Some Curves from a Portable Differential Thermal Analysis Unit

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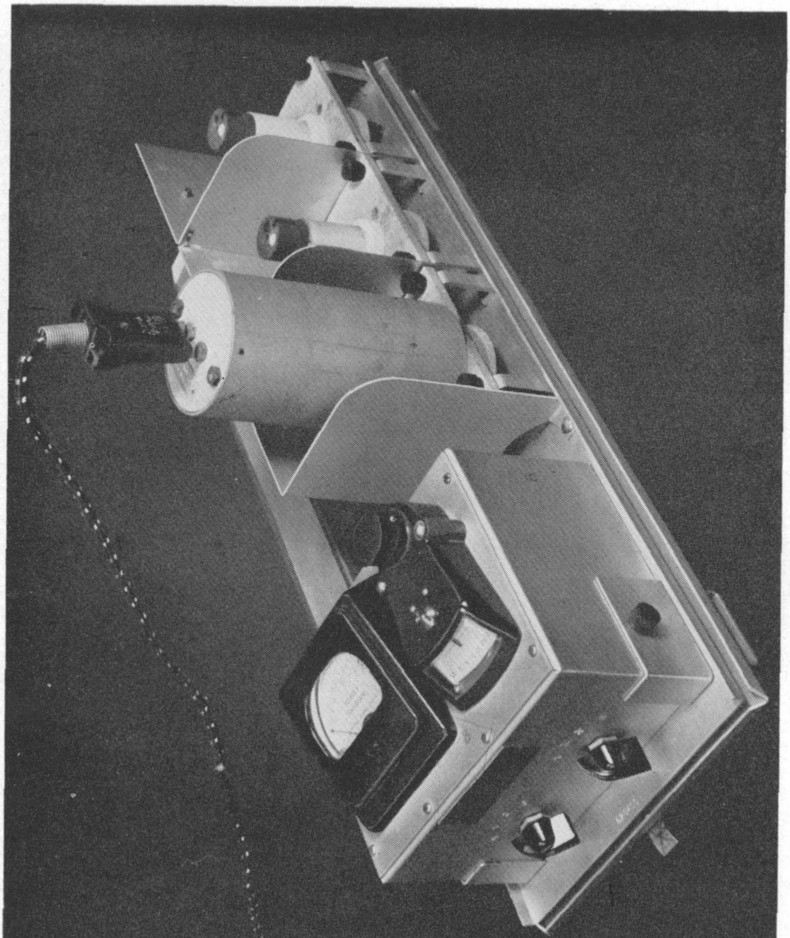

PORTABLE DIFFERENTIAL THERMAL ANALYSIS UNIT

A CONTRIBUTION TO GENERAL GEOLOGY

SOME CURVES FROM A PORTABLE DIFFERENTIAL THERMAL ANALYSIS UNIT

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ABSTRACT

Differential thermal analysis curves obtained with a portable unit are given for some standard clay minerals and other materials commonly associated with clays.

INTRODUCTION

Hendricks, Goldich, and Nelson (1946) described a portable device for obtaining differential thermal curves. Portable differential thermal analysis units have since been used in studies of lateritic soils (Goldich and Bergquist, 1947, p. 55; 1948, p. 65) and have been applied to the identification of clay minerals and other aluminous materials by various workers in the U. S. Geological Survey. Inasmuch as the curves obtained with these instruments are not always comparable with those obtained using standard differential thermal analysis apparatus, the authors feel that a publication showing some standard mineral curves obtained with a portable unit may increase the usefulness of these instruments to the field geologist. The curves presented in this paper were therefore prepared to serve as a reference for the interpretation of results obtained from portable differential thermal analysis units. Clay minerals have been emphasized, but some of the minerals most commonly associated with them have been included.

PROCEDURE

The curves were obtained on the portable differential thermal analysis apparatus shown in plate 28 by following the procedure described by Hendricks, Goldich, and Nelson (1946), supplemented by the instruction sheet accompanying the unit. The only departure from this procedure was in the preparation of the alundum (Al_2O_3) to be used as the reference material. This was powdered and passed through a 400-mesh sieve in an effort to minimize differences in packing between the reference material and the sample.

The principal difference between the method used with the portable unit and the usual laboratory methods of differential thermal analysis lies in the rapid and nonuniform heating rate obtained with the portable unit. The type of heating rate used is shown by curve *A* of figure 43, in which the run is initiated with the furnace at full temperature. The principal advantage of starting the run with the furnace at full temperature is the short time required for each run.

It is possible to achieve a less abrupt heating rate by the use of a rheostat in series with the furnace. Such a heating rate is shown by curve *B* of figure 43. This curve was obtained by starting the run with the furnace at room temperature and decreasing the resistance in steps, as shown on the graph. However, as the curves are recorded manually the longer heating period makes inefficient use of the operator's time. Besides, the furnace must be cooled before the next run can be made.

