Journal of Thermal Analysis, Vol. 48 (1997) 135-139

Dedicated to Dr. Robert Mackenzie on the occasion of his 75th birthday

THERMAL DIFFERENTIAL DIAGNOSIS OF MICA MINERAL GROUP

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Abstract

The following criteria can be used for differential diagnosis of mica mineral group: weight loss < 350°C; weight loss during dehydroxylation (500–1000°C); peak temperature of structural decomposition and formation of high temperature phases; course of dilatometric curves during dehydroxylation and structural decomposition interval (Fig. 1).

Using the single criteria by stepwise comparing a complete thermal differentiation is possible between the members of mica mineral group.

Keywords: dilatometry, DTA, mica, TG, thermal transformation

Introduction

Mica minerals are demanded industrial minerals. Especially the varieties muscovite, phlogopite, lepidolite and zinnwaldite are of economic interest as isolating material, fillers for paper, rubber, plastics and paints, pearl pigments for varnish colours of car industry and cosmetics, slip agents, lithium raw materials, furnace windows, paper decorations, etc.

The technological properties of ceramic raw materials are often determined by the behaviour of mica minerals. In any application case a qualified mineralogical diagnosis of these minerals will be the basis for interpretation of geological and mineralogical formation conditions as well as for preparation in industrial use.

Thus the paper presents a collection of data for mineralogical analysis and for characteristic of technological behaviour of mica minerals obtained by different thermal methods.

General thermal behaviour of mica minerals

Dehydratation

The adsorbed water content will be lost up to a temperature of approximately 300°C. The accompanying weight loss depends on crystal chemical properties (i.e.

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nature and amount of interlayer cations) and grain size. Decreasing grain size and potassium deficit, are characteristic for mica minerals in sedimentary formations. They cause higher amounts of adsorbed water.

Dehydroxylation

Between 450°C (illite) and 1000 °C (biotite) the loss of hydroxyl water content is obtained. The process is relatively continuous during a temperature range of 200 to 400°C and will be accompanied by crystal expansion along the c-axis. Lowering of grain size generally causes a slip of dehydroxylation intervals to lower temperature (coarse sized muscovite: dehydroxylation maxima ~900°C; fine sized sericite: dehydroxylation maxima ~700°C).

Further the dehydroxylation process is strongly influenced by crystal-chemical nature as it is seen from Table 1.

In some cases (Fe^{2+}– rich varieties) a small exothermic reaction at 400°C is obtained. It is caused by the autooxidation process ($Fe^{2+} \rightarrow Fe^{3+}$) and is normally accompanied by hydroxyl group deficit [1]. Dehydroxylation mechanism of margarite and paragonite could be described by AVRAMI – equations under kinetic point of view [2].

Crystal decomposition and high temperature phase formations

Dioctahedral varieties are characterized by structural decomposition (i.e. loss of typical 3-layer-structur by SiO_4-tetraheder-rotation) approx. 200 up to 300°C after the DTA dehydroxylation.

Trioctahedral varieties show a coincidence of dehydroxylation maxima and crystal structural decomposition. The nature and the amount as well as the temperature range of high temperature phase neoformations are determined by parent chemistry of the mica minerals. Typical high temperature phases are mullite, spinel ($MgAl_2O_4$), corundum and leucite. Forsterite was found in thermally transformed phlogopites. Strong formation of glassy phases was obtained in Fe-rich varieties, especially after the heating up to 900°C of lithium – containing mica minerals. This process can be observed by intensive shrinkage effects in dilatometric curves.

Method and materials

The investigations were carried out using a derivatograph in the combination DTA-TG and DTA-TD. Details of the method and preparation are described by SCHOMBURG & STÖRR (1984). The following raw materials were included in the investigations; muscovite (Dolni Bory, Czech; Modum, Norway), phengite (Rheinwaldhorn Massiv, Switzerland), margarite (Chester, Massach., USA), paragonite (Ochsenkopf, Fichtelgebirge, F.R.G.), lepidolite (Zinnwald, Erzgebirge, F.R.G.), biotite (Krankålet, Darlane, Sweden), phlogopite (Loughborough, South Burgess, Canada), hydromuscovite (Lukavice, Czech), illite (Morris, Illin., USA), glauconite (Gielow, Mecklenburg, F.R.G.) and seladonite (Krebsberg near Usti, Czech).

