9. Separation of glauconite by means of a modified Berg dielectric procedure

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Introduction.

Glauconite has been much discussed in geological literature, but the problem of its genesis has not been definitely solved. Uncertainty as regards its lithogenetic significance may be the reason for the fact that glauconite has scarcely played an important rôle in lithogenetic discussions.

As a matter of fact, glauconite may be formed in different ways. But the main processes seem to be either metamorphosis of biotite or resorption of chiefly iron and potassium by colloidal silica. In the latter case grains of irregularly rounded shape and fillings of the interior of shells are formed. Such precipitates may constitute the main part of the glauconite in the fossiliferous deposits of Scandinavia.

The basic cause for formation of glauconite in this way is that great quantities of silica are present. Another important reason is the fact that fairly great quantities of iron and potassium are supplied. As the glauconitic iron is ferric for the most part the formation of glauconite may take place in ventilated surroundings.

Such conditions may be created in coastal waters during inundations of kaolinized land surfaces. Great quantities of silica are supplied to the water on such occasions. A high content of electrolytes in the water causes the silica to be precipitated as highly concentrated colloids, to a great extent in the coastal zone. Together with the silica, iron is transferred to the water from the weathering products. Easily dissociable iron salts cannot be transported beyond the coastal zone; they are hydrolysed and oxidized into hydrous iron oxide, which is precipitated since it has a very low solubility product in sea water owing to the high pH prevailing there (about 8). It is a well-known fact that open sea water has an extremely low content of soluble iron compounds. As regards potassium, the great quantities which are included in glauconites (often 7—9 % K_2O, cf. HADDING 1932) are scarcely derived from the weathering products (parts possibly from mica, however). The water's content of potassium is very low. But in the coastal zone there exists a source of potassium, viz. phytal detritus. However, algal life cannot flourish during the initial phase of a transgression when the water is muddy and the transparency is low. Only somewhat later, when the transgression has proceeded so far that the very shore has come in greater distance and settlings in the water are fewer, can an abundant algal life arise. At this stage in the transgression one may expect glauconite to be formed, but scarcely during the first phase of the transgression when the erosive agencies stir about in large masses of weathering products causing bad conditions for algal life and, consequently, an inferior production of potassium.

We have had a very good opportunity to study the sedimentological consequences of a transgression over a deeply kaolinized land surface, not least as regards the formation of glauconite. The material is a drill core through the Senonian stratal sequence of the Kristianstad District in S. Sweden (Scania). The drilling was performed at Åhus. The Cretaceous layer extends from 5.63 m below the land surface to 182.86 m. It consists mainly of sand and sandstones with calcareous matter, but it is also partly a limestone; in the lowermost section there are sand and clay substances in different composition. Glauconite is included in parts of this section of the stratal sequence.

We have found that glauconite was formed during the part of the transgression which was just as theoretically expected to have been most favourable for formation of glauconite, i. e. somewhat after the violent initial stirring about of the weathering products by the erosive agencies.

These results have been arrived at by ascertaining the composition of the sediment on each half meter (results reproduced in part in Fig. 3). To establish the content of glauconite we have used a special method which is described in the present paper.

For courtesy and valuable assistance during the elaboration of the method we are indebted to Prof. P. OHLIN and Dr K. G. FRISKOPP.

The method.

The method is based upon the principle that particles are attracted to the electric field between two oppositely charged electrodes if the dielectric constant of a non-conducting medium in the electric field is inferior to that of the particles. On the contrary, particles with an inferior dielectric constant are repelled. As known, the dielectric constant of a medium indicates the force of the field in relation to the force of a field in vacuum under identical conditions.

This method is especially suited for separation of glauconite since this mineral has a high dielectric constant in relation to other minerals with exception for a few, such as ilmenite, magnetite, pyrite, and hematite. Such minerals have to be removed by means of magnetic separation and separation in heavy liquids (bromoform) before dielectric analyses.

According to Berg (1936), the dielectric constant of glauconite is 14—15, and is thus considerably different from those minerals which have a dielectric constant next inferior to glauconite (opal 8—9, biotite /Fe/ 6—7, augite and biotite /Mg/ 5—6). A great many minerals investigated have dielectric constants inferior to 5; among them is quartz.

