DERIVATOGRAPHIC RESEARCH OF SUBFOSSILE BONES

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Anthropology is „the natural history of the hominides in their conditions of time and space" (Martin); or „the scientific investigation of the natural history of hominides and that of the variations of their organism in time and space" (Bunak); or „understanding and explanation of the physical appearance of human groups and of their biological relations" (Fischer). This means: we have to do with a *group science* and a *natural science.* Anthropology cannot be restricted to the exterior research of some rarities, it has to investigate the physical structure of man having lived in different historical periods, achieving this according to the latest scientific development, with the help of all its means.

Historical anthropology has been increasingly compelled by several factors (bad and fragmentary state of the bones, secondary deranging etc.) to extend its investigations to the final bases of physical appearance, i. e. to the chemism of the organism (in our case that of the bone), paralle with the exterior morphological (metric) researches. Since historical periods mostly deliver us only bone material, it seems to be necessary to clear its constituents, to compare this with their appearance and in cases when we do not have sufficient quantity, to do metrical research in order to draw conclusions from the bones themselves. Such investigations have been started recently and there is not much literature on this object though they are greatly demanded and bid fair prospects. Preliminary investigations in order to gain informations have been made upon these considerations by the author together with Peter DÁVID.

We investigated the physical and chemical behaviour of the bone exposed to heat, and tried to draw conclusions useful to the archeology and historical anthropology. In compounds (in our case in the bone), when exposed to heat, chemical reactions ared physical transformations take place. Both chemical relations and changes of state or physical condition evoke smaller or greater changes in the inner amount of heat of the systhem. This transformation is accompanied by heat absorption (endothermic) and heat generation (exothermic) reaction. These calorific effects can be well demonstrated by the differential-thermic-analysis-method. The changes in weight accompanying these changes can be registered with the help of an instrument, applying a thermogravimetrical curve.

We tried to find a method *to define the age* of bones coming from cemeteries of historical periods between 4000 BC—1800 AD. The isotopic C^{14} method for time-determination is, on the one hand, very expensive, it cannot be done easily, on the other hand, it has a great dispersion within the half-period 5568, although this method is theoretically the best one. The method using the

ratio of the calcium-fluorine-phosphate in the bone in respect of the fluorine is also a rather cumbersome one and it depends greatly on the soil. Investigations concerning the time of decalcination of bones, their analysis in UV-light, their histological colourability, their radiologic-optical analysis are all rough and rather subjective methods.

On the derivatograph Paulik—Paulik—Erdey, with heating to 1000° C, under permanent air-flow the osseine was researched from the point of view, at which grade one can find the components of bone, which are the most dependent on the appearance of the bone, objective, can be reproduced and done easily. The first preliminary measurements of the author and Peter DÁVID beeing promising, it seemed reasonable to elaborate some details and to exclude disturbing factors. In this article a short account of this work will be given.

Research methods and results

As research material pure bone powder was used, taken from the middle part of tabular compact (diaphysis). Since in graves the greater bones can best resist to vicissitudes of time (thigh-bone, shin-bone, humerus etc.) it seemed reasonable to elaborate a method for the compact bone substance. In order to be able to converse the results for any given case, derivatogramms have been made for the *different parts of the same skeleton.*

Part of skeleton	170°	220°	320°	380°	420°	580°	920° C
tooth	2,5	3,5	8,5	11,6	16,0	17,5	22,0
d. temoris	2,5	3,5	8,5	11,6	12,0	15,0	20,5
d. tibiae	2,5	3,5	8,0	10,5	11,0	14,0	20,5
humerus	2,5	3,5	7,8	10,6	12,0	14,5	20,0
radius	2,5	3,5	7,8	10,8	12,0	15,1	21,0
parietal bone	2,5	3,5	7,5	11,5	15,0	16,5	21,0
pelvis	2,5	3,8	9,0	12,5	15,1	18,0	23,5
femur (upper par	2,5	3,3	7,5	9,0	10,0	13,0	17,5
vertebral body	2,5	3,3	8,0	12,5	15,0	19,8	26,5

Table 1. Thermogravimetrical loss of weight in different parts of the same skeleton in percentage. (10th century).

These examinations have shown that the middle parts of the compact bones (thigh-bone, shin-bone, humerus, radius, cubitus) are best suitable for measuring (Table I.; Fig. 1.). Different, but consequently corresponding results have been gained by examination of the teeth. Diploë are less suitable to derivatographic study. It has mainly mechanical reasons: pure diploë can be more difficultly separated from impurities of the soil. *Optimal quantitiy for analyses* is 1,0—0,2 gr. This quantity is enough to get reliably measurable and appraisable results and, at the same time, not too much for the processes to overlap each other, because of the bad heat conduction of bone material. The greatest advantage of the derivatographic method opposed to using fluorine or C^{14} is teh small quantity of substance required to it; 0,3 gr (in the case of microderivatography even less) is so little, which, if cut out with a diamond tool, used by the dentists, hardly damages the bone.

