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Differential thermal analysis: a means of identifying soil samples from Barbados, Trinidad, Tobago, St. Vincent, Jamaica and Guyana

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Abstract

Thermo-analytical curves over the temperature range 50–1000°C were obtained for 66 soil types of which 37 were from Barbados, 15 from Trinidad, five from Tobago, five from St. Vincent, three from Jamaica, and one from Guyana. Endothermic and exothermic peak areas under these curves were determined and used as the basis of a system derived for identifying soil types. In this system curves for different soil types were unique with respect to occurrence of endothermic and exothermic peaks and the magnitude of their corresponding peak areas. On re-examination of a selected number of soil samples after 18 months storage, each soil showed the same number of peaks at the same temperature but with altered intensities and in most cases a reduction in peak size, changes consistent with desiccation and spontaneous decomposition. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Peak area; Endothermic; Exothermic; Wholesoil; Soil group

1. Introduction

The major soil constituents including carbonates, organic matter, sand, clay and moisture all undergo thermal reactions when heated in the temperature range 50–1000°C. These reactions and the corresponding temperatures at which they occur can be determined by DTA. Some typical examples are shown in Table 1 [1]. Soils differing in constituents will generate thermal peaks reflecting the uniqueness of each soil [2]. Accordingly, thermal peaks can be used for quantitative and qualitative assessment of soil constituents.

DTA was first applied to soil research as an analytical method in the determination of kaolinite content of clays [3–5]. One problem with the application of DTA for assessment of wholesoils is that exothermic peaks often associated with the presence of organic matter are superimposed on endothermic peaks associated with clay, sand and silt fractions. For example, it has been demonstrated by Smothers and Chang [6] that organic matter present in a Madison surface soil obscured endothermic peaks for clay fractions at 98 and 270°C. For this reason there is limited use of DTA in studies of whole soils [7,8].

Soils of the Caribbean territories of Trinidad, Tobago, St. Vincent, Jamaica, Guyana and Barbados have been classified based on pedogenic, topographic and drainage characteristics and colour, texture and chemical properties to a lesser extent [9–16]. Soils of

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Table 1
Summary of the activity associated with the differential thermal analysis of wholesoil

Peak temperature (°C)	Thermal process of soil constituents	Enthalpy of reaction[a]
125	Loss of adsorbed H_2O from clay and organics	Endothermic
340	Oxidation and combustion of soil organic matter	Exothermic
505	Dehydroxylation of kaolinite and vermiculite	Endothermic
540	Decomposition of vermiculite	Exothermic
575	α–β transformation of SiO_2	Endothermic
810	Decarboxylation of clay-sized carbonate	Endothermic
910	Recrystallization of illite and montmorillonite	Exothermic
940	Recrystallization of kaolinite	Exothermic

[a] Enthalpy changes associated with corresponding peak temperatures.

Trinidad and Tobago are derived from claystone, sandstone or alluvium deposits, all of which were also found among soils from Guyana and Jamaica which also possesses soil of volcanic, shale or igneous origin. Soils of St. Vincent are of the three latter types whereas soils from Barbados are derived from alluvial deposits and sedimentary limestone.

Methods for determining physical and chemical properties for the purpose of soil classification or identification are cumbersome and time consuming as routine procedures [17–19]. In contrast, DTA is a rapid technique requiring availability of small samples (30–75 mg) only and when applied to soils, the data obtained are reproducible. In this study, the results of DTA of 66 soils obtained from six Caribbean territories are reported. A soil identification scheme based on these results is also proposed.

2. Experimental

The soil identification scheme outlined by Vernon and Carroll [16] was used by the authors in conjunction with the Soil Map of Barbados to select 37 soil types which represent all soil associations found on the island. Composite samples of each soil type were obtained by mixing 30 randomly selected soil cores (3 cm diameter and 30 cm long). The depth of each core represents the Ap1 and Ap2 Horizons for all soils and the B, C and G Horizons, when present [20]. Samples of 29 additional previously identified Caribbean soil types, obtained from the Soil Science Department, Faculty of Agriculture, St. Augustine Campus, University of the West Indies were used in the present study also [9–13]. All soils were originally obtained from lands under grass or sugarcane cultivation for 15–20 years.

