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WILD COVE CLAY, WESTERN NEWFOUNDLAND: A REVIEW AND RECENT WORK

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ABSTRACT

The Wild Cove clay program was conducted to determine the quantity and quality of clay and its potential for various clay products, particularly brick. Preliminary results indicate that with proper blending the right clay can be obtained to produce quality-face bricks suitable for maritime climates. The deposit is located near Corner Brook where a readily accessible market is available and from where the clay can be exported if markets are established.

INTRODUCTION

In July, 1986, detailed sampling was conducted in the Wild Cove clay deposit near Corner Brook (Figure 1). This is a follow-up program based on reconnaissance sampling (Vanderveer, 1977; Kirby, 1985). These sampling programs indicated that clay from the Wild Cove deposit could be used in the manufacturing of brick and/or other clay products. The aim of the current program is to assess the variability of the clay deposit by conducting detailed sampling and analyses for textural and mineralogical variation.

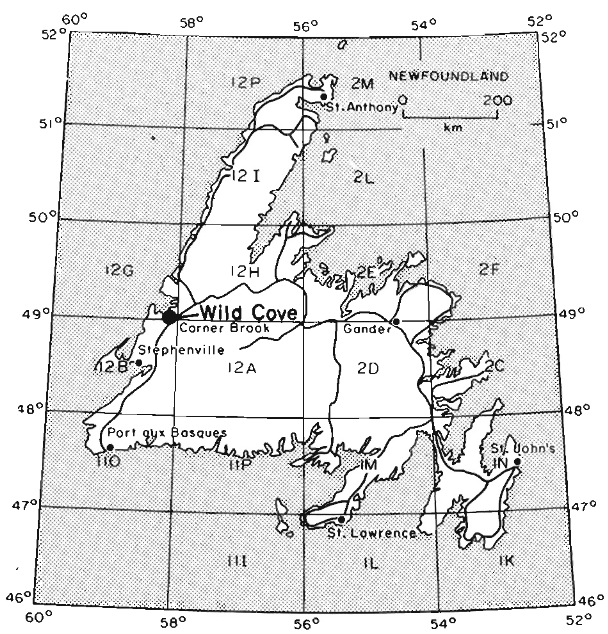

Figure 1: *Location of study area.*

Location

The Wild Cove clay deposit is located approximately 2 km northeast of Corner Brook in the Corner Brook (12A/13) map area. Wild Cove is situated in the lower end of the Wild Cove valley. The valley floor is overlain by dense to moderate tree growth and bogland; precipitous cliffs form parts of the valley walls. Small deposits of silty till to the north and south, and a small gravel terrace to the east are evident. The clay deposit borders the ocean along its western margin. The deposit is approximately 1.5 km long, 1 km wide and has an estimated thickness of 16 m. A narrow stream of less than one metre average depth cuts through the centre of the deposit.

The Bay of Islands Northshore highway and a transmission line are located along the western end of the deposit. A Teleglobe Canada building is also situated on the west side of the deposit, and an underground cable runs through the south-central part of the Wild Cove valley. The Corner Brook municipal dump is located on the north side of the Wild Cove valley and overlies a small portion of the clay deposit.

CLAY USES

Clay in Ceramic Products

In general, the term clay implies a natural, earthy, fine grained material that develops plasticity when mixed with limited amounts of water (Grim, 1968; Worrall, 1968). Articles made chiefly of clay are referred to as earthenware. Earthenware has a porous or semiporous body.

Products made from earthen materials by the application of high temperatures are referred to as ceramics. Plasticizing of clay by the addition of water is the general method by which clay can be shaped. After shaping, the clay is dried to increase its strength so that it may be handled; it is then fired at elevated temperatures (frequently in the range of 1100°C). Firing

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continues until there has been some vitrification or fusion of the components, which leads to the development of a glossy bond. This makes the shape permanent and prevents water absorption, which may lead to swelling and crumbling of the final product (Grim, 1962).

The ceramic properties and economic use of clay materials are determined by the clay-mineral composition, by the presence of impurities such as organic material and soluble salts, and by the texture (particle-size distribution) of the sand- to clay-size components. Coarser grained non-clay material can frequently be removed by particle-size separation, if necessary.

