MINERALS AND ENERGY BRANCH

Open File Report 96-003

CRETACEOUS DEPOSITS OF KAOLIN AND SILICA SAND IN THE SHUBENACADIE AND MUSQUODOBOIT VALLEYS, NOVA SCOTIA, CANADA

Stea, R. R.[1], Finck, P. W.[1], Pullan, S. E.[2] and Corey, M. C.[1]

Key words: Cretaceous, kaolin, silica sand, lignite, brightness

Suggested Reference: Stea, R. R., Finck, P. W., Pullan, S. E. and Corey, M. C., 1996: Cretaceous deposits of kaolin and silica sand in the Shubenacadie and Musquodoboit valleys, Nova Scotia, Canada; Nova Scotia Department of Natural Resources, Minerals and Energy Branch, Open File Report 96-003.

NOVA SCOTIA DEPARTMENT OF NATURAL RESOURCES

Honourable Donald R. Downe, Minister

[1] Nova Scotia Department of Natural Resources, 1701 Hollis Street, PO Box 698, Halifax, Nova Scotia B3J 2T9.

[2] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8

ABSTRACT

Early Cretaceous kaolin clay and silica sand are found in basins within the Hants-Colchester lowlands of Nova Scotia. A 3-dimensional basin model of Quaternary and Cretaceous sediments was constructed using outcrop information, water well data, old and new diamond-drill cores and refraction-reflection seismic data. The known extent of Cretaceous outliers in the Shubenacadie and Musquodoboit Valley has been expanded from an area < 1 km^2 to > 57 km^2 with a maximum thickness of 200m.

Preliminary results indicate that the Cretaceous sediments occur as clay- and sand-dominated units. The clay-dominated units consist of kaolinitic clay with repeating cycles of light to dark grey and black, lignitic clay and lignite. The sand-dominated units are characterized by thick, fining-upward sequences of quartzose gravelly-sand and sand, light grey and white clay, light grey-white clay with thin lignite horizons, and finally mottled red and yellow clay. Distinct fining-upward cycles can be recognized in core and outcrop, including channels with coarse traction-load gravel at the base, fining upward to clay. Armoured kaolin balls have been found within the coarse sediments. These strata are interpreted to have been deposited in fluvial/deltaic/estuarine environments.

The sands are dominated by subangular quartz grains (95-99% SiO), with poor roundness sorting. Heavy minerals are dominated by opaques, mostly ilmenite, pyrite and hematite. The lack of feldspar and phyllic rock fragments in sediments, interpreted as fluvial, is a paradox. The quartz-kaolin segregation is believed to reflect intense pre-depositional weathering. Grey and black, pyritiferous clay represents sedimentary kaolinite deposited under reducing conditions, whereas the mottled, ochre clay formed as humid-temperate podzolic-type soils. Source areas of the kaolinite and silica sand are believed to be deeply weathered crystalline Appalachian and Shield bedrock terranes to the north, with an input from local Carboniferous sediments.

Fission track and vitrinite reflectance data indicate heating up to temperatures of 80°C with average geothermal gradients this indicates a former depth of burial of at least 1 km (D. Arne, pers. comm, 1995). After early Mesozoic rifting and tectonism, the topography was gradually reduced from high to low relief, resulting in a regionally extensive, low relief, coastal plain. Tectonism after the Early Cretaceous is indicated the juxtaposition of mineralogically-mature, fluvial sediments in steep fault-bounded basins.

Revised mapping based on drill and seismic results indicates the potential for large tonnage kaolin and silica sand deposits within the Shubenacadie Basin and particularly within the Musquodoboit Basin. **In core MUSC95-4, five clay samples from 20 m of light grey and white clay beds spanning a 60m core interval met filler-grade brightness specifications. After beneficiation trials these samples attained G.E. brightness values ranging from 84.8 to 91.2%.** Clay units can be traced in seismic section over a horizontal distance in excess of 1.5 km.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The authors would like to thank Joe Campbell, Wayne Burt, Phil Belliveau, Reg Morrison, Janet Webster, Carol Murphy, and Cynthia Phillips of the media and drafting section for invaluable help preparing photos, figures and maps for this report. Thanks also to Bob Boehner and Doug MacDonald for editing the document.

Dr. Ron Dilabio, director of the terrain sciences mapping division of the Geological Survey of Canada provided technical, financial and moral support for this project.

Special thanks to George MacLeod and Earl Standing of the drilling section who did a great job drilling in adverse conditions into uncompromising sand and gravel.

INTRODUCTION

Under the auspices of the Canada-Nova Scotia Cooperation Agreement on Mineral Development 1992-1995 (CNSCAMD), the Nova Scotia Department of Natural Resources (NSDNR) and Geological Survey of Canada (GSC) initiated a project to examine the Cretaceous to Quaternary stratigraphy in the Shubenacadie and Musquodoboit valleys (NTS 11E/03). Isolated occurrences of economically valuable silica sand and kaolin clays were known to occur in these basins. Diamond-drilling and reflection seismic surveys were employed to map the three-dimensional distribution of Cretaceous to Quaternary unconsolidated sediments in the study area and to extend the known industrial mineral resources. Initial work focused on known clay and sand deposits at the Shaw Resources clay pit in the village of Shubenacadie and on the area immediately to the east of the quarry (Finck *et al.*, 1994) and later encompassed most of the Shubenacadie Valley (Finck et al., 1995). This open file report will summarize all work to date, incorporating both new and previously released data. These data are:

1. Stratigraphic logs for all of the 1995 drilling.

2. Interpreted seismic reflection lines from the Shubenacadie and Musquodoboit basins.

3. A listing of compiled diamond-drill holes in these areas from previous metallic and industrial mineral explorations.

4. Interpreted stratigraphic records from the Nova Scotia Department of the Environment drilled water well records.

5. Chemical analysis of the raw kaolin clay samples and a summary of the physical and chemical properties of a representative suite of kaolin clays that have been processed to meet paper filler and/or coater grade clay requirements.

A map showing the distribution of Cretaceous sediments in the study area is also included with the report (MAP 96-001). The authors would like to emphasize that this is an open file report, completed with the goal of releasing pertinent data as soon as possible. As such it is not subject to the comprehensive review of most departmental or external publications. Please notify us of any errors and omissions.

SURVEY METHODS

Basin stratigraphy was initially evaluated through existing stratigraphic databases (Appendices 1-3). These include:

1. Nova Scotia Department of the Environment water well records.
2. Nova Scotia Department of Natural Resources diamond-drill hole database.
3. NSDNR Assessment Reports.
4. Fundy and National Gypsum company records.
5. Geotechnical drilling for the Nova Scotia Department of Highways.

Field work was focused on determining the precise location of water wells. These records were selectively compiled from the Department of the Environment (NSDE) database of commercially drilled water wells (Appendix 1).

Drilling Methods

Project drilling was divided between the Nova Scotia Department of Natural Resources drill section and Logan Geotechnical Incorporated. In both cases standard rotary diamond drilling and wireline coring methods were employed. Water with an additive (lubricant) ALCOMER 12 LOS was used as a drill fluid. Holes were generally started with HQ diameter rods and reduced as required to NQ. Table 1 shows core recovery percentages from various stratigraphic units bases on results from drillholes SHU94-1-5 (Finck et al., 1994). Recovery of silica sand was very low, averaging 6%. Representative samples were recovered by advancing a split-spoon in front of the drill rods and bit. This provided uncontaminated samples of silica sand. In contrast, analysis of silica sand recovered by standard coring methods indicated a high level of contamination by the circulating drill mud.

TABLE 1. Summary of average core recovery

DRILLED UNIT	AVERAGE PERCENT RECOVERY
Till	48
Silica Sand	6
Clays, Silts and Lignite	84

Drilling at some sites was halted due to excessive bit wear and water loss in coarse, unconsolidated, siliceous sediments. Silica sand also tended to 'telescope' up the inside of the drill rods when the core tube was retrieved. This would result in stuck core tubes, loss of circulation and often necessitate pulling the entire drill string.

Shallow Seismic Survey Methods

Shallow seismic reflection techniques involve laying out a series of receivers (geophones) on the ground surface, and recording ground motions in response to the detonation of a small explosive/shotgun source or the impact of a weight drop or sledge hammer. Energy travels along the ground surface and is refracted along interfaces such as the water table where large increases in seismic velocity occur. Energy is also reflected from subsurface horizons such as lithological boundaries where there is a contrast in acoustic impedance (product of density and seismic velocity). Because of the interference of direct, refracted and reflected events in the near surface, seismic reflection profiles do not yield information on very shallow structure (i.e.from depths of 0 to 15-30 m below surface, depending on the geometry of the source/receivers and on the dominant frequency of energy transmitted by the ground), but can yield subsurface structural information in the depth range of 20 m to several hundred metres below surface.

The Shubenacadie-Musquodoboit shallow seismic reflection survey involved both a testing and a production phase. During the testing phase, one 24-channel geophone spread was laid out at each site, and data were recorded to:

1. Evaluate the quality (frequency and signal strength) of reflected energy.

2. Determine the depths from which reflection signals were recorded.

3. Establish the recording parameters (source/receiver geometry, recording timescale, input filter settings etc.) and line priorities for the production phase.

During the summer of 1995, as an extension of a testing and production program carried out in the Shubenacadie Valley in 1994 (Finck et al., 1994), tests were carried out at 32 sites across the Shubenacadie, Musquodoboit and Stewiacke valleys. The results of these tests were used to identify possible infilled bedrock valleys (test sites where deep seismic reflections were observed). The production phase involved the recording of continuous 12-fold CDP (common depth point) data along the chosen survey lines (where "fold" refers to the number of traces stacked or summed to produce a single trace on the final section; see Steeples and Miller, 1990). This was accomplished by "rolling" 24 channels through 36 geophones laid out on the ground surface as the shot point was moved every 5 m. Approximately 5 line-km of 12-fold CDP data were recorded in this manner in 10 working days with a 4 person crew. Additional time was required for surveying relative elevations along the lines so that elevation corrections can be made on the final processed sections. All data were recorded on an OYO DAS-1 36-channel engineering seismograph with an instantaneous floating point amplifier and 24-bit analog-digital conversion. The extra channels in the seismograph allowed the use of an internal rollalong capability, eliminating the necessity of an external rollalong switch. Both the tests and CDP data were recorded with single 50 Hz vertical geophones per channel, 5 m geophone spacing, and a 12-gauge black powder blank shotgun shell detonated at the bottom of a 1 m hole as the seismic source (Pullan and MacAulay, 1987).

Data Processing

The initial data processing sequence that has been applied to the 12-fold CDP data collected is depicted in Figure 1. First, survey information and observer notes (such as shot and cable locations, hole depths, etc.) were combined to create a geometry database, such that every shot and geophone location were properly located with respect to each other. The data were then reordered to correspond with the geometry information, and noisy or dead traces removed from the processing stream. The trace amplitudes were scaled by applying an automatic gain control (AGC) with a long time window (200 ms). This process adjusts the gain of each point along the trace according to the average absolute amplitude across the specified window centred on that point, such that amplitudes are increased in time zones where total signal strength is low and reduced in zones where large amplitude signals are measured. The low frequency components of the data were reduced by applying a digital bandpass filter (80-800 Hz BP). Statics (minor timing misalignments) caused by variations in near-surface conditions, such as the thickness of the unsaturated zone (low velocity layer), were corrected using the results of a refraction analysis. The data were then resorted into common-depth-point (CDP) gathers (groups of all traces with identical midpoints between source and receiver locations), and a velocity analysis performed by examining the brute stacks corresponding to a series of constant velocity depth functions. The final stacked seismic reflection section was produced after:

1. Applying normal moveout corrections (correcting each trace in time to correspond to a normal incidence travel path from the common midpoint between source and receiver) according to the optimum velocity functions determined from the velocity analysis,

2. Applying a digital bandpass filter (100-800 Hz), and

3. Stacking (or summing) all the traces in each CDP gather.

Analytical Techniques

Clay and sand samples were submitted to the Minerals Engineering Centre (Technical University of Nova Scotia) for Whole Rock analysis of major oxides. Samples were fused with lithium metaborate and tetraborate and leached with nitric acid. SiO_2 was determined by colorimetry, and other oxides by Atomic Absorption Spectrophotometry. The clay fraction ($<2,\mu$m) was separated from dispersed suspensions by timed centrifuge runs and decantation. Differential thermal analysis was conducted using an Eberbank unit.

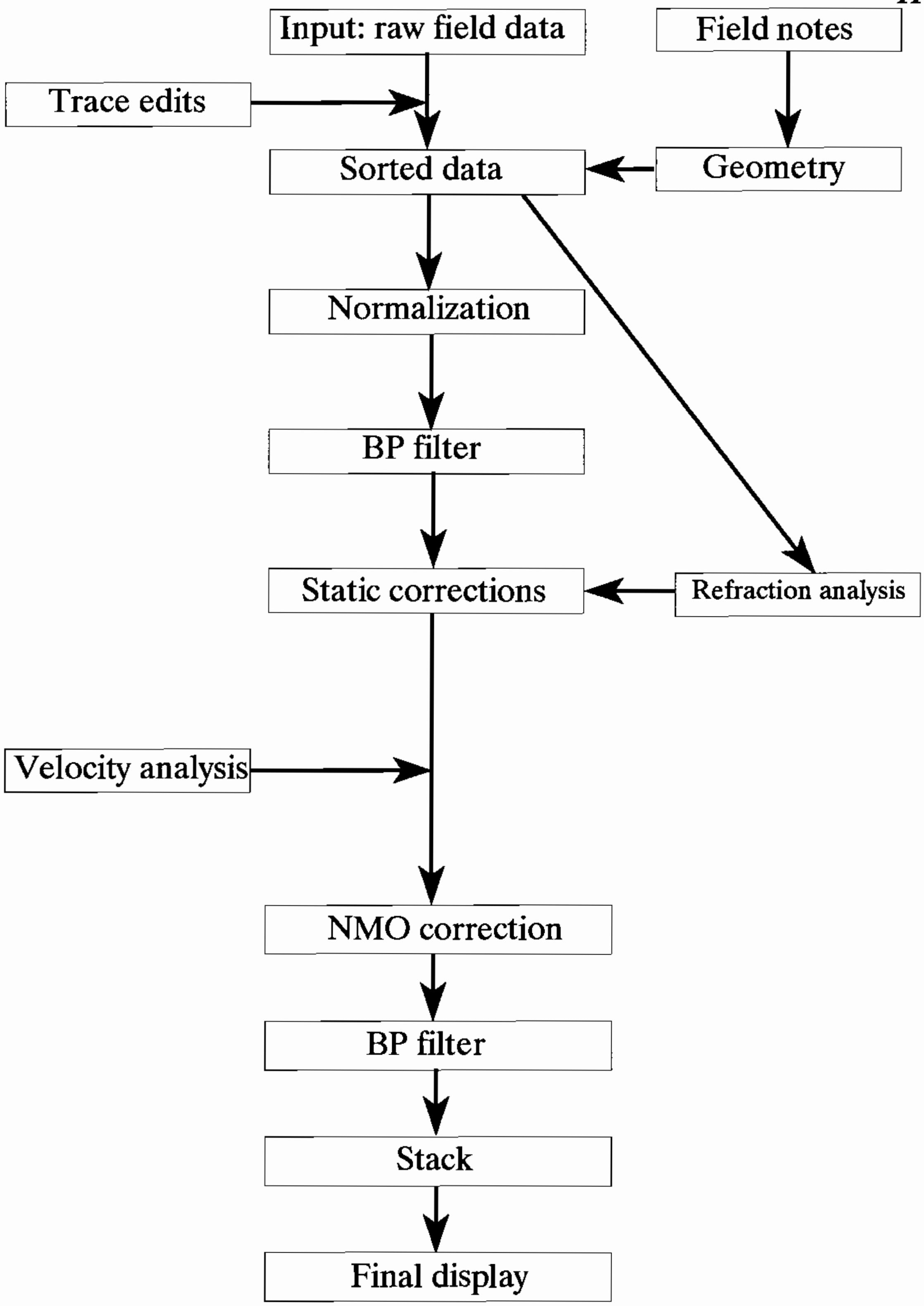


Figure 1. Data processing sequence applied to 12 fold CDP data.

Seventeen samples were submitted to MINEREX Laboratories INC. in Milledgeville, Georgia for kaolin processing. Duplicate splits were sent to English China Clay International INC., (ECCI) Sandersville, Georgia. These procedures will be described in detail in the Economic Geology chapter.

GENERAL GEOLOGY

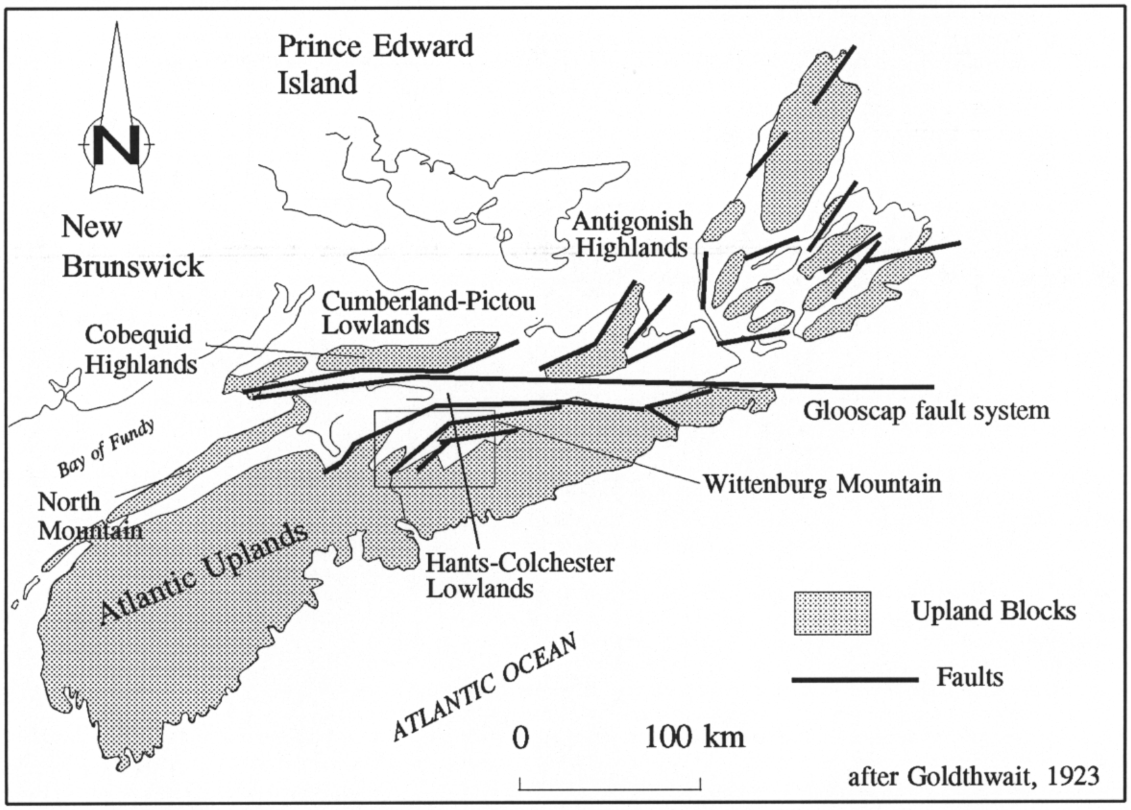
The Shubenacadie, Musquodoboit and Stewiacke river valleys are located in the Hants-Colchester Lowlands of central Nova Scotia (Fig. 2; Goldthwait, 1924). The Shubenacadie and Stewiacke valleys are underlain by Early to Late Carboniferous strata composed of evaporite and carbonate rocks interbedded with grey and red clastic sedimentary sequences. This lowland region comprises the Shubenacadie Basin of Giles and Boehner (1982). The Musquodoboit Basin is also underlain by Carboniferous strata and is separated from the Shubenacadie Basin by a prong of Cambro-Ordovician Meguma Group metasedimentary rocks which forms an upland block known as Wittenburg Mountain. The lowland regions are characterized by south- and southeast-trending drumlins and moraines with local relief of less than 50 m. Karst topography is locally well developed throughout the Shubenacadie and Musquodoboit basins underlain by evaporite and carbonate sequences. Cretaceous (Barremian to Aptian) sediments have been found preserved in dolines or uvalas produced by solution collapse, (Davis et al., 1984; Arne et al., 1990). Cretaceous sediments found in a large gypsum sinkhole (Dickie, 1986) at the West Indian Road deposit (Shaw Resources) are the largest source of silica sand in Nova Scotia. Additional deposits of kaolinitic clay and silica sand outcrop along the margins of the Musquodoboit Valley in road and river bank cuts and at Shubenacadie in the Shaw Resources clay quarry. Stea and Fowler (1981) suggested that Cretaceous deposits in the Musquodoboit Valley may be more extensive than isolated sink hole remnants. They also noted some effects of post-depositional tectonism at the West Indian Road deposit (Map 1). Dickie (1986) also suggested that the deposits were, in part, preserved in larger fault-bounded basins, thus establishing the potential for additional, laterally extensive deposits of kaolin clay and silica sand.

RESULTS

Shubenacadie Valley Lithostratigraphy

Transect 1

The margins of a Cretaceous sedimentary basin in the Shubenacadie Valley have been defined using 13 drillholes and other stratigraphic databases (Map 1; Appendices 1-4). The extent of known Cretaceous deposits has expanded from 0.5 km^2 to approximately 15 km^2 (Map 1). Cretaceous sediments are overlain by Quaternary deposits ranging in thickness from 13



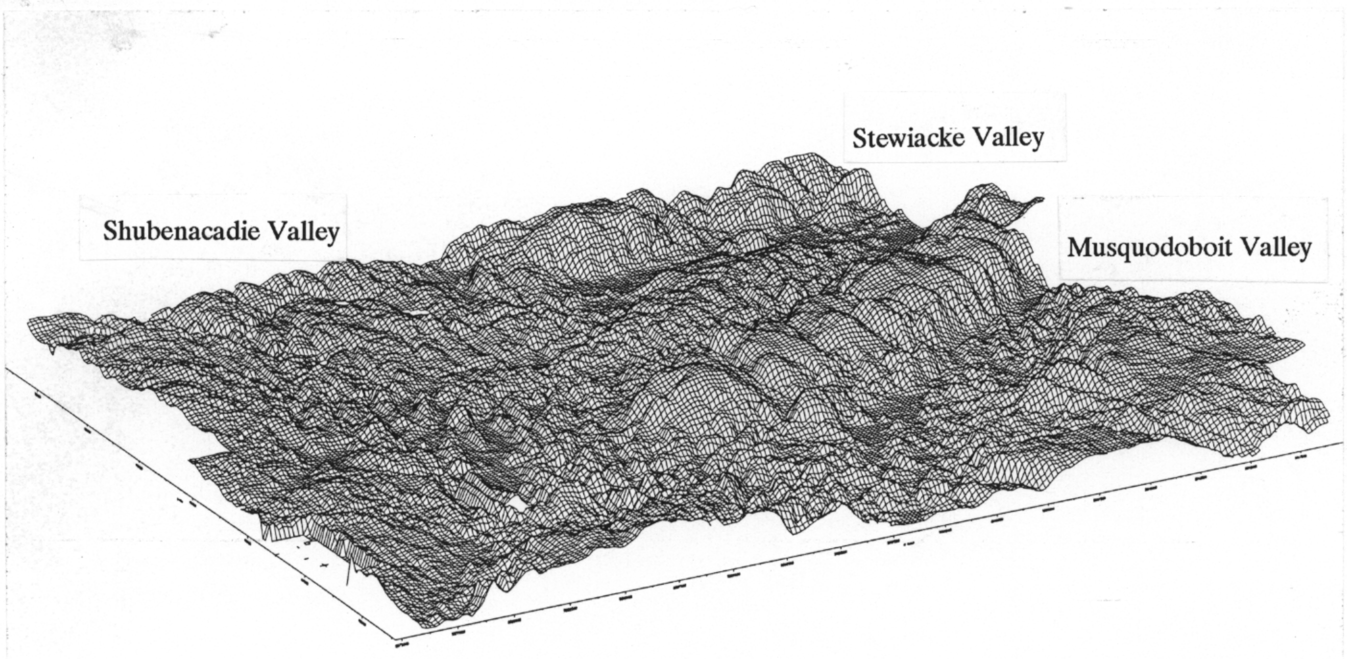


Figure 2. Location map, physiography, and digital terrain model of the study area.

m to 80 m. A west to east, cross-basin drillhole transect is shown in Figure 3. Seven unconsolidated lithostratigraphic units were defined. The stratigraphic package is consistent with that described by Dickie and Murphy (1992) for the main Shaw Resources clay pit. These are:

Base:

Upper Windsor(?) limestone bedrock and limestone breccia.

Unit 1: Black, organic-rich silty clay with associated lignite fragments, (ii) lignite and marcasitic lignite, (iii) dark to light grey silty clay. Individual beds of black clay, grey clay or lignite cannot be correlated between drillholes. The term 'lignite clay' is used to describe silty clay (based on qualitative observation) that contains visible fragments of organic material and silt- to clay-sized organic material. The black organics impart a dark colour to the silty clay, which varies from black to dark grey (10YR, 2.5Y or 5Y 4/1). Based on visual estimates, grain size of the lignite clay decreases as the percentage of fine-grained organic particles increases. The lignite clay may grade into or abruptly change to lignite breccia, composed of large fragments of lignite (typically up to 50%) in a black, silty clay matrix. The lignite is 'very hard' and scratches a dull reddish-brown. Thin lenses and layers of sand associated with the lignite may be replaced by marcasite.

Unit 2: Medium-to coarse-grained quartz (silica) sand in a white to light grey clay matrix. Opaque minerals are predominantly marcasite, ilmenite and magnetite (G. Dickie, personal communication, 1994). There are zones of gravel sized, well-rounded, quartz pebbles. The actual thickness of these gravel lags could not be estimated due to lack of core recovery. The top of the silica sand unit (Unit 2) strikes 022° and dips 6.5° to the east-southeast. The thickness of the unit is relatively consistent along strike between holes SHU94-1 and -2, but increases down-dip between holes SHU94-2 and -4. Unit 2 pinches out or was eroded between the 1994 drillholes and SHU95-5 (Fig. 3, Map 1)

Unit 3: Alternating layers of black and grey clay, essentially the same as those described above for Unit 1.

Unit 4: Medium- to coarse-grained quartz (silica) sand with minor to trace feldspar and opaque minerals in a white to light grey clay matrix. Unit 4 increases in thickness to the east, between drillholes SHU94-1 AND SHU94-5, but pinches out across the Shubenacadie River at SHU95-5. The bed strikes 143° and dips 4.5° to the northeast based on triangulation of the upper surface of the sand horizon between drillholes SHU94-1 and SHU94-4.

Unit 5: Matrix-supported grey-brown sandy diamicton, striated pebbles, Miller Creek Till?

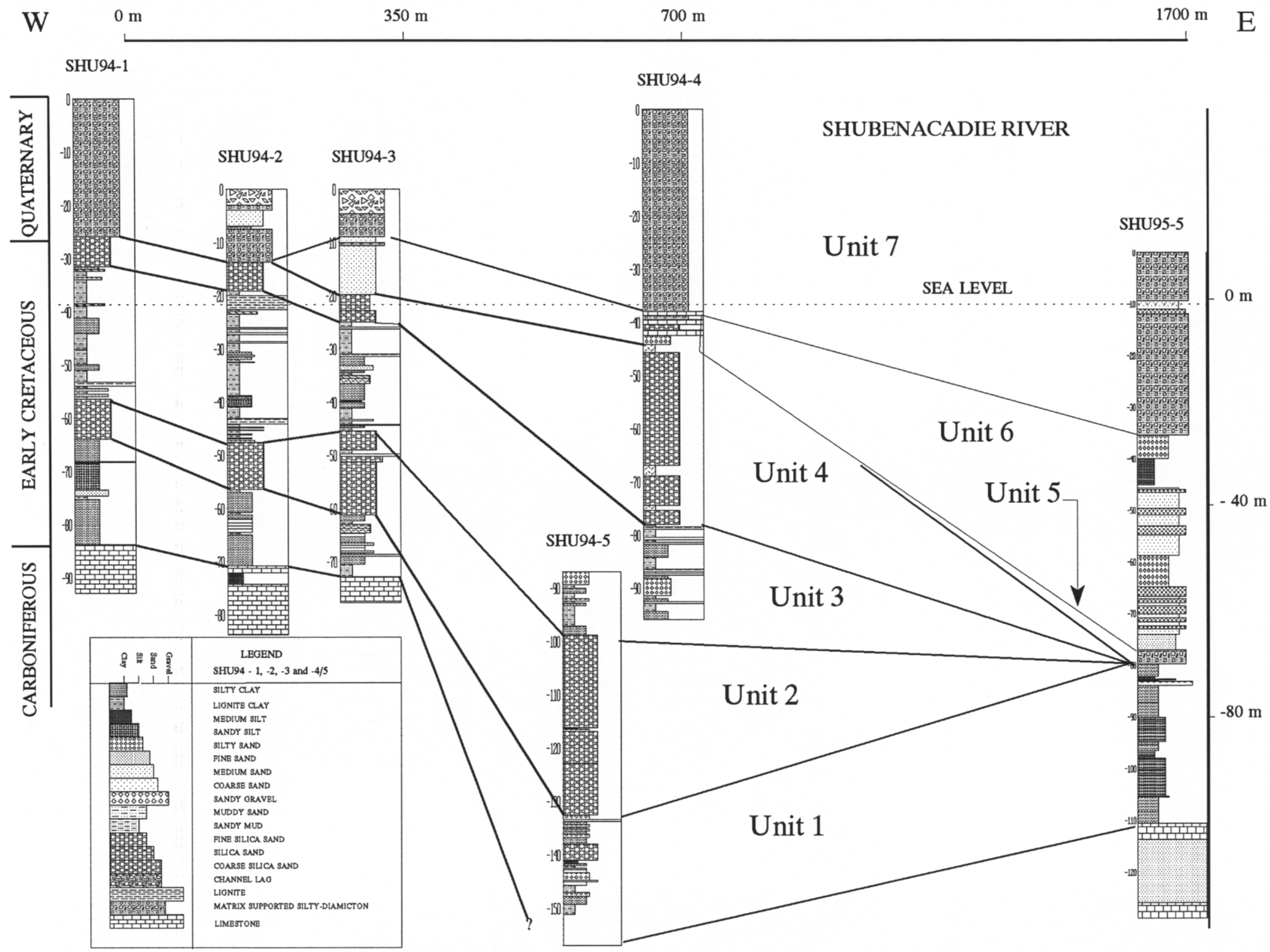


Figure 3. Correlation diagram for Transect 1 between drillholes SHU94 - 1 -5, and SHU95-5.

Unit 6: Alternating beds of poorly-sorted, feldspathic sand, medium and coarse gravel (sandy?) with rounded to subangular volcanic, plutonic, metamorphic and metasedimentary lithologies, and reddish-brown silty clay.

Unit 7: Matrix-supported silty diamicton, reddish-brown, calcareous, striated clasts, Cobequid Highland igneous erratics (East Milford Till); sand and gravel zones.

Top:

Transect 2

A second west to east drillhole transect can be constructed across the southern part of the Shubenacadie Basin (Map 1; Fig. 4). The first hole (SHU95-1) is located near the end of the Crombe Road on the property of Bokma Farms Ltd. and was drilled to a maximum depth of 65.5 m. Drillhole SHU95-2/3 was located on the property of Russell Moxsom near the intersection of the Densmore Road and Highway #2. This drillhole bottomed in limestone bedrock at 109 m. The third drillhole is located across the Shubenacadie River, in the property of Peter Suigest, and it encountered bedrock at 70 m. Ten lithostratigraphic units can be defined within the Quaternary and Cretaceous basin fill. These are:

Base:

At the base of drill holes SHU95-2,3 AND SHU95-5, respectively is a fossiliferous limestone and a limestone-dolostone breccia with interstitial greenish-grey clay.

Unit 1: A poorly sorted, greyish, quartzose (silica) sand with .25 to 10 cm diameter intraformational clasts of whitish and greyish, clay. The sand contains angular to subrounded quarts grains, with evidence of silica recrystallization on grain surfaces.

Unit 2: Fining upward sequences of greyish-white, quartzoze (silica) sand with gravelly, channel lag deposits at the base and white to dark grey lignitic clay, at the top. Intraformational clasts of lignite, and clay in lag deposits. Evidence of faulting and ductile deformation in clays. Silica sand contains muscovite, with globular or irregularly shaped secondary marcasite and other opaques.

Unit 3: Consists of large boulders of limestone, as in the Quaternary/Cretaceous interface in transect 1.

Units 4-7. Alternating matrix-supported diamictons (till?), varved and massive fine-grained sediments.

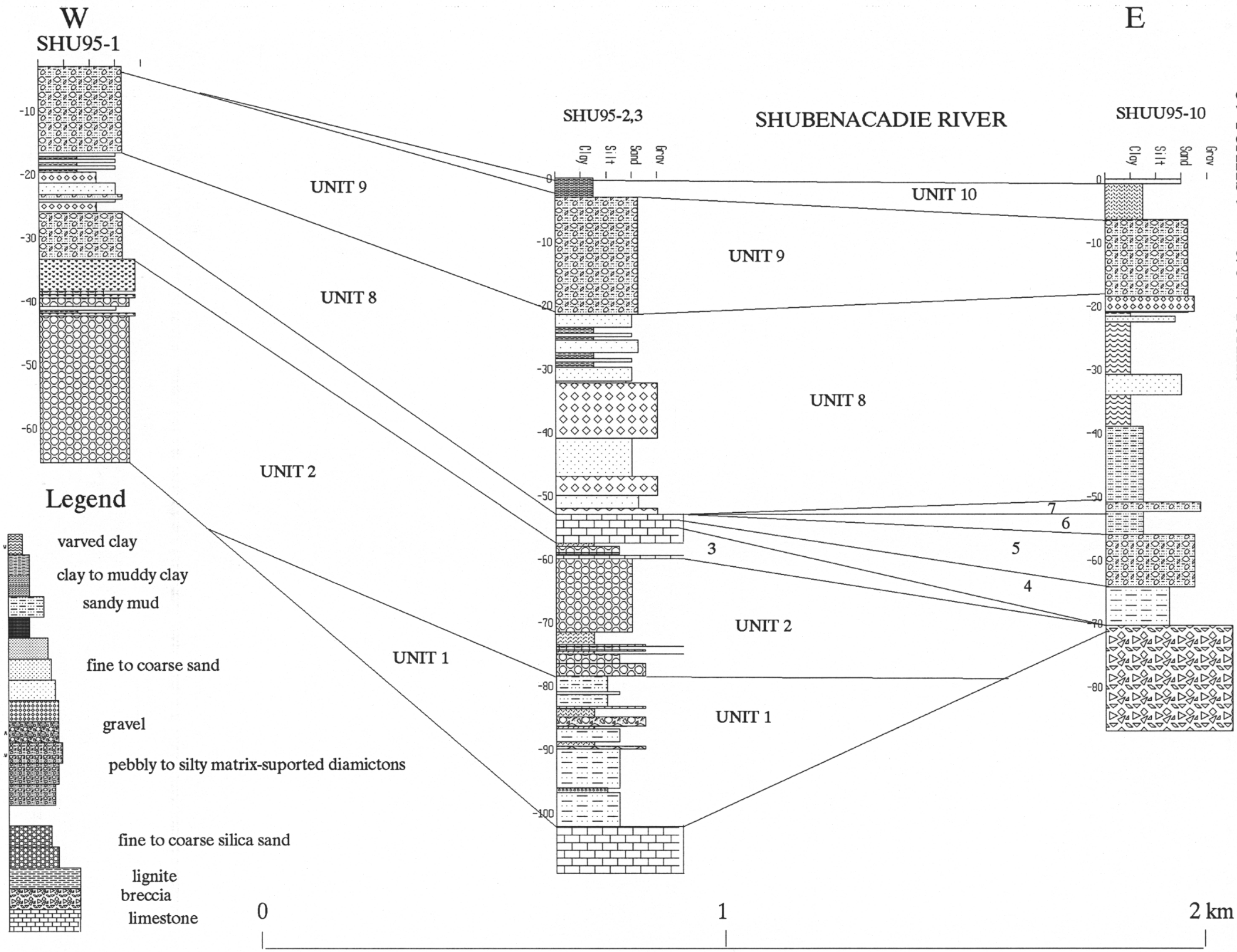


Figure 4. Correlation diagram for Transect 2 between drillholes SHU95-1, 2/3, and SHU95-10.

Unit 8: Thick sequence of coarse and fine-grained gravel to clay (glaciofluvial-glaciolacustrine sediments). Gravels contain reddish, foliated granites, volcanic, dioritic, metasedimentary and limestone clasts, reflecting both overlying and underlying tills. Sands are feldspathic-arkosic and orange-brown in colour. Thick, brown, massive clay in drill hole SHU95-5.

Unit 9: Reddish brown, calcareous, matrix-supported, silty diamicton (East Milford Till)

Unit 10: Brown, massive to banded clay-silty clay.

Top:

Seismic Stratigraphy

Test seismic spreads completed in 1994 and 1995, indicated that unconsolidated sediments underlie large areas of the Quaternary constructional landscape in the Shubenacadie Valley (Finck et al., 1994). In 1995, these test surveys were followed up using a detailed high resolution, seismic reflection profiling system described in the methods section. These profiles verify the continuity of unconsolidated strata between drillholes. The first line (Line 1-Densmore Road; Fig. 5-back) extends from west to east along the Densmore Road south of Shubenacadie and intersects drillholes SHU95-2/3 (Map 1). Together with Line 2-Crombe Road (Fig. 6-back) it represents nearly a complete cross-sectional view of the Cretaceous basin at this part of the Shubenacadie Valley.

In essence, the seismic reflection record is an acoustic cross-section of the geology (Sylwester, 1983). The main sources of reflections in the geological section are stratal surfaces and unconformities. Stratal surfaces are defined as bedding contacts or relict depositional surfaces (Brown and Fischer, 1982). Unconformities are surfaces of erosion and nondeposition which represent gaps in the geological record. Stratigraphic analysis is based on the method of Vail *et al.* (1977), termed seismic sequence analysis. This analysis is based on the recognition of unconformity-bound packages of strata called sesimic sequences. Boundaries between seismic sequences are recognized on seismic profiles by terminations of reflections. The boundaries are either erosional, lapout (hiatal) or conformable. Within each sequence, seismic "facies" can be defined (Mitchum *et al.*, 1977). The facies are based on the continuity, amplitude and frequency of the reflections. These wave front properties are an indication of the lithic properties of the strata. Seismic sequence and facies analysis permit the interpretation of the depositional history of the region including sea-level changes.

Densmore Road (Line 1)

The first line extends eastward approximately 1.5 km along Densmore Road. It crosses a large drumlin and extends out into a glacial lake plain that flanks the modern floodplain of the Shubenacadie River (Map 1, Fig. 5). This seismic line delineates a gently-dipping basin filled with unconsolidated sediments to depths of 110 m. The average velocity of 2000 m/s determined from the velocity analysis means that the time scale also corresponds to an approximate depth scale in metres below ground surface. This depth scale is most accurate in the near surface (</= 50 m); as depth increases, the velocities determined from the surface seismic data are less well-defined by the seismic data. Borehole seismic logs acquired in the Shubenacadie Valley suggest that velocity increases gradually with depth in the unconsolidated Quaternary/Cretaceous sequence. Such an increase in velocity with depth is also likely to be characteristic of this area, and if so, true depths below 50-60 m will be slightly greater than implied by a direct conversion of the time scale to depth. Vertical resolution is in the order of 4-8 m based on a dominant frequency of 150 Hz. Beds less than 4 m thick may or may not be resolved on the seismic record due to interference effects.

Between shot points 1-300, a prominent, continuous, flat-lying reflection at 200 ms (two-way travel time) is interpreted as the bedrock boundary (Sequence A, Fig. 5). Over much of the line this boundary appears to be "acoustic" basement, although from shot points 785-1010 several high amplitude, continuous reflections are resolved below the contact. Bedrock is interpreted at approximately 100 ms below the drill site, and bedrock was encountered at 100 m in the core.

