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ON THE IDENTIFICATION
OF FELDSPARS IN SOILS

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SUMMARY

The fertility of a soil is to some extent determined by its mineralogical composition. Therefore, the analysis of the entire mineralogical composition of a soil carries rather useful information. Even if the economic situation in a certain country allows for an unlimited use of all kinds of fertilizers the above statement remains true, especially for minor elements.

Attention is focussed on a relatively unknown part of the soil matter, viz, the light mineral fraction with a particle size between 50 and 420 μ . Among the minerals in this fraction feldspars are important. In the light of new developments in feldspar identification X-ray powder methods and measurements of indices of refraction are advocated as the most efficient and reliable techniques. It is explained that a quantitative mineralogical analysis of this fraction is made easier if satisfactory concentration techniques can be applied. Moreover, it is argued that the toilsome counting of particles in index liquids may be partly substituted by staining and the much easier counting of yellow and blue grains. A staining technique as well as a method for the separation of feldspars with heavy liquids, both developed by Favejee, are described. Finally the systematical treatment of a sample is discussed. Problems still present themselves in treating the fraction between 8 and 50 μ .

INTRODUCTION

One of the important aspects of a soil is its fertility. Soil fertility is determined by a large number of factors. Among these the contribution of elements for plant nutrition by the minerals present in the soil should not be overlooked, though the economic situation in a number of countries allows for an unlimited use of

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all kinds of fertilizers. This very function of minerals in soils completely warrants an attempt at analysing the entire mineralogical composition of soil samples.

For a systematic treatment the soil matter may be divided into a part consisting of minerals exclusively and a part holding the organic matter. The mineral fraction of the soil is composed of:

- a. a fraction consisting of light minerals, viz, minerals with a sp. gr. < 2.89,
- b. a fraction consisting of heavy minerals, viz, minerals with a sp. gr. > 2.89,
- c. a fraction consisting of a.o., the so-called clay minerals, the fraction smaller than 0.5 micron.

Because the fractions b and c have been studied intensively over a long period of time and by a large number of soil scientists, one would expect their contribution to the soil fertility to be well known at present. However, the clay fraction and the light fraction may well be a much larger source of minor elements such as copper, manganese, magnesium and borium than the negligible amounts of such elements present in the heavy fraction.

In comparison with these two the light fraction is still a rather unknown part of the soil matter, notwithstanding the efforts of a large group of workers in this field of investigation. The difficulty of quickly distinguishing between quartz and feldspar, and between different feldspars is one of the reasons for this fragmentary knowledge. We made a rather intensive study of the methods for the determination of these minerals. By a proper selection and by modifying existing methods a set of routine techniques has been developed. Such routine methods must rapidly give adequate information on the mineralogical composition of the light fraction of a soil sample. In the following we will describe the considerations pertinent to this selection and modification.

THE COMPOSITION OF THE LIGHT FRACTION

Any textbook of mineralogy may inform us about the minerals that may theoretically be found in the light sand fraction of a soil sample. Analyses of a

TABLE 1. Specific gravities of a number of minerals to be expected in the light fraction of some soils or sediments

Opal	1.95-2.10	Beryl	2.65-2.85
Sodalite	2.2 -2.4	Calcite	2.71-2.72
Gypsum	2.2 -2.4	Dolomite	2.87
Serpentinite	2.5 -2.65	Prehnite	2.80-2.95
Alkali feldspar	2.56-2.62		
Cordierite	2.57-2.66	Chlorite	2.6 -3.0
Chalcedony	2.6 -2.65	Stilpnomelane	2.7 -3.0
Scapolite	2.61-2.70	Muscovite	2.76-3.00
Plagioclase	2.62-2.76	Biotite	2.8 -3.4
Quartz*	2.63-2.67		

* The specific gravity of quartz may vary considerably due to small inclusions of gas, liquid and/or heavy minerals.

large number of samples from sediments and soils make it clear that quartz, feldspar, carbonates and mica are frequently important constituents of this fraction. Other minerals, cf., table 1, may occasionally be found.