The major clay minerals are illite, chlorite, montmorillonite and kaolinite. The common non-clay minerals generally associated with the clay minerals are quartz, calcite, dolomite, mica, pyrite, feldspar and iron oxides (Vanderveer, 1977; Grim, 1968).

The fired color of a clay (important in ceramic ware) may range from light yellow to dark brown, ‘due principally to its content of iron oxide, but also depends on the firing atmosphere and temperature, and is modified by other constituents such as Al_2O_3, CaO and MgO. Under oxidizing conditions, iron oxide fires buff to brown but the latter is bleached by oxides mentioned above. On the whole, the colour is darkened by increase of firing temperature‘ (Worrall, 1968).

Brick Clay

The particle-size distribution of clay suitable for the manufacture of brick may range from 25 microns to less than 2 microns. It is the distribution of particles below 2 microns that is most important (Carroll, 1970; Worrall, 1968).

Common brick can be made from almost any clay-mineral composition, provided it does not contain large percentages of coarse stony material that cannot be eliminated in the preparation process or ground to adequate fineness. Other factors that may affect the brick quality are high concentrations (>50 percent) of non-clay material, such as organics and soluble salts, which will reduce the green and fired strength of the ware. The presence of montmorillonite, large amounts of iron, alkalies, and alkaline earths will increase shrinkage and/or reduce the vitrification range. Large amounts of kaolinite are not preferred for brick because of the increased temperatures required for firing (Grim, 1962). The greater the firing range for any one product the better, especially when color is an important part of the final product, such as brick. For this reason, the development of a brick plant will have greater potential because customers will not be restricted to one brick color, thereby increasing the potential use of brick in the market place.

Other Clay Uses

Other ceramic uses of clay include roofing and structural tile, stoneware, pottery, refractory brick and face brick. These products may require either different mineral compositions or mineral types similar to those used in common brick. For example, face brick, which is considered to be somewhat higher in quality than common brick, can be made from approximately the same type of materials used in manufacturing common brick. However, for face brick it is more desirable to avoid detrimental components used in common brick, such as kaolinite and montmorillonite, because of the thinness of the product and its lack of tolerance for shrinkage.

REVIEW OF PREVIOUS PROGRAM

Analyses of this years field samples are not yet complete. However, results of reconnaissance sampling programs at Wild Cove (Figure 2) are included to provide a basic understanding of the type of clay in the Wild Cove area. The analyses include particle-size distribution, clay-mineral composition, and results of a study on selected samples conducted by CANMET (Canadian Centre for Mining and Energy Technology) to evaluate the ceramic properties of the Wild Cove clay.

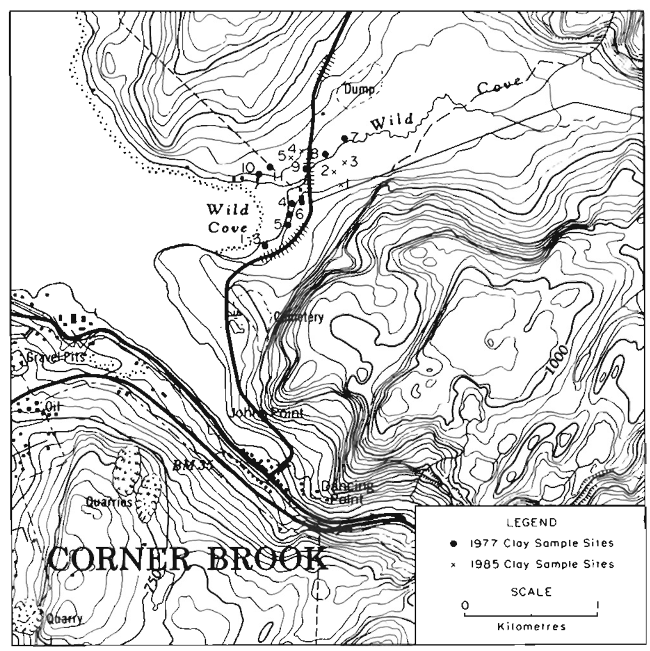

Figure 2: *Sample location map for reconnaissance sampling by Vanderveer (1977) and Kirby (1985).*

Sampling

The initial sampling program (Vanderveer, 1977) was part of a province-wide investigation of clays conducted in an effort to promote the use of Newfoundland clays. Most samples collected from the Wild Cove clay deposit under this program were taken from the western part of the deposit, and only two samples were collected east of the highway. These samples were taken from shallow hand-dug pits; hence, some contained rootlets, twigs, pebbles and other debris. This resulted in extra laboratory work including drying and wet sieving to remove unwanted material. Particle-size analyses (Vanderveer, 1977) indicate these samples contain an average of 12 percent sand, 50 percent silt, and 38 percent clay—one sample contained 5 percent gravel-size material (Table 1; Figure 3).

