

A visual Method for Separating Amphibole (Kaersutite) and Mg-Clinopyroxene

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INTRODUCTION.

Amphibole and clinopyroxene are common minerals in igneous rocks. In alkaline rocks, their respective compositions correspond mainly to kaersutite and diopside or Mg-rich augite (depending on their Ca content).

Analyzing separately these minerals from the same rock may be interesting for mineralogical and petrological studies (e.g. mineral chemistry, K^{40}/Ar^{40} or Ar^{40}/Ar^{39} dating of kaersutite). If thin section point analysis is not analytically possible or economically feasible, bulk analyses have to be carried out. Then, mineral separation between kaersutite and augite-diopside is needed. Unfortunately, this is not an easy task, due to their similar physical properties (e.g. Wysoczanski, 1993).

Their magnetic susceptibilities overlap, so the electromagnetic separator is unable to separate them. Regarding heavy liquid separation, the density of kaersutite ranges from 3200 to 3280 kg/m^3 , while the densities of augite and diopside are 3200-3600 and 3250-3550 kg/m^3 , respectively. Besides, inclusions of ilmenite and magnetite are very common in these minerals, modifying in variable amounts their density values. Therefore, separation with heavy liquids is neither trustworthy.

Separation of individual grains under the stereomicroscope is another possibility, although much more time consuming. Theoretically, kaersutite crystals are dark brown or black, long and sharp-ended due to their perfect cleavage at 124° - 56° angles. On the contrary, Mg-clinopyroxenes have a greenish hue to black and perfect cleavage at right angles, so they should appear as prismatic short crystals. However, these guides are not applicable in most real samples, where both minerals present a

very similar black, somewhat elongated and shiny appearance.

In this paper we describe an easy and cheap method to optically discriminate kaersutite and diopside-augite, applied to separate these minerals in samples of Cretaceous alkaline lamprophyres from the Catalanian Coastal Ranges.

THE PROBLEM.

Several Cretaceous lamprophyre dykes (camptonite) crop out in the northern sector of the Catalanian Coastal Ranges (NE Spain). They usually carry millimetre- to centimetre-sized megacrysts of kaersutite, Mg-clinopyroxene, olivine (pseudomorphosed) and oxide minerals. These megacrysts define a porphyritic texture, where the groundmass is composed of plagioclase, kaersutite, Mg-clinopyroxene, oxide minerals, accessory acicular apatite and minor amounts of glass.

Some camptonite dykes were selected for Ar^{40}/Ar^{39} dating of the kaersutite megacrysts, which are K-rich (wt. K_2O up to 2%) and big enough to allow their separation from the groundmass.

Kaersutite megacrysts were separated at the Mineral Separation Laboratory of the Vrije University (Amsterdam). Each sample was splitted, crushed and sieved to select the 250 to 500 μm fraction, which was washed with demineralized water. The LOC-50 (Liquid Overflow Centrifuge model-50; Ijlst, 1973) was used for heavy liquid mineral separation. Heavy liquids were Diiodomethane diluted with 1,2Dichlorobenzene. In order to purify the sample for kaersutite, the floating fraction using a 3200 kg/m^3 density heavy liquid (groundmass) and the sinking fraction using a 3300 kg/m^3 density heavy liquid (olivine and oxide minerals) were removed. The 3200-3300 kg/m^3 fraction was still purified

using a Frantz® separator. The fraction magnetically susceptible to a current intensity between 410 and 500 mA was selected. It was sieved over 400 μm for easier hand-picking and washed with demineralized water again.

The resulting fraction was studied under the stereomicroscope. It contained a high proportion of black, somewhat elongated, shiny crystals, so the sample could be easily purified hand-picking the remaining fragments of groundmass (grey) and megacrysts of olivine (yellow-green) and oxides (red) with the pickpen. However, taking into account that both kaersutite and augite-diopside were present as megacrysts in the original samples and that their densities and magnetic susceptibilities overlap (see Introduction), we could not be sure that the black crystals of the purified fraction were only kaersutite, but maybe also augite-diopside. It was crucial for us to isolate kaersutite for Ar^{40}/Ar^{39} analyses. Unfortunately, the visual criteria for differentiating these minerals macroscopically were not applicable on the separated crystals.

THE SOLUTION.