Sequence B is a package of discontinuous reflections of fairly uniform thickness (65 ms) across the line. Reflections vary in amplitude from low to moderate in the west to more continuous and higher amplitude in the east, past a large channel feature at shot point 635. This unit corresponds to lithostratigraphic units 1 and 2 from core SHU95-2,3, mainly silica sand (Fig. 4). Thin lignite horizons provide strong impedance boundaries and hence strong reflections.

Sequence C consists of moderate to high amplitude reflections, with more continuity than Sequence B. It varies in thickness from less than 10 ms at the east end of the line to 60 ms in the centre. The basal contact is undulatory-(channelized?). This unit correlates with unit 8 (Fig. 4), with alternating fine and coarse sediments.

The uppermost sequence (D) consists of acoustically homogenous material with few coherent reflections. It is interpreted as till cover. The basal contact is relatively flat, in contrast to the surface topography which varies by 30 m as the line traverses a large drumlin and a relatively flat plain flanking the drumlin.

Crombe Road (Line 2)

West to east across this line the demarcation between unconsolidated strata and basement or bedrock is difficult to define (Fig. 6-back). The bedrock boundary appears to dip gently to the east. A package of discontinuous, low to moderate amplitude reflections lap over the faint trace of acoustic basement (Sequence A). This seismic package (Sequence B) appears to pinch out abruptly against acoustic basement at shot point 865. Channels are developed at the base of B.

Overlying sequence (B) is a package of moderate to high amplitude reflections (Sequence C) with more continuity than Sequence B. This is overlain by Sequence D, with alternating incoherent zones and discontinuous, high amplitude reflections.

Sequence B is correlated with the coarse silica sand unit (Unit 2-Fig. 4). The lack of reflections within Sequence B suggests that silica sand rather than clay-sand is the dominant lithology. Sequence C corresponds to an alternating package of diamictons and fine-grained waterlain sediments in SHU95-1. Sequence D, represents the surface till cover, which is relatively consistent in thickness, averaging 20-30m.

Shubenacadie Water Tower (Lines 3 and 4)

These lines represent perpendicular transects across an existing silica sand quarry and a drumlin to the east (Map 1). The seismic profiles in Figures 7 and 8 (back) have been interpreted and subdivided into five seismic sequences.

The top of the lowermost sequence (A, Figs. 7, 8) varies in depth from 100-150 ms from west to east across the section. It is not a particularly high amplitude or coherent reflection (except at the western edge of the section), but it appears to be an unconformable horizon with the overlying sequence pinching off against the sloping surface at the east end of Line 3. This reflection is interpreted to be the bedrock surface. Limestone bedrock was encountered in drillhole SHU94-3 at a depth of 73 m, which is somewhat shallower than suggested by this interpretation of the seismic profile, assuming that the velocity estimates are accurate at this location (Fig. 7). One possible explanation for this would be that the limestone surface encountered in the drillhole is weathered and/or highly fractured and that the high amplitude reflection on the seismic section is not generated by this interface, but by the surface of competent rock at greater depth.

Sequences B, C and D as a group correlate with the Early Cretaceous strata in the cores (Fig. 9). These three sequences increase in thickness from an estimated 70 ms at the west end of the profile to approximately 120 ms at the east end (Fig. 9). Sequence B consists of low-amplitude, discontinuous reflections that lap onto the interpreted sloping bedrock surface at the east end of Line 3. Sequence B correlates with the lowermost package of silica sand and underlying clay in the drillholes (Fig. 9). Sequence C is a package of high-amplitude, continuous reflections which correlates with the unit of thin, alternating clay, lignite and silt horizons in drillholes SHU94-3 and -4/5 (Fig. 9). The high-amplitude reflections may be largely due to the presence of lignite, even though it occurs in thin bands, as lignite is generally characterized by a high seismic velocity. Sequence D, like B, is characterized by much lower amplitude arrivals. It correlates with the thick unit of silica sand encountered in the two drillholes which increases substantially in thickness toward the east.

Sequence E is characterized by largely discontinuous reflections and is more incoherent than the underlying sequences. It increases in thickness towards the east, largely as a result of the increasing surface elevation (drumlin). This sequence is interpreted to be the Quaternary till

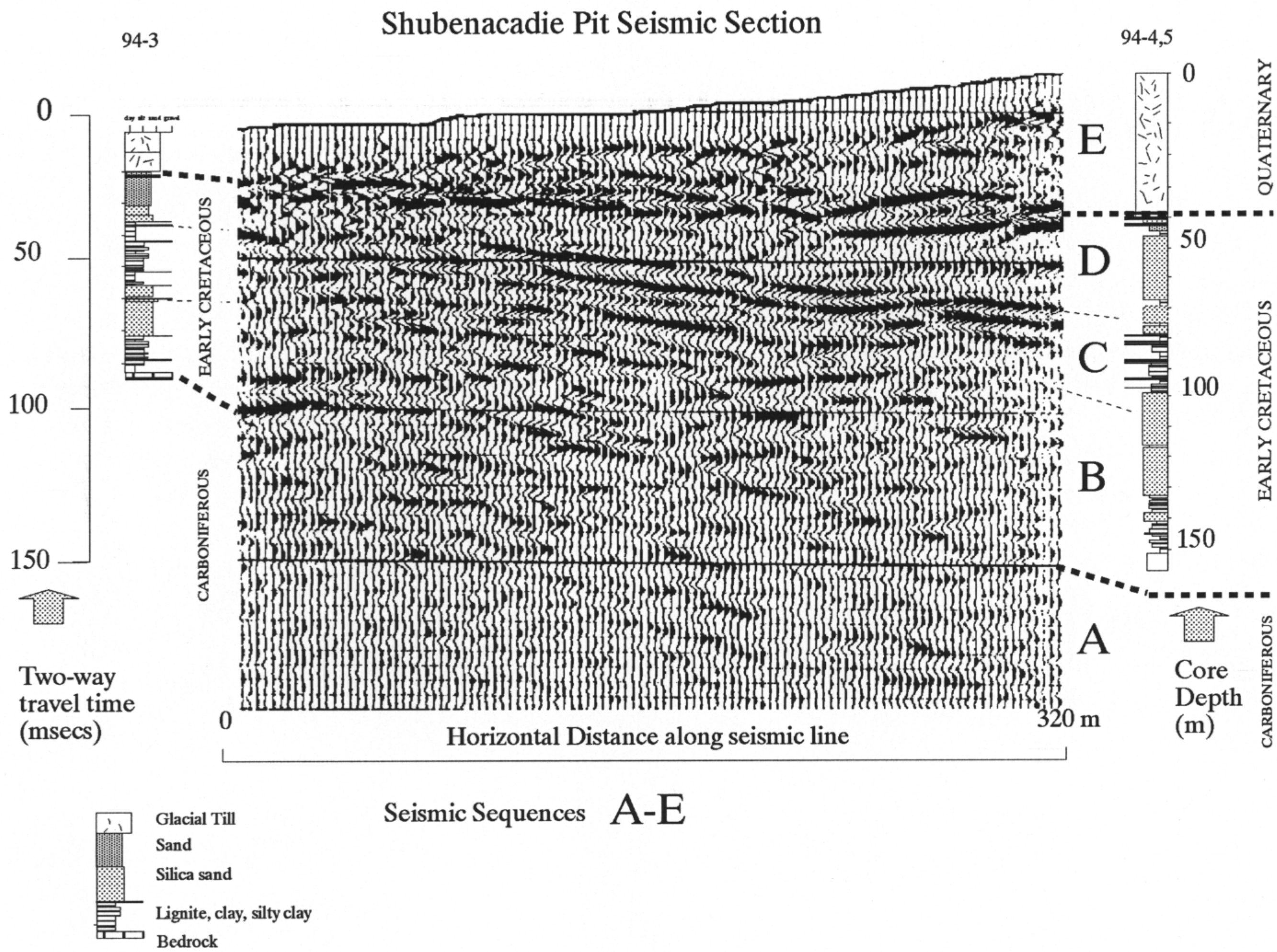


Figure 9. Part of the reflection seismic record along the Shubenacadie pasture transect (Figure. 7). The seismic profile is divided into five seismic sequences. Cores SHU94 - 3 and SHU94 - 4/5 are correlated with their approximate locations in the profile. Individual lithologic units in the core are stretched to match the seismic profile depending on their individual seismic velocities.

cover. The contact between sequences D and E (Quaternary-Cretaceous contact) is marked by a large amplitude reflection in this area, particularly just to the west of drillhole SHU94-4/5. In this hole the contact is marked by a 3 m thick limestone boulder lag which could easily give rise to such a reflection.

Nelson Hill (Line 5)

Line 5 is a north-south profile across a south-trending drumlin (Nelson Hill) located near the southern end of the Cretaceous basin in the Shubenacadie Valley. It passes through drillhole SHU95-4 (Map 96-001).

Three distinct sequences can be clearly differentiated at the south end of the profile (Fig. 10). The lowest sequence (A) consists of straight, or flat-lying, high amplitude reflections that gradually become muted down-section. This contact becomes less distinct proceeding north along the profile. SHU95-4 (Appendix 2) encountered limestone bedrock at 91 m which very closely matches a depth of 95 ms on the seismic record.

Sequence B is only present at the north end of the section, and is a package of discontinuous reflections that pinch out abruptly near shot point 240. This unit apparently wasn't sampled during drilling. Our interpretation implies that Cretaceous sediments may be encountered by drilling a few hundred metres to the north of SHU95-4.

Sequences C and D are characterized by continuous, high amplitude reflections. These are correlative with gravel-sand-clay contacts in SHU95-4. Sequence E is characterized by a continuous reflection which separates two incoherent zones. This corresponds to two till sheets separated by gravel in SHU95-4.

Stratigraphic Summary

Much of the glacial constructional topography of the Shubenacadie Valley is underlain by unconsolidated Mesozoic coarse and fine-grained sediments. Figure 11 is a digital terrain model of the region south of the town of Shubenacadie at the location of the Densmore seismic line. It shows the relationships between actual topography and stratigraphy based on the reflection profiles and diamond drill holes. The Mesozoic basin is interpreted as a half-graben structure due to the presence of a thick faulted limestone breccia at the base of drillhole SHU95-10. Dickie (1986) noted the relationship of the previously known Cretaceous occurrences and fault-bounded Carboniferous basins. The NE-trending Meadowvale fault mapped by Giles and Boehner (1982) crosses the east side of the Shubenacadie Valley near drillhole SHU95-10. These faults are post-Carboniferous but their exact age is uncertain (R. J. Boehner, pers. comm, 1996).

Early Cretaceous sediments consist of coarse- to fine-grained siliceous gravels and sands, lignite,

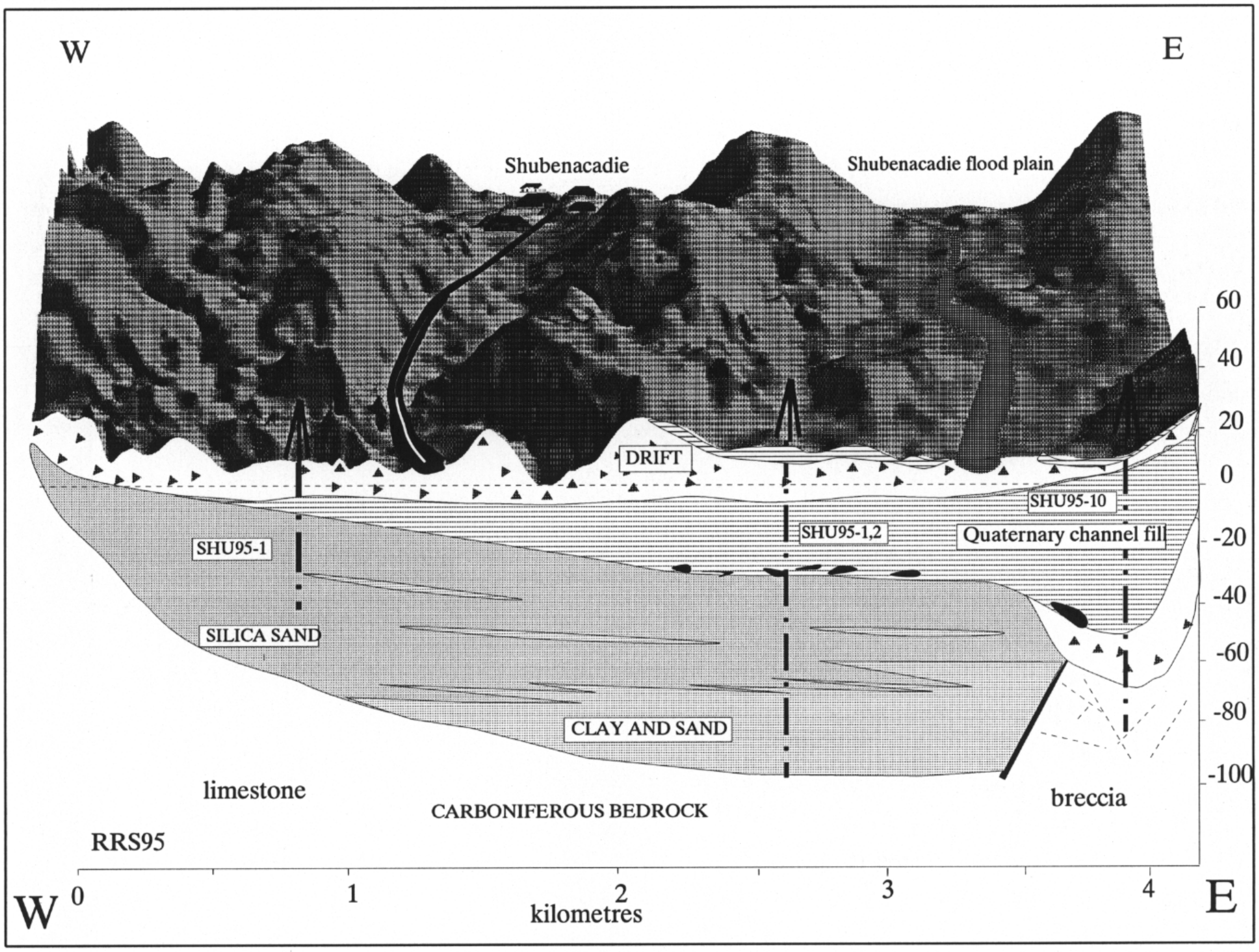


Figure 11. Schematic cross-section of the Densmore and Crombe road seismic transect region underneath a digital terrain model of the actual topography. Quaternary sediments consist of variable thicknesses of till conforming to the topographic variations. Glacial lake sediments overly till along the Shubenacadie flood plain. Thick deposits of Cretaceous silica sand and clay underlie Quaternary channel fill.

white clay and light grey- to black clay. There is an eastward and down-core increase in the amount of fine-grained material in these sediments. The known areal extent of Cretaceous deposits has been increased from approximately 0.5 km^2 to approximately 15 km^2.

Within the Shubenacadie Basin, thick deposits of Quaternary(?) gravel, sand and varved clays underlie the surface drift sheets (Fig. 11) These have been noted by Hughes (1957) in till sections along the Shubenacadie River. High-resolution reflection seismic surveys conducted along the Densmore and Crombe roads indicate that these deposits have a channel morphology with reflectors pinching out and forming an unconformity against underlying and surrounding Cretaceous sediments. In the vicinity of SHU95-10 a large channel has been carved out of bedrock and infilled largely with massive and varved brown clays. At the base of the Quaternary infill are boulders or blocks of limestone.

The surface Quaternary drift in the Shubenacadie study region is composed of three distinct till units. These are from top to bottom: Hants, East Milford and Miller Creek Tills (Stea, 1984). The topography is strongly rolling and the drift is shaped into southward-tapering drumlins. Average drift cover over much of the Shubenacadie Valley is 20 m with a maximum thickness of 50 m on drumlin crests.

Musquodoboit Valley Lithostratigraphy

Within the Musquodoboit Valley 9 new drill holes have been completed, 5 of which intersected Cretaceous sediments at depths varying from approximately 10 m to 30 m. The margins of the Mesozoic basin in the Musquodoboit valley have been defined (Map 96-001). Detailed stratigraphic logs of the nine MUSC95 series of holes are presented in Appendix 2. Additional drilling is continuing during the winter of 1996. Results have expanded the known distribution of Cretaceous sediments from an area of 8 km^2 to an area of approximately 42 km^2 (Map 96-001). The distribution of these sediments is open-ended to the east along the Musquodoboit River Valley.

Figure 12 shows log sections for drillholes MUSC95-1 to MUSC95-5 in a west to east transect. Drillhole MUSC95-2 contains many of the units representative of the Cretaceous sediments found within the Musquodoboit Valley and is considered to be a reference section. At the base of sections MUSC95-2 and MUSC95-11 are 5-10 m thick brecciated clay units. The breccias are composed of angular intraformational clay, mudstone and marlstone clasts in a clay matrix. Faulting and slickenside surfaces were noted.

Four lithostratigraphic units can be defined in the unconsolidated Mesozoic and Quaternary strata overlying Carboniferous limestone and breccia. These are:

Base:

Unit 1: Alternating sequences of light to black, organic rich, kaolinitic clay containing

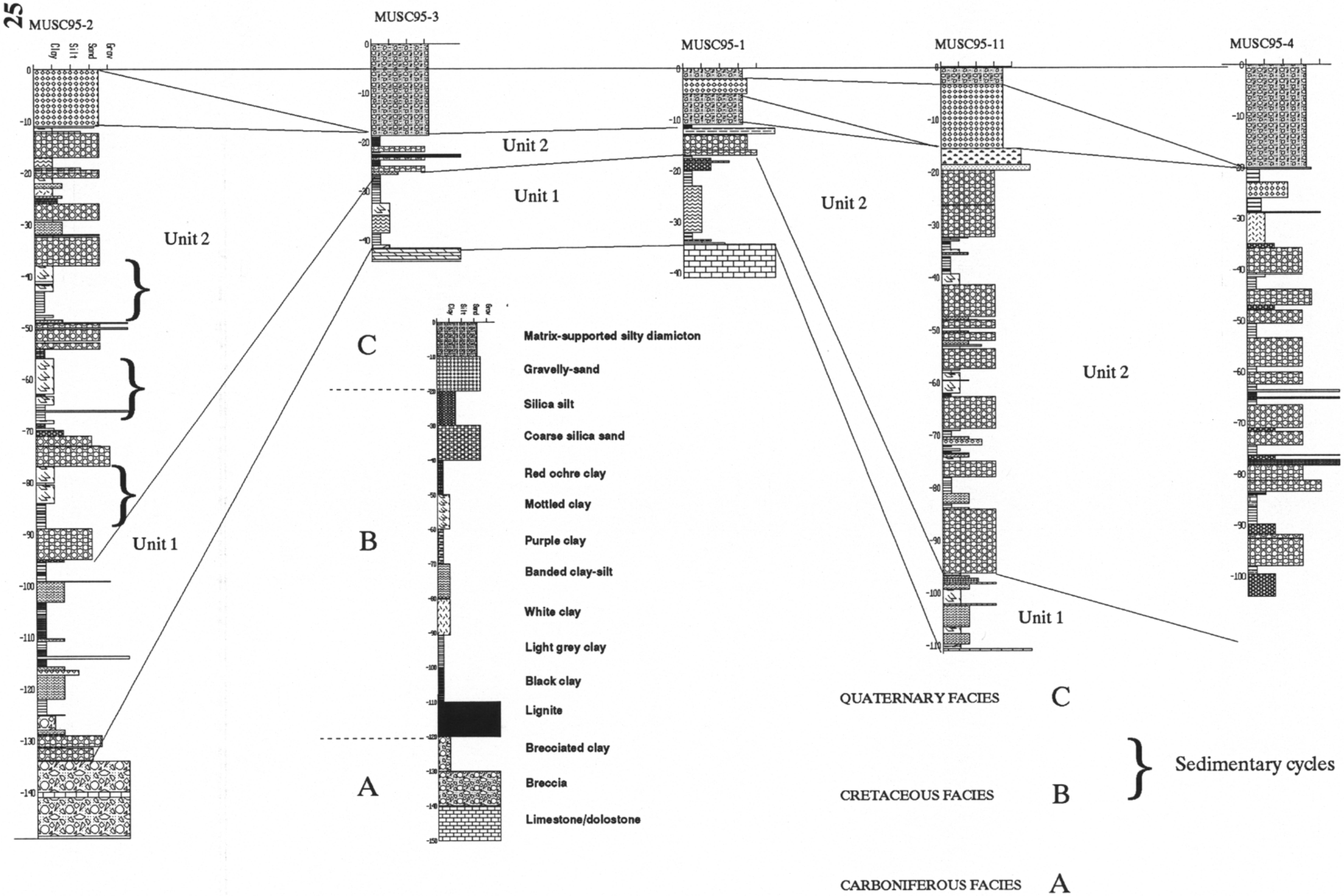


Figure 12. Correlation diagram for drill holes MUSC95-1,2,3,4,11.

lignite to sub-bituminous grade wood fragments, charcoal and pyrite nodules. Some of the grey clay units are rhythmically laminated with thin segregations of silty clay.

Unit 2: Cycles of fining-upward white silica sand capped with grey to light-grey to white massive kaolin; then mottled white, red and purple kaolinitic clay and finally a thin band of massive, red ochreous clay. Four well developed cycles can be discerned at the reference section (MUSC95-2, Fig. 12). Sedimentary cycles become coarser up-core with the percentage of sand increasing and the percentage of clay decreasing. Individual clay beds average 2 m in thickness but may reach thicknesses up to 10 m, e.g. MUSC95-2. The percentage of mottled and reddish clays at the tops of the individual cycles decreases across the basin towards the west with MUSC95-4 showing little mottling and thicker, coarser sand units.

Unit 3: Matrix-supported diamictons and gravels (undifferentiated).

Top:

The total thickness of Cretaceous sediments varies from 32 m (MUSC95-1) to > 200 m in the area of Middle Musquodoboit (Map 96-001; Fig. 12). Drillholes MUSC95-1 and 3 indicate that on a local scale the erosional surface between the Cretaceous and Quaternary sediments is approximately horizontal. Drift cover over Mesozoic sediments varies from 15 to 30 m.

Lignites

The lignitic beds of drillholes MUSC95-1, 2, and 3 are dominated macroscopically by two broad lithofacies; charred plant stems (fusain) with quartz and kaolin vesicles and homogenous, massive dull lignite. The fusain-rich lithotype predominates (J. H. Calder, pers comm., 1996).

Musquodoboit Valley Seismic Stratigraphy

Chaswood Meadows Seismic Line

The Chaswood Meadows seismic line shown in Figure 13 is a north-south profile approximately 2.5 km in length. The data are generally of high quality except for a 150 m section in the centre of the profile. In this area the surface conditions were boggy and source-receiver coupling to the ground was poor. The dominant frequency of the reflection signals on the rest of the section is on the order of 150 Hz. This implies a seismic wavelength of approximately 15 m (assuming an average velocity of 2000 m/s) and a subsurface vertical resolution of 4-8 m. The section clearly shows two superimposed basins overlying acoustic basement:

1. An asymmetrical basin at the south end of the line, steeper on the south side,

approximately 1 km wide and 50 m deep filled with Quaternary sediments.

2: A larger, symmetrical basin, 2 km+ wide and 130 m deep filled with Cretaceous sediments.

NSDNR drillholes (MUSC95-4 and MUSC95-9, Map 96-001) provide groundtruth that aids in interpreting the features observed on the seismic section and confirms that this profile delineates a valley infilled with Cretaceous sediments. A series of continuous, high amplitude reflections (Sequence A) mark the bedrock/sediment contact and the base of the valleys. It is not certain which one of these closely-spaced reflections represent the bedrock boundary, but from drill records it appears to be the uppermost reflection (Fig. 13). A clear break in reflection orientation and character is indicated from CDP 120-170 at the north end of the line. This may delineate a bedrock contact, perhaps the Meguma/Carboniferous boundary. This break which propagates through the overlying sequence may be a high angle fault.

Sequence B is defined by discontinuous, low-moderate amplitude reflections that downlap onto a prominent reflection (bedrock?) at 75 ms (CDP 200, Fig. 13). Sequence B has a uniform thickness of approximately 70 ms. Towards the top of the sequence there is a series of high amplitude continuous reflections. Sequence C is defined by possible onlap of high amplitude reflections, but the unit may be considered a seismic facies. Nonetheless, it is characterized by higher amplitude and more continuous reflections than Sequence B. The large amplitude reflections observed on the seismic section (e.g. at 65 ms, CDP 420) are likely related to the interference of reflections from a number of thin kaolin clay/silica sand layers (i.e. thin with respect to seismic wavelength) and especially to reflections from lignite and/or marcasite layers which will be characterized by large reflection coefficients. The contrast between higher amplitude reflections in Sequence C (30-60 ms) and the more transparent Sequence B (90-140 ms) on the seismic section suggests that the Cretaceous sediments become more massive with depth. The MUSC95-4 borehole supports this interpretation in that the thickness of the alternating layers of sand and clay increases with depth. A recently completed drill hole reached bedrock at 130 m which corresponds with the interpolated boundary at 135 ms.

MUSC95-9 was drilled off-line to the west of CDP 826 (2055 m from the south end of the line). It encountered Quaternary diamictons, sands and silty clay above limestone bedrock at a depth of 53 m (Appendix 2). The seismic section indicates that this hole was drilled on the southern margin of a Quaternary basin channel which cut down to the bedrock surface through the Cretaceous sequence. The Quaternary channel is 500-600 m wide and reaches a maximum depth of 80 m approximately 200 m north of the drillhole. This seismic line and associate drillholes define the continuity of valuable kaolin clay layers whose significance will be further outlined in the Economic Geology section. Some of these reflections can be traced up to 1.5 km along line.

Mineralogy

Mineralogical studies on core samples from the Shubenacadie and Musquodoboit drilling programs are ongoing. Fowler and Stea (1979) and Stea and Fowler (1981) reported on the stratigraphy and mineralogy of a newly-opened silica sand quarry (West Indian Road Quarry) in the Shubenacadie Basin near Brazil Lake, Hants County (Map 96-001). These data are summarized here.

The Brazil Lake pit (cover photo, Fig. 14) revealed a striking sequence of brightly-coloured fine-grained sediments and white sands in unconformable contact with overlying Quaternary glacial deposits. The Cretaceous beds were found to strike at 25° with a 35° dip to the north that seemed to be consistent along strike throughout the pit. Some beds also appeared nearly vertical. The unconformable nature of the Pleistocene-Cretaceous contact is well illustrated in a cross-section through subsurface deposits of silica sand at Elmsvale (Fowler, 1972).

One part of the pit displayed a section showing two distinct fining upward cycles spanning 4 m (Fig. 14). Exposed at the base of the sequence was a whitish, sandy, cobble-gravel (Unit 1) grading into a sandy mud (Unit 6). Following this cycle was another sandy-gravel (Unit 7) grading into a well sorted sand (Unit 9). These units were capped by another coarse unit (10) (pebbly gravelly-sand). The pink mottled mud unit displayed numerous black and white micaceous silt laminae. Some of the laminae were highly contorted. Black and red managanese oxide and hematitic staining was visible in the sand units. Swirls of reddish-brown staining (hematite) were found to crosscut bedding near the top of the sequence (Fig. 14).

Petrographic Summary

Quartz is the most abundant mineral in the modal fractions accounting for greater than 98% of all minerals observed. The grains are predominantly angular; the sediments in general exhibit poor roundness sorting. The quartz grains are primarily strongly undulose single and composite types. Kaolinitic clay and mica become major constituents in Units 5 and 6 (Fig. 14). Feldspar is a minor constituent comprising less than 1% of the modal fractions. Gypsum was found to occur in abundance in samples 6-9 as brown, rod shaped, brittle grains concentrated in the finer fractions.

Heavy minerals comprise from 0.3% to 2.9% of the fine- and medium-sized sand fractions of the samples. Opaque minerals are predominant averaging 92% of all the heavy minerals. Ilmenite and pyrite are the most abundant opaques. Hematite is also present in substantial amounts. The heavy mineral grains are mostly rounded. Of the translucent grains, yellow angular staurolite is the most abundant (36%) followed by rounded, fractured zircon (31%), angular and rounded tourmaline varieties (12%), a rare earth phosphate (11%) and barite (3%). Andalusite (2%), cassiterite, garnet and amphibolite-feldspar rock fragments are trace constituents (<2%).

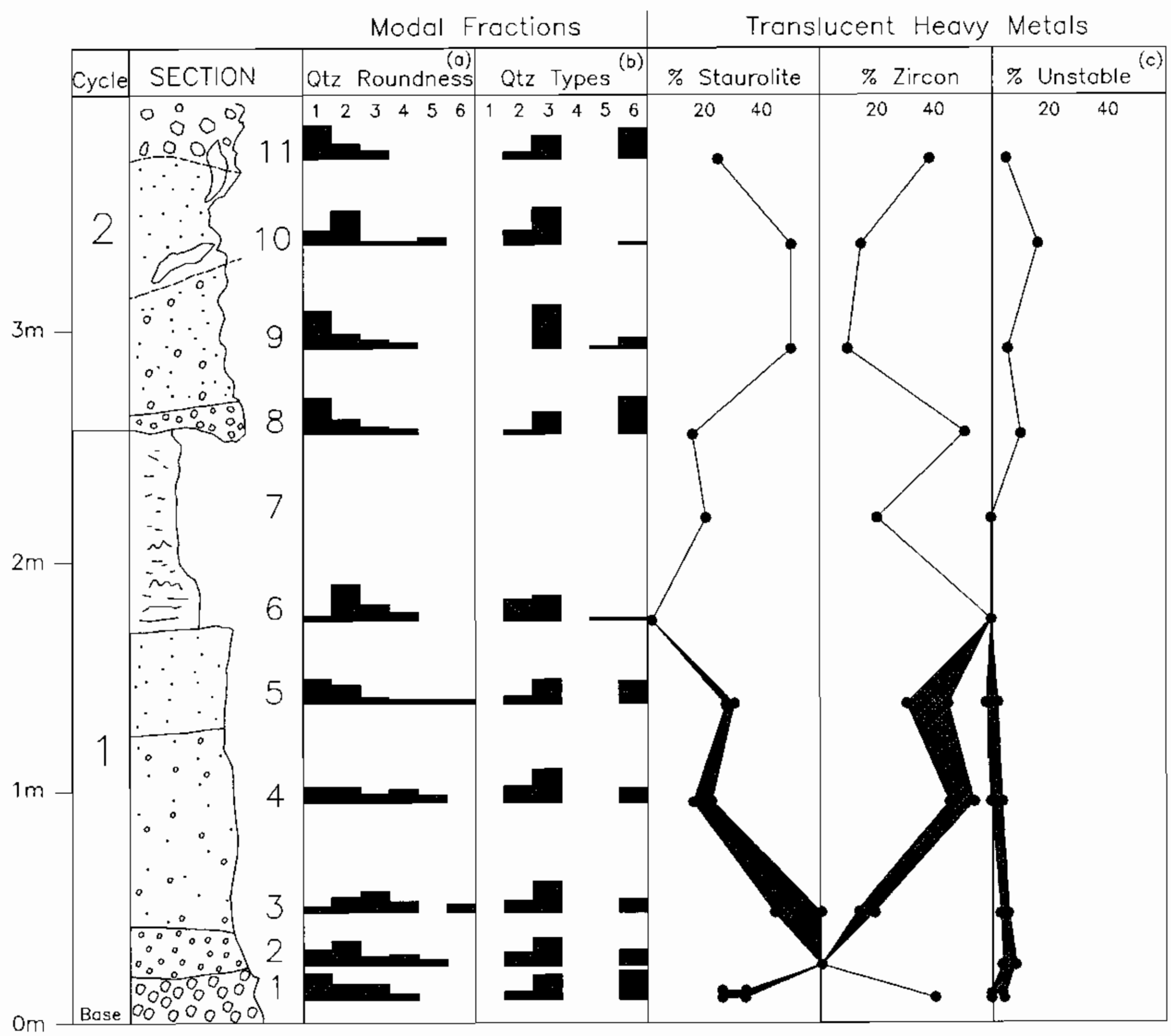


Figure 14. Stratigraphy of a section of the Brazil Lake quarry and some relevant sediment parameters (after Stea and Fowler, 1981).

INTERPRETATION

Age

Palynological studies were carried out on lignitic sediments and clays recovered from Unit 3 in drillhole SHU94-3 (Fig. 3). The faunal list is as follows:

Appendicisporites
Cicatricosisporites purbeckensis
Concavissimisporites apiverrucosus
Concavissimisporites granulosus
Concavissimisporites montuosus
Nodosisporites
Pilosisporites trichpapillosus
Rugubivesiculites
Saxetia elongata

The presence of forms *Appendicisporites* firmly places this suite above the Jurassic-Cretaceous boundary, and the lack of angiosperm pollen indicates a pre-Albian age. The richness in variety of cicatrose forms may indicate that the strata are Early Cretaceous, Barremian to Aptian in age (124 to 113 Ma) but an older age cannot be ruled out (R. Fensome, personal communication, 1995). Dickie (1986) reported Valanginian to early Albian ages for Diogenes Brook sediments.

Clays from Unit 1 (Fig. 3) were also sampled and produced poorly preserved spores typical of the Visean Windsor Group (G. Dolby, pers comm., 1995)

Depositional Environment

Cretaceous unconsolidated sediments were originally thought to be fluvial (Ries and Keele, Benteau, Lin. Stevenson, Stea and Fowler) or fluvial/deltaic (Dickie, 1986). This detailed stratigraphic study indicates that several depositional environments may be encompassed within the Cretaceous sedimentary basin. Cretaceous sediments occur as distinct sand and clay-dominated units. The clay-dominated units consist of kaolinitic clays with repeating cycles of light-grey kaolinitic clay to dark-grey and black lignitic clay and lignite. The sand-dominated units are characterized by thick basal sequences of quartzose gravelly-sand, sand and channels with coarse gravel at the base. Armoured kaolin balls (Stea et al., 1995) and lignified wood fragments (Benteau, 1973) have been described in these coarse gravel deposits which are interpreted as stream channel traction load deposits. The channel geometry is apparent in both field (Fig. 14) and seismic sections (Figs. 5, 6, and 13). Pirkle *et al.* (1964) postulated a fluvial origin for the Cretaceous Citronelle Formation in Florida citing the occurrence of armored kaolin balls.

The coarse gravels are usually overlain by medium- to fine silica sand beds, massive and laminated grey-white clays and lignite horizons capped with red mottled clays. The sediment cycles are a result of lateral migration of meandering streams and a succession of river deposits encompassing channel, point and braid bar, levee as well as flood plain environments. The lack of primary bedding features in the sands at Brazil lake, although noted at Shubenacadie by Benteau (1972), may be due to the tectonism that tilted the sequence or may be an apparent feature due to the absence of lithification.

Red and white mottled clays and red massive clays appear towards the top of many of the cycles (Fig. 12). These are interpreted as zoned paleosols similar to those described by Pickering and Hurst (1989) in Georgia kaolin deposits. This interpretation is based on:

1. Consistent stratigraphic position, near the top of fining-upward cycles,

2. Rootlets found in mottled clays from drill core MUSC95-2,

3. The preponderance of iron-oxides, and

4. A lack of lignite horizons.

Lignite horizons are most often associated with grey or black clays within the sand and the clay-dominated facies. The fusain-rich clays are interpreted as parautochtonous deposits washed into topographic lows or lakes as a result of fire-caused soil erosion. The darker clays resemble gyttja, fine organic debris which accumulates in reducing lake or lagoon bottom environments (J. H. Calder, pers comm, 1996). Marsh foraminifers have been identified in lignite horizons from the lowest clay unit in SHU94-5 suggesting an estuarine origin for at least part of the sequence (J. Warringer, pers comm, 1996).

The clay-dominated packages (Figs. 4 and 12) are interpreted as lacustrine or brackish lagoonal gyttja deposits. The lack of marls and glauconitic clays auger against fully marine conditions. Tertiary marine clays of the Georgia kaolin district are glauconitic, contain dinoflagellates, sponge spicules and molluscs (Patterson et al., 1984). J. Warringer (pers comm, 1996) did not find foraminfera within the clay horizons. Mechanisms of clay deposition within these lagoonal environments may involve flocculation by a change in Ph when kaolin-laden water encounters brackish water (Pickering and Murray (1994).

There appears to be a west to east decrease in overall grain size within the Cretaceous sequences. The Brazil Lake and Crombe Road areas are dominated by coarse sand whereas the Elmsvale area is predominately clay. Drillholes also generally show an upward increase in the frequency of sand and gravel beds. This progradational geometry is indicative of a deltaic system (Bhattacharya and Walker, 1992). Clinoform beds have not been noted within the seismic sections, but the geometry of the basins may have been altered by post-depositional tectonism.

Diagenesis and Post-Depositional Tectonism

The lack of feldspar and phyllic rock fragments in these sediments, interpreted to be fluviatile, is a paradox. Most modern fluvial sands are lithic and/or feldspathic, the average in large rivers being 19 and 15 per cent respectively (Pettijohn *et al.,* 1972). This lack of feldspar has been noted in terrestrial Cretaceous sands all over the continent (Hamblin, 1979; Pirkle *et al.,* 1964; Pryor, 1960) and in the marine sandstones of Lower Cretaceous age offshore (King *et al.*, 1969). Five hypotheses that may account for quartz-rich and kaolinitic sediment are:

1. A quartz and kaolin-rich source area,

2. Physical abrasion and reworking during transport,

3. Chemical weathering in the source area,

4. Postdepositional subaerial weathering, and

5. Postdepositional intrastratal solution.

The presence of visible mica in the finer Cretaceous sediments suggest that there were probably granitic sources of feldspar in the catchment areas (Hypothesis 1). The lack of feldspar in these sediments seems to be a characteristic of Cretaceous sediments in general and not just a local phenomenon. One can therefore assume that the mineralogy of the source area was only a minor factor in controlling the petrology of these sediments.

The poor roundness sorting of the quartz grains (Fig. 14) and the inferred fluvial environment of deposition precludes physical abrasion as an important process in the depletion of feldspar in these sediments (Hypothesis 2). The association of high grade kaolinite in these silica sands indicates that chemical weathering of the feldspars has occurred. Murray (1976) concluded that the Georgia kaolin deposits were derived from already weathered detritus (Hypothesis 3). Dryden and Dryden (1946) noted that Lower Cretaceous sands in Maryland, derived presumably from a nearby garnetiferous schist unit, contained little or no garnet while older and younger rocks of similar permeabilities contained abundant garnets. They attributed this depletion to source area weathering and deposition of already weathered materials. Kesler (1963), however, attributed the origin of the silica sand and kaolin clay deposits in Georgia to early diagenetic weathering of feldspathic sands deposited in a deltaic environment (Hypothesis 4). Dickie (1986) followed a similar line of reasoning in interpreting that the Nova Scotian clays were laid down as a mixture of clays and then diagenetically transformed into kaolin during Cretaceous and Tertiary weathering (Hypothesis 4).

The Cretaceous sediments of the Shubenacadie and Musquodoboit valleys are segregated according to primary depositional fluvial features. Armoured mud balls prove that clays existed before burial. The sand beds are noticeably deficient in clays which would be hard to explain if kaolins were formed solely by a process of intrastratal solution of a feldspathic sand (Hypothesis 5). Hypothesis 4 may be refuted on geochemical grounds as clays, once deposited, are not likely to be diagenetically transformed (Krauskopf, 1967, p. 192). If kaolins were produced by subareal weathering this would also be expected to produce limonitic or hematitic coloration throughout the sections instead of within vertically-limited zones. Hypothesis 3 is the most likely scenario. The clay beds were deposited largely as kaolin without substantial modification as suggested for the Georgia clays (Pickering and Hurst, 1989).

The suite of heavy minerals found in the Nova Scotian deposits differs from many published assemblages of fluvial Cretaceous sands in the abundance of ilmenite and staurolite. It is a 'limited' assemblage in the sense of Groot and Glass (1960), characterized by a lack of chemically unstable heavy minerals such as garnet and epidote. One exception of this rule however, seems to be the Cretaceous silica sands of the Hudsons Bay Lowlands where hornblende and garnet are major constituents (Hamblin, 1979), also implying that post-depositional weathering and intrastratal solution were not important factors. If source area weathering is a major controlling influence of the mineralogy of these silica sands, then variations of source area and climate may have produced the contrasting heavy mineral suites.