Table 1. Gravel, sand, silt and clay percentages of Wild Cove clay (Vandereer, 1977).

Sample	Gravel	Sand	Silt	Clay
1a	0	31	52	17
1b	0	24	54	22
2	0	3	31	66
3	0	1	32	67
4	0	18	61	21
5	0	15	60	25
6	5	20	59	16
7	0	10	29	61
8	0	trace	41	59
9	0	trace	48	51
10	0	8	65	27
11	0	8	65	28
Average	0.42	11.54	49.75	38.33

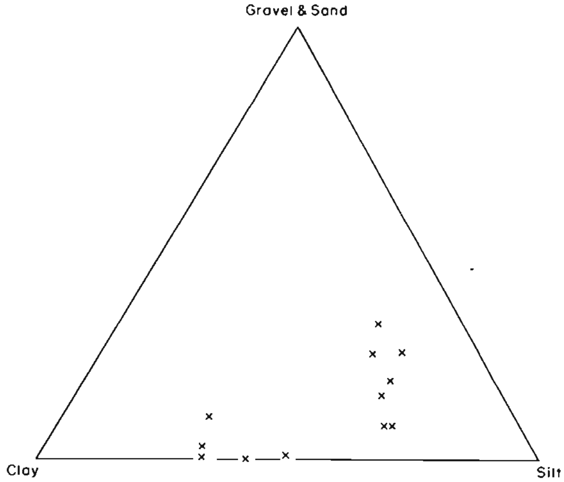

Figure 3: *Ternary diagram of grain-size distribution.*

Test Results

Mineralogy of the clay-size fraction was determined by X-ray diffraction analyses (Vanderveer, 1977). Results of these analyses (Table 2; Figure 4) show 56 percent illite, 17 percent montmorillonite, 16 percent chlorite, 10 percent kaolinite, plus traces of quartz, feldspar and amphibole. The absence of calcite in the clay fraction indicated that pinholing (small holes in brick surface) was due to the presence of calcite as sand- or silt-size particles.

The plasticity (ability of a material to flow under pressure without cracking or breaking) of tested samples was medium to good before sieving on three samples and fair to good after sieving on two other samples. A firing range of 1040°C to 1120°C produced an average shrinkage of 11 percent, with little or no warpage. There were slight distortions, cracking and small pinholes, due to outgasing of minor calcite, in all high-fired samples.

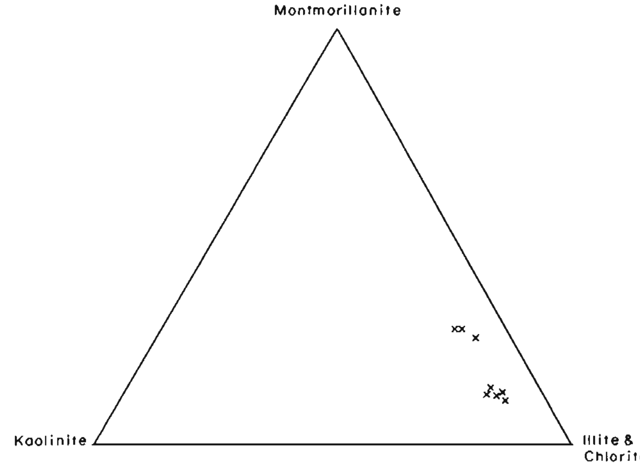

Figure 4: *Ternary diagram of Wild Cove clay mineralogy.*

In 1984 Kirby collected five clay samples from five backhoe pits in the Wild Cove area. Laboratory analyses were conducted on two samples, one from each side of the Northshore highway. Analyses were conducted by CANMET and included tests (Table 3) for moisture content, plasticity, pyrometric cone equivalent (PCE), extrusion pressure, and drying and firing behaviour (Bell, 1984). Due to the extreme differences in plasticity of both samples, a combined mixture (half-and-half) of each sample was also tested.