Number of grave at	170° C	320° C	420° C	580° C	920° C
Nr. 17. 10 years old	2,5	8,0	12,5	16,0	20,5
Nr. XXII. 20 years old	2,5	7,5	11,5	15,5	20,0
Nr. XXIV. 40 years old	2,5	7,5	12,0	15,0	20,0
Nr. I. 50 years old	2,5	8,5	13,0	16,0	22,5
Nr. XIII. 55 years old	2,5	7,5	11,5	15,0	20,0

Table 2. Thermogravimetrical losses in weight of different graves of the same cemetery (Szob, 10th century) in percentage (without correction).

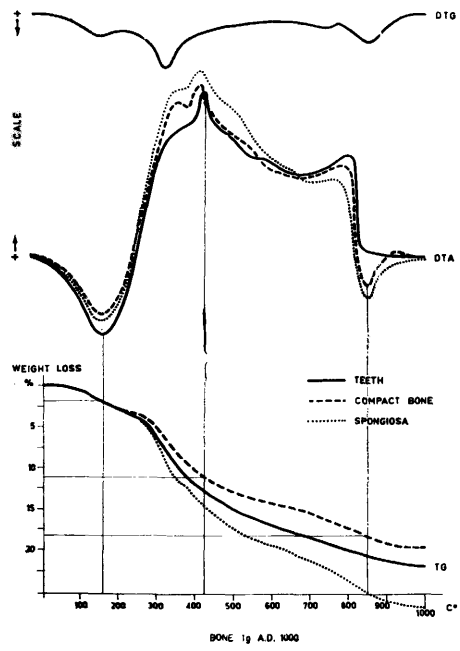

Fig. 1. The comparative derivatogramms of the bones of the same human skeleton.

Derivatographic analysis of bones coming from different periods of the same cemetery has been made by the author. The results ware nearly the same (Table 2.), however, the bones of the same cemetery, going back to different periods, have shown different losses in weight between 105° C and 580° C particularly as regards to the fraction between 380° C and 580° C. On this basis the relation of some bones to others can be befined, too, if the graves cannotbe separated with the help of grave furniture or burying rites.

Number of grave at	380° C	580° C	960° C
Kishomok, Nr. 69.	11,5	17,0	20,5
Kishomok, Nr. 81.	11,5	17,1	21,0
Kishomok, Nr. 50.	12,5	20,1	26,0
Kishomok, Nr. 76.	11,0	16,0	20,0

Table 3. Thermogravimetrical changes of bones found in different soil of the same cemetery, in percentage.

Thermogravimetrical changes of skeletons analyzed from the same cemetery give satisfactory results if we have *identical* or nearly identical soil. If the bones come from *totally different* soil in the same cemetery, the loss in weight as a consequence of calcination of the organic substance resisting to heat did not give the same results, these ones cannot be appraised without soil-correction and give merely informatory results.

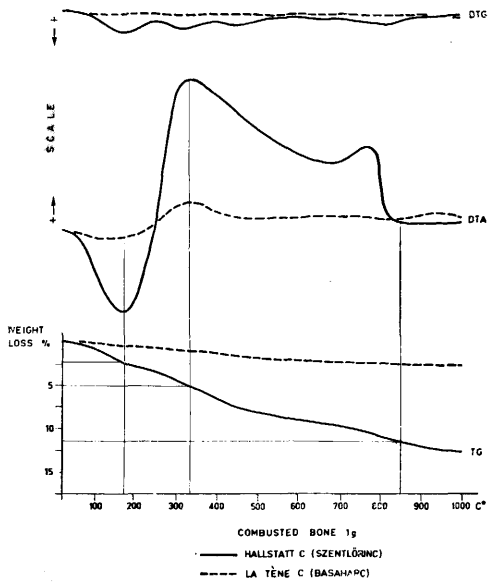

Fig. 2. Derivatogramms of calcined bones from the different periods of the iron age.