There is no doubt that some diagenetic effects have occurred. Early diagenetic pyritic and marcasitic replacement of organics is ubiquitous. The bright colours evident in some of the clays, notably at Paint Brook (Fowler, 1972) may be explained by oxidation of pyritiferous horizons or dehydration of limonitic paleosols. Goethite (yellow) and hematite (red) are common end products. As discussed earlier, the latter possibility is more likely because of the association of unaltered, pyritiferous grey clays and reddish, mottled clays. Secondary kaolin may also be present within silica sands, with extraordinary high clay contents.

Organics horizons have undergone metamorphosis due to heat or burial to lignite rank. Mean vitrinite reflectance data (R_o) from lignitic horizons in drillhole SHU94 - 4/5 range from 0.31 to 0.48 R_o (Table 2, P. Mukhopadhyay, personal communication, 1994). This level of organic maturity indicates heating to temperatures up to 80^0C and a depth of burial of at least 1 km for geothermal gradients typical of sedimentary basins (20 - 40^0C/km, D. Arne, personal communication, 1994; Stea et al., 1995).

Sediments within the Shubenacadie and Musquodoboit Valleys are preserved within regionally extensive, >55 km^2, basins. Faults appear to have disrupted Early Cretaceous strata along the Chaswood Meadows seismic line (Fig. 13) and are suspected to form the northern boundary of of the Musquodoboit Valley (North Border Fault) separating the Carboniferous basin sediments from horst-blocks of Cambro-Ordovician sediments (Boehner, 1974). NE-trending faults along the Meguma-Carboniferous contacts were mapped by Boehner (1974) and were originally inferred from steepening dips adjacent to the contact. The Chaswood Meadows fault appears to be a reverse fault from it's apparent dip. The fault hypothesis is also supported by the presence of fault breccias at the base of most basin margin drill sections. The anomalous dip of the strata at the Brazil Lake quarry also implies post-depositional faulting. It would appear that the lowlands are largely structural rather than erosional basins.

Table 2: Vitrinite reflectance data for drillhole SHU94-4/5.

Sample Number	**Mean Vitrinite Reflectance R_0**	**Standard Deviation**	**No. of Grains Measured**	
			Autochthonous	**Allochthonous**
Shub - 305'	0.33	0.06	5	23
Shub - 395'	0.31	0.02	50	0
Shub - 437'	0.31	0.02	24	1
Shub - 481'	0.41	0.06	27	14
Shub - 515'	0.48	0.08	46	4

Geomorphic Evolution Of Nova Scotia

The "memory" of past events recorded in the landscape of Nova Scotia is brief in a geological time scales. The evolution of Nova Scotia landscapes after the cataclysmic split of Pangaea and the opening of the present day Atlantic Ocean during the Triassic-Jurassic Periods has been debated for over century. The arguments centre on two basic theories of landform development: the time-dependant, evolutionary concepts of the geomorphic cycle (Davis, 1922), and steady-state landscape hypotheses (Hack, 1960). J. W. Goldthwait (1924) and Roland (1982) interpreted the geomorphic evolution of Nova Scotia in the light of Davisian concepts. They suggested that the entire region had been covered during the Mesozoic and then planed off and dissected during a Tertiary cycle of uplift and erosion. This erosional cycle was presumed to predate the deposition of kaolinitic clays and silica sands found in isolated sites in lowland regions of Nova Scotia (Goldthwait, 1924). However, the Early Cretaceous age of these sediments negates this erosional hypothesis. A more compelling hypothesis is that the lowlands are structural basins rather than erosional features. In this manner mineralogically-mature Early Cretaceous fluvial sediments were juxtaposed in steep-walled fault valleys.

King (1972) suggested that the lowlands of the Bay of Fundy may have been covered by extensive Cretaceous and Tertiary sediments and subsequently exhumed by uplift, although he questioned the existence of a peneplain. The presence of widespread unconformities in the Atlantic offshore implies erosion or rejuvenation of the landscape. Tertiary sediments have been found 40 km southwest of Yarmouth on the Meguma Group rocks of the Southern Uplands and are found in numerous outliers in the Gulf of Maine (King, 1972; G. B. Fader, pers. comm., 1986). Saprolites preserved on the North Mountain and in Cape Breton Island (McKeague et al., 1983; Rutherford and Thacker, 1988) indicate a period of warmer climates and deep, intense weathering during the Mesozoic or Tertiary (Grant, 1989) and may have been source areas for the Early Cretaceous sediments. The maximum extent of the Tertiary transgression is not known. The depth of burial of lignites in the Early Cretaceous outliers has been inferred to be 1 km based on vitrinite reflectance and fission track data (Hacquebard, 1984; Arne et al., 1989; Stea et al., 1995). At this depth of burial, Early Cretaceous or younger sediments would easily have overstepped the present day Southern Uplands as well as the Cape Breton Highlands, which only attain heights of 600 m. Ryan et al. (1992) measured apatite fission tracks on upland surface rock samples. These samples yielded Upper Carboniferous-Jurassic fission track ages which record the last time the region was buried by more than 2 kilometres of sediment. Ryan (pers comm, 1992) believes that the upland surfaces were exhumed in the Carboniferous-Permian and have not been overstepped by substantial volumes of younger rocks.

Recent work on the offshore Cretaceous sequence suggests that a huge drainage basin existed at that time deriving material from the Canadian shield (Grist et al., 1990). This is difficult to reconcile with a steady-state model where drainage patterns similar to today have been maintained since the Triassic.

Upland planation may have occurred during several cycles of deposition and subsidence followed uplift and erosion from pre-Carboniferous to the present. From the Jurassic to the Early Cretaceous the topography was gradually reduced from high to low relief by a combination of erosion and deposition. Valleys were infilled by accreting Cretaceous sediments. The end product was a coastal plain analogous to the Mississippi delta region (Fig. 15). Cretaceous fluvial sediments dominated by quartz and kaolinitic clays are found throughout eastern Canada (Stea and Fowler, 1981; Dickie, 1986). Tectonism after the Early Cretaceous may have brought an end to this depositional cycle. Pe-Piper et al., (1994) invokes reactivation of transform faults along the Orpheus graben to explain Cretaceous volcanism and a major Mid-Cretaceous unconformity. This tectonic event may have been propagated throughout the Glooscap fault system which bisects Nova Scotia and it's subsidiary NE-trending faults. Reverse as well as normal faulting may be expected in this transform-fault setting.

After this tectonic episode sedimentation again began to dominate with further subsidence of the offshore basins and Late Cretaceous sea level rise. During this time the uplands were again buried and a southward consequent drainage pattern developed. Uplift during the Tertiary, perhaps a result of lithospheric flexure (forebulge) induced by sediment loading in the offshore basins (King, 1972), resulted in denudation, superposition of drainage and re-establishment of the Early Cretaceous faulted landscape. Glaciation during the Quaternary modified the landscape but did not erode substantial quantities of rock.

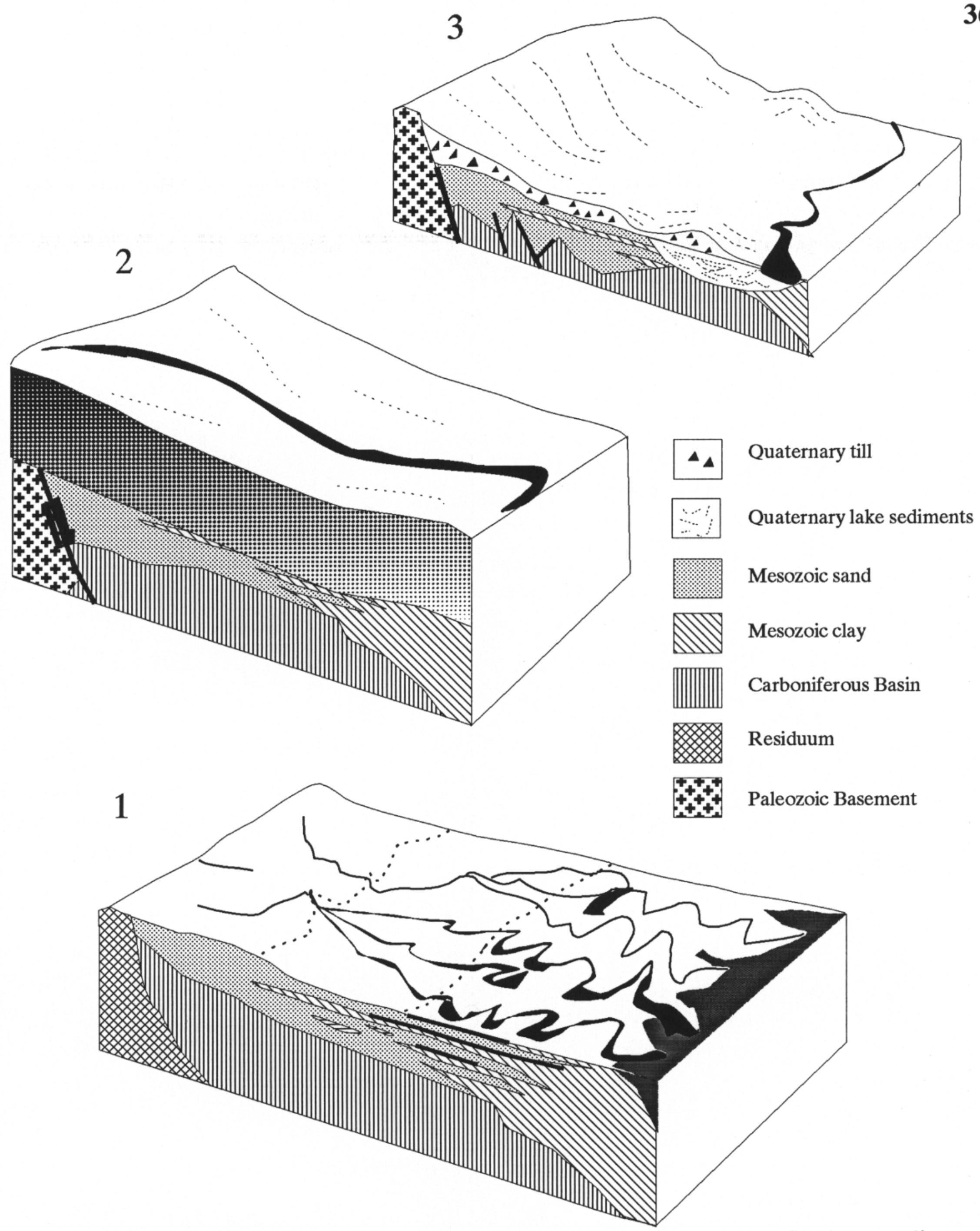


Figure 15. Model of the sedimentary environments and evolution of the Shubenacadie and Musquodoboit Basins throughout the Mesozoic and Cenozoic eras. 1. Deposition of the Early Cretaceous sediments in a low relief coastal plain fluvial/deltaic/lagoonal environment. Residuum in upland areas feeding the deltas provides kaolin and quartz. 2. Mid Cretaceous diastrophism creates or reactivates basin faults, structural valleys created. This event is followed by subsidence and deposition of Late Cretaceous sediments. 3. Tertiary uplift and denudation reestablished the Mid-Cretaceous structural basins, Quaternary modification, valley incision.

ECONOMIC GEOLOGY

Introduction

Quaternary clays and Cretaceous kaolin and sand deposits in the Musquodoboit and Shubenacadie basins have many potential economic applications (Finck et al., 1995). A partial listing of possible uses include:

1. Ceramic and refractory clay use
2. Adhesives
3. Animal bedding
4. Aggregate
5. Cement
6. Miscellaneous fillers
7. Glass
8. Pharmaceuticals
9. Paint
10. Plastics
11. Rubber
12. Liner/seal applications
13. Water supplies

To some extent these sediments have been evaluated for these industrial uses (Dickie, 1986; Gouthro, 1989; Luke, 1990). In this report we will focus on the potential use as filler and coater grade kaolin, as well as a short section on properties and uses of silica sand.

Silica Sand

The largest silica sand producer in Nova Scotia is the West Indian Road (Brazil Lake) quarry operated by Nova Scotia Sand and Gravel located approximately 12 km west of the Shubenacadie quarry (Map 1). Table 3 presents major oxide analysis of blast-and glass-grade silica sand from the West Indian Road deposit as well a raw sample (2 mm - 0.063 mm fraction) from a recently discovered outcrop of silica sand west of the study area near Antigonish (Stea et al., 1995). These data and others summarized by Finck et al. (1995) suggest that additional glass grade silica sand deposits are readily available in Nova Scotia within the newly discovered basins. In the present study, recovery of silica sand using traditional wire line drill methods averaged 6% (Table 1). Comparison of analytical results from these core samples with analyses of split spoon samples from the same intervals indicate that the silica sand core was contaminated by the drilling mud (Finck et al., 1995). Major oxide analysis of split spoon samples from this study is given in Table 4.

TABLE 3: Average analysis (in percent) of silica sand produced from the Shaw Resources West Indian Road Deposit (Adams, et al., 1994).

Major Oxides	Blast Sand Shaw Resources	Brierly Brook sand	Glass Sand Shaw Resources
SiO_2	97.80	99.40	99.5
Al_2O_3	0.30	0.26	0.25
Fe_2O_3	0.44	0.096	0.025
TiO_3	0.70	0.03	0.05
CaO	0.30	0.49	0.03
MgO	0.01	0.20	0.005
LOI	0.30		0.14

In the Musquodoboit Valley silica sand deposits are associated with deposits of coloured kaolinitic clay, near Elmsvale and Paint Brook (Map 1). The Elmsvale deposit, formerly owned by Shaw Resources Ltd., was a past producer of silica sand. The heavy mineral fraction of these deposits contained on average 40% ilmenite, 23% magnetite and 34% pyrite (Dickie, 1986). Silica sands were generally of a blast or low quality glass grade. The lithostratigraphy described earlier (Fig. 13; Appendix 1) indicates a wide spread distribution of silica sand within the valley. The silica sands occur as fining upward sequences interspersed with white, light grey, grey and/or coloured kaolinitic clays. Analyses of silica sand recovered from our drilling in the Musquodoboit Valley are pending.

Kaolin

Introduction

Ries and Keele (1911), Wright (1969) and Fowler (1972) evaluated samples of mottled red to white clay from the Paint Brook and Elmsvale deposits for refractory clay uses (see drillholes PB-1, EV-1 and Map 96-001 in back pocket). Differential thermal analysis (DTA) was utilized to identify clay mineral phases. Kaolinite was identified as the major phase. Dean (1975), using X-ray diffraction (XRD), examined the mineralogy of light- red kaolinitic clays from the Musquodoboit area and grey kaolinitic clay from the Shaw Resources Shubenacadie clay pit. He confirmed that the clay fraction contained a very high proportion of kaolinite and noted that kaolin from the Musquodoboit red clay was poorly crystallized.

Table 4. Major oxide analysis of the 2 mm-0.063 mm size fraction of selected silica sand samples from the Shubenacadie Valley.

Sample # (Depth)	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MgO	CaO	Na_2O	K_2O	Total Oxides
SHU94-2 95-100 m	97.45	0.17	0.17	0.54	0.03	0.10	0.05	0.12	99.63
SHU95-1 39.4 m	95.17	3.29	0.27	0.73	0.11	0.26	0.18	0.28	100.29
SHU95-2 40.9 m	92.24	2.65	0.14	1.19	0.26	1.71	0.40	0.50	99.09
SHU95-3 44.4 m	98.17	1.55	0.14	0.54	0.05	0.26	0.06	0.09	100.86
SHU95-4 45.4 m	97.71	1.15	0.08	0.57	0.08	0.18	0.14	0.19	100.10
SHU95-5 46.9 m	96.98	1.01	0.06	0.59	0.06	0.17	0.10	0.17	99.14
SHU95-6 49.9 m	96.61	2.45	0.39	0.78	0.08	0.11	0.19	0.28	100.89
SHU95-7 52.9 m	98.22	1.06	0.14	0.40	0.02	0.07	0.06	0.07	100.04
SHU95-8 55.3 m	97.38	1.00	0.13	0.65	0.10	0.19	0.12	0.21	99.78
SHU95-9 64.9 m	96.12	0.87	0.02	1.56	$<$0.01	0.04	0.03	0.03	98.67

However, fine kaolin with euhedral small crystals will often have a indistinct poorly organized X-ray pattern compared to coarse kaolin with stack-like crystals (Pickering and Murray, 1994).

Major oxide and differential thermal analysis (DTA) of the light grey to white clays in the Shubenacadie and Musquodoboit basins confirms that kaolinite is the predominant mineral phase in the $< 2\ \mu m$ fraction of these clays (Finck, et al., 1996). XRD analysis of the $<$ 53 μm fraction of 4 samples of Cretaceous 'clays' from drillhole SHU94 -4/5 indicated the presence of quartz (major), kaolinite +/- dickite (moderate) and minor calcite, apatite, feldspar and illite-mica.

Paper Filler And Coater Properties of Kaolin

Critical parameters that govern the suitability of paper filler and coater clays are:

1. Particle size (microns). Particle size governs the physical properties of a kaolin paper product. The optimal grain size distribution for paper filler and coater products are given in Table 3.

2. Abrasiveness (e.g. % of fine grained quartz)

3. Brightness (%). The ratio of the radiation reflected by a body to that reflected by a perfectly reflecting $BaSO_4$ standard.

4. Viscosity (% solids)

5. Whiteness (L). A measure of the degree of white coloration in a material. A material may be very white but have a low brightness value, ie it may be dull or flat.

6. Redness (A). A measure of the degree of red coloration in a material. Again a material may be very bright but have a red tint.

7. Yellowness (B). The difference in reflectance measured at 457 nm and 570 nm. A measure of the degree of yellow coloration in a material.

Table 5 shows typical ranges of the properties for paper filler and coater clays. However, it must be stressed that ranges of values quoted in the literature vary greatly and are commonly contradictory (e.g. Prasad et al., 1991, Bloodworth et al., 1993). Benbow (1989) describes product applications with physical properties that commonly span the extreme ranges of the values given in Table 5.

Chemical properties of kaolin are interesting and useful, but it is ultimately the physical properties that determine the suitability of the clay for specific applications. The chemistry of the clay in part governs the physical properties, but grain size and grain size distribution alter the other physical properties to such a degree that chemistry does not reflect physical properties such as brightness, viscosity, etc. However, chemistry can be used in a broad sense as a comparative tool (e.g. N.S. kaolin vs Georgia kaolin).

TABLE 5: Properties of paper filler and coater clays (values given are final beneficiated products). * ISO brightness values are generally 1% - 2% lower than the G.E. brightness.

	Filler Clay	Coater Clay
Raw ISO* Brightness (%)	75 - 85	81 - 92
Yellowness (%)	5.7 - 8	4 - 6.5
% < 2 microns	25 - 80	75 - 95
% > 10 microns	6 - 25	0 - 6
Viscosity (% solids)	61.2 - 71.5	64.2 - 74.5
SiO_2	46 - 48	45 - 47
Al_2O_3	37 - 38	37 - 38
Fe_2O_3	0.5 - 1.0	0.5 - 1.0
TiO_2	0.04 - 1.5	0.5 - 1.3
LOI	12.3 - 13.7	13.9 - 14.3

The physical and chemical properties of kaolin can be significantly improved through various processing techniques (beneficiation). Beneficiation is primarily used to increase the brightness, whiteness and grain size characteristics of raw kaolin clay. All kaolin requires some refinement. Sedimentary kaolin usually requires greater amounts of beneficiation compared to primary kaolins, however, recovery of kaolin from sedimentary deposits is much higher than primary deposits (>60% for sedimentary vs 10% for primary deposits). The seven main beneficiation processes are described below.

1. Fractionation. Separation of the < 325 mesh (blunged and screened) sample into several particle sizes. Used to prepare specific products (e.g. fillers or coaters) by varying brightness and other properties as a function of selected particle size.

2. High Intensity Magnetic Separation. Standard technique in which kaolin slurries are filtered through magnetized steel wool which removes magnetic and paramagnetic minerals. This process is used to increase brightness, whiteness, redness and yellowness. Factors in the use of this method include the field strength of production magnets (20,000 gauss to 50,000 gauss) and the retention time in the magnet.

3. Flocculation. Removes titano-ferrous impurities.

4. Chemical Leaching. Standard technique where a strong reducing agent is added to the clay slurry in an acid environment thus reducing ferric to ferrous iron; produces a 2% to 4% increase in brightness. The major factor in the use of this method is the amount of active chemical bleach used per tonne of kaolin.

5. Ozonation or chlorination. Oxidation of organic matter.

6. Delamination. Shearing of kaolin crystal stacks to produce individual crystals. This reduces grain size and increases brightness; allows chemical leaching to more effectively remove iron.

7. Calcining. Heating of kaolin (typically 1050 degrees C) to burn off organics with resulting increase in brightness and changes in physical properties of the clay due to water loss. This method tends to increase the abrasiveness of the kaolin.

Laboratory Methods (MINEREX)

What follows is a detailed description of the MINEREX beneficiation procedures that are also outlined in a flow chart (Fig. 16). A small portion of each sample was retained as a reference sample. Seventeen representative samples of 'kaolin clay' and silica sand with a kaolin clay matrix were submitted for processing and analysis. This included standard industry beneficiation techniques designed to estimate the potential of N.S kaolin for a standard filler and delaminated product. These samples were selected from several different drill sites based on visual grain size and colour and generally represented a 3m core interval. The purpose of the sampling was to determine if any of these materials could meet or exceed industry standards for a paper grade product.

Core and sample: Description (see Appendix 1 for depths/sampling interval)

SHU94 - 4 - 01: Mottled white and purple clay.
SHU95 - 5 - 15: White to light grey massive clayey silt.
SHU95 - 5 - 16: Massive and mottled grey to light-grey clayey silt; minor pyrite inclusions.
SHU95 - 5 - 17: Mottled grey clayey silt.
MUSC95 - 1 - 01: Massive light greenish grey clayey silt.
MUSC95 - 2 - 01: Highly mottled red and white mixed silty clays; minor dark pink, purple and yellow).MUSC95 - 3 - 01: Very light grey to light grey (when scraped) clayey silt; disseminated well crystallized pyrite nodules; greenish

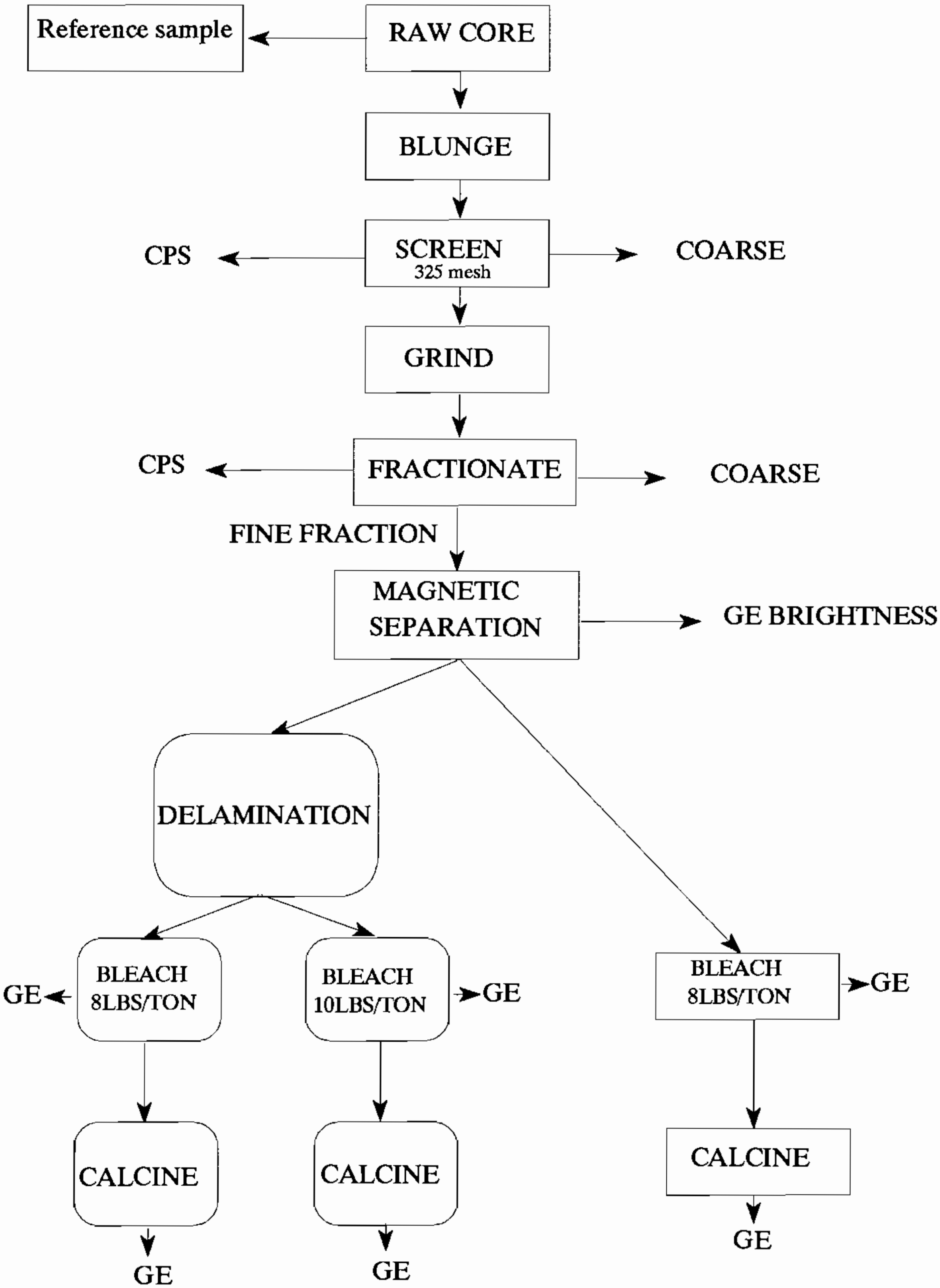


Figure 16. Flow chart of the clay processing steps in this study.

MUSC95 - 4 - 16: Massive white and red mottled silty clay.
MUSC95 - 4 - 17: Massive white clay with pyrite nodules.
MUSC95 - 4 - 19: Alternating layers of clay rich silica sand (white) and light grey silty clay (slightly plastic); difficult to clean; composite sample from 55 m to 62 m interval.
MUSC95 - 4 - 20: White to light grey to grey clay, shaves like chocolate.
MUSC95 - 4 - 21: Massive silica sand with a white to light grey clay matrix.
MUSC95 - 4 - 22: Massive purple clay.
MUSC95 - 4 - 23: Massive white clayey silt and silty clay.
MUSC95 - 4 - 25: Laminated dark grey and light grey silty clay and clayey silt.
MUSC95 - 4 - 26: Light grey massive clayey silt.
MUSC95 - 4 - 27: Massive light greyish brown (slight olive brown) silty clay.

The refinement steps were as follows:

1. Screen residue: A small amount was dried, weighed and blunged with dispersant chemicals and water. The slurry was screened on a 325 mesh screen and the residue retained on the screen was dried and weighed. The amount retained was the plus 325 mesh screen residue expressed as a percentage.

2. Dispersion and blunging: The remainder of the sample (1.8 kg to 2.5 kg) was mixed with water and dispersing chemicals and blunged on a Waring blender. This is generally done at a solids % ranging from 20% to 35% depending on the screen residue and the ease or difficulty of blunging.

3. Screening: The blunged sample was screened on a 325 mesh screen.

4. Fractionation: The screened sample was fractionated into a fine and coarse fraction.

5. Magnetic separation: The fine fraction was processed on a 20,000 gauss magnet at a retention period of two minutes.

6. Bleaching: All grey samples were bleached with hypochlorite (oxidation bleaching) followed by hydrosulfite under acidic conditions (reduction bleaching). Bleach dosages of 8 lbs. of active chemical per ton of clay were used. All

other samples were bleached with hydrosulfite at a dosage of 8 lbs. per ton. The bleached sample was filtered, dried and pulverized for determination of brightness value.

7. Dry samples were calcined in a laboratory furnace at a temperature of 1050°C. Subsamples were processed for brightness determination.

8. (For selected samples as specified) The sample from the magnetic separation was delaminated to reduce particle size and to determine the improvement in brightness (no bleaching initially).

9. Sedigraph particle size analysis on selected samples.

Viscosity measurements were not taken unless high brightness warranted. Selected samples were reprocessed with a retention time in the magnet of 4 minutes. Sample MUSC95-4-17 was split from MUSC95-4-18 and MUSC95-4-23 split from MUSC95-4-24.

Processing Results (MINEREX)

MINEREX prepared three types of product samples from the 17 crude samples submitted.

1. Intermediate size fraction (clay+fine silt) to approximate that of a standard filler product (Table 5). This is a product sample based on crude grain-size fractionation.

2. A delaminated product sample from the intermediate size fraction.

3. A calcined product sample derived from either the intermediate size fraction or the delaminated product.

Centrifugal Particle Size (CPS) values given in Table 6 are a rapid and crude laboratory method of determining grain size. It is a centrifuge method using cylinders graduated in millimetres. The three numbers shown in each analysis represent the amount of material in the cylinder after 1 minute, 3 minute and 6 minute runs on the centrifuge. The CPS for the < 325 mesh is measured on a raw screened sample (Table 6). The CPS (fractionated sample) represents the <325 mesh fraction that was ground for a standard period of time. All CPS measurements are made on samples with a standard percent solids. In general, smaller CPS numbers are an indication of finer grained samples. The magnitude of variation between the three successive CPS measurements is an indication of the grain size distribution of the sample. CPS measurements are used by the kaolin industry laboratories to quickly access the grain size of samples prior to initial processing. Sedigraph measurements are generally run at later stages in the processing procedure.

Based on visual and CPS values samples that showed economic potential were selected. Eleven of the seventeen samples were processed through the magnet (Table 6). Brightness values measured on the fractionated samples range from 42.3% to 77.7%. A second suite of 5 samples with brightness values ranging from 73.4% to 77.7% was tested to measure their reaction to oxidation and reduction bleaches. Bleached samples all showed improvement in brightness ranging from 0.6% to 6% (Table 6). Brightness values ranged from 75.5% to 79.4% following bleaching. These samples were calcined without delamination. This resulted in brightness increases ranging from 5% to 12.7% yielding final G.E. values of **83.5%** to **88.3%**.

Based on the results of this initial testing MINEREX concluded that the results were encouraging so further testing was conducted including delamination, varying the concentration of bleach and finally calcining. These additional tests were carried out on samples MUSC95-4-17, 19, 20, 21, 23 and SHUB94-4-1 (Table 7).

Comparison of Tables 6 and 7 indicates that delamination of samples MUSC95-4-19 and 20 resulted in a 1.3% to 4.8% increase in brightness. Delamination of samples MUSC95-4-17, MUSC95-4-21 and MUSC95-4-23 with an additional 25% increase in the concentration of bleach resulted in brightness increases of 0.5% to 4.8%. Calcining of these samples resulted in a final brightness ranging from **84.8%** to **91.2%**. Delamination improved the final calcined brightness values of all samples except MUSC95-4-19 (Table 6) which actually decreased in brightness by 1.8%. As a result of delamination sample SHUB94-4-1 showed a brightness increase from 70.8% to 75.6 with a final calcined value of **85.7%**

Processing Results (ECCI)

Table 8 shows the results of ECCI processing of the two sample splits (MUSC95 - 4 -18 and MUSC95 - 4 - 24). Each sample was blunged, delaminated (UL), and processed in a magnetic separator for 2 minutes (2 MIN MAG), and the magnetic separate was ozonated to remove organics (MAG/OZ). It is apparent that the raw samples have both silt and clay sizes represented and that the total clay (<2 μm) fraction percentages are generally less than 50%. Whiteness values range between 84.3 and 86.6 for the raw samples, while the final processed samples achive $>$ 90 whiteness.

TABLE 6: MINEREX LABORATORIES, INC., test results (2 minute retention in magnet, 8 lbs. of bleach per ton; no delamination).

				BRIGHTNESS VALUES (G. E.) ON FRACTIONATED SAMPLE		
SAMPLE	**> 325 mesh (%)**	**CPS < 325 mesh**	**CPS Fract. Spl.**	**Mag. Sep. (2 min.)**	**Bleached After Mag. Sep.**	**Calcined Bleached Magnetic**
MUSC95-1-1	20	30-35-40	10-20-31	58.5		
MUSC95-2-1	2	10-17-27	7-14-22		22.0	
MUSC95-3-1	20	24-30-34	22-28-34	53.7		
MUSC95-4-16	22	15-21-30	8-16-24		33.3	
MUSC95-4-17	24	24-32-38	8-18-30	74.5	78.5	83.5
MUSC95-4-18	ECCI Split from MUSC95-4-17					
MUSC95-4-19	34	21-31-44	12-25-39	72.4	75.5	86.6
MUSC95-4-20	1	20-31-40	8-18-31	77.7	78.3	87.2
MUSC94-4-21	58	23-32-40	6-18-32	74.5	75.6	88.3
MUSC95-4-22	25	30-35-41	8-18-32		56.9	
MUSC95-4-23	46	15-28-40	9-20-38	73.4	79.4	87.3
MUSC95-4-24	ECCI Split from MUSC95-4-23					
MUSC95-4-25	6	22-28-32	6-12-19		40.3	
MUSC95-4-26	41	24-30-38	14-22-30		58.1	
MUSC95-4-27	3	17-26-36	10-21-38	59.2		
SHUB94-4-1	32	28-35-40	12-23-38	67.3	70.8	
SHU95-5-15	26	30-34-40	11-20-30	55.2		
SHU95-5-16	22	22-30-38	20-30-39	42.3		
SHU95-5-17	34	28-34-40	28-34-40		45.1	

TABLE 7: Process results of delaminated, bleached (8 lbs. to 10 lbs./ton), calcined clays (selected samples).

	G. E. BRIGHTNESS (FRACTIONATED SAMPLE)		
Sample Number	**Magnet (2 min.); bleach (oxidation and/or reduction; 8 lbs./ton); delaminated**	**Magnet (2 min.); oxidative bleach at 10 lbs./ton; delaminated**	**Calcined**
MUSC95-4-17		79.0	**86.8**
MUSC95-4-19	78.3		**84.8**
MUSC95-4-20	79.6		**88.9**
MUSC95-4-21		80.4	**91.2**
MUSC95-4-23		80.1	**88.9**
SHUB94-4-1	75.6		**85.7**

ECCI analysis indicates that MUSC95-4-18 (raw) is considerably finer grained (12.1 vs 53.5% > 325 mesh) and brighter (70.4% vs 64.5%) than MUSC95-4-24 (raw). However, when delaminated both samples are fine grained (93.3% and 89.8% < 2 microns). This grain size is within the acceptable range for coater grade kaolin (Table 3). Both samples benefited from progressive beneficiation with brightness increases from 70.4% to 81.4% (MUSC95-4-18) and 64.5% to 79.7% (MUSC95-4-24). In absolute terms MUSC95-4-24 had the greatest percentage increase in brightness due to a higher initial Fe_2O_3 content and presumably a higher amount of organic contamination (compare the brightness increases for magnetic separation and ozonation for each sample). Absolute brightness values are well within the range of paper filler grade kaolins (Table 5). Viscosity (% solids) was measured for the unlaminated washed fraction of MUSC95-4-18 yielding a value of 64.3%. The viscosity is poor (B. Mallory, pers. comm., 1996) but is within the range of quoted values for paper fillers (Table 5). Viscosity can often be improved by mixing kaolins of differing grain sizes so that the resulting grain size distribution is broader. Whiteness values (L) for both samples are excellent and the redness values are good (B. Mallory, pers. comm., 1996; a slight greenish tinge). Yellowness values in Georgia kaolins are generally less than 3. Final values for the two beneficiated samples are 3.2 and 2.7.

TABLE 8: English China Clay International analysis of kaolin clay splits.

								SEDIGRAPH (% less than)					
SAMPLE	**BRI**	**L**	**a**	**b**	**TiO_2**	**Fe_2O_3**	**> 325**	**10μm**	**5μm**	**2μm**	**1μm**	**.5μm**	**.25μm**
MUSC95-4-18	70.4	86.6	-.22	4.1	1.47	1.361	12.1	84.4	67.1	46	35	25.3	13.5
Class UL	74.6	89.2	-.06	4.5	1.32	1.411		99.8	99	93.3	77.6	61.5	39.8
Class 6#	74.6	89.2	-.08	4.4									
2 MIN MAG 6#	76.6	90.1	-.11	4.1									
MAG/OZ 6#	**81.4**	**92.1**	-.31	3.2									
MUSC95-4-24	64.5	84.3	-.30	6.1	1.593	1.846	53.5	80.1	61.2	38.7	28	18.8	9
Class UL	66.7	86.7	-.40	7.4	1.643	1.682		99.8	99.4	89.8	71.5	54.4	32.9
Class 6#	68.3	87	-.33	6.6									
2 MIN MAG 6#	76.4	89.5	-.32	3.4									
MAG/OZ 6#	**79.7**	**90.9**	-.51	2.7									

Comparison of Duplicate Samples (MINEREX VS ECCI)

ECCI obtained a maximum G.E. brightness of 81.4% for sample MUSC95-4-18 after multiple beneficiation. MINEREX obtained a G.E. brightness of 79.0% using similar methods. ECCI obtained a maximum brightness of 79.7% for sample MUSC95-4-24 whereas MINEREX results for this sample are very similar, 80.1% and 79.4% (depending on the combination of process methods.

Major Oxide Analysis

In order to obtain base line geochemical data a small sample split was obtained from each of the 17 samples sent to MINEREX. A clay fraction (< 2 microns) was prepared from each sample by a centrifuge method (Stea and Fowler, 1979). These separates were analyzed for a suite of major oxides (Table 9). These raw clays will also be used for future clay mineralogy studies.

Pure kaolinite has a chemical content (expressed as oxides) of 46.5% SiO_2, 39.5% Al_2O_3 and 14% H_20. Paper grade kaolins rarely match these values and show considerable variation in all major oxide concentrations (Table 5). Values given in Table 9 cannot be compared with typical paper grade kaolins as the former reflect a refined product. Six samples in Table 9 are bolded. These are samples that show promise as a filler product based on MINEREX and ECCI processing. Oxide concentrations in Nova Scotia kaolins are similar to Cretaceous Georgia kaolins (Kesler, 1963; Table 10) which may reflect a similar pre-depositional weathering environment.

TABLE 9: Major oxide analysis of the clay (2 μm fraction) of raw samples.

	MAJOR OXIDES IN WEIGHT PERCENT								
SAMPLE NUMBER	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	LO1
SHUB94 - 4 - 01	**46.86**	**36.20**	**1.28**	**1.35**	**.02**	**0.19**	**1.08**	**1.75**	**11.5**
SHU95 - 5 - 15	46.23	37.36	1.38	0.93	.05	0.16	0.82	1.44	12.2
SHU95 - 5 - 16	50.89	25.88	4.76	0.84	.66	1.98	0.80	5.99	6.7
SHU95 - 5 - 17	51.60	24.87	5.74	0.80	.25	3.60	0.77	6.52	6.2
MUSC95 - 1 - 01	52.48	27.63	3.01	0.97	.03	1.53	0.62	7.07	5.9
MUSC95 - 2 - 01	43.75	33.46	8.29	1.59	.29	0.08	0.55	1.13	10.9
MUSC95 - 3 - 01	50.78	28.70	3.50	0.91	.05	1.85	0.80	7.21	6.2
MUSC95 - 4 - 16	45.19	36.04	4.29	1.15	.02	0.10	0.67	1.30	11.6
MUSC95 - 4 - 17	**44.89**	**37.7**	**1.18**	**1.10**	**.04**	**0.11**	**0.51**	**1.18**	**12.8**
MUSC95 - 4 - 19	**46.32**	**38.75**	**0.70**	**0.73**	**.03**	**0.08**	**1.05**	**1.95**	**11.1**
MUSC95 - 4 - 20	**45.95**	**38.35**	**0.80**	**1.35**	**.11**	**0.16**	**0.56**	**0.70**	**12.5**
MUSC95 - 4 - 21	**45.76**	**38.92**	**0.72**	**1.27**	**.03**	**0.03**	**0.63**	**0.33**	**13.2**
MUSC95 - 4 - 22	38.65	34.26	1.89	1.19	.03	0.51	0.91	1.31	21.5
MUSC95 - 4 - 23	**46.75**	**35.87**	**1.05**	**1.41**	**.03**	**0.13**	**0.55**	**0.67**	**12.3**
MUSC95 - 4 - 25	45.29	25.52	1.74	1.16	.03	1.03	0.38	4.25	21.4
MUSC95 - 4 - 26	48.89	26.47	2.97	0.86	.07	0.98	0.62	6.70	12.2
MUSC95 - 4 - 27	44.72	37.19	0.70	0.14	.11	0.11	0.70	1.20	15.6

DISCUSSION

Preliminary beneficiation trials indicate that brightness and whiteness values meet the requirements of standard filler kaolin products. Calcined brightness values exceed 90% which warrants further testing to evaluate their potential as coater products. Brightness and grain size results are entirely dependent on the types of beneficiation attempted and the variables available to the laboratory within each procedure (eg. time in the magnet, amounts of bleach, whether a sample is delaminated). Further testing would require detailed fractionation controlled by the desired end product and viscosity determinations. It is also important to recognize processing variability between laboratories. Examination of the sample splits indicates that a 2.5% difference in G.E. brightness values for an identical sample is possible.

