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COMPARATIVE THERMAL ANALYSIS OF COMMERCIAL AND LOW-GRADE BAUXITES

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This paper presents qualitative and quantitative comparative results on the simultaneous TG–DTG–DTA of five commercial and low-grade bauxites. The methodology of qualitative determination of the basic mineral forms contained in bauxites is currently being established. The weight losses relating to the steps in the TG curve allow determination of the contents of the basic minerals in bauxite. These are recalculated as percentages of Al_2O_3, SiO_2, CaO moisture and total volatiles. The final results are in accordance with the results of classical chemical analyses, and this jusitifies the use of this technique as a quick method for qualitative and quantitative determinations of both commercial and low-grade bauxites.

Bauxites, basic raw materials for the extraction of alumina and aluminium contain not only aluminium minerals (gibbsite, boehmite and diaspore), but also accompanying, mainly deteriorating minerals (kaolinite, hematite, goethite, quartz, calcite, rutile, etc.) of which the least desirable is kaolinite, since this mineral contains soluble SiO_2. Depending on the content of kaolinite, bauxites are divided into commercial, conditionally commercial and non-commercial bauxites. The establishment of the content of basic, useful and deteriorating mineral of bauxite is very important for the technology of bauxite-processing by the Bayer process. This paper presents results of such determinations by quick methods of thermal analysis, which yield significant information relatively rapidly, with a satisfactory degree of accuracy.

Experimental

Samples of commercial bauxites were used from the regions of Vlasenica and Jajce, as well as samples of non-commercial bauxites from the region of Western Serbia, Yugoslavia.

A 1500 derivatograph (MOM, Budapest) was used for the experiments.

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Results and discussion

Figures 1–5 present the results of thermal analysis for several typical samples of bauxite, and Fig. 6 shows the positions of these bauxites in Konti's diagram: aluminium minerals—clay minerals—iron minerals [1].

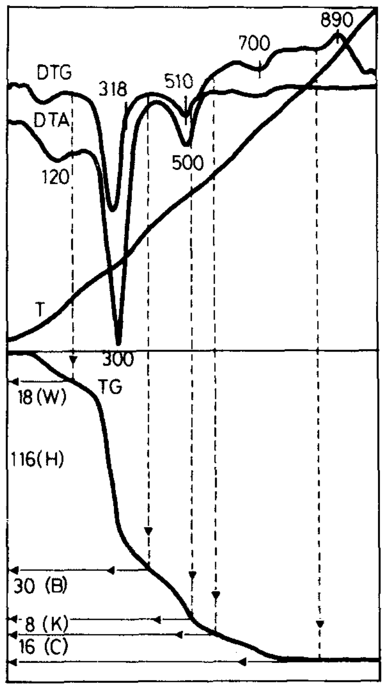

Fig. 1 DTA, TG and DTG curves of bauxite of the gibbsitic type

The TG curves illustrate the corresponding mass losses, the symbols in parenthesis used having the following meanings: m_W = humidity, m_H = mass loss due to dehydration of gibbsite, m_B = mass loss due to dehydration of boehmite or diaspore (monohydrate of aluminium), m_K = mass loss due to dehydration of kaolinite, and m_C = mass loss due to decarbonization of calcite.

Taking into account the initial mass of the examined samples, m_0, the stoichiometry of the process of dehydration of single minerals, and the decarbonization of calcite, the following methodology of calculation was used:

a) Determination of moisture content (W):