It should be noticed, however, that other values than those presented above are given in the literature (the International Critical Tables). As interpreted by Berg, these differences are most likely due to different procedures used and different liquids employed.

We have used practically identical voltage and frequency of the alternating current as did Berg and the same liquids in about identical composition. For this reason, the values presented by Berg are applicable in our case.

A mixture of furfural and benzene has been used as liquid (voluminal proportions 1 : 5). This gives a dielectric constant of 9.

The dielectric constant of the liquid is calculated in this way:

$$\left.\begin{aligned} 2.28\,x + 42\,y &= k \\ x + y &= 1 \end{aligned}\right\}$$

2.28 is the dielectric constant of benzene
42 » » » » » furfural
x » » voluminal quantity of benzene
y » » » » » furfural
k » » desired dielectric constant of the liquid.

First we worked with a dielectric constant of the liquid of about 13, but, as the dielectric constant of the mineral is rather rapidly decreased in the liquid, it happened that glauconitic grains were not attracted during the latest part of the analysis. To be sure on that point we decreased the dielectric constant of the liquid to about 9.

As mentioned by Berg the furfural should be colourless. For this reason it is very important that the furfural is newly distilled. Furthermore, the same mixture should not be used for more than a restricted number of analyses (about 10 samples), since the dielectric constant is altered on account of evaporation of benzene. The mixture stored in a brown bottle is very constant, however.

The electrical equipment is shown in Fig. 1. It consists of a regulation transformer (*A*) with a switch in the primary circuit (primary circuit 220—230 volts, secondary circuit 0—260 volts; we used a transformer of 500 watts), a stepping up transformer (*B*) 1 : 10 (60 watts), a resistance (*C*) of 2000 ohms, a voltameter *D* ([0—1200 volts], in the figure a universal instrument is shown), and the electrodes (*E*).