TABLE 10: Published raw chemical analysis of Georgia kaolin (Kesler, 1963).

Element	Analysis As Weight Percent
SiO_2	44 - 48
Al_2O_3	35 - 40
Fe_2O_3	0.3 - 1.7
FeO	0.06 - 0.20
MgO	0.00 - 0.90
CaO	0.10 - 0.60
Na_2O	0.02 - 0.40
K_2O	0.01 - 0.70
TiO_2	1.30 - 3.40
LOI	13 - 14

All sedimentary kaolins require beneficiation (Pickering and Hurst, 1989). Beneficiation includes standard processes such as blunging, screening and fractionation. One or more additional beneficiation procedures are then required depending on the sample characteristics and the economics of the process. Different samples respond in dramatically different manners to beneficiation. The results of beneficiation presented in this paper reflect this variability. In any mining operation clay horizons of varying quality would undoubtably be mixed to produce a uniform raw product for refining. Processing would be designed based on the properties of this bulk sample.

The results of this study indicate excellent potential for Nova Scotian kaolin. Detailed beneficiation trials involving larger bulk samples on a much larger suite of samples are required before further conclusions are possible.

Revised mapping based on drill and seismic results indicate the potential for large tonnage kaolin and silica sand deposits within the Shubenacadie Basin and particularly within the Musquodoboit Basin. In core MUSC95-4 five clay and clay-silica sand samples spanning a drill interval of approximately 60 m all met filler grade brightness requirements. These clay and clay-silica-sand units have a composite thickness of approximately 20 m and can be traced over a horizontal distance in excess of 1.5 km (Fig. 13). Filler grade kaolin units in MUSC95-4 are interspersed with silica sand. It is important to note that a sample of silica sand with a kaolin clay matrix (MUSC95-4-21) produced the highest calcined brightness value in this study (91.2%). This confirms the potential for recovery of high grade kaolin from the interspersed silica sand beds. Core recovery in the sands was very poor (Table 1), so we have little idea of the amounts of clay present within the white silica sand beds.

However, bore-hole geophysical logs from drillhole SHU95-2,3 (Appendix 2) indicated clay bodies within the thicker silica sand units.

Cretaceous sediments in the Musquodoboit Basin alone reach maximum total thicknesses in excess of 200 m and cover an area of approximately 40 km^2. The Chaswood seismic line (Fig. 13) suggests that the Cretaceous sediments onlap faulted Meguma Group basement. Thus, the geological model of these deposits implies the potential for additional Cretaceous sediments in any faulted or sheltered basin and/or depression within Nova Scotia. An exploration paradigm would be NE-trending, fault-bounded Carboniferous Basins adjacent to uplands. The best potential would be as close to the valley/upland break as possible as glaciations may have removed material down-ice of this break. This interpretation is supported by the presence of outcropping scattered Cretaceous deposits throughout the Carboniferous basins of central mainland Nova Scotia and Cape Breton Island.

Strategic Location

The majority of the North American industrial demand for kaolin is met by U.S. domestic production. Shipping costs for Georgia kaolin to Eastern Canada are relatively high, generally in the order of $100/tonne, primarily due to their lack of direct access to port facilities. High shipping costs leave North American producers vulnerable to competition from offshore suppliers where production costs and particularly shipping costs may be lower. This will make satellite deposits of kaolin that are located closer to the major paper producers economically attractive.

Nova Scotia is a maritime province and thus any potential kaolin deposit(s) have direct access to deep, ice-free ports. Nova Scotia also has excellent rail, road and ferry infrastructure linking potential deposits to potential present and future consumers of kaolin within the region (e.g. New Brunswick, Newfoundland). Due to low shipping costs a Nova Scotian kaolin producer would likely enjoy a major competitive advantage in supplying clay to paper producers in New England and particularly within the Atlantic Provinces. This competitive advantage would extend to potential markets in the Quebec - Ontario region due to a direct shipping route up the St. Lawrence Seaway.

Expanding Markets

In December 1995, Stora Forest Industries Ltd. announced plans to expand their paper mill operations at Point Tupper, Nova Scotia. The expansion involves construction of a 650 million dollar mill designed to produce supercalendered paper requiring approximately 112,000 tonnes of kaolin annually. Stora's kaolin requirements are filler grade with a G.E. brightness of 83% to 84.5% and a grain size of 60% less than 2 μm. Preliminary analytical results from Nova Scotia kaolins suggest that this grade of paper filler may be attainable. Several additional potential markets for kaolin exist in New Brunswick and Newfoundland. Given the reduced cost of shipping to these companies a Nova Scotia kaolin producer would have a good chance at market penetration in these areas. It is also likely that other paper producers in the region would move toward value added paper products if a competetive local supply of kaolin was available.

REFERENCES

Adams, G. C., Boehner, R. C., Carter, D. C., Fowler, J. H. and Prime, P. 1994: Industrial minerals in Nova Scotia; Guide Book, Field Trip #4, 30th Forum on the Geology of Industrial Minerals, Halifax, Nova Scotia, 49 p.

Arne, D. C., Duddy, I. R. and Sangster, D. F. 1990: Thermochronologic constraints on ore formation at the Gays River deposit, Nova Scotia, Canada, from apatite fission track analysis; Canadian Journal of Earth Sciences, v. 27, p. 1013-1022.

Benbow, J. 1989: Paper underpins current demand; *in* Industrial Clays, An Industrial Minerals Special Review; ed. G. Clarke, Pub. Industrial Minerals Division of Metal Bulletin Plc., p.19 - 33.

Benteau, R., 1973: The LaHave Clay; unpublished B. Sc (hons)thesis, Dalhousie University, Halifax, 42 p.

Bhattacharya, J. P., and Walker, R. G., 1992: Deltas; *in* Facies Models response to sea level change, eds. R. G. Walker and N. P. James, Geological Association of Canada, p. 157-178.

Boehner, R. C., 1974: The Lower Carboniferous stratigraphy of the Musquodoboit Valley, central Nova Scotia; M. Sc. Thesis, Acadia University, Wolfville, Nova Scotia, 171p.

Bloodworth, A. J., Highley, D. E. and Mitchell, C. J. 1993. Kaolin; Industrial Minerals Laboratory Manual, Technical Report WG/93/1, British Geological Survey, Keyworth, Nottingham, 76 p.

Brown, L. F., Jr., and Fischer, W. L., 1982: Seismic stratigraphic interpretation and petroleum exploration; American Association of Petroleum Geologists, Continuing Education Course Note Series, no. 16, 56 p.

Davis, E. H., Akande, S. O., and Zentilli, M. 1984: Early Cretaceous deposits in the Gays River lead-zinc mine, Nova Scotia; *in* Current Research, Part A, Geological survey of Canada, Paper 84-1A, p. 353-358.

Davis, W. M., 1922: Peneplains and the geographical cycle, Geological Society of America Bulletin, v. 23, p. 587-598.

Dean, R. S., 1975: Mineralogy of the ceramic clays and shales of the Atlantic provinces; Scientific Bulletin CM 75-8; Industrial Minerals Laboratory, Ore Mineralogy Section, Energy, mines and Resources Canada.

Dickie, G. B., 1986: Cretaceous deposits of Nova Scotia; Nova Scotia Department of Mines and Energy, Paper 86-1, D. MacDonald and J. Bates (eds.), 54 p.

Dickie, G. B. and Murphy, R., 1992: Report on Shubenacadie clay pit drill program; Aggregate Division, L. E. Shaw Limited, 4 p.

Dryden, L., and Dryden, C., 1946: Comparative rates of weathering of some common heavy minerals; Journal of Sedimentary Petrology, v.,16, p. 91-96.

Finck, P. W., Stea, R. R. and Dwyer, D. F., 1994: Preliminary results of drilling Quaternary and Cretaceous sediments near Shubenacadie, Hants County, Nova Scotia; Nova Scotia Department of Natural Resources, Mines and Energy Branches Open File Report 94-026, 31 p.

Finck, P. W., Stea, R. R. and Pullan, S., 1995: New discoveries of Cretaceous sediments near Shubenacadie, Nova Scotia; *in* Minerals and Energy Branch Report of Activities, Report 95 - 1, eds. D. MacDonald and K. Mills; Nova Scotia Department of Natural Resources, p. 139.

Finck, P. W., Stea, R. R. and Pullan, S.E., 1996: Cretaceous deposits of high purity kaolin and silica sand in Nova Scotia; Society of Mining and Metallurgy, Phoenix, Arizona.

Fowler, J. H. and Stea, R. R., 1979: Cretaceous deposits in Nova Scotia; in Mineral Resources Division, Report of Activities, 1978; Nova Scotia Department of Mines and Energy, Report 79-1, p. 9-14.

Fowler, J. H., 1972: Clay and sand deposit at Elmsvale, Halifax County; Nova Scotia Department of Mines, Miscellaneous publication.

Giles, P. S. and Boehner, R. C. 1982: Geological map of the Shubenacadie and Musquodoboit Basins, central Nova Scotia; Nova Scotia Department of Mines and Energy, Map 82-4, scale 1:50 000.

Goldthwait, J.W., 1924: Physiography of Nova Scotia; Geological Survey of Canada, Memoir 140, 179 p.

Gouthro, S., 1989: Properties and uses of Nova Scotia clays and shales; Nova Scotia Department of Mines and Energy, Economic Geology Series Report 89-1, 288p.

Groot, J. J., and Glass, H. D., 1960: Some aspects of the mineralogy of the northern

Atlantic Coastal Plain; *in* Clay and Clay Minerals, Proceedings of the Seventh National Conference, v 5, p. 271-284.

Grant, D. R., 1989: Quaternary Geology of the Atlantic Appalachian region of Canada; Chapter 5 *in* Quaternary Geology of Canada and Adjacent Greenland, R. J. Fulton, (ed.); Geological Survey of Canada, Geology of Canada no. 1 (also Geological Society of America, The Geology of North America, v. K-1), p. 393-440.

Grist, A. M., Reynolds, P. H. and Zentilli, M., 1990: Provenance and thermal history of detrital sandstones of the Scotian Basin, offshore Nova Scotia, using apatite fission track and AR 40/ AR 39 methods; *In:* Atlantic Geoscience Society, Program with Abstracts; p. 14.

Hack, J. T., 1960: Interpretation of erosional topography in humid temperate regions. American Journal of Science, v. 258-A, p. 80-97.

Hacquebard, P. A., 1984: Composition, rank and depth of burial of two Nova Scotia lignite deposits; In Current Research, Part A, Geological Survey of Canada, Paper 84-1a, p. 11-15.

Hamblin, A. P., 1979: Petrography of Mesozoic and Pleistocene sands in the Moose River Basin; *in* Mesozoic Geology and Mineral Potential of the Moose River Basin, District of Cochrane, eds, P. G. Telford and H. M. Verma; Ontario Geological Survey, Open File Report 21, p. 51-92.

Hughes, O. L. 1957: Surficial geology of the Shubenacadie map area, Nova Scotia; Geological Survey of Canada, Paper 56-3, 10 p.

Kesler, T. l., 1963: Environment and origin of the Cretaceous kaolin deposits of Georgia and South Carolina; Georgia mineral Newsletter, v.16, No. 1 - 2.

King, L. H., 1972: Relation of plate tectonics to the geomorphic evolution of the Canadian Atlantic Provinces. Geological Society of America Bulletin, Volume 83 p. 3083-3090.

King, L. H., MacLean, B., Bartlett, G. A., Jelestsky, J. A., and Hopkins, W. S., 1970: Cretaceous strata on the Scotian Shelf: Canadian Journal of Earth Sciences, v. 7, p. 145-155.

Krauskopf, K. B., 1967: Introduction to geochemistry, McGraw-Hill, Toronto, 721p.

Lin, C. L., 1971: Cretaceous deposits in the Musquodoboit river valley, Canadian Journal of Earth Sciences, v. 8, No. 9. p. 1152-1154.

Luke, P. 1990: Filler and extender minerals in Nova Scotia; Nova Scotia Department of Mines and Energy, Economic Geology Series, Report 90-2, 64p.

McKeague, J. A., Grant, D. R., Kodama, H., Beke, G. J. and Wang, C., 1983: Properties and genesis of soil and the underlying gibbsite-bearing saprolite, Cape Breton Island, Canada; Canadian Journal of Earth Sciences, v. 20, no. 1, p. 37-38.

Mitchum., R. M., Jr., Vail, P. R., and Thompson, S., 1977: Seismic stratigraphy and global changes of sea-level; Part 2, The depositional sequence as a basic unit for stratigraphic analysis; *in* Seismic Stratigraphy; Applications for Hydrocarbon Exploration; American Association of Petroleum Geologists, Memoir 26, p. 53-62.

Murray, H. H., 1976: The Georgia sedimentary kaolins: Symposium on the Genesis of Kaolin, International Geological Correlation Program, Tokyo, p. 114-125.

Patterson, S. H., and Murray, H.H., 1984; Kaolin, refractory clay, ball clay and Halloysite in North America, Hawaii, and the Caribbean region; United States Geological Survey, Professional Paper 1306, 56p.

Pe-Piper, G., Jansa, L. F., and Palacz, Z., 1994: Geochemistry and regional significance of the Early Cretaceous bimodal basalt-felsic associations on grand banks, eastern Canada; Geological Society of America Bulletin, v. 106, p. 1319-1331.

Pettijohn, F.J., 1975: Sedimentary Rocks (third edition), Harper and Row, Publishers, New York, 628p.

Pickering, S. M. jr., and Hurst, V., J., 1989: Commercial kaolins in Georgia; Georgia Geological Society Guidebooks, v9., p. 29-75.

Pickering, S. M. jr., and Murray, H. H., 1994: Kaolin; *in* Industrial Minerals and Rocks, 6th edition, Society for Mining, Metallurgy and Exploration Inc., Ed. D. Carr, Littleton, Colorado.

Pirkle, E. C., Yoho, W. H., and Allen, A. T., 1964: Origin of the silica sand deposits of the Lake Wales Ridge area of Florida; Economic Geology,v. 59, p. 1107-1139.

Prasad, M. S., Reid, K. J. and Murray, H. H. 1991: Kaolin: processing, properties and applications; In Applied Clay Science, Volume 6, pgs. 87 - 119.

Pryor, W. A., 1960: Cretaceous sedimentation in upper Mississippian embayment; Bulletin of the American Association of Petroleum Geologists, no. 9, p. 1473-1504.

Pullan, S. E., and MacAulay, H. A., 1987: An in-hole shotgun source for engineering seismic surveys; Geophysics, v. 52, p. 985-996.

Ries, H. and Keele, J., 1911: The clay and shale deposits of Nova Scotia and portions of New Brunswick; Canada Department of Mines, Geological Survey Branch, Memoir No. 16-E, 164 p.

Roland, A. E., 1982: Geological background and physiography of Nova Scotia, Nova Scotia Institute of Science, 311p.

Rutherford, G. K., and Thacker, D. J. 1988: Characteristics of two mafic saprolites and their associated soil profiles in Canada; Canadian Journal of Soil Science, v. 68, p. 223-231.

Ryan, R. J., Grist, A. M., and Zentilli, M., 1992: The Paleozoic Maritimes Basin of Eastern Canada: Metallogenetic implications of a fission track study; *in* Short Course Handbook on Low Temperature Thermochronology eds., M. Zentilli and P. H. Reynolds, Mineralogical Association of Canada, p.142-155.

Stea, R. R., 1984: The sequence of glacier movements in northern mainland Nova Scotia determined through mapping and till provenance studies; *in* W. C. Mahaney, ed., Correlation of Quaternary Chronologies, Geo Books, Norwich England, p. 279-297.

Stea, R. R., Finck, P. W., Arne, D., Grist, A. and Mukhopadhyay, P. 1995: Geomorphic evolution of Nova Scotia since the Triassic - constraints from fission track analysis and vitrinite reflectance (abstract); Annual Meeting of the Atlantic Geoscience Society, Antigonish, Nova Scotia, February 3-4, 1995.

Stea, R. R. and Finck, P. W., 1995: Geomorphic evolution of Nova Scotia since the Triassic - constraints from fission track analysis and vitrinite reflectance (abstract); Annual Meeting of the Atlantic Geoscience Society, Antigonish, Nova Scotia.

Stea, R. R., Finck, P. W., Prime, G., and DeMont, G. J., 1995: New discoveries of silica sand and kaolinite near Brierly Brook, Antigonish County; *in* Minerals and Energy Branch, Report of Activities, 1994, Report 95-1, p. 159-162

Stea, R. R., and Fowler, J. H., 1979: Minor and trace-element variations in Wisconsinan tills; Eastern Shore Region, Nova Scotia; Nova Scotia Department of Mines and Energy, Paper 79-4, 30 p.

Stea, R. R. and Fowler, J. H., 1981: Petrology of Lower Cretaceous silica sands at Brazil Lake, Hants County, Nova Scotia; in Mineral Resources Division Report of Activities, Report 81 - 1, Nova Scotia Department of Mines and Energy, p. 47-64.

Steeples, D. W., and Miller, R. D., 1990: Seismic reflection methods applied to engineering, environmental, and groundwater problems; *in* Geotechnical and Environmental Geophysics: Volume I - Review and Tutorial; ed. Ward, S.H., Society of Exploration Geophysicists, Tulsa, OK, p. 1-30.

Stevenson, I. M., 1959: Shubenacadie and Kennetcook Map Areas, Colchester, Hants and Halifax Counties, Nova Scotia. Geological Survey of Canada, Memoir 302, 88p.

Sylwester, R. L., 1983: Single-channel, high resolution, seismic reflection profiling: A review of the fundamentals and intrumentation; *in* R. A. Geyer, ed., CRC Handbook of Geophysical Exploration at Sea; CRC Press, Boca Raton, p. 77-124.

Vail, P. R., Mitchum, R. M., Todd, R. G., Widmier, J. M. S., Thompson III, Sangree, J. B., Bubb, J. N., and Hatlelid, W. G., 1977: Seismic stratigraphy and global changes in sea level, *in* C. E. Payton, ed., Seismic Stratigraphy-Applications to Hydrocarbon Exploration; Association of Petroleum Geologists, Memoir 26, 516 p.

Wright, J. D., 1969: Clay exploration in the Musquodoboit Valley, Halifax County, N. S.; Nova Scotia Department of Mines, Miscellaneous publication.

APPENDIX 1

NOVA SCOTIA DEPARTMENT OF THE ENVIRONMENT WATER WELL RECORD COMPILATION

Coordinates

These records were selectively compiled from the Department of the Environment (NSDE) data base of commercially drilled water wells. NSDE well coordinates are based on the Provincial Map Book published at a scale of 1:250 000 and are therefore inadequate for 1:50 000 or larger scale surveys. In order to accurately locate the wells it was necessary to locate the actual home or commercial owners. Where this was possible coordinates are given as 'E' (exact); ie they are accurate to +/- 100 m. Where land owners could not be located the centre of the NSDE grid block (shifted to the nearest road) was used as the northing and easting coordinate. These wells are designated as 'A' (approximate). The northings and eastings are left blank for other wells of interest where landowners were not located or a reasonable estimate of their location was not possible based on the NSDE coordinates.

Description

The well descriptions are taken directly from the NSDE data base. The following abbreviations were used: CL = clay; SS = sandstone; LS = limestone; SD = sand; SH = shale; GP = gypsum (may be white kaolin clay); GR = gravel; QS = quicksand (glaciofluvial or fluvial sand or Cretaceous silica sand); CO = coal (when interspersed with other unconsolidated sediments CO is Cretaceous lignite); PL = plaster (when underlain by sand, gravel or clay this is in fact white kaolin clay); MD = mud; HP = hardpan; BL = boulder; TS = top soil; RK = rock; QZ = quartzite; TI = till; SL = slate; ST = stones; SH = shale; LO = loam; OV = overburden and SO = soil. If two abbreviations are used together they represent a composite material; e.g. CL,BL is a bouldery clay (ie a till); SD,GR is a gravely sand, etc.

Depth To Cretaceous and/or Bedrock

Where possible the depth to the top of the Cretaceous is estimated based on the well stratigraphy. In some instances the rational for the 'depth' is not obvious as the interpretation of the stratigraphy for a particular well may be based on a knowledge of a diamond drill hole spatially associated with the water wells.

Where a depth estimate is not possible a qualitative comment may be given: ie Pr = Cretaceous is believed to be present at depth but the well was not drilled deep enough to intersect it or it is obvious that part of the sequence is Cretaceous but there is insufficient data to determine an actual depth; Ab = Cretaceous is not present in the section...these wells usually intersect bedrock at a shallow depth. A blank was left where the data was insufficient to make any interpretation. Usually these wells are shallow and ended in sand and gravel. A '?' indicates that the data is ambiguous, ie Cretaceous may be present. Depth to bedrock is given where the wells intersected bedrock. A blank was left where the wells did not reach bedrock.

NOVA SCOTIA DEPARTMENT OF THE ENVIRONMENT DRILLED WATER WELL RECORDS (SHUBENACADIE VALLEY)

Name		Community	Northing UTM	Easting UTM	Map Coord.	Accuracy	Description	Cretaceous Depth (Ft.)	Bedrock Depth (m)
Ann	Ackerman	Shubenacadie			11E3B80		0-180 CL; 180+ SS	Pr	54.9
Wayne	Adams	Milford			11E3B57		0-14 CL, ST; 14-20 LS	Ab	4.3
Wayne	Adams	Shubenacadie			11E3B57		0-14 CL, ST; 14-23 LS	Ab	4.3
Carl	Anthony	Mill Village			P23B5L14	A	0-5 CL; 5-8 SD; 8+ LS	Ab	2.4
Wally	Anthony	Shubenacadie	4994603	466533	11E3B81	E	0-217 CL; 217+ SH	Pr	66.1
	Atlantic Arch	Milford Ind. Park	4988733	464323	P24B1K8	E	0-41 CL; 41-43 SI; 43+ LS	Ab	13.1
George	Barbrick	Shubenacadie	4992279	465277	11E3B80		0-10 CL; 10+ SD		
Rick	Barbrick	Milford	4988265	465671	P24B1L11	E	0-48 MD; 48+ LS	Ab	14.6
John	Barrett	Milford, Lacey Rd.			P24B1L7		0-38 MD; 38+ LS	Ab	11.6
Eddy	Bates	Stewiacke East	4997680	476900	P23C5M9	A	0-48 CL, 48-68 GP		14.6
Mark	Bearss	Shubenacadie	4994980	467019	P23B5N12	E	0-98 CL, BL; 98+ SH	?	29.9
Peter	Bekkers	Pine Grove			P24C1F8		0-2 CL; 2-14 SD,GR; 14-168 CL,QS; 168-175 GR; 175-185 CL	53	
Donny	Bokma Farm	Milford	4990710	466880	P23B5M16	E	0-45 MD; 45-63 SD GR; 63-73 GR; 73-75 SD, GR; 75-98 SD; 98-103 GR	30.1	
Winston	Bokma Farms	Shubenacadie	4990800	466800	11E3B64		0-88 CL; 88-95 GR; 95-120 CL; 120-122 SD	29	
Donald	Brenton	Stewiacke	4997900	472500	11E3C5		0-12 CL; 12+ SH	Ab	3.7
Ken	Breaking	Shubenacadie			11E3B80		0-180 CL; 180+ GP	Pr	54.9
Roger	Bronson	Milford, Bayberry Dr.	4989065	465630	P24B1L9	E	0-22 MD; 22+ LS	Ab	6.7
Bill	Brown	Mill Village	4992055	465005	11E3B87	E	0-6 MD; 6-25 SD; 25+ LS	Ab	7.6
Fran	Calvert	Milford			11E3B39		0-39 MD; 39+ LS	Ab	11.9
Martin	Carroll	Milford	4987385	465430	11E3B39	E	0-40 CL; 40+ GP	Ab	12.2
Robert	Carruthers	Milford	4988380	466226	11E3B40	E	0-55 CL; 55+ SH	Ab	16.8
Ralph	Carter	Stewiacke Cross Roads			11E3C2		0-4 MD; 4-70 SS	Ab	1.2
Paul	Chiasson	Milford	4989090	465630	P24B1L7	E	0-21 CL; 21+ LS	Ab	6.4
Donald	Coffin	Milford, Rennie Ln	4989155	465623	11E3B57	E	0-26 CL; 26+ LS	Ab	7.9
Roger	Coffin	Milford			11E3B57		0-13 CL, ST; 13+ LS	Ab	4.0
Eric	Cole	Milford			P24B1L9		0-123 LS, PL	Ab	0.3
Eric	Cole	Milford, Coventry Ln.			11E3B39		0-33 MD; 33+ GP	Ab	10.1
E.	Cole	Milford			11E3B39		0-30 MD; 30+ GP	Ab	9.1
Fraser	Conrad	Stewiacke Cross Roads			P27A4K8		0-40 GR, SD		
Marjorie	Cook	Milford	4987468	465422	P24B1L9	E	0-10 MD; 10+ LS	Ab	3.0
Jeff	Cornick	Mill Village, MacKay Rd.	4993150	465100	P23B5L13	A	0-102 CL, SD; 102+ LS	?	31.1
Ralph	Currie	Stewiacke, Clov. Rd.	4999500	477500	P23C5N7	A	0-105 CL, SN; 105+ SH	?	32.0
Gerald	Davis	Stewiacke East			P23C5M8		0-33 MD; 33+ SL	Ab	10.1
Randy	Dean	Shubenacadie			P23B5L14	A	0-55 CL; 55+ SH	Ab	16.8
Philip	Debay	Milford			11E3B57		0-15 CL; 15+ SH	Ab	4.6
Ray	Dillman	Milford	4986695	465170	P24B1L10	E	0-14 MD; 14+ GP	Ab	4.3
Michael	Doncaster	Milford Station			P24B1L9		0-65 MD, CL; 65+ LS	Ab	19.8
Michael	Doncaster	Milford			P24B1L9		0-35 MD; 35-70 MD, GR; 70-95 GR		
Michael	Doncaster	Milford, Arden Est.			P24B1L9		0-42 MD; 42-50 GR; 50+GP	Ab	15.2
Michael	Doncaster	Milford			P24B1L9		0-40 MD; 40+ GP	Ab	12.2
Michael	Doncaster	Milford			P24B1L9		0-60 MD; 60+ GP	Ab	18.3
Michael	Doncaster	Milford, Arden Est.			P24B1L9		0-33 MD; 33+ GP	Ab	10.1
Michael	Doncaster	Milford Station			P24B1L9		0-75 MD; 75+ LS	Ab	22.9
Michael	Doncaster	Milford, Arden Est.			P24B1L9		0-68 MD; 68+ LS	Ab	20.7
Michael	Doncaster	Milford, Arden Est.			P24B1L9		0-35 MD; 35+ GP	Ab	10.7

Michael	Doncaster	Milford, Arden Est.			P24B1L9		0–53 MD; 53+ LS	Ab	16.2
Michael	Doncaster	Milford Station			P24B1L9		0–65 MD; 65+ SH	Ab	19.8
Michael	Doncaster	Milford, Hardwd Lands Rd.	4989100	464800	P24B1K7	A	0–34 MD; 34+ LS	Ab	10.4
Michael	Doncaster	Milford, Arden Est.			P24B1L9		0–45 MD; 45+ LS	Ab	13.7
Michael	Doncaster	Milford Station			P24B1L9		0–52 MD; 52+ SH	Ab	15.8
Michael	Doncaster	Milford, Arden Est.			11E3B39		0–35 MD; 35+ GP	Ab	10.7
Michael	Doncaster	Milford			11E3B39		0–25 MD; 25+ SS	Ab	7.6
Michael	Doncaster	Milford			11E3B39		0–20 MD; 20+ SS	Ab	6.1
Michael	Doncaster	Milford, Arden Est.			11E3B39		0–30 MD; 30+ GP	Ab	9.1
Michael	Doncaster	Milford			11E3B39		0–40 MD; 40+ GP	Ab	12.2
Michael	Doncaster	Milford, Hunter Rd.			P24B1L9		0–55 MD; 55+ SH	Ab	16.8
Michael	Doncaster	Milford			11E3B39		0–50 MD; 50+ SS	Ab	15.2
Michael	Doncaster	Milford			11E3B39		0–60 MD; 60+ SS	Ab	18.3
Michael	Doncaster	Milford			P24B1L11		0–55 MD; 55+ LS	Ab	16.8
Michael	Doncaster	Milford, Arden Est.			11E3B39		0–35 MD; 35+ GP	Ab	10.7
Michael	Doncaster	Milford			11E3B39		0–50 MD; 50+ SS	Ab	15.2
Michael	Doncaster	Milford			11E3B39		0–27 MD; 27+ LS	Ab	8.2
Michael	Doncaster	Milford			11E3B39		0–28 MD; 28+ SS	Ab	8.5
Michael	Doncaster	Milford Station			P24B1L9		0–30 CL; 30+ GP	Ab	9.1
Tom	Dort	Shubenacadie	4994600	467575	P23B5N12	A	0–14 CL; 14–29 QS, CL; 29–70 CL, BL; 70+ LS	Ab?	21.3
Larry	Elliot	Milford	4988500	462500	P24B1H8	A	0–50 CL; 50+ SH	Ab	15.2
Philip	Ettinger	Shubenacadie			11E3B80		0–30 CL; 30–40 SI, SH; 40+ LS	Ab	12.2
	Fire Hall	Milford Station	4988660	465500	P24B1L9	E	0–20 MD; 20+ SH	Ab	6.1
Rae	Flanders	Milford			P24B1L7		0–22 CL; 22–26 GP	Ab	6.7
Steven	Flynn	Shubenacadie	4992400	464800	P23B5K14	A	0–10 CL; 10–15 GR; 15–20 CL; 20–30 CL, GR; 30+ SS	Ab	9.1
K.	Frame	Milford			11E3B39		0–30 MD; 30+ GP	Ab	9.1
Irwin	Fraser	Milford Station			11E3B34		0–39 CL; 39+ SH	Ab	11.9
Mabel	Fraser	Milford	4989150	466150	11E3B57	A	0–43 CL, ST; 43+ SH	Ab	13.1
	Fundy Vet	Shubenacadie	4993460	468670	P23B5O13	E	0–100 CL; 100–105 GR; 105–117 SD	>35.7?	
Michael	Gaudet	Milford			P24B1L7		0–46 CL, GR; 46+ LS	Ab	14.0
Tony	Gaudet	Milford	4988500	465700	P24B1L9		0–45 MD; 45+ GP	Ab	13.7
Len	Giffin	Milford, Lacey Rd.			11E3B39		0–35 MD; 35+ LS	Ab	10.7
Alan	Goodwen	Stewiacke			11E3C20		0–50 MD; 50+ GP	Ab	15.2
Dianna	Graham	Shubenacadie	4993140	466750	P23B5M13	A	0–103 CL, BL; 103–123 SI; 123+ LS	Ab	37.5
Garnet	Graham	Stewiacke Cross Roads			P27A4K8		0–30 MD, GR; 30–60 MD, 60–74 GR		
Kevin	Graham	Stewiacke Cross Roads			P27A4K7		0–70 QS; 70–80 GR		
Philip	Grant	Milford			11E3B39		0–33 MD; 33+ LS	Ab	10.1
Philip	Grant	Milford	4987736	465445	11E3B39	E	0–20 MD; 20+ GP	Ab	6.1
Philip	Grant	Milford			11E3B39		0–20 MD; 20+ SS	Ab	6.1
Philip	Grant	Milford			11E3B57		0–25 CL, ST; 25–31 SH	Ab	7.6
William	Hanchard	Stewiacke	4997120	475300	P23C5L9	A	0–10 SD; 10–28 CL; 28+SL	Ab	8.5
	Hants Municipal	Shubenacadie	4993430	467180	P23B5N13	A	0–5 TS; 5–40 SD; 40–45 GR; 45–55 CL; 55–70 HP	Ab	
Robert	Harris	Milford			11E3B57		0–6 CL, ST; 6–9 LS	Ab	1.8
Derrick	Hiscock	Milford, Sunny Ridge	4988061	466097	P24B1L11	E	0–78 MD; 78+ LS	Ab	23.8
Rex	Hobgood	Milford, Bayberry Dr.			11E3B40		0–48 CL; 48+ LS	Ab	14.6
Dave	Hubley	Milford, Lacey Rd.			P24B1L9		0–35 MD; 35+ GP	Ab	10.7
Dave	Hubley	Milford, Sunny Ridge			P24B1L9		0–70 MD; 70+ GP	Ab	21.3
Dave	Hubley	Milford			11E3B39		0–27 MD; 27+ LS	Ab	8.2
Dava	Hubley	Milford, Lacey Rd.			P24B1L9		0–30 MD; 30+GP	Ab	9.1

Dave	Hubley	Milford			P24B1L9		0–55 CL; 55+ SH	Ab	16.8
Dave	Hubley	Milford, Lacey Rd.			P24B1L9		0–55 MD; 55–60 GR; 60–85 MD; 85–92 GR; 92+ LS	Ab	28.0
Dave	Hubley	Milford			11E3B39		0–15 MD; 15+ SH	Ab	4.6
Dave	Hubley	Milford			P24B1L9		0–20 MD; 20+GP	Ab	6.1
Dave	Hubley	Milford			11E3B39		0–25 MD; 25+ LS	Ab	7.6
Dave	Hubley	Milford			11E3B39		0–40 MD; 40+ SH	Ab	12.2
Dave	Hubley	Milford			P24B1L9		0–20 MD; 20+ GP	Ab	6.1
Dave	Hubley	Milford			11E3B39		0–10 MD; 10–14 SD; 14+ GP	Ab	4.3
Dave	Hubley	Milford			11E3B39		0–60 MD; 60+ SS	Ab	18.3
Dave	Hubley	Milford			11E3B39		0–10 MD; 10+ GP	Ab	3.0
Wilfred	Hulshof	Milford			11E3B39		0–65 MD; 65–70 SL; 70–112 MD; 112–118 QS; 118–184 SD; 184–190 MD; 190+ QS	?	
Wilfred	Hulshof	Milford			11E3B39		0–30 MD; 30+ SS	Ab	9.1
Wilfred	Hulshof	Milford			11E3B39		0–35 MD; 35+ GP	Ab	10.7
Leon	Isenor	Milford, Lacey Rd.	4987881	466100	P24B1M8	E	0–55 CL; 55+ SH	Ab	16.8
Philip	Isenor	Milford	4988704	465776	P24B1L7	E	0–45 MD; 45+ SH	Ab	13.7
Travis	Isenor	Pine Grove			P24C1F8		0–19 SD; 19–73 GR, SD; 73–94 CL; 94–96 GR; 96+ GP	22.3?	29.3
Travis	Isenor	Pine Grove			P24C1F8		0–30 SD; 30–95 GR, SD; 95–120 CL, GR; 120+ GP	29?	36.6
Jack	Johnson	Milford, Lacey Rd.			P24B1L9		0–63 MD; 63+ LS	Ab	19.2
Bill	Johnston	Milford			P24B1L9		0–30 MD; 30+ SH	Ab	9.1
W.	Johnstone	Milford			11E3B39		0–50 MD; 50+ LS	Ab	15.2
Mary	Jollimore	Stewiacke	4998700	474500	P23C5K8	A	0–80 CL; 80–90 GR; 90+ SS	Ab?	27.4
Susan	Jones	Milford	4988065	465698	P24B1L9	E	0–43 CL; 43+ GP	Ab	13.1
Michael	Kempt	Milford, Lacey Rd.			P24B1L9		0–30 MD; 30–40 SD, GR; 40+ GP	Ab	12.2
Marie	Kerr	Milford	4987185	465305	P24B1L9	E	0–26 MD; 26+ LS	Ab	7.9
	Lacey	Milford			11E3B39		0–40 MD; 40+ LS	Ab	12.2
George	Lacey	Milford, Lacey Rd.	4988120	465769	P24B1L7	E	0–45 MD; 45+ LS	Ab	13.7
Ron	Lee	Milford			P24B1L9		0–50 MD; 50+ LS	Ab	15.2
Barry	Lloyd	Milford, Lacey Rd.	4987990	466120	P24B1L9	E	0–74 MD; 74+ LS	Ab	22.6
Hugh	Logan	Shubenacadie	4990750	467000	P23B5M16	E	0–81 SD; 81–90 GR; 90–97 GR	27.4+	
Kent	MacDonald	Milford Stn.			11E3B39		0–18 MD; 18+ SS	Ab	5.5
Kim	Mackenzie	Milford			11E3B39		0–2 MD; 2+ SL	Ab	0.6
Alan	MacLellan	Milford	4984050	464500	11E3B15	A	0–40 SD; 40+ SS	Ab	12.2
Jerry	MacLellan	Milford			11E3B57		0–28 CL; 28+ LS	Ab	8.5
Kevin	MacMichael	Milford Stn.	4988508	465819	P24B1L9	E	0–22 MD; 32+ LS	Ab	9.8
Alden	MacPhee	Shubenacadie	4990720	467080	11E3B80		0–75 MD; 75–90 CO, GP; 90–105 SD, PL; 105–109 GR, SD	22.9	
Darrell	MacPhee	Mill Village			11E3B86		0–35 CL; 35+ LS	Ab	10.7
Darrell	MacPhee	Mill Village	4992078	465438	11E3B86	E	0–43 CL; 43+ GP	Ab	13.1
Earl	MacPhee	Milford	4987400	460250	11E3B36	A	0–50 MD; 50+ LS	Ab	15.2
Gerald	MacPhee	Mill Village	4992800	465100	P23B5K14	A	0–20 CL; 20+ LS	Ab	6.1
Lloyd	MacPhee	Stewiacke East			P23C5M8		0–55 MD, CL; 55–67 GR, SD, 67–68 MD		
Robert	MacPhee	Mill Village	4992003	465046	11E3B86	E	0–35 CL; 35+ GP	Ab	10.7
William	MacPhee	Mill Village	4992800	465100	P23B5K14	A	0–19 CL; 19+ LS	Ab	5.8
Blain	Mailman	Milford, Rennie Ln.			P24B1L9		0–20 MD; 20+SH	Ab	6.1
Stewart	McAlister	Milford	4989117	465618	11E3B39	E	0–18 MD; 18+ LS	Ab	5.5
Lewis	McCulloch	Shubenacadie			P23B5L14	A	0–4 SD; 4+ LS	Ab	1.2
Lewis	McCulloch	Mill Village	4994200	463900	P23B5K13	A	0–18 SD; 18+ SH	Ab	5.5
Wilfred	McLean	Shubenacadie	4991260	467530	P23B5N14	E	0–75 CL; 75–84 SD	?	
Borden	McLellan	Milford	4987806	465440	P24B1L9	E	0–48 MD; 48+ LS	Ab	14.6
Richard	McMullin	Milford, Nelson Hill	4987589	466949	P24B1M9	A	0–160 SN; 160–182 SD; 182+ LS	Ab	55.5

