

**HANDBOOK
OF
DIFFERENTIAL
THERMAL ANALYSIS**

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THERMAL ANALYSIS**

by

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Handbook of Differential Thermal Analysis

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Preface

Although this book is a revision of the earlier work entitled *Differential Thermal Analysis: Theory and Practice*, which was published in 1958, it was decided to title this book *Handbook of Differential Thermal Analysis* because it presents more concerning practice than theory. In reviewing a selected field of science the result can be either critical, or somewhat encyclopedic. We have chosen to lean toward the latter, with an attempt occasionally to be critical, because we believe that with such a wide interest in differential thermal analysis this approach will produce a book which will be useful to a greater number of people.

At the time of issue of the previous book the rate of publishing of articles on DTA in the fields of geology, soils, metallurgy, and ceramics was somewhat static. Chemists were becoming aware again of the usefulness of the method, and the rate of published papers in this field has been increasing. The most phenomenal rate of growth in this context has been in the study of polymers. It is primarily because of this interest, and, in general, of that of the organic chemists, that more commercially produced DTA apparatus has been offered for sale in recent years.

Disagreement still continues whether DTA can be considered a quantitative method, but the appearance of many more papers in the last few years in which quantitative results are presented shows that, at least under controlled conditions, fairly good quantitative results can be obtained. Also, the availability of better equipment and apparatus whereby reproducible conditions are more easily attainable, and the high sensitivity of such apparatus at controlled heating rates, makes the results more quantitative.

In addition to a few books on DTA covering somewhat limited areas, the reliability of the method has reached the point that a card index has been prepared by Dr. R. C. Mackenzie of the Macaulay Institute for Soil Research, at Aberdeen, Scotland. Comparisons with the ASTM card index for x-ray diffraction are inevitable, but it must be admitted that the reproducibility of results on various

DTA equipment may be difficult to obtain with precision. Nevertheless, this card index serves a very useful purpose in compiling information on more than 1600 materials. The cards are coded to give information about the DTA peaks, and a mineral classification, as well as literature references. Information on organic and inorganic materials is also included.

To educate scientists about DTA and other thermal techniques, Dr. Saul Gordon, who has been very active in this work, has been holding Thermoanalysis Institutes in the summer at Fairleigh Dickinson University, Madison, New Jersey. In addition to learning of the theory of DTA, the students have laboratory sessions, which give them the opportunity to use required equipment.

In preparing this book we have been mindful of the constructive criticisms of the previous edition and have attempted to answer them by making appropriate changes. In particular, we wish to thank Professor Wilhelm Eitel, of the University of Toledo (Ohio), for his continued interest and kindly help in all of our publications in this field.

As the basic work of P. L. Arens has withstood the test of this relatively short time, it has been presented again in this edition.

Full reference is given to tables and figures presented and we greatly appreciate the permission of authors and publishers to reproduce this material. In particular, Figures 1, 3, 4, 5, and 6 are from *Measurement of High Temperatures* (1912), by Chatelier and Burgess, John Wiley & Sons, Inc.; 7 is from *Introduction to Thermography* (1961), by L. G. Berg; 8, 9, and 31 are from the *Journal of the American Ceramic Society*; 14 is from *Soil Science*; 25 is from the *American Mineralogist*; and 26, 27, and 28 are from *Analytical Chemistry*.

We appreciate also the cooperation of the equipment manufacturers in making information and photographs available to us. In particular, we are happy to acknowledge the help of Professor Megumi Tashiro, of the Institute for Chemical Research at Kyoto University, in obtaining information on Japanese equipment, and for translating some of this information.

The major part of *Appendix 1* was typed by Miss Linda Lou Stocker, of Battelle Memorial Institute, and we are appreciative of her careful work. To the onerous job of alphabetizing and collating, the whole Smothers family was called, with typewriters in hand, and their help and patience are gratefully acknowledged.

This book is meant to introduce differential thermal analysis to those that are not familiar with the method, and sufficient references are given for those that wish to dig deeper and to study the original papers. To those, however, who are working in this field, our attempts to keep *Appendix 3*, which gives alphabetical reference lists for many materials, up-to-date should be useful.

In a book covering such a wide field there may be errors, both of commission and of omission, but we hope that these will not be sufficiently serious to affect its usefulness to those that will consult it.

April 1965

W. J. SMOTHERS
YAO CHIANG

Contents

1	ORIGINS OF DTA: AN INTRODUCTION	1
2	EQUIPMENT	13
3	FACTORS IN QUALITATIVE DTA	40
4	SELECTED APPLICATIONS OF QUALITATIVE DATA	72
5	THEORETICAL BACKGROUND IN QUANTITATIVE DTA (<i>N. F. Tsang</i>)	90
6	QUANTITATIVE DTA	124
7	USE AND CORRELATION OF DTA RESULTS	155
8	COMMERCIAL EQUIPMENT	209
	United States	209
	Germany	225
	Great Britain	226
	Hungary	228
	Japan	228
	APPENDIX 1: PUBLICATIONS ON DTA	235
	2: AUTHOR INDEX FOR PUBLICATIONS	525
	3: ALPHABETICAL LIST OF MATERIALS STUDIED BY DTA	571
	INDEX	619

chapter 1

ORIGINS OF DTA: AN INTRODUCTION

Hannay (1877, 1879) * pointed out that an examination of the rate at which the volatile constituent of a compound is driven off at a constant temperature may afford valuable information as to the constitution of the body so examined, and would bring out the relation between the varying vapor tension of a decomposing body and its chemical constitution. It was intended to extend this method to all kinds of compounds which have a volatile constituent, such as water. Ramsay (1877) suggested that the composition and constitution of many of the amorphous hydrates, such as aluminum oxide and iron oxide hydrate ($\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ and $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$), whose compositions are somewhat indefinite, might be accurately determined by this method, since the vapor tensions of hygroscopic and combined water would differ and a definite distinction could be made between them. Hannay and Ramsay have thus determined the rate of weight loss of water from hydrates while drying at a constant temperature. Both crystalline and amorphous hydrates were studied and included the following: $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, $\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$, and $\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$.

This technique of loss of weight *vs.* time at constant temperature has been gradually developed and reached a climax in the weight loss *vs.* time or temperature curve under uniform rate of heating. This later technique was developed by de Keyser (University of Brussels), who chose to call it *differential thermogravimetry*. Closely allied to this method is that of differential thermal analysis.

The differential thermal method had its origin and significant dates in 1887 (LeChatelier), 1897 (Callendar), and 1898 (Stansfield). The method was perfected by Roberts-Austen (1899), Saladin and LeChatelier (1904), and Carpenter and Keeling (1904, 1907); and was reviewed in great detail by Burgess (1908, 1912) in connection with differential-cooling curves used in metallography.

* All references in the text can be found in APPENDIX I. The number refers to the year of publication. When more than one article by the cited author appeared in the particular year, the specific number in APPENDIX I is also given.

EXPERIMENTS OF LE CHATELIER: ACTION OF HEAT ON PROPERTIES AND CONSTITUTION OF CLAYS

LeChatelier (1887) was interested in measuring the time rate of the transformations under observation. This was done by determining directly the rate of changing temperature dT_s/dt of the material in terms of its temperature T_s . He investigated the behavior of clays on heating to determine their constitution and, if possible, to devise a scheme of classification. The temperatures were measured by means of a thermocouple consisting of pure platinum and platinum containing 10% of rhodium. A photographic method, not previously used in recording heating-curve data, in which the photographic plate remained stationary, was developed and used in these experiments. Sparks from an induction coil were made to pass at intervals of 2 seconds before a slit and gave on the plate, after reflection from the galvanometer mirror, images of the slit whose spacing was a measure of the rate of heating—about 2°C/minute.

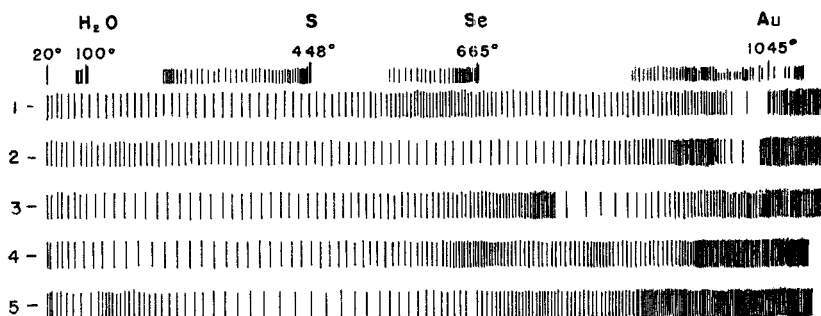


FIG. 1:1. HEATING CURVES OF CLAYS ACCORDING TO LECHATELIER

Roberts–Austen (1891) is credited with developing the method of automatic photographic recording of cooling curves. Kurnakov (1904) described a recording apparatus similar to that of Roberts–Austen except that a sensitized paper mounted on a rotating drum replaced the vertically moving photographic plate.

Figure 1:1 is a reproduction of LeChatelier's negatives from his experiments. The top row gives the graduated reference points of the thermocouple. By this method, he classified a large number of complicated clays into only five well-defined groups:

1) *Halloysite* from Niglos: A feebly marked endotherm (represented by contraction of lines in row 1 of Figure 1:1) at 150°–200°C,

a second well-marked endotherm ending at 700°C, followed by an exotherm (represented by diminution of lines in row 1 of Figure 1:1) at 1000°C;

2) *Allophane* from Saint Antoine: A well-marked endotherm at 150°–220°C, followed by an exotherm at 1000°C (row 2 of Figure 1:1);

3) *Kaolin* from Red Mountain, Colorado: An endotherm at 770°C, followed by a slight exotherm at about 1000°C (row 3 of Figure 1:1);

4) *Pyrophyllite* from Beresow: A well-marked endotherm, ending at 700°C, and a second less strongly marked endotherm at 850°C (row 4 of Figure 1:1);

5) *Montmorillonite* from St. Jean de Cole: A well-marked endotherm at 200°C, a second less strongly marked endotherm at 770°C, and a doubtful endotherm at 950°C (row 5 of Figure 1:1).

When hydrated silica is gently heated, it shows an endotherm between 100° and 200°C. Hydrated alumina precipitated from sodium aluminate shows a first endotherm below 200°C and a second endotherm ending at 360°C; and if precipitated from aluminum salts or prepared by calcination of the nitrate at a moderate temperature, it shows the same endothermic reactions, followed by a sudden acceleration in the rise of temperature at 850°C; bauxite shows an endotherm at 700°C.

From these facts, LeChatelier concluded that free silica cannot be present in pure clays and that the two hydrates of alumina cannot exist in any of the clays examined, whereas the hydrate present in bauxite may be present only in halloysite. The evolution of heat (exothermic) at high temperature is due to a molecular change in the alumina to the insoluble form. Free alumina does not exist in clays, but is liberated by their decomposition and dehydration reactions.

These conclusions, although interesting and important, are limited, because the difference in the rate of heating due to changes in the substance itself cannot be distinguished from those due to external causes. For example, the accidental fluctuations in the heat content not inherent to the sample are observed because no neutral body (Roberts–Austen, 1899) is used.

In order to eliminate the effect of irregularity of outside conditions that influence the rate of heating or cooling, a revised method is commonly used for detecting small transformations. This consists in placing a second thermocouple in the furnace or neutral body,

4 DIFFERENTIAL THERMAL ANALYSIS

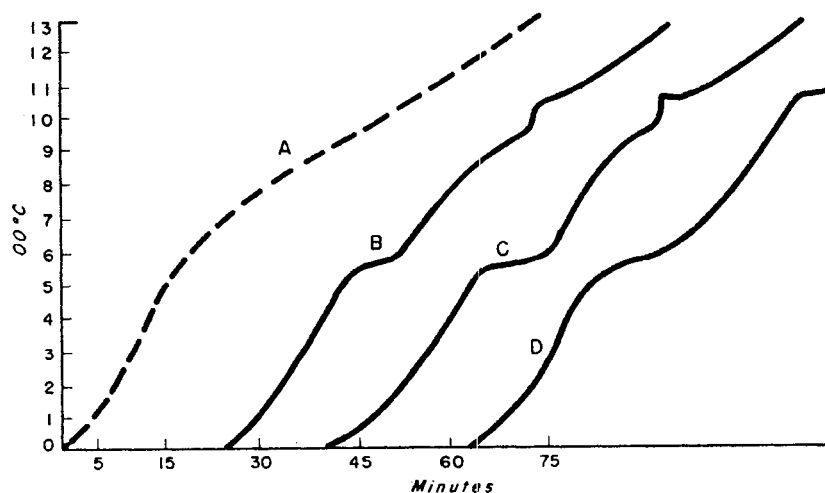


FIG. 1:2. TEMPERATURE VS TIME CURVES BY WOHLIN
A, Furnace heating curve; B, C, D, Furnace-heating rate with thermal reactions for clays superimposed

but sufficiently removed from the substance studied to be uninfluenced by its behavior. Alternate readings on the temperature of the sample (T_s) and of the furnace or neutral body (T_r) are then taken, preferably at definite time intervals. The data are most readily compared by plotting the two temperature-time curves side by side (Mellor, 1911, 1924, 1925; Ashley, 1911; Rieke, 1911; Wohlin, 1913) (Fig. 1:2); or by plotting the difference in temperature $T_s - T_r$,

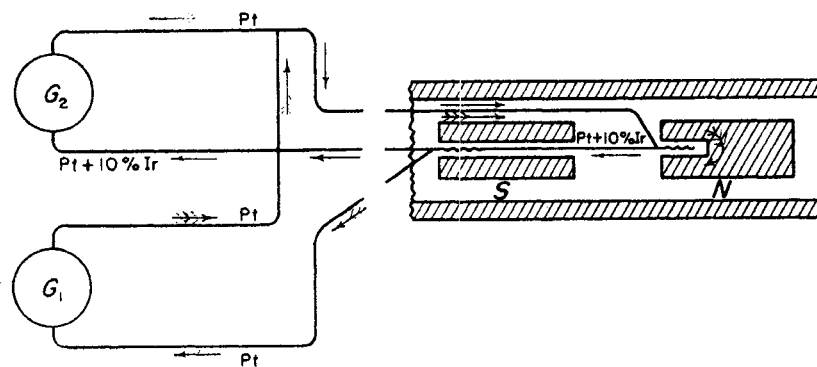


FIG. 1:3. USE OF NEUTRAL BODY (N) IN COMPARISON WITH SAMPLE (S)
(ROBERTS-AUSTEN)

against the temperature T_s of the sample. From the latter plotting, it is obvious that the precision of $T_s - T_r$ cannot be greater than that of either T_s or T_r .

TYPES OF APPARATUS

Differential Thermocouple Methods

Roberts–Austen (1899) was the first to modify the preceding arrangement so as to give the difference in temperature between the sample and neutral body ($T_s - T_r$) directly (Fig. 1:3), instead of by computation. It was subsequently simplified by Carpenter and Keeling (1904, 1907) (Fig. 1:4), and by Burgess (1908, 1912), (Fig. 1:5) into an arrangement that is commonly used in modern laboratories (see subsequent chapters).

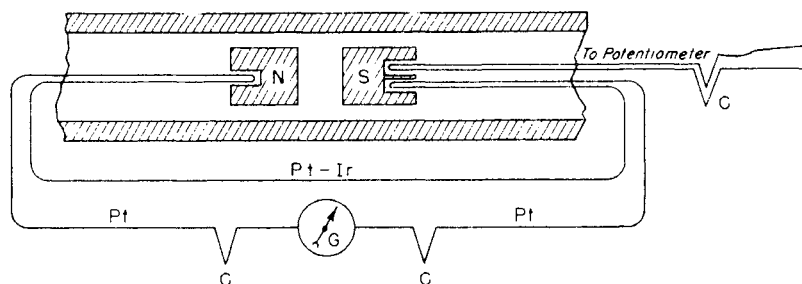


FIG. 1:4. ARRANGEMENT OF THERMOCOUPLES USED BY CARPENTER

In addition, Roberts–Austen was the first to advocate the use of a neutral body so that the accidental variations in the furnace temperature, not inherent to the heat content of the sample, are largely eliminated. The neutral body should be such that it undergoes no physicochemical transformations involving an absorption or evolution of heat within the temperature range investigated, and that its coefficients of thermal diffusivity and emissivity should be nearly the same as those of the sample. It is usually a piece of platinum (in metallurgy) or calcined alumina (in ceramics). Unfortunately, this rigid requirement has never been satisfied completely and needs yet to be explored. This complexity is further augmented by its dependence on the relative heat capacity of the furnace.

The arrangements shown in Figs. 1:3 to 1:5 illustrate an ideal application of the law of symmetry (Béhar, 1951), because every-

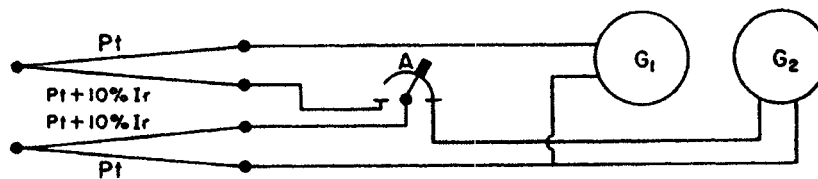


FIG. 1:5. ARRANGEMENT OF THERMOCOUPLES USED BY BURGESS

thing now comes in pairs: materials, temperatures, temperature gradients, potentials, and emf's. The precision of $T_s - T_r$ may thus be made as great as possible as compared with that of T_s , the temperature of the sample, as the latter is measured independently of the differential.

In the thermocouple circuits (Figs. 1:3 to 1:5), the two curves, $T_s - T_r$ vs. time and T_s vs. time had been recorded autographically on the same sheet of paper by means of a registering galvanometer, made by Siemens and Halske and described by Hoffman and Rothe (1905, 1906, 1907), in connection with their research on the change of state of liquid sulfur. It is evident that by recording the two curves on the same sheet, there is some sacrifice in the ability to detect small and rapid thermal transformations because the spacing has been doubled. Thus, it is sometimes convenient to consider a single chart recording $T_s - T_r$ vs. T_s or T_r directly without the time, though the uniform heating (or cooling) rate should be kept in mind constantly.

The Apparatus of Saladin-LeChatelier

Saladin (1903, published 1904) devised the first method of recording photographically the $T_s - T_r$ vs. T_s curve directly, using a fixed photographic plate. The arrangement of his apparatus, simplified by LeChatelier (1904) is sketched in Figure 1:6.

A beam of light from the source S strikes and then reflects from the mirror of the sensitive galvanometer G_1 , whose deflections measure the difference in temperature $T_s - T_r$ between the sample and the neutral body. These reflections then pass through a total-reflection prism M, placed at an angle of 45° and so arranged as to make the beam oscillate in a vertical plane. The light then falls on the mirror (a total-reflection prism, 10 cm high) of a second galvanometer G_2 , whose deflections measure the temperature (T_s) of the sample and whose mirror in its zero position is at right angles to that of G_1 . The beam is then reflected horizontally on the sta-

tionary photographic plate, at P. Thus, the light has impressed on the plate two motions at right angles to each other, giving a curve whose ordinates (Y), corresponding to the vertical part of the oscillation, are proportional to the differential temperatures $T_s - T_r$, and whose abscissae (X), corresponding to the horizontal part of the oscillation, are proportional to the temperature T_s of the sample. The horizontal motion (X) has a known relation to time, so that the photographic plate P need not be moved. The sensitivity of the

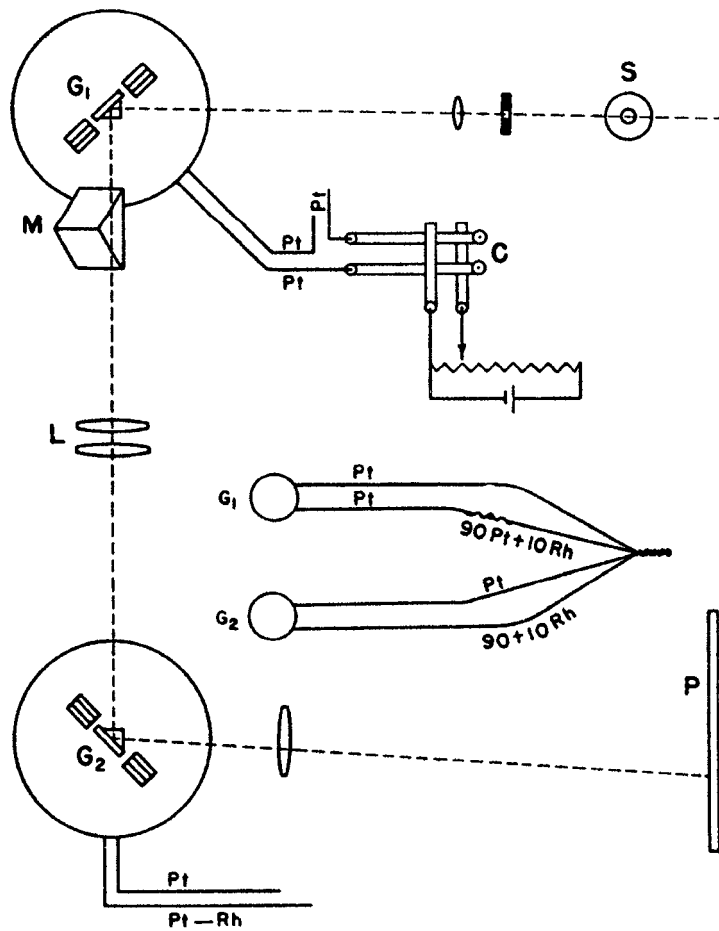


FIG. 1:6. SALADIN'S APPARATUS FOR PHOTOGRAPHIC RECORDING OF DIFFERENTIAL TEMPERATURE

method depends on that of the galvanometers G_1 and G_2 . The arrangement of the thermocouple circuits is the same as in Figure 1:4.

The Kurnakov Pyrometer

The Russians have been active in this field practically since its inception and almost all work to date has been accomplished with use of what is called the *Kurnakov Pyrometer*, or with some slight modification of it. A recent representation is shown in Figure 1:7. This apparatus included photographic recording (1) of the reactions taking place in the sample and control being heated in the furnace (3), and the thermostatic ice-bath (2).

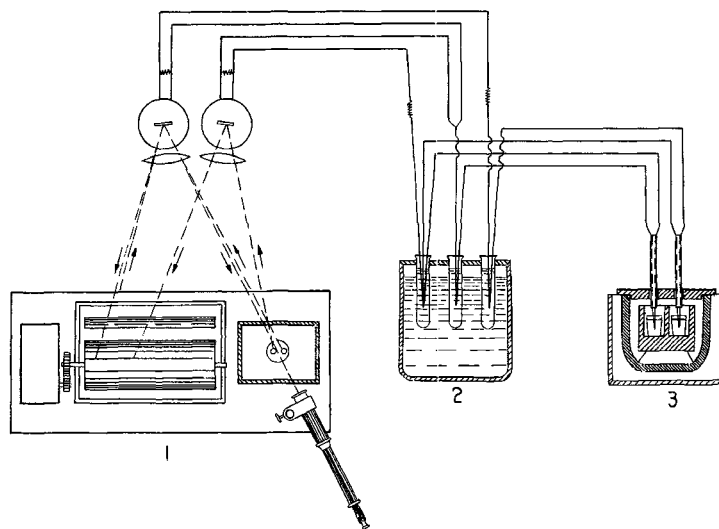


FIG. 1:7. KURNAKOV-TYPE APPARATUS FOR DTA

Other Recorders

In 1909, the Leeds and Northrup Company marketed the first autographic XY recorder. It was a mechanical recorder, tracing directly the $T_s - T_r$ vs. T_s curve by means of a double galvanometer system, the paper moving proportionally to the temperature T_s , and the pen proportionally to $T_s - T_r$. The same manufacturer brought out the improved Micromax in 1931. Their Speedomax

X-Y recorder, plus a DC Microvolt amplifier for the differential, has been used in several laboratories.

Béhar (1932) discussed extensively the development and operation of potentiometric recorders, beginning with Leeds and Northrup in 1909, continuing with Wilson-Maeulen in 1929, Uehling in 1930, Brown Company and Leeds and Northrup Micromax in 1931 (see also Weber, 1941, 1950; Foote, Fairchild and Harrison, 1921), and included in his description the photoelectric recorders (see also Payne, 1935, 1936).

DEVELOPMENTS IN USE OF DTA

Metallurgy

The basic foundations of DTA for metallurgy, as perfected by Saladin-LeChatelier and Roberts-Austen, have been applied extensively since their time. See:

Boudouard, 1903, 1904	Sykes <i>et al.</i> , 1935 (“double differential cooling curve method” and equip.)
Portevin <i>et al.</i> , 1908, 1913, 1919	Yatsevitch, 1935
Rosenhain <i>et al.</i> , 1908, 1910, 1915, 1935	Smith, 1939
Rengade, 1909	Weber, 1941, 1950 (equip.)
Broniewski <i>et al.</i> , 1912, 1913	Borelius <i>et al.</i> , 1943
Burgess <i>et al.</i> , 1913, 1916, 1918-19	Ageev, 1944
Foote <i>et al.</i> , 1919, 1921 (equip.)	Desch, 1944 (equip.)
Scott, 1919	Luzhnikov and Berg, 1948
Guertler, 1920 (equip.)	Wittig, 1950, 1952 (equip.)
Coe, 1935	ASTM Standards, 1951
Payne, 1935, 1936 (equip.)	Portevin, Albert, 1951, 1952
	Wyman, 1951, 1952 (equip.)

For study of a powdered material, the chief addition to the parts of equipment used by earlier metallurgical workers was a container holding both the sample and the neutral body. In many cases, platinum crucibles were employed very satisfactorily.

Ceramics

Although White (1911) used a “dead (or neutral) body” in his studies of high-temperature calorimetry for detecting small heat

effects, Fenner (1912) was the first to adopt the metallurgical DTA method in his work on the stability relations of silica minerals. Ceramists, contributing perhaps more than others, are interested not only in the naturally occurring clays and silicate minerals, but also in phase changes of mixed oxides, hydroxides, and fluorides and the differential thermocouples have been used even in firing processes (Segawa, 1949, Grim and Johns, 1951). The following list will cover some of those participating up to the end of World War II:

White, 1911, 1924, 1928 (calorimetry)	de Keyser, 1938-9 (review and equip.)
Fenner, 1912, 1913, 1919	Barrett <i>et al.</i> , 1938
Wallach, 1913, 1914	Trombe, 1938
Wohlin, 1913	Norton, 1939 (review and equip.), 1940
Cobb <i>et al.</i> , 1915 (carboniza- tion), 1922-3, 1924	Saldau <i>et al.</i> , 1939
Satoh, 1918, 1921, 1923	Harman <i>et al.</i> , 1940
Cohn, 1924	Steger, 1942
Kurnakov <i>et al.</i> , 1924, 1926, 1928	Yamauchi <i>et al.</i> , 1942
Urazov <i>et al.</i> , 1924, 1926	Mitchell <i>et al.</i> , 1943
Kôzu <i>et al.</i> , 1926	Nagai <i>et al.</i> , 1943
MacGee, 1926	Pask <i>et al.</i> , 1943, 1945
Sosman, 1927	Berkelhamer <i>et al.</i> , 1944 (review and equip.), 1945
Spangenberg, 1927	Favejee, 1944
Krakau <i>et al.</i> , 1932	Grimshaw <i>et al.</i> , 1944, 1945 ("double or bi-DTA" and equip.)
Geller <i>et al.</i> , 1934	Roberts <i>et al.</i> , 1944, 1945
Granger, 1934	Spiel <i>et al.</i> , 1945 (theory)
de Lapparent, 1936	
Jourdain, 1937	

Among the researchers on glass, Tool and his collaborators (1919, 1920, 1925, 1931, 1938, 1948) have consistently favored the use of DTA.

Geology, Mineralogy, Inorganic Chemistry

Shortly after the development and use of DTA in ceramics by Wallach and Fenner, the pure mineralogists Orcel (1926), Kurnakov

(1926), and Syromyatnikov (1926) employed this method in studies of asbestos minerals. Since that time, DTA has become a common method in mineralogy and geology, and it was soon applied to inorganic chemistry by Kracek (1929). The following references will cover the period before the end of World War II.

- | | |
|--|--|
| Kurnakov <i>et al.</i> , 1926, 1928,
1937 | Trombe, 1938 |
| Orcel <i>et al.</i> , 1926, 1927, 1930,
1935 (equip.), 1941 | Bateshev (chemistry), 1939 |
| Syromyatnikov, 1926, 1933,
1934, 1935, 1936 | Berg <i>et al.</i> (chemistry), 1939,
1940, 1941, 1942, 1943, 1944,
1945 |
| Kracek <i>et al.</i> (chemistry), 1929,
1930, 1932, 1937 | Conley, 1939 |
| Andreev, 1931 | Heindl <i>et al.</i> , 1939 |
| Geilmann <i>et al.</i> , 1932 | Kind <i>et al.</i> , 1939 |
| Caillère <i>et al.</i> , 1933, 1934, 1936,
1939, 1944, 1945 | de Leenheer, 1939 |
| Geller <i>et al.</i> , 1934, 1935 | Zakharov (chemistry), 1939 |
| Boullé (chemistry), 1935 | Efremov, 1940 |
| Insley <i>et al.</i> , 1935 (equip.) | Feodot'ev, 1940 |
| Pavlovitch, 1935 | Grim <i>et al.</i> , 1940, 1942, 1944,
1945 |
| Belyankin <i>et al.</i> , 1936, 1938 | Ivanova, 1940 |
| Lodochnikov, 1936 | Faust <i>et al.</i> , 1941, 1944 |
| Taylor <i>et al.</i> (chemistry), 1936 | Norin, 1941, 1944 |
| Kazakov, 1937 | Partridge <i>et al.</i> , 1941 |
| Vasenin, 1937 | Pask <i>et al.</i> , 1943, 1945 |
| Aseev, 1938 | Balandin <i>et al.</i> (chemistry), 1944 |
| Jensen <i>et al.</i> (chemistry), 1938 | Berkelhamer <i>et al.</i> , 1944 (review
and equip.), 1945 |
| de Keyser, 1938-9 (review and
equip.) | Cuthbert <i>et al.</i> , 1944 |
| Parmalee <i>et al.</i> , 1938 | Leont'eva (chemistry), 1944 |
| | Speil <i>et al.</i> , 1944 (theory), 1945 |
| | Brasseur (chemistry), 1945 |

Soils

Use of DTA in soils did not begin until 1922 when Matějka detected the presence of kaolinite in soils through use of DTA. Additional work was not done until 1933, when Agafonoff and Pavlovitch used the Saladin-LeChatelier double galvanometer in the study of red lateritic and Mediterranean soils. The following is a short list for the period up to the end of World War II:

Agafonoff <i>et al.</i> , 1933, 1934, 1935	Russell <i>et al.</i> , 1940, 1942
Hendricks <i>et al.</i> , 1939 (equip.), 1940, 1941	Page <i>et al.</i> , 1942, 1943 (equip.) Jeffries, 1944 (equip.)
Sedletskii, 1939	Caillère <i>et al.</i> , 1945

Other Fields

Applications of DTA after World War II are so numerous that separate chapters and tables are necessary. Although theories (see Chapter 5) have been gradually unified into a coherent story, it is still far from complete.

Diversified fields of study now include:

- Cement—Kalousek *et al.*, 1949, 1951; Gilliland, 1951
- White coat plaster—Murray and Fischer, 1951; Wells *et al.*, 1951
- Phosphors—Nagy and Lui, 1947; Rice, 1949
- Fuel Technology—Widell, 1947, 1949, on peat and wood; Breger and Whitehead, 1950; Smothers and Chiang, 1952; and Gamel and Smothers, 1952, on coal and lignite.
- Soaps—Vold *et al.*, 1941, 1945, 1947, 1948, 1949, 1950; Vinogradov, 1947; Stross and Abrams, 1950
- Organic Polymers—Brasseur *et al.*, 1946, 1947, 1949; and even proteins, Mishin and Garbuzov, 1951.

As DTA is so useful in so many different fields, each of them with different requirements, it deserves a careful reexamination, and a discussion of the equipment now used in modern laboratories.

chapter 2

EQUIPMENT

SAMPLE HOLDER

Most sample holders have been designed with two holes: one for containing the powdered sample and the other for containing the inert or standard material used for reference or control. A multiple sample holder, however, which contains six samples and a standard, has been described by Kulp and Kerr (1947, 1949) and has been modified slightly by other workers.