The disadvantages of the method in which the run is started with the furnace at full temperature are that it often causes severe broadening of the low temperature peaks and produces peaks that are not comparable in relative intensity with peaks produced by standard methods of differential thermal analysis. In addition, the temperatures at which the reactions occur do not always correspond exactly to the temperatures obtained for those reactions by apparatus in which the heating rate is uniform. A further effect is the small exothermic peak occurring at the beginning of most of the curves (figs. 44–51). Presumably this is the result of differences in specific heat, heat conductivity, and thermal diffusivity between the sample and the reference material. The temperature of the reference material apparently lags behind that of the sample when the sample block is subjected to the initial high thermal gradient imposed by the fully heated furnace.

The theory and methods of differential thermal analysis are described by Speil, Berkelhamer, Pask, and Davies (1945); Kerr and others (1949, Rept. 3); Smothers, Chiang, and Wilson (1951); and Grim (1953, p. 190–249).

COMPOSITION AND SOURCE OF SAMPLES

Table 1 lists the sample localities, and the major and minor constituents in each sample as determined by X-ray diffraction methods. Samples with numbers prefixed by *H* are clay mineral standards, described in American Petroleum Institute, Project 49, (Kerr and others, 1949). Those with numbers prefixed by *G* are described by Grim, Machin, and Bradley (1945, p. 11). The samples with numbers prefixed by *S* are from the collection of the sedimentary petrology laboratory of the U. S. Geological Survey.

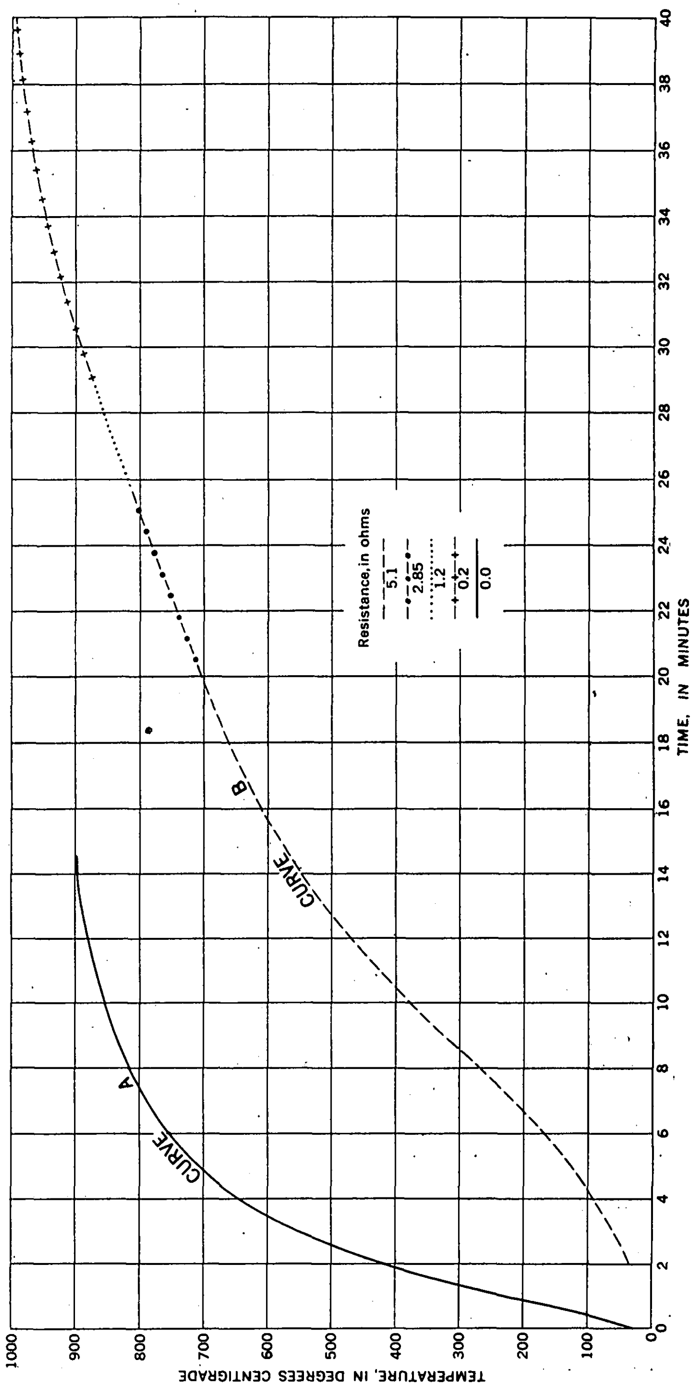

FIGURE 43.—Heating-rate curves for portable thermal apparatus.

