ON THE USE OF GRAPHICAL METHODS FOR A CLASSIFICATION OF LAKE SEDIMENTS

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(WITH 3 FIGURES IN THE TEXT)

In many branches of science graphical methods have proved very efficient for obtaining a classification of units, which are described by a large number of statistical data.

In most cases there can among the statistical data be found three data (or groups of data) which either *a priori* are recognized as the salient ones, or which through graphical rearrangements show themselves to be more important than the others.

Through three data (or groups of data) the unit can always be graphically represented by a point within a system of coordinates in the plane. If the third dimension is used the position of the point representing the unit may be determined through four data.

The essential thing is to get the unit represented by a point. When all the units in question are thus represented by points within a system of coordinates, they usually fall into natural groups, and a deeper understanding of their relationships is gained than is possible by any other method.

The graphical methods in question have been extensively used by petrologists and mineralogists. I here propose to use them for a classification of lake sediments, and ultimately for a classification of the lakes themselves.

In order to illustrate the possibilities of graphical methods towards classification of lake sediments, I have used data from the researches on North American lakes by C. S. Black (1929) and my own data from Norwegian lakes (Strøm, 1933).

I soon found that the only graphical method worth while was the use of Osann (1900) triangles. These are widely used in petrological studies. In an equilateral triangle the sides are subdivided (as a rule in 20 parts) and at each angle the symbol of one among the three statistical data is placed (e. g. SiO_2, CaO and Org. C, in fig. 2). The percentages for each of the components named is calculated to their total, which is very easily done by a sliding-rule.

This may be illustrated by an example:

	In percent of grand total	In percent of the 3 components total
SiO_2	50.65	70.7
Al_2O_3	17.69	24.6
Org. C	3.38	4.7
Total	71.72	100.0

The percentages are marked along the sides of the triangle. The opposite side of the angle marked with the sign for the component in question is used as the ground line, and the angle itself as an apex. When parallels to the ground lines are drawn through these points, the point representing the situation of the total within the coordinate system is found. It is determined by two parallels, but the third parallel always ought to be drawn for control, as they must necessarily meet in the point of intersection.

While experimenting with an arrangement of the different components, it soon became evident that those which are most important for the purposes of classification are SiO_2, Al_2O_3, CaO and Org. C. Among these Al_2O_3 is of mineral origin, Org. C of organic origin, while SiO_2 and CaO may be both.

For more special purposes, such as lakes with sea-ore, or lakes with deposits derived from dolomitic rocks, Fe_2O_3 and MgO respectively should also be considered. It is a matter of course that, if possible, only "pelagic" sediments from below the littoral zone and preferably from the greatest depths of the lake in question should be compared.

First taking chemical analyses from Norwegian lakes (STRØM, 1933), it was apparent that CaO did not play any part whatsoever in the composition of these samples. The quantities of SiO_2, Al_2O_3 and Org. C are given in table 1, and the graphical results in fig. 1. (Where on account of the possible reproduction scale, only that half of the triangle which contained the points was drawn.)

It is at once apparent that the lakes in question fall into three very distinct groups:

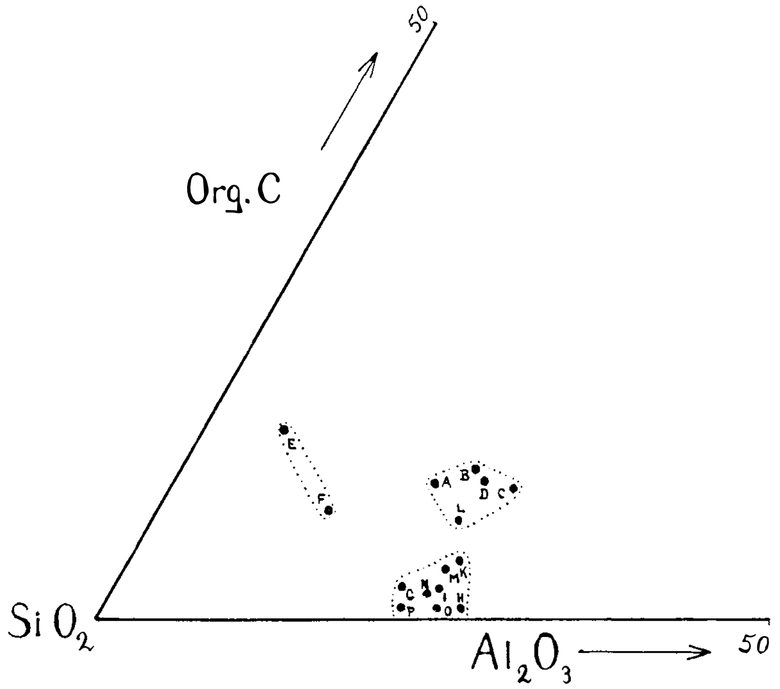

Fig. 1.