Derivatographic research of the calcinated bones going back to different periods of time has been made by the author. His results in this field are not final and fully elaborated, they have only an informatory character. Further research is required (actually in process) so much the more, because the way and „techniques" of cremation are important problems of both anthropology and archeology. The thermogravimetrical curve and the derivational thermo-analytical curve (Fig. 2.) give information about the degree of heat at which cremation had been done and about the fact if the body had been laid on a burning fire (glowing embers) or burned gradually. From this point of view a great difference has been found between the cremation dating from the Early Iron Age (Halstatt C) and that of the Late Iron Age (La Tène C). In the first case the cremation was imperfect, in the second one it was perfect. (Fig. 2.) Besides, it is important to define the degree of heat used in cremation also from the point of view, how far the bone is sultable to further chemical analyses.

Some examinations have been made by the author to eliminate faults. Concerning the *granulation* of the bones: it is optimal to grind the bone in a ball and tube mill to dust (fractions of 0,06 and smaller). In such a case the derivatogramm is rich details, the thermogravimetrical grades are explicit and nothing will be lost due to the fractioning of the bone. In case of granulated

(rough) bones the lines showing reactions are disturbed over 420° C owing to the mechanical change (scaling) of the bone. As regards *compactness:* greatly compacted and loose bone give exactly the same changes in quantity (TG), the DTA curves of the compacted bone are, however, much more explicit. Concerning *choosing of time:* 100 minutes proved optimal; less time is not enough for the bone-powder, having bad heat conduction, to behave consistently, longer time (e. g. 800 minutes), though optimal, needs too much time and owing to this is more expensive. The reactions are rich in details and appear at the degree of heat where the physical-chemical reactions take place. Concerning the *crucible:* platinum crucible gives about twolfold effects opposed to corundum. The process of the reactions is also more expressed.

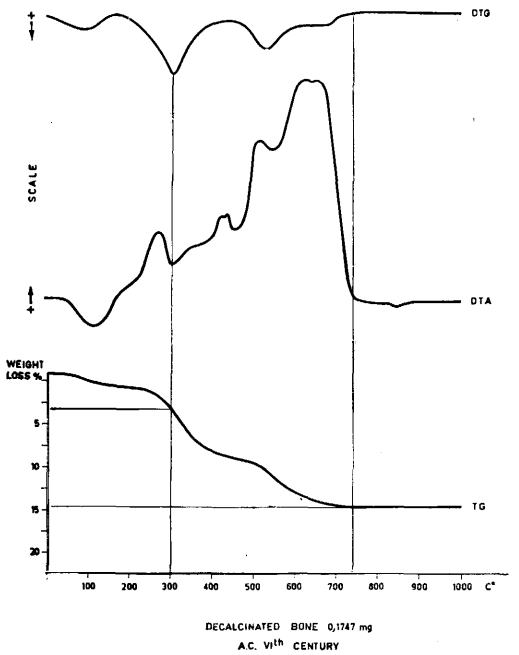

Fig. 3. Derivatogramm of decalcinated bones. The change of the numerous organic materials induced by a fine heat effect isn't oppressed by the change of the inorganic component of great mass.

The derivatographical analysis of decalcinated bone has been made by the author. Only organic substance of a bone unit (1 gr) was studied. (Fig. 3.) In this case considerably more changes under heat effect have been found. It has to be taken into consideration whether it worth while to work out the derivatography of the „organic substance" only, because changes of the greater quantities of inorganic substances, evoked by heat, inhibit the more delicious changes. In think the answer to this question must be *no;* 1. because decalcination can never be complete, the decalcinator does not only damage the substance but it brings foreign substances into the bone, too; 2. because the inorganic

substance of the bone, just as the organic one has its role in the evaluation. The derivatogramm is especially valuable if these two components can be measured together, can be shown in the same derivatogramm.

Historical period at	380° C	580° C	960° C
Upper Paleolith	6,5	7,5	12,0
La Tène C	9,0	13,0	21,2
Langobard	10,0	16,0	24,0
Gepid	11,0	17,0	20,5
Hungarian settlement	12,5	18,0	22,0
Middle Ages (13th cent.)	12,7	19,5	25,0

Table 4. Termogravimetrical losses in weight in bones going back to different historical periods (in percentage).