TABLE 1.—*Constituents and localities of samples*

Sample	Name	Constituents		Locality
		Major	Minor	
H-1	Kaolinite	Kaolinite		Murfreesboro, Ark.
4	do	do	Montmorillonite	Macon, Ga.
5	do	do		Bath, S. C.
9	do	do		Mesa Alta, N. Mex.
12	Halloysite	Halloysite	Gibbsite, endellite?	Bedford, Ind.
13	do	do	Gibbsite, endellite.	Eureka, Utah.
14	Dickite	Dickite		Ouray, Colo.
19	Montmorillonite.	Montmorillonite.		Polkville, Miss.
23	do	do		Chambers, Ariz.
24	do	do		Otay, Calif.
25	do	do	Quartz	Upton, Wyo.
26	do	do	do	Clay Spur, Wyo.
28	do	do		Little Rock, Ark.
31	do	do	Kaolinitic mineral, quartz.	Cameron, Ariz.
32	do	do	Kaolinitic mineral.	Pioche, Nev.
33A	Nontronite	Nontronite		Garfield near Spokane, Wash.
33B	do	do		Manito near Spokane, Wash.
34	Hectorite	Hectorite	Calcite	Hector, Calif.
35	Illite	Hydrous mica	Kaolinitic mineral, quartz.	Fithian, Ill.
36	do	do	Quartz	Morris, Ill.
41	Ordovician bentonite.	Mixed-layered hydrous mica.	Calcite, quartz	Tazewell, Va.
42	do	do	Quartz, feldspar	High Bridge, Ky.
49	Pyrophyllite	Pyrophyllite	Quartz, mica, kaolinite.	Robbins, N. C.
G-866	Underclay	Hydrous mica	Kaolinitic mineral, quartz	Grundy County, Ill.
869	Kaolin	Kaolinite	Quartz	Union County, Ill.
870	Shale	Hydrous mica	Chlorite, quartz	Menard County, Ill.
871	Plastic fireclay	Kaolinite	Hydrous mica, quartz.	Mexico, Mo.

TABLE 1.—*Constituents and localities of samples*—Continued

Sample	Name	Constituents		Locality
		Major	Minor	
G–875	Bauxite	Gibbsite	Kaolinite	Irwinton, Ga.
876	Hard kaolin	Kaolinite	Montmorillonite, hydrous mica	Gordon, Ga.
877	Soft kaolin	do		Dry Branch, Ga.
878	Plastic kaolin	do	Montmorillonite	Do.
880	Ball clay	do	Quartz	Atwood, Tenn.
882	Fuller's earth	Attapulgite	Montmorillonite, quartz	Quincy, Fla.
883	Kaolin	Kaolinite	Quartz	Hobart Butte, Oreg.
S–1	Artificial gibbsite	Gibbsite		Bayer Process, ALCOA.
2	Bauxite	do	Kaolinite	Andersonville district, Ga.
3	Attapulgite	Attapulgite	Montmorillonite, quartz	Attapulgus, Ga.
4	Sepiolite	Sepiolite	Montmorillonite, calcite, quartz, dolomite	Algeria.
5	Boehmite	Boehmite	Chlorite	Linn, Mo.
6	Diaspore	Diaspore	do	Drake, Mo.
7	Brucite	Brucite	Antigorite, dolomite	Bluemont, Md. (USNM 102,836).
8	Chlorite	Chlorite		Spruce Pine, N. C.
9	Vermiculite	Vermiculite		North Carolina.
10	do	do		South Africa.
11	Dioctahedral vermiculite	Dioctahedral vermiculitic mineral	Quartz, kaolinitic mineral, mica, hematite, feldspar	Middlesex County, N. J.
12	Muscovite	Muscovite		Locality unknown.
13	Phlogopite	Phlogopite		Do.
14	Talc	Talc		Do.
15	Quartz	Quartz		Hot Springs, Ark.
16	Calcite	Calcite		Grant County, N. Mex.
17	Dolomite	Dolomite	Calcite	Joplin, Mo. (USNM R–2,409).

TABLE 1.—*Constituents and localities of samples*—Continued

Sample	Name	Constituents		Locality
		Major	Minor	
S-18	Siderite	Siderite	Calcite	Sparta, N. J. (USNM 80,070).
19	Goethite	Goethite		Near Eufaula Ala. (USNM 46,039).