The determination of the CaCO_3 content is comparatively easy. The analysis of the quantity of mica may be done by sorting methods based on the difference of morphology and by magnetic separation, in the same way as described for the preparation of mica concentrates for age determination by the Rb-Sr method, cf., EMILY JÄGER (1962). The identification of feldspars in the light fraction of soils remains to be treated. The identification of quartz goes along with that of feldspars.

FELDSPARS

The latest developments in the study of the different phases that belong to the feldspar family necessitate a revision of the conception of older textbooks. It would lead too far to discuss the details of the present situation, the more so because a book on detrital feldspar identification for sedimentologists and soil scientists is in press (VAN DER PLAS, 1965). For those unfamiliar with the new ideas the following rather simplified feldspars scheme may be of interest, cf., table 2.

TABLE 2. An explicative scheme illustrating the more simple relation between the various feldspar phases known to occur frequently in rocks.

Chemically feldspars are crystalline phases of formula $A B_4O_8$;

A, a large low valent cation e.g., K, Na, Ca.

B, includes both Al and Si.

Chemically feldspars may thus be classified:

$K AlSi_3O_8$, abbreviated Or (from orthoclase) : Potassium feldspar

$(KNa)AlSi_3O_8$: Alkalifeldspar

$Na AlSi_3O_8$, abbreviated Ab (from albite) : Albite

$(NaCa)AlSi_3O_8$: Plagioclase feldspar

$CaAl_2Si_2O_8$, abbreviated An (from anorthite) : Anorthite

Physically feldspars form a system of various phases with a continuous structural variation between high- and low-temperature modifications. The low temperature binary systems of alkali feldspars and of plagioclases do *not* form a continuous series of mixed crystals between the endmembers; unmixing may be seen in some of the chemically intermediate phases. Perthites and peristerites are the result of such unmixing processes in the alkali feldspars and in the plagioclases respectively.

Alkali feldspars:

High temperature phases, monoclinic : sanidine*

Low temperature phases, triclinic : microcline

Perthites, lamellar aggregates formed of alkali feldspar and sodium-rich feldspar.

Plagioclase feldspars:

High temperature phases, triclinic continuous series of mixed crystals

Low temperature phases, triclinic discontinuous series of mixed crystals, with various structures.

* Such names as orthoclase, anorthoclase, adularia etc. should now be avoided in soil science.

FELDSPARS IN SOILS

It must be stressed that the feldspar assemblage of a soil is fundamentally different from that of an igneous or metamorphic rock. Methods for the study of feldspars, however, have been developed to a large extent by students of these igneous and metamorphic rocks. Therefore it is conceivable that these methods need some modifications.

The main difference between the feldspar content of igneous and metamorphic rocks on one hand and of soils developed on recent or old sedimentary deposits on the other hand is due to the fact that the mineral assemblages of the first group of rocks are governed by the laws of thermodynamics, whereas the mineral assemblages of soils are partly a function of other factors such as: region of provenance of the parent material; the various stabilities of minerals under weathering conditions; reworking of sediments and mixing of sediments from different sources. In igneous and metamorphic rocks, a limited number of minerals are found next to each other. The investigator of these rocks assumes from experience that the results of a few determinations of feldspar fragments may be generalized for the whole complex. In soils developed on sedimentary rocks the feldspars present may have derived from an unknown number of unknown rocks. Acid and calcic plagioclases as well as high- and low-temperature phases of alkali feldspars and plagioclases may be found next to each other in one sample.

A soil sample is, furthermore, a collection of large and small mineral particles. Feldspars are to be expected both in the small and in the larger size fractions. The methods for the study of large feldspar particles differ considerably from those for studying small feldspar particles. Still determinations have to be made in every size fraction, because the feldspar assemblages may differ from size fraction to size fraction. Moreover, the information of different methods is not always comparable.

Finally the amount of feldspar particles in a soil may well be rather low. For that reason it is difficult to make an efficient use of the available determination methods, especially if one wants quantitative information. Therefore, we make RETGERS' (1891) principle about the necessity to concentrate certain minerals before they are studied, the keystone of our procedures.