Various types of containers are used as sample holders: Orcel (1935) and his associates prefer quartz-glass tubes, and Grimshaw *et al.* (1945) described a ceramic sample block; but most workers in the United States prefer sample holders of high heat-conductivity (nickel, Inconel, platinum). Norton (1939) used a nickel sample holder to neutralize thermal gradients. Berkelhamer (1944, 359) described a stainless-steel block which many laboratories have duplicated for their use.¹

McConnel and Earley (1951) used an Inconel multiple-sample holder and point out that there are two schools of thought concerning the most desirable characteristics for the sample holder with regard to size and heat capacity. Gruver (1948) used small platinum crucibles, one for the sample and another for the standard. Gruver states that if the heat capacity of the sample holder is very small the sensitivity of the method is increased because there would not be enough metal to absorb heat rapidly during an exothermic reaction and thus reduce the exothermic effect. This statement is said not to take into account certain distinct advantages that may accompany the use of a sample holder of relatively high heat capacity. Furthermore, it should be pointed out that, as the thermal conductivity of the platinum crucibles described by Gruver is very high, one cannot consider the thermal capacity of the furnace,

¹ When the author has more than one paper listed in APPENDIX I for a given year, the reference number is also given to identify the paper cited.

appendix 3

**ALPHABETICAL LIST OF MATERIALS
STUDIED BY DTA**

ALPHABETICAL REFERENCE LIST OF MATERIALS STUDIED BY DTA

PREPARED MINERAL MIXTURES

- | | |
|---|---------------------------------------|
| Albite-quartz, 853 | Calcium saturated montmorillonite- |
| Allophane-Fe ₂ O ₃ , TiO ₂ , CaO, MgO,
alkalies, 1570 | calcium saturated kaolinite-calcium |
| Alumina-calcite, 68, 207 | saturated hydrated halloysite, 334 |
| Alumina-calcium saturated hal- | Calcium variety, binary and ternary |
| loysite, 334 | mixtures of kaolinite, illite, and |
| Alumina-calcium saturated hy- | montmorillonite, 444 |
| drated halloysite, 334 | Carbonaceous materials-kaolin, 1343 |
| Alumina-sand, 61, 102, 641, 970 | Chlorite-saponite, 1196 |
| Alunite-jarosite, 502 | Chlorite-saponite-antigorite, 1196 |
| Alunite-kaolinite, 502, 651 | Chromite-lime, 651 |
| Alunite-potassium chloride, 1950 | Chromite-silica, 651 |
| Anauxite-kaolinite, 266 | Chrysotile-asbestos, 1196 |
| Antigorite-chlorite-saponite, 1196 | Clay-limestone, 557 |
| Asbestos-chrysotile, 1196 | Cristobalite-quartz, 1273 |
| | Cristobalite-tridymite-quartz, 1343 |
| Bauxite-limestone, 557 | Diaspore-kaolinite, 394 |
| Bauxite-limestone-soda ash, 557 | Dickite-kaolinite, 502 |
| Bauxite-silica gel, 557 | Dickite-hydrous mica, 1600 |
| Bauxite-soda ash, 557 | Dickite-pyrophyllite, 3050 |
| Bentonite-amorphous carbon, 1006 | Dolomite-inorganic salts, 1213, 1523 |
| Bentonite-graphite, 1006 | Dolomite-kaolinite, 649 |
| Bentonite-kaolin, 380, 394 | Dolomite-rhodochrosite, 561 |
| | Dolomite-serpentine, 1033 |
| Calcite-alumina, 68, 207 | Dolomite-sodium carbonate, 685 |
| Calcite-fluorapatite, 992 | Dolomite-sodium chloride, 1476 |
| Calcite-kaolin, 68 | Dolomite-talc, 1633 |
| Calcite-kaolinite, 386, 1052 | |
| Calcite-orthoclase, 68 | Endellite (ethylene glycol-)-kao- |
| Calcite-pyrite-gypsum, 1462 | linite, 1190 |
| Calcite-quartz, 68 | Endellite (ethylene glycol-)-hal- |
| Calcite-serpentine, 1241 | loysite, 1190 |
| Calcium carbonate-rhodochrosite, 561 | |
| Calcium montmorillonite-kaolinite,
444 | Feldspar-calcium hydroxide, 1628 |
| Calcium saturated halloysite-calcium | Fluorapatite-calcite, 992 |
| saturated montmorillonite, 334 | Flint-gypsum, 1446 |
| Calcium saturated hydrated hal- | |
| loysite-alumina, 334 | Gibbsite-beidellite, 2624 |
| Calcium saturated kaolinite-calcium | Glaserite, schoenite, kainite, astra- |
| saturated montmorillonite, 334 | kanite, carnallite and leonite, 302 |
| | Goethite-kaolinite, 386, 502 |

- Goethite-lepidocrocite, 1774
 Graphite-bentonite, 1006
 Gypsum-alumina hydrate, 1446
 Gypsum-flint, 1446
 Gypsum-iron oxide, 1446
 Gypsum-kaolin, 1446
 Gypsum-kaolinite, 386, 854
 Gypsum-lime, 272
 Gypsum (phospho-)-lime, 272
 Gypsum-pyrite-calcite, 1462
- Halloysite-endellite (ethylene glycol-), 1190
 Halloysite-kaolinite, 1191
 Hectorite-montmorillonite, 3050
 Hematite-calcium hydroxide, 1628
 Hematite-graphite, 1507
 Hornblende-calcium hydroxide, 1628
 Hydrated halloysite-allophane, 1002
 Hydrated halloysite-kaolinite, 334
 Hydrated halloysite-pumice tuff, 1002
 Hydrous mica-dickite, 1600
- Illite-kaolinite, 401, 444, 1252
 Illite-montmorillonite, 1169, 1252, 3658
 Illite-sodium montmorillonite, 444
- Jarosite-alunite, 502
- Kaolin-alumina, 1621, 2224
 Kaolin-bentonite, 380, 394
 Kaolin-calcite, 68
 Kaolin-carbonaceous materials, 1343
 Kaolin-gypsum, 1446
 Kaolin (calcined) -hydrated lime, 1050, 1431, 1434
 Kaolin-limestone, 557
 Kaolin-limestone-soda ash, 557
 Kaolin-quartz, 380, 394, 502
 Kaolinite-alunite, 502, 651
 Kaolinite-anauxite, 266
 Kaolinite-beidellite, 2624
 Kaolinite-calcite, 386, 1052, 1570
 Kaolinite-calcium montmorillonite, 444
 Kaolinite-dickite, 502, 3050
 Kaolinite-diaspore, 394
- Kaolinite-dolomite, 649
 Kaolinite-endellite (ethylene glycol-), 1190
 Kaolinite-feldspar, 3073
 Kaolinite-Fe₂O₃, NaCl, or Na₂CO₃, 549, 564, 1570, 2085
 Kaolinite-fluorite, 2080
 Kaolinite-goethite, 386, 502
 Kaolinite-gypsum, 386, 854
 Kaolinite-halloysite, 1191, 3050
 Kaolinite-hydromica, 2624
 Kaolinite-illite, 401, 444, 1252, 3198, 3658
 Kaolinite-limonite, 386
 Kaolinite-marcasite, 386
 Kaolinite-montmorillonite, 184, 334, 502, 651, 745, 2624, 3658
 Kaolinite-muscovite, 641
 Kaolinite-oxides, 862, 2209
 Kaolinite-pyrite, 386
 Kaolinite-sericite, 502, 745
 Kaolinite-siderite, 386
 Kaolinite-sodium montmorillonite, 444
 Kaolinite-titania, 1570
 Kieserite-KCl, 1681
- Langbeinite-KCl, 1681
 Lepidocrocite-goethite, 1774
 Lepidolite-muscovite, 1252
 Lime-gypsum, 272
 Lime-gypsum (phospho-), 272
 Lime-limestone, 172
 Limestone-bauxite, 557
 Limestone-clay, 557
 Limestone, calcined,-silica gel, 557
 Limestone-inorganic diluents, 1213
 Limestone-kaolin, 557
 Limestone-soda ash, 557
 Limestone-soda ash-bauxite, 557
 Limonite-graphite, 1507
 Limonite-kaolinite, 386
- Magnetite-graphite, 1507
 Marcasite-kaolinite, 386
 Mica-lime, 1687
 Montmorillonite-hydrated halloysite, 334

- Montmorillonite-illite, 1169, 1251
 Montmorillonite-kaolinite, 184, 334, 502, 651, 653, 745
 Montmorillonite-nontronite, 266, 1252
 Montmorillonite-sericite, 502
 Muscovite-beidellite, 2624
 Muscovite-kaolinite, 641
 Muscovite-lepidolite, 1252
 Muscovite-sericite, 266
 Nontronite-montmorillonite, 266, 1252
 Orthoclase-calcite, 68
 Picromerite-KCl, 1681
 Polyhalite, gypsum, sodium chloride and alumina, 301
 Polyhalite-KCl, 1681
 Pyrite-calcite-gypsum, 1462
 Pyrite-kaolinite, 386
 Pyrolusite-ramsdellite, 504
 Quartz-calcite, 68
 Quartz-cristobalite, 1273
 Quartz-cristobalite-tridymite, 1343
 Quartz-kaolinite, 380, 394, 502
 Quartz-lime, 1050
 Quartz-tridymite, 375, 1273
 Ramsdellite-pyrolusite, 504
 Rhodochrosite-CaCO₃, 561
 Rhodochrosite-dolomite, 561
 Rhodochrosite-siderite, 561, 1786
 Sand-alumina, 61, 102, 641, 970
 Serpentine-calcite, 1241
 Saponite-chlorite, 1196
 Saponite-chlorite-antigorite, 1196
 Sericite-kaolinite, 502, 745
 Sericite-montmorillonite, 502
 Sericite-muscovite, 266
 Shamosite-graphite, 1507
 Siderite-kaolinite, 386
 Siderite-rhodochrosite, 561, 1786
 Silica-chromite, 651
 Silica-lime, 1687
 Sodium montmorillonite-illite, 444
 Sodium montmorillonite-kaolinite, 444
 Sodium variety, binary and ternary mixtures of kaolinite, illite and montmorillonite, 444
 Spodumene-potassium sulfate, 1174
 Tridymite-cristobalite, 1273
 Tridymite-cristobalite-quartz, 1343
 Tridymite-quartz, 375, 1273

CHEMICALLY TREATED MINERALS AND MIXTURES

- Alumina, 103, 374, 923
 Aluminum-saturated kaolinite, 1724
 Aluminum-saturated montmorillonite, 1724
 Amine-bentonite, 3213
 Amine-clay, 1006
 Ammonium-saturated bentonite, 1944
 Ammonium-saturated halloysite, 3003
 Ammonium-saturated illite, 1944
 Ammonium-saturated montmorillonite, 345, 2868, 3815
 Ammonium-saturated vermiculite, 1944
 Aniline-furfural loess, 2617
 Barium-kaolinite, 1592
 Bentonite-calcium hydroxide, 3094
 Bentonite, organic complexes, 471
 Bentonite-lime, 1488
 Bentonite treated with molten LiNO₃, 2009
 Calcium-bentonite, 1035
 Calcium-kaolinite, 1592
 Calcium-montmorillonite, 306, 854, 2897, 3197
 Calcium saturated kaolinite-alumina mixtures, 334
 Calcium saturated hydrated halloysite-alumina mixtures, 334
 Calcium saturated hydrated halloysite-hydrogen saturated hydrated halloysite mixtures, 334

- Calcium saturated kaolinite-calcium saturated hydrated halloysite mixtures, 334
- Calcium saturated kaolinite-calcium saturated montmorillonite mixtures, 334
- Calcium saturated montmorillonite-calcium saturated kaolinite-calcium saturated halloysite mixtures, 334
- Calcium saturated montmorillonite-alumina mixtures, 334
- Calcium vermiculite, 854
- Catalyst, 469, 735, 896, 976
- Cation-saturated halloysite, 334
- Cations fixed on illite, 334, 401
- Cations fixed on palygorskite, 401
- Chromium-montmorillonite, 1035
- Clay-acetic acid complex, 3324
- Clay-organic matter, 176, 309, 373, 468, 471, 553
- Cobalt-montmorillonite, 1035
- Copper-bentonite, 1035
- Dodecylamine-treated montmorillonite, 1254
- Endellite (ethylene glycol)-halloysite mixtures, 1190
- Endellite (ethylene glycol)-kaolinite mixtures, 1190
- Ethylene glycol-treated montmorillonite, 1254
- Germanium-saturated montmorillonite, 2576
- Glycerol-treated alumina, 2486
- Glycerol-treated kaolinite, 2486
- Glycerol-treated montmorillonite, 2486
- Glycerol-treated quartz, 2486
- Glycol-treated alumina, 2486
- Glycol-treated halloysite, 1940
- Glycol-treated kaolinite, 1940, 2486
- Glycol-treated montmorillonite, 2486
- Glycol-treated quartz, 2486
- Halloysite, calcium saturated, 334
- Halloysite-dye complex, 3920
- Halloysite, phosphated, 441
- Hydrated halloysite saturated with various cations, 334
- Hydrogen-bentonite, 940
- Hydrogen-kaolinite, 1712, 2842, 3927
- Hydrogen-montmorillonite, 1068, 1119, 2842
- Hydrogen-montmorillonite with sorbed C_6H_6 , 1068
- Illite-calcium hydroxide, 3094
- Illite, cations fixed on, 334, 401, 1883
- Illite-dye complex, 3920
- Iron-saturated kaolinite, 1724
- Iron-saturated montmorillonite, 1724, 1915
- Kaolin- AlF_3 treated, 3752
- Kaolin-calcium hydroxide, 3094
- Kaolin, basic dye on, 373, 3920
- Kaolin-lime, 1488
- Kaolinite, HF-treated, 2453, 3752
- Kaolinite saturated with various cations, 334
- Kinetic material, 498, 513, 569
- Lithium-hectorite, 901, 1107
- Lithium-kaolinite, 1592
- Lithium-montmorillonite, 901, 1107, 4069
- Magnesium-illite, 854
- Magnesium-kaolinite, 1592
- Magnesium-montmorillonite, 854
- Magnesium-vermiculite, 854
- Malachite green-montmorillonite, 3630
- Methylated halloysite, 2536
- Methylated kaolin, 2536
- Methylene blue-montmorillonite, 3630
- Montmorillonite- $Al(NO_3)_3$, HCl, or NH_4OH mixtures, 433
- Montmorillonite- $CaCl_2$, HCl or NH_4OH mixtures, 433
- Montmorillonite-dye complex, 3920
- Montmorillonite- $MgCl_2$, NH_4OH mixtures, 433

- Montmorillonite- Na_3AlO_3 , HCl, or NH_4OH mixtures, 433
 Montmorillonite, *p*-phenylenediamine salt of, 306
 Montmorillonite saturated with various cations, 287, 334, 364, 401
 Muscovite treated with molten LiNO_3 , 2009
- Nickel-antigorite, 842
 Nickel-montmorillonite, 842, 1035
 Nontronite-dye complex, 3920
- Organic anions-montmorillonite, 3011
- Palygorskite, cations fixed on, 401
 Peroxide-treated illite, 1724
 Piperidine-saturated bentonite, 2807
 Piperidine-saturated illite, 1491, 3631
 Piperidine-saturated kaolinite, 1491, 3631
 Piperidine-saturated montmorillonite, 1491, 3630, 3631
- Piperidine-saturated nontronite, 3631
 Piperidine-treated clay, 468, 1254
 Phenyl-montmorillonite, 1068
 Phosphated halloysite, 441
 Potassium-bentonite, 1944
 Potassium-kaolinite, 1592
 Potassium-montmorillonite, 1107, 1601, 3197
 Protein-clay, 1006
 Pyridine-montmorillonite, 1005
- Sodium-montmorillonite, 1076, 1077, 1107, 1735
 Sodium-kaolinite, 1402
 Sodium-vermiculite, 854
 Silver-bentonite, 1035
- Vermiculite with sorbed ions, 1883
- White coat plaster, 804, 844
- Zinc-bentonite, 1035
 Zinc-montmorillonite, 1377, 1915

CHEMICALS, CHEMICAL MIXTURES, ARTIFICIALLY
 PREPARED COMPOUNDS

- Acenaphthalene, 1620
 Acetamide, 2748
 Acetic acid, 3969
 Acetone, 3400, 3773
 Aconitic acid, 2748
 Adipamide-sebacamide series, 3530
 Adipamide-terphthalamide series, 3530
 Agar, 3431
 Alanylglycylglycine, 1620
 Alginic acid, 3431
 Aliphatic acids, 521
 Alum, 759, 1470
 Alum, dehydrated, 635
 Alumina-calcium sulfate mixtures, 1433
 Alumina-cobalt mixtures, 1768
 Alumina-ethyl alcohol mixtures, 505
 Alumina gel, 2926
 Alumina gel-silica gel mixtures, 1817, 2259, 3607
- Alumina hydrate, 748, 882, 1056, 1429, 1489, 1517, 1580, 1641, 1855, 2011
 Alumina-iron oxide mixtures, 1785, 3048
 Alumina-lithia mixtures, 3035
 Alumina-nickel catalyst, 3766
 Alumina-silica catalyst, 3881, 4000
 Alumina-sodium hydroxide mixtures, 994
 Alumina-sodium hydroxide-iron mixtures, 994
 Alumina-titania mixtures, 1364
 Aluminum-alumina mixtures, 3005
 Aluminum ammonium sulfate, 3540
 Aluminum arsenate, 1328
 Aluminum caprate, 3686
 Aluminum caprylate, 3686
 Aluminum chloride-silicon tetrachloride mixtures, 2011
 Aluminum-chromium oxide mixtures, 3005

- Aluminum-cobalt oxide mixtures, 3005
Aluminum fluoride, 1008
Aluminum fluoride-silica mixtures, 3568
Aluminum fluoride-sodium fluoride mixtures, 3130
Aluminum hydroxide gel, 2625, 3398
Aluminum-iron oxide mixtures, 3005
Aluminum laurate, 3686
Aluminum-manganese oxide mixtures, 3005
Aluminum-molybdenum oxide mixtures, 3005
Aluminum myristate, 3686
Aluminum-nickel oxide mixtures, 3005
Aluminum nitrate, 2823
Aluminum orthophosphate polymorphs, 525
Aluminum oxide, 3977, 4011
Aluminum palmitate, 3686
Aluminum phosphate, 654, 1637, 3794, 4005
Aluminum-silica mixtures, 3005
Aluminum stearate, 3686
Aluminum sulfate, 276, 1470
Aluminum sulfate, dehydrated, 635
Aluminum sulfite, 2763
Aluminum titanate, 1158
Aluminum-titanium dioxide mixtures, 3005
Aluminum trihydrate, 2602, 2675
Aluminum-vanadium oxide mixtures, 3005
Aluminum-zirconium dioxide mixtures, 3005
Aluminous cement-fused silica mixtures, 3918
Amides of rice, 742
Amino acids, 2248
Aminoguanidine picrate, 3100
Aminoguanidine styphnate, 3100
p-aminobenzoic-1,3,5-trinitrobenzene mixtures, 4017
p-aminohippuric acid, 3217
Ammonium acetate, 2748
Ammonium bromide, 3877, 4037
Ammonium calcium octaborate, 1818
Ammonium carbonate, 643
Ammonium chloride, 1809, 3518, 3785, 3877, 4037
Ammonium dichromate, 117, 1556
Ammonium fluoride, 4037
Ammonium heptafluorozirconate, 904
Ammonium hexachlorostannate, 4053
Ammonium iodide, 3877, 4037
Ammonium luteophosphotungstate, 3897
Ammonium metavanadate, 1678
Ammonium molybdates, 2597
Ammonium nitrate, 447, 448, 610, 854, 1155, 1441, 1535, 1568, 1619, 2677, 2819, 3045, 3110
Ammonium nitrate-ammonium chloride mixture, 1568
Ammonium nitrate-ammonium chromate mixture, 1568
Ammonium nitrate-ammonium sulfate mixture, 1568
Ammonium nitrate-lanthanum oxide mixtures, 3326
Ammonium nitrate-potassium nitrate mixture, 1954
Ammonium nitrate-sodium bromide mixture, 1568
Ammonium nitrate-sodium chloride mixture, 1568
Ammonium nitrate-sodium fluoride mixture, 1568
Ammonium nitrate-sodium iodide mixture, 1568
Ammonium nitrate with additives, 1722
Ammonium orthophosphate-calcium orthophosphate mixtures, 2889
Ammonium oxalate, 1172, 1610
Ammonium paratungstate, 3371
Ammonium perchlorate, 1535, 3247, 3300, 3378, 3403, 3474
Ammonium perchlorate, irradiated, 2777, 3474
Ammonium peroxide, 1153
Ammonium scandium halides, 3962
Ammonium succinamide, 1173

- Ammonium succinate, 1173, 1610
 Ammonium succinimide, 1173
 Ammonium sulfate, 3314
 Ammonium thiotungstate, 1958
 Ammonium uranium fluoride, 4078
 Ammonium uranyl nitrate, 3477
 Ammonium uranyl sulfate, 3477
 Amylopectin, 1620, 1897, 3431
 Amylose, 1620, 1897, 3431
 Anthranilic acid, 2748
 Antimony oxide, 291
 Antimony oxide-calcium carbonate mixtures, 1709
 Antimony oxide-calcium fluoride mixtures, 291
 Antimony oxide-calcium phosphate mixtures, 1709
 Antimony oxide-sodium nitrate mixtures, 291
 Antimony sulfide, 3184
 Aquopentammine cobalt complexes, 3713
 Arabinose, 2248
 Arsenic, 2165, 2304
 Arsenic acid, 3753
 Arsenic pentoxide, 3753
 Arsenious anhydride, 858

 Barium antimonate, 1766
 Barium bromide dihydrate, 2058
 Barium carbonate, 643, 1342, 1411, 1809, 2409, 3764
 Barium carbonate-antimony oxide mixtures 3948
 Barium carbonate dihydrate, 2436
 Barium carbonate-hafnia mixtures, 2992, 3531
 Barium carbonate-thoria mixtures, 2992
 Barium carbonate-titanium dioxide mixtures, 1126, 2283, 2324, 2409, 2653, 2981, 2992, 3677
 Barium carbonate-tungstic oxide mixtures, 3304
 Barium carbonate-zirconium dioxide mixtures, 2492, 2992, 3532
 Barium chloride, 854, 1747
 Barium dicalcium propionate, 819
 Barium ethyl sulfate, 3596
 Barium ferrocyanide, 3938
 Barium fluosilicate, 3799
 Barium formate, 2021
 Barium germanate, 2262
 Barium hexaniobate, 1922
 Barium hydroxide, 2392
 Barium hydroxide-titania mixtures, 2409
 Barium 8-hydroxyquinoline chelate, 3772
 Barium molybdate, 1497, 1986
 Barium nitrate, 1411, 1535, 3340, 3628, 3764
 Barium nitrate-potassium perchlorate-aluminum mixtures, 2128
 Barium oxalate, 1437, 1513, 2572, 3323, 3697, 3957
 Barium oxide-zirconium oxide-iron oxide mixtures, 1835
 Barium perchlorate, 1535, 3143
 Barium peroxide, 2127, 2665, 3593
 Barium peroxide-calcium resinate mixtures, 2127
 Barium phosphate, 1635
 Barium selenate, 2273, 2609, 3764
 Barium silicate hydrates, 2432, 3311
 Barium stannate, 1061
 Barium sulfate, 3244, 3245, 3764, 3953
 Barium sulfate-kaolinite mixtures, 3953
 Barium titanate, 2052, 3361, 3789, 4029, 4050
 Barium triuranate hydrate, 4059
 Barium zirconium metaniobate 3127, Bayerite, 651, 1458, 1537, 1665, 1696, 1797, 2828, 2930, 3518, 3766, 4047
 Bentonite catalyst, 3021
 Benzene, 1620, 3969
 Benzene-acenaphthalene, 1620
 Benzene diazonium chloride, 2059
 Benzene-toluene mixture, 1620
 Benzoic acid, 595, 742, 951, 952, 1610, 1620, 2748, 3969
m-aminobenzoic acid, 1355
o-aminobenzoic acid, 1355, 1610
p-aminobenzoic acid, 1355, 1610, 2748

- Benzoic acid
o-hydroxybenzoic acid, 1355
p-hydroxybenzoic acid, 973, 1610
p-nitrobenzoic acid, 1355, 1610
- Beryllium acetate, 449
 Beryllium actinium oxide, 447
 Beryllium carbonate, 1411, 3518
 Beryllium fluoride, 1908
 Beryllium hexaniobate, 1922
 Beryllium nitrate, 1411, 1535
 Beryllium oxide, 3416
 Beryllium oxyacetate, 583, 598, 915, 986, 1618
 Beryllium oxybenzoate, 2176
 Beryllium oxysalts of alicyclic and aliphatic acids, 3944
 Beryllium phosphate, 3757
 Beryllium sulfate tetrahydrate, 486, 1106
- Binary systems containing one or two elements:
- Ag-Cu, 3780
 Ag-S, 3327
 B-C, 3089
 Ba-BaCl₂, 2909
 Ba-Li, 2748
 Bi-S, 3327
 Ca-CaCl₂, 2909
 Ca-Sr, 2603
 Cd-CdBe₂, 3319
 Cd-CdCl₂, 3319
 Cd-CdI₂, 3319
 Cd-Te, 3208
 Cd-Tl, 2285
 CdTe-In₂Te₃, 3315
 Fe-As, 2304
 Fe-Pd, 2847
 Fe-Zr, 3308
 Ga-Te, 3597
 Ge-GeO₂, 2064
 Hf-Ga, 3917
 Hg-S, 415
 In-InP, 2275
 Li-Sr, 3978
 Mn-Ge, 2856
 Ni-As, 3726
 Ni-S, 3863
 Pb-S, 3327
- Pu-Cu, 3645
 Si-C, 3089
 Si-SiO₂, 2063
 Ti-Ga, 3917
 U-Al, 2373
 U-Fe, 2373
 U-Mo, 2373
 U-Zr, 2373
 W-C, 3930
 Zr-C, 3930
 Zr-Ga, 3917
- Binary systems containing two fluorides, oxides (other than silica), or mixed combinations:
- Ag₂O-Nb₂O₅, 2592
 Al₂O₃-MnO₂, 970
 Al₂O₃-SnO₂, 3738
 3BaO·B₂O₃-BaO, 563
 BaO-TiO₂, 1650
 BeF₂-SrF₂, 2731
 BeO-Al₂O₃, 3467
 BeO-TiO₂, 3163
 Bi₂O₃-MoO₃, 2784
 CaO-CaF₂, 1053
 CaO-ZrO₂, 2180
 CdO-B₂O₃, 1971, 4036
 CdO-Nb₂O₅, 3640
 CeO₂-SrO, 2151
 CsF-BeF₂, 2384
 Cs₂O-Nb₂O₅, 3642
 FeO-ZrO₂, 2101
 Fe₂O₃-Cr₂O₃, 1045
 GeO₂-K₂O, 3352
 GeO₂-Na₂O, 3352
 GeO₂-Rb₂O, 3352
 KAlF₄-RbAlF₄, 3915
 K₂CO₃-Ta₂O₅, 1934
 KF-AlF₃, 3915
 KF-BaTiO₃, 1124, 1326
 KF-MgF₂, 1069
 KNO₂-KOH, 3643
 KNO₂-NaOH, 3643
 KNbO₅-NaNbO₃, 2591
 KNbO₅-KTaO₃, 1652, 2109, 2591
 K₂O-Ta₂O₅, 1934
 LiF-FeF₂, 680, 962, 1396
 LiF-UF₄, 2370
 Li₂O-Li₂O·B₂O₃, 2929

- $\text{Li}_2\text{O}-\text{Nb}_2\text{O}_5$, 2592
 $\text{Li}_2\text{O}-\text{V}_2\text{O}_5$, 3923
 $\text{Li}_2\text{O}\cdot\text{B}_2\text{O}_3-\text{B}_2\text{O}_3$, 2601
 $\text{Na}_3\text{AlF}_6-\text{NaAlO}_2$, 253
 $\text{Na}_3\text{AlF}_6-\text{Na}_2\text{O}$, 253
 $\text{NaBeF}_3-\text{LiBeF}_3$, 2198
 $\text{NaBeF}_3-\text{Li}_2\text{BeF}_4$, 2198
 $\text{Na}_2\text{CO}_3-\text{Nb}_2\text{O}_5$, 2593
 $\text{NaF}-\text{FeF}_2$, 663, 1186
 $\text{NaF}-\text{UF}_4$, 2370
 $\text{NaF}-\text{ZrF}_4$, 2371
 $\text{NaNbO}_3-\text{KTaO}_3$, 3827
 $\text{Na}_2\text{O}-\text{Nb}_2\text{O}_5$, 2592, 2593, 2951
 $\text{Na}_2\text{O}-\text{SiO}_2$, 2995
 $\text{Nb}_2\text{O}_5-\text{Ta}_2\text{O}_5$, 3505
 $\text{P}_2\text{O}_5-\text{Fe}_2\text{O}_3$, 381, 398
 $\text{PbO}-\text{Fe}_2\text{O}_3$, 3887
 $\text{PbO}-\text{PbSe}$, 4061
 $\text{PbO}-\text{PbSeO}_3$, 3624
 $\text{Rb}_2\text{O}-\text{Nb}_2\text{O}_5$, 3625
 $\text{TiO}_2-\text{Li}_2\text{O}$, 2812
 UF_4-ZrF_4 , 2371
 $\text{V}_2\text{O}_5-\text{Li}_2\text{O}$, 3546
 $\text{ZnO}-\text{B}_2\text{O}_3$, 4009
 $\text{ZrO}_2-\text{ThO}_2$, 3223
- Binary systems containing other halides:
- $\text{AlCl}_3-\text{ZnCl}_2$, 2244
 $\text{BaCl}_2-\text{BaTiO}_3$, 2257, 2644
 $\text{BeCl}_2-\text{BeF}_2$, 2510
 $\text{CaCl}_2-\text{NaCl}$, 2871
 $\text{CdCl}_2-\text{CdSe}$, 3922
 $\text{CsCl}-\text{CoCl}_2$, 3282
 $\text{CsCl}-\text{CrCl}_2$, 3810, 3939
 $\text{CsCl}-\text{TiCl}_2$, 3455
 $\text{CsCl}-\text{VCl}_2$, 2945
 $\text{CuI}-\text{InI}_3$, 4031
 $\text{KBr}-\text{TiCl}_3$, 2765
 $\text{KCl}-\text{CoCl}_2$, 3282
 $\text{KCl}-\text{CrCl}_2$, 3810
 $\text{KCl}-\text{FeCl}_2$, 2252
 $\text{KCl}-\text{SmCl}_3$, 4075
 $\text{KCl}-\text{SrCl}_2$, 2711
 $\text{KCl}-\text{TiCl}_2$, 2087
 $\text{KCl}-\text{TiCl}_3$, 2765
 $\text{KCl}-\text{VCl}_2$, 2945
 $\text{LiBr}-\text{KBr}$, 1528
 $\text{LiCl}-\text{CoCl}_2$, 3282
 $\text{LiCl}-\text{LiClO}_4$, 3580
 $\text{LiCl}-\text{TiCl}_2$, 3455
 $\text{LiClO}_4-\text{NH}_4\text{ClO}_4$, 2866
 $\text{MgCl}_2-\text{CaCl}_2$, 2871
 $\text{MgCl}_2-\text{NaCl}$, 2871
 $\text{NaCl}-\text{CoCl}_2$, 3282
 $\text{NaCl}-\text{K}_2\text{TiF}_6$, 2493
 $\text{NaCl}-\text{VCl}_2$, 2945
 $\text{NiCl}_2-\text{CsCl}$, 3824
 $\text{PuCl}_3-\text{BaCl}_2$, 3524
 $\text{PuCl}_3-\text{CaCl}_2$, 3524
 $\text{PuCl}_3-\text{LiCl}$, 2716
 $\text{PuCl}_3-\text{MgCl}_2$, 3524
 $\text{PuCl}_3-\text{NaCl}$, 2716
 $\text{PuCl}_3-\text{SrCl}_2$, 3524
 $\text{RbCl}-\text{TiCl}_2$, 3455
 $\text{SnCl}_4-\text{SiCl}_4$, 2600
 $\text{TiCl}_4-\text{SiCl}_4$, 2600
- Binary systems containing two hydroxides:
- $\text{Ca}(\text{OH})_2-\text{Cd}(\text{OH})_2$, 319
 $\text{Ca}(\text{OH})_2-\text{Mg}(\text{OH})_2$, 725
 $\text{LiOH}-\text{KOH}$, 1181
 $\text{NaOH}-\text{KOH}$, 1181
- Binary systems containing water:
- $\text{Be}(\text{NO}_3)_2-\text{H}_2\text{O}$, 3974
 $\text{Cr}_2\text{O}_3-\text{H}_2\text{O}$, 1410
 $\text{H}_2\text{O}_2-\text{H}_2\text{O}$, 1616
 $\text{In}_2\text{O}_3-\text{H}_2\text{O}$, 1398
 $\text{KCl}-\text{H}_2\text{O}$, 1763
 $\text{KCl}\cdot\text{MgCl}_2-\text{H}_2\text{O}$, 1763
 $\text{K}_2\text{CO}_3-\text{H}_2\text{O}$, 3424
 $\text{K}_2\text{SO}_4-\text{H}_2\text{O}$, 1763
 $\text{MgCl}_2-\text{H}_2\text{O}$, 1763
 $\text{MgSO}_4-\text{H}_2\text{O}$, 1763
 $\text{Sc}_2\text{O}_3-\text{H}_2\text{O}$, 1410, 1763
 $\text{Tl}_2\text{O}_3-\text{H}_2\text{O}$, 1410
- Binary systems containing two carbonates:
- $\text{CaCO}_3-\text{CdCO}_3$, 319
 $\text{CaCO}_3-\text{MgCO}_3$, 319
 $\text{CdCO}_3-\text{KHCO}_3$, 319
 $\text{MgCO}_3-\text{NaHCO}_3$, 319
 $\text{Na}_2\text{CO}_3-\text{K}_2\text{CO}_3$, 2924
- Binary systems containing a nitrate:
- $\text{BaNO}_3-\text{KClO}_4$, 2452
 $\text{Ca}(\text{NO}_3)_2-\text{KClO}_4$, 2806, 3503
 $\text{CsNO}_3-\text{KClO}_4$, 3503