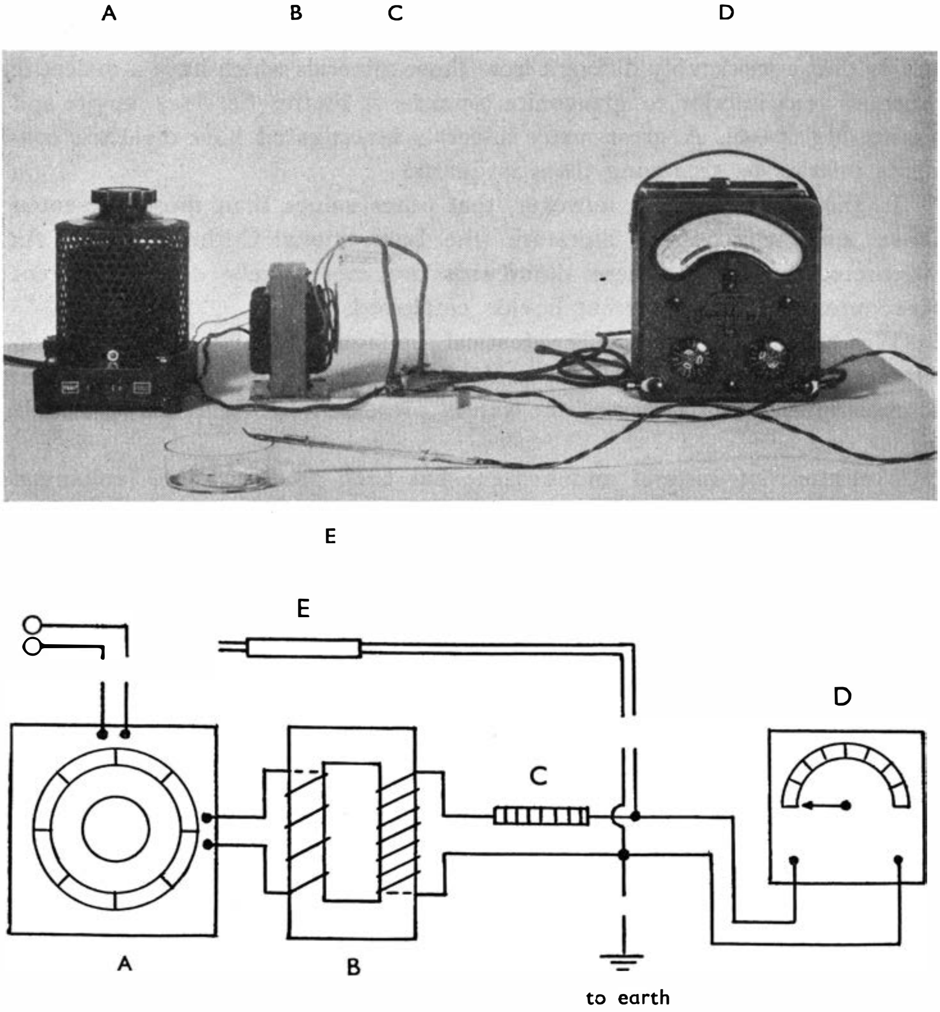


Fig. 1. View of the electric equipment and schematic diagram of coupling (cf. this page) *A* regulation transformer, *B* stepping up transformer, *C* resistance, *D* voltameter, *E* electrodes mounted in a glass handle.

The current of the primary circuit is ordinary 220 volts, 50 cycles alternating current. This is transformed in the regulation transformer into 88 volts which, in turn, is increased to 880 volts by means of the stepping up transformer. Having passed the resistance this high voltage current is conducted to the electrodes; the voltameter is coupled parallel to the high voltage circuit. The resistance is used for delimitation of the effect of short circuits to about 0.4 amperes which does not spoil the transformer. Short circuits take place if conducting minerals should happen to come between the needles; this, however, is seldom the case since such minerals have been removed by the preceding magnetic and heavy liquid separations.