Common soil associations of Barbados include red brown, yellow brown and St. John Valley, all resembling the Ustalts of the Alfisol order, and St. George Valley, St. Philip Plain, grey brown and Black all of which are likened to Usterts of the Vertisol order [20]. Soil samples representative of the Vertisol order and are collectively referred to as alluvials, were among samples from Jamaica, Trinidad and Tobago. The samples taken from Guyana and Jamaica were peats representing the Histosols order. Non-cracking, chocolate-coloured clays, assigned to the Mollisols order, were among the soil samples examined from Trinidad and Tobago. Samples from St. Vincent were young volcanic soils and yellow brown earths designated to the Insectisols order and Ultisols and Oxisols orders, respectively.

Soil samples were air-dried, and sieved using a 0.2 mm mesh and then suspended in deionized water to facilitate removal of unwanted materials, including plant debris. Soils were air-dried again and then ground in a mortar until homogeneous mixtures were obtained [21]. Soil samples, ranging from 30 to 75 mg in weight, were placed in platinum crucibles and heated in the temperature range 50–1000°C using a Du Pont 910 DSC Thermal Analyzer equipped with platinum–rhodium thermocouple and providing a heating rate of 20°C min^{-1} for observation of endothermic and exothermic peaks (Table 1). Heating was done under atmospheric conditions with no purge gas flowing through the system. A total of 66 soil types were heated.

The type and intensity of soil-based chemical reactions induced by temperature were identified by reference to thermo-analytical curves generated by DTA. Heat treatment of selected soil types was replicated once and the experiment was done twice.

The extent to which the occurrence and intensity of thermal reactions are affected by the duration of storage of soil was also investigated. In this investigation, two samples each of the 122-Joe's River Mud (normal), the 47-grey brown (sandy), the 64-St. John Valley (poorly drained) and the 65-St. John Valley (well drained) soil groups of Barbados were heated as previously described after 18 months storage to obtain thermo-analytical curves.

The possibility that peak area of ensuing thermo-analytical curves was linearly correlated with soil mass was investigated. The investigation was conducted by determining the linear correlation coefficient of a plot between peak areas and mass of each soil type used in the present study. The relationship between peak area and sample mass was assessed also using $CaCO_3$ (3–36 mg) of high quality (Analar BDH, UK) and in the form of limestone underlying most soils of Barbados. The calcium carbonate was prepared and heated as described for soils.

The temperature reliability and calorimetric sensitivity of the unit were given as ±1°C and 0.2 m cal s^{-1} $in.^{-1}$, respectively. The instrument was set at time base: 2.5; zero shift; range: 0.4 mV/cm; *Y*: zero shift; range: 20 mV/cm; and *Y*-axis at *y* and calibrated using pure potassium nitrate (Analar BDH, UK) and <2 μm calcined alumina.

3. Results and Discussions

Thermo-analytical curves obtained for the 66 soil samples were interpreted in accordance with the characteristic peaks observed by Smothers and Chang [6] and Schritzer [22] who associated specific physical phenomenon and chemical reactions with up to four endothermic and four exothermic peaks observed (Table 1).

The thermal notation developed in this study for identification of soils previously classified on the basis of chemical, physical and hydrological properties [16] requires conformation that all peaks identified in the present study relate to decomposition of specific minerals and soil constituents. Absence of characteristic peaks may be attributed to either the superimposition of exothermic and endothermic peaks on each other or the absence of specific soil constituents.