CONCENTRATION METHODS

Different methods have been used in order to identify the feldspars in the light fraction of soils. Determination of feldspars can be a rather time-consuming occupation. Therefore, the investigator does not like to waste much of his time inspecting large numbers of other particles. Consequently, a first step in setting up a routine procedure for feldspar identification is the development of an adequate concentration method.

In mineral industry flotation techniques and electrostatical separation are successfully used for the concentration of feldspars, cf., KIRCHBERG (1955). For large samples flotation is also used on a laboratory scale in many ore-dressing

laboratories. Preliminary investigations showed that soil scientists may expect good results from flotation of even small samples in the near future.

A well-known method for the concentration of feldspars is based on the specific gravity of these minerals. In the following sections we will deal with the specific gravity concentration of feldspars in detail. The other methods described before will not be discussed any further.

SPECIFIC GRAVITY SEPARATION OF FELDSPARS

Specific gravity concentration of feldspars in different fractions has already been used by RETGERS (1891), although the liquids he used at that time have now become obsolete. In specific gravity separation with liquids two aspects must be considered. The first deals with the shape and the size of separation vessels. The second aspect concerns the properties of the liquids and the particles therein.

Separating vessels.

After a large number of experiments with different types of vessels and funnels Favejee developed a special type of funnel with steep walls for the specific gravity separation of feldspar particles with a minimum size of 100 microns, cf., fig. 1. Particles smaller than 100 microns are efficiently separated into different specific gravity fractions by making use of a centrifuge. Centrifuge separations, however, are delicate to perform if the specific gravity difference between the particles and the liquid is rather small. Numerous suggestions as to the shape of the tubes and the special tools to be used for securing the separates

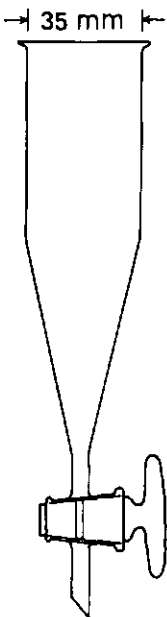


FIG. 1. Favejee funnel. The measure gives an impression of the size. The drawing is true to scale.

have been made. It will be found that tubes with stoppers, pipettes and plastic bags are difficult to handle in feldspar separation, because remixing occurs rather easily, not to mention particles that remain in suspension. The tube described by VAN DER VEEN (1963, p. 44, Fig. 3-2) and presumably designed by Taylor is rather easy to handle.

Heavy liquids

The practical limitations of specific gravity separation are for a large part due to the various properties of the liquid. These properties are systematically listed in the following enumeration:

- a. The viscosity of the liquid causes small particles to settle rather slowly.
- b. The small differences between the specific gravity of the different feldspars require an accurate determination of the specific gravity of the liquid.
- c. Some of the available feldspar particles may have exactly or approximately the same specific gravity as the liquid; they consequently stay in suspension.
- d. The occurrence of specific lighter or specific heavier inclusions in feldspars such as albites influences the specific gravity of the entire particle.
- e. Variations of the temperature of the heavy liquids cause variations in the specific gravity.
- f. Liquids obtained by mixing may change their properties in the course of time due to the different vapour pressures of the components of the mixture.

From the foregoing enumeration it follows that a useful liquid must have a low viscosity. If it is a mixture of liquids the components must have approximately the same vapour pressure. Favejee advocates a mixture of bromoform and decaline. This mixture has good wetting properties and the vapour pressure of the components is almost the same. Our experiments show this liquid to be extremely stable over periods of more than two years.

Mixtures of liquids for use in routine procedures.

The feldspars of the light fraction must be divided into a few subfractions. Every subfraction must hold a group of feldspars. The group limits must be set in such a way that they meet the requirements of the subsequent mineralogical analysis. The limits also depend on the specific gravity differences that can still be used efficiently in a separation with heavy liquids. We found that the difference between the specific gravity of the liquids must be at least 0.04.

The light fraction is generally rich in quartz. RETGERS (1891) already observed that an abundance of quartz hinders the identification of other minerals. Therefore, the specific gravity fraction holding the bulk of quartz particles must be separated from the rest of the sample. The apparent specific gravity of quartz particles ranges between 2.63 and 2.67. Unfortunately oligoclases are also found within this range.