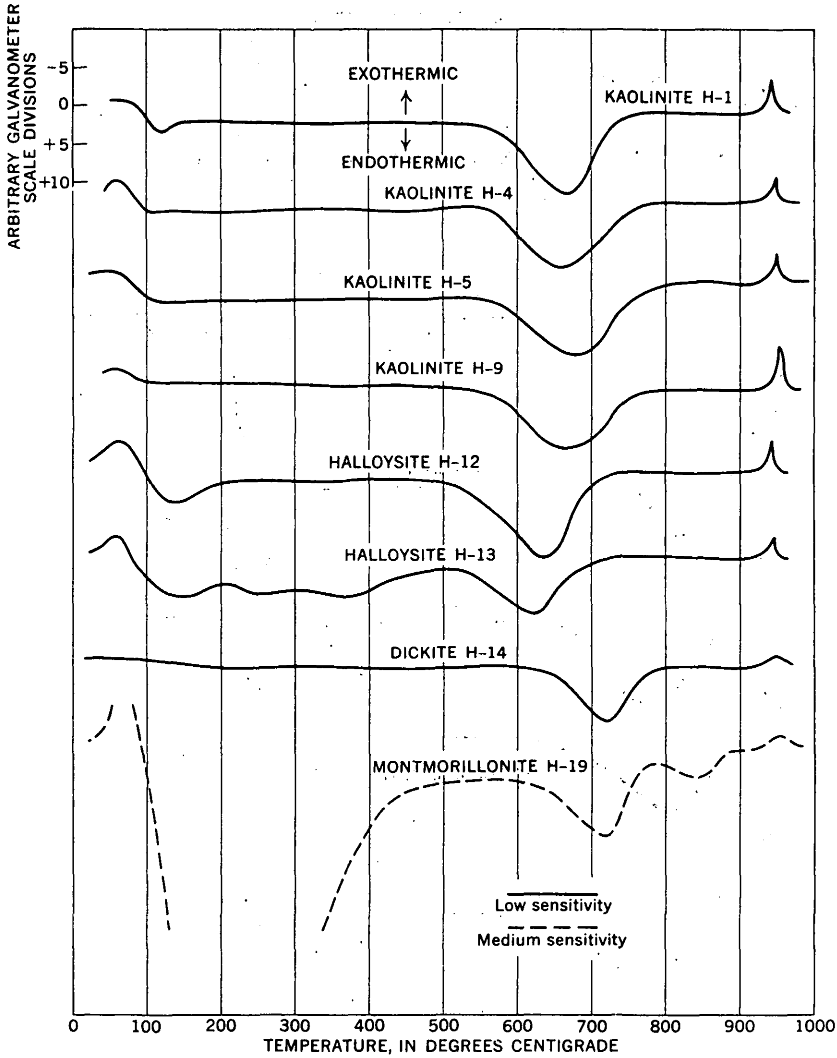

FIGURE 44.—Thermal analysis curves obtained with portable unit.

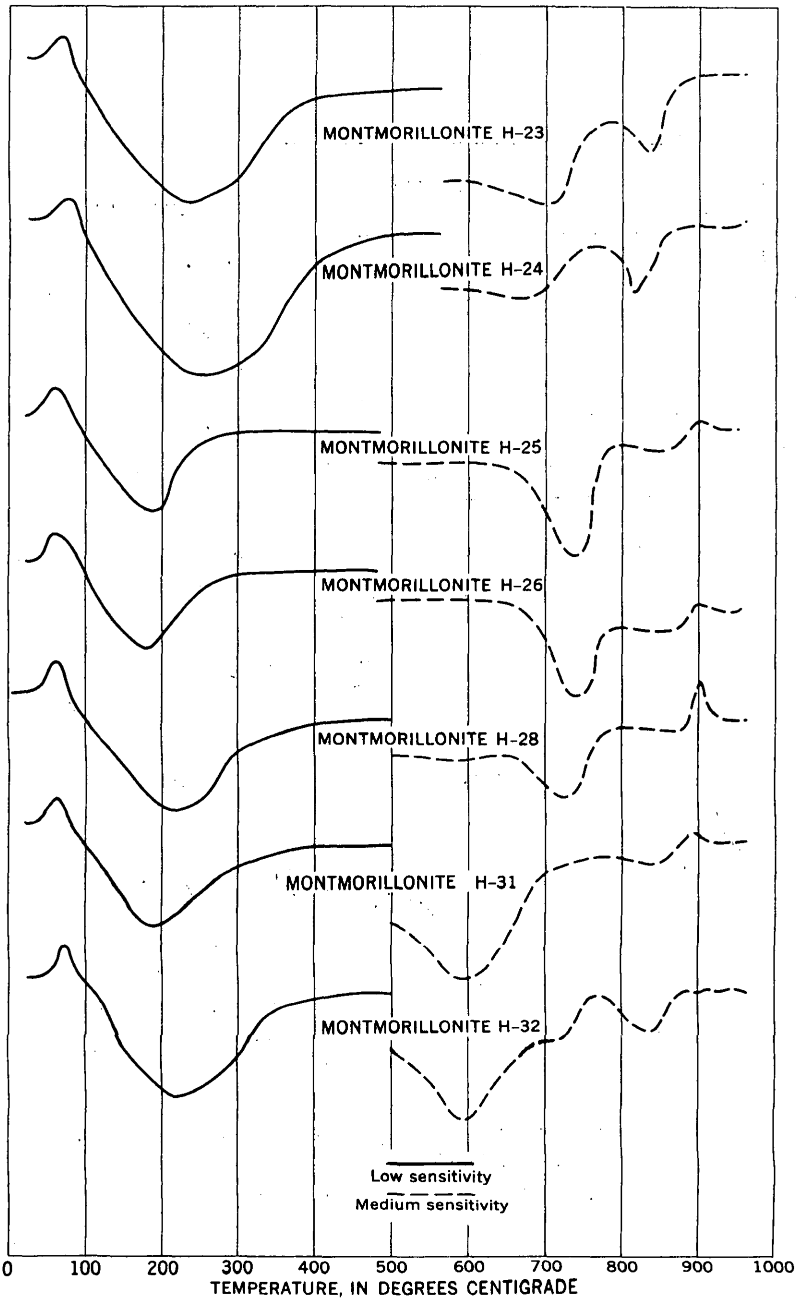

FIGURE 45.—Thermal analysis curves obtained with portable unit.