All reactions associated with DTA curves which were previously described by Tan et al. [1] were recognized for curves of separate soil constituents including carbonate, sand, pure clays and organic matter (H.A. Gibbs, unpublished data). The exothermic peak at 540°C, which was not described by Tan et al. [1], was observed as a strong decomposition peak for humic acid extracted from selected Barbadian soil types (H.A. Gibbs, unpublished data). DTA curves of pure clays including vermiculite, illite, montmorillonite and kaolinite obtained from the Soil Science Department, Faculty of Agriculture, St. Augustine Campus, University of the West Indies were used to confirm peak assignment at 505, 910 and 940°C.

In the present study, thermo-analytical curves of soils belonging to the same group shared many common features. Four curves, each representing a soil type of the grey brown association of Barbados and designated B, C, D and F and one representing a St. John Valley clay and designated E in Fig. 1, are presented as examples. Samples B, C and D, which appear similar in Fig. 1, all differ in the intensity of the endothermic and exothermic peaks at 810 and 910°C, respectively (Table 6). Each curve exhibited weak endothermic peaks associated with thermal reactions involving moisture and organic matter at 125 and 340°C, respectively.

Organic matter content of all samples ranged from 0.57 to 6.69% [2] and was too low to reveal the double exothermic peaks associated with peats and other soils rich in organic matter. Large endothermic peaks at 810°C are present also and reveal the typical calcareous nature of these Barbadian soil types.

Of the peaks of thermo-analytical curves obtained for 66 soil types used in the present study, only those occurring at 125 and 340°C were invariably present. None of the soil types were associated with all peaks. The distribution of peaks amongst the soil types is shown in Tables 2 and 3.

Each soil sample used in the DTA was of a different mass and therefore the weight-related standardization of the thermo-analytical curves was done to allow direct comparison of thermal characteristics of each soil sample examined. Standardization consisted of converting peak areas of the curves to peak area per 100 mg soil.

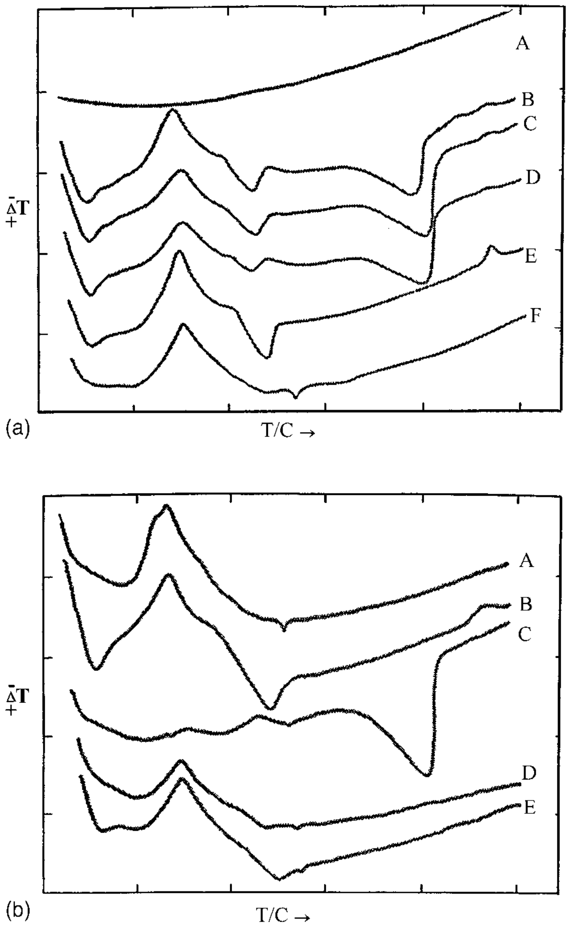

Fig. 1. (a) DTA patterns of an empty platinum crucible and five Barbadian soil types obtained using the Du Pont 910 DSC Thermal Analyzer. Curves specifically represent: A, empty crucible (baseline); B, 41-grey brown (normal); C, 40-grey brown (normal); D, 42-grey brown (very shallow); E, 65-St. John Valley (well drained); F, 103-grey brown (oceanic). (b) DTA patterns of four Trinidadian and one Tobagonian soil types obtained using the Du Pont 910 DSC Thermal Analyzer. Curves specifically represent: A, 81-Maracas SCL; B, 171-Talparo C; C, Tobago No. 1; D, River Estate; E, Cunupia.

