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CERAMIC PROPERTIES OF SEVENTEEN SAMPLES FROM NORTHERN ONTARIO

by

K. E. BELL AND L. K. ZEMGALS

MINERAL PROCESSING DIVISION

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SYNOPSIS

Seventeen samples, from two properties on the Mattagami River in Northern Ontario, were submitted by Northclay Developments Limited for evaluation of their ceramic potential.

The samples from the Hilder property consisted primarily of white-burning (kaolinitic) clay and siliceous sand. Beneficiation to remove the coarse sand, minor amounts of iron-bearing minerals, and mica impurities, would probably be required.

One of the samples from the Douglas property proved to be a common red-burning clay of no commercial value; the remainder were refractory, kaolinitic clays containing various amounts of silica, iron and mica impurities. Most of these samples burned to various shades of red, pink or buff, and their usefulness would probably be restricted to the manufacture of low- or medium-heat duty fireclay brick. Four of the samples, however, burned near-white: with proper beneficiation to remove impurities, the quality of these samples might be improved to that of high-heat duty fireclays or ceramic grade china clays.

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INTRODUCTION

Seventeen clay and sand samples were submitted to the Mines Branch by Mr. Steven Polon, Northclay Developments Limited, 825 Eglington Avenue, West, Suite 404, Toronto, Ontario, for evaluation of ceramic potential. It was stated that 13 samples were taken from the company's Douglas property and 4 from its Hilder property. Both properties are on the Mattagami River, near the Smoky Falls Hydro Project.

The samples were marked and assigned laboratory numbers as follows:

Douglas Property

	Lab No.
Mine No. 1, Pit 1, F.C.	2980
Mine No. 1, Pit 2, F.C.	2981
Mine No. 1, Pit 3, Red	2982
Mine No. 1, Pit 3, Grey	2983
Mine No. 1, Pit 4, F.C.	2984
Mine No. 1, Pit A, F.C.	2985
Mine No. 1, Pit 7, Red and Grey F.C.	2986
Mine No. 1, Pit 7, Brown F.C.	2987
Mine No. 1, Pit 7, Grey F.C.	2988
Mine No. 1, Pit 7, Black F.C.	2989
Mine No. 2, Sand	2990
Mine No. 2, B.C.	2991
Mine No. 2, B.C.	2992

Hilder Property

Clay	2993
Clay	2994
Sand	2995
Sand	2996

PROCEDURE

The materials were dried and crushed to pass a 16-mesh (Tyler) screen and were tested with dilute hydrochloric acid for calcium carbonate. The ground clays were tempered with water to obtain a stiff-plastic consistency and the

amount of water (water of plasticity) was noted. The prepared samples were extruded under vacuum (28 in. of mercury) from a Midvale-Heppenstall laboratory de-airing extrusion press. Test briquettes measuring approximately 1 x 1 x 4 inches were cut from the extruded column, identification numbers and linear shrinkage marks were applied. One freshly formed briquette of each material was submitted to rapid drying conditions at 85°C (185°F) and the results observed. The remaining test briquettes were air-dried for about 24 hours and finally dried at 85°C (185°F). The drying shrinkage was measured and calculated in per cent of wet length. Test cones were hand-moulded from the extruded material and the pyrometric cone equivalent (PCE) or heat softening point was determined. Duplicate test specimens were then fired in electric kilns at appropriate temperatures. The fired shrinkage, hardness, colour and water absorption after a 24-hour soak in cold water were determined.

RESULTS

The unfired characteristics and a summary of the fired properties - shrinkage, absorption, colour and hardness over appropriate temperature ranges - and the PCE's are given in Tables 1 and 2.