- $\text{KNO}_3\text{-BaClO}_4$, 2805
 $\text{KNO}_3\text{-KClO}_4$, 3503
 $\text{KNO}_3\text{-LiOH}$, 3644
 $\text{LiNO}_3\text{-KClO}_4$, 3503
 $\text{LiNO}_3\text{-LiClO}_4$, 2535
 $\text{LiNO}_3\text{-NaNO}_3$, 3644
 $\text{Mg}(\text{NO}_3)_2\text{-NH}_4\text{OH}$, 4035
 $\text{NaNO}_3\text{-KClO}_4$, 3503
 $\text{NaNO}_3\text{-NaNO}_2$, 1043
 $\text{RbNO}_3\text{-KClO}_4$, 3503
 $\text{Sr}(\text{NO}_3)_2\text{-KClO}_4$, 2806, 3503
- Binary systems containing a sulfate, a carbonate, or a hydroxide:
- $\text{Al}(\text{OH})_3\text{-CaSO}_4 \cdot 2\text{H}_2\text{O}$, 319
 $\text{CaCO}_3\text{-CaSO}_4 \cdot 2\text{H}_2\text{O}$, 319
 $\text{CdCO}_3\text{-CaSO}_4 \cdot 2\text{H}_2\text{O}$, 319
 $\text{Cs}_2\text{CO}_3\text{-Fe}_2\text{O}_3$, 3609
 $\text{K}_2\text{CO}_3\text{-Fe}_2\text{O}_3$, 3609
 $\text{K}_2\text{CO}_3\text{-Nb}_2\text{O}_5$, 1651
 $\text{Li}_2\text{CO}_3\text{-Fe}_2\text{O}_3$, 3609
 $\text{Mg}(\text{OH})_2\text{-SiO}_2$, 3743
 $\text{MgCO}_3\text{-CaSO}_4 \cdot 2\text{H}_2\text{O}$, 319
 $\text{MgSO}_4\text{-KCl}$, 1763
 $\text{Na}_2\text{CO}_3\text{-Fe}_2\text{O}_3$, 3609
 $\text{Na}_2\text{SO}_4\text{-Na}_2\text{CO}_3$, 1879
 $\text{Na}_2\text{SO}_4\text{-ZnSO}_4$, 1083
 $\text{PbSO}_4\text{-PbO}$, 3202
 $\text{ZnSO}_4\text{-TiCl}$, 1873
- Binary system containing phosphorus in the radical:
- $\text{NaPO}_3\text{-Na}_4\text{P}_2\text{O}_7$, 312
- Binary systems containing silica:
- $\text{Al}_2\text{O}_3\text{-SiO}_2$, 1092
 BeO-SiO_2 , 3146
 $\text{Ca}(\text{OH})_2\text{-SiO}_2$, 970, 1129
 CdO-SiO_2 , 3922
 CdSe-SiO_2 , 3922
 CuO-SiO_2 , 984
 $\text{K}_2\text{CO}_3\text{-SiO}_2$, 2565
 $\text{K}_2\text{O-SiO}_2$, 153
 $\text{K}_2\text{SiO}_3\text{-SiO}_2$, 229
 $\text{K}_2\text{Si}_2\text{O}_5\text{-SiO}_2$, 164
 MgO-SiO_2 , 984, 1065, 1132
 $\text{Na}_2\text{CO}_3\text{-SiO}_2$, 803, 970, 2565
 $\text{Na}_2\text{O-SiO}_2$, 970
 Si-SiO_2 , 2063
 ZnO-SiO_2 , 984
- Binary systems containing sulfur:
- $\text{AgBiS}_2\text{-PbS}$, 3327
 $\text{Ag}_2\text{S-Bi}_2\text{S}_3$, 3327
 $\text{Ag}_2\text{S-PbS}$, 3327
 $\text{CuS-Cu}_2\text{S}$, 3404
 FeS-Fe , 327
 FeS-FeS_2 , 3404
 $\text{Ni}_3\text{S}_2\text{-Cu}_2\text{S}$, 2178
 $\text{PbS-Bi}_2\text{S}_3$, 3327
- Binary systems, organic:
- Lithium stearate-cetane, 702
 Lithium stearate-decahydronaphthalene, 702
 Lithium stearate-*n* hexadecane, 2077
 Phenanthrene-anthracene, 3150
 Phthalic anhydride-polypols, 399, 428
 Sodium stearate-cetane, 694, 830
 Stearic acid-palmitic acid, 483
 Tristearin-tripalmitin, 483
- Biphenyl, 2723
 3,3-bis(nitratomethyl)oxetane, 3903
 Bismuth ferrite, 3468
 Bismuth *o*-hydroxybenzoate, 1610
 Bismuth salicylate, 974
 Bismuth stannate, 1061
 Bismuth sulfide, 3404
 Bismuth telluride, 3372
 Bismuth titanate, 3790, 3960
 Black powder, 2745
 Borate, 232
 Boric oxide-calcium oxide-zirconium oxide mixtures, 1835
 Boric oxide-magnesia mixtures, 385, 2214, 2215
 Boron oxide, 192, 2214
 Brownmillerite, 263, 1710
cis-butadiene rubber, 4021
n-butane, 3969
 Butyl iodide-magnesium mixtures, 3577
 Butyl phosphate-nitric acid mixtures, 3034
- Cadmium basic sulfate, 3168
 Cadmium borate, 455

- Cadmium carbonate, 689, 1411, 1467, 1742, 3260, 3518
Cadmium chloride, 1747
Cadmium ferrocyanide, 4066
Cadmium formate, 2021
Cadmium hydroxide, 882, 3428
Cadmium 8-hydroxyquinoline chelate, 3772
Cadmium nitrate, 689, 1535
Cadmium orthophosphate, mono-, 3925
Cadmium oxalate, 1437
Cadmium oxide, 3899
Cadmium oxide-uranium oxide mixtures, 3513
Cadmium peroxide, 1442, 2665, 2801, 3925
Cadmium phosphate, 3267
Cadmium selenate, 2837
Cadmium selenide, 4062
Cadmium selenite, 2837
Cadmium silicate, 1741
Cadmium stannate, 1061
Cadmium sulfate, 308, 584, 804, 1093, 2569, 3563, 3904
Cadmium sulfate 8/3-hydrate, 278
Cadmium sulfide, 4062
Cadmium sulfite, 3244
Cadmium telluride, 4062
Calcium, 2603
Calcium acetate, 3905
Calcium aluminate, 422, 1571, 1627, 1878, 2395, 3422
Calcium aluminocarbonate, 2736
Calcium aluminoferrite, 555
Calcium aluminosilicate, 1755, 1878, 3391, 3422, 3707
Calcium aluminum hydrate, 555, 1753, 2358, 2395, 2502, 2737, 2937
Calcium arsenate, 1683
Calcium borate hydrate, 3102
Calcium carbonate, 578, 854, 970, 996, 1019, 1399, 3260
Calcium carbonate-antimony oxide mixtures, 1709, 3948
Calcium carbonate-calcium phosphate mixtures, 1709
Calcium carbonate-calcium phosphate-calcium fluoride mixtures, 1709
Calcium carbonate-ferrous carbonate solid solution, 3569
Calcium carbonate-hafnia mixtures, 3531
Calcium carbonate hydrate, 2928
Calcium carbonate-salt mixtures, 2538
Calcium carbonate-silica mixtures, 1129, 3720, 3959
Calcium carbonate-sodium tungstate mixtures, 1438
Calcium carbonate-titania mixtures, 2324, 2409
Calcium carbonate-tungstic oxide mixtures, 3304
Calcium carbonate-uranium oxide mixtures, 3392
Calcium carbonate-vanadium oxide mixtures, 3538
Calcium carbonate-zirconia mixtures, 2492
Calcium chloride tetrahydrate, 2277
Calcium chloride, calcium aluminate hydrate, 1946
Calcium chromate, 516
Calcium ferrite, 1571, 1710
Calcium ferrocyanide, 3938
Calcium fluoride, 3445
Calcium fluoride-antimony oxide mixtures, 291
Calcium fluoride-calcium carbonate-calcium phosphate mixtures, 1709
Calcium fluoride-sodium nitrate mixtures, 291
Calcium fluosilicate, 3779
Calcium formate, 2021
Calcium germanate, 3652
Calcium hexaniobate, 1922
Calcium hydrogen phosphate dihydrate, 841, 3253
Calcium hydrosilicate, 263
Calcium hydroxide, 724, 882, 1359, 3259
Calcium hydroxide-fly ash mixtures, 3564

- Calcium hydroxide-silica mixture, 1245, 1559, 2117, 2232, 2375
 Calcium hydroxide-silica gel mixtures, 1559
 Calcium hydroxide-titania mixtures, 2409
 Calcium hydroxychloride, 2003
 Calcium iodate hexahydrate, 4013
 Calcium monocarbonate aluminate hydrate, 1992
 Calcium nitrate, 854, 1411, 1535, 3503, 3636, 3764
 Calcium orthophosphate, mono, 3636
 Calcium orthosilicate, 3720
 Calcium oxalate, 1437, 1513, 2572, 2778, 3611, 3712, 3957
 Calcium oxide, 2336, 3684
 Calcium oxide-alumina-iron oxide mixtures, 2560, 2561
 Calcium oxide-copper sulfate mixtures, 3064
 Calcium oxide-magnesium carbonate mixtures, 2667, 3064
 Calcium oxide-magnesium hydroxide mixtures, 2667
 Calcium oxide-magnesium sulfate mixtures, 3064
 Calcium oxide-zinc sulfate mixtures, 3064
 Calcium oxide-zirconia mixtures, 1461
 Calcium perchlorate, 1535
 Calcium peroxide, 2665
 Calcium peroxytungstate, 3402
 Calcium phosphate, 3278
 Calcium phosphate-antimony oxide mixtures, 1709
 Calcium selenate, 2611, 2946, 3764
 Calcium silicate, 916, 964, 1472, 1640, 2939
 Calcium silicate hydrates, 2044, 2374, 2375, 2395, 2465, 2533, 2681, 2740, 2788, 3075, 3311
 Calcium silicate-silica mixtures, 1756
 Calcium sodium phosphate, 2939
 Calcium stannate, 1061
 Calcium stearate, 517
 Calcium stearate monohydrate, 517
 Calcium sulfate, 254, 2569, 3764
 Calcium sulfate, alpha-CaSO₄·1/2 H₂O, 1051
 Calcium sulfate, beta-CaSO₄·1/2 H₂O, 1051
 Calcium sulfate-alumina mixtures, 1433
 Calcium sulfate dihydrate, 278, 854, 2436, 3656, 3941, 4067
 Calcium sulfate hemihydrate, 2364, 2581, 3865
 Calcium sulfate-silica mixture, 1987
 Calcium sulfite, 2549
 Calcium sulfoaluminate, 555, 2489, 3420
 Calcium triuranate hydrate, 4059
 Calcium tungstate, 3674
 Calcium vanadate-uranium oxide mixtures, 3538
 Calcium zeolite, 3823
 Calcium zirconate, 2700
 Calcium zirconate-borate mixtures, 2511
 Camphor, 2137, 2661
 ε-caprolactam, 2723
 Carbon, 1534, 2938
 Carbohydrates, 742
 Carbonates (anhydrous), 591
 Carbonato-tetramminocobaltic nitrate, 239
 Carboxymethylcellulose, 1620
 Carrageenan, 3431
 Castor oil, 2446
 Catechol, 2661
 Cellobiose, 1620, 2248
 Cellulose, 2902, 3161, 3992
 Cellulose acetate, 2902, 3161
 Cellulose cotton, 615, 691, 742, 1620
 Cellulose, dehydrated from filter paper, 993
 Cellulose from wood, 993, 1492
 Cellulose nitrate, 2902, 3161
 Cellulose triacetate, 1620
 Cement, 555, 752, 774, 920, 1014, 1054, 1075, 1283, 1314, 1323, 1324, 1365, 1432, 1485, 1627, 1866, 1869, 1981, 2060, 2390, 2750, 3043, 3081, 3386, 3626, 3806
 Cement-calcium sulfite mixtures, 2886
 Cement-lime mixtures, 920

- Cement-pozzolan mixtures, 2709
Cement-pumice mixtures, 920
Cement-shale mixtures, 920
Cement-silica mixtures, 920
Ceresin, 2636
Ceric oxide, hydrated, 2885
Cerium chloride hydrate, 3009
Cerium ethyl sulfate, 3596
Cerium iodide, 3441
Cerium nitrate, 3423, 3628
Cerium oxalate, 3369, 3715, 3954, 4077
Cerium sulfate, 4077
Cerium sulfate octahydrate, 2690
Cesium, 3845, 3894
Cesium bromide-cesium chloride mixtures, 2679
Cesium carbonate, 2590, 3264
Cesium dihydrogen orthophosphate, 1912
Cesium hexachlorostannate, 4053
Cesium monohydrogen orthophosphate, 1912
Cesium nitrate, 1535, 3423, 3503
Cesium perchlorate, 1535, 3581
Chloroform, 3400
Chocolate, 2446
Chromic acid, 117
Chromic hydroxide, 254, 882, 1487, 1654, 3428
Chromic hydroxide-silicic acid mixtures, 3385
Chromic oxide, 117, 132, 186, 347, 447, 462, 497, 2049, 3552
Chromium ammine bromate, 3870
Chromium ammine iodate, 3870
Chromium ammine periodate, 3870
Chromium nitrate, 2823
Chromium oxide catalysts, 2596, 2714, 2984
Chromium sulfate, 1900
Cinnamic acid, 2748
Citric acid, 2748
Cobalt ammine complexes, 3716
Cobalt ammine perchlorate, 3998
Cobalt ammine polybromides, 3507
Cobalt catalyst, 3077
Cobalt carbonate, 3764
Cobalt chloride dimethyl sulfoxide complex, 3338
Cobalt chloride hydrate, 2058, 2902
Cobalt ferrite, 2052
Cobalt formate, 2021
Cobalt hexammine hydroxide, 1638
Cobalt 8-hydroxyquinoline chelate, 3772
Cobalt molybdate, 1497, 1986
Cobalt nitrate, 2823
Cobalt nitrate dimethyl sulfoxide complex, 3338
Cobalt oxalate, 1437, 3323, 3478, 3479, 3540, 3697
Cobalt oxide, 1636, 3899
Cobalt selenide, 1810
Cobalt silicate, 3077
Cobalt soaps, 3837
Cobalt stannate, 1061
Cobalt sulfide, 1810
Cobalt sulfite, 1742
Cobalt sulfate, 2569, 3563
Cobaltiamine iodate, 2851
Cobaltous sulfate heptahydrate, 278
Coconut oil, 2446, 3520
Coconut oil-tallow mixtures, 3520
Coffee, 3300
Copper bis(β -diketone)polymers, 3450
Copper ferrocyanide, 3937
Copper formate, 2021
Copper 8-hydroxyquinoline chelate, 3772
Copper oxide-chromium oxide mixtures, 3771
Copper oxide-molybdenum oxide mixtures, 1456
Copper oxide-silica gel mixtures, 1399
Copper oxychloride, 3109
Copper perchlorate, 1535
Copper-pyrite mixtures, 2309
Copper selenate, 3942
Copper-zinc-iron oxalate, 3614
Corn oil, 2446, 3520
Cotton, 3300
Cottonseed oil, 2446, 3520
Cupric acetate monohydrate, 3501
Cupric ammonium sulfate, 4081
Cupric chloride, 1560

- Cupric ferrite, 3748
 Cupric fluoride, 1447
 Cupric hydroxide, 1741, 3428
 Cupric nitrate, 1535
 Cupric oxalate, 1437, 3739
 Cupric oxide, 2178, 3899
 Cupric silicate, 1741
 Cupric stannate, 1061
 Cupric sulfate, 223, 239, 447, 1106, 1742, 2178, 2569, 3300, 3563, 3739
 Cupric sulfate, basic, 3875
 Cupric sulfate dihydrate, 3539
 Cupric sulfate pentahydrate, 278, 610, 1747, 2058, 2140, 2436, 254, 2902, 3478, 3539, 3982, 4081
 Cuprous acetate dimethyl sulfoxide complex, 3338
 Cuprous chloride dimethyl sulfoxide complex, 3338
 Cuprous fluoride, 1308
 Cuprous oxide, 2178, 3899
 Cuprous sulfide, 1809, 2178
 Cyano-nitrosyl transition metal complexes, 3805
- Dacron, 3279, 3842
n-decane, 3969
 Dextran, 1896, 1897
 Diammonium platinic chloride, 254
 Diazobenzene chloride, 2059
 Dibenzathrone, 2241
 Dicalcium ferrite, 263, 1571, 3071
 Dicalcium silicate, 263, 419, 964, 2599, 2728, 3555, 3950
 Dicalcium silicate, hydrated, 2982, 3183, 3210, 3484
 2,3 dichloroquinoline, 3739
 Dihydrogen phosphate-silica mixtures, 3263
 Diglycolic acid, 2748
 2,3-dimethyl-2,3-dibromobutane, 3685
 2,4-dimethyl fluorstyrene, 4022
 3,4-dimethyl fluorstyrene, 4022
 3,5-dimethyl fluorstyrene, 4022
 Dimethylaniline-ethyl iodide mixtures, 2059
 Dimethylolurea, 3890
m-dinitrobenzene, 3785
- Dinitro-tetramminocobaltic nitrate, 239
 Dinitrotoluene, 2758
n-diotriacontane, 3161
 Dipentene dioxide polymer, 3375
 Diphenylamine, 2723
 Dipyridine rhenium tetrachloride, 2648
 Disodium aluminosilicate, 3724
 Disodium hydrogen phosphate hydrate, 3384
 Disodium phosphate, 3781
 1,3-distearin, 3612, 3613
 Dolomitic lime, 872
n-dodecane, 3969
 Dysprosium carbonate, 3714
 Dysprosium chloride hydrate, 3009
 Dysprosium ethyl sulfate, 3596
 Dysprosium trinitrate tetrahydrate, 3342
- Edestin-bentonite mixtures, 1006
 Epoxides, 2697, 3026
 Epoxy resins, 2696, 2833, 3541
 Erbium carbonate, 3714
 Erbium chloride hydrate, 3009
 Erbium ethyl sulfate, 3596
 Erbium trinitrate tetrahydrate, 3342
 Ethyl acetate, 3039
 Ethyl alcohol, 505, 3400
 Ethyl alcohol-alumina mixtures, 505
 Ethyl benzene, 505
n-ethyl dinitropyrrole, 2589
 Ethylene- α -butene copolymer, 3843
 Ethylenediaminetetraacetic acid chelates of transition metals, 3346
 Ethylenedinitrilotetraacetic acid, 3341
 Ethylene-propylene copolymer, 3843
n-ethylguanidine picrate, 3100
n-ethyl guanidine styphnate, 3100
n-ethyl guanidine sulfate, 3100
 Ethyl iodide-dimethylaniline mixtures, 2059
 Europium carbonate, 3714
 Europium chloride hydrate, 3009
 Europium ethyl sulfate, 3596
 Europium trinitrate tetrahydrate, 3342

- Explosives (See Perchlorate mixtures.)
- Fatty acids, 3912
- Ferric ammonium sulfate, 3982
- Ferric chloride dimethyl sulfoxide complex, 3338
- Ferric citrate, 2748
- Ferric hydroxide, 254, 882, 1389, 2245, 2625, 2641, 3428, 3459, 3768
- Ferric nitrate, 2823
- Ferric oxalate, 2748
- Ferric oxyhydroxides, alpha- and gamma-, 684
- Ferric phosphate, 1586, 4005
- Ferric salicylate, 3739
- Ferric stannate, 1061
- Ferric sulfate, 254
- Ferric vanadate, 4065
- Ferrous carbonate, 1844, 3390, 3744
- Ferrous carbonate-magnesium carbonate mixtures, 3745
- Ferrous carbonate-manganese carbonate mixtures, 3745
- Ferrous ethylenediammonium sulfate, 3344
- Ferrous monohydrogen phosphate, 1586
- Ferrous oxalate, 1437, 3322, 3323, 3697, 3698
- Ferrous oxide-silica mixtures, 1098
- Ferrous stannate, 1061
- Ferrous sulfate, 2569, 3244
- Ferrous sulfate heptahydrate, 278, 1682, 2677
- p*-fluorystyrene, 4022
- Formalin-phenol mixtures, 1180
- Fructose, 2248
- Fulvic acid, 2703
- Fumaric acid, 254, 2748
- Gadolinium carbonate, 3714
- Gadolinium chloride hydrate, 3009
- Gadolinium ethyl sulfate, 3596
- Gadolinium oxalate, 3058
- Gadolinium trinitrate tetrahydrate, 3342
- Galactose, 2248
- Gallium antimonate, 1949
- Gallium arsenate, 1949
- Gallium hydroxide, 882
- Gallium oxide, 748
- Gallium phosphate, 1924, 1949
- Gelatin-hectorite mixtures, 1006
- Germanium hydroxide, 882
- Germanium oxide, 3274
- Glass, 76, 83, 86, 87, 107, 116, 160, 248, 515, 593, 845, 1013, 1921, 2557, 2663, 2914, 3141, 3489, 3778, 4010
- α -glucose, 1620, 1897, 2248, 3773
- Glycerides, 2515
- Glycogen, 1897, 2220
- Glycylglycylglycine, 1620
- Graphite, irradiated, 3635
- Grease, 596, 702
- Guanidine carbonate, 2748
- Guanidine hydrochloride, 2748
- Guanidine nitrate, 3100
- Guanidine picrate, 3100
- Guanidine styphnate, 3100
- Guanidine sulfate, 3100
- Guanylurea picrate, 3100
- Guanylurea styphnate, 3100
- Guaran, 3431
- Gypsum, 1898, 2222, 2223, 2341, 2413, 2580, 3106
- Hafnium oxide, 1270
- Hafnium oxynitrate hexahydrate, 3995
- Hemicellulose, 1620, 3431
- n*-heptane, 3969
- 1-hexadecanol, 2883
- Hexachlorobenzene, 1534
- Hexamethylenetetramine, 2661
- Hexamine cobalt complexes, 2476, 2477, 2526, 4082
- Hexamminocobaltic nitrate, 239
- Hexamminonickelous chloride, 239
- Hexamminonickelous nitrate, 239
- Holmium carbonate, 3714
- Holmium chloride hydrate, 3009
- Holmium ethyl sulfate, 3596
- Holmium trinitrate tetrahydrate, 3342
- "Hopcalite" surface, 236
- Humic acid, 2295, 2703
- Hydrazine picrate, 3100
- Hydrazine styphnate, 3100

- Hydrofluoric acid-zirconium fluoride mixtures, 3896
 Hydroquinone, 2748
- Indium antimonide, 3521
 Indium telluride, 3798
 Indium phosphide, 2275
 Indole-3-acetic acid, 2748
 Indole-3-butyric acid, 2748
 Indole-3-propionic acid, 2748
 Inulin, 2248
 Iron ammine perchlorate, 3998
 Iron hydroxide, 3448, 3860
 Iron oxide, 70, 132, 250, 564, 786, 895, 945, 1784, 2049, 2713, 2900, 2940, 3733, 3784, 3899, 4046
 Iron oxide-alumina mixtures, 1785
 Iron oxide-barium carbonate mixtures, 2900
 Iron oxide-cadmium carbonate mixtures, 2900
 Iron oxide-chromia mixtures, 2049
 Iron oxide-cobalt carbonate mixtures, 2900
 Iron oxide-copper carbonate mixtures, 2900
 Iron oxide-lithium carbonate mixtures, 2900
 Iron oxide-manganese oxide mixtures, 1833, 2900
 Iron oxide-magnesium carbonate mixtures, 2900
 Iron oxide-molybdenum oxide mixtures, 1456
 Iron oxide-nickel oxide mixtures, 2900
 Iron oxide-zinc oxide mixtures, 2900
 Iron oxide-zirconium oxide-barium oxide mixtures, 1835
 Iron oxide-zirconium oxide-strontium oxide mixtures, 1835
 Iron oxide with carbon, 1507
 Iron oxide with kaolin, 549, 564
 Iron phosphate, 3486
 Iron-sodium hydroxide mixtures, 994
 Iron-sodium hydroxide-alumina mixtures, 994
 Iron sulfate-barium carbonate mixtures, 2900
- Iron sulfide, 931, 3404
 Iron sulfide-manganese dioxide mixtures, 1547
 Isonicotinoyl hydrazide, 1610, 1642
 4-4'-isopropylidenediphenol, 3300
- Keratin, 3280
 Kodel, 3842
- Lactose, 2248
 Lanthanum chloride hydrate, 3009
 Lanthanum ethyl sulfate, 3596
 Lanthanum hydroxide, 2952, 3561
 Lanthanum iodide, 3441
 Lanthanum oxalate, 3241, 3479, 3715, 3933, 3954
 Lanthanum oxide, 3058
 Lanthanum oxide-maleic acid mixtures, 3702
 Latosols, 697, 698
 Lead antimonate, 1766
 Lead carbonate, 2606, 3478, 3764
 Lead chloride, 3218
 Lead dioxide, 3593
 Lead fluoride, 1735
 Lead hexaniobate, 1922
 Lead 8-hydroxyquinoline chelate, 3772
 Lead nitrate, 3593, 3764
 Lead oxalate, 1437, 3957
 Lead oxide, 2291, 2419, 3593, 3899
 Lead oxide-titania mixtures, 2324
 Lead oxide-tin oxide mixtures, 2324
 Lead oxyselenite, 3999
 Lead perchlorate, 3362
 Lead phosphate, 1635
 Lead platinide, 4043
 Lead selenate, 2273, 2609, 3764
 Lead selenide-lead sulfide mixtures, 3453
 Lead selenite, 3203, 3999
 Lead silicate, 789, 935, 1342, 3147, 3517
 Lead stannate, 1061
 Lead sulfate, 2569, 3764, 3953
 Lead sulfate-kaolinite mixture, 3953
 Lead sulfide, 3499
 Lead titanate, 3966

- Lead zirconate, 3966
Leutetium ethyl sulfate, 3596
Lignin, 615, 691, 993
Lime-chromite mixtures, 651
Lime-clay mixtures, 3961
Lime-fly ash mixtures, 3211
Lime-kyanite mixtures, 3936
Lime-silica mixtures, 1253, 1303, 1589, 2068, 2343, 2893, 2987, 3210, 3276
Lime-slag mixtures, 3211
Lime-pozzolan mixtures, 2709
Limestone, calcined, 557
Limestone-bauxite mixtures, 557
Limestone, calcined-silica gel mixtures, 557
Limestone-clay mixtures, 557
Limestone-kaolinite mixtures, 557, 3551
Limestone-salt mixtures, 2038
Limestone-silica mixtures, 3551
Limestone-soda ash mixtures, 557
Linoleic acid, 2748
Lithium, 3894
Lithium aluminate, 768
Lithium aluminum hydride, 1892
Lithium aluminoborate, 3846
Lithium aluminospinel, 2827, 3840
Lithium antimonate, 1766
Lithium beryllium fluoride, 2313
Lithium carbonate, 643, 1184, 2539, 2590, 3518, 3945
Lithium carbonate-alumina mixtures, 2539, 2548
Lithium carbonate-silica mixtures, 2870
Lithium dihydrogen orthophosphate, 1912
Lithium disilicate, 3495
Lithium ferrite, 2473
Lithium ferrosinon, 2827, 3840
Lithium fluoride, irradiated, 2852, 3587
Lithium fluosilicate, 3779
Lithium hydride, irradiated, 2852, 3587
Lithium hydrocastorate, 2351
Lithium 12-hydroxystearate, 2351
Lithium hydroxystearate grease, 885
Lithium metaphosphate, 3691
Lithium metaphosphate-lithium pyrophosphate mixtures, 3582
Lithium metasilicate, 3495
Lithium nitrate, 1535, 3503, 3628
Lithium nitrate-magnesium mixtures, 1789
Lithium orthophosphate, 3691
Lithium perchlorate, 1535, 3032, 3206, 3581
Lithium peroxide, 1073, 1185, 1655, 3088
Lithium phosphate, 3205
Lithium pyrophosphate, 3691
Lithium selenate, 3943
Lithium silicate, 66
Lithium silicotungstate, 1961
Lithium stearate, 2077, 2410
Lithium stearate grease, 885
Lithium sulfate, 2606, 3563
 β -luteophosphotungstic acid, 3897
Lutetium chloride hydrate, 3009
Lutetium trinitrate tetrahydrate, 3342
Magnesia-boric oxide mixtures, 385
Magnesia-chromite mixtures, 3758
Magnesia-silica gel mixtures, 682, 1399
Magnesia-silica-water mixtures, 1325, 3354
Magnesium aluminate, 673
Magnesium ammonium carbonate, 2760
Magnesium ammonium phosphate hexahydrate, 254
Magnesium antimonate, 1766
Magnesium bromide trietherate, 3638
Magnesium carbonate, 643, 685, 689, 1342, 1467, 3260, 3764
Magnesium carbonate, basic, 2738
Magnesium carbonate hydrate, 1459, 1692, 3196, 3965
Magnesium cements, 3926
Magnesium chloride hexahydrate, 3383
Magnesium ferrocyanide, 3938
Magnesium fluoride, 3445