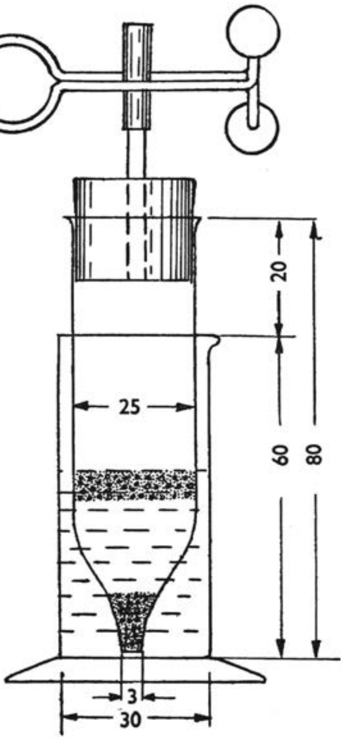
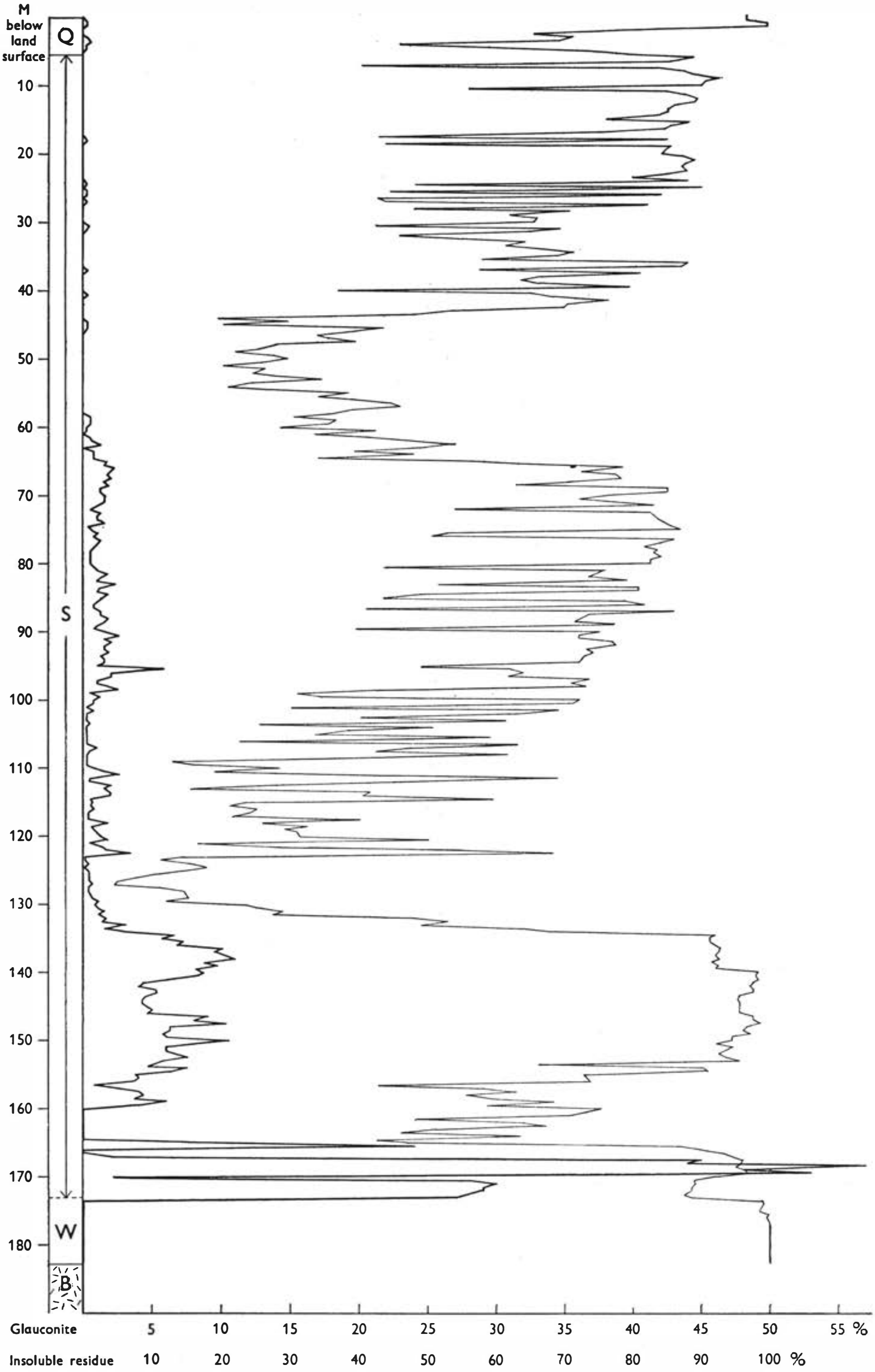


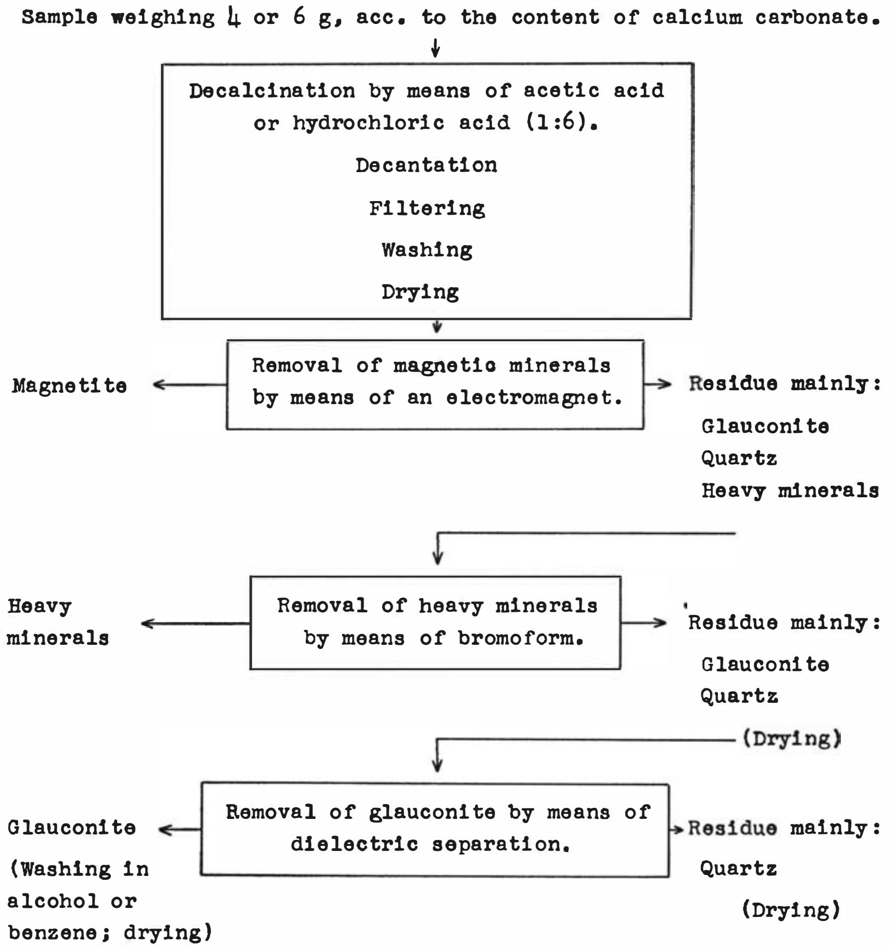
Fig. 2. Apparatus used for heavy mineral separation (cf. below), measures in mm.