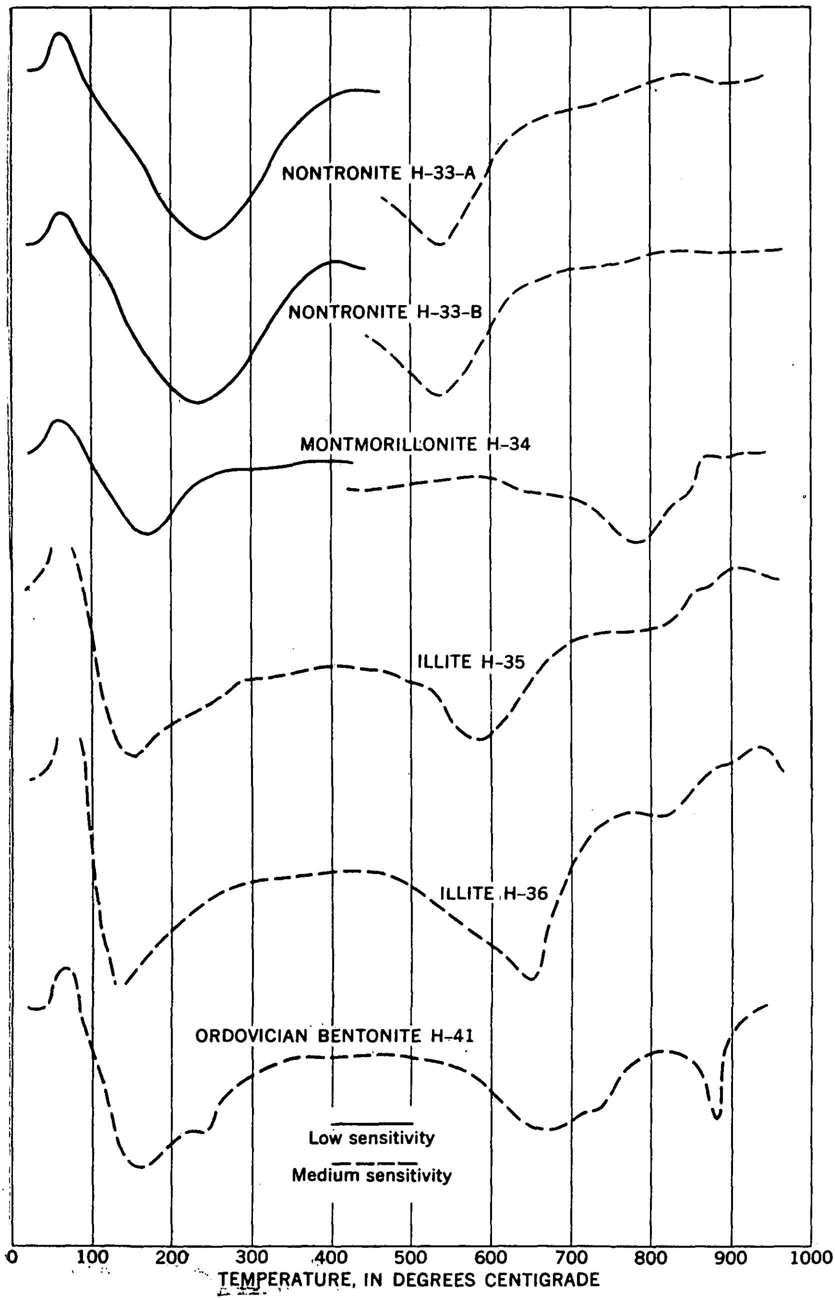

FIGURE 46.—Thermal analysis curves obtained with portable unit.