1. Mixed organic (allochthonous and plankton detritus) sediments and sediments of mineral origin.
2. Plankton detritus. (F. with a little clay.)
3. Clays with little or no organic detritus.

With the graphical method the different samples with high contents of SiO_2 are at once resolved into natural groups as to whether the origin of the silica content is mainly organic, mineral or mixed; all depending upon the fact that we have a coordinate system with three sample components represented, that of organic origin (Org. C), that of mineral origin (Al_2O_3) and that which may be of mixed origin (SiO_2).

The chemical analyses (table 2) from North American lakes must be arranged with inclusion of the CaO content. This I have done in two ways, the one (fig. 2) as an ordinary triangle with SiO_2, Org. C and CaO.

The lakes at once fall into two divisions, the one with quantities of CaO (1) and the other practically without. In the second division

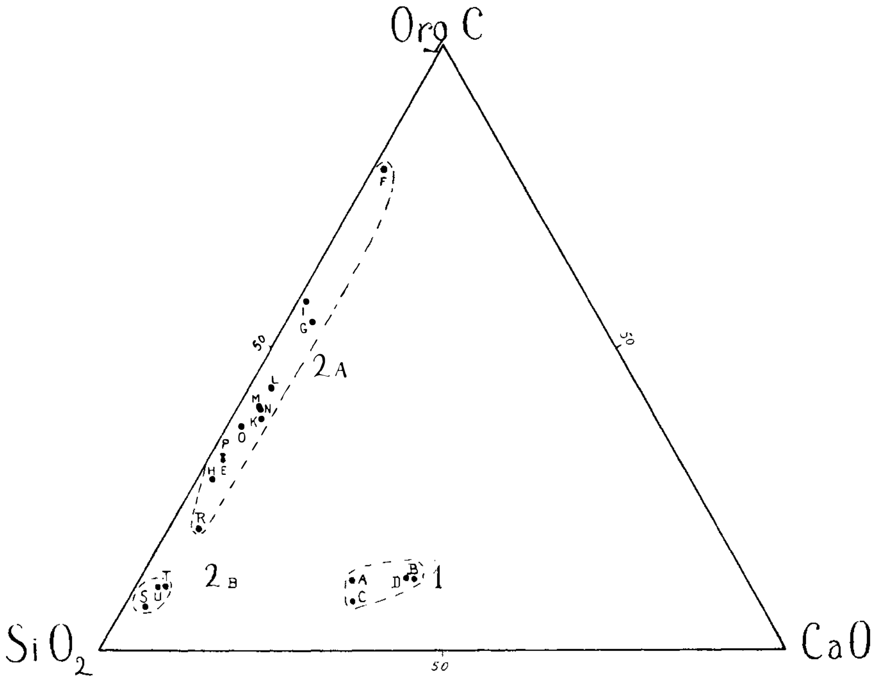

Fig. 2.

(2A and 2B) the arrangement is mainly due to the relation between Org. C and SiO_2. Two sub-groups 2A (Forest lakes in Wisconsin with much organic deposits) and 2B (Arctic lakes in Alaska with mainly mineral or mineralized deposits) may be distinguished, though the boundary between them is hard to tell from the diagram alone, as there are greater gaps within the group 2A than between the two groups. A better arrangement is obtained by using SiO_2, CaO and Al_2O_3 contents as determining factors. (Because Al_2O_3 is the component of purely mineral origin.) If then the third dimension is used to show the Org. C content we get a very useful representation. Org. C is plotted along vertical lines as percentages of grand total. The scale is one half to that used within the triangle. Of course the scale used in the third dimension may be quite arbitrary. (As all the "ground" points fall within the left corner, only one half of the triangle is shown, to get a clearer drawing.)