It is only too obvious that we aim in the first place at the production of an alkali feldspar fraction and a plagioclase fraction. Therefore, one of the liquids must have a specific gravity of 2.59, the maximum specific gravity observed in alkali feldspars.

On the basis of these considerations Favejee suggested the densities listed in table 3. NOTA and BAKKER (1960) proved this suggestion to be of practical value. In the course of our investigations since 1960, the usefulness of these limits has been experienced in numerous routine analysis of light fractions of samples from sands and soils. Finally one must be aware of the possible presence of other minerals in the feldspar concentrates obtained in the way just described. These minerals may be found in the list of table 1.

TABLE 3. Density limits for the separation of feldspar fractions with heavy liquids

Sp.gr., 2.59; the lighter fraction holds alkali feldspars exclusively
2.59 - 2.63; the fraction holding albite and some quartz
2.63 - 2.67; the fraction holding quartz and acid plagioclases
2.67 - 2.89; the fraction holding calcic plagioclases

IDENTIFICATION METHODS

In this section we will deal with three types of identification methods. The first one is based on a selective staining of feldspars as a whole and a selective staining of alkali feldspars. This method enables an evaluation of the total feldspar content, of the alkali feldspar content and consequently of the quartz content and the plagioclase content by subtraction. Moreover staining methods enable the analyst to prepare small concentrates by handpicking, provided the grain size is fairly large.

The second method is based on optical properties in general and on index of refraction and axial angle in particular. A third deals with the X-ray powder method.

In petrography staining techniques are used on a large scale in order to facilitate identification. Staining of feldspars in thin sections is an old technique and especially useful if these minerals form a small part of the sample only. Favejee developed a routine method for staining feldspar particles with a minimum size of 50 μ . The method is based on the formulas of GABRIEL and COX (1929) and of REEDER and MACALLISTER (1957). The coatings produced on the mineral surface by hydrofluoric acid vapour are stained with different chemicals. Alkali feldspars are stained yellow with sodium cobaltinitrite forming the yellow potassium cobaltinitrite with the potassium ions in the etch coating. The aluminium ion present in the coatings reacts with hemateine forming a purplish blue compound. If both staining methods are simultaneously applied the cobaltinitrite staining method must precede the hemateine staining. It is perhaps not superfluous to say that the etch coatings on quartz particles remain unstained, hence the identification of quartz particles from the absence of a coloured coating in samples stained with hemateine.

We use a small platinum dish, with a flat bottom (fig. 2 G). The particles should just about cover the bottom of the dish in a layer of single particles. Only then can the etching vapour and the wetting with solutions afterwards

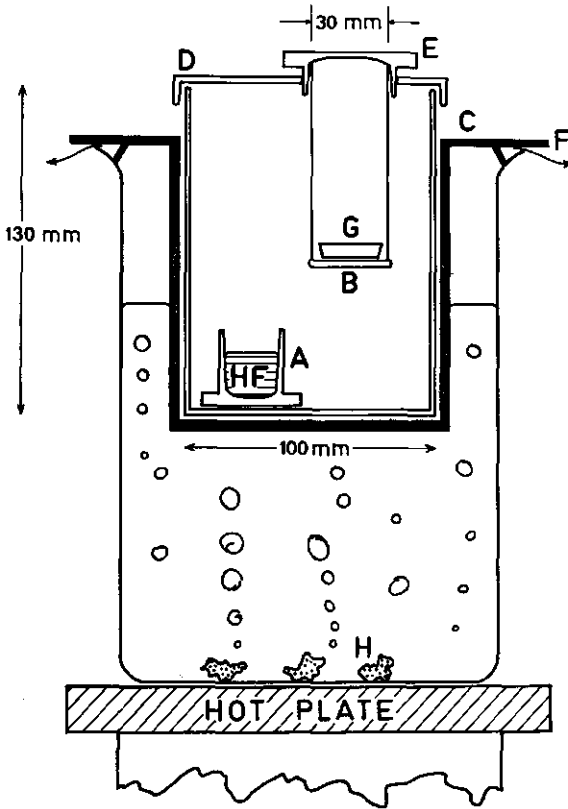


FIG. 2. Vessel for etching feldspar particles with HF-vapour. A; the plastic crucible holding HF-liquid. B; the support, made of polyethylene, for the platinum dish G. C; a tin mantle supporting the plastic vessel with openings F, for the escaping steam of the waterbath. D; the lid of the etching vessel. E; the stopper made of plastic closing the hole in the lid D. H; boiling stones. The measures are approximate and give an impression of the size of the different parts.