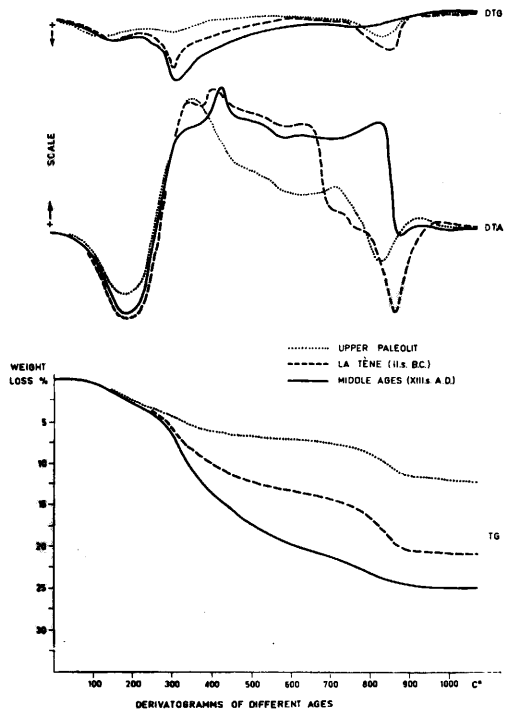

Fig. 4. Derivatogrammes of bones coming off different ages.

After the preliminary measurements, made together with Peter DAVID, the author has prepared the derivatogramm of several bones, going back to different historical periods, this time under optimal circumstances. His results came closer up to the straight line given by Peter DÁVID (Fig. 5.); the gravimetrical loss of weight of the organic fractions, resisting to heat due to heat generation seemed nearly parallel with the absolute age.

Further tasks

Though results are promising it still might not be said that derivatographic analysis of subfossile bones can always and exactly define absolute age between 180 of our era and 5000 before our era. Derivatographic research of the soil sample at the same time as that of the bone, and the determination of soil correction are still to be done.

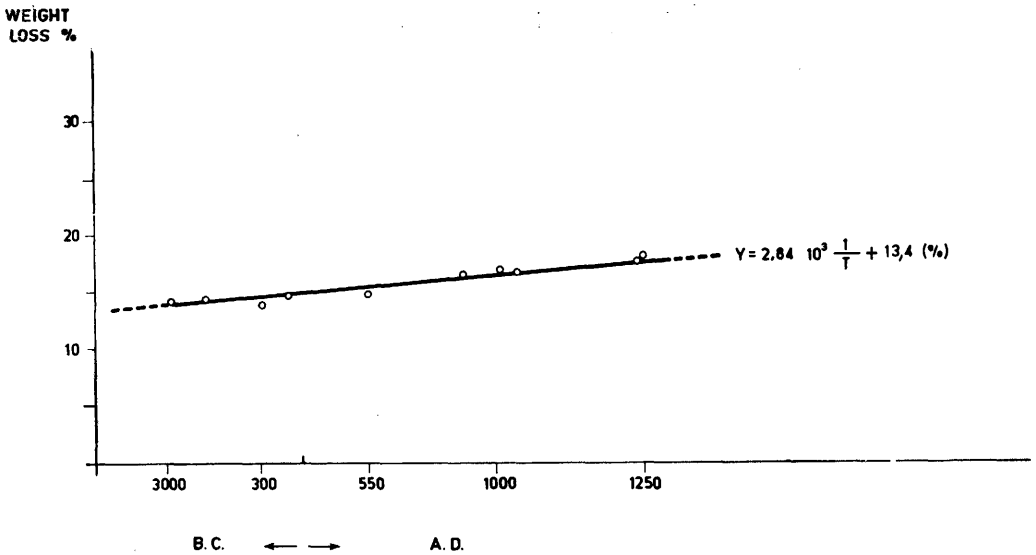

Fig. 5. Termogravimetric values on 580° C of bones origining from different ages and their places on the scale determined by Peter David.

Besides, the whole organic and inorganic analysitic (and gas-chromatographic) research of the derivatogramms of bones at temperatures measured at their effectpoints and that of the products of decomposition owing to calcination are proceeding. In this case we can exactly determine, what kind of changes happen in the organic or inorganic bone substance at a certain temperature. On the basis of the definition of each components separately, and of the relation of the organic substances to the inorganic ones further conclusions can be drawn as to sex and age, too.

Summary

After some preliminary measurements of informatory character, made together with Peter DÁVID, the author of the present paper has prepared derivatographic analyses of different subfossile bones from several points of view. The aim to be achieved has been to gain impersonal, reproducible information, registered by an instrument concerning the organic and inorganic components of bone substance. The final aim is to gain such informations for time

determination which concern the period where most of our archeological anthropological material belong.

The author has been succeeded in clearing the optimal granulation, the quantity, the crucible, the choosing of time and the medium of calcination. Further, derivatographic analysis of calcinated bones has been started, and through this some informations can be gained about cremation. Derivatogramms of bones going back to different ages have given reassuring results about the estimative absolute age. Separation of bones of the same cemetery going back to different periods seems to be possible in a derivatographical way. Further results can be achieved by analyzing derivatographically the soil sample and the bone substance at the same time; and by fully analyzing chemically the bones at different degrees of heat.

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