TABLE 1

Ceramic Properties of Samples from the Hilder Property

Clay No.	UNFIRED CHARACTERISTICS	P.C.E.	FIRED CHARACTERISTICS					REMARKS
			Cone No. *	Fired Shrinkage, %	Absorption, %	Colour	Hardness	
2993 (Hilder property)	Rusty, iron stained chunks of clay, some very heavily contaminated, non-calcareous. Good plasticity, extrudes well under vacuum, water of plasticity 27.2%. Safe drying drying shrinkage 4.6%.	29 (1659°C, 3018°F)	02	2.7	17.7	Salmon, with dark and buff streaks.	Fairly hard.	Many very small dark specks at cone 13.
			3	4.9	14.0	Streaked, pale red.	Very hard.	
			6	5.7	12.2	Streaked, light pinkish red.	Steel hard.	
			13	6.5	8.8	Buff with brown and cream streaks.	Steel hard.	
2994 (Hilder property)	Rusty, iron stained chunks of clay (somewhat lighter than No. 2993), non-calcareous. Good plasticity, extrudes well under vacuum, water of plasticity 24.5%. Safe drying, drying shrinkage 4.7%.	30 (1665°C, 3029°F)	02	3.2	16.4	Light salmon with darker streaks.	Fairly hard.	Many very small dark specks at cone 13.
			3	4.4	12.7	Pale red with dark and cream streaks.	Steel hard.	
			6	5.3	10.4	Streaked pale pinkish buff.	Steel hard.	
			13	5.9	7.9	Streaked buff	Steel hard.	
2995 (Hilder property, sand No. 1)	Light grey, rather coarse sand with some whitish clay.							Too sandy for ceramic use.
2996 (Hilder property, sand No. 2)	Similar to No. 2995							Too sandy for ceramic use.

* 02 = 1101°C (2014°F); 3 = 1152°C (2106°F); 6 = 1201°C (2194°F); 13 = 1321°C (2410°F).

TABLE 2

Ceramic Properties of Samples from the Douglas Property

Clay No.	UNFIRED CHARACTERISTICS	P.C.E.	FIRED CHARACTERISTICS					REMARKS
			Cone No. *	Fired Shrinkage, %	Absorption, %	Colour	Hardness	
2980 (Mine 1, Pit 1)	Very light grey chunks of non-calcareous clay with a few iron stains, slightly sandy. Good plasticity, extrudes well under vacuum, water of plasticity 24.7%. Safe drying, drying shrinkage 5.0%.	31 (1683°C, 3061°F)	02	1.7	17.0	Off white pinkish shade.	Fairly soft.	Soft-fired specimens (Cones 02 and 3) developed a fairly heavy yellow-green (vanadium) efflorescence.
			3	3.0	15.7	White.	Hard.	
			6	4.7	12.1	White.	Very hard.	
			13	5.3	9.3	White.	Steel hard.	
2981 (Mine 1, Pit 2)	Cream chunks of non-calcareous clay with a few iron stains, very slightly sandy. Good plasticity, tendency to be greasy, extrudes fairly well under vacuum, some torn edges, water of plasticity 29.8%. Safe drying, drying shrinkage 4.6%.	31	02	3.0	20.2	Light pink.	Fairly soft.	Contains iron-bearing particles, which cause a few specks in the fired body.
			3	4.9	16.2	Light pinkish buff.	Hard.	
			6	6.3	13.0	Light buff.	Steel hard.	
			13	7.5	8.6	Cream.	Steel hard.	
2982 (Mine 1, Pit 3 Red)	A few grey, but mostly heavily iron-stained chunks of clay, non-calcareous. Good plasticity, extrudes well under vacuum, water of plasticity 27.1%. Safe drying, drying shrinkage 4.6%.	28 (1646°C, 2995°F)	02	3.2	17.1	Pale red.	Fairly hard.	Slight whitish scum at cone 13. A few dark specks at the higher firing temperatures.
			3	4.7	14.0	Light red.	Hard.	
			6	5.3	13.0	Red with cream streaks.	Very hard.	
			13	6.7	9.5	Streaked purplish pink and cream.	Steel hard.	
2983 (Mine 1, Pit 3 Grey)	Hard, varved, dark and light grey clay, some thin sandy seams, non-calcareous, very plastic, tendency to be greasy, extrudes well under vacuum, water of plasticity 28.1%. Safe drying, drying shrinkage 4.7%.	31	02	2.0	21.0	Light cream.	Very soft.	At cone 02 slight, and at cone 3 rather heavy Va efflorescence; at high temperature a brownish scum.
			3	3.0	19.2	" "	Fairly soft.	
			6	3.7	17.3	" "	Fairly hard.	
			13	4.3	15.7	" "	Hard.	
2984 (Mine 1, Pit 4)	Rusty, non-calcareous clay with some heavily iron-stained chunks. Good plasticity, extrudes well under vacuum, water of plasticity 26.4%. Safe drying, drying shrinkage 4.3%.	30 (1665°C, 3029°F)	02	2.3	18.5	Light pinkish buff with reddish and cream streaks.	Soft.	Light Va efflorescence at cone 02, becoming heavier at cone 3.
			3	3.3	16.1	" " "	Fairly hard.	
			6	4.0	14.6	" " "	Hard.	
			13	4.9	12.8	Light buff with brown streaks and specks.	Very hard.	
2985 (Mine 1, Pit A)	Grey, brown and buff chunks of clay, non-calcareous, few stones, some rather large (1/2"), sandy, good plasticity, extrudes very well under 28 in. vacuum, water of plasticity 21.7%. Safe drying, drying shrinkage 3.3%.	30	02	1.3	18.1	Off white, pinkish shade.	Soft.	At cone 6 a few rather coarse black specks, many dark, fused specks at cone 13.
			3	2.0	16.9	Very light cream, pinkish cast.	Soft.	
			6	2.7	15.2	Very light cream.	Fairly soft.	
			13	3.0	13.7	Very light cream.	Hard.	
2986 (Mine 1, Pit 7, Red and Grey)	Light grey iron-stained chunks of clay, non-calcareous, slightly sandy. Good plasticity, extrudes well under vacuum, water of plasticity 22.1%. Safe drying, drying shrinkage 4.8%.	31	02	2.0	14.8	Pale pinkish buff.	Fairly hard.	Probably contains hematite, causing very small dark specks at cone 13. Fired surfaces lightly crazed.
			3	3.3	12.1	Light buff, pinkish cast.	Very hard.	
			6	4.5	9.6	Light buff.	Steel hard.	
			13	4.7	8.0	Light buff.	Steel hard.	