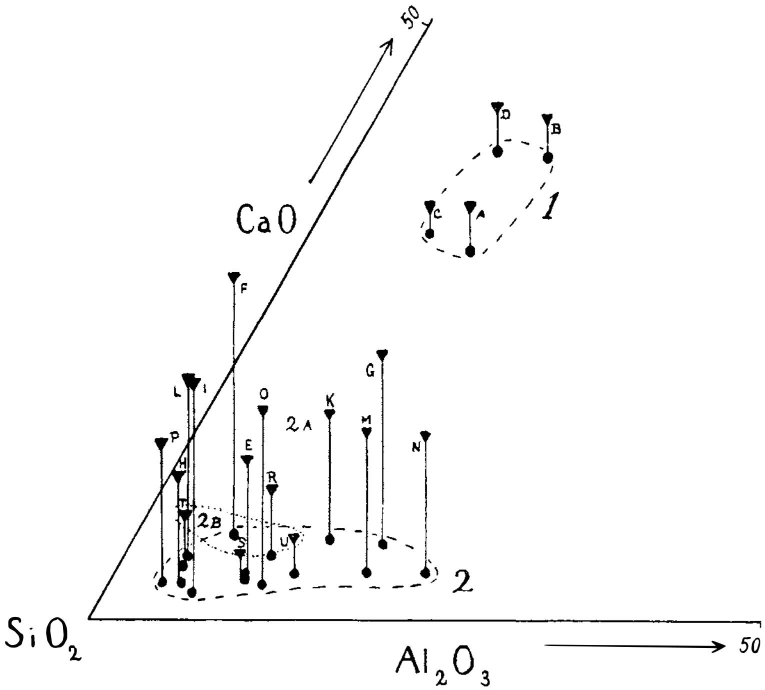

Fig. 3.

We now have points within the triangle which are determined by the mineral components of the samples (Al_2O_3 exclusively of mineral origin also, the other two of more or less mixed origin), and points additionally determined by the more transient Org. C factor without this framework.

The 2B group is more easily circumscribed here than in fig. 2, if we use the apices of the vertical lines as the points representing the different sediment samples. This, if not strictly correct, we may well do, since the bases of the lines are nearly equidistant from the horizontal ground line. The 2B group appears as a very natural one, not only are the apex points below all the others (on account of less Org. C), but the group is also compact, while the 2A group is spreading over a great area.

We thus have two natural groups: 1. Eutroph lakes rich in lime, 2. Dystroph-oligotroph lakes, which falls into two subdivisions: 2A. Forest lakes in Wisconsin, 2B. Arctic lakes in Alaska.

Table 1.

Name	Lønavatn	Øvre Vangs-vatn	Nedre Vangsvatn	Evangervatn	Feforvatn	Feforvatn	Steinsfjord	Steinsfjord	Holsfjord	Holsfjord	Hornindals-vatn	Breimsvatn	Strynsvatn	Loenvatn	Oldenvatn
Symbol	A	B	C	D	E	F	G	H	I	K	L	M	N	O	P
Depth ms	26	56	42	107	53	53.5	19	20	148	283	461	278	209	132	92
SiO_2	50.73	46.12	43.10	45.33	55.59	57.66	59.11	55.27	55.42	50.65	48.82	52.49	57.41	57.47	59.40
Al_2O_3	14.08	15.35	17.36	16 07	4.28	9.60	16.78	20.17	18.45	17.69	15.97	17.25	18.34	19.34	17.07
Org. C	8.14	8.90	7.29	8.18	11.16	6.56	1.80	0.76	1.55	3.38	5 67	2.95	1.36	0.74	0.65

Table 2.

Name	Mendota	Monona	Monona	Okauchee	Adelaide	ForestryBog	Ike Walton	Laura	Long	Lost Canoe	Mary	Plum	Silver	Star	Trout	Turtle	Karluk	O'Malley	Thumb
Symbol	A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	R	S	T	U
Depth ms	24	8	22	27	19	2	18	12	12	12	21	15	17	18	32	13	120	12	10
SiO_2	36.32	28.15	36.50	31.26	39.33	9.35	22.07	42.54	22.67	30.20	33.50	30.13	30.68	42.78	41.29	40.70	60.26	69.42	58.12
CaO	19.88	23.32	20.40	24.70	1.39	0.76	1.84	1.36	0.60	2.38	1.90	1.48	1.72	1.63	1.42	2.44	2.19	3.67	2.58
Al_2O_3	8.28	8.98	5.34	6.49	4.44	0.80	5.45	2.34	1.43	5.63	1.78	7.24	9.56	5.84	1.79	5.19	6.63	3.63	9.36
Org. C	7.05	6.57	4.72	7.22	18.50	38.95	28.66	17.09	31.99	19.80	26.92	21.30	21.30	25.86	20.27	10.54	4.41	8.22	6.37

By the use of graphical methods for classification of lake sediments we may very often arrive at a classification of the lakes themselves, as in so many cases the sediment is the final expression of the lake type.

The graphical method can certainly also be used for a classification of lakes based upon the chemical composition of the waters. E. g. a classification recognizing the essential Ca, N + P and Humus factors, or indeed any factors that can be numerically expressed, even if these factors are not strictly within the same category. Comparative limnology may vastly benefit from the use of this method, as has petrology done in the past.

Literature Cited:

1929. C. S. BLACK: Chemical Analyses of Lake Deposits. — Trans. Wisconsin Acad. Sci. *24*.

1900. A. OSANN: Versuch einer chemischen Klassifikation der Eruptivgesteine. 1. — Tschermaks Min. Petrogr. Mitt. *19*.

1933. K. M. STRØM: Recente bunnavleiringer i norske innsjøer. — Norsk Geol. Tidsskr. *13*.

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