- Magnesium formate, 2021
Magnesium hexaniobate, 1922
Magnesium hydroxide, 610, 724, 882, 1359, 1487, 1505, 1692, 2629, 3069, 3259, 3367
Magnesium hydroxide-magnesium carbonate mixtures, 3042
Magnesium hydroxide-silica mixtures, 2965
Magnesium 8-hydroxyquinoline chelate, 3772
Magnesium metasilicate, 3015
Magnesium nitrate, 689, 1535, 3340
Magnesium orthophosphate, monohydrogen, 670, 3518
Magnesium oxalate, 1437, 1513
Magnesium oxide, 3259
Magnesium oxide-copper sulfate mixtures, 3064
Magnesium oxide-uranium oxide mixtures, 3623
Magnesium oxide-zinc sulfate mixtures, 3064
Magnesium oxychloride, 1477, 1496, 1505, 2471, 3831
Magnesium perchlorate, 1535
Magnesium peroxide, 1442, 2665
Magnesium phosphate, 510
Magnesium pyrophosphate, 132, 510
Magnesium selenate, 3283, 3284
Magnesium-sodium nitrate-Laminac mixtures, 2804
Magnesium stannate, 1061
Magnesium silicate, 3674
Magnesium silicate catalyst, 1658, 2764
Magnesium silicate hydrates, 2073, 2394
Magnesium sulfate, 254, 713, 1106, 2569, 3367, 3563, 3764
Magnesium sulfate heptahydrate, 278, 610, 854, 2923, 3367, 3747
Magnesium sulfite, 2899
Magnesium thiosulfate, 2899
Magnesium tungstate, 455
Maize cellulose, 742
Maleic acid, 254, 2748
Maleic anhydride resin, 3987
Malic acid, 2748
Maltose, 1620, 2248
Mandelic acid, 2748
Manganese ammonium sulfate, 4057
Manganese carbonate, 1787, 2458, 2717, 3056, 3764
Manganese carbonate plus additives, 2242
Manganese chloride-dicyandiamide complex, 4007
Manganese chloride hydrate, 2058
Manganese dioxide-iron sulfide mixtures, 1547
Manganese ferrite, 4057
Manganese formate, 2021
Manganese hydroxides, 3799
Manganese 8-hydroxyquinoline chelate, 3772
Manganese-magnesium-iron oxalate, 3614
Manganese nitrate, 2823
Manganese oxides, 1653, 2124, 2260, 3799
Mn₂O₃, 970, 2713, 3056, 3899
Mn₃O₄, 970, 3056
MnO₂, 504, 567, 628, 1386, 1787, 2292, 2383, 3056, 3397, 3472, 3485, 3679
MnO, 970, 3056
Manganese oxide-iron oxide mixtures, 1833
Manganese phosphate, 1586, 2903
Manganese stannate, 1061
Manganese sulfate, 254, 2569, 3563, 3656
Manganese sulfate pentahydrate, 278
Manganese sulfide, 2020
Manganese-zinc-iron oxalate, 3614
Manganous carbonate, 1743, 1844, 2242
Manganous monohydrogen phosphate, 1586
Manganous oxalate, 1437, 1513
Mannose, 2248
Margarine, 2445, 2446
Marlex, 4041
Melamine, 3403
Mercuric nitrate, 1535

- Mercuric oxalate, 1437
Mercuric oxide, 3899
Mercuric perchlorate, 1535
Mercurous nitrate, 1535
Mesoxalic acid, 2748
Methyl alcohol, 3400
Methylenediurea, 3890
m-methyl fluorstyrene, 4022
o-methyl fluorstyrene, 4022
n-methylguanidine picrate, 3100
n-methylguanidine styphnate, 3100
2-methylnaphthalene-*n*-heptane mixtures, 2881
Mohr's salt, 3545
Molybdenum carbide, 4034
Molybdenum oxide-calcium oxide mixtures, 1456
Molybdenum oxide catalyst, 2984
Molybdenum oxide-carbon mixtures, 3139
Molybdenum oxide-copper oxide mixtures, 1456
Molybdenum oxide-iron oxide mixtures, 1456
Molybdenum trioxide, 1497, 1986, 3924
Molybdenum trisulfide, 3650
Monoethyl urea, 3890
1-mono-stearin, 3612, 3613
Mylar, 3842
- Naphthalene, 742, 806
Neodymium carbonate, 3714
Neodymium chloride hydrate, 3009
Neodymium ethyl sulfate, 3596
Neodymium oxalate, 3058, 3715, 3986
Neodymium oxide, 3058
Neodymium sulfate octahydrate, 2690
Nickel-alumina catalyst, 4068
Nickel ammine complex, 4033
Nickel ammine perchlorate, 3998
Nickel carbonate, basic, 2104, 3518
Nickel catalyst, 3191
Nickel chloride, 4030
Nickel chloride dicyandiamide complex, 4007
- Nickel chloride dimethyl sulfoxide complex, 3338
Nickel chloride hexammine, 4030
Nickel ethylenediammine complex, 3802, 4033
Nickel ferrite, 2052, 2713
Nickel formate, 2021
Nickel hexammine hydroxide, 1638
Nickel hydroxide, 701, 882, 1741, 3428
Nickel hydroxide-aluminum hydroxide mixtures, 3603
Nickel hydroxide-kieselguhr mixtures, 701
Nickel 8-hydroxyquinoline chelate, 3772
Nickel molybdate, 1497, 1986
Nickel nitrate, 2823, 3980
Nickel oxide, 2178, 3899
Nickel oxide-molybdenum oxide mixtures, 3673
Nickel propylene diamine complex, 3802
Nickel selenide, 1810
Nickel silicate, 1741
Nickel sulfide, 1810, 2177, 2178
Nickel sulfate, 2178, 2569, 3563, 3764
Nickelous nitrate hexahydrate, 239, 1322, 1557
Nickelous oxalate, 1437
Nickelous stannate, 1061
Nickelous sulfate heptahydrate, 278
Nickelous sulfate hexahydrate, 610
Nickel-zinc ferrosphenel, 2138
Nickel-zinc-iron oxalate, 3614
Niobic acid, 934
Niobium chloride, 3797
Niobium metaperoxyacid, 3808
Niobium tetrachloride, 3475
Nitrocellulose, 3378
Nitroguanidine, 3100
p-nitrophenol, 2661
Nylon, 1714, 3161, 3279, 4039
- n*-octane, 3969
Oleic acid, 2748, 3031
Olive oil, 2446

- Orlon, 3279
 Oxalic acid, 2661, 2748, 3957
 Oxygen-vanadium bronzes, 2243
- Palmitates and stearates (metal soaps), 314, 395, 551
 Palmitic acid, 3031
 Palm oil, 2445, 2446
 Paraffin wax, 1268, 1269, 1498, 2636, 3300
 Paraffinic oil, 4021
n-pentane, 3969
 Peanut oil, 2445, 2446, 3520
 Pectin, 3431
 Pentaerythritol, 2902, 3903
 Pentaerythrityl tetranitrate, 2902, 3903
 Pentaerythrityl trinitrate, 2902, 3903
- Perchlorate mixtures:
 BaClO₄-KNO₃, 2805
 KClO₄-C, 1534
 KClO₄-C-Zn, 1534
 KClO₄-C₆Cl₆, 1534
 KClO₄-C₆Cl₆-Zn, 1534
 KClO₄-KNO₃, 2744
 KClO₄-Zn, 1534
- Petrolatum, 2636
 Phenol, 2748
 Phenol-formaldehyde resins, 3594
 Phenol-formalin mixtures, 1180
m-phenoxyene, 3411
 Phenyl glycidyl ether, 2833, 3541
 Phloroglucinol, 2748
- Phosphates, 670
 2K₂HPO₄·KH₂PO₄·H₂O, 277
 3K₂HPO₄·KH₂PO₄·2H₂O, 277
 K₂HPO₄·KH₂PO₄·3H₂O, 277
 K₂HPO₄·KH₂PO₄·2H₂O, 277
- Phosphomolybdic acid, 1713, 1906
 Phosphoric acid, 1707
 Phosphoric acid catalyst, 2132
 Phosphoric acid-nepheline mixtures, 1980
 Phosphorus, 2396
 Phosphotungstic acid, 1713, 1906
 Phosphotungstic heteropoly acids, 2595
- Phthalic acid, 2748
 Phthalic anhydride, 2748, 3161
 Picric acid, 3773
 Platinum complex compounds, 254, 1162, 3983
 Polyacrylonitrile, 3161, 3162, 3279, 3992
 Polyamides, 2076, 3992
 Poly(3,3-bischloromethyl oxacyclobutane), 4039
 Poly-1-butene, 4012
 Polyesters, 3992
 Polyethylene, 871, 3160, 3161, 3231, 3529, 3653, 3722, 3777, 3888, 3901, 3969, 3992, 4019, 4039, 4073
 Polyethylene glycol terephthalate, 2076
 Polyethylene terephthalate, 3281, 3842
 Polyglucosans, 2220
trans-polymer butadiene, 4021
 Polymethylene, 4041
 Polymethyl methacrylate, 4072
 Poly-4-methylpentene-1, 4041
 Poly(organo)siloxanes, 3737
 Polyoxymethylene, 4039
 Ploy(*p*-xylene), 3788
 Polypropylene, 3160, 3161, 3231, 3992, 4039, 4042, 4072, 4073
 Polystyrene, 3161, 3777
 Polytetrafluorethylene, 3225, 3901
 Polyundecanamide, 2076
 Polyvinyl acetate, 2070
 Polyvinyl alcohol, 3992
 Polyvinyl chloride, 1620, 2070, 2241, 3161, 3225, 3226, 3888, 3901, 3992
 Polyvinylidene fluoride, 3901
 Polyvinyl fluoride, 3901
 Porcelain enamel frit, 291, 1554, 2018, 2136, 2267, 2578
 Portland cement-fused silica mixtures, 3918
 Potassium, 3894
 Potassium acid sulfate-potassium monohydrogen phosphate mixtures, 1240
 Potassium alum, 276, 1470
 Potassium aluminate, 3030

- Potassium borohydride, 2240, 3885
 Potassium carbonate, 643, 2590, 3264
 Potassium carbonate, hydrogen, 1467
 Potassium carbonate-uranium oxide mixtures, 3454
 Potassium chlorate, 3137
 Potassium chloride, 1520, 1950
 Potassium chloride-alunite mixtures, 1950
 Potassium chloride-sodium chloride mixtures, 434
 Potassium chloride-uranium oxide mixtures, 3704
 Potassium chromate, 1809
 Potassium dihydrogen phosphate-potassium monohydrogen phosphate mixtures, 965
 Potassium ethyl sulfate, 3596
 Potassium ferrate, 3030, 3609
 Potassium ferrite, 3991
 Potassium fluoride-fluorophlogopite mixtures, 3592
 Potassium fluosilicate, 3779
 Potassium hexachlorostannate, 4053
 Potassium hydrogen carbonate, 1747
 Potassium hydrogen phthalate, 1747, 3040
 Potassium hydrogen tartrate, 1610
 Potassium hydroxide, 3885
 Potassium maleate, 2109
 Potassium magnesium chloride, 2923
 Potassium mercurous chloride monohydrate, 2749
 Potassium metaphosphate, 3001
 Potassium metaphosphate-magnesium chloride mixtures, 3001
 Potassium metaphosphate-calcium chloride mixtures, 3001
 Potassium metaphosphate-calcium oxide mixtures, 3001
 Potassium metaphosphate-magnesium oxide mixtures, 3001
 Potassium metasilicate, 229
 Potassium niobate, 1863
 Potassium nitrate, 154, 610, 1535, 1809, 2744, 2778, 2836, 2876, 3143, 3388, 3587, 3628, 3785
 Potassium nitrate-ammonium nitrate mixtures, 1954
 Potassium nitrate-barium chloride mixtures, 3142
 Potassium nitrate-barium nitrate mixtures, 3142
 Potassium nitrate-potassium perchlorate mixtures, 2744
 Potassium nitrate-uranium oxide mixtures, 3704
 Potassium ozonide, 4070
 Potassium perchlorate, 1534, 1535, 1809, 2199, 2778, 3137, 3143, 3206, 3581, 3735
 Potassium perchlorate-aluminum-barium nitrate mixtures, 2128
 Potassium permanganate, 3593
 Potassium permanganate-antimony mixtures, 3593
 Potassium peroxide, 1183
 Potassium peroxodicarbonate, 3882
 Potassium peroorthoniobate, 3808
 Potassium peroorthotantalate, 3808
 Potassium pervanadate, 3807
 Potassium *o*-phthalate, 4068
 Potassium silicotungstate, 1960
 Potassium sodium sulfate, 2923
 Potassium sulfate, 635, 970, 1481, 1809, 2923, 3205, 3518, 3785
 Potassium sulfate-silica mixtures, 2109
 Potassium sulfate-sodium nitrate mixtures, 434
 Potassium sulfate-uranium oxide mixtures, 3704
 Potassium tartrate, 1610
 Potassium tetrasilicate, 164, 229
 Potassium zeolite, 3823
 Potato starch, 742
 Praseodymium carbonate, 3714
 Praseodymium chloride hydrate, 3009
 Praseodymium ethyl sulfate, 3596
 Praseodymium iodide, 3441
 Praseodymium oxalate, 3715
 Praseodymium oxides, 1307, 3669
 Praseodymium sulfate octahydrate, 2690

- n*-propylamine, 3773
 Protein, 801, 2248
 Pyrogalllic acid, 2748
 Quaternary systems:
 CaO-Al₂O₃-SiO₂-H₂O, 3382
 CaO-MgO-Al₂O₃-SiO₂, 2008
 Li₂O-Al₂O₃-Fe₂O₃-H₂O, 3682
 Li₂O-MgO-Al₂O₃-SiO₂, 3657
 MgO-Al₂O₃-SiO₂-H₂O, 1660
 Na₂O-Al₂O₃-CaO-SiO₂-H₂O, 3976
 Quinhydrone, 2748
 Quinol clathrates, 3119
 Quinolinol, 3347, 3739
 8-quinolinol complexes of metals, 3985
 Quinolinium phosphomolybdate, 3345
 Radulan, 3431
 Rape seed oil, 2446
 Rare earth carbonates, 3053
 Rare earth oxalates, 3053
 Rare earth selenites, 3803
 Resins, 2552, 2553
 Resorcinol, 3685
 Rhamnose, 2248
 Ribose, 2248
 Rochelle salt, 239
 Rubber, natural, 4021
 Rubidium, 3894
 Rubidium carbonate, 2590, 3264
 Rubidium chloride, 3785
 Rubidium ferrite, 3991
 Rubidium hexachlorostannate, 4053
 Rubidium nitrate, 1535, 3503, 3628
 Rubidium perchlorate, 1535, 3206, 3581
 Ruthenium dioxide, 3423
 Safflower oil, 2446
 Salicylic acid, 973, 2661, 2748, 3739
 Samarium carbonate, 3714
 Samarium chloride hydrate, 3009
 Samarium ethyl sulfate, 3596
 Samarium hydroxide, 3947
 Samarium oxalate, 3947
 Samarium oxide, 2078, 3058
 Samarium sulfate octahydrate, 2690
 Saran, 2241
 Scandium oxalate, 3933
 Scandium 8-quinolinol chelate, 4049
 Selenic acid, 2004
 Selenium oxide, 3800
 Sesame oil, 2446
 Silanes, 1393
 Silica, 1331, 2182
 Silica-alumina catalysts, 2300, 2346, 3048
 Silica-alumina mixtures, 555, 2116, 2388, 2671, 3154
 Silica-calcium carbonate mixtures, 1129
 Silica-calcium silicate mixtures, 1756
 Silica-calcium sulfate mixtures, 1987
 Silica-chromite mixtures, 651
 Silica-ferrous oxide mixtures, 1098
 Silica-hydrofluoric acid mixtures, 2719
 Silica-lime mixtures, 1303
 Silica-magnesia-water mixtures, 1325
 Silica-magnesia gel mixtures, 682, 1399
 Silica-potassium sulfate mixtures, 2109
 Silica-sodium carbonate mixture, 1921, 2675
 Silica-sodium carbonate-sodium fluoaluminate mixture, 1921
 Silica-sodium carbonate-sodium fluosilicate mixture, 1921
 Silica-sodium carbonate-sodium nitrate mixture, 1921
 Silica-sodium chloride mixtures, 1054
 Silica gel, 555, 909, 1805, 2011, 3711
 Silica gel-alumina mixtures, 888, 909, 1817, 2376, 2412, 2647, 2988, 3339
 Silica gel-bauxite mixtures, 557
 Silica gel-calcium hydroxide mixtures, 920, 1245, 1559, 2117
 Silica gel-calcined limestone mixtures, 557
 Silica gel-copper oxide mixtures, 1399
 Silica gel-magnesia mixtures, 909, 1399
 Silica gel-sodium hydroxide mixtures, 3717

- Silicic acid-magnesium chloride mixtures, 2689
 Silicic acid gel, 882, 909
 Silicomolybdic acid, 1713, 1906
 Silicon carbide, 1387, 3841, 4003
 Silicon tetrachloride-aluminum chloride mixtures, 2011
 Silicone rubber, 4042
 Silicones, 3412
 Silicotungstic acid, 1713, 1906
 Silicotungstic heteropoly acids, 2595
 Silver carbonate, 3260
 Silver chloride, 854
 Silver iodide, 854, 2864
 Silver nitrate, 854, 1535, 3785, 4052
 Silver perchlorate, 1535
 Silver 8-quinolinolate, 3984
 Silver sulfate, 646, 854
 Silver sulfide, 1809
 Slag, 1914, 2175, 3135, 3859, 3928, 3996
 Soda ash-bauxite mixtures, 557
 Soda ash-limestone mixtures, 557
 Soda ash-limestone-kaolin mixtures, 557
 Sodium, 3894
 Sodium acid sulfate-sodium dihydrogen phosphate mixtures, 1240
 Sodium aluminate, 2037, 3030, 3895, 4079
 Sodium aluminum hydride, 4025
 Sodium *p*-amino-*o*-hydroxybenzoate, 1610
 Sodium *p*-aminosalicylate, 1151
 Sodium antimonate, 1766
 Sodium benzoate, 951, 952, 1610
 Sodium beryllium fluoride, 2313
 Sodium bicarbonate, 2547
 Sodium borohydride, 2240
 Sodium calcium sulfate, 3637
 Sodium carbonate, 643, 1121, 2155, 2590, 3264
 Sodium carbonate, hydrogen, 1467, 3712
 Sodium carbonate complex, $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O} \cdot 1.5\text{H}_2\text{O}_2$, 949
 Sodium carbonate-dolomite mixtures, 685
 Sodium carbonate-silica mixture, 1921, 2676, 3314
 Sodium carbonate-sodium fluoaluminate-silica mixtures, 1921
 Sodium carbonate-sodium nitrate mixtures, 3314
 Sodium carbonate-sodium nitrate-silica mixtures, 1921
 Sodium carbonate with kaolin, 549, 564
 Sodium carbonate-uranium oxide mixtures, 3514
 Sodium chloride, 854, 3314, 3785
 Sodium chloride-potassium chloride mixtures, 434
 Sodium chloride with kaolin, 549, 564
 Sodium chloride-iron hydroxide mixtures, 3290
 Sodium chloride-iron oxide mixtures, 3290
 Sodium chloride-uranium oxide mixtures, 3704
 Sodium chromate hydrate, 2382, 3025
 Sodium disilicate, 2675
 Sodium ferrite, 2037, 3030, 3991
 Sodium fluoaluminate-sodium carbonate-silica mixture, 1921
 Sodium fluoride, 3278, 3314
 Sodium fluosilicate, 291, 1075, 3779
 Sodium fluosilicate-aluminum sulfate mixtures, 2759
 Sodium fluosilicate-borax-sodium nitrate mixtures, 291
 Sodium fluosilicate-sodium carbonate-silica mixtures, 1921
 Sodium fluosilicate-sodium nitrate mixtures, 291
 Sodium formate, 974, 1610
 Sodium hydroxide, 1413
 Sodium hydroxide-alumina mixtures, 994
 Sodium hydroxide-alumina-iron mixtures, 994
 Sodium hydroxide-iron mixtures, 994
 Sodium *o*-hydroxybenzoate, 1610
 Sodium 12-hydroxystearate, 2351
 Sodium laurate, 314

- Sodium metaphosphate, 187
 Sodium metasilicate hydrate, 2534
 Sodium metavanadate, 3872
 Sodium molybdate, 854
 Sodium myristate, 314
 Sodium niobate, 1863, 2951
 Sodium nitrate, 291, 610, 854, 1535, 2058, 2836, 2876, 3262, 3314, 3628, 3785, 4071, 4081
 Sodium nitrate-antimony oxide mixtures, 291
 Sodium nitrate-borax-sodium fluosilicate mixtures, 291
 Sodium nitrate-calcium fluoride mixtures, 291
 Sodium nitrate-magnesium mixtures, 1789
 Sodium nitrate-potassium sulfate mixtures, 434
 Sodium nitrate-sodium carbonate-silica mixture, 1921
 Sodium nitrate-sodium fluosilicate mixtures, 291
 Sodium nitrate-uranium oxide mixtures, 3704
 Sodium nitrite, 447
 Sodium oleate, 314
 Sodium orthophosphate, 3782
 Sodium oxalate, 1162, 1172, 1367, 1610
 Sodium perchlorate, 1535, 3581
 Sodium peroxide, 1183, 1935
 Sodium peroxyorthoniobate, 3808
 Sodium peroxyorthotantalate, 3808
 Sodium pervanadate, 3807
 Sodium phosphate, mono-, 3781
 Sodium phosphate glass, 3406
 Sodium potassium tartrate, 1610
 Sodium pyrophosphate, 3090, 3782, 3825
 Sodium salicylate, 952, 974
 Sodium salts of phosphomolybdate, 2563
 Sodium salts of phosphotungstate, 2563
 Sodium salts of silicomolybdate, 2563
 Sodium selenate decahydrate, 3025
 Sodium silicate, 1150, 1754, 2606
 Sodium silicofluoride, 3314
 Sodium sulfate, 152, 610, 1501, 2876, 2922, 2923, 3045, 3587, 3637
 Sodium sulfate-uranium oxide mixtures, 3704
 Sodium thiosulfate-cadmium carbonate mixtures, 3647
 Sodium thiosulfate-cadmium sulfate mixtures, 3647
 Sodium sulfide-silica mixtures, 2366
 Sodium sulfite, pentahydrate, 854, 1742, 2436
 Sodium trimetaphosphate, 3090
 Sodium tungstate-calcium carbonate mixtures, 1438
 Sodium uranyl carbonate, 3301
 Sodium zeolite, 3823
 Soybean oil, 2446
 Stannous oxalate, 1437
 Stannous sulfate, 3953
 Stannous sulfate-kaolinite mixture, 3953
 Starch, 1370, 1620, 1897, 2220, 2248, 2661
 Starch-bentonite mixtures, 1006
 Stearates and palmitates (metal soaps), 463, 464, 517, 551, 596, 806, 978
 Stearic acid, 595, 2748, 3031
 Strontium, 2603
 Strontium ammonium borotartrate, 2281
 Strontium antimonate, 1766
 Strontium carbonate, 643, 1411, 3764
 Strontium carbonate-antimony oxide mixtures, 3948
 Strontium carbonate-hafnia mixtures, 3531
 Strontium carbonate-titania mixtures, 2324
 Strontium carbonate-zirconia mixtures, 3532
 Strontium chloride hexahydrate, 239, 854, 2058
 Strontium ferrocyanide, 3938
 Strontium fluosilicate, 3779

- Strontium formate, 2021
 Strontium hexaniobate, 1922
 Strontium hydroxide, 882, 2392
 Strontium 8-hydroxyquinoline chelate, 3772
 Strontium nitrate, 1411, 1535, 3423, 3503, 3764
 Strontium orthophosphate, mono-, 3925
 Strontium oxalate, 1437, 2572, 3957
 Strontium oxide, 1442
 Strontium oxide-zirconium oxide-iron oxide mixtures, 1835
 Strontium perchlorate, 1535, 3774
 Strontium peroxide, 2665
 Strontium selenate, 2273, 2609, 3764
 Strontium stannate, 1061
 Strontium sulfate, 2569, 3764
 Strontium titanate, 3789
 Strontium triuranate hydrate, 4059
 Styrene-butadiene rubber, 4021
 Succinamide, 1610
 Succinic acid, 1173, 1610, 2748
 Succinimide, 1610
 Sucrose, 2248, 2661
 Sucrose-bentonite mixtures, 1006
 Sugars, 743, 2248
 Sulfates of metals of the second group, 585, 688
 Sulfur, 27, 29, 2165, 2890, 2974, 3155, 3526, 3931, 4017
 Sulfur dioxide, 3451
 Sulfur-rubber mixtures, 3049
 Sulfur-selenium mixtures, 2890
 Sulfuric acid, 1707
 Sunflower oil, 2446

 Tannic acid, 2748
 Tantalum metaperoxyacid, 3808
 Tantalum phosphate, 3670
 Tartaric acid, 1610, 2748
 Teflon, 3300, 3888, 3969, 4042
 Terbium carbonate, 3714
 Terbium chloride hydrate, 3009
 Terbium ethyl sulfate, 3596
 Terbium oxides, 1306

 Ternary systems:
 Ag-Sb-Te, 4016
 AgBr-KNO₃-NaCl, 1777
 AgNO₃-KCl-NaBr, 1777
 Ag₂S-Bi₂S₃-PbS, 3327
 BaO-Al₂O₃-SiO₂, 3662
 CaF₂-Ca(OH)₂-SiO₂, 970
 CaO-Al₂O₃-SiO₂, 1007, 1333
 CaO-SiO₂-H₂O, 1719, 3755, 3829, 3932
 KAlF₄-RbAlF₄-KBF₄, 3915
 K₂CO₃-KOH-H₂O, 3424
 KCl-K₂SO₄-H₂O, 1763
 KCl-MgCl₂-CaCl₂, 1120
 KClO₄-KCl-KClO₃, 1312
 KF-LaF₃-K₂BeF₄, 3509
 La(NO₃)₃-Mg(NO₃)₂-H₂O, 2323
 La(NO₃)₃-NH₄NO₃-H₂O, 2323
 LiF-BeF₂-UF₄, 2817, 3834
 Li₂O-Al₂O₃-SiO₂, 4027
 Li₂O-Al₂O₃-TiO₂, 3167
 MgCl₂-CaCl₂-NaCl, 2871
 MgO-MgCl₂-H₂O, 3708
 Mg(OH)₂-MgCO₃-SiO₂, 3041
 MgSO₄-K₂SO₄-H₂O, 1763
 NaAlF₆-Li₃AlF₆-Al₂O₃, 2203
 Na₂CO₃-B₂O₃-SiO₂, 2565
 Na₂CO₃-CaCO₃-SiO₂, 2849
 NaF-BeF₂-UF₄, 4026
 NaF-LiF-BeF₂, 2198
 NaF-ZrF₄-UF₄, 2371
 Na₂O-B₂O₃-SiO₂, 3180
 Na₂O-PbO-SiO₂, 593
 Nb₂O₅-K₂O-H₂O, 3651
 NiO-SiO₂-H₂O, 842
 PbO-SiO₂-P₂O₅, 1916
n-tetracosane, 806, 2883
 Tetraethoxysiloxane, 1585
 Tetraisobutoxysiloxane, 1585
 Tetraisomyloxysiloxane, 1585
 Tetramethoxysiloxane, 1585
 Tetrammine cupric sulfate, 3914
 Thallium hydrogen sulfate, 2043, 2321
 Thallium nitrate, 3628, 3761
 Thallium oxalate, 3438
 Thallium 8-quinolinol chelate, 4049
 Thiourea, 2661

- Thoria-alumina catalyst, 3048
 Thorium hydroxide, 882
 Thorium nitrate, 3419
 Thorium oxalate, 3241, 3419, 3715, 3954
 Thorium silicate, 1097
 Thulium carbonate, 3714
 Thulium chloride hydrate, 3009
 Thulium ethyl sulfate, 3596
 Thulium trinitrate tetrahydrate, 3342
 Tin hydroxide, 882
 Tin oxide, 2291
 Tin selenide, 4024
 Titanium dioxide, 132, 728, 3601
 Titanium dioxide, hydrous, 2967
 Titanium dioxide-barium carbonate mixtures, 1126
 Titanium hydroxide, 882, 3522
 Titanium peroxide, hydrated, 3523, 3833
 Toluene, 1620, 3855, 3969
 Triallyl cyanurate, 2405
 Tricalcium aluminate, 263, 3027, 3131, 3994
 Tricalcium aluminate, hydrated, 3488
 Tricalcium silicate, 2342, 3353, 3993
 Tricalcium silicate, hydrated, 263, 2877, 2982, 3183, 3210, 3488, 3867
 Triethylamine, 3773
 Triglyceride, 521
 Triglycine sulfate, 3685
 Trilaurin, 521
 Tris-(ethylenediammine)cobalt bromide, 3378
 Tristearin, 3612, 3613, 3969
 Tungsten 8-quinolinol chelate, 4049
 Tungsten trioxide, 921, 3312
 Tungsten trioxide-carbon mixture, 3138

 Ultramarine, 3931
 Urania-thoria mixtures, 2488
 Uranium dicarbide, 4034
 Uranium dioxide, 805, 1783, 1822, 1823, 1824, 2094, 2139, 2400, 2761, 3576, 3850, 4011
 Uranium monocarbide, 4034
 Uranium oxalate, 3715, 4014
 Uranium oxide-chromium mixtures, 2724, 3062
 Uranium oxide hydrate, 3813, 3832, 4023
 Uranium oxide-iron mixtures, 2724, 3062
 Uranium oxide-nickel mixtures, 2724, 3062
 Uranium oxide-niobium mixtures, 2724, 3062
 Uranium peroxide hydrate, 3649, 3660
 Uranium sulfate, 1106
 Uranium tetrafluoride, 1783
 Uranium trioxide, 3236
 Uranyl acetylacetonato-solvates, 3343
 Uranyl carbonate, 3301
 Uranyl oxalate, 3241, 4014
 Uranyl potassium phosphate, 2789
 Uranyl sulfate, 3235, 3236, 4056
 Urea, 2748
 Urea-formaldehyde resin, 3890
 Uric acid, 2748

 Vanadium oxide, 1321, 2888
 Vanadium oxide-phosphorus pentoxide mixtures, 3227
 Vanadium oxide-silica mixtures, 2888, 3585
 Vinyl chloride, 2206
 Vinyl chloride-vinyl acetate polymer, 1620
 Vinylcyclohexene dioxide polymer, 3375
 Vinylidene chloride resin, 2206
 Vinylidene fluoride-perfluoropropene copolymer, 3901, 3902

 Water, 1707
 Water (ice), 2445
 Whale oil, 2446

 Xylan, 3431
 Xylose, 2248

 Ytterbium ethyl sulfate, 3596
 Ytterbium chloride hydrate, 3009

- Ytterbium trinitrate tetrahydrate, 3342
 Yttrium carbonate, 3714
 Yttrium chloride hydrate, 3009
 Yttrium-iron garnet, 3370
 Yttrium oxalate, 3058, 3369, 3933
- 4A-zeolites, 4001
 Zeolitic germanates, 2013
 Zinc anthranilate, 1281
 Zinc beryllium silicate, 455
 Zinc borate phosphors, 2185
 Zinc borotartrate, 3306
 Zinc carbonate, 689, 1399, 3260, 3764, 4046
 Zinc carbonate, basic, 3964
 Zinc chromate, 1901
 Zinc ferrite, 1643
 Zinc ferrocyanide, 4062
 Zinc fluoride, 3445
 Zinc formate, 2021
 Zinc hydroxide, 882, 3428
 Zinc 8-hydroxyquinoline chelate, 3772
 Zinc molybdate, 1497, 1986
 Zinc nitrate, 689, 1535
 Zinc oxalate, 1437, 1513
 Zinc oxide, 117
 Zinc oxide-chromia catalyst, 2133, 2377
 Zinc oxide-uranium oxide mixtures, 3622
 Zinc oxide-zinc phosphate mixtures, 2245
 Zinc perchlorate, 1535
 Zinc peroxide, 2665, 3925
 Zinc selenate, 2837
 Zinc selenide, 2837, 4062
 Zinc selenide-sulfur mixtures, 3876
 Zinc silicate phosphors, 455, 573
 Zinc stannate, 1061
 Zinc sulfate, 254, 584, 714, 2569, 3244, 3518, 3563, 3764
 Zinc sulfate heptahydrate, 278, 2245
 Zinc sulfide, 2997
 Zinc sulfide-selenious acid mixtures, 3876
 Zinc sulfide-selenium oxide mixtures, 3204
 Zinc sulfide-sodium chloride mixtures, 2997
 Zinc sulfite, 3238, 3244, 3246
 Zinc telluride, 4062
 Zirconia-calcium oxide mixtures, 1461, 1569, 1835, 2210
 Zirconium dioxide, 132, 387, 1270, 1363, 2210, 2497, 3817
 Zirconium disulfide, 2406
 Zirconium hydroxide-neodymium hydroxide mixtures, 3560
 Zirconium oxide-barium oxide-iron oxide mixtures, 1835
 Zirconium oxide-calcium oxide-boric oxide mixtures, 1835
 Zirconium oxide-strontium oxide-iron oxide mixtures, 1835
 Zirconium oxide-vanadium oxide mixtures, 3435, 3585
 Zirconium oxide-vanadium oxide-silica mixtures, 3435, 3585
 Zirconium oxynitrate hexahydrate, 3995
 Zirconium phosphate, 1311
 Zirconium silicate, 1097
 Zirconium silicate-alkaline earth carbonate mixtures, 2152
 Zirconium sulfate tetrahydrate, 2494
 Zirconium tetrafluoride, 2403
 Zirconyl nitrate, 3423
 Zirconyl oxalate, 3369