Plasticity. Sample 2 displayed extreme plastic characteristics, such as those associated with a substantial portion of very fine grained material. The sample therefore exhibited poor extrusion properties. Sample 5 had the basic minimum plastic characteristics for satisfactory extrusion of mechanically sound bricks, but had weak unfired (green) strength and was easily broken. This was probably due to the coarser particle-size content in the sand–silt range. Sample 25 showed an optimum plasticity and green strength required for a commercial extrusion operation.

Pyrometric Cone Equivalent (PCE). The PCE or heat-softening temperature is the temperature at which deformation of samples occur at a prescribed heating rate (Bell, 1984). To conduct PCE experiments an appropriate amount of water is first added to the clay samples. The samples are then formed into standard-size cones (elongated triagonal prisms), which are put in a laboratory down-draft furnace designated for such testing. The PCE of Sample 2 was 1145°C; of Sample 5, 1205°C; and of Sample 25, 1170°C.

Extrusion test. Extrusion tests determine the amount of pressure needed to extrude a sample through a 2.54- by 2.54-cm die under vaccum with a Loomis hydraulic press. Extrusion tests indicate the flow properties of samples and any 'tearing' problems that might be expected during commercial extrusion.

Sample 2 was dense and tough, and the pressure required for extrusion was a relatively high (5 to 6 tonnes). The sample showed severe laminar flow and the corners of the bars were completely stripped away. Sample 5 required a low pressure

Table 2. Percentages of clay minerals in the Wild Cove clay deposit (Vanderveer, 1977)

Sample	Montmorillonite	Illite	Chlorite	Kaolinite	Quartz	Feldspar	Amphibole	Calcite
1a	12	60	16	12	x	x	x	
1b	27*	50	12	11	x	x	x	x
2	26	54	12	7		x		
6	11	57	21	11		x		
7	12	67	9	12	x	x		
9	28	48	14	10	x	x	x	
10	12	53	26	10	x	x		
Average	17.25	56.38	16.13	10.13	Trace	Trace	Trace	

* Duplicate analysis
x Present in minor amounts

Table 3. Results of tests conducted on Wild Cove clay samples

Sample	Moisture content	Plasticity	PCE	Extrusion pressure
2	23.5%	High	1145°C	5-6 tonnes
5	21.5%	Low	1205°C	1-2 tonnes
25*	21.5%	Optimum	1170°C	3-5 tonnes

* Sample 25 is a combined mixture (half-and-half) of samples 2 and 5.

Table 4. Fired properties of Wild Cove clay

Sample	Drying shrinkage (%)	Firing temperature (°C)	Fired shrinkage (%)	Cold water absorption after 24 hours (%)	Hot water absorption after 5 hours (%)
2	6.0	991	1.3	15.2	15.9
		1050	3.1	8.7	9.1
		1101	6.3	0.2	0.2
		1152*	2.7	1.0	3.1
5	3.3	991	0.0	15.6	18.0
		1050	2.3	10.4	13.2
		1101	4.7	3.6	6.2
		1152†	6.1	0.6	1.1
25	5.0	991	0.5	15.0	16.1
		1050	1.5	10.1	11.5
		1101	4.3	1.0	1.9
		1152*	3.7	0.6	4.9

* Overfired, bloated
† Vitrified, slightly bloated

of only 1 to 2 tonnes to extrude a column of excellent mechanical appearance. However, the column was weak from poor bonding and so soft that the bricks would suffer finger markings if manually handled and deformation if mechanically handled. Sample 25 required moderate pressure for extrusions (3 to 5 tonnes). This sample showed good smooth flow characteristics and only slight tearing at the corners, producing a firm dense column.

Drying and firing behaviour. None of the samples showed any cracking after five minutes in an oven preheated to 85°C. This is indicative of safe drying behaviour in commercial conditions. As expected, samples showed varying degrees of change under elevated firing conditions (Table 4).