Standardization was possible because of observation of a linear relationship between soil mass and peak areas of thermo-analytical curves as indicated by the linear regression coefficient of 0.975 obtained.

Calcium carbonate which gave a large distinct exothermic peak at 810°C was used to confirm the linearity between mass and peak areas of DTA curves. Linear regression coefficients (*r*) of 0.979 and 0.999 for plots of square root of peak area versus mass were obtained for pure and limestone-derived calcium carbonate, respectively. The peak area data derived for soil samples from Barbados and the other Caribbean territories using standardized DTA curves are tabulated (Tables 2 and 3).

The standardized endothermic and exothermic peaks, and their corresponding temperatures were used to develop a soil identification scheme. Each set of four standardized endothermic and exothermic peak areas associated with each soil type and denoted by E and X, respectively, were divided into class intervals designated as A, B, C and D. Class intervals were generated by dividing the range of the peak area associated with the corresponding temperature into four equal sectors as shown in Tables 4 and 5. Another class interval, O, was used to indicate the absence of a peak.

The combination of class intervals associated with the endothermic and exothermic peak areas was then determined from the thermo-analytical curve of each soil type. The combination of class intervals, referred to as the ‘‘EX’’ notation in this study, was characteristically different for each soil type tested in the present study (Tables 6 and 7).

The possibility that soil chemical and physical properties may influence DTA curves was investigated. In an attempt to determine the influence of chemical composition on peak size and in the absence of X-ray diffraction data, other soil parameters including TEB, CEC, percent organic carbon and percent clay were used to correlate with thermal properties. All statistical analyses were performed using the Minitab Microcomputer program (Making Data Analysis Easier, State College, PA).

Linear correlation analysis showed that there is a significant relationship between thermal properties and mineralogical composition of each Barbadian soil type. Peaks observed at 125 and 340°C were the only peaks present in all DTA curves and therefore it was on this basis that peak areas associated with these temperatures were selected for correlation with chemical and physical properties of each Barbadian soil type.

A correlation coefficient (*r*) of 0.348 was obtained for the correlation of peak area at 340°C with percent organic carbon, whereas coefficients of 0.521, 0.498 and 0.587 were obtained for correlations of peak area

Table 2
Peak areas (mm^2 100 mg^{-1}) determined for 37 Barbadian soil types using differential thermal analysis