Shannon	McNutt	Stewiacke Cross Roads			P27A4K8		0-32 SD, GR		
Reserve #14	Mig Mogs	Shubenacadie			P23B5N15		0-12 QS; 12-14 GR; 14-24 CL, SN; 24-29 QS; 29-45 GR; 45-53 CL; 53+ SH	Ab	16.2
	Milford Rec.	Milford Stn.	4988680	465494	P24B1M8	E	0-30 MD; 30+ GP	Ab	9.1
Brian	Miller	Mill Village, N. Salem Rd.	4992800	465140	P23B5K12	A	0-10 SD, CL; 10-18 CL	?	
Donald	Miller	Shubenacadie	4994930	469130	P23B5P12	E	0-51 CL, BL; 51+ SH	Ab	15.5
Leon	Miller	Stewiacke Cross Roads			P27A4L10		0-5 CL; 5+ SH		10.7
Robert	Miller	Shubenacadie	4995600	468050	P23B5O11	E	0-160 CL, BD; 160-230 SD; 230-249 SD, CL; 249+ SH	?	75.9
Pat	Mills	Milford, Lacey Rd.	4987980	466120	P24B1L9	E	0-84 MD; 84+ LS	Ab	25.6
Keith	Moxsom	Shubenacadie	4990869	468250	P23B5O15	E	0-125 CL; 125-186 CL, QS; 186-191 SD; 191-198 GR; 198+ SD	57.9	
Kenneth	Moxsom	Shubenacadie	4991984	468440	P23B5O14	E	0-158 CL, SN; 158-160 QS; 160-163 GR; 163-177 SD, CL; 177-184 SD, GR; 184+ CI	56.1	
	Municipality	Shubenacadie			P23B5N13		0-40 SD; 40-45 GR; 45-55 CL; 55-70 HP		
Ken	Munroe	Milford	4985770	465040	P24B1L9	E	0-35 MD; 35+ LS	Ab	10.7
L.	Nason	Stewiacke Cross Roads			P27A4J8		0-60 CL, GL; 60+ GR, SD		
	Native Housing	Milford			P24B1L10		0-6 CL; 6-7 SD; 7-20 CL; 20-23 CL, RK	Ab	7.3
Kevin	Neejing	Milford			P24B1L9		0-37 SD; 37+ SH		11.3
Glen	Nelson	Milford	4988600	465770	P24B1L9	E	0-60 MD; 60+ SH	Ab	18.3
Dennis	Newman	Milford			P24B1L9		0-30 MD; 30+ GP	Ab	9.1
Stephen	Newman	Shubenacadie	4990860	470750	P23B5P16	E	0-178 MD, CL; 178+ GP, PL	Ab	54.3
	NSDSS	Wildlife Park			P23		0-17 SD; 17-21 CL	Ab	
	NSDSS #1	Wildlife Park			P23C5F12		0-12 CL, SD; 12-96 CL, ST; 96+ LS	Ab	29.3
	NSDSS #2	Wildlife Park			P23B5L14		0-17 SD; 17-21 CL	Ab	
Tom	Nutter	Milford			11E3B57		0-21 CL; 21+ LS	Ab	6.4
Vera	O'Neil	Shubenacadie	4992456	465413	P23B5L14	E	0-12 GR; 12+ SH	Ab	3.7
Don	Pace	Milford	4988110	466037	P24B1L9	E	0-70 MD; 70+ LS	Ab	21.3
Josephine	Parker	Milford			11E3B39		0-23 CL; 23+ SH	Ab	7.0
Alfred	Pearl	Mill Village			11E3B82		0-8 CL; 8+ SH	Ab	2.4
Nora	Pearse	Shubie. East	4996300	470650	P23C5F10	A	0-10 SD; 10-17 CL		
Walter	Pinch	Shubenacadie			P23B5M16		0-80 CL, GR; 80-95 GR, BL; 95-121 GR		
W.	Poolini	Mill Village	4992500	464460	11E3B82	E	0-29 CL; 29+ GP	Ab	8.8
Don	Preiss	Shubenacadie	4994400	470500	P23C5F12		0-18 CL; 18-22 GR; 22+ GP	Ab	6.7
Bob	Purcell	Shubenacadie	4991100	471260	P23C5G15	A	0-40 CL; 40-60 CL; 60+ GP	Ab	4.9
Phillip	Redden	Stewiacke Cross Roads			P27A4J8		0-145 CL, GR; 145-151 GR, SD		
Graham	Reid	Milford			11E3B39		0-30 MD; 30+ SH	Ab	9.1
Frank	Reyno	Coldstream	4991550	475600	P23C5L15	A	0-28 CL SD; 28+ GP	Ab	8.5
Chris	Roberts	Shubenacadie	4991483	468445	P23B5O15	E	0-103 CL; 103-111 GR; 111+ SD	33.8	
Burnie	Rogers	Stewiacke Cross Roads			11E2C1O6		0-20 CL; 20+ SS	Ab	6.1
Ken	Ross	Milford			P24B1L9		0-18 MD; 18+ SH	Ab	5.5
Creighton	Russell	Shubenacadie	4992600	466500	P23B5M14	A	0-15 MD; 15-35 SH	Ab	4.6
Frances	Scott	Shubenacadie	4993300	464850	P23B5K13	A	0-14 SD, MD; 14+ LS	Ab	4.3
J.	Shine	Shubenacadie			11E3B81		0-115 CL, GR; 115+ LS	?	35.1
Floyd	Singer	Shubenacadie	4992270	465290	P23B5L15	A	0-15 MD; 15-30 SH	Ab	4.6
Carl	Skinner	Milford	4989145	465673	P24B1L8	E	0-55 CL; 55+ SH	Ab	16.8
Gary	Smeltzer	Mill Village			11E3B82		0-14 CL; 14+ SH	Ab	4.3
Dorothy	Snares	Milford			P24B1L9		0-36 MD; 36+ LS	Ab	11.0
Ken	Squire	Milford			P24B1L9		0-35 MD; 35+ LS	Ab	10.7
Robert	Stillman	Milford			11E3B34		0-108 CL; 108-120 GR		
Peter	Suidgeest	Pine Grove	4989120	469680	P24C1F8	E	0-67 GL; 67-74 SD; 74-79 CL; 79-85 GR	Ab	
Elmer	Sutherland	Stewiacke East			11E3C2		0-30 GR		
Tracey	Thibeau	Milford			11E3B34		0-30 CL; 30+ SH	Ab	9.1

Chris	Thoms	Shubenacadie	4991848	469312	P23B5P15	E	0–104 CL; 104–122 QS; 122–155 QS; 155+ GR	Pr	
Andy	Thurber	Milford, Sunny Ridge	4988169	465965	P24B1L9	E	0–70 MD; 70+ LS	Ab	21.3
Robert	Tipping	Shubenacadie			11E3B80		0–40 CL; 40+ SS	Ab	12.2
Frank	Tree	Stewiacke Cross Roads			P27A3M15		0–60 CL, GR; 60+ SH	Ab	18.3
Charlie	Trenman	Stewiacke Cross Roads			11E3C2		0–30 MD; 30+ GP	Ab	9.1
Gary	Tully	Pine Grove			P24C1F8		0–35 SD; 35–97 GR		
John	Van De Riet	Shubenacadie			11E3B81		0–30 SD, GR; 30–57 CL; 57–65 CL, GR	9.1?	
Peter	Van Wychen	Shubenacadie			11E3B80		0–10 CL; 10+ SS	Ab	3.0
W.	VanDerKooi	Mill Village			11E3B82		0–50 CL; 50+ SH	Ab	15.2
John	Vantol	Milford			11E3B40		0–57 CL; 57+ SH	Ab	17.4
Len	Vantol	Milford	4988450	465850	11E3B40	A	0–62 CL; 62+ SH	Ab	18.9
Ben	Vermeulan	Milford	4987150	466150	11E3B33	A	0–112 CL, ST; 112+ LS	Ab	34.1
Ben	Vermeuland	Milford			11E3B33		0–40 CL,SD; 40–70 SD,GR; 70+ LS	Ab	21.3
	Village	Shubenacadie			P23B5N13		0–20 SD; 20–30 CL; 30–45 GL; 45+ BR	Ab	13.7
	Village	Shub. 100'from pump stn	4993722	467106	P23B5N13	E	0–20 SD; 20–30 CL, SI; 30–45 GL; 45+ SS	Ab	13.7
Peter	Vissers	Milford	4987839	467144	P24B1N8		0–199 CL, BL; 199–212 SD; 212–220 GR, SD; 220–224 SD	Ab	
George	Vowley	Pine Grove			P24C1F8		0–96 CL, GR; 96+ SL	Ab	29.3
Dan	Walker	Milford	4987030	465234	P24B1L9	E	0–27 MD; 27+ SH	Ab	8.2
Wayne	Wallen	Milford			P24B1L9		0–82 MD; 82+ LS	Ab	25.0
Lou	Wambolte	Stewiacke Cross Roads			P27A4K7		0–133 CL, GR		
Ralph	Wardrope	Milford	4987401	465380	11E3B39	E	0–33 MD; 33+ LS	Ab	10.1
Roger	Wardrope	Milford			11E3B39		0–25 MD; 25+ SH	Ab	7.6
Roger	Wardrope	Milford	4987490	465460	P24B1L9	E	0–15 MD; 15–64 SH	Ab	4.6
Kenneth	Warnica	Milford			11E3B57		0–31 CL, 31+ LS	Ab	9.4
Charles	Watson	Shubenacadie	4986800	472850	11E3B29	A	0–130 GP	Ab	
Lloyd	Watson	Pine Grove	4987650	4472540	P24C1H9		0–110 CL, BL; 110+ GP	Ab	33.5
Arthur	West	Milford	4986830	465170	P24B1L9	E	0–35 MD; 35+ GP	Ab	10.7
Brian	White	Shubenacadie			11E3B65		0–50 CL, BL; 50+ SH	Ab	15.2
Dan	White	Milford			11E3B57		0–32 CL; 32+ SH	Ab	9.8
Joan	White	Milford			P24B1L9		0–55 MD; 55+ SH	Ab	16.8
Clair	Whyte	Milford, Rennie Ln.			P24B1L11		0–10 MD; 10–21 SD, GR; 21+ LS	Ab	6.4
Joseph	Whyte	Milford	4989055	465614	P24B1L7	E	0–25 CL; 25+ SH	Ab	7.6
Ervin	Williams	Shubenacadie			11E3B80		0–20 MD; 20+ SS	Ab	6.1
Ralph	Williams	Milford			11E3B57		0–51 CL, 51+ LS	Ab	15.5
Wayne	Williams	Mill Village, Crombe Rd.	4992130	465145	11E3B82	E	0–35 CL; 35+ SH	Ab	10.7
Tim	Wilson	Stewiacke East	4998650	475500	P23C5L8	A	0–6 CL; 6–30 GR		
Christa	Woodworth	Milford			11E3B39		0–26 MD; 26+ LS	Ab	7.9
Thomas	Young	Shubenacadie			P23B5O14		0–8 CL, SD; 8–92 CL, SD; 92–170 CL, SD; 170–188 CL, GR	Pr	

NOVA SCOTIA DEPARTMENT OF THE ENVIRONMENT
DRILLED WATER WELL RECORDS (MUSQUODOBOIT VALLEY)

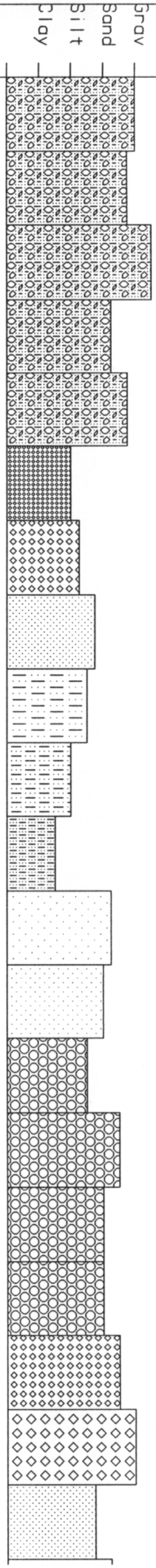
Name		Community	Northing UTM	Easting UTM	Map Coord.	Record Number	Description	Cretaceous Depth (m)	Bedrock Depth (m)
Ada	Aikems	Chaswood	4988532	484550	P24D1K8	1	0–1 TS; 1–8 CL; 8–17 CL,GP	Ab	>5.2
Albert	Ainslie	Meadowvale			P23E4013	2	0–12 CL, GR; 12–38 SD, GR; 38–48 CL	?	>14.6
Keith	Andrews	Cooks Brook, Cooks Lake			P24C1P13	3	0–1 TS; 1–17 CL	Ab	>5.2
Carl	Archibald	Middle Musquodobit	4990157	488059	P24D1N7	4	0–12 CL,GR; 12–45 CL; 45+ SL	Ab	13.7
Greg	Archibald	Middle Musquodobit	4987651	487711	11E2C12	5	0–30 GR		>9.1
John	Archibald	Middle Musquodobit	4988069	487410	11E3A40	6	0–20 CL; 20–37 CL, SD; 37–50 CL; 50–80 CL; 80 – 85 CL;	6.1	>59.4
John	Archibald	Middle Musquodobit			11E3A40	7	85–110 CL; 110–130 CL; 130–140 CL; 140–165 CL; 165–190 CL; 190–195 SD		
Smith	Archibald	South Section			P24D1O11	8	0–60 CL, BL; 60+ SH	Ab	18.3
S&P	Attenburg	South Section	4984110	485445	P24D1L12	9	0–37 CL,SS; 37+ LS	Ab	11.3
Jack	Belfontaine	Brookvale	4986780	492736	11E3A29	10	0–44 CL, SS; 44–56 SD; 56+ GP	Ab	17.1
Barbra	Bell	Middle Musquodobit	4987250	488977	11E3A96	11	0–100 CL, BL; 100+ SH	Ab	30.5
Dora	Benere	Cooks Brook, Keddie Rd	4982780	476892	P24C1O13	12	0–6 TS, GR; 6+ SL	Ab	1.8
	Bible Camp	Cooks Brook	4988532	480862	11E3A36	13	0–10 CL; 10+ SH	Ab	3.0
Earl	Blades	Cooks Brook	4986620	479566	11E3B25	14	0–25 CL; 25–95 CL; 95+ GP	?	29.0
Clint	Boutilier	Middle Musquodobit			11E3A42	15	0–120 GR		>36.8
Dwayne	Brewer	Elderbank			P24D2H8	16	0–20 CL, ST; 20–30 SD; 30+ LS	Ab	9.1
John	Brewer	Elderbank			P24D2J7	17	0–18 CL,ST; 18+ GP	Ab	5.5
Keith L.	Caborn	Middle Musquodobit	4986358	487480	11E3A32	18	0–70 CL, BL; 70+ LS	Ab	21.3
Branch 147	Cdn Legion	Reynolds			P27A5G11	19	0–65 CL, BL; 65+ LS	Ab	19.8
Sheldon P.	Chisholm	Middle Musquodobit	4985787	487400	11E2B107	20	0–75 CL; 75+ SH	Ab	22.9
David Paul	Church	Cooks Brook	4982900	478940	11E3B22	21	0–23 BL, CL; 23+ QZ	Ab	7.0
Robert A.	Clarence	Middle Musquodobit			P24D1N9	22	0–30 CL; 30+SH	Ab	9.1
Vincent	Clark	Middle Musquodobit	4988026	487489	11E3A41	23	0–15 CL; 15–18 SD, CL; 18–60 CL,BL; 60–70 CL, GR; 70–79 CL; 79–81 SD	21	>24.7
	CMHC	Elmsvale			P23E5G15	24	0–10 RK, CL; 10–12 SD; 12–26 RK, CL		>7.9
	CMHC	Cooks Brook, lot #3			P24C1M11	25	0–26 SD; 26–35 SD, GR; 35–41 SD, GR; 41–47 CL	?	>14.3
	CMHC (Mrs. Lucy)	Cooks Brook	4985745	476356	P24C1M11	26	0–90 SD; 90+ QZ	Ab	27.4
Dean	Cole	South Section	4983702	484790	P24D1L13	27	0–50 CL,BL; 50+ SH	Ab	15.2
Lionel	Cortney	Middle Musquodobit	4987639	488700	11E3A42	28	0–34 CL, ST; 34–43 SD; 43–64 CL; 64–85 SD	10.4	>25.9
Darrel	Creelman	South Branch			11E3D29	29	0–50 GR		>15.2
Lloyd	Creelman	South Branch			11E3D44	30	0–20 GR, SD; 20–98 SD; 98–105 CL, ST; 105+ GP	?	32.0
Mary	Csoma	Chaswood/Shubie	4989740	481773	P24D1G7	31	0–8 CL; 6+ SL	Ab	1.8
Evelyn	Deale	South Section	4983885	484636	P24D1M12	32	0–20 CL, 20+ SH	Ab	8.1
Wayne	Dean	Newcomb Corner	4991397	495330	P23E5L15	33	0–35 CL,SD;35–53 CL; 53–62 SD;62–115 CL;115–117 CO;117–170 CL;170–185 SD	10.7	>56.4
Gordon	Dickie	Reynolds			P23E5P11	34	0–110 CL, BL; 110–140 SD; 140–150 SD; 150–160 SD, GR; 160–164 SD	?	>50.0
Micheal	Erskine	Centre Musquodobit			11E3A96	35	0–20 CL, GR; 20–22 SD, GR	?	>6.7
A.	Ettinger	Middle Musquodobit	4987648	487715	11E2C12	36	0–32 GR	Pr	>9.8
Percy	Fisk	Elmsvale	4989045	490300	11E3A68	37	0–45 CL, BL; 45–80 BL; 80–180 CL; 180–200 CL, BL; 200–214 SD, GR	24.4	>65.2
Glen	Fox	South Section	4984010	485179	P24D1N11	38	0–18 MD; 18+ LS	Ab	5.5
George	Fulton	Middle Musquodobit	4987700	487966	11E3A97	39	0–32 ST, GR; 32–37 GR	>11.3	>11.3
	Fundy Gypsum	Dutch Settlement			P24B1L14	40	0–15 MD; 15+ GP	Ab	4.6
	Funeral home	Middle Musquodobit	4987600	488223	11E2C12	41	0–88 CL; 88–90 SD, GR	Pr	>27.4
Lenord	Gaffney	Elderbank			P24D2F7	42	0–2 OB; 2–10 SD; 10–15 CL, BR	Ab	>4.6
Dr.	Giffin	Middle Musquodobit	4988182	487331	P24D1O9	43	0–60 CL; 60–220 CL; 220–260 CL; 260–262 CL, SD; 262–270 CL, CO	<18.3	>82.3
Lea	Gloade	Dutch Settlement			P24B1L16	44	0–10 SD; 10–90 CL; 90+ GP	Ab	27.4
Don	Grant	Meadowvale			P23E5M8	45	0–20 TI; 20–45 SD; 45+ SS	Ab	13.7
Darrell	Harris	Cooks Brook, Cooks Lake	4983081	479047	P24C1P14	48	0–2 CL; 2+ QZ	Ab	0.6

Paul	Haverstock	Middle Musquodobit	4987898	488469	11E3A41	47	0-20 CL, BL; 20-35 CL, GR; 35-65 CL; 65-90 SD; 90-200 CL; 200-216 SD, GR	<10.7	>65.8
Steve	Hayden	Murchyville			P24D1P14	48	0-110 MD; 110-130 MD; 130+ SL		39.8
Craig	Higgins	Middle Musquodobit	4988503	487460	P24D1N8	49	0-102 CL, ST; 107-170 SD; 170+ LS		32.6
Gerald	Higgins	Mid. Musq. (Brookvale Rd)	4987209	490365	11E3A42	50	0-22 CL, SS; 22-28 SH, CL; 28+ GP	Ab	8.5
Gordon	Higgins	S. Section, Moose R. Rd.	4990312	497293	P24D1O11	51	0-55 CL, BL; 55+ SH	Ab	18.8
Seldon	Higgins	Lindsay Lake	4988159	498327	P24D1O9	52	0-2 TS; 2+ SH	Ab	0.6
Frank	Holman	Middle Musquodobit	4987211	488690	11E2B107	53	0-20 CL, BL; 20-36 CL, GR; 36-40 CL; 40-45 CL, GR;	11	31.7
Frank	Holman	Middle Musquodobit			11E2B107	54	45-55 CL; 55-58 CL, GR; 58-70 CL; 70-95 SI, GR; 95-104 SD, GR; 104+ SH		
	Hosp. Auxillary	Middle Musquodobit	4987259	488887	11E3A41	55	0-50 CL, BL; 50-59CL; 59-61 CL; 61-64 CL; 64-66 CL;	15.2	>27.4
	Hosp. Auxillary	Middle Musquodobit			11E3A41	56	66-73 CL; 73-74 CL; 74-77 CL; 77-79 CL; 79-83 CL; 83-86 CL; 86-90 CL		
Bert	Hull	Cooks Brook/Gay's River	4986126	474260	P24C1J10	57	0-3 TS; 3-12 GR, SD; 12-30 CL, GR	Ab	>9.1
Garnet	Hutchinson	Middle Musquodobit	4988849	490155	11E3A41	58	0-10 CL, GR; 10-12 BL, 12-20 SD, GR; 20-22 GR		>6.7
Garth	Isenor	Dutch Settlement			P24B1J18	59	0-5 RK, MD; 5-30 CL, ST; 30+ GP	Ab	9.1
Margaret	Jones	Middle Musquodobit	4992251	493300	P23E5N12	60	0-120 CL, GR; 120-125 QS; 125-130 CL; 130-136 SD, GR	<36.6	>41.4
	Kent Homes Ltd	Meadowvale			11E3D50	61	0-8 CL, ST; 8-30 SD, CL; 30-55 CL, ST; 55-60 SD; 60-94 CL, ST; 94+	?	>28.8
John	Le Due	Elderbank			11D14D86	62	0-63 CL,ST; 63+ LS	Ab	19.2
Larry	Lee	Middle Musquodobit	4989179	490526	11E2C10	63	0-95 CL; 95-140 SD, CL; 140-150 CL; 150-161 SD, GR	<29	>49.1
Cornelius	Levering	Murchyville			11E3A17	64	0-32 CL, ST; 32 + LS	Ab	9.8
Cornelius	Levering	Brookvale	4984876	488295	P24D1O12	65	0-23 CL, ST; 23-50 SD, CL; 50+ LS	Ab	15.2
William	Levering	Middle Musquodobit			11E3A41	66	0-20 TI, BL; 20-41 GR, SD		>12.5
Doug	Lively	Cooks Brook			P24C1O13	87	0-32 CL, GR; 32+ QZ	Ab	9.8
Harvey	Lively	Cooks Brook	4982977	478630	P24C1M11	66	0-6 SD; 8+ QZ	Ab	2.4
John	MacKinnon	Meadowvale, 98 McLean St.			P23E5M8	69	0-15 CL; 15+ SH	Ab	4.6
R.G.	Matheson	Elmsvale	4992585	494925	11E3A75	70	0-50 CL; 50-52 SD, GR	15.2	>15.8
Bill	McCurdy	Middle Musquodobit	4987700	487665	11E3A41	71	0-42 SD, GR	Pr	>12.8
Michael	McEwen	Cooks Brook	4983317	478663	11E3B2	72	0-14 CL; 14+ QZ	Ab	4.3
Michael	McFetridge	Middle Musquodobit	4987893	488115	11E3A41	73	0-190 CL, BL; 190-200 SD	Pr	>61
Kevin	McLellan	Lake Egmont			P24C1L15	74	0-4 LO, CL; 4-10 GR; 10-20 CL	?	>6.1
William	McMurchas	White's Lake			P24D1P16	75	0-15 CL, BL; 15+ GT	Ab	4.6
Fraser	Miller	Centre Musquodobit	4993232	496050	P23E5L13	78	0-22 GR		>6.7
Jacqueln	Miller	Lake Egmont			11D14C95	77	0-60 MD; 60+ GP	Ab	18.3
Ralph	Miller	Elderbank	4983400	484300	11E2B107	78	0-50 CL, BL; 50+ SH	Ab	15.2
Sharon	Mills	Middle Musquodobit			P24D1N8	79	0-54 CL; 54+ ST		16.5
Cecil	Mitchell	Murchyville (Lacey Rd)			P24E1H14	80	0-8 MD; 8+ SH	Ab	2.4
Bruce	Moulton	Elderbank			P24D2G7	81	0-60 CL,ST; 60+ LS	Ab	16.3
Janet & Bruce	Moulton	Elderbank			P24D1H18	82	0-2 OV; 2-10 CL; 10-25 CL	Ab	>7.8
Ann	Murphy	Chaswood	4987890	483621	11E3A38	63	0-49 CL, ST; 49+ ST		>14.9
	Musqu. Valley Hm	Middle Musquodobit	4987235	488908	P24D1P9	64	0-80 CL, BL; 80+ SH	Ab	24.4
	Musq. Enterprises	Middle Musquodobit	4987786	488573	11E2C11	65	0-18 GR; 16-30 CL, GR; 30-65 CL; 65-80 CL	9.1	>24.4
Hilden	Myers	Middle Musquodobit	4987630	487489	11E2C12	66	0-15 SD; 15-35 GR		>10.7
Harold	Naugle	Lake Egmont			11D4C93	87	0-20 CL, SD; 20-75 CL; 75-95 CL; 95-104 SD, GR	?	>31.7
Wilfred	Naugle	Middle Musquodobit			P24D1N8	88	0-5 CL, GR; 5-12 SD,GR; 12-20 GR		>6.1
Danita	Newman	Murchyville			P24D1O13	89	0-26 MD; 26+ SL	Ab	7.9
	NSDLF	Middle Musquodobit	4988300	488971	11E3A41	90	0-185 CL; 165+ GP	Pr	58.4
Howard	Oxner	Reynolds			P23E5O11	91	0-30 CL; 30-31 BL; 31-115 CL; 115-120 SD, GR	?	>36.6
Steven	Paugh	Lindsay Lake	4987609	498820	P24E1O9	92	0-18 CL; 18-25 BL; 25-35 CL; 35+ SH	?	10.7
Vincient	Pettipas	Middle Musquodobit	4987750	485020	11E3A39	93	0-65 CL, BL; 65-90 CL; 90-97 CL; 97-119 SD; 119+ SH	19.8	36.3
Gary	Preeper	Dutch Settlement			P24B1M13	94	0-10 GR, CL; 10-16 SD, CL; 16+ GP	Ab	4.9
Doug	Ransome	Carrolls Corner			P24C1F12	95	0-5 CL, BR; 5+ QZ	Ab	1.5

Myrtle	Redden	Lindsay Lake	4987579	498865	P24D1O9	96	0–37 CL, BL; 37+ SH	Ab	11.3
Robert	Redden	Lindsay Lake	4987435	498640	P24E109	97	0–45 CL, BL; 45+ SH	Ab	13.7
Darlene	Redding	Coldstream/Pine Grove			P24C1H9	96	0–2 TS; 2–10 CL; 10–22 CL	?	>6.7
Dave	Ross	Middle Musquodobit	4988010	488165	11E3A41	99	0–80 CL, BL; 80–120 CL; 120–125 SD; 125–160 CL; 160–171 SD	24.4	>52.1
	Rural/Nat. Housing	Elderbank			11D14D87	100	0–20 SO; 20–32 CL; 32+ SH	Ab	9.8
	Scotia Homes	Elmsvale			P23E5J14	101	0–80 CL; 80–95 GR; 95–110 SS; 110–123 SD; 123–134 SS;		49.4
	Scotia Homes	Elmsvale			P23E5J14	102	134–146 QS; 146–162 CL; 162+ SS		
	Scotiaview Farm	Middle Musquodobit			P24D1O10	103	0–88 CL,ST; 88+ GP	Ab	26.8
Ethel	Scott	Elmsvale	4991397	495260	11E3A70	104	0–20 TI; 20–60 CL, GR; 80–95 SD, GR	6.1	>59.4
	Sen. Cit. Home	Middle Musquodobit	4987701	488204	P24D1N9	105	0–39 TL;39–55 CL,GR;55–65 SD;65–116 CL;116–120 GR;120–142 CL;142–151 SD	16.8	>46
Ted	Seward	Murchyville			P24D1N14	106	0–15 CL; 15–17 BL; 17–40 CL,BL; 40–100 GP,PL		12.2
Robert	Standing	Middle Musquodobit	4983880	487788	11E3A41	107	0–15 CL; 15+ SS	Ab	4.6
Andy	Stewart	Elmsvale			P23E5L15	108	0–10 CL, BL; 10–40 CL; 40–45 SD; 45–75 CL; 75–100 SD	3	>30.5
Currie	Stewart	Lindsay Lake	4987000	499456	P24D109	109	0–32 CL, SN; 32+ SL	Ab	9.8
Allan	Streatch	Elderbank			11D14D84	110	0–101 CL, ST; 101+ SH	Ab	30.8
Mrs.	Taylor	Middle Musquodobit			P24D1N9	111	0–12 MD, RK; 12+ QZ	Ab	3.7
Rob	Taylor	Middle Musquodobit	4986603	483789	P24D1N9	112	0–15 CL; 15–20 GR; 20–30 SD; 30–40 GR; 40–47 CL	12.1	>14.3
Lou	Thornhill	Meadowvale			P23E4D12	113	0–36 CL, ST; 36–42 GR, SD; 42–48 CL, ST		>14.6
Dennis	Tully	Dutch Settlement			11D14C88	114	0–75 CL; 75+ GP	Ab	22.9
	Twin Mtn Const.	Middle Musquodobit			P24D1N9	115	0–95 CL, BL; 95+ SH		29.0
James	Urguhart	Cooks Brook			11E3B22	116	0–10 CL; 10+ QZ		3.0
Rodney	Vaughn	Middle Musquodobit	4987823	488675	11E3A41	117	0–8 GR, BL;8–29 CL,SD; 29–40 SD,GR; 40–51 CL, 51–55 SD; 55–95 CL; 95–120 SD	12.1	>36.6
Rodney	Vaughn	Middle Musquodobit	4988080	488573	11E2C11	118	0–24 GR		>7.3
Bruce	White	Middle Musquodobit	4987905	488357	11E2C11	119	0–12 ST; 12–15 GR; 15–18 CL, GR; 18–70 CL; 70–88 GR, CL; 80–110 CL	5.5	>70.4
Bruce	White	Middle Musquodobit			11E2C11	120	110–180 CL; 180–225 CL; 225 – 231 SD, GR		
Pier	Wiersma	Brookvale	4986307	491165	P24D1P9	121	0–22 CL, BL; 22–39 SD, CL; 39–45 GR, SD; 45+ LS	Ab	13.7
Robert	Wilmont	Cooks Mills Rd.			P24C1G10	122	0–10 CL; 10–11 SD; 11–18 CL		>5.5
	Young	Musquodobit Harbour			P24D1N8	123	0–36 CL; 36+ SL	Ab	11.8

APPENDIX 2

LOGS OF DRILLING CONDUCTED DURING 1995 BY THE NOVA SCOTIA DEPARTMENT OF NATURAL RESOURCES IN THE MUSQUODOBOIT AND SHUBENACADIE VALLEYS



LEGEND

CLAST SUPPORTED SILTY-DIAMICTON:

CLAST SUPPORTED CLAY-RICH-DIAMICTON:

CLAST SUPPORTED PEBBLY-DIAMICTON:

MATRIX SUPPORTED SILTY-DIAMICTON:

MATRIX SUPPORTED PEBBLY-DIAMICTON:

SANDY SILT:

SILTY SAND:

FINE SAND:

MUDDY SAND:

SANDY MUD:

CLAYEY MUD:

COARSE SAND:

MEDIUM SAND:

FINE SILICA SAND:

COARSE SILICA SAND:

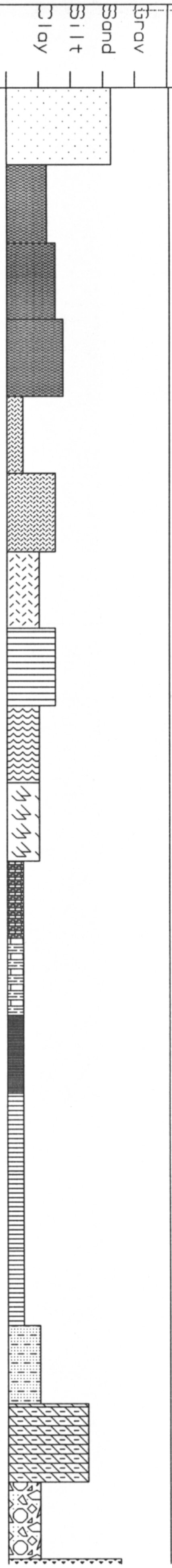
SILICA SAND:

CEMENTED SILICA SAND:

GRAVELLY SAND:

SANDY GRAVEL:

VERY FINE SAND:



LEGEND

VERY COARSE SAND:

FINE SILT:

MEDIUM SILT

COARSE SILT:

FINE CLAY:

SILTY CLAY:

WHITE CLAY:

VARVED CLAY:

BANDED CLAY:

MOTTLED CLAY:

RED OCHRE CLAY:

PURPLE CLAY:

BLACK CLAY:

DARK GREY CLAY:

GREY CLAY:

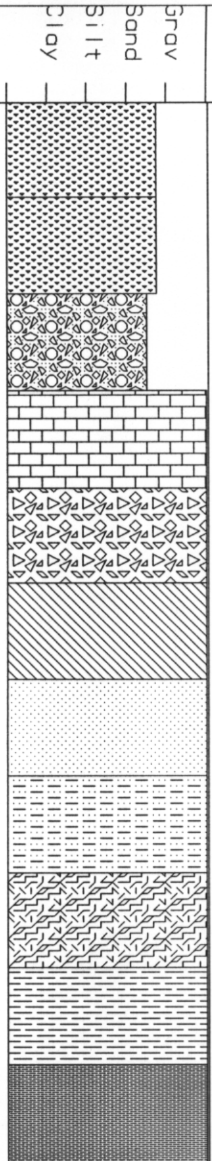
LIGHT GREY CLAY:

LIGNITE CLAY:

LIGNITE BRECCIA:

BRECCIATED CLAY:

LEGEND



COARSE GRAVEL:

VERY COARSE GRAVEL:

CHANNEL LAG:

LIMESTONE:

BRECCIA:

GYPSUM:

SANDSTONE:

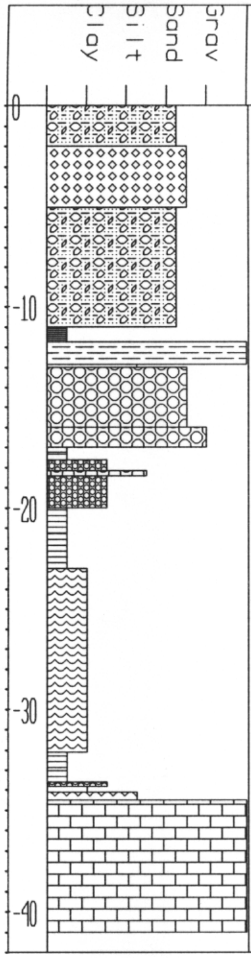
SILTSTONE:

METAWACKE:

LIGNITE:

PYRITE:

MUSC95-1	TOTAL DEPTH: 41.0m NORTHING: 4989240 EASTING: 492000



MATRIX SUPPORTED SILTY-DIAMICTON:

GRAVELLY SAND:

MATRIX SUPPORTED SILTY-DIAMICTON:

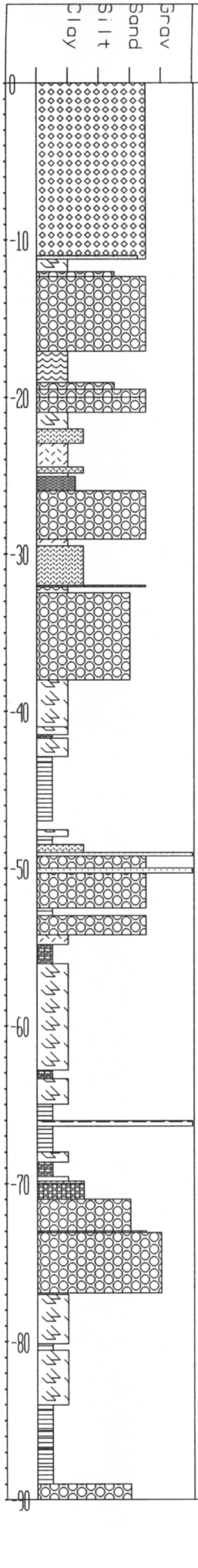
BLACK CLAY: contains lignite-fragments and minor pyrite-lenses/blebs

LIGNITE: coal-like, hard

SILICA-SAND: section grades from siltly-to-gravelly (top to bottom)

PREDOMINATELY GREY-CLAY/SILT WITH MINOR SILICA-SILT/SAND: clays vary from light to dark grey to black in colour. Darker coloured clays may contain minor organic fragments. Texture varies from massive to mottled and is locally finely laminated.
SAMPLE: MUSC95-1 (23.0 to 26.0m)

LIMESTONE: massive



MUSC95-2

TOTAL DEPTH: 149.0m

NORTHING: 4991900
EASTING: 494550

GRAVELLY SAND: lower 22cm comprised of silty diamicton

MOTTLED CLAY: white to red, minor-silt

SILICA-SAND: common limonitic-cement, minor coarse white-sand

BANDED CLAY: <0.5-2.5cm thick, yellow, white and red horizontal bands

SILICA-SAND: yellow to white, intercalated silt/fine-sand and massive, white silica-sand

CLAY/SILT: mottled red/white to massive white, plastic-clay (minor-silt). Locally banded (mm). Predominately WHITE-CLAY from 23.0-25.1m

SILT/SAND: varies from banded white and light-yellow/silt to massive, coarse, pink to yellow silica-sand.

INTERCALATED SAND/CLAY: contains plastic, white (+red) silt-clay at top of section. Also contains 40cm of horizontally laminated yellow and white-clay (minor-silt).

SILICA SAND: coarse-grained; contains white-clay in matrix.
SAMPLE: MUSC95-2-1 (32.5-33.5m)

CLAY/MINOR-SILT: vary from mottled (red, white, yellow, purple) to massive, hard, red (ochre) and grey clays. Section contains narrow bed of hard, dark grey-black, lignitic-clay (47.0-47.58); pyritic.

SILICA-SAND: interbedded carbonate-cemented and non-cemented white silica-sand.

CLAY: varies from massive, light to dark-grey and white (54.2m/50cm) to mottled, red-yellow-grey. Minor silty-clay. Section contains lignite and pyrite-bearing, dark-grey and black-clay (66-68m).

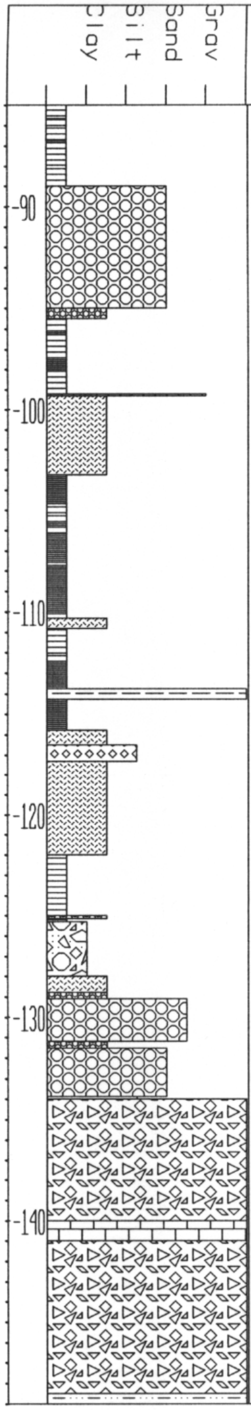
SILICA-SILT/SAND: interval shows the transition from silt-to-gravelly-sand from top to bottom of section. Locally limonitic/pyritic.

CLAY: predominately light to dark-grey to black, locally mottled. Dark-grey clays may contain organic fragments.