All samples fired to shades of brick red, varying from salmon at the lower temperature to brownish red at vitrification. In each case darkening increased with firing temperature. Sample 5 developed the most pleasing dark-red color (most pleasing in the brick industry), whereas Samples 2 and 25 were marred by varying amounts of white dryer scum formed by precipitation of water-soluble components that migrated to the surface as the sample dried.

All clay products expand slightly once they leave the kiln and are exposed to the action of water vapour. As shown in Table 4, Sample 5 showed the greatest water absorption after removal from three of the four temperature conditions at which samples were fired; Sample 2 showed the least absorption. All samples showed signs of bloating at the highest temperature (1152°C) at which they were fired.

Summary of Extrusion and Firing Tests

In view of results conducted on samples from previous years, it can be concluded that samples from the Wild Cove clay deposit are not consistent. Its potential for use in ceramics varies greatly east and west of the highway. Test results of Sample 2 on the east side of the Northshore highway show a higher plasticity due to a high moisture content. This results in moisture-control problems. Its high plasticity also causes poor flow properties, high combined shrinkages and a short firing range for dense products. Test results of Sample 5 from the west side of the highway show less plasticity due to higher sand–silt content; it is too soft and weak to handle successfully in the green state. This sample has acceptable firing shrinkage and fired absorption qualities, a wide firing range and a more acceptable brick-red color. The combined mixture (Sample 25) of both these samples produced the best overall results, and can be used to negate the undesirable properties of Samples 2 and 5.

1986 SAMPLING PROGRAM

The intent of the 1986 field season program was to evaluate the variability of the overall deposit and to determine whether or not part(s) of the deposit possesses the necessary textural and chemical properties to preclude the necessity of blending and/or mixing.

In total, 72 samples were collected during the 1986 field season for grain-size analyses, mineral composition and X-ray diffraction analysis. Sampling was conducted at 100-m intervals along grid lines spaced 200 m apart (Figure 5), using a chain and compass. Samples were usually collected from test pits dug using a backhoe-mounted skidder, which could reach a maximum depth of 3.4 m. In areas of dense tree growth or bog cover that could not be traversed by the skidder, samples were collected using a 1-m-long bore auger having a diameter of 3.5 cm; it could reach a depth of 1 m. Samples were also collected from shoreline exposures.

Backhoe test pitting proved to be very effective and made sample collection relatively easy. It was possible to get below the organic (topsoil) layer, ensuring that the samples were uncontaminated by plant debris. The auger method proved ineffective in many places. It was difficult to retrieve or remove the samples from the ground, and samples collected by auger were poor to fair in quality. Contamination by the overlying organic layer as the auger was extracted was common. Thick organic layers (reaching a depth of 3 m in some places) often prevented the recovery of any clay by the auger method.

Field observations showed that the western part of the deposit (from the highway to the shoreline) consisted of moderate to well compacted, stratified and laminated clay, silt and sand. Exposure thicknesses along the shoreline ranged from 10 to 12 m. Backhoe penetration was slow, although removed chunks of clay, silt and sand could easily be broken along the lines of stratification.

The eastern part of the clay deposit (east of the Northshore highway) showed no observable stratification. This section appears to be composed predominantly of clay–silt and minor sand. It is less compact except for some areas along the north and south margins of the deposit. For the most part, the clay in this area appears to have a higher moisture content, which, combined with a higher clay-size composition, gives it a more extreme plasticity than the material to the west.

CONCLUSIONS

Although certain obstacles such as the transmission line, underground cable and municipal dump may prevent extraction in some areas, it is believed that the clay deposit is more than large enough to supply the raw material to support the manufacture of clay bricks.

Results of reconnaissance sampling programs conducted by Vanderveer (1977) and Kirby (1985) indicate that the Wild Cove clay deposit contains large percentages of silt and sand. However, samples collected during the current field investigation indicate that most of the deposit, from the Northshore highway to its eastern margin, contains predominantly clay–silt and much less sand.

Particle-size analyses of samples collected during 1986 are on-going and will determine if there is a portion of the deposit that has an adequate mixture of coarse (silt–sand) and fine (clay) material. If blending is required, it may be possible to import sand from nearby areas (Ricketts, *this volume)* and blend it with the more clay-rich and moist parts of the deposits. Mineral content must also fall within specified limits if a suitable brick clay is to be provided.