TABLE 2 (continued)

Clay No.	UNFIRED CHARACTERISTICS	P.C.E.	FIRED CHARACTERISTICS					REMARKS
			Cone No.	Fired Shrinkage %	Absorption %	Colour	Hardness	
2987 (Mine 1, Pit 7, Brown)	Light greyish brown, partly iron-stained chunks of clay, non-calcareous, very slightly sandy. Very plastic, tough, greasy, difficult to extrude, torn edges, water of plasticity 30.4%. Safe drying, drying shrinkage 5.2%.	31 (1683°C, 3061°F)	02	3.7	19.2	Light pinkish buff	Hard.	Surface hairline cracks in firing. Many small dark and light specks give a finely mottled appearance.
			3	5.7	14.0	" " "	Steel hard.	
			6	7.3	8.6	" " "	Steel hard.	
			13	8.2	5.9	Light buff.	Steel hard.	
2988 (Mine 1, Pit 7, Grey)	Light grey chunks of clay, non-calcareous, fairly sandy. Good plasticity, extrudes well under vacuum, water of plasticity 21.8%. Safe drying, drying shrinkage 4.3%.	31	02	1.2	18.6	Almost white.	Soft.	Probably contains hematite. At cones 02 and 3 surfaces are marred by Va efflorescence. Many tiny specks, becoming darker with increased firing temperature.
			3	2.0	16.9	White.	Soft	
			6	2.9	14.6	Off white.	Soft.	
			13	3.7	12.6	Off white.	Hard.	
2989 (Mine 1, Pit 7, Black)	Greenish grey, partly weathered clay, non-calcareous. Good plasticity, extrudes well under vacuum, water of plasticity 31.7%. Cracks internally lengthwise and splits open after rapid drying, drying shrinkage 7.9%	7 (1215°C, 2219°F)	08	2.0	15.1	Medium reddish brown.	Fairly hard.	Slight whitish scum on edges.
			06	3.0	13.0	" " "	Steel hard.	
			04	6.4	6.1	Medium brownish red.	Steel hard.	
			02	8.9	0.0	Dark brownish red.	Vitrified.	
2990 (Mine 2, Sand)	Very light grey sand with some clay, contains a few dark, small stones.							Too sandy for any ceramic use.
2991 (Mine 2, B.C.)	Light grey chunks of clay, non-calcareous, contains some roots and many small stones. Although very sandy, has a good plasticity and extrudes well under vacuum, water of plasticity 20.5%. Safe drying, drying shrinkage 3.3%.	30 (1665°C, 3029°F)	02	0.7	17.4	Almost white.	Soft.	At cones 02, 3 and 6, surfaces are marred with Va efflorescence. Many grey specks (sand) and a few iron specks.
			3	1.3	16.2	Very light cream.	Soft.	
			6	2.0	15.0	" " "	Soft.	
			13	2.5	13.5	" " "	Fairly hard.	
2992 (Mine 2, B.C.)	Tan chunks of clay, non-calcareous, contains some roots, many small stones and is very sandy. Has good plasticity, extrudes well under vacuum, water of plasticity 19.1%. Safe drying, drying shrinkage 4.0%.	28 (1646°C, 2995°F)	02	0.7	15.1	White, with pinkish cast.	Soft.	Light Va efflorescence at Cone 3. Above Cone 6, surfaces are mottled with grey specks (sand), black specks (iron), and greyish, fused specks.
			3	1.0	14.0	Light cream.	Fairly soft.	
			6	2.0	12.7	Light cream.	Fairly soft.	
			13	2.0	11.6	Light cream.	Hard.	