MUSC95-2

TOTAL DEPTH:149.0m

NORTHING: 4991900
EASTING: 494550



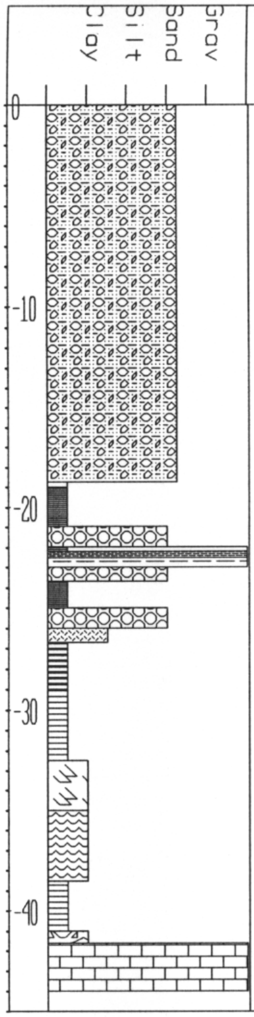
SILICA-SAND/SILT:

INTERCALATED CLAY/SILTY-CLAY: predominately dark-grey to black, massive, with common organic-fragments(lignite)and pyrite-nodules. Silty-sandy sections (115-125m)are usually mottled.

BRECCIATED CLAY: mottled, light-green/black, silty.

SILTY-CLAY/SAND: predominately mottled, green to black, silty-clay. Locally laminated, with organic-rich layers.

INTERBEDDED SILT-STONE/LIME-STONE: silt-stone is pervasively-brecciated, mottled green whereas lime-stone is dark-grey in colour.



MUSC95-3

TOTAL DEPTH: 44.0m

NORTHING: 4989820
EASTING: 492540

MATRIX SUPPORTED SILTY-DIAMICTON: reddish-brown

DARK GREY TO BLACK-CLAY: minor silt and lignite-fragments
SILICA SAND: fine-to coarse-grained

BLACK-CLAY/LIGNITE: organic-rich, contains local concentration of lignite/pyrite
SILICA SAND: coarse-grained, contains minor silt and black organics
BLACK CLAY: hard, minor silt and coarse silica fragments
SILICA SAND: medium-grained, light-brown

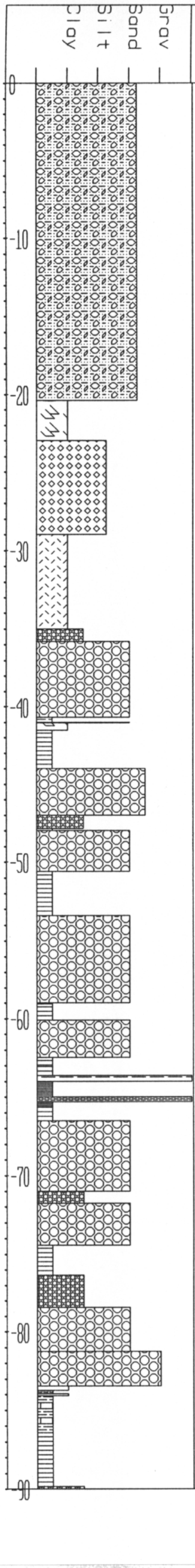
CLAY: predominately massive, light to dark-grey, some reddish-brown; locally banded/laminated or mottled; minor silt. Bottom of section adjacent to bedrock is brecciated.
SAMPLE: MUSC95-3-1 (29.5-31m)

LIMESTONE: only slightly calcareous (dolomite?)

MUSC95-4

TOTAL DEPTH: 122.5m

NORTHING: 4984260
EASTING: 482946



MATRIX SUPPORTED SILTY-DIAMICTON: silty near bottom of section

MOTTLED CLAY: massive with minor drop-stones

SILTY SAND: varies from silty near top of section to-gravelly near bottom

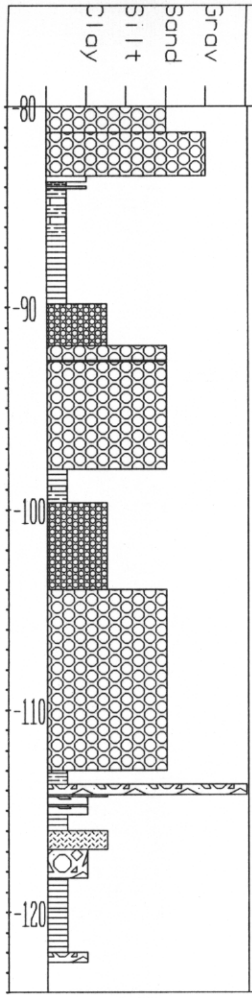
WHITE CLAY: contains minor-silt/sand and has local mottled reddish-brown colouration.
SAMPLE: MUSC95-4-16 (29-35m)

INTERBEDDED SAND/CLAY: sand-rich sections may be limonitic and contain finely-disseminated pyrite/marcasite. Silt-rich sections of silica-sand also occur. Section of white clay from 41.5 - 44.0m; sandy sections may have <50% core recovery
SAMPLES: MUSC95-4-17 & 18 (41-44m)
MUSC95-4-19 (55-62m)
MUSC95-4-27 (59m)

CLAYS: vary from light-grey to black in colour; silty sections. Minor marcasite nodules and lignite-fragments (63.6m); zones of coarse marcasite at 65m

INTERBEDDED SILICA-SILT/SAND: coarse -to fine- grained, contains minor minor marcasite. Some sections are clay-rich. Massive-clay (light-grey) from 74.4 - 76.3m. Gravelly near base of section.
SAMPLES: MUSC95-4-20 (74-75.5m)
MUSC95-4-21 (79-81m)

MIXED CLAYS: massive to silty; also locally sandy. Contains minor marcasite nodules. Contacts between colour variations are sharp.
SAMPLES: MUSC95-4-23 & 24 (87.5-89m)



MUSC95-4

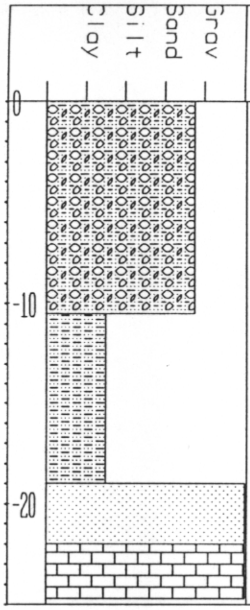
TOTAL DEPTH: 122.5m

NORTHING: 4984260
EASTING: 482946

MIXED CLAYS: massive to silty; also locally sandy. Contains minor marcasite nodules. Contacts between colour variations are sharp.
SAMPLES: MUSC95-4-23 & 24 (87.5-89m)

INTERBEDDED SILICA-SAND/CLAY: contains silt-rich sections; shows transition from silica-silt to sand-to white-clay from top of section to 92.7m; 15cm of soft, white-clay from 92.62-92.7m. Lower 10m of section consists of fine to medium silica-sand with intercalated white-clay (<10% core recovery); >marcasite.
SAMPLE: MUSC95-4-22 (101m)

CLAYS: variable colour and silt-content. Local development of mm-scale laminations (subhorizontal/CA.) and brecciation (near botom of section). Section contains two beds of pyritic quartz-pebble conglomerate at (113m/113.7m).
SAMPLES: MUSC95-4-25 (116-117m)
MUSC95-4-26 (118-119m)



MUSC95-6

TOTAL DEPTH: 24.7m

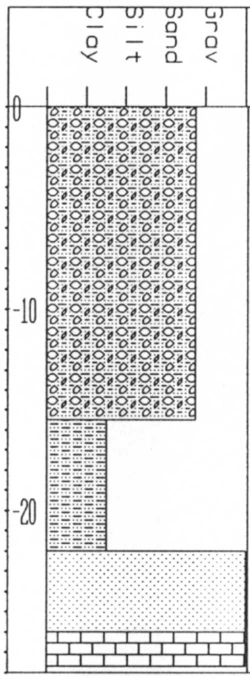
NORTHING: 4984707
EASTING: 481849

MATRIX SUPPORTED STONEY-DIAMICTON:

CLAYEY MUD: dark-brown, minor silt/sand, lower 1m of section dark -grey, brecciated.

SANDSTONE: medium-grained, reddish-brown

LIMESTONE: dark-grey



MUSC95-7

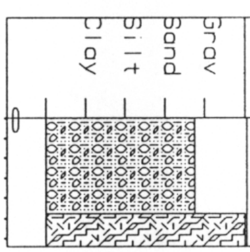
TOTAL DEPTH: 27.7m

NORTHING: 4984519
EASTING: 482207

MATRIX SUPPORTED STONEY-DIAMICTON:

CLAYEY MUD: dark-brown, minor silt/sand

SANDSTONE: medium-grained, reddish-brown
LIMESTONE: dark-grey



MUSC95-8

TOTAL DEPTH: 6.4m

NORTHING: 4984650
EASTING: 480646

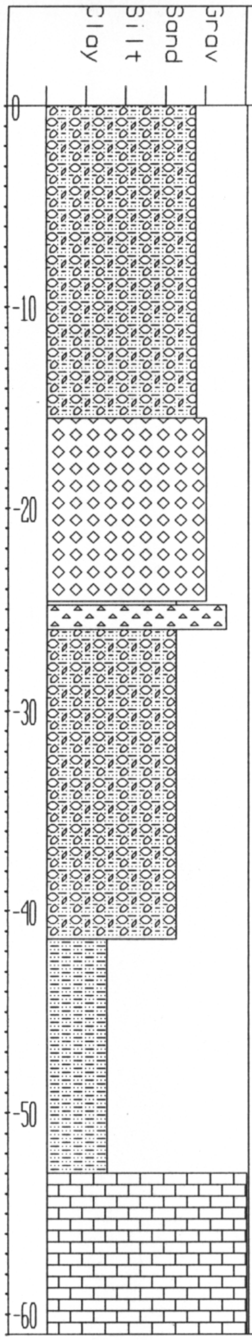
MATRIX SUPPORTED STONEY-DIAMICTON:

METAWACKE: dark-grey, siliceous

MUSC95-9

TOTAL DEPTH 61.0m

NORTHING: 4983300
EASTING: 482600



MATRIX SUPPORTED STONEY-DIAMICTON:

SANDY GRAVEL:

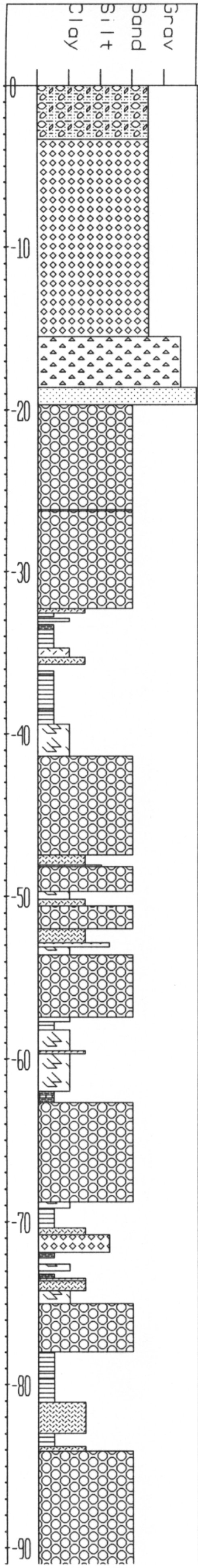
COARSE SAND:
GRAVEL: very coarse-grained

MATRIX SUPPORTED SILTY-DIAMICTON:

CLAYEY MUD:

LIMESTONE:

MUSC95-11	TOTAL DEPTH: 111.0m NORTHING: 4986600 EASTING: 486200



MATRIX SUPPORTED SANDY-DIAMICTON

GRAVELLY SAND

GRAVEL:

SANDSTONE: cemented silica-sand, hole reduced to NQ at 18.6m.

SILICA SAND: minor-silt

PREDOMINATELY CLAYS WITH MINOR SILT/SAND: minor marcasite
nodules; WHITE-CLAY from 34.7 to 35.3m;

MIXED SAND/CLAY: minor-silt; minor marcasite and sericite
from 48.2 to 49.7m;
LOST CORE from 41.4 to 47.5m, assumed silica-sand

CLAYS: hard; predominately mottled with minor-silt

SILTY SILICA SAND: 10% core recovery

CLAYS: predominately mottled with minor finely
laminated sections at 75 degrees/CA.; sand-section
is iron-cemented.

SILTY SILICA SAND: 30% core recovery

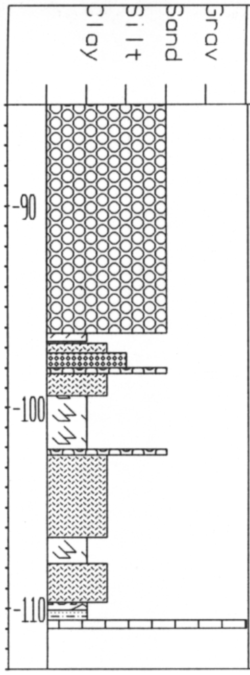
CLAYS: dark grey to black; minor-silt

SILICA SAND: approx. 50% core recovery; limonitic

MUSC95-11

TOTAL DEPTH: 111.0m

NORTHING: 4986600
EASTING: 486200



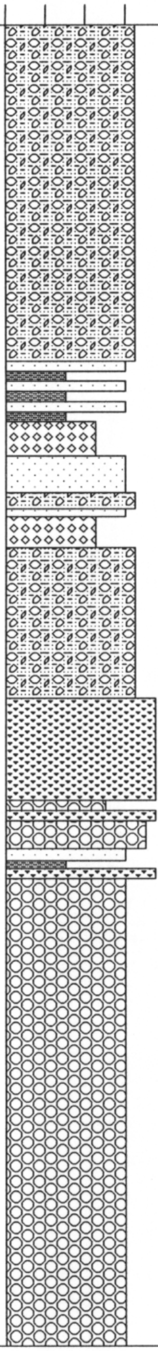
SILICA SAND: approx. 50% core recovery; limonitic

CLAYS: with minor silt/sand; 1.0m section directly above bedrock is brecciated with minor-lignite. Clay-section from 99.4 to 102.1 finely laminated at 52 degrees/CA.
WHITE-CLAY from 96.3 tO 96.7m;

LIMESTONE:

SHU95-1

Clay Silt Sand Grav



MATRIX SUPPORTED SILTY-DIAMICTON:

INTERBEDDED SAND/SILT:

MATRIX SUPPORTED SILTY-DIAMICTON:

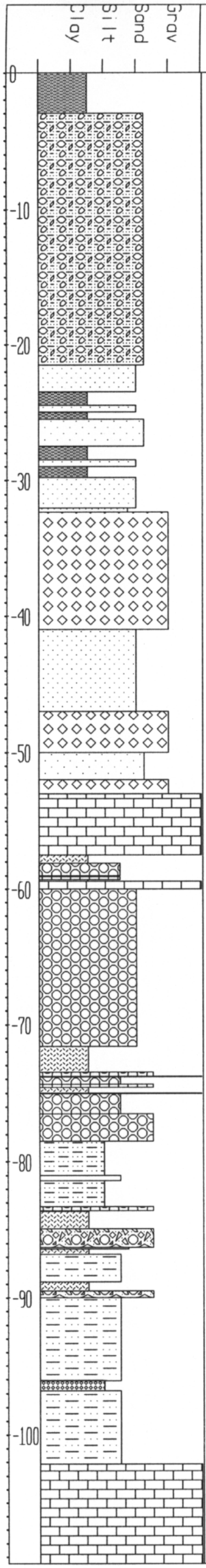
COARSE GRAVEL:

SILICA-SAND: graded downhole from fine- to coarse- grained, section contains thin bed of coarse-gravel at 39.0m

INTERBEDDED SAND/SILT:

COARSE GRAVEL:

SILICA SAND: coarse-grained



SHU95-3

TOTAL DEPTH: 109.5m

NORTHING: 4990222
EASTING: 468234

MEDIUM SILT:

MATRIX SUPPORTED SILTY-DIAMICTON:

INTERBEDDED SILT/SAND: predominately medium-grained

INTERBEDDED GRAVEL/SAND: medium -to coarse- grained

LIMESTONE:

INTERCALATED CLAY/SAND: minor-silt

LIMESTONE:

INTERBEDDED SAND/CLAY: predominately fine -to coarse- grained silica-sand, minor lignite-fragments

INTERBEDDED MUD/SAND: dark-brown

COARSE SILICA SAND:

LIGNITE CLAY

INTERBEDDED CLAY/SAND: silty-to-muddy, section contains lenses of channel-lag

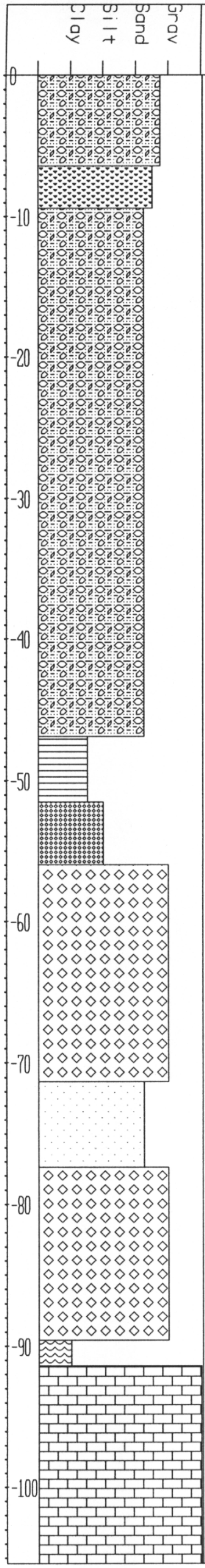
LIMESTONE:

SHU95-4

TOTAL DEPTH: 105.4m

NORTHING: 4988400

EASTING: 467300



MATRIX SUPPORTED PEBBLY-DIAMICTON:

MEDIUM GRAVEL:

MATRIX SUPPORTED SILTY-DIAMICTON:

VARVED CLAY:

SANDY SILT:

INTERBEDDED SAND/GRAVEL:

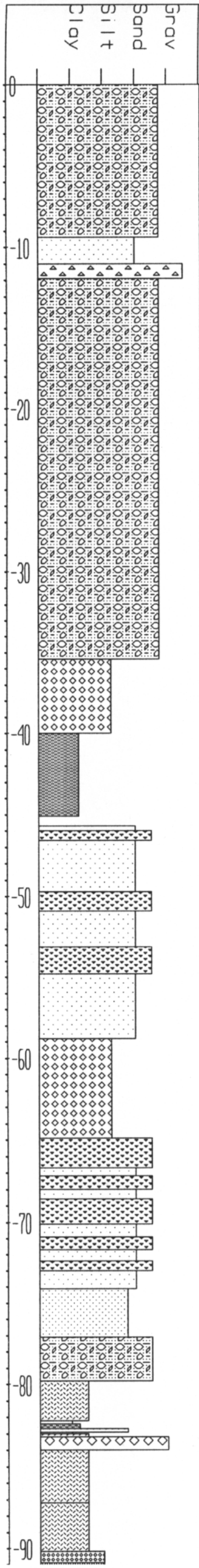
BANDED CLAY:

LIMESTONE:

SHU95-5

TOTAL DEPTH: 128.9m

NORTHING: 4991460
EASTING: 469420



MATRIX SUPPORTED PEBBLY-DIAMICTON: clay-rich matrix; interbedded with glacio-fluvial sand and silt; locally >calcareous. Poor core recovery in sand/silt sections

MEDIUM-SAND: gravelly at base of section

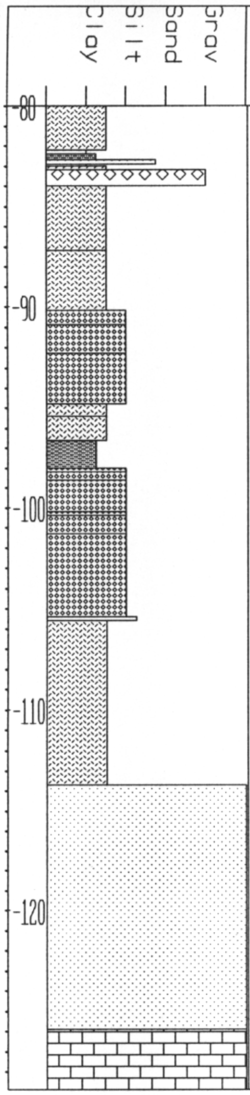
MATRIX SUPPORTED PEBBLY-DIAMICTON:

SAND/SILT:

PREDOMINATELY SAND: with intercalated-gravel; polymictic, rounded to subangular clasts. Bottom of section contains >coarse pebbles.

MATRIX SUPPORTED SANDY-DIAMICTON:

INTERCLATED SILT/CLAY/SAND: predominately light-grey silty-clay and grey-brown sandy-silt. Section includes 20cm of black, lignite-clay at 82.2m. SAMPLE: SHU95-5-15 (92.3-95.4m)



SHU95-5

TOTAL DEPTH: 128.9m

NORTHING: 4991460
EASTING: 469420

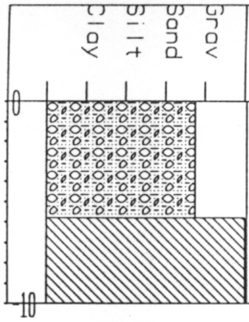
INTERCLATED SILT/CLAY/SAND: predominately light-grey silty-clay and grey-brown sandy-silt. Section includes 20cm of black, lignite-clay at 82.2m.
SAMPLE: SHU95-5-15 (92.3-95.4m)

SAND/SILT: light-grey; section becomes increasingly clay-rich near the bottom. Clay is also light-grey, and may contain dark-grey to black organic fragments.
SAMPLE: SHU95-5-16 (100-106.1m)

SILTY CLAY: soft, grey-mud; probable outcrop; >calcareous near base of section. Contains clasts of white sandstone.
SAMPLE: SHU95-5-17 (106.1-110.6m)

SANDSTONE: brecciated with minor calcareous silt/mud over upper half of section. Lower part of section contains massive, red-sandstone.

LIMESTONE: black, laminated



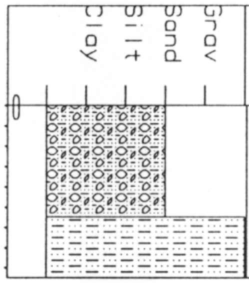
SHU95-6

TOTAL DEPTH: 10.0m

NORTHING: 4994252
EASTING: 463745

MATRIX SUPPORTED PEBBLY-DIAMICTON: clay-rich matrix

GYPSUM:



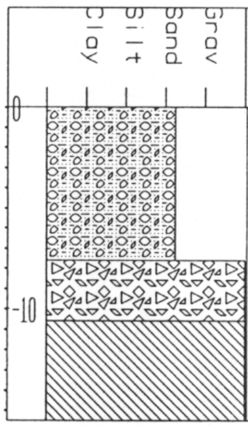
SHU95-7

TOTAL DEPTH: 8.5m

NORTHING: 4994200
EASTING: 463170

MATRIX SUPPORTED CLAY-RICH-DIAMICTON:

SILTSTONE:



SHU95-8

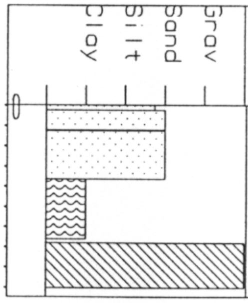
TOTAL DEPTH: 15.5m

NORTHING: 4992200
EASTING: 467100

MATRIX SUPPORTED SILTY-DIAMICTON:

BRECCIA:

GYPSUM:



SHU95-9

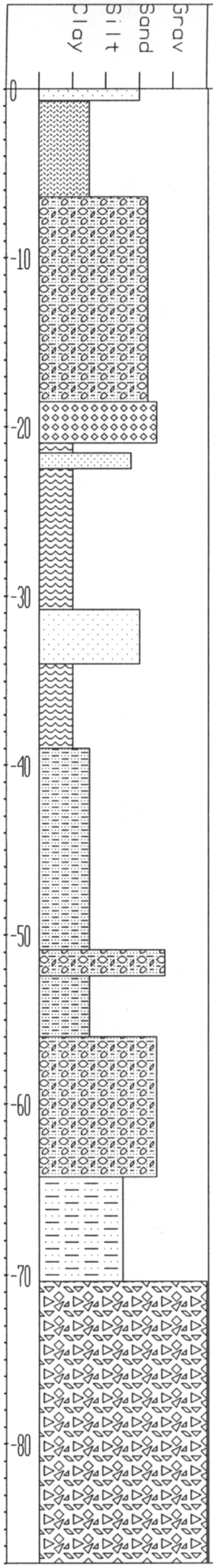
TOTAL DEPTH: -9.05m

NORTHING: 4993700
EASTING: 469580

INTERBEDDED FINE/MEDIUM-SAND:

BANDED CLAY:

MATRIX SUPPORTED SILTY DIAMICTON:
GYPSUM: 50cm. thick clay-band at 8.27m



SHU95-10

TOTAL DEPTH 87.0m

NORTHING: 4989580
EASTING: 469320

MEDIUM SAND:

SILTY CLAY: dark brown

MATRIX SUPPORTED SILTY-DIAMICTON:

GRAVELLY SAND: bottom 10cm. of section is silty diamicton

INTERBEDDED CLAY/SAND: dark brown

MATRIX SUPPORTED PEBBLY-DIAMICTON:

CLAYEY MUD: dark brown

MATRIX SUPPORTED SANDY-DIAMICTON:

MUDDY SAND:

BRECCIA: contains clay/limestone clasts, possible fault-gouge

APPENDIX 3

COMPILATION OF GOVERNMENT AND PRIVATE EXPLORATION DIAMOND DRILLHOLE RECORDS

Sources

These drill records were primarily compiled from the Nova Scotia Department of Natural Resources diamond drillhole data base. Large clusters of drillholes (eg. around the Gays River Mine) were eliminated as well as drillholes where the 'depth to bedrock' data was obviously incorrect. Other drillholes were eliminated that had the same drillhole number but different coordinates. Coordinates given are UTM northing and eastings. Additional drill holes in this data base include previously unpublished Fundy Gypsum drillholes; drillholes compiled from NSDNR Open File Report 92-021 (Golder Associates Ltd., 1992), and from departmental drilling conducted as part of this project during the years 1994 and 1995. A reference is given for each drillhole where additional information can occasionally be found. However, in most 'exploration drilling' a tricone was used when drilling through thick 'overburden'. Thus, in most instances there is no record of what type of 'unconsolidated material' was drilled (Quaternary or Cretaceous).

Depth To Cretaceous And/or Bedrock

Where possible the depth to the top of the Cretaceous is given. This was possible only for recent departmental drillholes and for holes drilled by Goldar Associates (1992). For the remaining drillholes no estimate is usually possible. In a small number of instances literature suggests the presence at a given depth, usually at the point where the tricone was removed and core recovery commenced. In these cases a '<' value is given. Occasionally it is obvious that Cretaceous was intersected but no depth estimate is possible, thus a Pr = present was given. In several drillholes the depth of the hole is such that the presence of Cretaceous is strongly suspected. These are represented as a '?'.

Depth to bedrock information is given as a 'total thickness of unconsolidated sediments'. This will include the thickness of Cretaceous present in any given drill hole. Where a drillhole was terminated before it intersected bedrock a '>' value is given. If a drill hole has a depth to bedrock of greater than 40m to 50m and is spatially associated with Cretaceous sediments then the presence of Cretaceous in that particular drillhole should be suspected.

As noted above, this is not a complete drillhole compilation and should only be considered as a guide. Drillhole data should be checked by reference to the original source documents.

GOVERNMENT AND PRIVATE EXPLORATION DIAMOND DRILLHOLE RECORDS

North UTM	East UTM	Depth (m) Bedrock	Depth (m) Cretac.	Hole Number	NTS Sheet	Assessment Number
4986325	472125	18.5	16.5	GA−9A	11E/03B	OFR 92−021
4986325	472125	18.7	17.5	GA−9B	11E/03B	OFR 92−021
4986525	472375	42	17.5	GA−10A	11E/03B	OFR 92−021
4986550	473100	>55	23	GA−15	11E/03B	OFR 92−021
4986480	472650	33	24	GA−22A	11E/03B	OFR 92−021
4986440	472500	>37	33	GA−27	11E/03B	OFR 92−021
4991491	467449	79	25	SHU94−1	11E/03B	OFR 94−026
4991662	467718	70	14	SHU94−2	11E/03B	OFR 94−026
4991845	467932	70	20	SHU94−3	11E/03B	OFR 94−026
4991660	468100	>154	44	SHU94−4/5	11E/03B	OFR 94−026
4990466	466800	>66	39	SHU95−1	11E/03B	NSDNR R. ACT. 95−1
4990222	468234	109.5	59	SHU95−2/3	11E/03B	NSDNR R. ACT. 95−1
4988400	467300	105.5	104	SHU95−4	11E/03B	OFR 96−003
4991460	469420	129	78	SHU95−5	11E/03B	SME Paper 96−128
4990860	470750	6.5		SHU95−6	11E/03B	OFR 96−003
4994200	463780	6		SHU95−7	11E/03B	OFR 96−003
4992200	467100	15		SHU95−8	11E/03B	OFR 96−003
4993700	469580	12.8		SHU95−9	11E/03B	OFR 96−003
4989580	469320	70		SHU95−10	11E/03B	OFR 96−003
4989240	492000	30	11	MUSC95−1	11/E03A	SME Paper 96−128
4991900	494550	133	12.5	MUSC95−2	11/E03A	SME Paper 96−128
4989820	492540	41	19	MUSC95−3	11/E03A	SME Paper 96−128
4984260	482946	122.5	29	MUSC95−4	11/E03A	SME Paper 96−128
4986600	486200	109	19.7	MUSC95−11	11/E03A	OFR 96−003
4984707	481849	19		MUSC95−6	11/E03A	OFR 96−003
4984519	482207	22		MUSC95−7	11/E03A	OFR 96−003
4984650	480646	5		MUSC95−8	11/E03A	OFR 96−003
4983300	482600	53		MUSC95−9	11/E03A	OFR 96−003
4992300	494850	180	12	Hole 404?	11/E03A	MINES WTR SECT.
4987600	494360	47		MUS−92−21	11E/O3	Fundy Gypsum
4989310	491200	>32	<22.8	MUS−92−23	11E/03	Fundy Gypsum
4992780	496610	24	<17.5	MUS−93−73	11E/03	Fundy Gypsum
5008930	485970			2	11E/03D	06−D−34(02)
5008930	485970			3	11E/03D	06−D−34(02)
5008990	486000			4	11E/03D	06−D−34(02)
5008950	486070			5	11E/03D	06−D−34(02)
5008930	486040			6	11E/03D	06−D−34(02)
5008890	485910			7	11E/03D	06−D−34(02)
5008900	485850			8	11E/03D	06−D−34(02)
5008930	486130			9	11E/03D	06−D−34(02)
5008830	486210			10	11E/03D	06−D−34(02)
5008500	484480	18		C3	11E/03D	06−D−34(14)
5008420	484260	11		C4	11E/03D	06−D−34(14)
5008560	484260	11		C5	11E/03D	06−D−34(14)
5008540	484200	14		C8	11E/03D	06−D−34(14)
5008580	484440	5		C2	11E/03D	06−D−34(14)
5008620	484310	9		C6	11E/03D	06−D−34(14)
5008490	484270	7		C7	11E/03D	06−D−34(14)
5002760	499430	19		77−1	11E/03D	06−D−42(01)
5002800	499420	45		77−2	11E/03D	06−D−42(01)
5002750	499350	33		77−3	11E/03D	06−D−42(01)
5002790	499500	14		77−4	11E/03D	06−D−42(01)
5002830	499470	43		77−5	11E/03D	06−D−42(01)
5002880	499390	59		77−6	11E/03D	06−D−42(01)
5002780	499460	14		77−7	11E/03D	06−D−42(01)

5002770	499400	37		77–8	11E/03D	06–D–42(01)
4986330	478670	28		GR73–280	11E/03B	07–H–08(01)
4989800	487750	26		214–01	11E/03A	07–H–40(01)
4990510	488860	41		214–02	11E/03A	07–H–40(01)
4988340	487240	78	72	208–1	11E/03A	07–H–40(02)
4989330	489010	64		208–10	11E/03A	07–H–40(02)
4989890	489600	10		208–11	11E/03A	07–H–40(02)
4989810	489580	1		208–12	11E/03A	07–H–40(02)
4990030	489570	2		208–13	11E/03A	07–H–40(02)
4989960	489740	2		208–14	11E/03A	07–H–40(02)
4988020	487490	>148	38	208–2	11E/03A	07–H–40(02)
4987470	487850	45		208–3	11E/03A	07–H–40(02)
4991570	491100	91		208–4	11E/03A	07–H–40(02)
4991630	490710	24		208–5	11E/03A	07–H–40(02)
4990190	489020	10		208–6	11E/03A	07–H–40(02)
4989880	489030	4		208–7	11E/03A	07–H–40(02)
4989770	488010	12		208–8	11E/03A	07–H–40(02)
4989580	489020	21		208–9	11E/03A	07–H–40(02)
4989560	494580	10		209–1	11E/03A	07–H–40(02)
4989830	494460	12		209–2	11E/03A	07–H–40(02)
4994110	495900	17		209–3	11E/03A	07–H–40(02)
4990420	491810	93		209–4	11E/03A	07–H–40(02)
4989690	489380	16		208–15	11E/03A	07–H–40(03)
4984950	464400	49	?	M–3	11E/03B	07–H–41(01)
4986000	466600	43	?	M–4	11E/03B	07–H–41(01)
4984620	464800	>54	Pr	M–1A	11E/03B	07–H–41(01)
4984650	464800	98	64	M–1B	11E/03B	07–H–41(01)
4983000	465100	4		M–2	11E/03B	07–H–41(01)
4985110	491400	24		B–2	11E/03A	07–H–77(01)
4988840	483080	11		B–3	11E/03A	07–H–77(01)
4993100	493810	30		B–4	11E/03A	07–H–77(01)
4994180	498060	68		B–5	11E/03A	07–H–77(01)
5004630	465090	13		B–6	11E/03A	07–H–77(01)
5006740	465710	30		B–7	11E/03A	07–H–77(01)
4994570	497660	46		B–8	11E/03A	07–H–77(01)
4984830	491450	9		B–1	11E/03A	07–H–77(01)
4999260	464030	0		B–9	11E/03A	07–H–77(01)
4986290	493500	43		B–16	11E/03A	07–H–77(02)
4987400	494430	37		B–17	11E/03A	07–H–77(02)
4987460	494410	54		B–18	11E/03A	07–H–77(02)
4988040	494150	34		B–19	11E/03A	07–H–77(02)
4989100	495530	32		B–20	11E/03A	07–H–77(02)
4990260	496960	32		B–22	11E/03A	07–H–77(02)
4989560	497850	31		B–24	11E/03A	07–H–77(02)
4985900	493330	10		B–26	11E/03A	07–H–77(02)
4986240	494070	11		B–27	11E/03A	07–H–77(03)
4986320	494020	7		B–28	11E/03A	07–H–77(03)
4986050	493290	0		B–29	11E/03A	07–H–77(03)
4987130	481580	11		CH73–1	11E/03A	07–H–79(01)
4987240	481520	53		CH73–2	11E/03A	07–H–79(01)
4986930	481450	23		CH73–3	11E/03A	07–H–79(01)
4987210	481320	76		CH73–4	11E/03A	07–H–79(01)
4987210	481320	72		CH73–4A	11E/03A	07–H–79(01)
4986660	480640	56		CH73–5	11E/03A	07–H–79(01)
4986860	481260	32		CH73–6	11E/03A	07–H–79(01)
4985870	484280	>94	Pr	CH73–7	11E/03A	07–H–79(01)
4985580	483090	>67	Pr	CH73–8	11E/03A	07–H–79(01)
4987410	481400	22		CW–1	11E/03A	07–H–79(02)
4988470	484460	11		CW–2	11E/03A	07–H–79(02)
4987760	484850	24		CW–3	11E/03A	07–H–79(02)

4987690	485160	35		CW-4	11E/03A	07-H-79(02)
4988300	484410	9		CW-5	11E/03A	07-H-79(02)
4988370	485690	5		211-1	11E/03A	07-H-79(03)
4988790	486770	39	32	211-2	11E/03A	07-H-79(03)
4988130	484930	24		211-3	11E/03A	07-H-79(03)
4987950	484990	40		211-4	11E/03A	07-H-79(03)
4987790	484990	42		211-5	11E/03A	07-H-79(03)
4988060	485950	17		211-6	11E/03A	07-H-79(03)
4987930	486020	31		211-7	11E/03A	07-H-79(03)
4987990	485990	24		211-8	11E/03A	07-H-79(03)
4988200	485860	12		211-9	11E/03A	07-H-79(03)
4987000	494920	6		3094W-48	11E/03A	07-H-87(01)
4987140	495190	13		3094W-49	11E/03A	07-H-87(01)
4987470	495550	18		3094W-50	11E/03A	07-H-87(01)
4987500	495300	10		3094W-51	11E/03A	07-H-87(01)
4987370	495390	12		3094W-52	11E/03A	07-H-87(01)
4988380	496040	9		3094W-53	11E/03A	07-H-87(01)
4988270	495990	21		3094W-54	11E/03A	07-H-87(01)
4988090	495880	38		3094W-55	11E/03A	07-H-87(01)
4988680	496860	28		3094W-56	11E/03A	07-H-87(01)
4988610	496710	13		3094W-57	11E/03A	07-H-87(01)
4988480	496570	13		3094W-58	11E/03A	07-H-87(01)
4988310	496150	12		3094W-59	11E/03A	07-H-87(01)
4990250	497870	4		3094W-60	11E/03A	07-H-87(01)
4990750	497770	7		3094W-61	11E/03A	07-H-87(01)
4990650	497670	30		3094W-62	11E/03A	07-H-87(01)
4991250	498650	5		3094W-63	11E/03A	07-H-87(01)
4991460	498470	17		3094W-64	11E/03A	07-H-87(01)
4991750	498230	24		3094W-65	11E/03A	07-H-87(01)
4992100	498610	6		3094W-66	11E/03A	07-H-87(01)
4988810	496130	20		3094W-67	11E/03A	07-H-87(01)
4987780	495490	29		3094W-68	11E/03A	07-H-87(01)
4989850	497050	4		3094W-69	11E/03A	07-H-87(01)
4989840	497470	4		3094W-70	11E/03A	07-H-87(01)
4990090	474090	14		MA73-1	11E/03B	07-I-61(01)
4992670	473730	0		MA73-10	11E/03B	07-I-61(01)
4990270	472480	13		MA73-2	11E/03B	07-I-61(01)
4990080	474430	38		MA73-3	11E/03B	07-I-61(01)
4990270	473750	14		MA73-4	11E/03B	07-I-61(01)
4990330	471520	19		MA73-5	11E/03B	07-I-61(01)
4991120	471280	18		MA73-6	11E/03B	07-I-61(01)
4990150	473890	17		MA73-7	11E/03B	07-I-61(01)
4992090	473120	19		MA73-8	11E/03B	07-I-61(01)
4992250	473510	31		MA73-9	11E/03B	07-I-61(01)
4988950	464520	6		113	11E/04A	07-I-62(02)
4999160	464910	6		WJ75-1	11E/03C	07-I-66(01)
4999390	464480	20		WJ75-2	11E/03C	07-I-66(01)
4999530	464290	10		WJ75-3	11E/03C	07-I-66(01)
4999810	463810	8		WJ75-4	11E/03C	07-I-66(01)
5000040	463600	38		WJ75-5	11E/03C	07-I-66(01)
4989690	473310	4		1	11E/03B	21-D-21(02)
4990110	473240	3		2	11E/03B	21-D-21(02)
4990610	473190	7		3	11E/03B	21-D-21(02)
4990990	473140	8		4	11E/03B	21-D-21(02)
4991320	473080	1		5	11E/03B	21-D-21(02)
4997420	485590	63		SAR81-1	11E/03D	21-D-73(01)
4997000	484390	38		SAR81-2	11E/03D	21-D-73(01)
4996510	482850	40		SAR81-3	11E/03D	21-D-73(01)
4995310	480200	12		SAR81-4	11E/03D	21-D-73(01)
4994820	480060	16		SAR81-5	11E/03D	21-D-73(01)