The electrodes consist of copper threads (1 mm diameter) mounted in a glass handle (about 20 cm length); silver electrodes are less suitable, since silver is difficult to fuse in glass (melting point of silver is inferior to that of glass). The free parts of the threads are about 10 mm and are gently curved. The gap is about 1 mm.

In the present investigation, samples weighing 6 g were decalcified by hydrochloric acid 1 : 6 (acetic acid may also be used), and dried (a weight of 4 g was suitable for samples from non-calcareous or little calcareous sections). Decalcination is necessary. Magnetite was extracted by means of an electromagnet, and other heavy minerals were separated in bromoform. For bromoform separation the apparatus shown in Fig. 2 is useful. When the inner tube is lifted up, after the rubber stopper has been tightly fixed, the heavy minerals are gathered in the outer tube and the other minerals


M below land surface
Q
S
W
B
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
Glauconite 5 10 15 20 25 30 35 40 45 50 55 %
Insoluble residue 10 20 30 40 50 60 70 80 90 100 %

SCHEME OF PROCEDURE.



in the inner. After drying, the latter minerals, which consist mainly of quartz grains and also include glauconite grains, if present, are placed in a small dish with low walls which, in turn, is placed in a somewhat larger glass container. So much liquid is poured into the container that the small dish is entirely submerged. The electrodes are put down in the sample and the current is

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Fig. 3. Distribution of glauconite in the Senonian stratal sequence investigated by means of the procedure described in this paper; the curve with somewhat thicker lines referable to glauconite. The curve with the thinner lines reproduces the distribution of the residue insoluble in acetic acid (includes the glauconite).

B Bed-rock.

W Weathering products of wide granulometric distribution.

S Alternating strata of calcareous sand, calcareous sandstones, and limestones; between about 160 and 167 m clay substances.

Q Quaternary.

Discussion of the genesis of the glauconite-bearing section, cf. p. 571 f.

switched on by the switch on the regulation transformer. When glauconite grains have been collected in the electric field the electrodes are transferred to the outer container, and the current is switched off. Then the grains sink to the bottom. The electrodes should not be removed from the liquid as long as the current is switched on, since sparks (which may appear at the switching off) can set fire to gaseous benzene; sudden disruptive discharges do not occur in the liquid, provided that conductive minerals have been carefully removed.

When the glauconite of the sample is entirely removed, the small dish is taken up with a pair of tweezers, and the liquid filtered off. The liquid of the large container is removed by decantation. The glauconite may be washed in alcohol or benzene before drying and weighing, but this is not absolutely necessary.

Since benzene is highly inflammable the separation must be performed in good ventilation.

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The method described above is rapid and sufficiently reliable for lithogenetic investigations of the present type. Minerals other than glauconite are scarcely attracted by means of the dielectric effect used. However, it may happen that some non-glauconitic grains are enclosed mechanically among the glauconite grains in the electric field and thus removed together with the glauconite. But such grains are easily detected at the ordinary binocular examination of the glauconite extracted, and may thus be excluded.

Bibliography.

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