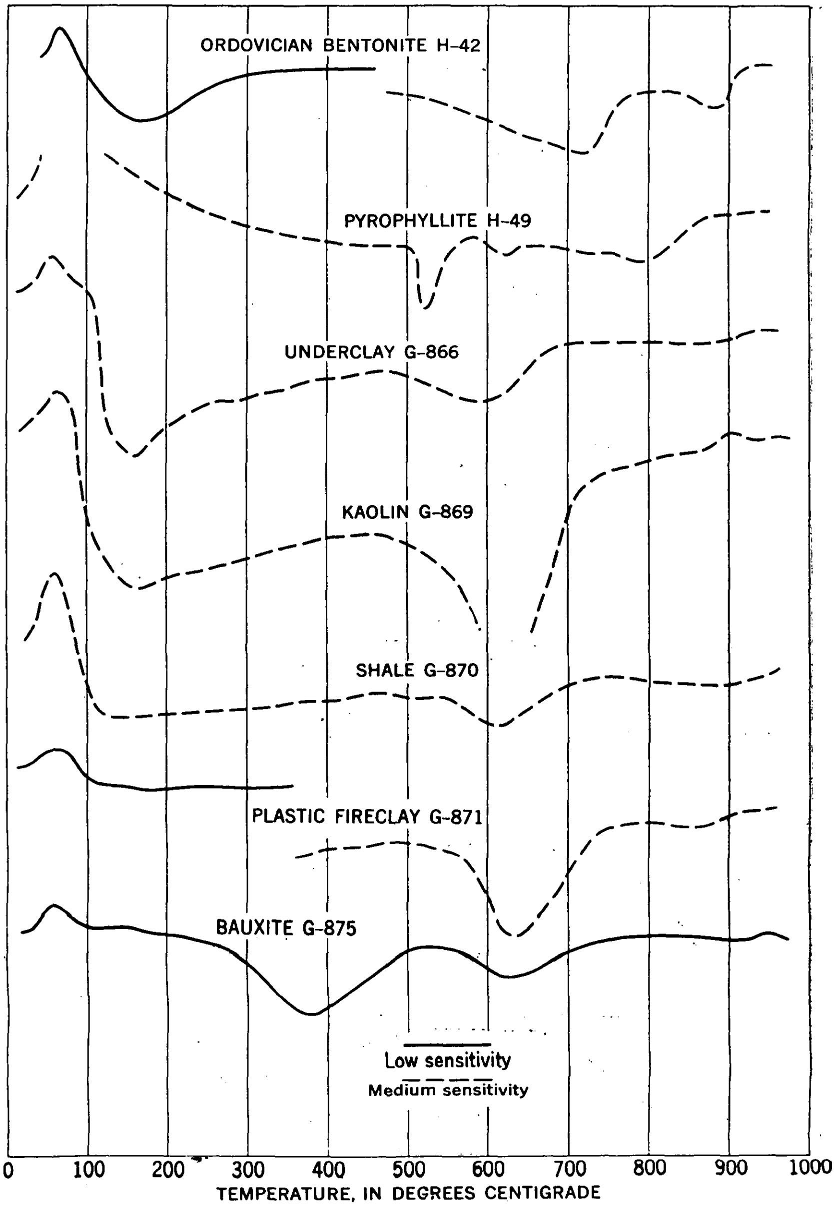

FIGURE 47.—Thermal analysis curves obtained with portable unit.

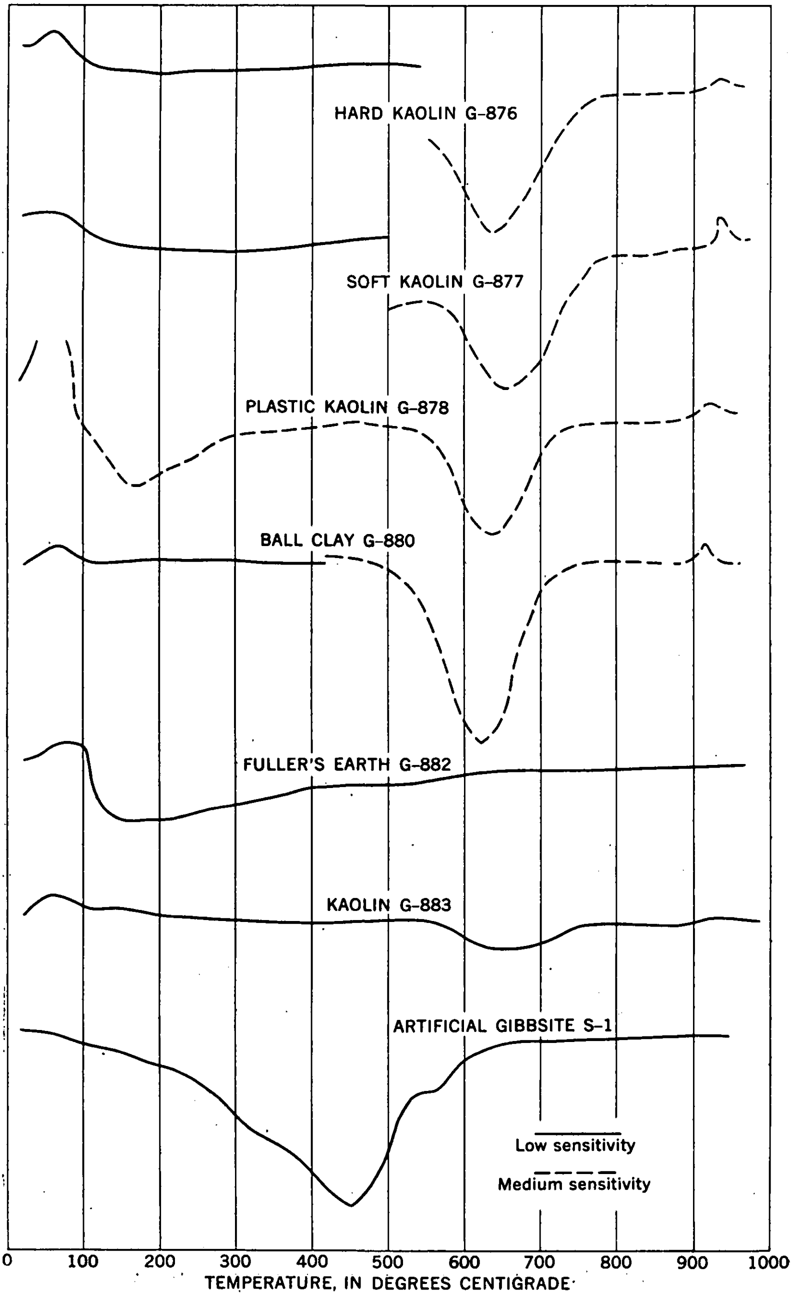

FIGURE 48.—Thermal analysis curves obtained with portable unit.