$$W = \frac{m_W}{m_0} \cdot 100(\%)$$

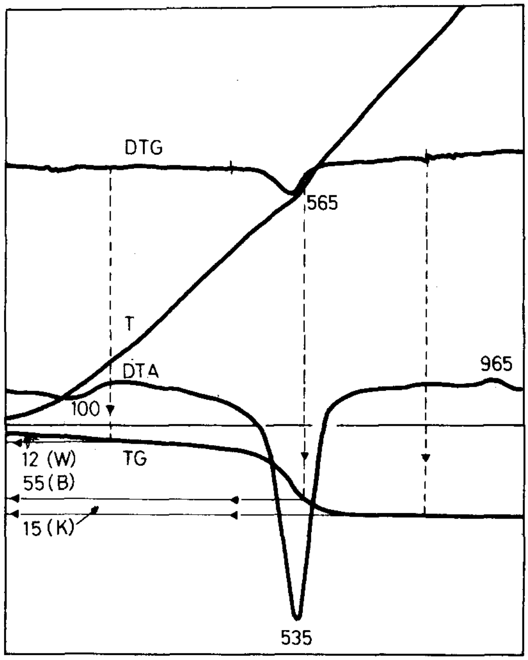

Fig. 2 DTA, TG and DTG curves of bauxite of the boehmitic type

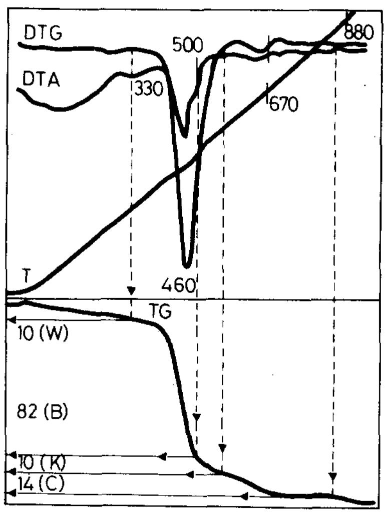

Fig. 3 DTA, TG and DTG curves of bauxite of the diaspore type

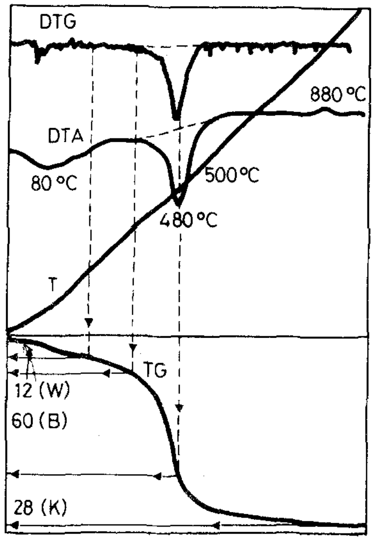

Fig. 4 DTA, TG and DTG curves of bauxite (sample 4)

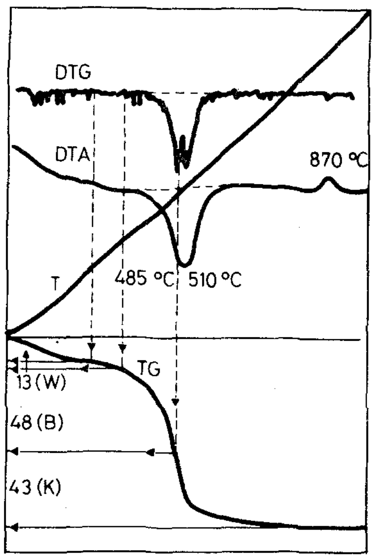

Fig. 5 DTA, TG and DTG curves of bauxite (sample 5)

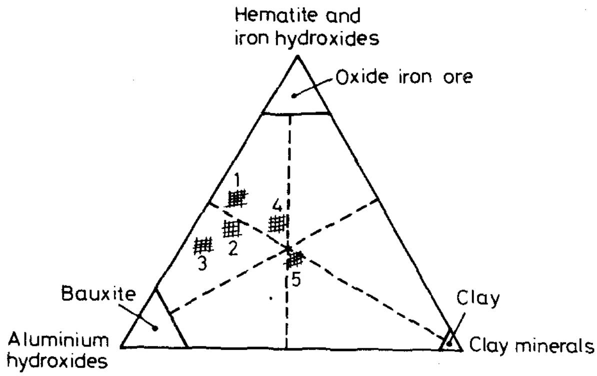

Fig. 6 Position of bauxite (samples 1–5) in Konti's diagram

b) Determination of gibbsite content (H):

From numerous examinations [2–4], it has been established that, in the process of dehydration, gibbsite, $Al_2O_3 \cdot 3H_2O$, does not lose all three molecules of water, but only 2.75, and the remaining 0.25 H_2O is removed by dehydration of the "scarce boehmite". Accordingly, the gibbsite content in bauxite is:

$$H = \frac{m_H \, M(Al_2O_3 \cdot 3H_2O)}{m_0 \, 2.75M(H_2O)} \cdot 100\%$$

where m_H is the mass loss due to dehydration of gibbsite, as measured from the TG curve, and M(i) is the formula weight of compound i.

c) Determination of boehmite content (B):

$$B = \frac{m_{Br} M(Al_2O_3 \cdot H_2O)}{m_0 M(H_2O)} \cdot 100\%$$

We introduce the expression "real boehmite" (B_r), as it is necessary to correct the mass loss obtained from the TG curve for the mass loss caused by dehydration of "scarce boehmite", m_s, in the following way:

$$m_{B_r} = m_{B_t} - m_s$$

$$m_s = \frac{0.25M(H_2O)}{2.75M(H_2O)} \cdot m_H = 0.091 \, m_H$$

d) Determination of kaolinite content (K):

$$K = \frac{m_K}{m_0} \cdot 100 = \frac{m_K \cdot M(Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O)}{2m_0 M(H_2O)} \cdot 100\%$$

e) Determination of calcite content (C):

$$C = \frac{m_C}{m_0} \cdot 100 = \frac{m_C \mathrm{M(CaCO_3)}}{m_0 \mathrm{M(CO_2)}} \cdot 100\%$$

f) Determination of loss by annealing (L.A.):

$$\mathrm{L.A.} = \frac{\sum m_{\mathrm{TG}}}{m_0} \cdot 100\%$$

where $\sum m_{\mathrm{TG}}$ is the total mass loss of the sample up to 1000°.