4994600	479400	19	SAR81-6	11E/03D	21-D-73(01)	(4 of 8)
4994220	476500	7	SAR81-7	11E/03D	21-D-73(01)	
4997650	486970		W2	11E/03D	21-D-73(02)	
4996510	482830		W3	11E/03D	21-D-73(02)	
4996510	483250		W4	11E/03D	21-D-73(02)	
4996570	482160		W5	11E/03D	21-D-73(02)	
4997830	487000	67	SAR81-10	11E/03D	21-D-73(02)	
4997690	486510	55	SAR81-8	11E/03D	21-D-73(02)	
4998210	488170	27	SAR81-9	11E/03D	21-D-73(02)	
4998980	484070	52	SR-1	11E/03D	27-D-43(01)	
5005620	479380	12	SR-2	11E/03D	27-D-43(01)	
5005620	479380	8	SR-3	11E/03D	27-D-43(01)	
5003690	498980	83	116-1	11E/03D	27-D-48(01)	
5001989	496398	41	116-2	11E/03D	27-D-48(01)	
5010228	498038	0	117-1	11E/03D	27-D-48(01)	
5009740	491105	40	117-2	11E/03D	27-D-48(01)	
5010020	491110	10	117-3	11E/03D	27-D-48(01)	
5010233	491105	17	117-4	11E/03D	27-D-48(01)	
5009488	495247	65	117-5	11E/03D	27-D-48(01)	
5009334	495377	15	117-6	11E/03D	27-D-48(01)	
5010500	497960	4	OB-61	11E/03D	27-D-48(01)	
5010500	498990	11	OB-62	11E/03D	27-D-48(01)	
4989970	474690	27	GR73-129	11E/03B	27-H-11(01)	
4989600	474550	30	GR73-132	11E/03B	27-H-11(01)	
4992400	476580	10	C10-73	11E/03B	27-H-11(02)	
4992740	476510	12	C11-73	11E/03B	27-H-11(02)	
4993010	476450	15	C12-73	11E/03B	27-H-11(02)	
4993340	476400	19	C14-73	11E/03B	27-H-11(02)	
4993740	476310	25	C15-73	11E/03B	27-H-11(02)	
4992380	473840	2	C106-74	11E/03B	27-H-11(03)	
4992700	474380	10	C90-74	11E/03B	27-H-11(03)	
4985190	471290	0	1	11E/03B	27-H-14(01)	
4985240	471520	17	13	11E/03B	27-H-14(01)	
4985090	471320	12	17	11E/03B	27-H-14(01)	
4985300	471320	2	2	11E/03B	27-H-14(01)	
4984990	471590	20	20	11E/03B	27-H-14(01)	
4985300	471590	15	29	11E/03B	27-H-14(01)	
4985300	471370	3	3	11E/03B	27-H-14(01)	
4985400	471610	13	37	11E/03B	27-H-14(01)	
4985210	471350	2	4	11E/03B	27-H-14(01)	
4985470	471560	12	41	11E/03B	27-H-14(01)	
4985350	471640	14	42	11E/03B	27-H-14(01)	
4985540	471590	18	43	11E/03B	27-H-14(01)	
4985210	471610	26	44	11E/03B	27-H-14(01)	
4985540	471640	23	45	11E/03B	27-H-14(01)	
4985500	471730	23	46	11E/03B	27-H-14(01)	
4985200	471640	30	47	11E/03B	27-H-14(01)	
4985480	471790	26	48	11E/03B	27-H-14(01)	
4985520	471850	42	49	11E/03B	27-H-14(01)	
4985280	471400	3	5	11E/03B	27-H-14(01)	
4985560	472030	41	50	11E/03B	27-H-14(01)	
4985460	471850	31	51	11E/03B	27-H-14(01)	
4985440	471910	37	52	11E/03B	27-H-14(01)	
4985640	472120	52	53	11E/03B	27-H-14(01)	
4985550	471970	37	54	11E/03B	27-H-14(01)	
4985520	472080	40	55	11E/03B	27-H-14(01)	
4985710	472240	61	56	11E/03B	27-H-14(01)	
4985510	472160	45	57	11E/03B	27-H-14(01)	
4985570	472120	63	58	11E/03B	27-H-14(01)	
4985630	472080	66	59	11E/03B	27-H-14(01)	

4985100	471400	3	6	11E/03B	27-H-14(01)
4985460	472020	34	60	11E/03B	27-H-14(01)
4985440	472080	37	61	11E/03B	27-H-14(01)
4985400	472060	35	62	11E/03B	27-H-14(01)
4985660	472180	88	63	11E/03B	27-H-14(01)
4985690	472100	95	64	11E/03B	27-H-14(01)
4985570	472190	41	65	11E/03B	27-H-14(01)
4985670	472250	22	67	11E/03B	27-H-14(01)
4985260	471440	8	7	11E/03B	27-H-14(01)
4985080	471420	3	8	11E/03B	27-H-14(01)
4985060	471440	1	9	11E/03B	27-H-14(01)
4985040	471400	3	10	11E/03B	27-H-14(01)
4985470	472650	35	104	11E/03B	27-H-14(01)
4985580	472460	24	105	11E/03B	27-H-14(01)
4985190	471400	7	11	11E/03B	27-H-14(01)
4985100	471440	1	12	11E/03B	27-H-14(01)
4985040	471470	2	14	11E/03B	27-H-14(01)
4985020	471510	2	15	11E/03B	27-H-14(01)
4984970	471560	2	16	11E/03B	27-H-14(01)
4985260	471480	2	18	11E/03B	27-H-14(01)
4985250	471510	3	19	11E/03B	27-H-14(01)
4984630	471740	28	201	11E/03B	27-H-14(01)
4985290	471460	3	21	11E/03B	27-H-14(01)
4985320	471440	3	22	11E/03B	27-H-14(01)
4985300	471510	4	23	11E/03B	27-H-14(01)
4985330	471500	4	24	11E/03B	27-H-14(01)
4985330	471470	4	25	11E/03B	27-H-14(01)
4985360	471520	3	26	11E/03B	27-H-14(01)
4985320	471540	4	27	11E/03B	27-H-14(01)
4985460	471510	9	28	11E/03B	27-H-14(01)
4985350	471530	4	30	11E/03B	27-H-14(01)
4985410	471530	8	31	11E/03B	27-H-14(01)
4985390	471550	8	32	11E/03B	27-H-14(01)
4985240	471540	3	33	11E/03B	27-H-14(01)
4985220	471580	3	34	11E/03B	27-H-14(01)
4985270	471580	5	35	11E/03B	27-H-14(01)
4985420	471570	10	36	11E/03B	27-H-14(01)
4985330	471560	4	38	11E/03B	27-H-14(01)
4985360	471580	0	39	11E/03B	27-H-14(01)
4985340	471590	3	40	11E/03B	27-H-14(01)
4985570	472960	2	101	11E/03B	27-H-14(01)
4985500	472830	4	102	11E/03B	27-H-14(01)
4985370	472750	5	103	11E/03B	27-H-14(01)
4984380	471930	4	200	11E/03B	27-H-14(01)
4987230	470660	18	G-2	11E/03B	27-H-14(04)
4985990	473150	11	G-3	11E/03B	27-H-14(04)
4985210	471550	2	G-1	11E/03B	27-H-14(04)
4986310	471490	9	G-4	11E/03B	27-H-14(04)
4984060	471340	7	GR72-68	11E/03B	27-H-14(07)
4985720	471890	7	GR72-68	11E/03B	27-H-14(07)
4984010	471460	11	GR73-70	11E/03B	27-H-14(07)
4985660	472060	37	GR73-71	11E/03B	27-H-14(07)
4985740	472070	58	GR73-72	11E/03B	27-H-14(07)
4984280	472130	20	GR73-73	11E/03B	27-H-14(07)
4985690	471800	34	GR73-74	11E/03B	27-H-14(07)
4985150	470960	0	GR128	11E/03B	27-H-14(09)
4985240	470900	0	GR134	11E/03B	27-H-14(09)
4985170	470930	0	GR140	11E/03B	27-H-14(09)
4985290	470870	0	GR141	11E/03B	27-H-14(09)
4985240	470900	0	GR142	11E/03B	27-H-14(09)

4985040	470990	0	GR143	11E/03B	27–H–14(09)
4985240	470270	20	GR73–108	11E/03B	27–H–14(09)
4985170	470140	19	GR73–111	11E/03B	27–H–14(09)
4985200	470130	18	GR73–113	11E/03B	27–H–14(09)
4985110	470170	15	GR73–116	11E/03B	27–H–14(09)
4985300	470090	26	GR73–118	11E/03B	27–H–14(09)
4985400	470030	45	GR73–122	11E/03B	27–H–14(09)
4985240	470900	44	GR73–134	11E/03B	27–H–14(09)
4985010	470270	5	GR73–92	11E/03B	27–H–14(09)
4984900	470240	37	GR73–95	11E/03B	27–H–14(09)
4985160	470290	17	GR73–98	11E/03B	27–H–14(09)
4986800	477040	35	GGR17	11E/03B	27–H–14(10)
4985460	472500		GR73–156	11E/03B	27–H–14(11)
4985500	472490		GR73–157	11E/03B	27–H–14(11)
4985530	472450		GR73–158	11E/03B	27–H–14(11)
4985530	472420		GR73–159	11E/03B	27–H–14(11)
4985580	472400		GR73–160	11E/03B	27–H–14(11)
4985640	472370		GR73–161	11E/03B	27–H–14(11)
4985650	472340		GR73–162	11E/03B	27–H–14(11)
4985680	472310		GR73–163	11E/03B	27–H–14(11)
4997700	486950	26	W–2	11E/03B	27–H–14(16)
4998900	486700	36	W–3	11E/03B	27–H–14(16)
4996350	483300	40	W–4	11E/03B	27–H–14(16)
4996650	482150	40	W–5	11E/03B	27–H–14(16)
4999700	491400	8	W–1	11E/03B	27–H–14(16)
4985730	469210	13	GR405	11E/03B	27–H–14(24)
4985470	469300	34	GR406	11E/03B	27–H–14(24)
4985180	469380	36	GR407	11E/03B	27–H–14(24)
4985110	469400	69	GR408	11E/03B	27–H–14(24)
4984710	469590	24	GR–409	11E/03B	27–H–14(24)
4984620	469550	48	GR–442	11E/03B	27–H–14(24)
4987390	474360		GR482	11E/03B	27–H–14(24)
4987680	474310		GR483	11E/03B	27–H–14(24)
4987580	474490		GR484	11E/03B	27–H–14(24)
4987030	473210	34	GR74–370	11E/03B	27–H–14(25)
4987120	473180	53	GR74–371	11E/03B	27–H–14(25)
4984550	467880		AGGR–106	11E/03B	27–H–14(30)
4984550	468360		AGGR–107	11E/03B	27–H–14(30)
4984770	469580	31	GR–441	11E/03B	27–H–14(33)
4984550	469190	46	GR–443	11E/03B	27–H–14(33)
4984630	469630	26	GR–444	11E/03B	27–H–14(33)
4984680	469120	29	GR–559	11E/03B	27–H–14(33)
4984750	469090	36	GR–590	11E/03B	27–H–14(33)
4984600	469450	19	GR–591	11E/03B	27–H–14(33)
4984610	469380	29	GR–592	11E/03B	27–H–14(33)
4984670	469350	8	GR–593	11E/03B	27–H–14(33)
4984740	469280	7	GR–594	11E/03B	27–H–14(33)
4984810	469220	18	GR–595	11E/03B	27–H–14(33)
4984890	469270	41	GR–596	11E/03B	27–H–14(33)
4984950	469210	37	GR–597	11E/03B	27–H–14(33)
4984960	469330	39	GR–598	11E/03B	27–H–14(33)
4984800	469370	38	GR–599	11E/03B	27–H–14(33)
4983040	488940	29	B–21	11E/03A	27–H–50(01)
4983820	489880	24	B–23	11E/03A	27–H–50(01)
4983880	490150	41	B–25	11E/03A	27–H–50(01)
5002770	467990	31	AR–1	11E/03C	27–I–01(01)
5003010	468330	8	AR–2	11E/03C	27–I–01(01)
5002190	466960	9	AR–3	11E/03C	27–I–01(01)
5001670	467090	6	AR–4	11E/03C	27–I–01(01)
5001630	466400	7	AR–5	11E/03C	27–I–01(01)

5002270	467550	15	AR-6	11E/03C	27-I-01(01)
5003420	469990	24	AR-7	11E/03C	27-I-01(01)
4998082	463328	18	113-1	11E/03B	27-I-43(02)
4989184	465223	6	113-3	11E/03B	27-I-43(02)
5001149	466838	50	114-1	11E/03B	27-I-43(02)
5000136	465785	55	114-2	11E/03B	27-I-43(02)
5001263	468695	3	114-3	11E/03B	27-I-43(02)
4999356	467462	27	114-4	11E/03B	27-I-43(02)
4994791	466915	33	153-1	11E/03	40-D-12(01)
5004229	484376	7	153-3	11E/03	40-D-12(01)
5006093	496335	52	153-4	11E/03	40-D-12(01)
4992140	494550	4	68	11E/03A	41-H-20(01)
4990590	493810	3	69	11E/03A	41-H-20(01)
4990590	493810	2	70	11E/03A	41-H-20(01)
4990590	493810	2	71	11E/03A	41-H-20(01)
4990590	493810	2	71	11E/03A	41-H-20(01)
4990590	493810	4	72	11E/03A	41-H-20(01)
4990590	493810	6	73	11E/03A	41-H-20(01)
4990590	493810	1	74	11E/03A	41-H-20(01)
4990590	493810	2	75	11E/03A	41-H-20(01)
4990590	493810	1	76	11E/03A	41-H-20(01)
4990590	493810	1	77	11E/03A	41-H-20(01)
4990590	493810	2	78	11E/03A	41-H-20(01)
4990590	493810	1	79	11E/03A	41-H-20(01)
4990590	493810	2	80	11E/03A	41-H-20(01)
4990590	493810	1	81	11E/03A	41-H-20(01)
4990590	493810	2	82	11E/03A	41-H-20(01)
4990590	493810	1	83	11E/03A	41-H-20(01)
4990590	493810	1	84	11E/03A	41-H-20(01)
4990590	493810	6	85	11E/03A	41-H-20(01)
4990590	493810	6	86	11E/03A	41-H-20(01)
4990590	493810	1	87	11E/03A	41-H-20(01)
4990590	493810	1	88	11E/03A	41-H-20(01)
4990590	493810	1	89	11E/03A	41-H-20(01)
4990590	493810	1	90	11E/03A	41-H-20(01)
4990590	493810	1	91	11E/03A	41-H-20(01)
4990590	493810	7	92	11E/03A	41-H-20(01)
4990590	493810	1	93	11E/03A	41-H-20(01)
4990590	493810	1	94	11E/03A	41-H-20(01)
4990590	493810	1	95	11E/03A	41-H-20(01)
4990590	493810	1	96	11E/03A	41-H-20(01)
4990590	493810	1	97	11E/03A	41-H-20(01)
4990590	493810	1	98	11E/03A	41-H-20(01)
4990590	493810	1	99	11E/03A	41-H-20(01)
4990590	493810	4	100	11E/03A	41-H-20(01)
4990590	493810	2	101	11E/03A	41-H-20(01)
4990590	493810	4	102	11E/03A	41-H-20(01)
4990590	493810	1	103	11E/03A	41-H-20(01)
4990710	494240	3	104	11E/03A	41-H-20(01)
4990660	494250	0	105	11E/03A	41-H-20(01)
4990750	494240	1	DH106	11E/03A	41-H-20(02)
4990590	494230	4	DH107	11E/03A	41-H-20(02)
4990550	494230	4	DH108	11E/03A	41-H-20(02)
4990510	494220	4	DH109	11E/03A	41-H-20(02)
4990470	494210	5	DH110	11E/03A	41-H-20(02)
4990430	494210	1	DH111	11E/03A	41-H-20(02)
4990570	494240	12	117	11E/03A	41-H-20(03)
4990630	494210	3	112	11E/03A	41-H-20(03)
4990630	494320	1	113	11E/03A	41-H-20(03)
4990610	494410	1	114	11E/03A	41-H-20(03)

4990630	494240	7		115	11E/03A	41-H-20(03)
4990600	494240	8		116	11E/03A	41-H-20(03)
4990540	494240	6		118	11E/03A	41-H-20(03)
4999950	474620	45		S-1	11E/03C	58-D-43(01)
4999950	474620	46		S-2	11E/03C	58-D-43(01)
4999950	474620	43		S-3	11E/03C	58-D-43(01)
4998457	475189	0		1-74	11E/03C	58-D-43(01)
5002107	472933	0		2-74	11E/03C	58-D-43(01)
5001475	476686	0		3-74	11E/03C	58-D-43(01)
4986740	473840	35		707		REPORT 82-006
4986860	473900	46		712		REPORT 82-006
4986960	473960	18		714		REPORT 82-006
4989220	486550	9		1		REPORT 83-003
4994160	497500	10		UM-1		REPORT 84-005
4987460	474160	33		CMB-2		REPORT 92-019
4987490	474160	31		S-864		REPORT 92-019
4991140	489240	37		GLM-3		REPORT 92-024
4990940	489140	66		GLM-4		REPORT 92-024
4986950	392250	47		SGR-4		REPORT 92-025
4990880	488380	36.6		MUS92-1	11E/03A	FUNDY GYPSUM
4991480	490800	28.3		MUS92-2	11E/03A	FUNDY GYPSUM
4992900	494000	30.5		MUS92-4	11E/03A	FUNDY GYPSUM
4991600	497460	24.1		MUS92-7	11E/03A	FUNDY GYPSUM
4990720	496270	10.4		MUS92-8	11E/03A	FUNDY GYPSUM
4990140	496300	13.7		MUS92-9	11E/03A	FUNDY GYPSUM
4989000	494500	18.6		MUS92-10	11E/03A	FUNDY GYPSUM
4986460	491080	26.2		MUS92-13	11E/03A	FUNDY GYPSUM
4984840	490270	9.1		MUS92-14	11E/03A	FUNDY GYPSUM
4983820	489060	16.8		MUS92-15	11E/03A	FUNDY GYPSUM
4983220	488470	53.3		MUS92-16	11E/03A	FUNDY GYPSUM
4982760	487620	18.6		MUS92-17	11E/03A	FUNDY GYPSUM
4994000	499000	13.7		MUS92-24	11E/03A	FUNDY GYPSUM
4993000	498260	18		MUS92-25	11E/03A	FUNDY GYPSUM
4993040	498590	18.6		MUS92-26	11E/03A	FUNDY GYPSUM
4993160	498820	25.9		MUS92-32	11E/03A	FUNDY GYPSUM
4989890	490380	>45.7	?	MUS92-34	11E/03A	FUNDY GYPSUM
4990800	489470	>56.4	?	MUS92-35	11E/03A	FUNDY GYPSUM
4990120	486920	22.9		MUS92-36	11E/03A	FUNDY GYPSUM
4989490	485530	>27.4		MUS92-37	11E/03A	FUNDY GYPSUM
4989900	485080	>50.3	?	MUS92-38	11E/03A	FUNDY GYPSUM
4993270	494250	>42.7	?	MUS92-39	11E/03A	FUNDY GYPSUM
4993640	495000	27.4		MUS92-40	11E/03A	FUNDY GYPSUM
4990230	490750	>53.3	?	MUS92-41	11E/03A	FUNDY GYPSUM
4990100	490580	>32	?	MUS92-42	11E/03A	FUNDY GYPSUM
4991700	497830	41.8		MUS93-69	11E/03A	FUNDY GYPSUM
4990170	489380	34.1		MUS93-86	11E/03A	FUNDY GYPSUM
4989690	490080	25.9		MUS93-89	11E/03A	FUNDY GYPSUM
4989550	489870	39.6		MUS93-90	11E/03A	FUNDY GYPSUM
4983270	484300	11.2		QU-2	11E/03A	07-H-76(01)
4983000	494520	17.4		QU-3	11E/03A	07-H-76(01)
4982770	484770	10.4		QU-4	11E/03A	07-H-76(01)

APPENDIX 4

CLAY PROJECT DRILLHOLE COMPILATION

Sources

These drillhole records were not included in the Nova Scotia Department of Natural Resources drillhole data base. The drill records were compiled by summer students from publications by Wright (1969a), Wright (1969b) and Fowler (1972). Stratigraphy and thickness information was summarized from published drill sections. Coordinates were measured from published and unpublished base maps.

This is a preliminary compilation. Obvious gaps exist in the data set where logs were not located and/or base maps with locations and thus coordinates are lacking. Published and unpublished records are available that will provide the additional data.

CLAY PROJECT DRILLHOLE COMPILATION (1 of 2)

Record Number	Northing UTM	Easting UTM	Hole #	Depth (m) (CRET.)	Depth (m) (BED.)
1	4987517	488594	SP-1	0	>19.0
2	4987523	488654	SP-2	2	>17.5
3	4987687	488611	SP-8	<18	>27.0
4			PB-9	0	>7.3
5			PB-16	1.7	>11.9
6			PB-17	1.9	>13.1
7			PB-18	3	>15.2
8			PB-19	6.1	>12.2
9			PB-20	2.5	>6.1
10	4993420	495840	PB-21		>7.6
11			PB-22	2.5	>14.3
12			PB-23	3	>10.7
13			PB-24	7.4	>10.7
14	4992632	495101	EL-26		>10.9
15	4992704	494988	EL-27	16.6	>17.6
16	4992063	494880	EL-28	6.3	>19.3
17	4992236	495139	EL-29	4.3	>18.7
18	4992459	494981	EL-30	14	>20
19	4991835	494765	EL-33	6.3	>15.1
20	4991763	494916	EL-34	0.3	>15.6
21	4991674	494870	EL-35		>8.4
22	4991898	494904	EL-36	8.5	>12.8
23			PB-37		>13.7
24			PB-38		>13.7
25			PB-39	10.3	>19.8
26	4993220	496050	PB-40	7	>18.9
27			PB-41		>10.7
28			PB-42	4.4	>21.9
29			PB-43	4.4	>21.3
30	4989500	486422	MNB-44		>10.7
31	4949454	486405	MNB-45	7.2	>16.8
32	4989549	486393	MNB-46	2.5	>15.5
33	4989978	486712	MNB-47	Ab	4.0
34	4989254	486634	MNB-53	6.7	>25.3
35	4989149	486667	MNB-54	11.2	>16.5
36	4989073	486473	MNB-55	10.7	>14.3
37	4988888	436712	MNB-56		>16.8
38	4988502	487034	MNB-57		>14.0
39	4989080	486673	MNB-59	11.4	>18.3
40	4987515	488658	SP-63	<4	>31.0
41	4987548	488618	SP-65	<25	>29.0
42	4992940	495820	PB-75	3.8	>47.9
43	4993820	495900	PB-76	2.6	>38.4
44	4990742	489582	HOLE-84		>14.3
45	4990717	489623	HOLE-85		>10.5
46	4990698	489587	HOLE-86	Ab	16.4
47	4990691	489691	HOLE-87	Ab	8.8
48			HOLE-88	Ab	9.0
49			HOLE-89	Ab	5.1
50			HOLE-90	Ab	5.5
51			HOLE-91	Ab	3.4
52	4987332	489820	HOLE-92	Ab	14.3
53	4987384	489746	HOLE-93		>16.8
54	4987559	489727	HOLE-94		>16.8
55	4987601	489691	HOLE-95		>16.8
56	4986960	468229	HOLE-96	Ab	12.6
57	4986998	488155	HOLE-97	Ab	10.5
58	4987170	488101	HOLE-98		>16.8
59	4986980	486980	HOLE-99		>10.6
60	4987420	486990	HOLE-100		>13.3
61	4991550	494820	EL-102	3.4	>21.1
62	4991550	494800	EL-103	2.6	>28.7
63	4991460	495100	EL-104	2.7	>33.5
64	4991387	494759	EL-105	2	>22.7
65	4991507	494802	EL-106	0	>12.7
66	4991575	494844	EL-107	5.9	>22.1
67	4991632	494857	EL-108	9	>19.8
68	4991604	494844	EL-109	4	>30.5
69	4991544	494831	EL-110	6.3	>16.8
70	4991560	494885	EL-111	10.1	>18.3
71	4991531	494873	EL-112	5.8	>13.5
72	4991536	494893	EL-113	3.8	>13.5
73	4991575	494844	EL-114	9.3	>25
74	4991604	494776	EL-115	3	>30.5
75	4990480	494200	EL-116	0	>21.5
76	4991640	494698	EL-117	4	>30
77	4991405	494712	EL-118	4.6	>20

Record Number	Stratigraphy
1	0–4.0 grey and red clay; 4.0–19.0 grey and red clay
2	2–10.0 grey and red clay; 10.0–17.0 clay
3	18–27.0 clay
4	0–7.3 red and grey clay
5	0–1.7 till; 1.7–11.4 red and grey clay; 11.4–11.9 silica sand
6	0–1.9 till; 1.9–5.9 red and grey clay; 5.9–13.1 silica sand containing organic matter, mica and magnetite
7	0–3.0 till; 3.0–14.7 red and grey clay; 14.7–15.2 silica sand containing organic matter, mica and magnetite
8	0–6.1 till; 6.1–12.0 red and grey clay; 12.0–12.2 silica sand
9	0–2.5 till; 2.5–2.9 red and grey clay; 2.9–3.6 sandy clay /clayeysand; 3.6–6.1 silica sand
10	0–7.6 till
11	0–2.5 till; 2.5–14.3 red and grey clay
12	0–3.0 till; 3.0–4.0 red and grey clay; 4.0–5.5 till; 5.5–8.0 red and grey clay; 8.0–10.7 silica sand containg organic matter, mica and magnetite
13	0–7.4 till; 7.4–8.2 red and grey clay; 8.2–10.7 silica sand containing organics, mica ned magnetite
14	0–10.9 glacial drift
15	0–16.6 glacial drift; 16.6–17.6 silica sand
16	0–6.3 glacial drift; 6.3–11.2 silica sand; 11.2–16.6 red and grey clay; 16.6–19.3 silica sand
17	0–4.3 glacial drift; 4.3–10.6 silica sand; 10.6–16.7 red and grey clay
18	0–14.0 glacial drift; 14.0–20.0 silica sand
19	0–6.3 glacial drift; 6.3–15.1 red and grey clay
20	0–0.3 glacial drift; 0.3–1.5 red and grey clay; 1.5–2.7 silica sand; 2.7–11.5 red and grey clay; 11.5–15.6 silica sand
21	0–6.4 glacial drift
22	0–6.5 glacial drift; 6.5–12.6 silica sand
23	0–13.7 till
24	0–13.7 till
25	0–6.1 till; 6.1–10.3 till; 10.3–15.0 silica sand; 15.0–19.6 silica sand containg organics, mica and magnetite
26	0–7.0 till; 7.0–7.4 red and grey clay; 7.4–16.1 silica sand; 16.1–16.9 red and grey clay
27	0–10.7 till
28	0–4.4 till; 4.4–21.7 red and grey clay; 21.7–21.9 silica sand
29	0–3.6 till; 3.6–4.4 till; 4.4–6.0 silica sand; 6.0–20.6 red and grey clay; 20.6–21.3 sandy clay / clayey sand
30	0–4.2 till; 4.2–10.7 pebbly clay
31	0–7 2 till; 7.2–11.2 silica sand; 11.2–16.6 silica sand containing organic matter, mica and magnetite
32	0–2.5 till; 2.5–4.5 red and grey clay; 4.5–11.6 silica sand; 11.6–12.6 pebbly clay; 12.6–15.5 silica sand with organics, mica and magnetite
33	0–4.0 till; 4.0–5.5 gypsum
34	0–6.7 till; 6.7–7.4 red and grey clay; 7.4–7.6 till; 7.6–6.2 red and grey clay; 6.2–25.3 silica sand
35	0–11.2 till; 11.2–13.3 red and grey clay; 13.3–13.9 sandy clay / clayey sand; 13.9–16.5 silica sand
36	0–10.7 till; 10.7–12.6 silica sand containg organics, mica and magnetite; 12.6–14.3 silica sand
37	0–16.6 till
38	0–14.0 till
39	0–11.4 till; 11.4–13.0 sandy clay / clayey sand; 13.0–16.3 silica sand.
40	4.0–11.0 red clay with carbonaceous material; 11.0–23.0 clay with pebbles; 23.0–31.0 brown calcareous clay with few pebbles
41	25.0–29.0 red and grey clay with some pebbles and silica sand
42	0–3.6 gravel; 3.6–15.6 red–grey clay; 15.6–24.4 sil. sd.; 24.4–36.0 red–grey clay; 36.0–36.6 silt–sand; 36.6–36.5 alternating red–grey clay and silt–sand to base
43	0–2.6 till; 2.6–6.5 silica sand; 6.5–35.0 red and grey clay; 35.0–36.0 lost core; 36.0–36.4 silica sand
44	0–1.7 till; 1.7–3.4 clay with sand, pebbles and boulders; 3.4–14.3 till
45	0–1.7 till; 1.7–10.5 clay with sand, pebbles and boulders
46	0–1.7 till; 1.7–5.7 clay with sand, pebbles and boulders; 5.7–7.6 glacial drift; 7.6–15.2 clay with sand, pebbles and boulders; 15.2–16.4 glacial drift; 16.4+ gypsum
47	0–7.6 glacial drift; 7.6–6.2 sand; 6.2–6.4 clay with sand, pebbles and boulders
48	0–1.0 glacial drift; 1.0–9.0 sand, silt and clay; 9.0+ gypsum
49	0–1.0 glacial drift; 1.0–5.1 clay, silt and sand; 5.1+ gypsum
50	0–1.0 till; 1.0–5.5 sand; 5.5+ gypsum
51	0–0.6 till; 0.6–3.4 clay, silt and sand; 3.4–4.0 gypsum
52	0–3.6 till; 3.6–9.1 sand; 9.1–10.9 till; 10.9–14.3 sand; 14.3+ limestone
53	0–3.6 till; 3.6–9.1 clay, sand and boulders; 9.1–16.6 sand
54	0–3.0 till; 3.0–16.6 sand, pebbles and boulders
55	0–1.5 till; 1.5–16.6 sand, pebbles and boulders
56	0–12.6 till; 12.6+ limestone
57	0–10.5 till; 10.5+ limestone
58	0–16.6 till
59	0–10.6 till
60	0–13.3 till
61	0–3.4 till; 3.4–12.0 clay; 12.0–12.5 silty sandy clay; 12.5–16.4 clay; 15.4–21.1 silica sand
62	0–1.5 till; 1.5–2.6 silty sandy clay; 2.6–6.6 silica sand; 6.6–16.9 clay; 16.9–17.5 silica sand; 17.5–16.6 clay; 16.6–19.5 silica sand; 19.5–24.1 clay; 24.1–26.7 silica sand
63	0–2.7 till; 2.7–4.2 clay; 4.2–5.0 sil. sd.; 5.0–6.9 silty sandy clay; 6.9–12.2 sil. sd.; 12.2–15.4 alternating clay and silica sand to base
64	0–2.0 overburden; 2.0–6.0 sil. sd.; 6.0–6.6 bluish/black clay; 6.6–9.1 mottled clay; 9.1–11.4 sil. sd.; 11.4–17.3 mottled clay; 17.3–16.1 grey clay; 16.1–22.7 sil. sd.
65	0–3.2 silica sand; 3.2–4.0 bluish/black clay; 4.0–4.4 silica sand; 4.4–5.5 mottled red and brown clay; 5.5–5.9 bluish/black clay; 5.9–12 7 silica sand
66	0–5.9 till; 5.9–16.0 bluish–black clay; 16.0–16.1 mottled red and brown clay; 16.1–2.1 silica sand
67	0–9.0 overburden; 9.0–15.2 silica sand; 15.2–16.2 mottled red, brown and grey clay; 16.2–19.6 silica sand
68	0–40 overburden/till; 4.0–4.6 mottled clay; 4.6–5.7 till; 5.7–10.5 sil. sd.; 10.5–19.6 mottled clay; 19.6–23.4 bluish/black clay; 23.4–25.1 mottled clay; 25,1–25.5 no core; 25.5–27.6 bluish/black clay; 27.6–30.5 sil. sd.
69	0–6.3 overburden; 6.3–6.5 sil. sd.; 6.5–6.6 overburden; 6,6–10.1 lost core; 10.1–11.0 mottled clay; 11.0–11.6 grey clay; 11.6–12.2 lost core; 12.2–16.6 sil. sd.
70	0–9.5 overburden; 9.5–10.1 lost core; 10.1–13.5 mottled red, grey and brown clay; 13.5–15.0 lost core; 15.0–16.3 silica sand
71	0–5,6 overburden; 5.6–6.1 grey clay; 6.1–7.6 mottled red, grey and brown clay; 7.6–13.5 silica sand
72	0–3.6 overburden; 3.6–4.6 mottled red, gray and brown clay; 4.6–5.1 overburden; 5.1–6.6 mottled red, grey and brown clay; 6.6–13.5 silica sand
73	0–9.3 till; 9.3–16.3 mottled red and grey clay; 16.3–21.3 bluish black clay; 21.3–22.6 mottled red and grey clay; 22.6–25.0 silica sand
74	0–3.0 till; 3.0–3.5 mottled clay; 3.5–5.0 grey/black clay; 5.0–6.3 sil. sd.; 6.3–11.3 alternating mottled clay and grey/black clay to base
75	0–21.5 silica sand
76	0–4 till; 4–6.6 mottled red and grey clay; 6.6–9.4 lost core; 9.4–20.4 silica sand; 20.4–25.2 mottled red and grey clay; 25.2–26.7 grey clay; 26.7–30 mottled red and grey cley
77	0–4.6 till; 4.6–6.5 silice sand; 6.5–10 mottled red and grey clay; 10–12.5 lost core; 12.5–13.5 mottled red and gray clay; 13.5–14.3 grey clay; 14.3–20.0 silica sand

OPEN FILE NO. 96-003 FIGURE 5

AREA: Shubenacadie, NS

LINE 1: Densmore Road

SP 4 EAST SP 1594

REVERSE POLARITY

MIGRATION STACK

FIELD PARAMETERS

Date shot:	Oct. 1994
Instruments:	OYO DAS-1
Filter:	3(72) - OUT, NOTCH OUT
Spread:	24 trace, 5 - 120 m.
Source:	12 gauge
Spacing:	5 m.
Geophones:	50 Hz.
Array:	Single geophone
Spacing:	5 m.

PROCESSING PARAMETERS

Date:	Dec 1994
Trace Edits	
Exponential Scaling	A*t*exp(B*t)
Phase Compensation	Geophone response only
Trace Equalization	Surface consistent mean amplitude
Deconvolution	5 component surface consistent
Equalization Scaling	First break region
Trace Gathers	
Structure Statics	Datum 0 m., Vr 1500 m/s.
Residual Statics	Shot + Station, hand picked
Velocity analysis	Semblance
Mute	32m. 22ms., 144m. 85 ms.
Cdp Trim Statics	+/- 3.0 ms.
Stack	12 fold
Filter	60/90 - 280/320 Hz.
Trace Equalization	Mean amplitude scale 10 - 200 ms.
Migration	Kirkhoff Summation

SCALE:
Horizontal 21 Traces/in Vertical 20 in/second

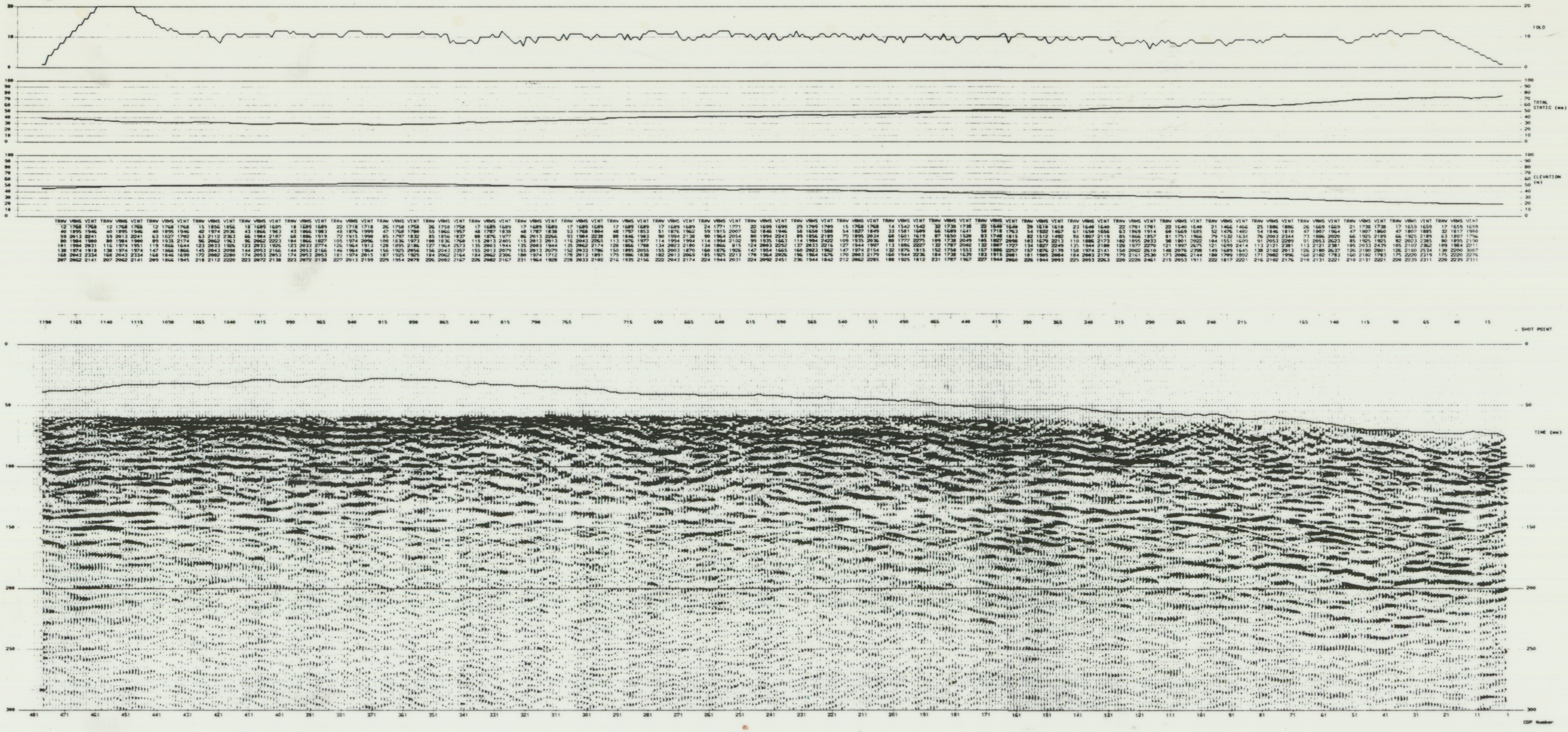
GEOLOGICAL SURVEY OF CANADA

Nova Scotia Department of Natural Resources

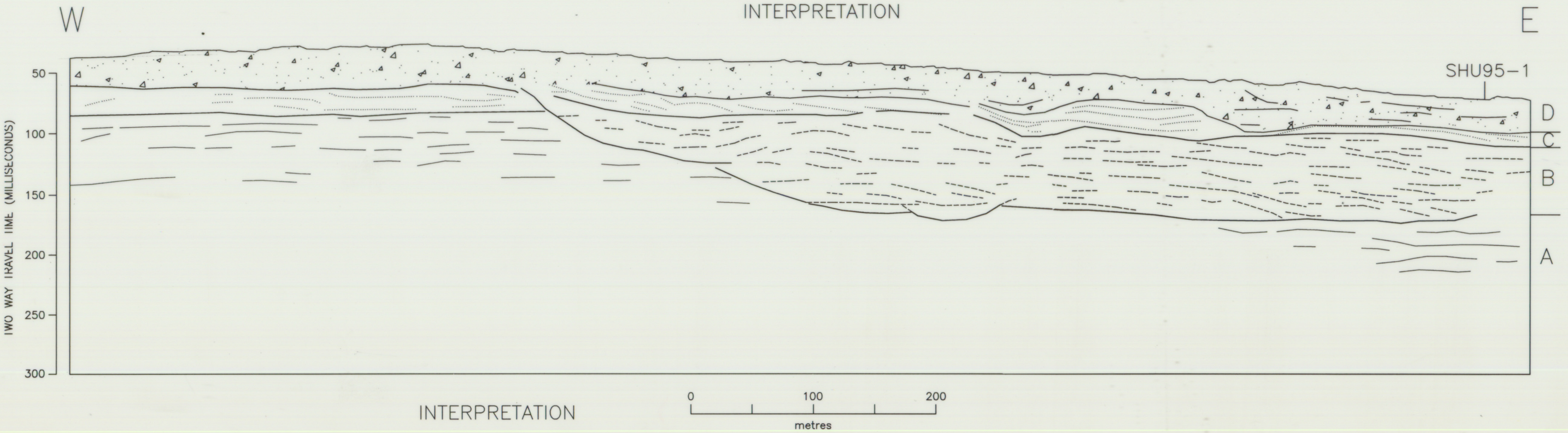
Canada-Nova Scotia Mineral Development Agreement

SEISMIC STRATIGRAPHIC INTERPRETATION

SEISMIC SEQUENCE	INTERPRETATION
D	Quaternary drift; till sheets separated by gravelly sand lenses
C	Quaternary drift; glaciolacustrine and glaciofluvial silt and gravelly sand
B	Early Cretaceous sediments; silica sand, clay, lignite
A	Carboniferous bedrock; limestone, breccia



INTERPRETATION



INTERPRETATION

AREA: Shubenacadie, NS

LINE 2: Crombe Road

REVERSE POLARITY

MIGRATION STACK

FIELD PARAMETERS

Date shot:	Oct. 1994
Instruments:	OYO DAS-1
Filter:	3(72) - OUT, NOTCH OUT
Spread:	24 trace, 5 - 120 m.
Source:	12 gauge
Spacing:	5 m.
Geophones:	50 Hz.
Array:	Single geophone.
Spacing:	5 m.