easily reach the surface of each particle. Etching is done in a plastic vessel with a lid, fig. 2D. The vessel containing a small plastic crucible with the HF-liquid, fig. 2A, is surrounded with a water mantle. The water is kept at boiling temperature. The lid of the vessel has a small hole, again covered with a plastic stopper, fig. 2E. A support for the small platinum dish, fig. 2G, is attached to the stopper as pictured in fig. 2B. The platinum dish is placed on the support and lowered in the etching vessel. The particles of feldspar are kept in the vessel at a temperature of about 90°C for exactly one minute. The stopper closes the vessel during this time. The coating produced in this way is slightly hygroscopic and only loosely connected with the particle surface. Therefore, Favejee heats the sample in a small furnace at 400°C for about 5 minutes. The coatings are now more strongly fixed on the surface. In this way staining is

more easily performed, the quality of the stain is better and the particles do not tend to agglomerate. Staining is done in much the same way as described in the paper of REEDER and MACALLISTER (1957). For the interested reader the formulas follow here in a concise form.

Staining of feldspars

Reagents: A., a solution of 50 mg of hemateine in 100 ml of 95% ethanol.

B., a buffer solution consisting of 20 g sodium acetate in 100 ml of distilled water, to which 6 ml of glacial acetic acid is added afterwards. Dilute the whole to 200 ml. The solution is approximately 0.5 N and is buffered at pH 4.8.

Procedure: The sample after etching and heating in the furnace is covered with 10 drops of the hemateine solution A., and 5 drops of the buffer solution B. The whole is immediately mixed by swirling the platinum dish for about one minute. Five minutes after the addition of the liquids, the sample is washed with 95% ethanol. The liquid is siphoned off and the sample is twice washed with acetone. The feldspars now show a purplish blue stain.

Staining of alkali feldspars

Reagents: A solution of 1 g of sodium cobaltinitrite in 4 ml of distilled water.

Procedure: The sample in the platinum dish, after etching and heating in the furnace is covered with the cobaltinitrite solution for one minute. Afterwards the sample is washed with distilled water. The excess of water can be siphoned off. The alkali feldspars show a yellow stain.

N.B., If one wants to stain the samples with cobaltinitrite and hemateine simultaneously, the cobaltinitrite staining has to precede the hemateine staining. On the other hand, staining can also be done on samples that have previously been stained and cleaned. For the removal of the cobaltinitrite stain as well as the hemateine stain we treat the particles for some time in a small porcelain crucible in one ml of a solution of HCl 2N, to which a few drops of H₂O₂ 30% are added. The crucible is placed on a waterbath at boiling temperature. In this way the stain is removed together with the etch residue. The sample can now be etched and stained anew.

Identification with optical methods

Numerous papers have been written on the optical identification of feldspars. In our opinion the determination of the index of refraction gives the best results for the identification of detrital feldspars. Alkali feldspars can be identified by their low index of refraction, plagioclases can even be separated into a few groups according to the chemical composition. The choice of the proper liquids for such an identification procedure is dealt with by NOTA and BAKKER (1960). Measurements of the orientation of the indicatrix though more accurate, are time-consuming and require additional apparatus in most cases. These methods are not fit for routine procedures. Moreover, the last mentioned technique can only successfully be applied with thin sections and not with grain slides. Finally routine work on the basis of optical properties, e.g., on index of refraction measurements, is dependent on particle size; if the particles are too small, an

efficient identification is out of the question. A distinction between alkali feldspars and plagioclases can still be made by phase contrast microscopy, as witnessed by the results of SCHÖNER (1960). For routine identifications a minimum size of about 35μ seems a necessity. If we realize that X-ray powder work on feldspars is restricted by a maximum particle size of about 8μ , it is clear at once that the main problem of a quantitative feldspar analysis of a soil sample is met with in the size fraction between approximately 8 and 35μ . Some more will be said about this aspect in the section on X-ray powder analyses.