Soil association[a]	Endothermic peak area				Exothermic peak area			
	125°C	505°C	575°C	810°C	340°C	540°C	910°C	940°C
41-Grey brown (normal)	596.5	622.7	–[b]	1821	1947	219.8	34.01	34.01
40-Grey brown (normal)	555.3	356.3	4.63	22.91	1222	121.5	–	27.76
42-Grey brown	825.6	273.1	–	2582	1499	93.11	–	49.66
81-Coastal (association)	1117	313.8	7.13	1564	1783	166.4	–	26.15
41/40-Grey brown (normal)	1065	574.8	–	1308	1728	225.5	74.33	37.17
10-St. Philip Plain	472.8	246.3	17.42	2588	1095	74.65	37.32	–
30-Black (normal)	1280	775.6	–	478.3	5933	258.5	25.85	–
65-St. John Valley	651.9	1358	–	–	3441	–	–	246.3
64-St. John Valley	524.6	1695	–	163.4	2825	–	–	240.1
54-Yellow brown	963.4	788.7	–	957.7	2599	2169	105.6	–
103-Grey brown (oceanic)	312.2	–	–	3560	876.2	–	71.19	–
110-Red brown (oceanic)	637.8	124.0	–	1533	2539	–	–	–
115-Bissex Hill (oceanic)	621.1	112.9	6.27	903.4	4548	53.33	–	–
122-Joe's River Mud	515.2	–	16.73	–	2559	–	–	–
173-Scotland sandstone	92.75	28.99	57.97	–	2087	–	–	–
47-Grey brown (sandy)	294.4	299.5	19.20	384.0	1382	81.93	12.80	–
48-Grey brown (leeward)	453.4	850.1	9.45	188.9	1850	–	–	141.7
70-Red sand	324.6	297.8	57.27	34.36	580.4	–	45.82	–
42/40-Grey brown (normal)	610.6	403.5	4.27	2172	1435	121.7	85.40	–
32-Black (shallow)	1273	630.0	–	270.0	2440	247.5	48.22	–
80-Coastal (normal)	2776	377.2	–	125.7	2137	85.49	140.8	–
86-Coastal (south coast)	1929	287.0	–	858.8	1894	58.55	119.4	–
61-Red sand (shallow)	592.7	1621	6.97	120.3	2353	–	–	287.7
60-Red brown (normal)	849.7	1412	–	44.14	3443	–	25.75	271.0
131-Scotland sandstone	99.41	253.3	44.19	–	1479	–	–	–
172-Alluvial	186.8	253.3	16.89	443.4	950.1	–	–	–
141-Alluvial	273.9	106.5	15.22	–	2276	–	–	–
20-St. George Valley	273.9	847.7	–	585.9	2166	–	100.5	–
12b-St. Philip Plain	955.2	498.4	–	988.5	2166	–	100.5	–
171-Alluvial	471.2	–	16.66	–	5245	–	–	–
13-St. Philip Plain	529.4	330.8	–	3275	661.5	–	–	–
174-Alluvial	568.7	265.4	–	1769	4738	190.5	71.08	94.76
84-Coastal (leeward)	235.3	408.6	19.62	2043	2287	98.56	–	–
81-Coastal (shallow)	636.0	473.4	9.57	1020	2552	96.15	63.77	–
42-Grey brown (shallow)	185.2	514.3	–	4105	2593	139.7	51.43	34.28
50-Yellow brown	303.5	956.5	–	1020	2071	153.8	163.2	–
71-Red sand (dark)	286.0	317.7	11.55	2304	2253	156.0	–	40.44

[a] Prefixed mapping units and associated soil group as described by Vernon and Carroll [16].

[b] Indicates no associated peaks were found at the temperatures indicated.

at 125°C with TEB, CEC and percent clay, respectively. These coefficients were all significant ($P < 0.05$). These results indicate that clay content and, to a lesser extent organic matter, have profound effects on Barbadian soil types differentiated on the basis of their thermal properties.

When compared to the earlier scheme [8–12] used to identify soils of the Caribbean, the current thermal approach is more objective and less time consuming. The notation developed above successfully differentiated the 37 soil types of Barbados and is therefore recommended for identification of these soils. In addition DTA also proved useful in the identification of 29 additional soils from five other Caribbean territories. However, even though investigations were carried out on podzolic, lateritic and rendzina only,

Table 3
Peak areas (mm^2 100 mg^{-1}) determined by differential thermal analysis of 29 soil samples taken from five Caribbean islands (Trinidad and Tobago, Guyana, St. Vincent, Jamaica)