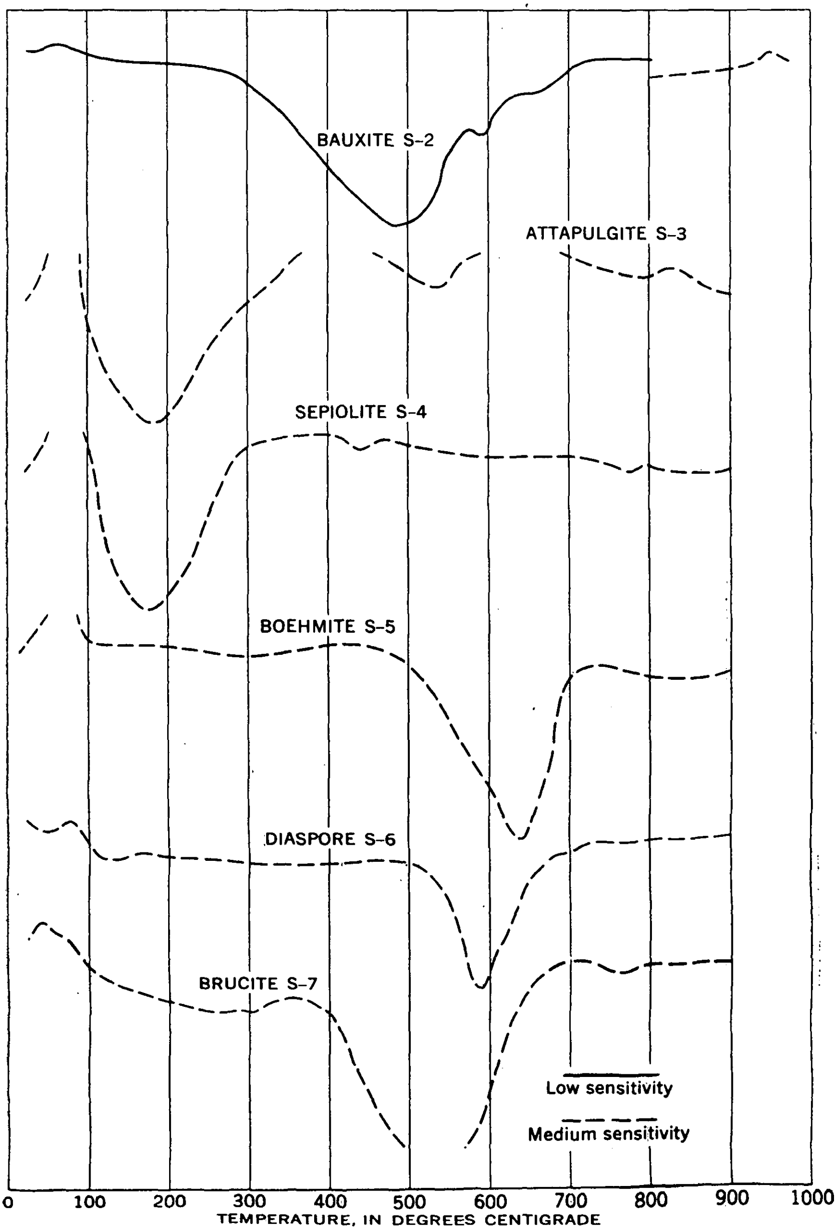

FIGURE 49.—Thermal analysis curves obtained with portable unit.