The structural properties of feldspars may be of interest for the rate of weathering of these minerals. It is known, that high temperature feldspars such as sanidine weather more rapidly than low-temperature feldspars such as microcline. Since MARFUNIN (1961) brought evidence of the assumption that monoclinic alkali feldspars are generally characterized by axial angles smaller than 44° , it is possible to distinguish between high-temperature and low-temperature alkali feldspars. From now on alkali feldspars with an axial angle larger than 44° have to be termed microcline, even if microscopical inspection does not give further evidence for the presence of a triclinic phase. The presence of cross-hatched twinning or oblique extinction on (001) is not the only diagnostic property for the identification of triclinic alkali feldspars.

X-ray powder methods

For the study of feldspars in soil samples X-ray methods may have advantages. In some cases the available amount of sample can be rather small, viz, a specific gravity separate or a small number of grains isolated by hand picking from a stained sample. It is experienced that the samples are in most cases too small for the standard sample holders of most diffractometers. For that reason we rely on cameras. For extremely small samples, e.g., 5 grains, a small Debeye-Scherrer camera (FAVEJEE, 1939) is used with a sample prepared according to HIEMSTRA's method (1959). If the samples are larger the quadruple Nonius Guinier-de Wolff camera, also advocated by GOLDSMITH and LAVES (1954, 1961) for feldspar work, is used.

Powder patterns prepared with this camera permit an easy distinction between sanidines, microclines and perthites. The identification of the various plagioclases is difficult and from the results of PETERSON and GOLDBERG (1962) with fine-grained marine sediments, it can be concluded that the identification methods developed by SMITH (1956) and SMITH and GAY (1958) give the best performance.

Experiments with feldspar samples taught us, that the maximum particle size giving reproducible results in X-ray powder patterns is about 8μ . The quantification of feldspar particles in silt size samples with a microscope is efficiently done if the particle size is over 35μ . The problem remains how to determine the amount of total feldspar as well as the amount of the various types of feldspars in samples with a particle size between 8 and 35μ .

An efficient method to treat this fraction has not yet been found. The minerals in this fraction can be powdered and quantitatively analysed with X-ray

methods. The main drawback of this procedure is the fact that, because of differences in toughness and the perfect cleavages present in feldspars, the powder thus prepared holds more fine feldspar material than fine quartz. To avoid this disadvantage one may powder the sample by hand in an agath mortar under acetone using small amounts of sample at a time.

ASPECTS OF A TENTATIVE ANALYTIC SCHEME

It is self-evident that the discussion of the entire mineralogical analysis of a soil sample is out of the question. We restrict ourselves to those parts for which we developed a new combination of methods.

To begin with the pretreatment of the sample, the organic matter is removed by a 10% H_2O_2 treatment over a water-bath. In order to remove the carbonates the sample is treated with cold 0.2 N HCl. The iron compounds covering the particles are removed with sodium dithionite. After these treatments the sample is wetsieved over a 50 micron sieve and over a 420 μ sieve, the parts are weighed and retained.

The fraction 50–420 microns

The analytical results secured from this fraction are used as a source of preliminary information. The heavy minerals are separated with bromoform, weighed and counted. The light fraction is carefully collected and weighed. This fraction is afterwards stained with hemateine as described before. The stained sample, usually about 10 mg., is inspected with a stereomicroscope and incident light in order to estimate the total feldspar content and in order to get an impression about the distribution of feldspars over the particle sizes. The magnification usually does not exceed 40x. The same sample after cleaning in the way described is stained yellow with cobaltinitrite for an estimate of the alkali feldspar content. Combining the results lead to an insight in the feldspar content of the sample. If necessary these samples can be counted.

The fractions 420–210 μ and 210–105 μ .