Soil association[a]	Endothermic peak area				Exothermic peak area			
	125°C	505°C	575°C	810°C	340°C	540°C	910°C	940°C
474/L Princestown C	545.7	801.8	–[b]	–	1218	–	–	55.86
41 Blanchissuse	183.6	–	11.98	1697	–	–	–	–
233 River Estate	255.2	280.7	12.76	4884	89.30	167.7	–	–
139 Cromaty C	720.7	50.50	–	18.77	6331	325.3	–	–
81 Maracas SCL	362.8	46.28	66.64	–	1369	–	–	–
143 St. Augustine	284.8	194.2	31.07	–	951.5	25.89	–	–
335 Sevilla C	472.3	297.8	17.49	–	3289	–	–	–
68/L Monseratt C	1071	112.0	9.22	–	6294	50.72	–	–
55/241 Piarco/	192.3	97.15	54.65	–	364.3	15.18	–	15.18
Las Lomas FSL/FSC	322.2	–	16.96	–	1119	11.30	12.72	–
278/L tarouba C	319.1	142.1	25.84	–	3225	113.7	–	–
82/L Diego Martin FSL	286.8	103.4	31.00	–	1424	25.19	–	–
575 Moruga FSC	289.0	108.4	7.22	–	2059	26.49	–	–
177 Talparo FSL	811.5	626.8	–	–	1045	15.90	–	104.1
33 Cunupia FSC	321.7	162.2	11.29	–	632.0	18.81	–	–
55 Piarco FSL	193.9	–	46.37	–	3113	–	5.19	7.78
32 Crown Point Clay (0–5 in.)	3381	147.3	14.14	–	678.5	–	–	–
32 Crown Point Clay (16–29 in.)	924.4	146.6	–	–	132.8	–	111.6	–
30 Crown Point Clay (9–18 in.)	869.2	869.2	–	–	279.4	–	161.7	–
30 Crown Point Clay (0–9 in.)	30.73	33.17	10.48	6678	41.90	–	–	–
32 Sereviche CL	561.2	431.7	–	841.8	1655	79.15	–	86.34
Soufrier Cindery Gravelly	1370	165.6	–	–	1662	36.12	–	33.86
Greggs Clay Loam	425.4	877.6	–	–	2731	169.6	–	–
Akers SCL	511.5	211.5	–	–	306.7	26.92	28.85	–
Claxton CL	955.7	726.5	–	–	1012	262.4	–	57.66
Montreal	1560	81.28	–	–	667	48.77	–	–
Morass Peat	1174	141.7	–	–	23456	337.4	–	–
Linstead CL	323.8	364.3	7.08	1105	1102	32.38	–	44.53
Cave Valley C	1145	712.2	–	–	6528	101.7	–	56.52
Guyana Frontline Clay	828.1	394.4	–	–	499.5	–	–	–

[a] Prefixed land capability survey number and profiles as described by Havord (1961).

[b] Indicates no associated peaks were found at the temperatures indicated.

Table 4
Ranks of class intervals derived from the endothermic peaks of thermo-analytical curves associated with wholesoils

Assigned rank to class intervals	Class interval of peak area[a] (mm^2 100 mg^{-1}) at corresponding temperature			
	125°C	505°C	575°C	810°C
O	0	0	0	0
D	1–700	1–425	1–30	1–1051
C	701–1400	426–850	31–60	1050–2100
B	1401–2100	851–1275	61–90	2101–3150
A	2101–2800	1276–1700	91–120	3151–4200

[a] Class intervals were generated by subdividing the range of peak areas from each temperature into four equal sectors.

Table 5
Ranks of class intervals derived from the exothermic peaks of thermo-analytical curves associated with wholesoils

Assigned rank to class intervals	Class interval of peak area[a] (mm^2 100 mg^{-1}) at corresponding temperature			
	340°C	540°C	910°C	940°C
O	0	0	0	0
D	1–1500	1–550	1–45	1–75
C	1501–3000	551–1100	46–90	76–150
B	3001–4500	1101–1650	91–135	151–225
A	4501–6000	1651–2200	135–180	226–300

[a] Class intervals were generated by subdividing the range of peak areas from each temperature into four equal sectors.

Table 6
Relationship between "EX" notation derived from thermo-analytical curves and identification of 37 Barbadian soil types