FUELS AND CARBONIZATION PRODUCTS

- Anthracite, 71, 72, 1299, 1320, 3007
 Asphaltite, 894
- Balsam fir, 3377
 Beechwood, 3165
 Birchwood, 1409, 2135, 3165
 Bitumen, 2944, 3254
 Bituminous coals, 71, 72, 1299, 1494, 1572, 2158, 2911, 3008
 Bituminous coal-inorganic salts or organic compound mixtures, 1572
 Bongossi wood, 3165

- Brown coal, 3008, 3709
 Cannel coal, 71, 72, 1775
 Cellulose, 71, 72, 1409, 1918, 2047, 2241, 3217
 Cellulose, dehydrated, 71, 72
 Charcoal, 1775, 3535
 Clarain, 369, 2135
 Coal and organic shales, 707
 Coal fractions, 2045, 2168
 Coal, original, 71, 615, 699, 706, 893, 1031, 1130, 1133, 1206, 1320, 1532, 1561, 1775, 1854, 1918, 2047, 2230, 2435, 2437, 2841, 3036, 3037, 3249, 3516
 Coal-inorganic mixtures, 3115
 Coal tar pitch, 2241
 Coke, 1320, 1493, 1775, 3164, 3533, 3534
 Exinite, 1573
 Graphite, 691, 1145, 1775, 2582, 3535, 3635
 Holocellulose, 2216, 3217
 Humic acid, 2295, 2703, 3217
 Humic acid (coal), 1134, 2047, 2216
 Humic acid (peat)
 Carbo-lignin, 1252, 1883
 Cekanol, 1252
 Dopplerite, 1252
 DUSARTITE, 1252
 Larchwood, 3165
 Lignin, 1409, 1918, 2047, 3217
 Lignite, 71, 615, 871, 993, 1320, 2241, 3300
 Lignocellulose, 2950
 Oil shale, 323
 Peat, 466, 615, 1918, 2216, 2573, 3217, 3471, 3654
 Petroleum pitch, 2241
 Pitch, 3124
 Poplar wood, 3165
 Pyridine extract of coal, 71
 Pyridine residue of coal, 71
 Teakwood, 3165
 Turf, 2100
 Vitrain, 369, 1573, 2135, 2435
 Wood, 599, 2134, 2135
 Xylan, 1409
 Xylite, 1918
 Xylose, 1409

METALS

- Aluminum, 1319, 2373, 4071
 Aluminum alloys, 204, 503, 1319
 Aluminum-bronze, 274
 Aluminum-copper alloy, 342
 Aluminum-iron alloy, 204
 Aluminum-oxide mixtures, 3005
 Aluminum-zinc mixtures, 2850
 Antimony, 3593, 4043
 Barium, 2478
 Barium-strontium, 1812
 Beryllium, 2867
 Beryllium-copper alloy, 247
 Bismuth, 4043
 Bismuth-cadmium system, 3087
 Brass alloy, beta-, 204, 270
 Cadmium, 2799, 4043
 Cadmium-gallium alloys, 2799
 Cadmium-sulfur mixtures, 3061
 Cadmium-thallium alloys, 2285
 Carbon steel, 23, 81, 201
 Cesium, 3845, 3894, 4043
 Chromium, 3170, 3307, 3688
 Chromium-iron alloy, 3170
 Chromium-nickel alloy, 3170
 Chromium-niobium alloy, 3170
 Cobalt, 1276, 1358, 4043
 Cobalt-chromium alloys, 3491
 Copper, 204
 Copper-gold alloy, 221, 1857
 Copper-magnesium-nickel alloy, 1891
 Copper-selenium mixtures, 3061

- Copper-silver alloy, 247
Copper-sulfur mixtures, 3061
- Gallium-tellurium alloys, 3597
Germanium, 2064
Gold-copper alloy, 2169
- Indium, 2275, 4043
Iron, 15, 17, 42, 55, 56, 57, 58, 60, 75, 77, 85, 191, 2054, 3079, 4043
Iron alloy, 17, 20
Iron-aluminum alloy, 204
Iron-arsenic alloys, 2304
Iron carbide, 92
Iron-carbon alloy, 94
Iron-cobalt-palladium alloys, 3554
Iron-nickel alloy, 952
Iron-palladium mixtures, 2847
Iron silicide, 1718
Iron-arsenic-sulfur mixtures, 3061
Iron-sulfur mixtures, 3061
Iron-zirconium mixtures, 3308
- Kovar alloy, 3769
- Lead, 4043, 4071
Lead-indium antimonide alloys, 3889
Lead-selenium mixtures, 3061
Lead-sulfur mixtures, 3061
Lead-tin alloy, 34
Lithium, 2478, 3894, 3978, 4043
- Magnesium, 257, 2127, 3579, 4043
Magnesium-copper-nickel alloy, 1891
Manganese carbon steel, 203
Manganese-germanium alloys, 2856
- Manganese-sulfur mixtures, 3061
Molybdenum, 2373, 3688
- Nickel, 37
Nickel-copper-magnesium alloy, 1891
Nickel-zinc alloy, 1700
Nickel steel, 19, 81
Niobium, 3688
- Rose metal, 4006
Rubidium, 3894
- Silicon, 2014, 2063
Silver, 2283, 4043
Silver-bismuth alloy, 3891
Silver-copper alloys, 3780
Silver-zinc alloy, 204
Sodium, 3894, 4043
Steel, 24, 25, 56, 81, 206, 849, 1454, 3769
Steel-sulfide reactions, 2415
Strontium, 3978
Strontium-barium, 1812
- Tellurium, 4043
Thallium, 4043
Tin, 1319, 3087, 4043, 4071
Titanium, 4040
Tungsten, 3930
- Uranium, 1030, 2373, 2525, 3635
Uranium alloys, 2708
- Zinc, 1534, 3087, 4043
Zinc-nickel alloy, 1700
Zirconium, 2373, 3930, 4040

MINERALS, MINERAL MIXTURES, AND ROCKS

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Acanthite	Ag ₂ S	3559
Achtaragdit	Serpentine + chlorite + garnet	941
Actinolite	2CaO · 5(Mg, Fe)O · 8SiO ₂ · H ₂ O	1852, 3549, 3518
Aegirite	Pyroxene group	3518
Aeschynite	(Ce, Th)(Nb, Ti) ₂ (O, OH) ₆	780, 3730
Afwillite	Ca(SiO ₃ OH) ₂ · 2H ₂ O	802, 3421
Aksait	2MgO · 5B ₂ O ₃ · 8H ₂ O	3754
Alabandite	MnS	651, 2020
Albite	NaAlSi ₃ O ₈	310, 641, 981, 1335
Allanite	Ca ₂ (Al, Ce, Fe) ₃ OH(SiO ₄) ₃	651, 1165, 1702, 1826, 2727, 3095, 3518
Allevardite	Micaceous (phyllitic) silicate	619, 1994, 2814
*Allophane	Al ₂ O ₃ · SiO ₂ · nH ₂ O	61, 359, 394, 723, 855, 1087, 1226, 1510, 2543, 3084
Alstonite	CaBa(CO ₃) ₂	609
Aluminite	Al ₂ O ₃ · SO ₃ · 9H ₂ O	261, 1530, 2500, 3518
Alumoferroascharite	(Mg, Fe)(OH)(B, Al)O ₂ · aq.	1947
Alumogen	Al(SO ₄) ₃ · 18H ₂ O	759, 873
*Alunite	KAl ₃ (OH) ₆ (SO ₄) ₂	261, 276, 413, 545, 2825
Alunite clay	— — —	413, 545, 635
Amarantite	FeSO ₄ OH · 3.5H ₂ O	873
Amazonite	Syn. of Amazonstone, a var. of Microcline	3929
Amblygonite	LiAl(F, OH)PO ₄	670, 3518
Amesite	(Mg _{1.6} Al _{1.0} Fe _{0.4} ²⁺)(SiAlO ₅)(OH) ₄	244, 732, 1371
Amorphous silica	SiO ₂ · nH ₂ O	641
Amosite	Amphibole asbestos	1016
Ampangabéite	(U, etc.) ₂ (Nb, etc.) ₇ O ₁₈	1165
Amphibole	See Hornblende.	212, 246, 848, 1027, 1378, 1852, 2998
Analcite (Analcime)	NaAlSi ₂ O ₆ · H ₂ O	724, 1135, 1842, 3518, 3770, 3910
Anatase	TiO ₂	1800, 2023
Anauxite	Al ₂ Si ₂ O ₅ (OH) ₄ · SiO ₂	196, 394, 431, 502, 608, 1911
Andalusite	Al ₂ SiO ₅	112, 1957
Andesite	Medium acid rock	2330, 2835
Anglesite	PbSO ₄	873, 3336, 3518
Anhydrite	CaSO ₄	308, 621, 651, 3350, 3368, 3518
Ankerite	Magnesiodolomite-ferrodolomite	609, 686, 836, 1330, 1540, 1788, 2197, 2649, 2730, 2854, 3542, 3518
Annabergite	Ni ₃ (AsO ₄) ₂ · 8H ₂ O	1646, 3518
Anorthite	CaAl ₂ Si ₂ O ₈	224, 310, 878, 1335
Anorthosite	Mostly labradorite	388
Anthoinite	Al(WO ₄)(OH) · H ₂ O	2234

* The asterisk indicates those materials for which only the important references are given.

ALPHABETICAL REFERENCE LIST OF MATERIALS STUDIED BY DTA 601

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Anthophyllite	$(\text{Mg,Fe})_7\text{Si}_3\text{O}_{22}(\text{OH})_2$	331, 507, 1016, 3153, 3429, 3518
*Antigorite	$\text{Mg}_6(\text{OH})_8\text{Si}_4\text{O}_{10}$	135, 188, 435, 912, 961, 1250, 2455
Antimonite	Sb_2S_3	3866
Antlerite	$3\text{CuO} \cdot \text{SO}_3 \cdot 2\text{H}_2\text{O}$	3336
Apatite	$\text{Ca}_5(\text{F,Cl,OH})(\text{PO}_4)_3$	227, 1832, 2192, 2720, 3277, 3518
Aphrosiderite	See Chlorite.	135, 3575
Apophyllite	$\text{KFCa}_4(\text{Si}_2\text{O}_6)_4 \cdot 8\text{H}_2\text{O}$	119, 120, 3518, 3571
Aragonite	CaCO_3	52, 440, 544, 609, 631, 641, 643, 651, 2610, 3518
Arcanite	K_2SO_4	759
Arfvedsonite	See Amphibole.	1852, 3518, 3549
Argentite	Ag_2S	1550, 3404
Argentojarosite	$\text{AgFe}_3(\text{OH})_6(\text{SO}_4)_2$	656, 1214
Arsenate belowite	$\text{H}_2\text{Ca}_2\text{Mg}(\text{AsO}_4)_2(\text{OH,F})_2 \cdot \text{H}_2\text{O}$	2015
Arsenopyrite	FeAsS	1810, 2165, 2361, 3404, 3866
Artinite	$\text{Mg}_2(\text{OH})_2\text{CO}_3 \cdot 3\text{H}_2\text{O}$	410, 609
Ascharite	$\text{Mg}_2\text{B}_2\text{O}_6 \cdot \text{H}_2\text{O}$	1680
Asbestos	— — —	1739, 3277
Asbophite	See Chrysotile.	217
Askanite	Montmorillonoid?	489
Astrakanite	$\text{MgSO}_4 \cdot \text{Na}_2\text{SO}_4 \cdot 4\text{H}_2\text{O}$	302, 3518, 3746
Atacamite	$\text{Cu}_2\text{Cl}(\text{OH})_3$	633, 3336, 3518
*Attapulgitite	$(\text{OH})_4 \cdot (\text{OH})_2\text{Mg}_5\text{Si}_8\text{O}_{20} \cdot 4\text{H}_2\text{O}$	371, 394, 679, 740, 2826, 3553
Augelite	$\text{Al}_2(\text{OH})_3\text{PO}_4$	670, 3518
Aurichalcite	$(\text{Zn,Cu})_5(\text{OH})_6(\text{CO}_3)_2$	609, 741, 3336
Autunite	$\text{CaO} \cdot 2\text{UO}_3 \cdot \text{P}_2\text{O}_5 \cdot 8\text{H}_2\text{O}$	2753, 2789, 3188
Axinite	$6(\text{Ca,Fe,Mn})\text{O} \cdot 2\text{Al}_2\text{O}_3 \cdot \text{B}_2\text{O}_3 \cdot 8\text{SiO}_2 \cdot \text{H}_2\text{O}$	3310, 3518, 3946
Azurite	$\text{Cu}_3(\text{OH})_2(\text{CO}_3)_2$	609, 651, 741, 3336, 3518
Bakerite	$8\text{CaO} \cdot 5\text{B}_2\text{O}_3 \cdot 6\text{SiO}_2 \cdot 6\text{H}_2\text{O}$	2034
Barbertonite and Stichtite	— — —	609, 3518
Barite	BaSO_4	651, 1110, 3287, 3518
Barrandite	$(\text{Fe,Al})\text{PO}_4 \cdot 2\text{H}_2\text{O}$	4005
Basalt	Extrusive basic magma	2002, 2835, 3405
Bassanite	$\text{CaSO}_4 \cdot 0.5\text{H}_2\text{O}$	4064
Bastnasite	$(\text{Ce,Ln,Dy})\text{FCO}_3$	609, 1105, 3518
*Bauxite	Aluminum hydroxide mixtures	64, 197, 394, 442, 556, 763, 1118, 1244, 2482, 3252, 3277
Bavalite	See Chlorite.	135, 403
Beaverite	(Pb,Cu,Fe) aluminosilicate	2472, 3336
*Beidellite	$(\text{OH})_4(\text{Si}_{6.34} \cdot \text{Al}_{1.66}, \text{Na}_{0.66}) \cdot \text{Al}_{4.34}\text{O}_{20}$	266, 325, 328, 394, 1391, 2172, 2348, 2506, 3981
Belyankinite	Manganese-bearing titanate	2274
*Bentonite	Essentially montmorillonite	325, 359, 572, 1227, 1941, 2791, 3213, 3277
Berthierine	See Antigorite.	1759
Berthierite	$\text{FeS} \cdot \text{Sb}_2\text{S}_3$	3866

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Berlinite	AlPO_4	670, 4005
Bertrandite	$4\text{BeO} \cdot 2\text{SiO}_2 \cdot \text{H}_2\text{O}$	3078, 3518
Betafite	$(\text{U}, \text{Ca})(\text{Nb}, \text{Ta}, \text{Ti})_3\text{O}_9 \cdot n\text{H}_2\text{O}$	780, 835, 1165, 1166, 2727, 2730
Betpakdalite	$(\text{CaFe}_2\text{H}_4(\text{As}_2\text{Mo}_5\text{O}_{26}) \cdot 12\text{H}_2\text{O}$	3460
Beudantite	$\text{PbFe}_3(\text{OH})_6\text{AsO}_4 \cdot \text{SO}_4$	623
Beyerite	$\text{CaBi}_2\text{O}_2(\text{CO}_3)_2$	609
Bieberite	$\text{CoSO}_4 \cdot 7\text{H}_2\text{O}$	358, 873
Bikitaite	$\text{LiAlSi}_2\text{O}_6 \cdot \text{H}_2\text{O}$	2129
Bilibinitite	$3(\text{Ca}, \text{Pb})\text{O} \cdot (\text{U}, \text{Th})\text{O}_2 \cdot 7\text{UO}_2 \cdot 10\text{SiO}_2 \cdot 19\text{H}_2\text{O}$	2393
Bindheimite	Hydrous lead antimonate	3815
Biotite	$\text{H}_2\text{K}(\text{Mg}, \text{Fe})_3(\text{Al}, \text{Fe})(\text{SiO}_4)_3$	470, 575, 1144, 1242, 1252, 1359
Birnessite	MnO_2	3595
Birunite	$8.5\text{CaSiO}_3 \cdot 8.5\text{CaCO}_3 \cdot \text{CaSO}_4 \cdot 15\text{H}_2\text{O}$	2039
Bischofite	$\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$	3518
Bismuthinite	Bi_2S_3	3404
Bismutite	$\text{Bi}_2\text{O}_2\text{CO}_3$	609, 3518
Bismutotantalite	$(\text{Bi}, \text{Sb})(\text{Ta}, \text{Nb})\text{O}_4$	2130
Bixbyite	$(\text{Mn}, \text{Fe})_2\text{O}_3$	3449
Bloedite	$\text{Na}_2\text{O} \cdot \text{MgO} \cdot 2\text{SO}_3 \cdot 4\text{H}_2\text{O}$	873, 2086
Blomstrandite	$(\text{Y}, \text{Er}, \text{Ce}, \text{U})(\text{Ti}, \text{Nb})_3\text{O}_9$	1165
Bobierite	$\text{Mg}_3\text{F}_2\text{O}_8 \cdot 8\text{H}_2\text{O}$	346, 670
*Boehmite	$\text{AlO}(\text{OH})$	394, 905, 1056, 1059, 1379, 1537, 3766
Bokite	$\text{KAl}_3\text{Fe}_6\text{V}_6^{+4}(\text{V}_2\text{O}^{+5}\text{O}_{76}) \cdot 30\text{H}_2\text{O}$	4004
Bolivarite	$\text{Al}_2\text{PO}_4(\text{OH})_3 \cdot \text{H}_2\text{O}$	670
Boltwoodite	$\text{K}(\text{H}_3\text{O})\text{UO}_2(\text{SiO}_4) \cdot n\text{H}_2\text{O}$	3506
Boracite	$\text{Mg}_7\text{Cl}_2\text{B}_{16}\text{O}_{30}$	1842, 3539
Borax	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$	291, 1502, 1770, 2034, 2836
Borickite	Hydrated phosphate of Ca and Fe	2680, 3481
Bornite	Cu_4FeS_4	634, 1810
Bosphorite	$\text{Fe}_9(\text{PO}_4)_6(\text{OH})_9 \cdot 21\text{H}_2\text{O}$	2340
Botryogen	$\text{MgFe}(\text{SO}_4)_2\text{OH} \cdot 7\text{H}_2\text{O}$	873
Botryolite	Var. of datolite	3518
Boussingaultite	$(\text{NH}_4)_2\text{Mg}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$	873
Bowenite	See Serpentine.	383
Bowlingite	See Saponite.	189, 279, 739
Brannerite	Complex uranium-containing mineral	3020, 3625
Braunite	$(\text{Mn}, \text{Si})_2\text{O}_3$	651, 657, 1723, 2428, 3449, 3518
Bravaisite	Illite (?) and some montmorillonite	431, 771
Brunnerite		609, 686, 892, 3518
Brewsterite	$(\text{Sr}, \text{Ba}, \text{Ca})\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2 \cdot 5\text{H}_2\text{O}$	3910
Brochantite	$\text{CuSO}_4(\text{OH})_6$	873, 3336
Bronzite	Ferriiferous enstatite	4045

ALPHABETICAL REFERENCE LIST OF MATERIALS STUDIED BY DTA 603

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Brookite	TiO ₂	3634
Brucite	Mg(OH) ₂	121, 295, 394, 502, 651, 854, 1399, 2159, 3277, 3518
Brugnatellite	Mg ₆ Fe(OH) ₁₃ CO ₃ ·4H ₂ O	344
Brushite	CaHPO ₄ ·2H ₂ O	1899
Calamine	H ₂ Zn ₂ SiO ₅	651, 3518
Calcite	CaCO ₃	68, 74, 98, 544, 643, 846, 2159, 2316, 2532, 3063
Caledonite	Cu ₂ PB ₆ (SO ₄) ₃ CO ₃ (OH) ₆	873
Cancrinite	Na ₆ Ca ₂ (SiAlO ₄) ₆ (CO ₃) ₂	174, 3518
Carbocernaite	Calcareous rare-earth carbonate	3417
Carnallite	KMgCl ₃ ·6H ₂ O	302, 2519, 3518, 3746
Carphosiderite	Fe ₃ (SO ₄) ₂ (OH) ₆ ·2H ₂ O	873
Catapleite	Na ₂ Zr(Si ₃ O ₉)·H ₂ O	1842
Celadonite	Glaucosite	325, 771, 999, 1252, 1359, 1880, 3156, 3510, 3518, 3575
Celestite	SrSO ₄	651, 2516, 3518
Ceruleolactite	Ca analog of turquoise	3246
Cerussite	PbCO ₃	52, 440, 609, 643, 651, 1266, 1701, 2320, 3269, 3336, 3518, 3979
Cervantite	Sb ₂ O ₄	1020
Chabazite	CaAl ₂ Si ₄ O ₁₂ ·6H ₂ O	1135, 1146, 2369, 3518, 3910, 3921
Chalcanthite	CuSO ₄ ·5H ₂ O	358, 873
Chalcedony	SiO ₂	799, 1565, 2809, 2954
Chalcocite	Cu ₂ S	2650, 3404
Chalcopyrite	CuFeS ₂	1427, 1550, 2165, 2650, 3404, 3866
Chambersite	Mn ₃ B ₇ O ₁₃ Cl	3820
Chamosite	See Chlorite.	539, 730, 1001, 1455, 1937, 2207, 2236, 2829, 3002
Chlorargyrite	AgCl	854
*Chlorite	(Mg,Fe,Al) ₆ (OH) ₈ (Si,Al) ₄ - O ₁₀	128, 537, 681, 1259, 2316, 2678
Chloropal	See Nontronite.	948
Chlorophaeite	Mg,Fe aluminosilicate	1951
Chrome-illite	— — —	1888, 2481
Chrome ore	— — —	1931, 3364, 3732
Chromite	Fe(Cr,Fe) ₂ O ₄	446, 892, 3518
Chrysocolla	CuSiO ₃ · <i>n</i> H ₂ O	626, 651, 833, 2314, 3336, 3518
Chrysotile	(OH) ₆ Mg ₆ Si ₄ O ₁₁ ·H ₂ O	121, 130, 183, 279, 961, 1341, 1359, 1648, 1903, 2000, 2145, 3518, 3584
Chukhrovite	Rare-earth Ca aluminosilicate	3096
Churchite	Rare-earth phosphate	3234
Cimolite	Al ₄ Si ₉ O ₂₄ ·6H ₂ O	325
Cinnabar	HgS	1425
Clausthalite	PbSe	3453
Clinocllore	See Chlorite.	135, 617, 797, 1367, 1608, 3518, 3575

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Clinoenstatite	MgSiO ₃	3044
Clinoptilolite	Complex alkali-alkaline earth aluminosilicate	3207, 3222, 3893
Clinozoisite	4CaO · 3Al ₂ O ₃ · 6SiO ₂ · H ₂ O	2499
Cobaltite	CoAsS	1550, 1810, 2361
Coffinite	U silicate	3366
Colemanite	2CaO · 3B ₂ O ₃ · 5H ₂ O	358, 2034, 2836
Collyrite	Al ₄ SiO ₈ · 9H ₂ O	325
Columbite	(Fe, Mn)O · (Nb, Ta) ₂ O ₅	2727
Conichalcite	CaCu(AsO ₄)(OH)	3783
Cookeite	Structure similar to that of chlorite	1101, 1457, 3313, 3518
Copiapite	MgFe ₄ (SO ₄) ₆ (OH) ₂ · 18H ₂ O	873, 3157, 3518
Coquimbite	Fe ₂ (SO ₄) ₃ · 9H ₂ O	873, 3762
Cordierite	Mg ₂ Al ₃ (AlSi ₅ O ₁₈)	1125, 2964, 3295
Coronadite	Var. of hollandite	3125, 3518
Corrensite	Chlorite-vermiculite	1345, 1750, 2859, 3518, 3617
Corundophilite	Type of chlorite	1608
Corundum	Al ₂ O ₃	2853
Covellite	CuS	1266, 1550, 1761, 1809, 1810, 2650, 3404
Creedite	Ca ₃ Al ₂ (SO ₄)F(OH) ₁₀ · 2H ₂ O	889, 1081, 3518
Crestmoreite	2CaSiO ₃ · 3H ₂ O	651
*Cristobalite	SiO ₂	1141, 1522, 1795, 2088, 2102, 2263, 2449, 2666, 3473
Crocidolite	Amphibole asbestos	1016, 3434, 3518, 4038
Cronstedite	See Chlorite.	674, 1883
Cryolite	Na ₃ AlF ₆	651, 2836, 3518
Cryptomelane	K(Mn, Zn, Co) ₈ O ₁₆	504, 1484, 1997, 2428, 2448, 3239, 3449, 3595, 3830
Cumingtonite	(Mg, Fe) ₇ Si ₈ O ₂₂ (OH) ₂	1471
Cuspidine	3CaO · 2SiO ₂ · CaF ₂	2657
Cyanotrichite	Cu ₄ Al ₂ (SO ₄)(OH) ₁₂ · 2H ₂ O	3452
Cyrtolite	Zr(SiO ₄) _{1-x} (OH) _{4x}	1097
Danburite	CaO · B ₂ O ₃ · 2SiO ₂	3145, 3518
Dannemorite	(Fe ₃ Mn ₂ Mg ₂)(OH) ₂ Si ₈ O ₂₂	3879
Daphnite	27FeO · 10Al ₂ O ₃ · 18SiO ₂ · 28H ₂ O	3518
Datolite	2CaO · 2SiO ₂ · B ₂ O ₃ · H ₂ O	2800, 3518, 3664
Davidite	Fe ²⁺ (Fe ³⁺ , Ce) ₂ Ti ₆ O ₁₇	780, 2727, 2730, 3610
Dawsonite	NaAl(OH) ₂ CO ₃	609
Deweylite	Mg ₃ (OH) ₄ Si ₂ O ₅ — surplus water	651, 784, 1851, 2830, 3518, 3558, 3791
Diabase	Medium acid rock	2330
Diamond	— — —	1387
*Diaspore	AlO(OH)	103, 295, 359, 388, 905, 998, 1399
Diatomaceous earth	SiO ₂	412, 1182, 3727
*Dickite	Al ₄ (OH) ₈ Si ₄ O ₁₀	196, 266, 394, 828, 2213, 2287, 2935, 3784
Dillnite	Hydrated aluminosilicate	1581

ALPHABETICAL REFERENCE LIST OF MATERIALS STUDIED BY DTA 605

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Diopside	$\text{CaMgSi}_2\text{O}_6$	1034, 1977
Dioptase	$\text{Cu}_3\text{Si}_3\text{O}_9 \cdot 3\text{H}_2\text{O}$	397, 2314, 3518
Diorite	Medium acid rock	2835
*Dolomite	$\text{CaMg}(\text{CO}_3)_2$	341, 367, 378, 440, 459, 609, 724, 762, 1046, 1523, 2112, 2627, 3186, 3277, 3740
Donbassite	$\text{Al}_2(\text{OH})_2\text{SiO}_4(?)$	659, 3518
Dufrenite	$\text{Fe,Fe}_4(\text{OH})_6(\text{PO}_4)_3 \cdot 2\text{H}_2\text{O}$	651
Edingtonite	$\text{BaO} \cdot \text{Al}_2\text{O}_3 \cdot 3\text{SiO}_2 \cdot 3\text{H}_2\text{O}$	3910
Ehlite	$5\text{CuO} \cdot \text{P}_2\text{O}_5 \cdot 3\text{H}_2\text{O}$	624, 1004
Ekmanite	$(\text{Fe,Mn,Mg})\text{O} \cdot \text{SiO}_2 \cdot \text{H}_2\text{O}$	1367
Ellsworthite	U — pyrochlore	780, 930, 2174
Endellite	Hydrated halloysite	359, 480, 502, 614, 1190, 1510, 2693, 2848, 3557
Enstatite	MgSiO_3	102
Epididymite	$\text{Na}[\text{BeSi}_3\text{O}_7(\text{OH})]$	2279, 3854
Epidote	$\text{Ca}_2(\text{Al,Fe})_3\text{OH}(\text{SiO}_4)_3$	1811, 2498, 2727, 3518
Epistilbite	Zeolite	1135
Epistolite	$5\text{Na}_2\text{O} \cdot 2\text{Nb}_2\text{O}_5 \cdot$ $9(\text{Si,Ti})\text{O}_2 \cdot 10\text{H}_2\text{O}$	3666
Epsomite	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	714, 759, 854, 873, 2915, 3518
Erythrite	$\text{Co}_3(\text{AsO}_4)_2 \cdot 8\text{H}_2\text{O}$	1646, 3518
Eschynite	$2(\text{Ca,Fe})\text{O} \cdot 2\text{Ce}_2\text{O}_3 \cdot 8\text{TiO}_2 \cdot$ $3\text{Nb}_2\text{O}_5$	780, 1165, 2174
Ettringite	$3\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot 3\text{CaSO}_4 \cdot$ $32\text{H}_2\text{O}$	1432, 1753, 3883
Eudidymite	$\text{HNaBeSi}_3\text{O}_8$	3854
Euxenite	Niobate and titanate of Y, Er,Ce,U,etc.	780, 1165, 1702, 2174, 2730
Evansite	$[\text{Al}(\text{OH})_2]_6(\text{PO}_4)_2 \cdot 12\text{H}_2\text{O}(?)$	670
Ezcurrite	$2\text{Na}_2\text{O} \cdot 5\text{B}_2\text{O}_3 \cdot 7\text{H}_2\text{O}$	2211
Faratsihite	Ferriferrous kaolinite (?) or nontronite (?)	363, 431
Faujasite	$\text{Na}_2\text{CaAl}_4\text{Si}_{10}\text{O}_{28} \cdot 20\text{H}_2\text{O}$	1738, 3910
Fayalite	Fe_2SiO_4	4045
Feldspar	Akali or alkaline earth aluminum silicate	708, 790, 1232, 2861, 3365
Fenghuanite	Metamict apatite-like mineral	3911
Ferberite	FeWO_4	3518
Fergusonite	$(\text{Y,Er,Ce,Fe})(\text{Nb,Ta,Ti})\text{O}_4$	780, 930, 1165, 1702, 1907, 2174, 3097, 3129
Ferrihalloysite	See Halloysite.	288
Ferrimolybdite	$\text{Fe}_2(\text{MoO}_4)_3 \cdot n\text{H}_2\text{O}$	4044
Ferroselite	FeS_2	3404
Fersmite	CaNb_2O_6	4051
Fibroferrite	$\text{Fe}(\text{SO}_4)(\text{OH}) \cdot 4.5\text{H}_2\text{O}$	1215, 2106, 2785, 3518
*Fireclay	Essentially $\text{Al}_4(\text{OH})_8\text{Si}_4\text{O}_{10}$	90, 325, 369, 394, 493, 500, 758, 905, 2081, 2316