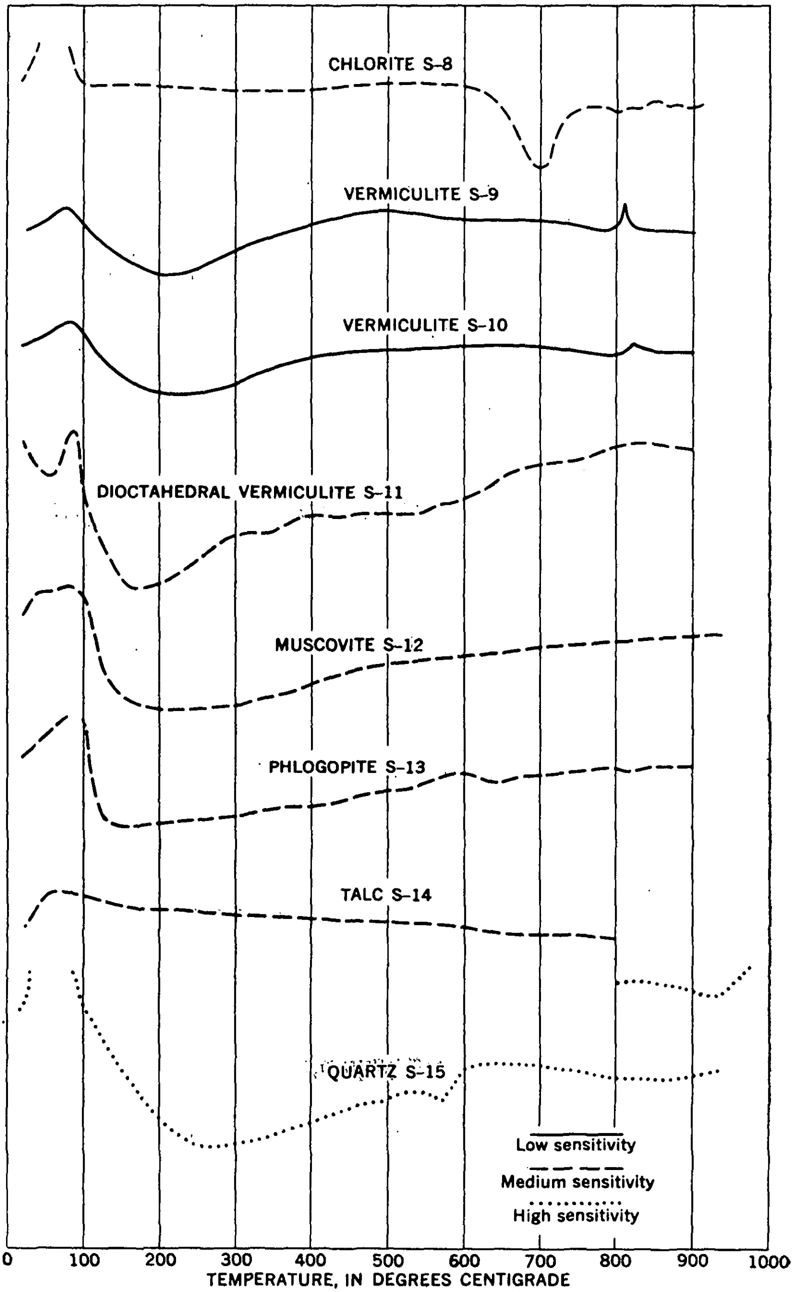

FIGURE 50.—Thermal analysis curves obtained with portable unit.

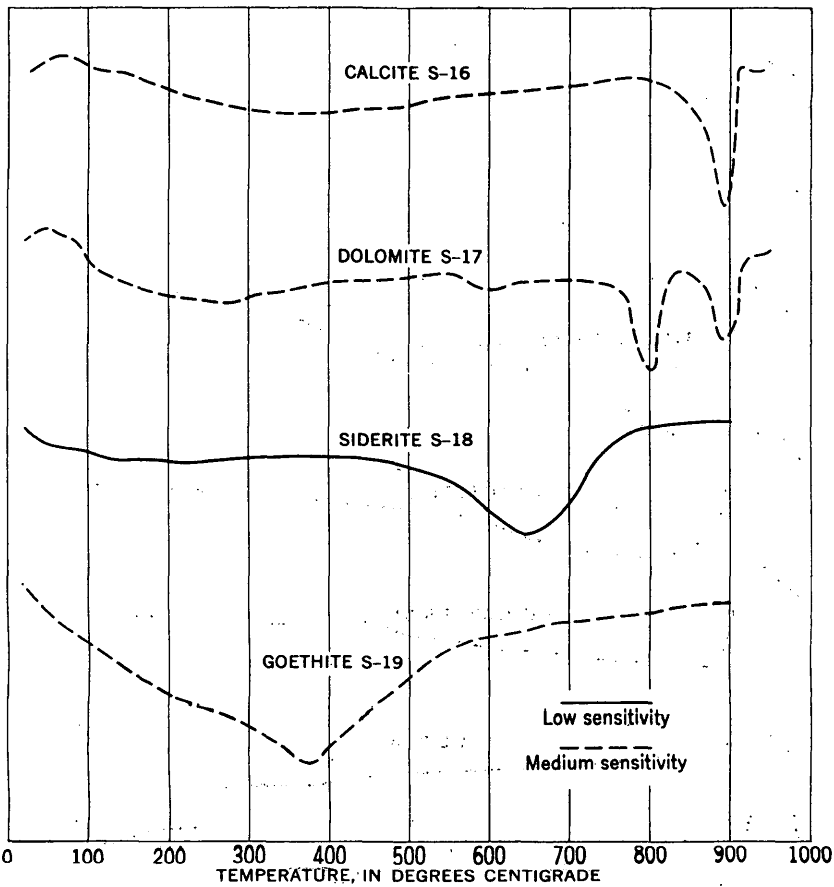

FIGURE 51.—Thermal analysis curves obtained with portable unit.

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