PROCESSING PARAMETERS

Date:	Dec 1994
Trace Edits	
Exponential Scaling	A*t*exp(B*t)
Phase Compensation	Geophone response only
Trace Equalization	Surface consistent mean amplitude
Deconvolution	5 component surface consistent
Equalization Scaling	First break region
Trace Gathers	
Structure Statics	Datum 0 m., Vr 1500 m/s.
Residual Statics	Shot + Station, hand picked
Velocity analysis	Semblance
Mute	32m. 22ms., 144m. 85 ms.
Cdp Trim Statics	+/- 3.0 ms.
Stack	12 fold
Filter	60/80 - 280/320 Hz.
Trace Equalization	Mean amplitude scale 10 - 200 ms.
Migration	Kirkhoff Summation

SCALE:
Horizontal 21 Traces/in Vertical 20 in/second

GEOLOGICAL SURVEY OF CANADA

Nova Scotia Department of Natural Resources

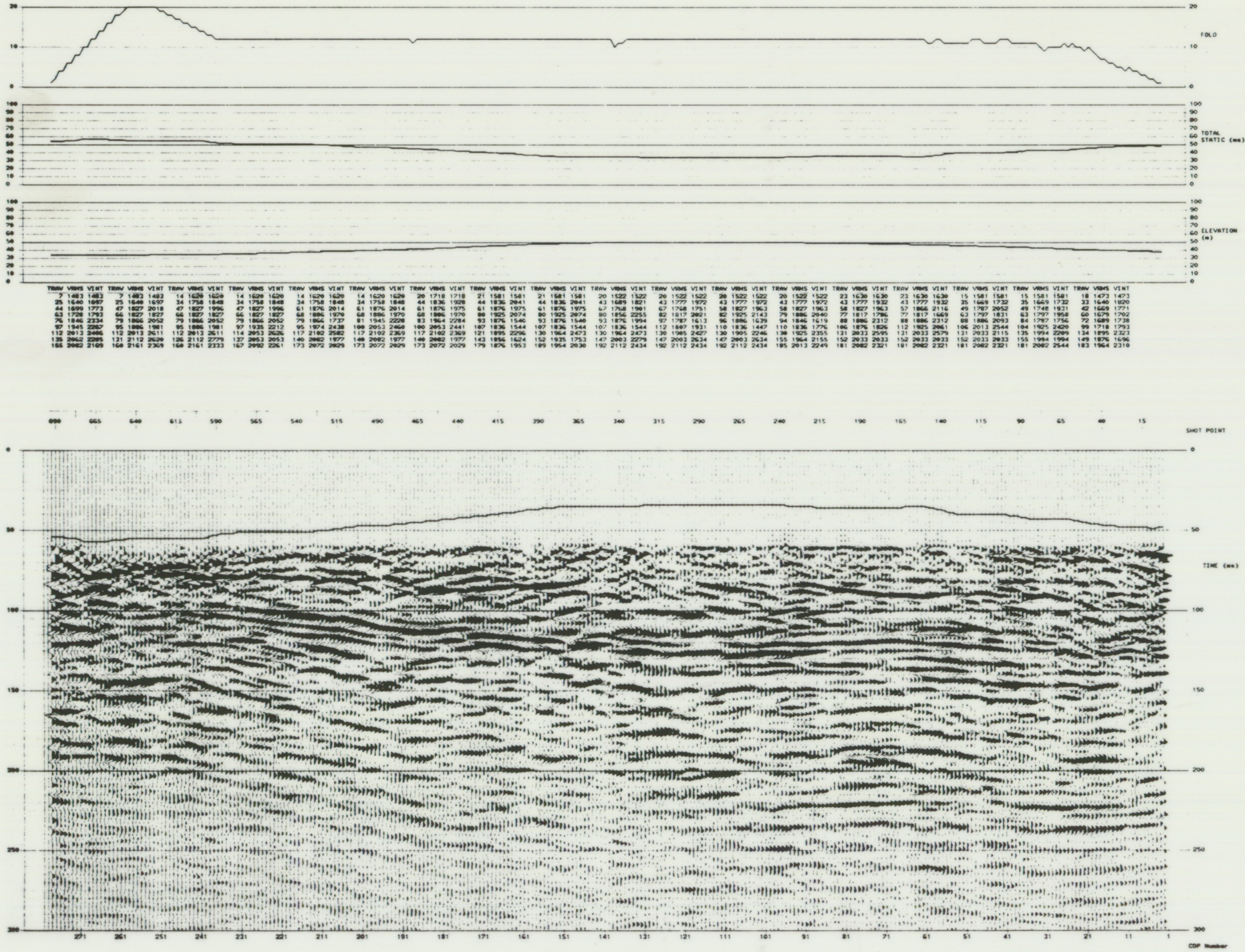
Canada-Nova Scotia Mineral Development Agreement

SEISMIC STRATIGRAPHIC INTERPRETATION

SEISMIC SEQUENCE	INTERPRETATION
D	Quaternary drift; mainly till; 2 till sheets with intervening sand – gravel lenses
C	Quaternary drift; mainly glaciolacustrine deposits, clay, sand, gravel
B	Early Cretaceous sediments; mainly silica sand, lenses of kaolinitic clay – lignite
A	Carboniferous bedrock; limestone, dolostone

INTERPRETATION

OPEN FILE NO. 96-003 FIGURE 7



AREA: Shubenacadie, NS

LINE 3: Through pasture

SP 705 EAST SP 0

REVERSE POLARITY

MIGRATION STACK

FIELD PARAMETERS

Date shot:	Oct. 1994
Instruments:	OYO DAS-1
Filter:	3(72) - OUT, NOTCH OUT
Spread:	24 trace, 5 - 120 m.
Source:	12 gauge
Spacing:	5 m.
Geophones:	50 Hz.
Array:	Single geophone
Spacing:	5 m.

PROCESSING PARAMETERS

Date:	Dec 1994
Trace Edits	
Exponential Scaling	A*t*exp(B*t)
Phase Compensation	Geophone response only
Trace Equalization	Surface consistent mean amplitude
Deconvolution	5 component surface consistent
Equalization Scaling	First break region
Trace Gathers	
Structure Statics	Datum 0 m., Vr 1500 m/s.
Residual Statics	Shot + Station, hand picked
Velocity analysis	Semblance
Mute	32m. 22ms., 144m. 85 ms.
Cdp Trim Statics	+/- 3.0 ms.
Stack	12 fold
Filter	60/80 - 280/320 Hz.
Trace Equalization	Mean amplitude scale 10 - 200 ms.
Migration	Kirkhoff Summation

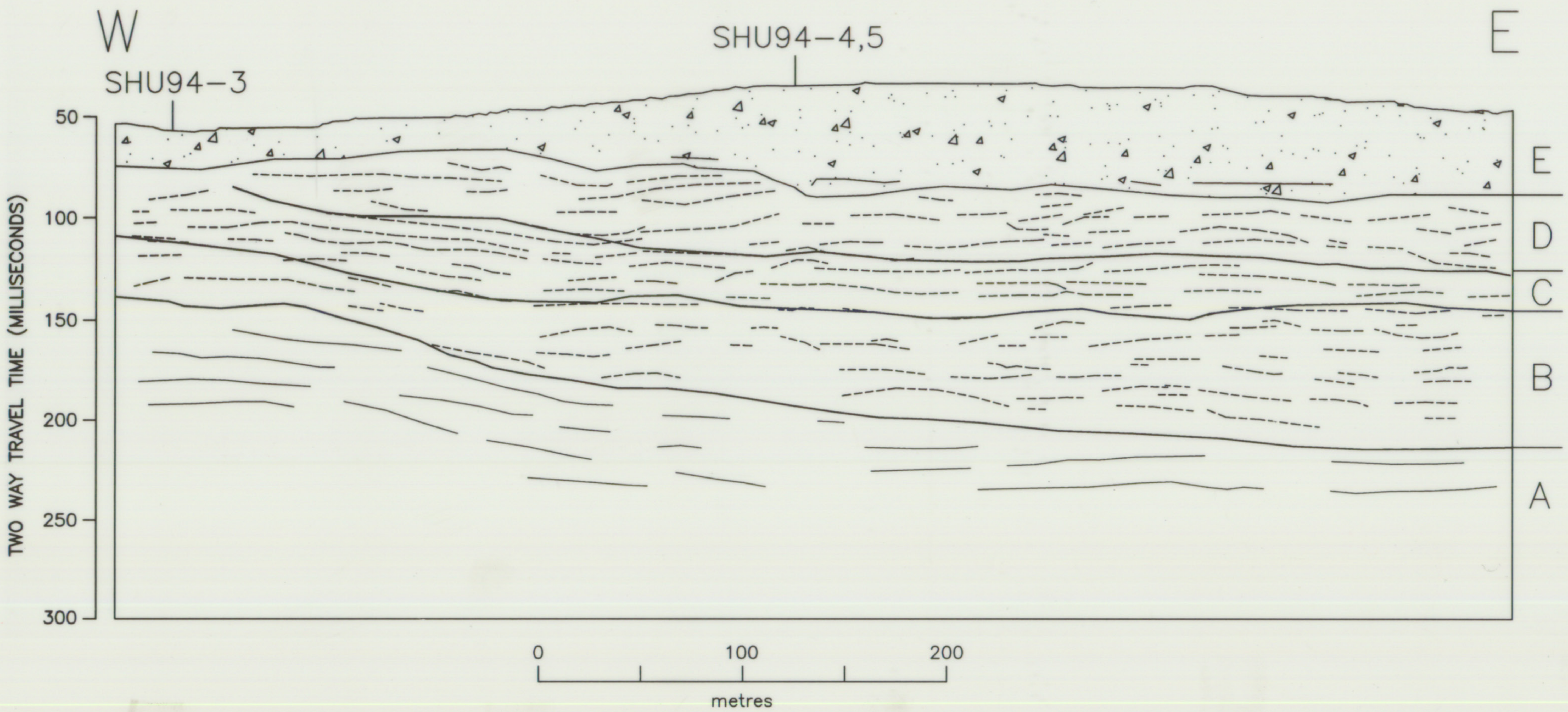
SCALE:
Horizontal 21 Traces/in Vertical 20 in/second

GEOLOGICAL SURVEY OF CANADA

Nova Scotia Department of Natural Resources

Canada-Nova Scotia Mineral Development Agreement

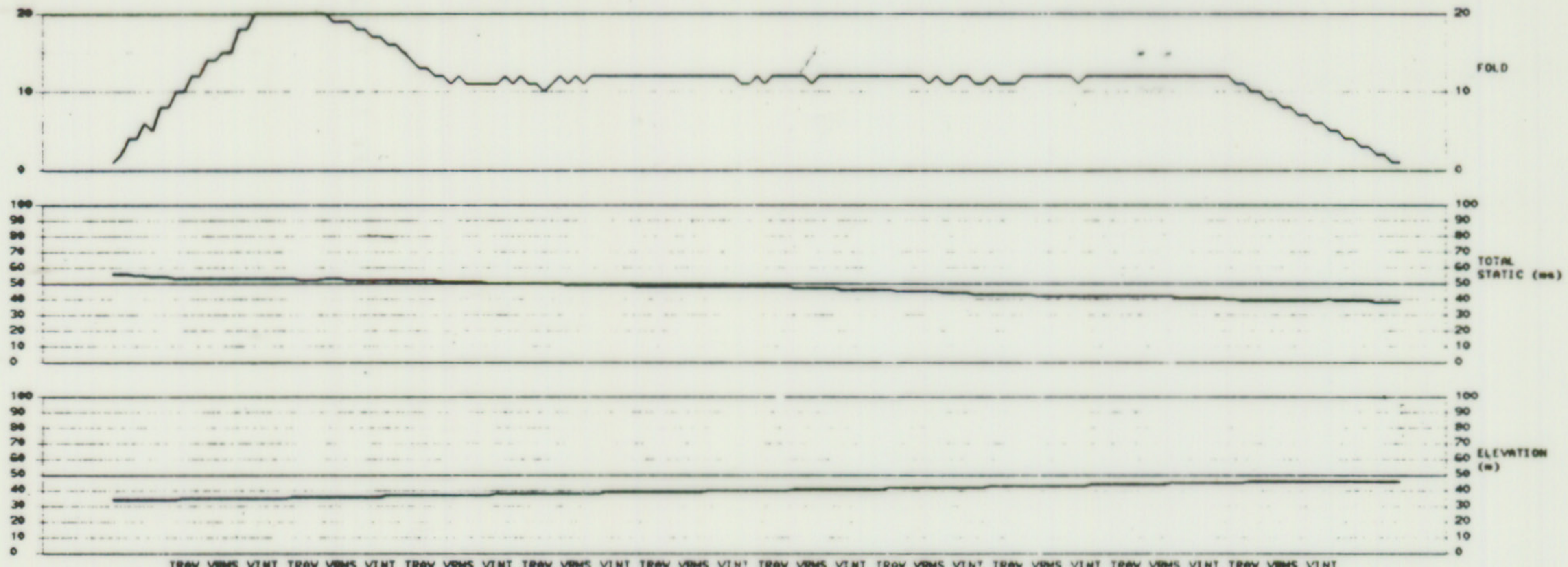
INTERPRETATION



SEISMIC STRATIGRAPHIC INTERPRETATION

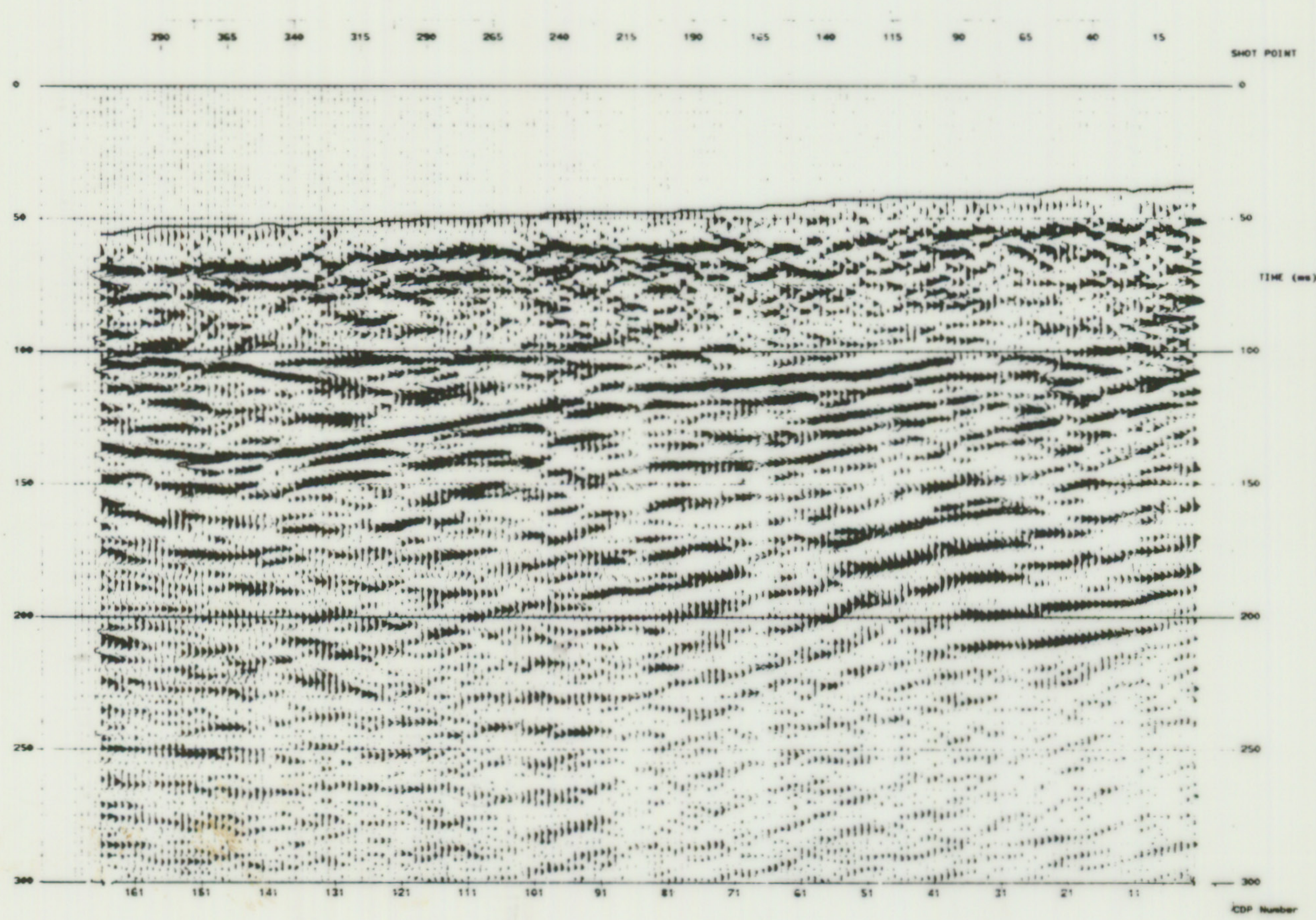
SEISMIC SEQUENCE	INTERPRETATION
E	Quaternary drift; till sheets
D	Early Cretaceous sediments; silica sand, minor clay, lignite
C	Early Cretaceous sediments; lignite, kaolinitic clay
B	Early Cretaceous sediments; silica sand, kaolinitic clay
A	Carboniferous bedrock; limestone, breccia

OPEN FILE NO. 96-003 FIGURE 8



TRAV	VRMS	VINT	TRAV	VRMS	VINT	TRAV	VRMS	VINT	TRAV	VRMS	VINT	TRAV	VRMS	VINT
23	1453	1453	23	1453	1453	23	1453	1453	23	1453	1453	23	1453	1453
45	1601	1742	45	1601	1742	45	1601	1742	45	1601	1742	45	1601	1742
54	1810	2615	54	1810	2615	54	1810	2615	54	1810	2615	54	1810	2615
66	1915	2329	66	1915	2329	66	1915	2329	66	1915	2329	66	1915	2329
82	1974	2200	81	1866	1633	88	1876	1753	92	1928	1960	92	1928	1960
100	1974	1974	105	1925	2111	105	1925	2160	105	1925	1903	105	1925	1903
115	1964	1895	115	1964	2334	115	1984	2521	115	1984	2521	121	1964	2202
126	1994	2284	126	1994	2284	126	1994	2095	129	2023	2318	137	2053	2630
145	2062	2465	145	2062	2465	145	2062	2465	150	1994	1805	157	2112	2478

TRAV	VRMS	VINT	TRAV	VRMS	VINT	TRAV	VRMS	VINT	TRAV	VRMS	VINT	TRAV	VRMS	VINT
23	1453	1453	23	1453	1453	23	1453	1453	23	1453	1453	23	1453	1453
45	1601	1742	45	1601	1742	45	1601	1742	45	1601	1742	45	1601	1742
54	1810	2615	54	1810	2615	62	1748	2087	62	1748	2087	62	1748	2087
66	1915	2329	69	1879	2108	75	1827	2164	75	1827	2164	78	1777	1885
92	1928	1960	92	1928	2068	89	1797	1626	90	1856	1994	91	1817	2040
105	1925	1903	105	1997	2429	111	1905	2290	111	1905	2102	111	1905	2262
121	1964	2202	120	2105	2744	125	2062	3031	123	1915	2005	123	1915	2005
137	2053	2630	139	2164	2504	144	2072	2136	137	1954	2267	137	1954	2267
157	2112	2478	158	2200	2447	161	2072	2072	161	2072	2646	166	2013	2271



AREA: Shubenacadie, NS

LINE 4: Water tower to drillhole

SP 420 NORTH SP 0

NORMAL POLARITY

MIGRATION STACK

FIELD PARAMETERS

Date shot:	Oct. 1994
Instruments:	OYO DAS-1
Filter:	3(72) - OUT, NOTCH OUT
Spread:	24 trace, 5 - 120 m.
Source:	12 gauge
Spacing:	5 m.
Geophones:	50 Hz.
Array:	Single geophone
Spacing:	5 m.

PROCESSING PARAMETERS

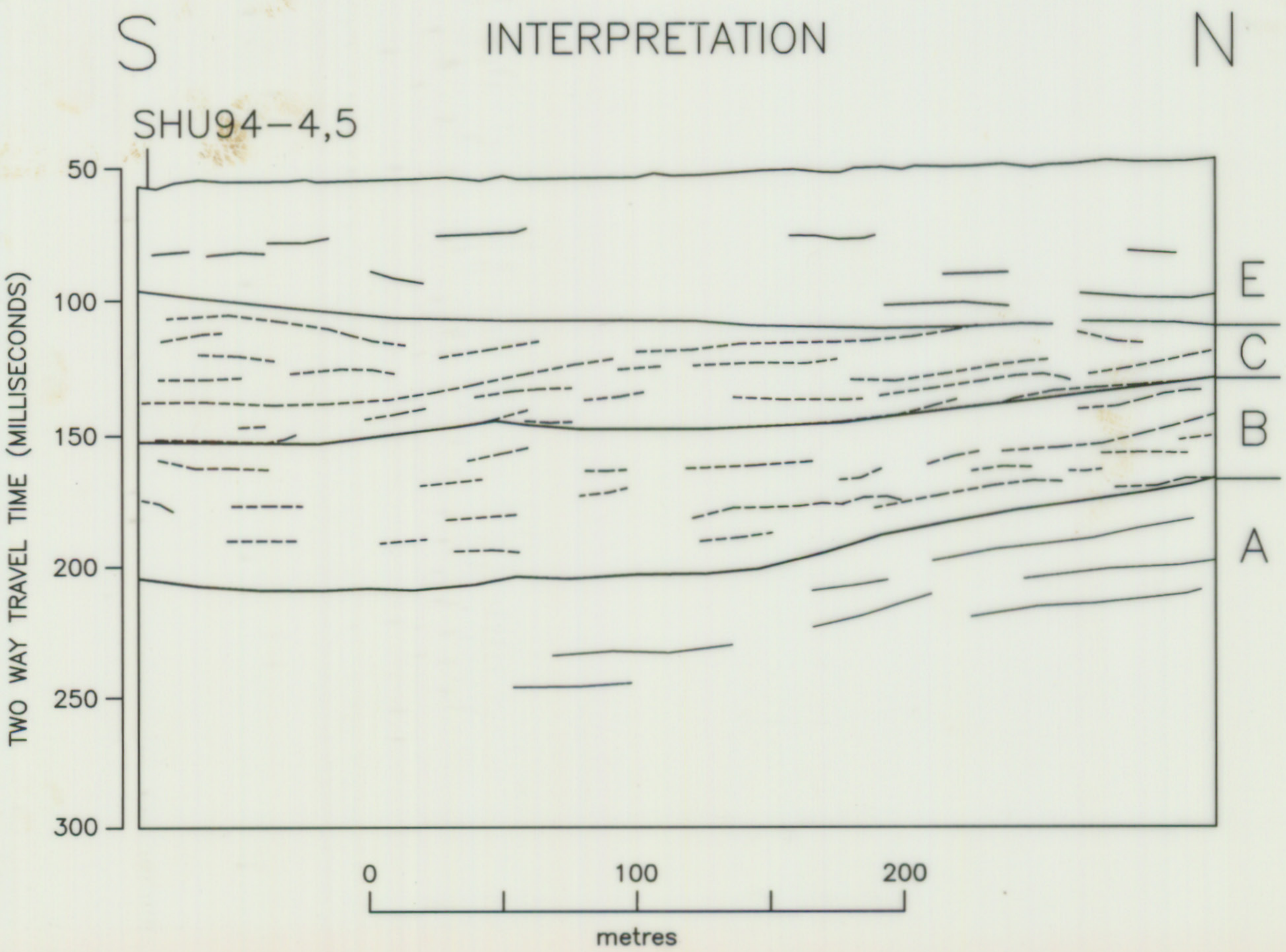
Date:	Dec 1994
Trace Edits	
Exponential Scaling	A*t*exp(B*t)
Phase Compensation	Geophone response only
Trace Equalization	Surface consistent mean amplitude
Deconvolution	5 component surface consistent
Equalization Scaling	First break region
Trace Gathers	
Structure Statics	Datum 0 m., Vr 1500 m/s.
Residual Statics	Shot + Station, hand picked
Velocity analysis	Semblance
Mute	32m. 22ms., 144m. 85 ms.
Cdp Trim Statics	+/- 3.0 ms.
Stack	12 fold
Filter	60/80 - 200/320 Hz.
Trace Equalization	Mean amplitude scale 10 - 200 ms.
Migration	Kirknoff Summation

SCALE:
Horizontal 21 Traces/in   Vertical 20 in/second

GEOLOGICAL SURVEY OF CANADA

Nova Scotia Department of Natural Resources

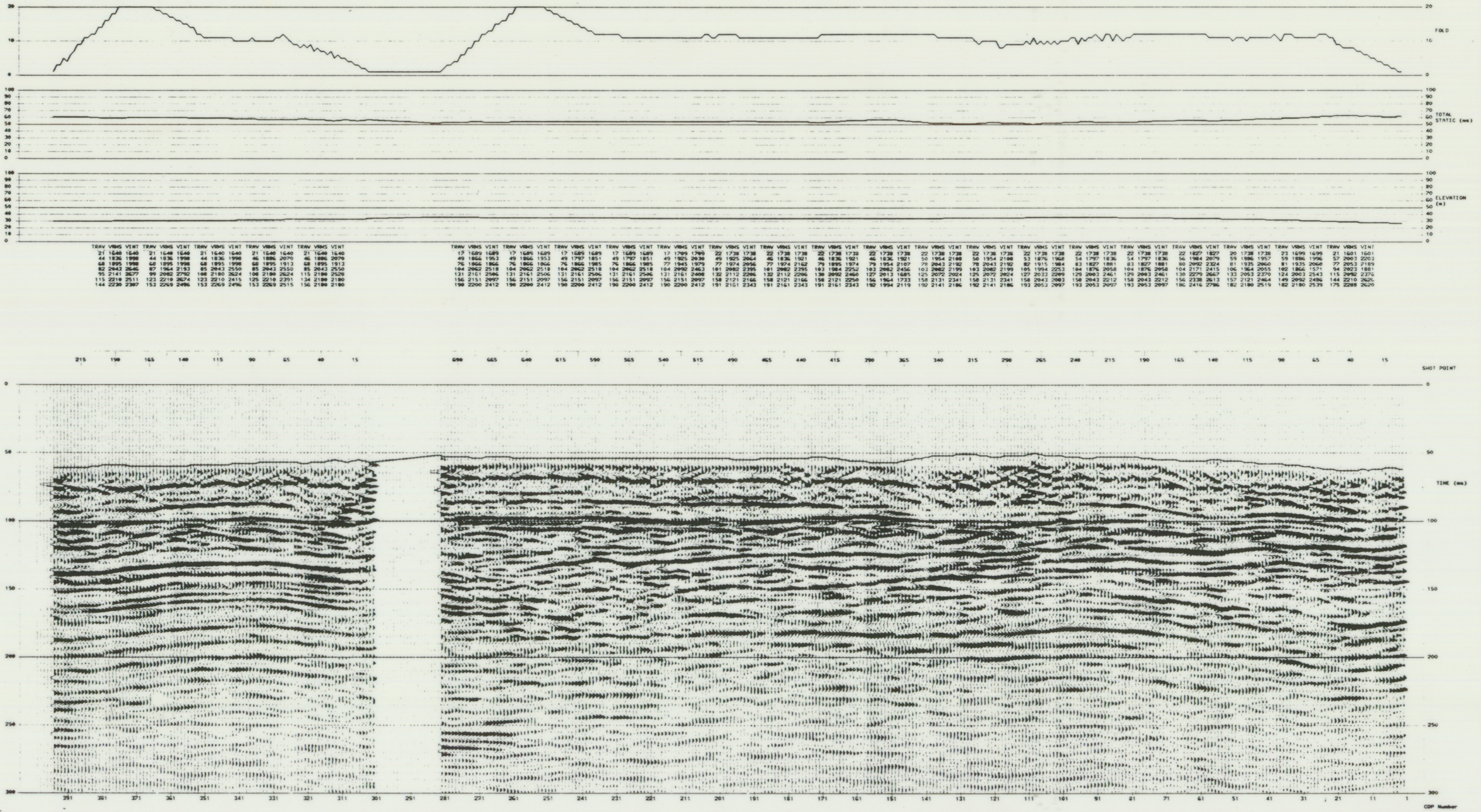
Canada-Nova Scotia Mineral Development Agreement



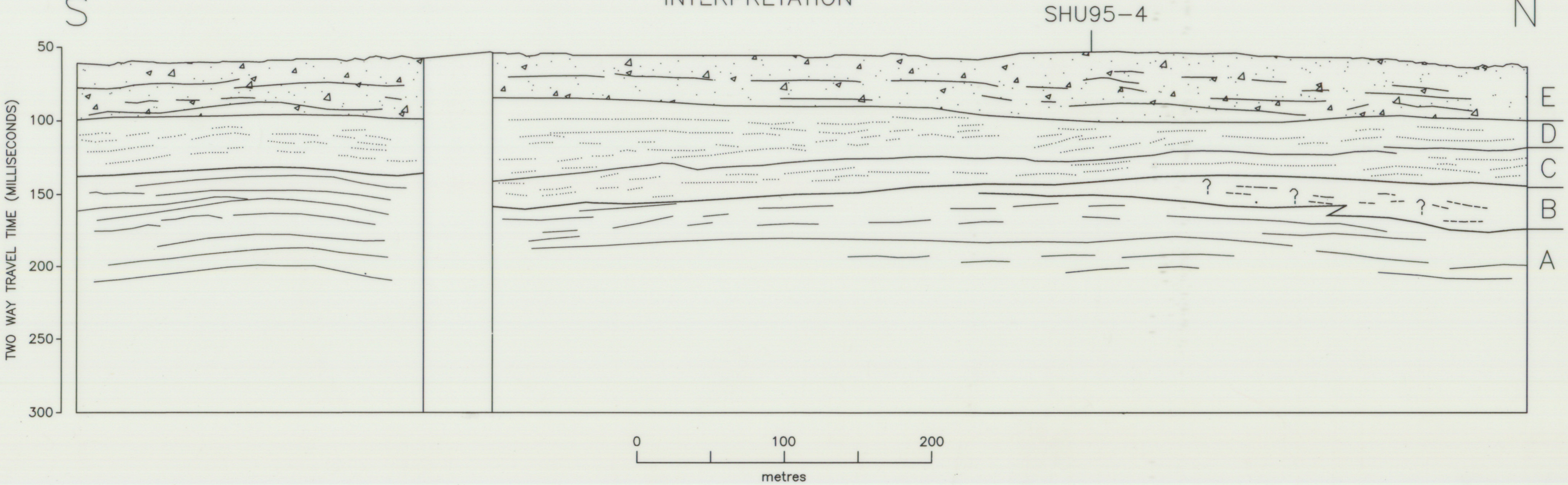
SEISMIC STRATIGRAPHIC INTERPRETATION

SEISMIC SEQUENCE	INTERPRETATION
E	Quaternary drift; till sheets
C	Early Cretaceous sediments; lignite, kaolinitic clay
B	Early Cretaceous sediments; silica sand, kaolinitic clay
A	Carboniferous bedrock; limestone, breccia

OPEN FILE NO. 96-003 FIGURE 10



INTERPRETATION



AREA: Shubenacadie, NS

LINE 5: Nelson Hill Road

REVERSE POLARITY

MIGRATION STACK

FIELD PARAMETERS

Date shot:	Oct. 1994
Instruments:	OYO DAS-1
Filter:	3(72) - OUT, NOTCH OUT
Spread:	24 trace, 5 - 120 m.
Source:	12 gauge
Spacing:	5 m.
Geophones:	50 Hz.
Array:	Single geophone
Spacing:	5 m.

PROCESSING PARAMETERS

Date:	Dec 1994
Trace Edits	
Exponential Scaling	A*t*exp(B*t)
Phase Compensation	Geophone response only
Trace Equalization	Surface consistent mean amplitude
Deconvolution	5 component surface consistent
Equalization Scaling	First break region
Trace Gathers	
Structure Statics	Datum 0 m., Vr 1500 m/s.
Residual Statics	Shot + Station, hand picked
Velocity analysis	Semblance
Mute	32m. 22ms., 144m. 85 ms.
Cdp Trim Statics	+/- 3.0 ms.
Stack	12 fold
Filter	60/80 - 200/320 Hz.
Trace Equalization	Mean amplitude scale 10 - 200 ms.
Migration	Kirkhoff Summation

SCALE:
Horizontal 21 Traces/in Vertical 20 in/second

GEOLOGICAL SURVEY OF CANADA

Nova Scotia Department of Natural Resources

Canada-Nova Scotia Mineral Development Agreement

SEISMIC STRATIGRAPHIC INTERPRETATION

SEISMIC SEQUENCE	INTERPRETATION
E	Quaternary drift; till sheets separated by discontinuous gravel layers
D	Quaternary drift; glaciolacustrine varved clay
C	Quaternary drift; glaciofluvial gravel
B	Early Cretaceous sediments; ? silica sand, kaolinitic clay lenses
A	Carboniferous bedrock; limestone

OPEN FILE NO. 96-003 FIGURE 13

INTERPRETATION

GEOLOGICAL SURVEY OF CANADA

Nova Scotia Department of Natural Resources

Canada-Nova Scotia Mineral Development Agreement

SEISMIC STRATIGRAPHIC INTERPRETATION

SEISMIC SEQUENCE	INTERPRETATION
E	Quaternary drift; till sheets
D	Quaternary drift; glaciolacustrine clay
C	Early Cretaceous sediments; silica sand, kaolin clay
B	Early Cretaceous sediments; silica sand, kaolin clay
A	Bedrock; Carboniferous limestone and Cambro-Ordovician metawacke

LEGEND

EARLY CRETACEOUS

EK silica sand, kaolin clay, lignite

EARLY CARBONIFEROUS

Windsor Group

EC marine evaporites, carbonates and redbeds

CAMBRIAN TO ORDOVICIAN

Meguma Group

€O metasedimentary rocks

SYMBOLS

Geological contact (approximate, assumed) . . . . —————-----

Drillhole (Cretaceous, possible Cretaceous, no Cretaceous) . . . . ● ● ●

Seismic Line . . . .

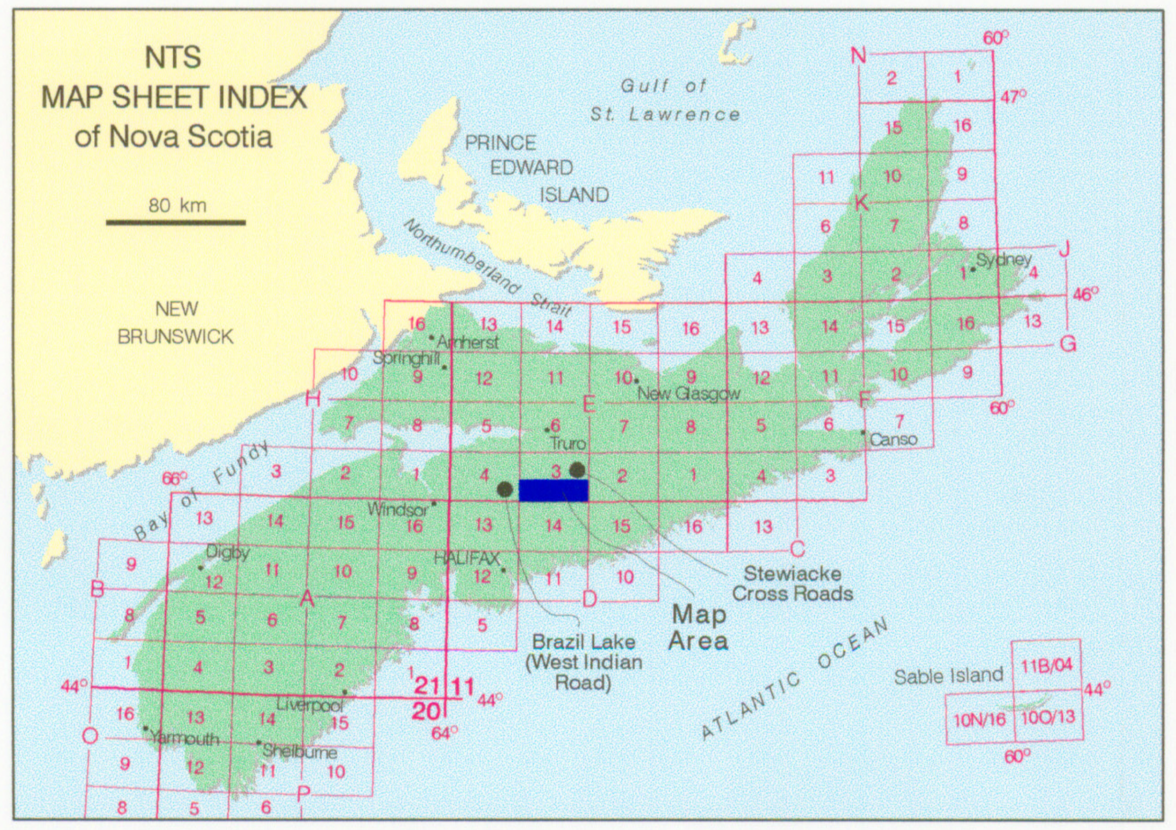
MAP NOTES

Geology after P.S. Giles and R.C. Boehner, 1982: Geological map of the Shubenacadie and Musquodoboit Basins, central Nova Scotia; Nova Scotia Department of Mines and Energy, Map 82-04, scale 1:50 000

Planimetric base derived from National Topographic System (NTS) map sheet 11E/03, Department of Energy, Mines and Resources Canada, 1980, scale 1:50 000, 6° UTM projection, datum NAD 27.

UTM grid shown is based on Zone 20, 1000 m intervals.

Cartography by Nova Scotia Department of Natural Resources, Corporate Services Branch, Graphic and Mapping Services, 1996.



Nova Scotia Department of Natural Resources
Minerals and Energy Branch

Map 96-001

Geological Map of the

Shubenacadie and Musquodoboit Basins showing the extent of Early Cretaceous sediments

(Part of NTS Map Sheet 11E/03),
Colchester and Halifax Counties, Nova Scotia

R.R. Stea, P.W. Finck, S.E. Pullan and M.C. Corey

Scale 1:50 000

1000 0 1000 2000

metres

Nova Scotia Department of Natural Resources
Honourable Donald R. Downe, Minister

Halifax, Nova Scotia
1996

Nova Scotia Department of Natural Resources

Canada-Nova Scotia Cooperation Agreement on Mineral Development 1992-1995

Map 1 to accompany Nova Scotia Department of Natural Resources, Minerals and Energy Branch, Open File Report 96-003