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Fleischerite	$\text{Pb}_3\text{Ge}(\text{OH})_4(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O}$	3113
Fluroapatite	See Apatite.	942
Fluroite	CaF_2	651, 1821, 2048, 3518
Flurophlogopite	$\text{KMg}_3(\text{Si}_3\text{AlO}_{10})\text{F}_2$	1717, 3228
Fouchérite	$\text{Ca}_3\text{Fe}_5(\text{OH})_6(\text{PO}_4)_6 \cdot 5-6\text{Fe}(\text{OH})_3 \cdot 21-23\text{H}_2\text{O}$	2340, 2680
Francevillite	$(\text{Ba},\text{Pb})(\text{UO}_2)_2(\text{VO}_4)_2 \cdot 5\text{H}_2\text{O}$	2062
Francolite	Carbonate apatite	942, 3230
Friedelite	$\text{Mn}_8\text{Si}_6\text{O}_{14}(\text{OH},\text{Cl})_{10}$	3836
Frovolite	$\text{CaO} \cdot \text{B}_2\text{O}_3 \cdot 3.5\text{H}_2\text{O}$	2250
Fuchsite	Cr mica	3518
Fuller's earth	Hydrous aluminum silicates	380, 394, 1063, 3215
Gadolinite	$(\text{OBeSiO}_4)_2\text{Y}_2\text{Fe}$	1165, 1399, 1907, 3518
Gahnite	Zn spinel	3518
Galapektite	See montmorillonite	2098
Galena	PbS	2545, 3061, 3453
Gargarinite	$\text{Na}_2\text{Ca}_2\text{Y}_3(\text{F},\text{Cl},\text{OH})_{15} \cdot \text{H}_2\text{O}$	3680
Garnet	e.g., $\text{Ca}_3\text{Fe}_2\text{Si}_3\text{O}_{12}$	522, 3963
Garnierite	$(\text{Ni},\text{Mg})_6(\text{OH})_6\text{Si}_4\text{O}_{11} \cdot \text{H}_2\text{O}$	190, 640, 2350, 2830, 3518
Gaylussite	$\text{Na}_2\text{Ca}(\text{CO}_3)_2 \cdot 5\text{H}_2\text{O}$	609
Gearksutite	$2\text{CaF}_2 \cdot 3\text{Al}_2(\text{OH},\text{F})_6 \cdot 2\text{H}_2\text{O}$	755, 2631, 3175, 3518
Gedroizite	High alkali, Mg-free vermiculite	313
Gerasimovskite	Nb-bearing titanate	2274
Gersdorffite	NiAsS	3866
*Gibbsite	$\text{Al}(\text{OH})_3$	266, 295, 386, 394, 854, 1011, 1048, 1059, 1516, 2142, 2607, 2943, 3321, 3409
Ginorite	Ca borate hydrate	2034
Giorgiosite	Similar to hydromagnesite	343
Gismondite	$\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2 \cdot 4\text{H}_2\text{O}$	3910
Glaserite	$(\text{K},\text{Na})_2\text{SO}_4$	302
Glauberite	$\text{Na}_2\text{Ca}(\text{SO}_4)_2$	873, 3518
*Glaucosite	$\text{K}(\text{Mg},\text{Fe})(\text{Al},\text{Fe})(\text{OH})_2 \cdot \text{Si}_4\text{O}_{10} + \text{K}(\text{Al},\text{Fe})\text{Al}(\text{OH})_2\text{Si}_3\text{AlO}_{10}$	757, 1316, 1317, 2354, 2656, 2895, 3277
Glaucophane	$\left[\begin{array}{l} \text{Na}_2\text{Mg}_3\text{Al}_2(\text{OH})_2\text{Si}_8\text{O}_{22} \\ \text{Na}_3\text{Mg}_3\text{Al}_2(\text{OH})\text{Si}_8\text{O}_{22} \\ \text{Na}_2\text{CaMg}_3\text{Al}_2\text{O}_2\text{Si}_8\text{O}_{22} \end{array} \right]$	651
Gmelinite	$\text{Na}_2\text{O} \cdot \text{CaO} \cdot 2\text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2 \cdot 10\text{H}_2\text{O}$	3910
*Goethite	FeOOH	394, 786, 854, 1399, 2480, 3193, 3277
Gorceixite	$\text{BaAl}_6(\text{PO}_4)_3(\text{OH})_{11} \cdot n\text{H}_2\text{O}$	2699
Goslarite	$(\text{Zn},\text{Mg},\text{Mn},\text{Cd})\text{SO}_4 \cdot 6.65\text{H}_2\text{O}$	1512, 3336
Gowerlite	$\text{CaO} \cdot 3\text{B}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$	2767
Graphite	C	691, 1145
Griffithite	Ferroan saponite	1518
Grochanite	Magnesian prochlorite	244

ALPHABETICAL REFERENCE LIST OF MATERIALS STUDIED BY DTA 607

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Grossularite	$\text{Ca}_3\text{Al}_2(\text{SiO}_4)_3$	710, 1346
Guanajuatite	Bi_2S_3	3404
*Gypsum	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	759, 958, 1230, 1446, 2612
Gyrolite	$\text{Ca}_4(\text{OH})_2\text{Si}_6\text{O}_{15} \cdot 3\text{H}_2\text{O}$	2504, 3033, 3421, 3588
Halite	NaCl	309, 358, 854, 2836, 3518
*Halloysite	$\text{Al}_4\text{Si}_4\text{O}_{10}(\text{OH})_8$	266, 394, 441, 502, 554, 1087, 1190, 1300, 1804, 1843, 2072, 2316, 3277
Halotrichite	$\text{FeAl}_2(\text{SO}_4)_4 \cdot 24\text{H}_2\text{O}$	873, 3518
Halurgite	$2\text{MgO} \cdot 4\text{B}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$	3871
Hanksite	$\text{Na}_{22}\text{K}(\text{SO}_4)_9(\text{CO}_3)_2\text{Cl}$	873
Harmotome	$2\text{BaO} \cdot \text{K}_2\text{O} \cdot 3\text{Al}_2\text{O}_3 \cdot$ $26\text{SiO}_2 \cdot 20\text{H}_2\text{O}$	3518, 3910
Hastingsite	$(\text{Ca}, \text{Na}, \text{K})_3(\text{Fe}^{2+}, \text{Fe}^{3+})_5-$ $(\text{Si}, \text{Al})_8\text{O}_{22}(\text{OH})_2$	848, 1027, 3518
Hauerite	MnS_2	1810, 3237
Hausmannite	MnMn_2O_4	651, 657, 1723, 2428, 2660, 3449, 3518, 3748
Hectorite	$(\text{OH})_4\text{Si}_8(\text{Mg}_{5.34}\text{Li}, \text{Na}_{0.66})-$ O_{20}	328, 437, 502, 520, 560, 771, 1196, 1359, 1840, 2771
Hematite	Fe_2O_3	227, 359, 482, 538, 641, 2066, 2862, 3193, 3277, 3518, 3733
Hemimorphite	$(\text{OH})_2\text{Zn}_4\text{Si}_2\text{O}_7 \cdot \text{H}_2\text{O}$	746, 1936, 2344, 3336
Hetite	Hydrated iron oxide	126
Heulandite	$(\text{Ca}, \text{Na}, \text{K})_6\text{Al}_{10}(\text{Al}, \text{Si})\text{Si}_{29}-$ $\text{O}_{80} \cdot 25\text{H}_2\text{O}$	119, 1135, 1336, 3222, 3309, 3518, 3893, 3910, 3921
Hibbschite	$\text{Ca}_3\text{Al}_2(\text{SiO}_4)_2(\text{OH})_4$	3229
Hillebrandite	$\text{Ca}_2\text{SiO}_4 \cdot \text{H}_2\text{O}$	651, 2646, 2985, 3233, 3518
Hisingerite	$2\text{SiO}_2 \cdot \text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O}$ (canbyite?)	1000, 1001, 2221, 3518, 3718
Hoferite	$2\text{Na}_2\text{O} \cdot 5\text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O}$	3436, 3437
Hoernsite	$3\text{MgO} \cdot \text{As}_2\text{O}_5 \cdot 8\text{H}_2\text{O}$	1646
Hollandite	$\text{Ba}(\text{Mn}, \text{Co})_8\text{O}_{16}$	651, 3449
Holmquistite	Li aluminosilicate	3272, 3518
Hornblende	$\text{Ca}_2(\text{Mg}, \text{Fe})_4\text{Al}(\text{OH})_2 \cdot$ $\text{AlSi}_7\text{O}_{22} +$ $\text{Ca}_2\text{Na}(\text{Mg}, \text{Fe})_4\text{Al}(\text{OH})_2-$ $(\text{Al}_2\text{Si}_6\text{O}_{22})$	641, 1852, 3277, 3518, 3549
Howlite	$4\text{CaO} \cdot 5\text{B}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 5\text{H}_2\text{O}$	2034
Huebnerite	MnWO_4	3518
Humboldtine	$\text{FeC}_2\text{O}_4 \cdot 1.5\text{H}_2\text{O}$	1367
Huntite	$\text{Mg}_3\text{Ca}(\text{CO}_3)_4$	1085, 2041, 2705, 2756, 3518
Hureaulite	$5\text{MnO} \cdot 2\text{P}_2\text{O}_5 \cdot 5\text{H}_2\text{O}$	3082
Huttonite	Fe, Mn rare-earth complex	3853
Hydralsite	Hydrous aluminosilicate	1397
*Hydrargillite	See Gibbsite.	1537, 2930, 2989, 4046
Hydrated halloysite	$\text{Al}_4\text{Si}_4\text{O}_{10}(\text{OH})_8 \cdot 4\text{H}_2\text{O}$	325, 334, 369, 1001, 1002, 1423, 1975, 2826
Hydrated iron oxide	— — —	250, 295, 325, 641
Hydrobiotite	Interlayer mixture of biotite and vermiculite	843, 3401, 3440

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Hydroboracite	$\text{CaMgB}_6\text{O}_{11} \cdot 6\text{H}_2\text{O}$	358
Hydrocerussite	$\text{Pb}_3(\text{OH})_2(\text{CO}_3)$	609
Hydrogarnet	$3\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$	299
Hydrogoethite	— — —	641, 2724
Hydrohematite	— — —	126, 641
Hydronasturan	Pb-bearing uranium mineral	3482
Hydrous mica	See Illite.	250, 260, 641, 1102, 1340, 1549, 1988, 2157, 35677
Hydromagnesite	$\text{Mg}_5(\text{OH})_2(\text{CO}_3)_4 \cdot 4\text{H}_2\text{O}$	609, 840
Hydrotalcite	$\text{Mg}_6\text{Al}_2(\text{OH})_{16}\text{CO}_3 \cdot 4\text{H}_2\text{O}$	143, 361, 362, 609, 3518
Hydrozincite	$\text{Zn}_5(\text{OH})_6(\text{CO}_3)_2$	609, 651, 741, 2344, 2682, 2741, 3518
Ianthinite	$\text{UO}_2 \cdot 5\text{UO}_3 \cdot 10.6\text{H}_2\text{O}$	2793
*Illite	$(\text{OH})_4\text{K}_y(\text{Al}_4 \cdot \text{Mg}_4 \cdot \text{Mg}_6) \cdot (\text{Si}_{8-y} \cdot \text{Al}_y)\text{O}_{20}$	225, 266, 325, 369, 394, 444, 1558, 2487, 3277, 3464
Illite-montmorillonite	— — —	917, 1495
Ilmenite	FeTiO_3	2005, 3518
Inderite	$\text{Mg}_2\text{B}_6\text{O}_{11} \cdot 15\text{H}_2\text{O}$	358
Innelite	Complex Ba silicate	3550
Inyoite	$2\text{CaO} \cdot \text{B}_2\text{O}_3 \cdot 13\text{H}_2\text{O}$	1162
Iodargyrite	AgI	854
Iriginite	See moluranite	2766
Iron ore	— — —	1564, 1919, 1926, 2079, 2187, 3355
Ishkyldite	$\text{H}_{20}\text{Mg}_{15}\text{Si}_{11}\text{O}_{47}$ (a chrysotile)	205, 222
Istisuite	$(\text{Na}, \text{Ca})_7(\text{Si}, \text{Al})_8\text{O}_{20}(\text{OH})_3$	1563
Itotite	$\text{Pb}_3[\text{GeO}_2(\text{OH})_2](\text{SO}_4)_2$	3113
Jamesonite	$4\text{PbS} \cdot \text{FeS} \cdot 3\text{Sb}_2\text{S}_3$	3866
Jarosite	$\text{KF}_3(\text{OH})_6(\text{SO}_4)_2$	502, 559, 656, 820, 1214, 1257, 1280, 1509, 2006, 2106, 2417, 2839, 3518
Jefferisite	See Vermiculite.	575, 1359, 1799, 3518
Johannsenite	$\text{MnCaSi}_2\text{O}_6$	1195
Jordanite	Pb arsenate	2447
Kainite	$\text{MgSO}_4 \cdot \text{KCl} \cdot 3\text{H}_2\text{O}$	302, 2470
Kaliborite	$\text{KMg}_2\text{B}_{22}\text{O}_{19} \cdot 15\text{H}_2\text{O}$	358
Kalinite	$\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$	2090
Kalistrontite	$\text{K}_2\text{Sr}(\text{SO}_4)_2$	3973
*Kaolin, Kaolinite	$(\text{OH})_8\text{Si}_4\text{Al}_4\text{O}_{10}$ (theoretical)	266, 325, 350, 418, 441, 450, 502, 506, 549, 568, 862, 1041, 1096, 1122, 1140, 1147, 1190, 1300, 1399, 1417, 1490, 1661, 1688, 1804, 1808, 1843, 1883, 2055, 2072, 2339, 2487, 2638, 2732, 2913, 2975, 3201, 3331, 3570, 3672, 3699
Kaolin-illite	— — —	602

ALPHABETICAL REFERENCE LIST OF MATERIALS STUDIED BY DTA 609

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Karpinskite	(Mg,Ni) ₂ Si ₂ O ₄ (OH) ₂	1938
Karpinskyite	Na ₂ (Be,Zn,Mg)Al ₂ Si ₆ O ₁₆ ·(OH) ₂	1952
Kerchenite	Fe phosphate	1766, 2340, 2459, 3518
Kernite	Na ₂ O·2B ₂ O ₃ ·4H ₂ O	2034, 2836
Kerolite	MgH ₂ SiO ₄	640, 809, 1685, 1938, 2694, 3518, 3591
Kieserite	MgSO ₄ ·H ₂ O	873
Kingite	Al phosphate hydrate	2235
Kischtymite	Hydroxyl bastnasite (?)	609
Klockmannite	CuSe	3404
Kobellite	6PbS·2Bi ₂ S ₃ ·Fe ₂ S	3866
Koettigite	3ZnO·As ₂ O ₅ ·8H ₂ O	1646
Kotschubeite	See Chlorite.	135, 2514
Kröhnkite	Na ₂ Cu(SO ₄) ₂ ·2H ₂ O	873
Kruzhanovskite	(Mn,Ca,Mg)Fe ₂ O ₃ ·P ₂ O ₅ ·2H ₂ O	639
Kukersite	Carbonaceous aluminosilicate	1072
Kupletskite	(K,Na) ₂ (Fe,Mn) ₄ (Ti,Zr)(Si ₄ O ₁₄)(OH,F) ₂	1945
Kurgantaitite	Strontium Borate	1033
Kurskite	Carbonate apatite	2340
Kutnahorite	CaMn(CO ₃) ₂	1524, 3542
Kyanite	Al ₂ SiO ₅	112, 1957
Labradorite	Lime-soda feldspar	1335
Langbeinite	K ₂ Mg ₂ (SO ₄) ₃	358
Langite	Cu ₄ (SO ₄)(OH) ₆ ·H ₂ O	873
Lansfordite	MgCO ₃ ·5H ₂ O	609
Laterite	Contains aluminum and iron hydroxides	197, 651, 1216, 1579, 2001, 3461
Laumonite	Zeolite	1135, 2840, 3518, 3910
Lawsonite	CaAl ₂ (Si ₂ O ₇)(OH) ₂ ·H ₂ O	834
Lazulite	MgAl ₂ (PO ₄) ₂ (OH) ₂	670, 1428, 3518
Leadhillite	Pb ₄ (OH) ₂ (CO ₃) ₂ SO ₄	609
Leonite	MgSO ₄ ·K ₂ SO ₄ ·4H ₂ O	302, 358
Lepidocrocite	FeO(OH)	126, 359, 786, 991, 1693, 1701, 1774, 1937, 2381, 2752, 3193
Lepidolite	K ₂ Li ₃ Al ₃ (F,OH) ₄ (AlSi ₃ O ₁₀) ₂	575, 1252, 1883, 1984, 3082, 3518
Lepidomelane	Trioctahedral mica	1252, 3518
Leuchtenbergite	See Chlorite.	135, 244, 288, 1608, 2237, 2621, 3518
Leucite	KAlSiO ₄	1842
Leucophosphate	KF ₂ (PO ₄) ₂ (OH)·2H ₂ O	4005
Leverrierite	Illite group	1671
Levyntite	CaO·Al ₂ O ₃ ·3SiO ₂ ·5H ₂ O	3910
Liebigite	Ca ₂ U(CO ₃) ₄ ·10H ₂ O	609
Limestone	CaCO ₃	256, 513, 557, 644, 1022, 1088, 1266, 1374
*Limonite	Fe ₂ O ₃ ·nH ₂ O	394, 479, 897, 2225, 3277

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Linarite	PbO · CuO · SO ₃ · H ₂ O	3336, 3518
Lithiophorite	LiMn ₃ Al ₂ O ₉ · 3H ₂ O	3449
Lithiophyllite	Li(Fe, Mn)PO ₄	651
Loellingite	FeAs ₂	2361
Loess	— — —	870, 991, 1274, 1407, 1408, 1670, 1672, 2695, 3195
Loewigite	Alkaline sulfoaluminate	1017, 1214
Lomonosovite	Na ₂ Ti ₂ Si ₂ O ₉ · Na ₃ PO ₄	638, 3666
Loparite	Rare-earth titanate	3731
Loranskite	See gadolinite	3463
Ludwigite	(Mg, Fe) ₂ FeBO ₅	2123
Lueneburgite	3MgO · B ₂ O ₃ · P ₂ O ₅ · 8H ₂ O	3518
Maghemite	γ-Fe ₂ O ₃	2618, 2640, 2941, 2942
*Magnesite	MgCO ₃	609, 1416, 2159, 2316, 3063, 3277
Magnesium clay	— — —	266
Magnesium monothermite	— — —	581
Magnetite	(Fe, Mn, Zn, Mg)Fe ₂ O ₄	227, 1668, 2186, 3277, 3287, 3518
Malachite	Cu ₂ (OH) ₂ CO ₃	609, 741, 3336, 3518
Manasseite	Mg ₆ Al ₂ (OH) ₁₆ CO ₃ · 4H ₂ O	609
Manganese ores	— — —	628, 2051
Manganite	MnO(OH)	142, 198, 295, 657, 1188, 1723, 1786, 2448, 3449, 3518
Mansfieldite	Isomorphous with scorodite	1257
Marcasite	FeS ₂	369, 1810, 2496, 2650
Margarite	CaAl ₄ Si ₂ O ₁₀ (OH) ₂	1252, 1531
Marl	Argillaceous calcareous rock	2874, 3303, 3359, 3615, 3671
Marmatite	ZnO · Fe ₂ O ₃	1643
Mascagnite	(NH ₄) ₂ SO ₄	873
Matilidite	Ag ₂ S · Bi ₂ S ₃	3404
Mauritzite	See montmorillonite	2311
Medmontite	Copper-bearing montmorillonite	625
Meerschaum	See Sepiolite.	359
Melanterite	FeSO ₄ · 7H ₂ O	1215, 1684, 2417, 3518
Melaphyre	Porphyritic rock	2331, 3000
Mesolite	Ca ₂ Na ₂ Al ₆ Si ₉ O ₃₀ · 8H ₂ O	1135, 1639, 3910
Metabentonite	K bentonite	524, 721, 1022
Metahalloysite	See Halloysite.	612, 620, 771, 991
Metavoltine	K ₅ Fe ₃ (SO ₄) ₆ (OH) ₂ · 8H ₂ O	873
Meyerhofferite	2CaO · 3B ₂ O ₃ · 7H ₂ O	2034
Miargyrite	3Ag ₂ S · Sb ₂ S ₃	3404
Mica	See Muscovite.	119, 309, 335, 426, 606, 691, 1199, 1976, 2487, 3399
Michenerite	BiTe	4032
Microcline	K ₂ O · Al ₂ O ₃ · 6SiO ₂	2381
Microlite	(Na, Ca) ₂ (Ta, Nb) ₂ O ₄ · (O, OH, F)	780, 930
Miersite	CuI · 4AgI	3518
Millerite	NiS	2361

ALPHABETICAL REFERENCE LIST OF MATERIALS STUDIED BY DTA 611

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Mimetite	$9\text{PbO} \cdot 3\text{As}_2\text{O}_5 \cdot \text{PbCl}_2$	3518
Mirabilite	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$	3518
Mitridatite	$\text{Ca}_4\text{Fe}_5(\text{OH})_5(\text{PO}_4)_6 \cdot 1.5\text{Fe}(\text{OH})_3 \cdot 5.5\text{H}_2\text{O}$	2340, 2680
Molybdenite	MoS_2	2024, 2585, 3404
Moluranite	$\text{UO}_2 \cdot 3\text{UO}_3 \cdot 7\text{MoO}_3 \cdot 20\text{H}_2\text{O}$	2766
Monazite	$(\text{Ce}, \text{La}, \text{Di})_2\text{O}_3 \cdot \text{P}_2\text{O}_5$	2509, 2884, 3518
Monheimite	Var. of smithsonite	3518
Montebrasite	$\text{Al}_2\text{O}_3 \cdot \text{P}_2\text{O}_5 \cdot 2\text{Li}(\text{OH}, \text{F})$	3518
Moraesite	$\text{Be}_2\text{PO}_4(\text{OH}) \cdot 4\text{H}_2\text{O}$	4060
Morinite	$\text{Ca}_4\text{Na}_2\text{Al}_2(\text{AlOF}_3)_2 \cdot (\text{PO}_4)_4 \cdot 5\text{H}_2\text{O}$	3105
Monothermite	Illite-type clay	579, 580, 641, 745, 779, 1982, 2249, 2575, 3512, 3518
*Montmorillonite	$(\text{OH})_4\text{Si}_8(\text{Al}_{3.34}\text{Mg}, \text{Na}_{0.66})\text{O}_{20}$	325, 351, 364, 393, 471, 568, 1107, 1376, 1558, 1688, 2487, 2529, 2826, 3480, 3492
Montroseite	$\text{VO}(\text{OH})$	3410
Mordenite	$(\text{Ca}, \text{K}_2, \text{Na}_2)\text{Al}_2\text{Si}_{10}\text{O}_{24} \cdot 7\text{H}_2\text{O}$	1135, 3910
Morenosite	$\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$	358
Moresnetite	A mixture containing sauconite	746, 2093
Mountainite	$(\text{Ca}, \text{Na}_2, \text{K}_2)_{16}\text{Si}_{32}\text{O}_{80} \cdot 24\text{H}_2\text{O}$	2108
Mourite	U, Mo complex	3852
Murmanite	$2\text{Na}_2\text{O} \cdot (\text{Fe}, \text{Mg}, \text{Ca})\text{O} \cdot 4\text{SiO}_2 \cdot 4(\text{Ti}, \text{Zr})\text{O}_2 \cdot 4\text{H}_2\text{O}$	3666
*Muscovite	$\text{K}_2(\text{Al}, \text{Fe}, \text{Mg})_4(\text{OH})_4 \cdot (\text{Si}, \text{Al})_6\text{O}_{20}$	2099, 2126, 2649
Nacleodovite	Pb alkaline earth aluminocarbonate	2420
Nacrite	HNaCO_3	182, 226, 266, 771, 2312
Nahcolite	$(\text{Na}, \text{K})\text{Al}_3(\text{OH})_6(\text{SO}_4)_2$	609
Nasinite	$2\text{Na}_2\text{O} \cdot 5\text{B}_2\text{O}_3 \cdot 7\text{H}_2\text{O}$	3437
Natroalunite	$\text{Na}_2\text{Al}_2\text{Si}_3\text{O}_{10} \cdot 2\text{H}_2\text{O}$	413, 414, 1214, 1470, 1772
Natrochalchite	$\text{NaCu}_2(\text{SO}_4)_2\text{OH} \cdot \text{H}_2\text{O}$	873
Natrolite	See Brucite.	724, 928, 1135, 1639, 3518, 3910
Naumannite	Ag_2Se	3404
Nefedyevite	Mg aluminosilicate	3057
Nemalite	Hydrous silicate of Mn, containing Mg, Fe, Ca	121, 3518
Nenadkevite	U-bearing silicate	2253
Neotocite	NaAlSiO_4	1202, 3023, 3718
Nephelite	$\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$	267, 3000
Nephrite	See Amphibole.	1852
Nepouite	$3(\text{Ni}, \text{Mg})\text{O} \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$	3518
Nesquehonite	$\text{HMgPO}_4 \cdot 3\text{H}_2\text{O}$	609, 2760
Newberyite	$(\text{Ca}, \text{Zn})\text{CO}_3$	1704
Niccolite	NiAs	2361

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Nicholsonite	— — —	609
Nickel ore	$(\text{OH})_4(\text{Si}_{7.34}\cdot\text{Al},\text{Na}_{0.66})\text{-Fe}_4^{3+}\text{O}_{20}$	651, 3076
Nifontovite	$\text{CaO}\cdot\text{B}_2\text{O}_3\cdot 2.3\text{H}_2\text{O}$	3574
Nitratine	NaNO_3	854
Nitrocalcite	$\text{Ca}(\text{NO}_3)_2\cdot 4\text{H}_2\text{O}$	854, 2089
*Nontronite	$\text{H}_4\text{Fe}_2\text{Si}_2\text{O}_9$	163, 394, 458, 948, 2357, 2826
Nouméite	Siliceous nickel ore	190
Novaculite	SiO_2	651
Nsutite	Mn oxide-hydroxide	4002
Obruchevite	Metamict Ta-Nb complex	2143
Obsidian	Volcanic glass	651, 1422
Oligoclase	Soda-lime feldspar	1335
Oligonite	Mn-Fe mineral	3433
Olivenite	$4\text{CuO}\cdot\text{As}_2\text{O}_5\cdot\text{H}_2\text{O}$	3518
Olivine	$(\text{Mg},\text{Fe},\text{Mn})_2\text{SiO}_4$	651, 2036, 3000, 3169, 3851, 4045
Opal	SiO_2	928, 1606, 2776, 2809, 3277, 3727
Orcelite	Ni_2As	2742
Orthoclase	KAlSi_3O_8	234
Osarizawaite	Var. of alunite	3689
Palagonite	See Phlogopite.	1801
Palygorskite	Similar to attapulgite and sepiolite	121, 179, 212, 288, 384, 400, 431, 676, 736, 740, 1233, 1359, 1415, 1731, 2024, 2194, 3951
Pandermite	$4\text{CaO}\cdot 5\text{B}_2\text{O}_3\cdot 7.6\text{H}_2\text{O}$	511, 2730
Paragasite	See Amphibole	1852, 3549
Paragonite	$\text{NaAl}_2(\text{OH})_2\text{AlSi}_3\text{O}_{10}$	1252, 1773, 2422, 3518
Paratacamite	$\text{Cu}_2\text{Cl}(\text{OH})_3$	633
Paravauxite	$\text{FeAl}_2(\text{PO}_4)_2\cdot 8\text{H}_2\text{O}$	3822
Pentlandite	$(\text{Fe},\text{Ni})\text{S}$	1427, 3844
Peridotite	Rock containing ferro-magnesian minerals	199
Pelite	Volcanic glass	651, 925, 2389, 3997
Petalite	$\text{LiAl}(\text{Si}_2\text{O}_5)_2$	267, 3518
Petzite	Ag_3AuTe_3	2780
Phillipsite	$(\text{Na},\text{K})_2\text{O}\cdot\text{CaO}\cdot 2\text{Al}_2\text{O}_3\cdot 6\text{SiO}_2\cdot 8\text{H}_2\text{O}$	3910
Pholerite	See Kaolinite.	168, 335
Phlogopite	$\text{Mg}_3\text{KAlSi}_3\text{O}_{10}(\text{OH},\text{F})_2$	1252, 1801, 2542, 3518
Phonolite	Medium acid rock	2330
Phosgenite	$\text{Pb}_2\text{Cl}_2\text{CO}_3$	609
Phosphate rock	— — —	651
Phosphorite	Massive apatite	227
Phosphosiderite	$\text{FePO}_4\cdot 2\text{H}_2\text{O}$	4005
Phosphotridymite	— — —	4005
Phosphouranylite	$3\text{UO}_3\cdot\text{P}_2\text{O}_5\cdot 6\text{H}_3\text{O}$	2753
Phyllite	Scaly minerals (French)	534, 782, 814
Pickeringite	$\text{MgAl}_2(\text{SO}_4)_4\cdot 22\text{H}_2\text{O}$	873
Picotite	Chrome spinel	1674

ALPHABETICAL REFERENCE LIST OF MATERIALS STUDIED BY DTA 613

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Picrolite	Serpentine mineral	279, 3518
Picromerite	$K_2Mg(SO_4)_2 \cdot 6H_2O$	873
Picropharmacolite	$3(Ca,Mg)O \cdot As_2O_5 \cdot 6H_2O$	3518, 3620
Pinnoite	$MgB_2O_4 \cdot 3H_2O$	358
Pisanite	$(Fe,Cu)SO_4 \cdot 7H_2O$	873
Pistomesite	$MgCO_3 - FeCO_3$	609
Planchéite	Cu silicate hydrate	2314
Planerite	$3Al_2O_3 \cdot 2P_2O_5 \cdot nH_2O$	3426
Plattnerite	PbO_2	3336
Plumbian dolomite	— — —	2131
Plumbojarosite	$Pb[Fe_3(OH)_6(SO_4)_2]_2$	656, 1214, 1280, 1440, 2149
Plumbolimonite	— — —	2664
Polianite	MnO_2	1260
Polycrase	(Y,Ca,Ce,U,Th)- (Ti,Nb,Ta) ₂ O ₆	780, 960, 2029
Polyhalite	$K_2MgCa_2(SO_4)_4 \cdot 2H_2O$	873, 3518, 4054
Potash clay	Similar to illite and or montmorillonite	266
Powellite	$CaO \cdot (Mo,W)O_3$	3518
Prehnite	$Ca_2Al_2Si_3O_{10}(OH)_2$	309, 3518
Preobrazhenskite	$3MgO \cdot 5V_2O_5 \cdot 4.5H_2O$	2017
Pricite	$Ca_5B_{12}O_{23} \cdot 9H_2O$	243, 358, 2034
Priorite	— — —	780, 2334, 3176
Probertite	$Na_2O \cdot 2CaO \cdot 5B_2O_3 \cdot 10H_2O$	2034
Prochlorite	Syn. of Ripidolite	359, 470, 1359, 1608, 3277
Proustite	$3Ag_2S \cdot As_2S_3$	3404
Pseudowavellite and millisite	— — —	647, 1018
Psilomelane	Black hematite	651, 657, 1188, 1723, 3107, 3518,
Ptilolite	Zeolite	1135
Pumice	Volcanic ash	1499, 1846, 2179, 2219, 2821
Pumpellyite	Glaucofane (?)	834
Priorite	(Y,Er)(Nb,Ti) ₂ O ₆	1165
*Pyrite	FeS_2	1809, 1810, 2165, 2496, 2650
Pyroaurite and sjogrenite	$Mg_6Fe_2(OH)_{16}CO_3 \cdot 4H_2O$	143, 609, 3518
Pyrochlore	(Na,Ca) ₂ (Nb,Ta) ₂ O ₆ F	930, 1764, 3099, 3114, 3667
Pyrochroite	Zn serpentine	2368
Pyrolusite	MnO_2	504, 628, 651, 657, 970, 1188, 1723, 1786, 1997, 2448, 3144, 3190, 3449, 3595
*Pyrophyllite	$Al_2(OH)_2Si_4O_{10}$	145, 245, 266, 394, 763, 1252, 2239, 2316
Pyroxene	<i>e.g.</i> , (Ca,Fe,Mg)SiO ₃	913
Pyrrhotite	$Fe_{1-x}S$	327, 1148, 1266, 1427, 1550, 1810, 2226, 2361, 2650, 3404
*Quartz	SiO_2	50, 80, 108, 129, 137, 140, 360, 370, 375, 484, 494, 711, 763, 815, 887, 922, 943, 1066, 1404, 1645, 1861, 1902, 2722, 3117