From the DTG curve, the beginning and the ends of the individual dehydration processes in the TG curve are established, and the DTA curve is used for the qualitative characterization of the processes considered.

This is the way to establish the mineralogical composition of the bauxite, from which it is also possible to establish the chemical composition of the major components contained in the bauxite, i.e.:

$$\mathrm{Al_2O_3}(\%) = \frac{\mathrm{M(Al_2O_3)}}{\mathrm{M(Al_2O_3 \cdot 3H_2O)}} \cdot H(\%) + \frac{\mathrm{M(Al_2O_3)}}{\mathrm{M(Al_2O_3 \cdot H_2O)}} \cdot B(\%) + \\ + \frac{\mathrm{M(Al_2O_3)}}{\mathrm{M(Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O)}} \cdot K(\%)$$

$$\mathrm{SiO_2}(\%) = \frac{2\mathrm{M(SiO_2)}}{\mathrm{M(Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O)}} \cdot K(\%)$$

$$\mathrm{CaO}(\%) = \frac{\mathrm{M(CaO)}}{\mathrm{M(CaCO_3)}} \cdot C(\%).$$

Table 1 presents the results, compared with those of classical chemical analysis, which takes more time. The results show good coincidence, but the thermoanalyt-

Table 1 Comparative results of thermal analysis and of classical chemical analysis

Sample no.	Content of component, %									
	Thermal analysis					Chemical analysis				
	Al_2O_3	SiO_2	CaO	L.A.	W	Al_2O_3	SiO_2	CaO	L.A.	W
1	44.12	3.16	2.4	22.4	2.2	43.15	3.85	2.3	23.4	2.3
2	50.60	7.13	—	11.7	1.7	50.86	7.00	—	12.1	1.8
3	51.35	3.46	1.8	12.1	1.1	52.50	3.10	1.9	13.5	1.5
4	38.33	8.55	—	9.9	1.1	38.87	9.08	—	9.8	1.1
5	40.95	16.44	—	11.3	1.3	40.83	16.54	—	11.2	1.3

ical results yield more information than does classical chemical analysis, primarily as concerns the origin of the basic components Al_2O_3 and SiO_2. This is valuable information determining the technology of bauxite processing.

References

1 J. J. Konta, Sediment Petrol, 28 (1958) 83.

2 H. Veković and Janeković, Proc. 3 ICSOBA, Ice (1973) 345.

3 Ž. D. Živković and B. Dobovišek, Differential Thermal Analysis (Theory and Application), Bor, 1985. (in Serbocroatian).

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Zusammenfassung — Qualitative und quantitative Ergebnisse vergleichender simultaner TG–DTG–DTA-Untersuchungen an 5 kommerziellen und geringwertigen Bauxiten werden vorgestellt. Die Methodologie der qualitativen Bestimmung der wichtigsten im Bauxit enthaltenen Minerale wird ausgearbeitet. Die Gewichtsverluste bei den entsprechenden TG-Stufen erlauben die Berechnung der Gehalte an den wichtigsten Mineralen. Diese werden umgerechnet in die Anteile an Al_2O_3, SiO^{02}, CaO, Feuchtigkeit und Glühverlust. Letztere Resultate stimmen mit denen klassisch-chemischer Analyse überein. Das erlaubt die Anwendung thermoanalytischer Methoden als Schnellverfahren für qualitative und quantitative Bestimmungen in kommerziellen und geringwertigen Bauxiten.

Резюме — Представлены сравнительные качественные и количественные результаты исследования пяти продажных и низкосортных образцов боксита совмещенным методом ТГ, ДТГ и ДТА. Разработана методология качественного опрехеления основных минералов, содержащихся в бокситах. Соответствующие стадии потери веса на кривой ТГ позволили определить содержание минералов в боксите и вновь вычислить процентное содержание окиси алюминия, двуокиси кремния, окиси кальция, влаги и суммарное содержание летучих веществ. Полученные результаты согласуются с результатами классического химического анализа, который фактически дает возможность использовать эту методологию в качестве быстрого метода качественных и количественных определений, включая продажные и низкосортные бокситы.