Sample station[a]	"EX" notation (E_{1234}/X_{1234})[b]	Soil type
Edgecumbe (St. Philip)	DCOC/CDDD	41-Grey brown (normal)
Hampton (St. Philip)	DDDB/DDOD	40-Grey brown (normal)
National Hatcheries (St. Philip)	CDOB/DDOD	42-Grey brown (very shallow)
Home Agricultural Station	CDOD/CDOD	81-Coastal Association
Bushy Park (St. Philip)	CCOC/CDCD	41/40-Grey brown (normal)
Three Houses (St. Philip)	DDDB/DDDO	10-St. Philip Plain
Gov't Livestock (St. Michael)	CCOD/ADDO	30-Black (normal)
Sherbourne (St. John)	DAOO/BOOA	65-St. John Valley (well drain)
Wakefield (St. John)	DAOD/COOA	64-St. John Valley (poorly drain)
Society Plantation (St. John)	CCOD/CABO	54-Yellow brown
Mt. Cannel Heights (St. John)	DOOA/DOCO	103-Grey brown oceanic
Bissex Hill (St. Joseph)	DDOD/COOO	110-Red brown oceanic
Cambridge (St. Joseph)	DDOD/ADOO	115-Bissex Hill oceanic
St. Sylvan's (St. Joseph)	DODO/COOO	122-Joc's River mud (normal)
Chalky Mt. (St. Andrew)	DDCO/COOO	173-Scotland SS alluvial
Seaview (St. James)	DDDD/DDDO	47-Grey brown sandy
Hope Plantation (St. Thomas)	DBDD/COOC	48-Grey brown leeward
Sixmen's Plantation (St. Peter)	DDCD/DOCO	70-Red sand
Pickerings (St. Lucy)	DDDB/DDCO	42/40-Grey brown (normal)
Forte George (St. Michael)	CCOD/CDCO	32-Black (shallow)
Chanchery Lane NE (Christ Church)	ADOD/CDAO	80-Coastal (normal)
Chanchery Lane SE (Christ Church)	BDOD/CDBO	86-Coastal (coastal variant)
Mount Wilton (St. Joseph)	DADD/COOA	61-Red brown (shallow)
Easy Hall (St. Joseph)	CAOD/BODA	60-Red brown (normal)
Haggatts (St. Andrew)	DDCO/DOOO	131-Scotland sandstone
Greenland (St. Andrew)	DDDD/DOOO	172-Alluvial
Belleplaine (St. Andrew)	DDDO/COOO	141-Alluvial
Carmichael (St. George)	DCOD/COBO	20-0 St. George Valley
River Plantation (St. Philip)	CCOD/COBO	12b-St. Philip Plain
Cattlewash (St. Joseph)	DODO/AOOO	171-Alluvial
Sterlin and Kirton (St. Philip)	DDOA/DOOO	3-St. Philip Plain
Cattlewash (St. Joseph)	DDOC/ADCC	174-Alluvial
Sixmen's Bay (St. Lucy)	DDDC/CDOO	84-Coastal (leeward)
Piecorner (St. Lucy)	DCDD/CDCO	81-Coastal (shallow)
Mt. Gay Factory (St. Peter)	DCOA/CDCD	42-Grey brown (shallow)
Castle Estate (St. Lucy)	DBOD/CDAO	50-Yellow brown (normal)
Barrow's (St. Lucy)	DDDB/CDOD	71-Red sands (dark variant)

[a] Location in Barbados where soil samples were obtained.

[b] 1, 2, 3 and 4 indicate endothermic (E) and exothermic (X) peaks of thermo-analytical curves of soil in the direction of increasing temperature (Table 1). O represents the absence of a peak whereas, A, B, C or D indicate the class interval or intensity of the corresponding peak (see Tables 4 and 5).

based on the above results it seem feasible to suggest that the method can differentiate major soil types found within the geographic region.

In an attempt to test the effect of storage on the "EX" notation scheme, four samples were selected from the Barbadian soils and re-examined 18 months later. With the exception of peaks at 575, 810 and 910°C of the thermo-analytical curves associated with the 122-Joe's River Mud (normal) and 47-grey brown (sandy) soil groups, there is a general decrease in peak areas of all other thermo-analytical curves obtained after 18 months storage (Table 8). According to Ahmad [23], this phenomenon is attributed to the spontaneous decomposition of clay minerals as well as loss of water during storage. Though storage had no apparent effect on the "EX" notation, differential

Table 7
Relationship between “EX” notation derived from thermo-analytical curves and identification of 29 soil types from five Caribbean territories