Table 1 DTA-, TG- and TD-data of members of the mica group

Mineral	Dehydratation <350°C		Dehydroxylation 350–1000°C		Structure decomposition	
	DTA/°C[a]	TG/w%	DTA/°C	TG/w%	DTA/°C[a]	TD/°C[b]
Muscovite (2-M-type)	130	1.0	840–890	4.0	1100	900–920
Phengite	–	0.3	890	4.1	n.d.	n.d.
Margarite	–	0.4	830	4.2	n.d.	820
Paragonite	–	0.3	810	4.2	1120	880
Lepidolite	140	0.7	900	1.3	–	910
Zinnwaldite	140	0.7	880	0.8	–	820
Biotite	–	0.1	980–1150	1.0[c]		
				1.7–5.0[d]	–	980
Phlogopite	–	0.1	1180	2.0[c]		
				4.3[d]		930
Hydromuscovite	100–160	1.9	600–700	4.0	900–1100	850
Illite	130–160	4.0	550–600	5.2–5.6	880–920	800
Glauconite	140–160	3.0	510–600	4.2–5.1	880–950	800
Seladonite	140	7.5	600–660	3.8	920–950	780

[a] endothermic reaction

[b] shrinkage caused by structure decomposition (initial temperature)

[c] iron rich members

[d] low in iron content

n.d. - not determined.

Results

The measured data and some values from literature are collected in Table 1. It can be observed that the mica minerals seladonite, glauconite, illite and hydromuscovite can be differentiated from trioctahedral varieties and muscovite, paragonite and margarite using the following thermoanalytical criteria:

- weight loss <350°C
- peak temperature of dehydroxylation
- peak temperature of crystal structure decomposition.

Between the varieties of magmatic-metamorphous genesis it is possible to differentiate due to their weight loss during dehydration and dehydroxylation (Table 1).

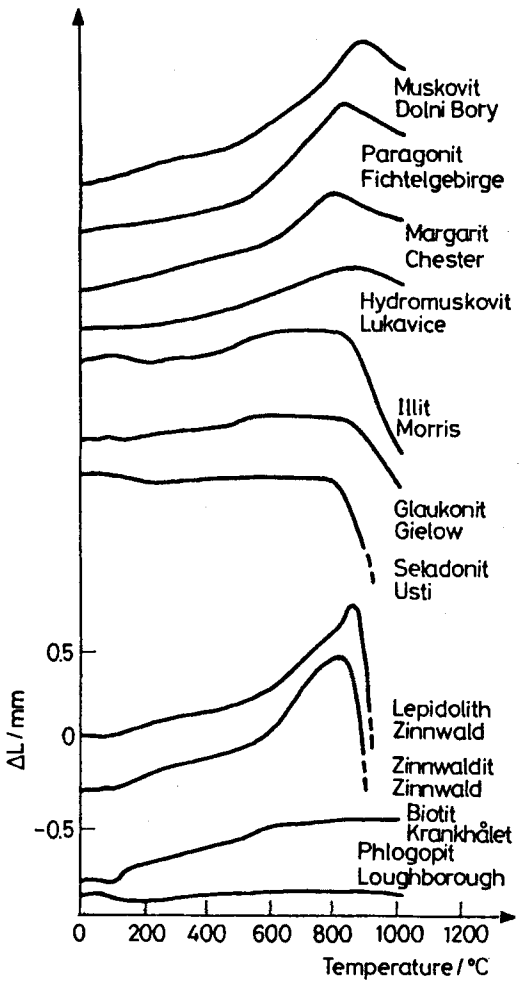

Fig. 1 Dilatometric curves of various members of the mica group (nomenclature in German)

Dilatometric curves of mica minerals can be used for determination of small contents of lithium (<0.3%) because of characteristic strong shrinkage beginning at 800°C (Fig. 1). Further it is possible to detect the nature of interlayer cations in dioctahedral micas from dilatometric curves. The temperature of the maximum expansion varies in the following range:

Muscovite (K^+): 920°C
Paragonite (Na^+): 880°C
Margarite (Ca^{2+}): 800°C.

At least the different course of dilatometric curves of illites and muscovites in the temperature range between 600 and 700°C is usable as diagnostic criterion studying mica rich clays. While muscovite is characterized by continuous expansion with temperature for illite no changes in dimension could be observed.

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