The fractions 420–210 μ and 210–105 μ are treated similarly. Firstly the heavy minerals are collected, weighed and counted. The light minerals are used for evaluating the amount of feldspar. Each size fraction is treated with heavy liquids in Favejee funnels as described before. Afterwards the specific gravity fractions are used as follows: (cf. NOTA and BAKKER, 1960, Fig. 1).

The alkali feldspar fraction, specific gravity < 2.59

If the specific gravity separation has been carefully performed, this fraction holds alkali feldspars and perthites exclusively. The sample is first weighed and then stained yellow with cobaltinitrite and counted. It is experienced that apart from feldspars the fraction may hold flint fragments catching a faint yellow stain. Inspection with incident light enables the analyst to distinguish between feldspars and flint fragments. In questionable cases it is advisable to separate a few suspicious fragments, clean them with HCl and inspect them with a petro-

graphic microscope. If the various properties of stained particles are frequently inspected in this way, the analyst will soon get experienced.

Partly stained particles occur frequently. The proper nature of these grains may be ascertained by means of microscopic inspection after cleaning. Another method is to isolate and clean a few fragments, and stain them purplish blue with hemateine. If albite-alkali feldspar aggregates (perthites) are present, the fragments are coloured throughout; quartz-alkali feldspar aggregates still show partly coloured particles.

The nature of the feldspars can further be determined by optical or X-ray analysis. One has to be aware of the fact that the optical data and the X-ray powder patterns of alkali feldspars need not give similar results. Under the microscope a fragment may well appear homogeneous, fully transparent, untwinned and suggesting the presence of a sanidine, whereas X-ray analysis of the same fragment betrays its perthitic nature, and makes it evident that an aggregate of microcline and albite is present.

The albite-quartz fraction, specific gravity 2.59–2.63

This fraction normally holds quartz fragments also and may still hold alkali feldspar-quartz aggregates and flint. Therefore, the weighed fraction is stained first yellow in order to spot the alkali feldspars, afterwards the cleaned sample is stained with hemateine for an estimate of the total feldspar content. Here too problems are solved with isolated and cleaned grains as described in the former section.

The quartz plagioclase fraction, specific gravity 2.63–2.67

Soil samples generally are rich in quartz. This fraction holding a large quantity of quartz has a rather subordinate feldspar content. The weighed fraction holding plagioclases exclusively, is stained blue and counted. A number of stained fragments is isolated, cleaned and inspected in index of refraction liquids. This is necessary because plagioclases, especially those of metamorphic rocks quite often contain numerous inclusions and may be found in the wrong fraction.

The calcic plagioclase fraction, specific gravity 2.67–2.89

Dutch soils are virtually devoid of calcic plagioclases. In literature, however, reports are given of soils rich in andesine and even labradorite. The samples may be stained blue and counted. In one of our experiments on a river sand from a Swiss tributary of the Rhine, viz the Valserrhein, a large fraction with specific gravity over 2.67 was found. From a petrographical description of the region we knew that only albite-bearing metamorphic rocks occur. Optical inspection of the feldspar fragments showed albites with numerous inclusions of epidote and hornblende. This example may caution not to rely on staining methods only; a control with other methods is necessary.

The fraction 105–50 microns

Our experiences with centrifuge methods for specific gravity separation are rather limited. Some of these methods, however, turned out to be inefficient for

a routine analysis. At present we treat this entire light fraction with staining methods only; adequate optical or X-ray control gives these results a higher reliability.

The fraction 50–8 microns

This fraction is our main problem and up till now efficient methods did not result from our experiments. Therefore, we rely in general on time-consuming optical determinations in the appropriate index of refraction liquids.

CONCLUSION

From the methods reported and from the information about our experiments it may be clear, that specific gravity separation and staining reactions, though not used exclusively as means of identification, provide rather quick results about the constituents of the light fraction of a soil sample. The concentration technique provides us with fractions in which only a limited number of feldspar types occurs. This limited number is experienced as a real contribution towards the efficiency of this part of the mineralogical analysis, although we still need to check our results with optical methods and X-ray photographs.

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