Sample station[a]	“EX” notation (E_{1234}/X_{1234})[b]	Soil type
Trinidad	DCOO/DOOD	474/L-Princestown C
	DODO/OOOO	41 Blanchissuse
	DDDA/DDOO	223 River Estate
	CDOD/ADOO	139 Cromaty C
	DDBO/DOOO	81 Maracas SCL
	DDDO/BOOO	143 St. Augustine
	DDDO/BOOO	335 Sevilla C
	CDDO/ADOO	68/L Monsteratt C
	DDCO/DDOD	55/241 Piarco/Las Lomas FSL/FSC
	DODO/DDDO	278/L Tarouba C
	DDDO/BDOO	82/L Diego Martin FSL
	DDDO/CDOO	575 Moruga FSC
	CCOO/DDOC	177 Talparo FSL
	DDDO/DDOO	33 Cunupia FSC
	DOCO/BODD	55 Piarco FSL
Tobago	DODO/DDOO	32 Crown Point Clay (0–5 in.)
	CBOO/DOAO	32 Crown Point Clay (16–29 in.)
	CDOO/DOBO	30 Crown Point Clay (9–18 in.)
	DCOD/CDOC	30 Crown Point Clay (0–9 in.)
	DDDA/DOOO	32 Sereviche CL (29–32 in.)
St. Vincent	CDOO/CDOD	Soufrier Cindery Gravelly
	DBOO/CDOO	Greggs Clay Loam
	DDOO/DDDO	Akers SCL
	CCOO/DDOD	Claxton CL
	BDOO/BDOO	Montreal
Jamaica	CDOO/ADOO	Morass Peat
	DDDD/DDOD	Linstead CL
	CCOO/ADOD	Cave Valley C
Guyana	CDOO/DOOO	Guyana Frontline C

[a] Location where soil samples were obtained.

[b] 1, 2, 3 and 4 indicate endothermic (E) and exothermic (X) peaks of thermo-analytical curves of soil in the direction of increasing temperature (Table 1). O represents the absence of a peak whereas, A, B, C or D indicate the class interval or intensity of the corresponding peak (see Tables 4 and 5).

Table 8
Differential thermal analysis of four soils showing reduced peak areas after 18 months storage at room temperature

Soil group showing first and second analysis	Endothermic peak area				Exothermic peak area			
	125°C	505°C	575°C	810°C	340°C	540°C	910°C	940°C
65-St. John Valley (wd)[a,b]	651.9	1358	–[c]	–	3441	–	–	246.3
65-St. John Valley (wd)[d]	631.4	1313	–	–	3143	–	–	236.9
64-St. John Valley (pd)[b]	524.6	1695	–	163.4	2825	–	–	240.1
64-St. John Valley (pd)[d]	430.6	1682	–	83.36	2011	–	–	228.3
122-Joe’s River Mud (n)[b]	515.2	–	16.73	–	2559	–	–	–
122-Joe’s River Mud (n)[d]	383.0	–	18.42	–	2127	–	–	–
47-Grey brown sandy[b]	294.4	299.5	19.20	384.0	1382	81.93	12.80	–
47-Grey brown sandy[d]	32.16	213.3	15.17	407.7	646.0	22.75	39.82	–

[a] Represent hydrological properties of soils: wd, well drained; pd, poorly drained; n, normal.

[b] First analysis of soil samples.

[c] Second analysis of soil samples.

[d] Indicate no associated peaks were found at the temperatures indicated.

thermal analysis as a basis for soil identification seems better suited to freshly collected samples.

4. Conclusions

Results for DTA of soils tested in the present study indicate that the "EX" notation can be used for easy and quick identification of the soil types in Barbados and other Caribbean territories. Significant correlations for thermal properties with properties used in the soil classification scheme of Vernon and Carroll, namely chemical and physical properties, imply that this index can replace the current method of classifying these soils. This method of classification has an advantage over any scheme which employs chemical and physical analysis because it is less tedious and requires very small soil samples.

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