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Racewinites	(Al,Fe) ₃ Si ₅ O ₁₆ ·9H ₂ O	325
Ralstonite	(Na ₂ Mg)F ₂ ·3Al(F,OH) ₃ · 2H ₂ O	3955
Ramsdellite	MnO ₂	504, 657, 1260, 2448, 3485, 3518, 3595
Realgar	AsS	3404
Revdanskite	Ni serpentine	121, 3518
Reyerite	CaO·2SiO ₂ ·0.5H ₂ O	3588
Rhabdophane	Var. of monazite	2947
Rhodesite	(Ca,Na ₂ ,K ₂) ₈ Si ₁₆ O ₄₀ ·11H ₂ O	2108
Rhodochrosite	MnCO ₃	52, 440, 502, 561, 609, 637, 651, 1524, 1701, 1786, 1844, 1883, 2242, 3449
Rhodonite	Mn ₂ (SiO ₃) ₂	1786, 3449, 3518
Rhodusite	Var. glaucophane	3518
Richterite	(Na,K) ₂ (Mg,Mn,Ca) ₆ - Si ₈ O ₂₂ (OH) ₂	848, 1027, 3518
Riebeckite	Na ₂ O·Fe ₂ O ₃ ·FeO· 5SiO ₂ ·H ₂ O	3518
Rinkite	Na ₂ Ca ₄ CeTiSiO ₁₅ (F,OH) ₃	2284
Ripidolite	Chlorite group mineral	135, 311, 470, 1860, 3518
Rockbridgeite	2FeO·4Fe ₂ O ₃ ·3P ₂ O ₅ ·5H ₂ O	3082
Roemerite	FeO·Fe ₂ O ₃ ·4SO ₃ ·14H ₂ O	873, 3518
Rosasite	2(Cu,Zn)O·CO ₂ ·H ₂ O	3336
Roselite	3(Ca,Co,Mg)O·As ₂ O ₅ ·2H ₂ O	3518
Rozenite	FeSO ₄ ·4H ₂ O	3179
Rubellite	Variety of tourmaline	562
Rusakovite	(Fe,Al) ₅ [V,(PO ₄) ₂](OH) ₉ · 3H ₂ O	3029
Rutherfordite	UO ₂ CO ₃	609
Rutile	TiO ₂	102
Samaraskite	(Y,Ce,U,Ca,Fe,Pb,Th)- (Nb,Ta,Ti,Sn) ₂ O ₆	780, 930, 1165, 1702, 2174, 3330
Samiresite	(U,Pb,etc.)(Nb,Ti)O ₄	1165
Saponite	(OH) ₄ (Si _{7.34} Al _{1.66}) Mg ₆ O ₂₀	279, 502, 608, 641, 739, 746, 954, 1196, 1255, 1418, 1711, 1883, 1890, 2218, 2803
Sassolite	B ₂ O ₃ ·3H ₂ O	2034
Satpavevite	6Al ₂ O ₃ ·V ₂ O ₄ ·3V ₂ O ₅ ·30H ₂ O	3734
Sauconite	Zn montmorillonite	424, 746, 1706, 2421
Scapolite	[Na ₄ ClSi ₉ Al ₃ O ₂₄] [Ca ₄ CO ₃ Si ₆ Al ₆ O ₂₄]	651, 1757, 3518
Scheelite	CaWO ₄	3518
Schoderite	2Al ₂ O ₃ ·V ₂ O ₅ ·P ₂ O ₅ ·16H ₂ O	3814
Schoenite	MgSO ₄ ·K ₂ SO ₄ ·6H ₂ O	302, 1932
Schroëckingerite	NaCa ₃ UO ₂ SO ₄ (CO ₃) ₃ Fe· 10H ₂ O	609, 2035
Schweizerite	Serpentine mineral	279, 1780
Scolecite	CaAl ₂ Si ₃ O ₁₀ ·3H ₂ O	1135, 1639, 3518, 3910
Scorodite	FeAsO ₄ ·2H ₂ O	1257, 3082, 3336, 3518

ALPHABETICAL REFERENCE LIST OF MATERIALS STUDIED BY DTA 615

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Scorzalite	$\text{FeAl}_2(\text{PO}_4)_2(\text{OH})_2$	1428
Searlesite	$\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 4\text{SiO}_2 \cdot 2\text{H}_2\text{O}$	2034
Selenite	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	3106
Sellaite	MgF_2	902
*Sepiolite	$\text{Si}_4\text{O}_{11}(\text{Mg} \cdot \text{H}_2)_3\text{H}_2\text{O} \cdot 2\text{H}_2\text{O}$	737, 1149, 1677, 2550, 2976
Serendibite	$\text{Ca}_4(\text{Mg}, \text{Fe}, \text{Al})_6(\text{Al}, \text{Fe})_9\text{B}_3(\text{Si}, \text{Al})_6\text{O}_{40}$	2908
Sericite	See Muscovite.	304, 426, 745, 924, 1101, 1131, 1252, 1788, 2162, 2316, 3462
*Serpentine	Chrysotile and/or antigorite	124, 171, 211, 667, 926, 1132, 1399, 2316, 2378, 3584, 3971
Serpierite	$(\text{Cu}, \text{Zn}, \text{Ca})_5(\text{SO}_4)_2(\text{OH})_6 \cdot 3\text{H}_2\text{O}$	873, 3336
Shale	— — —	1362, 1403, 1519, 1526, 1574, 1577, 1846, 1847, 1866, 2065, 2119, 2299, 2554, 2730, 3271, 3701
Shattuckite	$3\text{CuSiO}_3 \cdot \text{H}_2\text{O}$	3687
Sheridanite	Similar to prochlorite	135, 244, 359, 438, 617, 3518
Sibirskite	$\text{Ca}_2\text{B}_2\text{O}_4(\text{OH})_2$	3968
*Siderite	FeCO_3	52, 394, 440, 451, 487, 574, 1329, 2475, 2627
Siderose	— — —	1263
Siderotil	$\text{FeSO}_4 \cdot 4\text{H}_2\text{O}$	3884
Sigloite	$\text{Fe}_2\text{Al}_2(\text{PO}_4)_2 \cdot 8\text{H}_2\text{O}$	3822
Sillimanite	Al_2SiO_5	112, 1617
Sjogrenite and pyroaurite	See Pyroaurite.	609
Slate	Finely foliated rock	1297
Smirnovskite	Metamict rare-earth complex	2118
Smithsonite	ZnCO_3	52, 440, 502, 609, 746, 1883, 2683, 2741, 3336, 3518
Sokolovite	$2(\text{Ca}, \text{Sr})\text{O} \cdot 4\text{Al}_2\text{O}_3 \cdot \text{P}_2\text{O}_5 \cdot 11\text{H}_2\text{O}$	2616, 3121
Specularite	See Hematite.	2005
Spencite	$[\text{Y}(\text{Ce}, \text{Pr}, \text{Th})\text{Ca}]_2(\text{Si}_2\text{B})\text{O}_{12}\text{O}$	3828
Sphalerite	$(\text{Zn}, \text{Fe})\text{S}$	651, 1590, 2495, 3404
Spodumene	$\text{LiAlSi}_2\text{O}_6$	267, 310, 1991, 2307, 2322, 3518, 3621, 3921
Stainierite	$\text{Co}(\text{OH})_2$	2566, 2567
Stannite	$\text{Cu}_2\text{S} \cdot \text{FeS} \cdot \text{SnS}_2$	3404
Stellerite	$\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot 7\text{SiO}_2 \cdot 7\text{H}_2\text{O}$	3518
Stevensite	Similar to saponite, containing Mn	1086, 2771, 2920
Stewartite	$3\text{MnO} \cdot \text{P}_2\text{O}_5 \cdot n\text{H}_2\text{O}$	3082
Stibiconite	$\text{Sb}_2\text{O}_4 \cdot \text{H}_2\text{O}$	1020, 3518
Stibnite	Sb_2S_3	1550
Stichtite and barbertonite	$\text{Mg}_6\text{Cr}_2(\text{OH})_{16}\text{CO}_3 \cdot 4\text{H}_2\text{O}$	322, 344, 609

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Stilbite	$(\text{Ca}, \text{Na}_2)\text{Al}_2\text{Si}_7\text{O}_{18} \cdot 7\text{H}_2\text{O}$	1135, 1146, 1336, 3309, 3518 [#] 3910, 3921
Stilpnomelane	$(\text{OH})_{20}\text{K}(\text{Fe}^{2+}\text{Mg})_9\text{-}$ $(\text{Fe}^{3+}\text{Al})_{5-6}\text{Si}_{16}\text{O}_{39-40}$	1367, 2221
Strengite	$\text{FePO}_4 \cdot 2\text{H}_2\text{O}$	4005
Srortianite	SrCO_3	52, 440, 643, 651, 1883, 3086, 3511, 3518
Strunzite	$\text{MnFe}_2(\text{PO}_4)_2(\text{OH})_2 \cdot 6\text{H}_2\text{O}$	3082
Sudoite	Diocahedral chlorite	3786
Suanite	Magnesium borate	1220
Sulunite	Fe chlorite	2896
Syabite	$\text{Ca}_5(\text{AsO}_4)_3(\text{OH}, \text{F}, \text{Cl})$	3700
Syenite	Medium acid rock	2330
Sylvite	KCl	309, 358, 2836, 3518
Symplesite	$3\text{FeO} \cdot \text{As}_2\text{O}_5 \cdot 8\text{H}_2\text{O}$	1646
Syngenite	$\text{CaSO}_4 \cdot \text{K}_2\text{SO}_4 \cdot \text{H}_2\text{O}$	873, 2359, 2643
Szaibelyite	MgBO_2OH	358, 1220, 1680, 3967
Takovite	$\text{Ni}_5(\text{Al}_4\text{O}_2)(\text{OH})_{18} \cdot 6\text{H}_2\text{O}$	2531
*Talc	$\text{Mg}_3(\text{OH})_2\text{Si}_4\text{O}_{10}$	145, 193, 394, 518, 1381, 2316, 2949, 2973
Taranakite	Hydrated alkaline aluminophosphate	1899, 4005
Teniolite	$\text{KMg}_2\text{Li}(\text{Si}_4\text{O}_{10})\text{F}_2$	1717
Tetrahedrite	$\text{Cu}_{12}\text{Sb}_4\text{S}_{13}$	3404, 3497, 3866
Tennantite	$\text{Cu}_{12}\text{As}_4\text{S}_{13}$	3404, 3497
Thaumasite	$\text{CaSiO}_3 \cdot \text{CaSO}_4 \cdot \text{CaCO}_3 \cdot$ $15.2\text{H}_2\text{O}$	1734, 2039, 2347, 3108, 3518
Thenardite	Na_2SO_4	152, 358, 623, 759, 3518
Thomsonite	$\text{Na}_4\text{Ca}_3\text{Al}_{20}\text{O}_{80} \cdot 24\text{H}_2\text{O} (?)$	224, 1135, 3518, 3910
Thorite	ThSiO_4	1097, 3360, 3518, 3858
Thorogummite	$\text{Th}(\text{SiO}_4)_{1-z}(\text{OH})_{4z}$	1097
Thuringite	See Chlorite.	135, 329, 1608, 1860, 3518, 3575
Tikhvinit	See Sokolovite	3121
Tincalconite	$\text{Na}_2\text{O} \cdot 2\text{B}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$	2034
Titanite	CaTiSiO_5	3518
Titanomagnetite	— — —	2948
Tobermorite	$5\text{CaO} \cdot 6\text{SiO}_2 \cdot 5\text{H}_2\text{O} (?)$	1210, 1347, 1796, 2144, 2740, 3210, 3294, 3421, 3883
Todorokite	Hydrous Mn oxide	3112, 3190, 3302, 3604
Topaz	$\text{Al}_2(\text{OH}, \text{F})\text{SiO}_4$	3518
Torbernite	$\text{CuO} \cdot 2\text{UO}_3 \cdot \text{P}_2\text{O}_5 \cdot 12\text{H}_2\text{O}$	2753, 3082
Tourmaline	$\text{M}_7\text{B}_2\text{Al}_2(\text{AlSi}_2\text{O}_9)_3\text{-}$ $(\text{O}, \text{OH}, \text{F})_4$	651, 658, 1138, 2498, 2956, 3082, 3518
*Tridymite	SiO_2	1141, 1522, 1795, 2088, 2102, 2263, 2450
Triphylite	$\text{Li}(\text{Fe}, \text{Mn})\text{PO}_4$	651
Triplite	$3\text{MnO} \cdot \text{P}_2\text{O}_5 \cdot \text{MnF}_2$	3082
Trona	$\text{HNa}_3(\text{CO}_3)_2 \cdot 2\text{H}_2\text{O}$	609
Tschermite	$\text{NH}_4\text{Al}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$	873
Tunellite	$\text{SrO} \cdot 3\text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O}$	3458

ALPHABETICAL REFERENCE LIST OF MATERIALS STUDIED BY DTA 617

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Tungstenite	WS ₂	3404
Tuff	Volcanic ash	2879, 3286, 3413
Turquoise	CuAl ₆ (OH) ₂ (PO ₄) ₄ ·4H ₂ O	670, 3426, 3518, 3736
Tyrolite	5CuO·As ₂ O ₅ ·9H ₂ O	3518
Tysonite	(Ce,La,Dy)F ₃	609
Ufertite	U,Fe,Th,Ti oxide	3573
Ulexite	NaCaB ₅ O ₉ ·8H ₂ O	358, 2034, 2800
Uralborite	CaB ₂ O ₄ ·2H ₂ O	3573
Uramphite	(NH ₄ UO ₂)PO ₄ ·3H ₂ O	2229, 2558
Uraninite	UO ₂ , may contain Pb,Th,Zr	609, 651, 780, 2753
Uranophane	CaO·2UO ₂ ·2SiO ₂ ·6H ₂ O	2154, 2753, 3442
Uranothallite	Ca ₂ U(CO ₃) ₄ ·10H ₂ O	651
Urgite	U-mineral	3482
Ussingite	2Na ₂ O·Al ₂ O ₃ ·6SiO ₂ ·H ₂ O	3518
Vanalite	4Al ₂ O ₃ ·5V ₂ O ₅ ·Na ₂ O·30H ₂ O	3734
Vanthoffite	Na ₆ Mg(SO ₄) ₄	358
Vanuxemite	Mixture, hemimorphite and halloysite (?)	746
Variscite	(Al,Fe)PO ₄ ·2H ₂ O	670, 3134, 3518, 4005
*Vermiculite	(Mg,Fe) ₄ (OH) ₄ Si ₄ O ₁₀ ·4H ₂ O + (Mg,Fe) ₃ (Al,Fe)· (OH) ₂ Si ₃ AlO ₁₀ ·4H ₂ O	470, 523, 703, 843, 1090, 1118, 2372, 2826, 3212, 3277
Vesuvianite	Ca ₂ Al ₂ (OH,F)Si ₂ O ₇	1378, 3173, 3616
Vivianite	Fe ₃ P ₂ O ₈ ·8H ₂ O	670, 1647, 2340, 3518, 3565, 3736
Volcanic ash	Zeolitic glasses + ?	1047
Volcanic glass	— — —	2564
Volkonskoite	Cr nontronite	288, 1444, 3518, 3756
Wagnerite	Mg ₂ FPO ₄	651
Wardite	Na ₄ CaAl ₁₂ (OH) ₁₈ (PO ₄) ₈ · 6H ₂ O	670
Wavellite	Al ₆ (F,OH) ₆ (PO ₄) ₄ ·9H ₂ O	651, 670, 3082, 3518, 3736, 4005
Whewellite	CaC ₂ O ₄ ·H ₂ O	1597
Wiikite	See euxenite	3393, 3463
Willemite	ZnSiO ₄	3518
Witherite	BaCO ₃	52, 74, 440, 643, 651, 1110, 1883, 3518
Wolframite	(Fe,Mn)O·WO ₃	3518
Wollastonite	CaSiO ₃	2333, 3518, 4080
Wulfenite	PbO·MoO ₃	3518, 3767
Wyartite	3CaO·UO ₂ ·6UO ₃ ·2CO ₂ · 12-14H ₂ O	2793
Xonotlite	Ca ₃ Si ₃ O ₈ (OH) ₂	1881, 2614, 2740, 2985, 2986, 3033, 3421, 3518
Xylotile	See Sepiolite.	478
Yoderite	Hydrous Mg-Fe aluminosilicate	2863

<i>Material</i>	<i>Composition</i>	<i>Reference</i>
Yttrialite	$(Y,Ce,Th,Ca,Mn)_2(Si_2O_7)$	3919
Zanthosiderite	Hydrated iron oxide	126
Zermatite	Serpentine mineral	279
Zincian dolomite	— — —	2131, 3018
Zinciferous berthierine	Phyllite type	1782
Zinciferous phyllite	Phyllite type	1782
Zincite	ZnO	3518
Zincsilite	$Zn_3Si_4O_{10}(OH)_2 \cdot nH_2O$	3293
Zinkenite	$PbS \cdot Sb_2S_3$	3866
Zinnwaldite	Trioctahedral mica	1252, 1883, 3518
Zircon	$ZrSiO_4$	930, 1097, 1165, 3285, 3518
Zirconolite	$CaZrTi_2O_7$	1748, 3065
Zirkelite	$(Ce,Fe,Ca)O \cdot 2(Zr,Ti,Th)O_2$	3518
Zoisite	$5CaO \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot H_2O$	3518
Zunyite	$Al_{13}Si_5O_{20}(OH,F,Cl)_{19}$	1001

Author Index

- Abrams, S. T., 40, 47, 65, 76, 146, 153, 178
 Adams, E. T., 23
 Adams, L. H., 29, 31
 Adams, M., 188
 Adomaviciute, B., 192
 Agafonoff, V., 11, 151, 161
 Agarwala, R. P., 142
 Aguilera, N., 164
 Aharoni, A., 206
 Albareda, J. M., 172
 Aleixandre, V., 198
 Allaway, W. H., 51, 65, 77, 78
 Allgeuer, K., 168
 Allison, E. B., 121, 134, 136, 143
 Amero, R. C., 172
 Anderson, A. E., 204
 Anderson, D. A., 157, 183, 186
 Andreeva, E. P., 190
 Andrews, A. I., 199
 Andrianov, K. A., 186
 Anikin, A. G., 19
 Anosov, V. Ya., 151
 Ao, T., 75
 Apel, K., 40
 Arens, P. L., 14, 16, 17, 19, 21, 47, 49, 50,
 51, 55, 56, 59, 60, 62, 69, 70, 72, 75, 78,
 119, 146, 149
 Ariizumi, A., 189
 Arndt, R. A., 36
 Arutyunova, L. B., 179
 Ashley, H. E., 4
 Audrieth, L., 65, 85, 86, 87
 Avetikov, V. G., 35
 Ayres, W. M., 89

 Baiburt, L., 197
 Baikov, A. A., 40
 Bailey, D. R., 22, 179
 Bailly, F. H., 207
 Bair, G. B., 195
 Baker, O. J., 160
 Balint, J., 164
 Ball, J. G., 23
 Bandi, W. R., 200

 Barrall, E. M., 148, 150, 180
 Barrett, L. R., 56
 Barshad, I., 15, 48, 66, 68, 77, 78, 129,
 132, 133, 148, 152, 163
 Basden, K. S., 160, 169
 Bates, T. F., 85, 86, 152, 158
 Bayliss, P., 58, 59, 60
 Beck, C. W., 17, 27, 76, 85, 86, 125, 129
 Beck, L. R., 185
 Behar, M. F., 5, 8
 Bellot, J., 31
 van Bemst, A., 189, 193
 Bens, E. M., 89
 Benson, D., 160
 Benton, E. V., 189
 Beranek, M., 59
 Bereczky, A., 191
 Berg, L. G., 24, 29, 35, 48, 60, 65, 68, 74,
 76, 89, 124, 131, 145, 147, 151, 167, 170
 Berg, P. W., 52
 Bergeron, C. G., 64
 Berkelhamer, L. H., 13, 22, 23, 64, 124,
 143, 152
 Berkenblit, M., 18, 175
 Berman, R., 36, 177
 Betreimeux, R., 162
 Bhattacharyya, S. K., 172
 Bhaumik, M. L., 183
 Bhide, V. G., 206
 Bibb, A. E., 33
 Bidet, J. P., 81
 Bielanski, A., 88
 Bishui, B. M., 79
 Bittrich, H. J., 34
 Blum, S. L., 205
 Blumberg, A. A., 142
 Boersma, S. L., 125, 136, 137, 150, 197
 Bogomolov, B. N., 204
 Bohon, R. L., 30
 Boksha, S. S., 30
 Bolgiu, O., 31, 66, 204
 Bollin, E. M., 14, 19
 Bonetti, G., 197
 Boor, J., 187

- Borchardt, H. J., 20, 62, 141, 142, 143, 148, 170, 176, 197
Borisov, V. M., 168
Borisova, L. A., 145
Boryta, D. A., 62, 171
Boyer, A. F., 201
Bozhenov, P. I., 188
Bradley, W. F., 78, 200
Bramao, L., 57, 145, 163
Brasseur, P., 168, 181
Breger, I. A., 22, 31, 49, 59, 65, 68, 159, 160
Brewer, L., 28
Brindley, G. W., 51, 82, 84
Broukal, J., 196
Brown, G. P., 180
Brown, R. N., 155
de Bruijn, C. M., 58, 132, 134
Budnikov, P. P., 28, 35, 81, 88, 188, 189, 191, 204
Buehrer, T. F., 163
Burgess, G. K., 1, 5
Burmistrova, N. P., 35, 170
Bussen, I. V., 159
Bussiere, P., 89
Butt, Yu. M., 189
Butuzov, V. P., 30

Caillere, S., 26, 52, 56, 70, 74, 75, 76, 77, 80, 85, 86, 162, 171
Callendar, H. L., 1
Calvet, E., 36, 174
Campbell, C., 24, 27, 128, 175
Campbell, P. F., 177
Cap, M., 195
Carpenter, H. C., 1, 5
Carroll, B., 141
Carthew, A. R., 64, 79, 144
Chalder, G. H., 176
Chamberlin, M. M., 171
Champetier, G., 168, 181
Chang, Ta. Yu., 173
Charles, R. G., 45, 85
Charuel, R., 36
Chesters, G., 164, 179, 182
Chiang, Y., 33, 182
Chiu, J., 17, 22, 180
Chopra, S. K., 193
Clampitt, B. H., 182
Clark, G. L., 40, 129
Claussen, W. F., 89
Clegg, K. E., 59
Cobb, J. W., 46, 86, 89

Cohn, W. M., 128
Cole, W. F., 64, 84, 189, 202, 205
Constantinides, G., 178
Costa, D., 181
Costa, G., 181
Crandall, W. B., 199
Crook, D. N., 205
Crowley, M. S., 81
Cunningham, R. L., 26
Cuthbert, J. L., 47

Damle, R. V., 206
Daniels, F., 31, 33, 62, 141, 142, 143, 156, 197
Dannis, M. L., 185
Das Gupta, I. H., 198
David, D. J., 128
Davies, B., 166
Davison, S., 198
Dean, L. A., 57, 124, 162
Deason, W. R., 168
Deeg, E., 130
Demediuk, T., 84
Dempster, T. B., 144, 201
DeMumbrum, L. E., 165
Dhenkne, B., 81
Dias, J. C. Soveral, 164
Dietzel, A., 81
Dilling, E. D., 26
Dobovisek, E., 200
Drain, J., 198
Drinkard, W. C., 186
Duchene, J., 174
Dumitrescu, A., 66, 204
Durand, R., 176
Dusenbury, J. H., 180

Eades, J. L., 165
Earley, J. W., 13, 22, 23, 49
Eberlin, E. C., 184
Eckert, F., 194
Edelman, D., 127, 128
Efendiev, R. M., 173
Efremov, N. E., 50
Egorov, B. N., 170
Eichlin, C. G., 194
Eisenwein, P., 188
Eitel, W., 36, 203
Ellis, B. G., 148
Erdey, L., 87, 169
Eriksson, E., 149
Esin, O. A., 74
Evdokimov, V., 168

- Everhart, J. O., 201
 Ewell, R. H., 81
 Eyraud, L., 36, 41, 130, 206

 Fadeeva, V. S., 86
 Fahn, R., 79
 Fairchild, C. O., 9
 Fang, P. H., 206
 Farmer, V. C., 97, 120
 Farquharson, K., 49
 Faust, G. T., 87, 91, 92, 152
 Fauth, M. I., 179
 Favjee, J. C., 56
 Feldman, R. F., 193
 Fenner, C. N., 9
 Feodotev, K. N., 203
 Fieldes, M., 143, 144, 163
 Filonenko, N. E., 20
 Finch, L. G., 24
 Fischer, H. C., 188
 Flaschen, S. S., 36
 Florke, O. W., 203
 Fojtik, L., 26
 Foldvari-Vogl, M., 51
 Franciosi, O., 147
 Franzen, P., 80
 Frederickson, A. F., 42, 126
 Freeman, E. S., 127, 128, 141, 157, 175, 183
 Freuh, A. J., 85, 88, 155
 Frondel, C., 156
 Fujita, F. E., 36

 Gad, G. M., 56, 202
 Gaines, A. F., 161
 Gal, S., 169
 Gaman, V. I., 195
 Gamel, C. M., 129, 132
 Ganelina, S. G., 48, 68
 Garbuzov, A. I., 50
 Garn, P. D., 15, 36, 87, 89
 Gaskell, J. A., 153
 Gasson, D. B., 199
 Gatzke, H., 35
 Geffcken, W., 197
 Gerard-Hirne, J., 15, 23, 27, 47, 51
 Gheith, M. A., 88
 Gibson, R. E., 29
 Giedroyc, V., 33, 74
 Gilford, M., 179
 Gita, Gh., 67
 Glass, H. D., 58, 82, 83, 159, 160
 Goldich, S. S., 209

 Goranson, R. W., 29
 Gorbunov, N. I., 165
 Gorbunova, Z. N., 166
 Gordeev, V. I., 204
 Gordon, S., 22, 27, 170, 175, 179
 Gorshtein, M. G., 168
 Goton, R., 28, 208
 Gottardi, V., 197
 Govorov, A. A., 87, 191
 Graf, D. L., 60
 Grankovskii, I. G., 87
 Granquist, W. T., 172
 Gray, T. J., 84
 Greene, A. F., 171
 Greene, F. T., 28
 Greene, K. T., 192
 Greene-Kelly, R., 77
 Gregorio, E., 195
 Greig, J. W., 18
 Grigor'ev, A. T., 198
 Grim, R. E., 10, 14, 56, 75, 78, 132, 143, 165, 167, 200, 201, 204
 Grimshaw, R. W., 13, 22, 49, 50, 56, 58, 124, 132, 152
 Gruver, R. M., 13, 48, 74, 86, 143, 145
 Guillot, M., 205
 Gusev, V. V., 204

 Haddock, J. I., 162
 Haendler, H. M., 167
 Haighton, A. J., 179
 Halot, D., 205
 Hamilton, P. K., 90
 Hammel, L., 30, 32, 34, 35
 Hannay, J. B., 1
 Hannewijk, J., 179
 Harden, J. C., 29, 180, 208
 Harker, R. I., 31
 Harrison, T. R., 9
 Harvey, A. E., 50
 Hattiangdi, G. S., 153
 Hattori, T., 165
 Haul, R. A., 60, 168
 Hauser, E. A., 85, 89
 Hayashi, H., 202
 Hedvall, J. A., 48, 152
 Hegedus, A. J., 199
 Hendricks, S. B., 36, 77, 162
 Henin, S., 26, 52, 56, 70, 74, 76, 77, 80, 85, 86, 162
 Henry, E. C., 50
 Herold, P. G., 14
 Heumann, Th., 198

- Heystek, H., 60, 129, 164, 202
Hill, J. A., 186, 200
Hill, R. D., 201
Hill, V. G., 43, 203
Hinz, W., 197
Hiraro, K., 199
Hirst, R. G., 198
Hoffmann, F., 6
Hofmann, U., 131
Hogan, V. D., 22, 170, 175
Holdcroft, A. D., 128
Holland, H. D., 156
Honeyborne, D. B., 203
Horte, C. H., 83
Hosking, J. S., 164
Houldsworth, H. S., 46, 86, 89
Hummel, F. A., 76
- Imota, F., 199
Inone, M., 182
Insley, H., 82, 195
Ippolitova, E. A., 176
Irie, M., 173
Iskhakov, Kh. A., 160
Ito, F., 199
Ito, Y., 201
Ivanova, V. P., 56, 65, 86, 159
Iwasaki, A., 206
- Jaeger, F. M., 14
Jaffe, H. H., 87, 176
Jaffray, J., 29, 42, 50, 86
Jakobi, R., 156
Jayaraman, A., 30
Jeffries, C. D., 58, 128
Johns, W. D., 10, 14, 201
Johnson, J. R., 176
Jonas, E. C., 17, 33, 61, 85
de Jong, G., 149
Jonich, M. J., 22, 179
Jouenne, C. A., 81
- Kahler, F. v., 168
Kalnen, N. S., 60
Kalousek, G. L., 75, 188, 189
Kamel, A. M., 64
Kanda, F. A., 27
Kantzer, M., 25, 204
Kanwar, J. S., 166
Kapustinskii, A. F., 170
Karsulin, M., 80
Kataeva, G. V., 196
Kato, C., 29, 42, 81
- Kato, E., 155
Kaufman, A. J., 26, 75, 157, 167
Kawaguchi, K., 165
Kazakov, A. V., 158
Ke, B., 19, 182, 183, 184, 187
Keavney, J. J., 184
Keeling, B. F., 1, 5
Keenan, A. G., 174
Keith, M. L., 66, 152, 158
Keler, E. K., 34
Keller, W. D., 84
Kelley, D. G., 160, 162
Kelly, W. C., 56
Kennedy, G. C., 30
Kerr, P. F., 13, 14, 19, 23, 26, 27, 55, 90, 205
Kessler, J. E., 89
de Keyser, W. L., 1, 58, 87, 88, 168, 188
Kiefer, C., 55
King, L. H., 160
Kissinger, H. E., 48, 58, 138, 140, 141, 187
Kitazaki, U., 158
Kiyoura, R., 176, 201
Kleber, W., 88
Kliburszky, B., 51
van Klooster, H. S., 14
Klug, H. P., 167
Klute, C. H., 183
Kobzenke, G. F., 28
Kocherzhinskii, U. A., 28
Kocik, J., 196
Kodama, S., 172
Koehler, E., 35
Kolar, D., 177
Kononova, V. A., 157
Kopp, O. C., 205
Korab, O., 24
Kornilov, N. A., 56
Kracek, F. C., 10, 14, 18, 29, 76, 131
Krasil'nikova, L., 195, 196
Kravchenko, I. V., 189
Krawetz, A. A., 171
Kroger, C., 196
Kronig, R., 94
Kroone, B., 189
Krotov, I. V., 198
Kruger, J. E., 193
Kuhne, K., 196, 198
Kulbicki, G., 204
Kulp, J., 13, 23, 26, 27, 55, 78, 90, 132, 143, 156, 158
Kumanin, K. G., 41, 60
Kurabayshi, S., 164

- Kurath, S. F., 156
 Kurczyk, H. G., 192
 Kurdowski, W., 195
 Kurnakov, N. S., 2, 8, 10
 Kutsev, V. S., 20
 Kuznetsov, A. K., 34

 Lakin, J. R., 204
 Lal, K., 193
 Lambert, A., 17
 Lambert, M., 157
 Lamy, C., 15, 23, 47, 51
 Lapham, D. M., 202
 Lavery, H., 179
 Lavrov, I. V., 20
 Lawrence, W. G., 52
 Laws, W. D., 54
 LeBeau, D. S., 85
 Lebedew, I. W., 83
 LeChatelier, H., 1, 2, 3, 6
 LeFloch, G., 88
 Lehmann, H., 25, 27, 35, 44, 79, 193
 Leonard, G. W., 21, 179, 182, 207
 LePage, M., 174
 Levin, E. M., 19
 Levina, S. S., 42, 206
 Levy, C., 156
 Lewis, D. R., 65, 153
 Lindner, R., 167
 Linseis, M., 31, 50
 Lloyd, S. J., 31
 Locardi, B., 197
 Locke, C. E., 173
 Lodding, W., 20, 30, 32, 35
 Lomas, T. W., 24
 Low, M. J., 64
 Lui, C. K., 85, 155
 Lynch, E. D., 206

 McConnel, D., 13, 22, 23, 49
 McDowall, I. C., 143, 144, 203
 McLaren, A. C., 155
 McLaughlin, R. J., 56, 57, 58, 76
 McMurdie, H. F., 19

 MacGee, A. E., 34, 128
 Mackenzie, R. C., 49, 79, 97, 120, 124,
 148, 163
 Majumdar, A. J., 201
 Manucharova, I. F., 186
 Mardon, P. G., 32, 87
 van der Marel, H. W., 58, 131, 132, 134,
 145