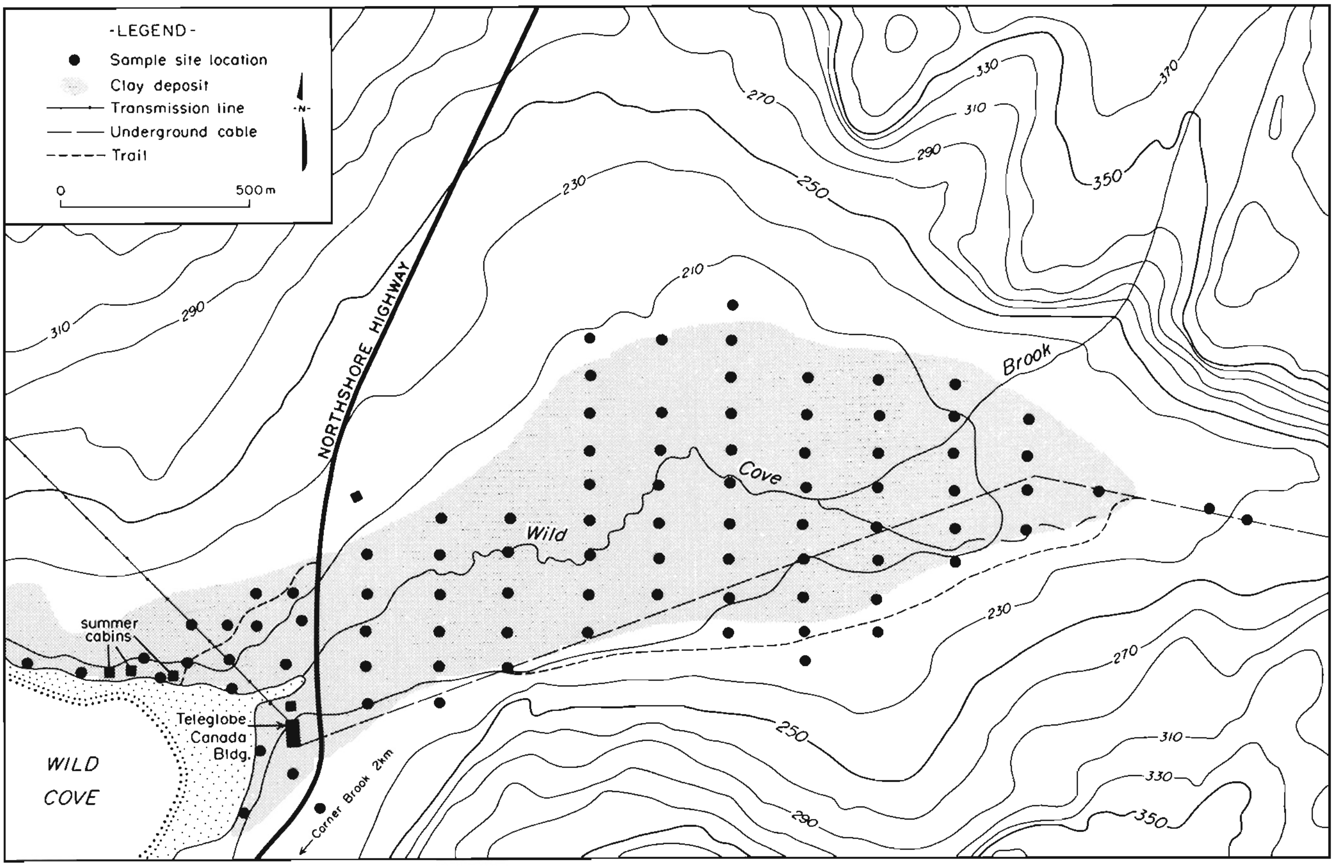

Figure 5: *1986 sample location map.*

Ceramic potential from reconnaissance sampling of the Wild Cove clay, as determined by CANMET, show that a desirable ceramic product can be achieved using a material having a moderate particle-size range between the two extremes displayed by samples from the east and west parts of the deposit. It is hoped that the results of this year's field program will help locate a suitable site within the clay deposit that has an appropriate mixture of sand–silt–clay material, thereby eliminating the need for blending.

ACKNOWLEDGEMENTS

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