* 08 = 945°C (1733°F); 06 = 991°C (1816°F); 04 = 1050°C (1922°F); 02 = 1101°C (2014°F); 3 = 1152°C (2106°F); 6 = 1201°C (2194°F); 13 = 1321°C (2410°F).

DISCUSSION AND CONCLUSIONS

Two of the samples from the Hilder property, No.'s 2995 and 2996, and No. 2990 (Mine 2, sand) from the Douglas property were considered to contain too little clay substance to be of any commercial value for clay products, and were not further evaluated. If beneficiated, however, they might prove a useful source of silica sand for glass-making.

The other two samples from the Hilder property, No.'s 2993 and 2994, are nearly identical, the former being a little more heavily contaminated with iron. Both just qualify as medium-heat duty fire clays, and fire to a fairly dense condition at temperatures normal to the industry. Medium-heat duty fire-brick are widely used, e.g., in the backs of boiler settings, removed from the direct flame.

Sample No. 2989, from the Douglas property (Mine 1, Pit 7, black), is a common red-burning clay of moderate fusion point. Its drying properties are extremely poor and it vitrifies too rapidly above cone 06 to be of commercial value for clay products.

Most of the other samples from the Douglas property qualify as medium-heat duty fire clays, having PCE's between cones 29 and 31½, as specified in ASTM Designation: C 27-66, "Standard Classification of Fireclay and High-Alumina Refractory Brick". The refractoriness of Sample No. 2982 (Mine 1, Pit 3 - red) is no doubt reduced below the above limit owing to its high iron content, because of which the red coloration persists in specimens fired as high as cone 13. The other low-PCE sample, No. 2992 (Mine 2, B.C.), is not, however, highly contaminated by iron. The higher-fired specimens show a number of greyish, glassy specks on the surfaces, attributed to fusion of mica fragments: the introduction of alkalies as mica impurities could account for the

reduced PCE, compared with the neighboring sample No. 2991 (Mine 2, B.C.). Both of these samples from Mine 2 could probably be substantially upgraded by washing to remove coarse silica, particulate iron and mica flakes.

Among the remainder of the samples from the Douglas property, four fire to a relatively open body of off-white coloration: No. 2980 (Mine 1, Pit 1), No. 2983 (Mine 1, Pit 3, grey), No. 2985 (Mine 1, Pit A) and No. 2988 (Mine 1, Pit 7, grey). Samples No. 2980 and 2983 have the cleanest appearance, although the latter contains some soluble salts that migrate to the surfaces during drying and subsequently react during firing to form a discolouring scum. Samples No. 2985 and No. 2988 both contain particulate iron-bearing impurities that produce black spots on the fired specimens: the former contains the greater number and the larger impurities. Except for No. 2985, these open-firing samples contain vanadium impurities which cause a yellow-green efflorescence on the fired specimens when wetted and dried. This is of no significance in fireclay brick, which are never wetted in service, nor for dense, impermeable bodies. It could present problems if the clays were used as components of non-vitrified ceramic bodies, e.g., earthenware.

The four remaining samples, No. 2981 (Mine 1, Pit 2), No. 2984 (Mine 1, Pit 4), No. 2986 (Mine 1, Pit 7, red and grey) and No. 2987 (Mine 1, Pit 7, brown), all fire to some shade of pink or buff and their usefulness would probably be restricted to fireclay refractory brick. Sample No. 2984 is relatively open-firing, whereas the other three are plastic, dense-firing fire clays.

KEB/LKZ/am