 Margotin, P., 176
 Markowitz, M. M., 62, 171
 Martin, J. L., 80
 Martin, R. T., 164
 Masui, J., 163
 Mateev, M. A., 196
 Matejka, J., 11, 161
 Matsui, M., 40
 Matsusaka, Y., 166
 Mazieres, C., 19, 34
 Mchedlov-Petrosyan, O. P., 27, 190
 Meisel, A., 174
 Mellor, J. W., 4, 128
 Meneret, J., 27
 van der Merwe, C. R., 164
 Metzner, K., 34
 Midgley, H. G., 158, 192
 Milne, A., 77
 Mishin, V. P., 50
 Mitchell, B. D., 161
 Mitchell, J. C., 187
 Mitchell, L., 50
 Moore, D. G., 188
 Moorehead, F. F., 31, 33, 56
 Morikawa, K., 174
 Morita, H., 52, 178, 181, 182
 Moriya, T., 196
 Mortland, M. M., 148
 Mui, D., 188
 Murakami, K., 189, 190
 Murphy, C. B., 89, 183, 186
 Murray, H. H., 202
 Murray, J. A., 188
 Murray, J. R., 31
 Murray, P., 48, 121, 137, 138, 141

 Nagasawa, K., 140, 158
 Nagy, B., 86, 158
 Nagy, R., 85, 155
 Nalk, M. C., 142
 Nakahira, M., 84
 Nakamura, Y., 186
 Nathans, M. W., 171
 Nazarov, V. I., 181
 Nebrensky, J., 196
 Nechitailo, N. A., 182
 Neuroth, N., 197
 Newman, S. B., 187
 Ney, P., 168
 Nikogosyan, K. S., 192
 Noack, H., 88
 Noddack, W., 156
 Norin, R., 83, 152

- Norton, F. H., 13, 22, 52, 124, 125, 149, 151, 203
 Nozaki, F., 174
- Oates, W. A., 200
 Ohira, N., 159
 Olcina, P. V., 206
 Olympia, F. C., 199
 O'Neill, M. J., 71
 Onikura, Y., 165
 Orcel, J., 10, 13, 31, 57, 75, 76, 156
 Ormsby, W. C., 81
 Ossaka, J., 144, 145
 Osterheld, R. K., 65, 85, 86, 87
 Otsubo, Y., 81, 206
- Paciorek, K. L., 187
 Page, J. B., 54, 162
 Pakulak, J. M., 21, 179, 182, 207
 Papailhau, J., 18
 Parker, C. J., 36
 Parkert, C. W., 55
 Partington, R. G., 161
 Partridge, E. P., 14, 44, 65, 76, 85, 86
 Pask, J. A., 16, 27, 166
 Patel, C. C., 19
 Paulik, F., 207, 228
 Paulin, A., 200
 Pavel, L., 26
 Pavlovitch, S., 11, 161
 Payne, R. M., 9
 Pearce, J. H., 32, 87
 Peco, G., 15
 Penther, C. J., 23, 25, 43, 45
 Pepler, R. B., 189
 Perel'man, A. I., 165
 Perkins, A. T., 54, 201
 Phipps, L. W., 24
 Piottukh, Yu. N., 161
 Planje, T. J., 14
 Pobeguín, T., 171
 Pole, G. R., 188
 Pompeo, D. J., 25
 Pospisil, Z., 59, 153
 Poulos, N. E., 199
 Powell, D. A., 87
 Prasad, N. S., 19, 142
 Predel, B., 198
 Preining, O., 132
 Primak, W., 157
 Prod'homme, M., 195, 197
 Proks, I., 24
 Protzenko, P. I., 171
- Pucci, J. R., 167
- Quasebart, K., 194
 Quetier, M., 157
- Rabatin, J. G., 63
 Ramachandran, V. S., 79, 172, 201
 Ramsay, W., 1
 Rao, C. N. R., 155
 Rappeneau, J., 157
 Rase, D. E., 27
 Rase, H. F., 173
 Rashkovich, L. N., 189
 Rassonskaya, I. S., 29, 60
 Rathousky, B., 30
 Ravich, G. B., 19, 170
 Reed, L., 87, 140, 141, 142
 Reisman, A., 18, 35, 63, 87, 175
 Rice, A. P., 52
 Rice, H., 178, 181
 Ritchie, P. D., 144, 201
 Robbins, C. R., 206
 Roberts, A. L., 51, 58, 132
 Roberts-Austen, W. C., 1, 2, 3, 5
 Robertson, R. H., 202
 Rode, E. Ya., 176
 Rogers, B. N., 34, 148, 150, 175, 180
 Rojas-Cruz, L. A., 163
 Romo, P. C., 206
 Rosenhain, W., 24
 Rosenthal, G., 205
 Ross, C. S., 162
 Rothe, R., 6
 Rowland, N. M., 64
 Rowland, R. A., 17, 33, 47, 56, 61, 65, 85, 125, 129, 132, 153
 Roy, R., 27, 30, 43, 80, 83, 86, 159, 203
 Rudin, A., 186
 Russel, M. B., 129, 132, 162
- Saalfeld, H., 81
 Sabatier, G., 66, 132, 134, 152, 168, 203
 Sakka, S., 197
 Saladin, E., 1, 6
 Samoilov, Ya. V., 41, 46, 73
 Sand, L. B., 81, 152
 Satoh, S., 50
 Saunders, H. L., 33, 74
 Schafer, G. M., 129, 132
 Schedling, J. B., 202
 Schmidt, E. R., 56, 205
 Schreiber, H. P., 169
 Schwenker, R. F., 180, 185

- Schwiete, H. E., 150, 192
 Schwob, Y., 33, 74
 Scott, N. D., 185
 Sedletskii, I. D., 161
 Segawa, K., 10
 Sersale, R., 195
 Setinek, K., 30
 Sewell, E. C., 138
 Shaver, R. C., 27
 Shchetkina, E. D., 158
 Sheeler, J. B., 79
 Sherman, G. D., 166
 Shibuya, I. G., 159
 Shnaid, H., 122
 Shurygina, E. A., 166
 Siffert, B., 81
 Silvent, J. A., 170
 Siske, V., 24
 Skatulla, W., 196
 Skinner, K. G., 28
 Slaughter, M., 84
 Smirnova, S. I., 159
 Smith, C. S., 14, 41, 134
 Smothers, W. J., 33, 62, 77, 129, 132, 182
 Smyth, F. H., 29, 31
 Smyth, H. T., 43, 44, 121, 129, 150
 Snoodijk, F., 94
 Sologubova, O. M., 188
 Solow, G., 197
 Soule, J. L., 94, 98
 Soveri, U., 75
 Speil, S., 42, 46, 52, 53, 54, 74, 90, 95, 97,
 129, 146
 Speros, D. M., 129
 Spinedi, P., 147
 Sprague, R. S., 40, 129
 Stansfield, A., 1
 Starostina, V. G., 203
 Stefanovits, P., 165
 Stegmuller, L., 14, 168
 Stoch, L., 195
 Stone, R. L., 30, 33, 52, 60, 65, 148, 173,
 207
 Stott, J. B., 160
 Stratmann, J., 196
 Strella, S., 184, 185
 Streubel, P., 174
 Stross, F. H., 40, 47, 65, 76, 146, 153,
 178
 Stubican, V., 80
 Sturm, E., 20, 137
 Sudo, T., 57, 86, 144, 145, 202
 Suito, E., 201
 Suvorova, G. F., 188
 Sykes, C., 41, 128
 Syromyatnikov, F. V., 10
 Talibudeen, O., 68, 78, 87
 Taylor, T. I., 167
 Teitel'baum, B. Ya., 35
 Theron, J. J., 26
 Thomasson, C. V., 196
 Thompson, B. A., 170
 Thompson, S. O., 182
 Tiemstra, P. J., 179
 Todd, D. D., 200
 Tool, A. Q., 10, 194, 195, 197
 Torklar, K., 151
 Tovmas'yan, I. K., 167
 Tovrog, T., 171
 Trambouze, Y., 172, 173
 Traynard, Ph., 36
 Treiber, J., 164
 Tresvyatskii, S. G., 28
 Trites, A. F., 55, 132, 143, 158
 Tsang, N. F., 90
 Tscheischwili, L., 89
 Tsuchiya, T., 164
 Tsuzuki, Y., 140, 142
 Tsvetkov, A. I., 52
 Tupper, W., 160
 Tuttle, O. F., 66, 152, 158
 Tykachinskii, I. D., 196
 Urusov, V. V., 31
 Valasek, J., 194
 Valussi, S., 178
 Van Der Beck, R., 201
 Vanis, M., 24
 Vassallo, D. A., 29, 180, 208
 Vaughan, F., 141
 Velya, V. V., 197
 Venderovich, A. M., 196
 Vermaas, F. H., 56, 205
 Viehmann, W., 183
 Viloteau, J., 86
 Vital, D. A., 68
 Vold, M. J., 76, 91, 94, 95, 121, 134, 148,
 153, 177
 Vold, R., 153
 Voldan, J., 88
 Vol'fkovich, S. I., 29, 31, 42
 Vol'nova, V. A., 29, 34, 48
 Voorthuijsen, J., 80
 Vose, W., 143, 144, 203

- Waldman, M. H., 169
Walker, G. F., 77
Walker, R. F., 203
van der Walt, C. F., 189
Walton, J. D., 59, 199
Warburton, R. S., 196
Warne, S. J., 59, 60
Warner, M. F., 16, 27
Watanabe, T., 155
Weaver, C. E., 80
Webb, T. L., 27, 149, 189
Weber, R. L., 9
Wein, J. B., 202
Weingarten, G., 175
Weiss, J., 52
Weltner, M., 160
Wendlandt, W. W., 23, 26, 33, 35, 36, 141, 180
West, R. R., 84, 199, 201, 202, 204, 205
Westermann, I., 194
Wever, F., 40
Wey, R., 81
White, J., 48, 137, 138, 141, 198
White, J. L., 79
White, T. R., 182
White, W. P., 9
Whitehead, W. L., 22, 31, 49, 59, 65, 68, 159, 160
Wiegmann, J., 83
Wilburn, F. W., 196
Williams, D., 24
Wittels, M., 125, 132, 133, 146
Wohlin, R., 4
Wood, E. A., 198
Woodhouse, R. I., 130
Yagashita, H., 159
Yagfarov, M. Sh., 24, 148, 154
Yamaguchi, K., 206
Yanat'eva, O. K., 76
Yee, T. B., 199
Yoder, H. W., 29
Young, J. F., 193
Yurevich, A. L., 159
Yusupova, S. M., 80
Zakharov, M. V., 61
Zavitsanos, P., 28
Ziegler, G., 150
Zin'ko, E. I., 35
Zul'fugarov, Z. G., 174

Subject Index

A

- Activation energy, 48, 77, 120, 138, 140–143
Admixtures, 73, 75
Akermanite, 195
Allophane, 3, 165, 189
Alumina, 41, 42, 50, 166
 hydrated, 1, 3, 41, 73, 130
Aluminum bronze, 61
Aluminum orthophosphate, 76
Aluminum sulfate, 173
Ammonium chloride, 171
Ammonium heptafluorozirconate, 167
Ammonium nitrate, 35, 42, 66, 155, 174, 175
Ammonium perchlorate, 157
Anauxite, 74
Andalusite, 18
Anthracene, 22
Anthracite, 160
Antigorite, 56, 80, 85
Aragonite, 73, 86, 87, 190
Arsenic oxide, 168
Asbestos, 10
ASTM specification, 37
Asymmetric peak, 45, 58, 140, 141, 145
Asymptotic reaction temperature, 69–71
Atactic polypropylene, 185, 187
Atmosphere, 87
 controlled, 18, 24, 29–33, 60, 65, 129, 153
 flowing, 32–35, 60, 65, 148, 169, 177, 207
 superheated steam, 35, 160
 water vapor, 60, 65
Attapulgite, 42, 74, 172
- ## B
- Barium nitrate, 170
Barium oxide, 19
Barium titanate, 205, 206
Base line deviation, 15, 17, 49, 50, 59, 124, 128, 150, 184
Bauxite, 3, 86, 167, 209
- Beidellite, 163
Bentonite, 54, 55, 79, 81, 172, 174
Benzene diazonium chloride, 141
Benzoic acid, 52, 65, 131, 178
Beryllium oxyacetate, 155
Betafite, 156
Bidifferential thermal analysis, 51
Bornite, 85, 88, 155
Brick, 14, 201, 204
Brucite, 134
- ## C
- Cadmium hydroxide, 64
Cadmium selenide, 18, 175
Calcite, 46, 58, 73, 74, 78, 86, 87, 132, 142, 164, 189
Calcium aluminate, 75
Calcium aluminate hydrate, 188
Calcium carbonate, 40, 55, 130, 133, 149
Calcium hydroxide, 149, 188
Calcium oxalate, 127
Calcium oxalate monohydrate, 141
Calcium silicate, 189
Calcium sulfite, 190
Calibration curve, 45, 94, 129, 132
Calibration of apparatus, 131–134, 137, 150
Calorimeter, 36, 43, 130, 174
Carbon black, 169
Catalysis, 172, 207
Cellulose, 181, 182
Cement, 12, 75, 168, 187–189, 191, 204
 aluminous, 189
 magnesia, 193
Ceramics, 9, 200
Cerium nitrate, 177
Cermets, 199
Cerous oxalate, 142
Cesium, 30
Cetane, 47, 76
Chalcedony, 158
Chemical analysis, 86, 145
Chlorite, 31, 56, 202
Chrome ore, 129

- Chromic oxide, 86, 88, 172
 Clays
 calcined, 50
 calculated curves, 140
 dehydration, 121, 134, 204, 205
 digested, 204
 endothermic peaks, 64
 heating curves, 2, 3
 impure, 75
 landslide, 159
 mixtures, 75, 76
 organic complexes, 78, 79
 physical characteristics, 149
 rehydrated, 79
 synthesis, 80, 81
 treated, 74, 78, 79
 water-vapor pressure, 60
 Coal, 12, 129, 132, 159-161
 Cobalt, 172, 173, 198
 Cobalt ferrite, 205
 Cocoa fat, 179
 Combined tests, 34
 Comparison of DTA results, 49, 68-71, 152
 Conduction theory, 95, 98, 101, 102, 119
 Cooling curves, 41, 50, 175, 179
 Cooling rate, 23-25
 Copper sulfate, 167
 Cosmetics, 180
 Cristobalite, 18, 152, 153, 203
 Crucibles, 13, 17, 151
 platinum, 13, 14, 34
 tantalum, 32
 Crystallinity
 antigorite, 56
 calcite, 58
 cement, 189, 192
 fire clay, 56, 143
 halloysite, 143, 163, 202
 hydrous iron oxide, 56
 kaolinite, 52, 54, 56, 57, 86, 143, 145, 163, 202
 nylon yarn, 182
 polymers, 183, 184
 quartz, 158
 Crystallization rate, 187
 Curie point, 205, 206
 Curing of resins, 186, 187
- D**
- Dehydration peaks, 58, 63, 69, 77, 79, 81, 121, 151
 Derivative thermal analysis, 26, 126, 128
- Derived differential thermal curve, 42
 Diamond, 157
 Diaspore, 134, 151
 Dicalcium phosphate, 31
 Dicalcium silicate, 30, 189, 192
 Dickite, 55, 56, 57
 Dielectric constant, 88
 Differential calorimeter, 36
 Differential enthalpy analysis, 130
 Differential thermocouple methods, 5
 Differential thermogravimetry, 1
 Dilatometry, 35, 86, 121, 131, 155, 160, 188, 203
 Diluents, 52, 132, 133, 150, 180, 182
 alumina, 52, 58, 60, 68, 134, 178, 180, 186
 graphite, 41, 130, 208
 magnesia, 68
 silicon carbide, 148, 180
 silver, 46
 Dimethylaniline, 141
 Dinitrotoluene, 168
 Diopside, 29
 Disordered structure, 57, 143, 145, 155, 156, 159, 182
 Dolomite, 33, 60, 65, 73, 74, 125, 145, 153
 Dotriacontane, 184
 Double differential thermal analysis, 51
 Drilling mud, 157, 158
 Dynamic difference calorimetry, 150
- E**
- EDTA, 180
 Effluent gas analysis, 219
 Electrical conductivity, 64, 88, 170, 191
 Electrical resistivity, 35, 155, 198
 Electrical tests, 88
 Ellsworthite, 156
 Emissivity, 5
 Endellite, 152
 Epoxides, 183
 Equilibrium constant, 167
 Ethyl alcohol, 172
 Ethyl iodide, 141
 Ettringite, 192, 193
 Exchange capacity, 79
 Exchangeable ions, 76, 79
 Explosive materials, 174
- F**
- Feldspar, 203
 Fergusonite, 156
 Ferric oxide, 55, 158

Ferroelectric transition, 206
 Ferromagnetic transition, 42, 206
 Figure of merit, 71
 Fire clay, 51, 56, 81, 86, 143
 First-order transition, 184, 185, 208
 Flint, 158
 Foundry sand, 198
 Frequency factor, 48, 120, 138, 141
 Furnaces, 22, 27
 constant gradient, 24
 electric, 22
 heat capacity, 22
 heating elements, 22, 31
 induction, 24, 28
 insulation, 22
 Kanthal, 32
 shielding, 22, 32
 vacuum, 22
 winding, 22, 32

G

Gadolinite, 156
 Gamma alumina, 82, 83, 143, 153, 167
 Gas analysis, 89
 Gas buret, 35
 Gehlenite, 195
 Gibbsite, 151
 Glass, 10, 64, 88, 193
 annealing, 194
 borosilicate, 195
 devitrification, 195–197
 fining, 196
 Glass transition, 184–187
 Glauconite, 72
 Glucosan, 178
 Glycerol, 168, 181
 Glycogens, 182
 Glyptal resins, 168, 181
 Goethite, 56, 132, 134
 Graphite, 41, 142, 157
 Gypsum, 75, 189, 191

H

Halloysite
 conditions for DTA of, 72, 146
 crystallinity, 202
 decomposition on heating, 137
 diluted, 162
 grain size, 144
 heating curve, 2
 impure, 145
 in soils, 163
 low-temperature peaks, 42

order of reaction, 143
 slope ratio of peak, 57, 58
 synthesized, 80
 Heat of fusion, 153
 Heat of polymerization, 183
 Heating rate, 23, 61, 63, 72, 73, 123, 146,
 147, 148, 150
 constant, 48
 control, 23, 24
 effect, 46–48, 179
 fast, 24, 48, 191
 linear, 23, 24, 26
 program control, 23
 slow, 24, 65
 Heat of reaction, 94, 129, 132, 134, 140,
 148, 170
 Heat of sorption, 169
 Heat of transformation, 132, 134, 137
 Heat of transition, 41, 128, 130, 153
 Hematite, 132
 High-pressure DTA, 29–32, 189, 191, 217
 High-temperature DTA, 27–31, 208
 Hillebrandite, 192
 Hydrargillite, 134
 Hydrates, 63
 Hydration number, 77

I

Illite, 42, 51, 70, 72, 73, 75, 80, 81, 162,
 164, 200
 Impurities, 145
 Infrared absorption, 89
 Infrared analysis, 157, 179, 186
 Indium antimonide, 30
 Indium telluride, 200
 Internal standards, 66, 67, 131
 Inverse-rate curves, 26
 Inversion temperature, 44, 69
 Iron, 89, 172
 Iron hydroxide, 34, 56, 73, 88, 143, 207
 Iron ore, 204
 Iron oxide, 172, 206
 Irradiated materials, 36, 177, 186

K

Kaolinite
 calculated curve, 137
 conditions for DTA of, 15, 46, 70, 146,
 147
 crystallinity, 56, 57, 202
 dehydration, 58, 70, 148, 153
 derivative curve, 126
 exothermic peak, 81–142, 153

- ground, 201
 heating curve, 3
 impure, 74, 75, 84, 144, 145
 in clay mixtures, 75, 76
 in soils, 162
 low-temperature peaks, 42
 order of reaction, 143
 packing, 59, 68, 149
 particle size, 52, 54, 55
 rehydrated, 81, 201
 slope ratio, 57, 145
 synthesis, 80, 81, 84
 thermal properties, 51
 treated, 74, 76, 79, 89
 Kurnakov pyrometer, 8, 27, 174
- L**
- Lard, 179
 Larnite, 195
 Latent heat, 41
 Lead, 65
 Lepidocrocite, 56, 166
 Lignin, 159
 Lignite, 12, 33
 Liquid nitrogen, 42, 48
 Lithium ferrite, 155
 Lithium fluoride, 156, 157
 Lithium perchlorate, 62
 Lithium silicate, 14
 Low-pressure equipment, 31
 Low-temperature DTA, 29, 34, 42, 48, 185
- M**
- Maghemite, 159, 166
 Magnesia, 50
 Magnesite, 30, 142, 148, 149
 Magnesium hydroxide, 129
 Magnesium pyrophosphate, 86
 Magnesium silicate, 173
 Magnetic tests, 88, 166, 206
 Magnetite, 56, 205
 Manganese oxide, 20
 Margarine, 179
 Merwinite, 195
 Metamict minerals, 156, 157
 Metallography, 1
 Metallurgy, 9
 Methyl alcohol, 34
 Mica, 159
 Microanalysis, 34, 68, 157, 208
 Microscopy, 86, 131, 158
 Modified cooling curve, 41
 Molecular weight, 187
- Molybdenum carbide, 208
 Molybdenum oxide, 199
 Montmorillonite
 asymptotic reaction temperature, 70
 conditions for DTA of, 73
 dehydration, 87
 heating curve, 3
 in clay mixtures, 75
 in soils, 164, 166
 interlayer structure, 202
 low-temperature peaks, 42
 peak area, 129, 146, 152
 rehydration, 200
 spurious peak, 64
 treated, 74, 77, 78, 80, 81, 152, 159,
 162, 166
 Mullite, 82, 84, 143, 173
 Muscovite, 79
- N**
- Neoprene, 185
 Neutral body, 3, 5
 Nickel, 40, 172
 Nickel ferrite, 205
 Nickel molybdate, 170
 Nickel oxide, 174
 Nontronite, 42, 74, 162
- O**
- Oleic acid, 179
 Opal, 158
 Order-disorder, 85, 88, 155
 Order of reaction, 58, 137, 138, 141-143,
 168, 170
 Organic substances, 177
- P**
- Palm oil, 179
 Palmitic acid, 179
 Paraffin oil, 50
 Paraffin wax, 178
 Particle size
 ball clay, 52
 chlorite, 56
 goethite, 56
 halloysite, 57, 144, 163
 hydrous ferric oxide, 55, 143
 kaolinite, 52, 54, 57, 145, 163
 magnetite, 56
 marcasite, 205
 pyrite, 205
 quartz, 55, 143, 144
 reactant powders, 175

- siderite, 61
 - Patents, 206
 - Peak area
 - calibration, 131–133, 144, 145, 148, 151
 - determination, 124, 125, 129, 156, 184
 - for exothermic peaks, 129
 - effect of diluent, 150
 - effect of heating rate, 146, 147, 148
 - effect of heat treatment, 153, 183
 - effect of impurities, 145
 - effect of reference temperature, 149
 - effect of sample block, 149, 150
 - effect of thermocouples, 150
 - theoretical considerations, 94, 99, 122, 142, 184
 - Peak height, 137, 140, 142, 149, 152
 - Peak masking, 16, 17, 51, 64
 - Peak overlap, 64, 65
 - Peak shape, 57, 58, 143, 144, 205
 - Peak shift, as a function of
 - crystallinity, 56
 - heating rate, 47, 48, 141
 - heat treatment, 182
 - impurities, 74, 75
 - particle size, 55, 56
 - sample block, 15, 150
 - thermal properties, 141
 - vapor pressure, 148, 173
 - Peak temperature, 48, 49, 137, 149
 - Peanut oil, 179
 - Peat, 12, 159, 161
 - Penanthrene, 22
 - Phase studies, 76, 177
 - Phenyl glycidyl ether, 183
 - Photographic method, 2, 6, 25
 - Phosphors, 12, 85, 155
 - Phosphorus, 30
 - Phthalic anhydride, 168, 181
 - Piezoelectric properties, 171
 - Piperidine-treated clay, 51, 77, 79
 - Plaster, 12, 187, 188
 - Polyacrylonitrile, 185
 - Polyethylene, 182, 186
 - Polyethylene terephthalate, 185, 187
 - Polyhalite, 131
 - Polymethyl methacrylate, 185
 - Polymers, 12, 19, 181, 182, 187
 - Polysaccharides, 181
 - Porcelain enamel, 199
 - Portable DTA equipment, 36, 209
 - Potassium chloride, 50
 - Potassium dichromate, 65
 - Potassium nitrate, 35, 127, 131, 145, 175
 - Potassium perchlorate, 50, 62, 127, 170, 175
 - Potassium phosphate, 167
 - Potassium sulfate, 65
 - Pozzolanic material, 189
 - Propellants, 175
 - Proteins, 12, 180
 - Pyrolysis, 160, 169
 - Pyrophyllite, 3, 57
- Q**
- Quartz
 - as reference, 49, 50
 - dielectric constant, 88
 - determination, 124, 132, 146, 152
 - high pressure inversion, 29
 - in brick, 204
 - in clays, 64
 - irradiated, 157
 - inversion temperature, 66, 158
 - particle size, 55, 143, 144, 163, 201
- R**
- Radiation damage, 156, 157
 - Radioactive wastes, 176
 - Rate of reaction, 120, 137, 140–142
 - Rate of transformation, 121
 - Recorders, 8, 25–27
 - amplifier, 27, 32
 - photopen, 25, 26
 - Reference substance, 49, 50
 - acid clay, 51
 - active materials, 51, 65, 66, 131, 207
 - alumina, 50, 72
 - graphite, 208
 - isophthalic acid, 185
 - magnesia, 50
 - paraffin oil, 50
 - particle size, 50
 - potassium chloride, 50
 - precalcined, 50, 51, 72
 - sintered glass, 169
 - sodium chloride, 50
 - sulfuric acid, 168
 - water, 168
 - Reference temperature, 44, 47–49, 149
 - Rhodochrosite, 17, 73, 78
 - Rubidium carbonate hydrate, 63
- S**
- Sample holder, 13
 - ceramic, 13, 15, 71, 72, 149, 150
 - closed, 14, 18, 30

- covered, 17, 30, 61, 64, 72, 73, 151
 fused quartz, 13, 18, 22, 33
 geometry, 44, 61, 72, 73, 94, 138, 149
 glass, 14, 31
 graphite, 208
 grounded, 27, 28
 hole depth, 16, 17
 hole radius, 16, 17
 hypodermic tube, 175
 "Inconel," 13
 liners, 30
 metal, 14, 15, 150
 micro, 29, 175
 molybdenum, 28
 multiple, 13
 nickel, 13-16, 61, 72, 92, 149, 150
 platinum, 13, 14, 21
 rotating, 17
 silver, 30, 151
 stainless steel, 13
 thermal symmetry, 49
 thermocouples, 14, 19
 volume, 17
 Sample packing, 49, 58, 59, 61, 72, 73, 143, 149
 Sample shape, 58, 60, 136, 149, 150
 brick, 14
 pressed pellet, 28, 59
 Sample size, 122
 Sample temperature, 49
 Sample weight, 32, 61, 68
 "Sandwich-pack" sample, 68
 Second-order transition, 170, 185, 205, 208
 Self-diffusion, 167
 Sensitivity of DTA, 40, 59, 68, 129, 151
 Sericite, 201
 Serpentine, 85, 86, 134
 Shale, 202, 205
 Shape index, 138-140
 Shrinkage, 35, 50, 62, 64, 131, 151
 Siderite, 17, 33, 61, 73, 85
 Silica, 3, 9
 Silica-alumina gel, 173, 174
 Silica brick, 152
 Silicon, 198
 Silicon carbide, 157
 Silicon monoxide, 28, 202
 Silicone polymers, 186
 Sillimanite, 18
 Silver nitrate, 66, 130, 131, 133, 148
 Silver sulfate, 48, 152
 Silver sulfide, 29
 Slag, 193, 195
 Slope ratio, 57, 144, 145, 163
 Smithsonite, 73
 Sodium carbonate, 141
 Sodium chloride, 50, 65
 Sodium dichromate dihydrate, 62
 Sodium hydroxide, 62, 65, 86
 Sodium nitrate, 131, 133, 170
 Sodium stearate, 47, 76
 Sodium sulfate, 18, 35
 Soil stabilization, 165
 Solid-state reaction, 168, 170, 176, 188
 Solid-vapor reaction, 168, 173
 Soils, 10, 161
 Soldering fluxes, 200
 Solubility, 158, 166
 Sorbed ions, 76, 78, 152, 166
 Specific heat, 31, 41, 51, 114, 128, 140, 195, 197
 Spurious peaks, 62, 64, 131
 Stalactites, 159
 Starch, 181
 Stearic acid, 91, 153, 179
 Stedite, 195
 Strontium nitrate, 177
 Sublimation temperature, 171
 Sugars, 181
 Sulfur, 6, 170, 183
 Sulfur dioxide, 174
 Surface area, 169, 172, 174
- ### T
- Talc, 35
 Tallow, 179
 Temperature calibration, 65
 Temperature indicators, 48, 68, 132
 Thallous nitrate, 155
 Theoretical DTA curves, 142
 Thermal capacity, 122, 154, 169, 170, 184
 Thermal conductivity
 affected by packing, 58
 change to produce peak, 63
 improvement with graphite mixture, 41, 130
 in quantitative studies, 122, 132, 140, 150, 154
 of clay, 51
 of evolved gases, 35, 89
 of sample blocks, 15, 149
 of thermocouple wires, 64, 137
 Thermal diffusivity, 58, 121, 132, 154
 Thermal stability, 168, 186
 Thermistors, 21, 22, 35, 179, 182, 207

- Thermocouples, 14, 18
 arc welding, 19
 attack, 19, 20, 30
 bead, 14, 19, 20
 Chromel-Alumel, 18, 30
 container, 14, 34, 151
 copper-Constantan, 29
 disc, 19
 electrical resistance, 20
 Geminol, 19
 gold-Constantan, 29
 gold, platinum, palladium-rhodium, 18
 graphite, 20
 graphite-boronated graphite, 28, 208
 grounded, 27, 28
 heat loss, 19
 micro, 19, 34
 multiple, 20
 oxidation, 76
 placement, 14, 64, 185
 Platinel, 18
 platinum-rhodium, 18, 19, 23, 28, 30
 position, 20, 21, 43, 44
 pressure effect, 31
 refractory metal, 20, 28
 sensitivity, 133
 shields, 19, 20, 30, 32
 silicon carbide, 20
 stray emf, 27, 28
 thermal capacity, 14, 19, 34
 thermal conductivity, 64, 150
 Thermogravimetry, 87, 151, 176, 186
 differential, 1, 87
 Thorite, 156
 Thorium oxalate, 89
 Tobermorite, 192
 Toluene, 171
 Transition temperature, 40, 42, 43, 47, 48,
 58, 123, 135
 Tremolite, 132, 146
 Triallyl cyanurate, 182
 Tricalcium aluminate, 190, 191, 193
 Tricalcium silicate, 189–192
 Tridymite, 152, 153, 203
 Tungsten, 199
- U**
- Uranium, 31, 32, 176
 Uranium carbide, 208
 Uranium oxide, 176, 177
 Uranyl sulfate, 87, 176
- V**
- Vacuum operations, 18, 31, 32, 33
 Vapor pressure, 34, 60, 61, 63, 69, 171
 Vaterite, 190
 Vermiculite, 42, 64, 73, 77, 78, 165
- W**
- Weight loss, 87, 149, 160
 Wood, 12
- X**
- X-ray analysis
 as correlative test, 158, 173, 188–190,
 193, 202
 high-temperature, 62, 81, 85
 of clay, 81, 131, 145
 of irradiated material, 157
 room-temperature, 85, 155
- Y**
- Yttrium iron garnet, 206
 Yttrium oxalate, 142
- Z**
- Zinc hydroxide, 172
 Zinc oxide, 88, 172
 Zircon, 156
 Zirconia, 121
 Zirconium, 31
 Zirconyl nitrate, 177
 Zirconyl oxalate, 142
 Zone refining, 179

