detachment, 1994). Consequently, there is potential for potash and thicker sections of salt in the St. Patricks Channel area due to its geological similarity to the Boularderie salt deposit, which contains significant intersections of potash and is located approximately 20 km to the northeast.

The section intersected in drillhole R1/R1W is correlated with the Malagawatch stratigraphic section established by Chevron (1982) and Giles (2001). The stratigraphic units in R1/R1W representing the lower part of Major Cycle 2 (intersected three times due to folding) appear to be very similar to the Little Narrows gypsum mine section (MacAulay Quarry) of carbonates, gypsum/anhydrite and red beds described by Wilson and Sharpe (1994). These include an unnamed carbonate at the base and overlying limestone/dolostone units including the Hazeldale, Cains Mountain, and Magazine units. These correlate approximately with the Chevron (1982) stratigraphic markers 4-8, 4-7, 4-6, and 4-4.

Exploration seismic surveys and diamond-drilling for base metal deposits in the late 1990s by Savage Resources (Jubilee Joint Venture, 1998a, b) have contributed substantially to the data available on the subsurface geology in the Jubilee and Little Narrows area. They have established the occurrence of the Macumber Formation basal carbonate and thick basal anhydrite section typical of Major Cycle 1 units to depths of 500 m. In addition, the section drilled in SJL97-3 by Jubilee Joint Venture (1998b), southwest of the Little Narrows gypsum mine (Fig. 2), included up to 170 m of interstratified and folded (recumbent) gypsum, anhydrite, salt, carbonate and siliciclastics. This section probably correlates with the Little Narrows Gypsum mine section (Wilson and Sharpe, 1994). Related exploration drilling by Jubilee Joint Venture (1998) has also established the presence of sheared pre-Carboniferous basement units on the peninsula south of Bucklaw, near the Little Narrows water supply (located approximately 1.5 km to the north of SJL97-3). This area was indicated on previous geological maps by Kelley (1967) and Lynch and Lafrance (1996) to be underlain by the Windsor Group, although no outcrop was identified.

The implication is that the contact between the Carboniferous Windsor Group and older rocks must be relocated approximately 1 km to the southeast from its current position on the maps of Kelly (1967) and Lynch and Lafrance (1996). Although this is not a large distance, geological map interpretations have generally associated lowland topography with the distribution of Carboniferous rocks, especially the Windsor Group. It is also apparent that there are anomalies in the variety of rocks mapped along the strike of the major fault bordering the north side of the Carboniferous basin. These include basement rocks juxtaposed with basin rocks in patterns typical of faulted relationships. These maps and the deep drilling in the area (R1/R1W) indicate that the St. Patricks Channel Fault probably is a system of faults (fault zone) and has relative dip-slip in excess of 1.5 km. It is likely to be steep near surface, and perhaps a reverse fault or possibly a thrust at depth (Fig. 3).

Geophysics

The area in the vicinity of St. Patricks Channel salt deposit is included on a Chevron Bouguer anomaly map (Chevron, 1982). The discovery drillhole (R1/R1W) is situated near the center of a narrow northeastward-trending gravity trough centered beneath St. Patricks Channel between Little Narrows and Nyanza (Figs. 1 and 2). The salt mass presumed to have produced the gravity low has been defined only by this drillhole. The Bouguer anomaly indicates the structure may continue several kilometres to the northeast toward Baddeck and into the Baddeck River valley. It appears to be bounded to the southwest by an area of coincident magnetic and gravity high near Alba, approximately 8 km south of Little Narrows. A
subdued gravity high extends from Little Narrows and Jubilee southwest to Alba. Steep contours are evident along the northwestern side of the St. Patrick's Channel gravity low at the faulted boundary with Horton Group and pre-Carboniferous basement rocks in the adjoining highlands. Exploration seismic surveys and potential field maps were utilized to delineate diamond-drilling targets for base metal deposits in the Jubilee and Little Narrows area. The most recent work was completed in the late 1990s by Savage Resources (Jubilee Joint Venture, 1998a, b and 1999). Gravity and magnetic field data have been mapped and modelled in the area by King (2003, in press).

**Economic Geology**

The St. Patrick's Channel salt deposit is presently defined in only one deep exploratory drillhole located on a moderate amplitude Bouguer gravity anomaly. Little Narrows is located near the southern end of St. Patrick's Channel approximately 2 km south of Bucklaw, and 8 km east-northeast of Whycocomagh (Figs. 1 and 2). Significant sections of salt were intersected at the St. Patrick's Channel Site in a complex folded structure typical of the saline Windsor Group sections in south-central Cape Breton Island. Anhydrite, siltstone, dolostone and limestone are interbedded with the salt in sections representing the lower to middle part of Major Cycle 2. A thin, structurally attenuated section of the main salt unit of Major Cycle 1 was intersected from approximately 1008 m to 1169 m. The main potash zone associated with this stratigraphic unit was not present in R1/R1W. The section of the lower Major Cycle 2 correlates with similar sections at the Malagawatch and Orangedale salt deposits and is characterized by a low content of salt.

The lower part of the recumbently folded Major Cycle 2 section probably correlates up-dip to the southeast with the CGC Little Narrows Gypsum Mine section described by Wilson and Sharpe (1994). Salt present in the deep subsurface has been removed by groundwater dissolution in the near-surface environment and anhydrite has been hydrated to gypsum. Salt in minor, erratically distributed impurity zones has been encountered in certain parts of the gypsum mine, especially in the deeper parts in association with anhydrite. The distribution and chemistry of the salt occurrences in the gypsum mine were studied and described by Holleman (1976) in an unpublished M.Sc. thesis at Acadia University. Deep drilling down-dip of the gypsum mine by Chevron at MacIvers (McIvor) Point (R1W) intersected substantial salt in the unhydrated correlative stratigraphic section of the Lower Windsor. Salt dissolution, and hydration of anhydrite to gypsum, in the Windsor Group generally occur in the subsurface above depths of 300 m. Hydration of anhydrite to gypsum generally occurs at shallower depths than the salt dissolution zone, which extends to a depth of nearly 400 m at MacIvers (McIvor) Point.

Two thin zones of low-grade potash salts including carnallite were intersected in R1/R1W. These occur as a fold-repeat section of the uppermost part of the main salt section of Major Cycle 1. Carnallite with sylvite is also known in a similar section in the Boularderie salt deposit located 23 km to the northeast, as well as in the Orangedale (Ashfield) salt deposit located 23 km to the southwest. The main salt section of Major Cycle 1 is the most prospective potash and salt target in the region and the section intersected in R1W is highly attenuated and structurally incomplete. This is in part due to removal and disruption by the Ainslie Detachment, a regional detachment fault. The depth to the top of the salt section is 396 m, which is typical for deposits in the region.

Brine springs and seeps indicative of subsurface solution, have been reported and documented in the Bucklaw and Baddeck area immediately to the north and west. Further exploration and possible development of the St. Patrick's Channel salt deposit may be hindered because the major portion of the salt structure occurs beneath St. Patrick's Channel. The intersection of the attenuated main salt of Major Cycle 1 (approximately 160 m thick) near the bottom of R1/R1W may be economically significant. The salt-bearing sections in Major Cycle 2 in R1/R1W are relatively thin and less economically attractive. The extension of the deposit into the Baddeck area to the northeast may
be prospective for further exploration. The St. Patricks Channel salt deposit is advantageously situated close to tide-water shipping in the Little Narrows area.

References


Kelley, D. G. 1967: Baddeck and Whycocomag map areas with emphasis on Mississippian stratigraphy of central Cape Breton Island, Nova Scotia; Geological Survey of Canada, Memoir 351.