The separated fraction, magnetically susceptible between 410 and 500 mA, with 3200-3300 kg/m^3 density, 400-500 μm size, purified hand-picking the remaining groundmass and megacrysts fragments, was entirely composed of black, somewhat elongated, shiny crystals. They all had the same appearance and we could not assess if they were kaersutite or clinopyroxene.

The problem of visual recognition contrasted with the simplicity of differentiating these minerals in thin section: under plane polarized light, kaersutite is brown, while clinopyroxene is colourless to light-green.

palabras clave: separación mineral, kaersutita, clinopiroxeno.

key words: mineral separation, kaersutite, clinopyroxene.

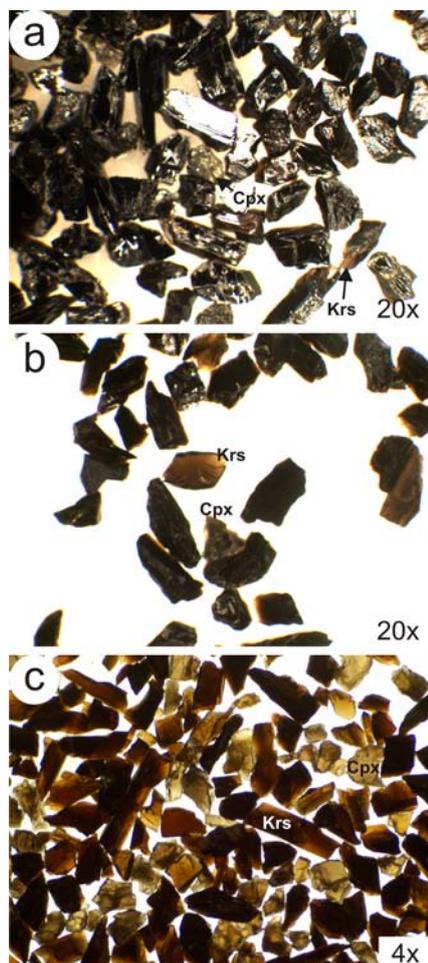


Fig. 1. Microphotographs of the 3200-3300 kg/m³ density and 410-500 mA current intensity magnetic susceptibility fraction on a transparent tray under the petrographic microscope, plane polarized light. a) 400-500 µm fraction. b) 400-500 µm fraction, with ethanol. c) 250-300 µm fraction, with acetone and tracing paper; note the easily recognizable brown and light-green colours in this photograph, in spite of its lower magnification.

Following this idea, we poured the separated fraction on a transparent tray and observed it both under the stereomicroscope (choosing the white surface) and under the petrographic microscope with plane polarized light (Fig. 1a). Some crystal rims (thinner than the cores) were brown-coloured, as kaersutites are when observed in thin section. A few others were identified as clinopyroxene, due to their colourless to light-green hue on their thin areas. Identification was not possible for thick crystals without thin rims. These observations were clearer if acetone or alcohol was poured within the tray, as refraction of light inside the liquid helped transmitting the light (Fig. 1b).

Given that the brown or light-green colours were only recognized in the

thinned rims of the crystals, we tried the observation with the finer fraction we had rejected because it was harder to hand-pick (same density and magnetic susceptibility ranges, but 250-400 µm particle size). We made the fraction even finer, sieving it under 300 µm. In this case, all the crystals were coloured, brown in most cases, light-green in others (e.g. Fig. 1c).

We carried out a series of experiments on the mentioned 250-300 µm fraction, always poured on a transparent tray. We used liquids with different refractive indexes, namely: acetone (1.359 at 20°C), ethanol (1.361 at 20°C) and ethylene glycol (1.438 at 20°C). Water (1.333 at 20°C) was ruled out due to its high surface tension, which made the studied fraction to float. We tried the observations both under the stereomicroscope and the petrographic microscope. Finally, we also tried adding a tracing paper below the transparent tray which contained the fraction and the liquid, in order to disperse the light.

Best results (Fig. 1c) were obtained adding acetone or ethanol to the studied fraction. Acetone is preferable as it evaporates quicker. Both acetone and ethanol evaporate much quicker than ethylene glycol. The tracing paper below the transparent tray also helped to show the brown or light-green colours. Finally, the observations were clearer under the petrographic microscope, although acceptable under the stereomicroscope.

THE PROPOSED METHOD.

When dealing with kaersutite and Mg-clinopyroxene separation we propose the following methodology:

- First, traditional separation has to be carried out. Split, crush and sieve the sample. Select the 250 to 500 µm fraction and purify it with heavy liquids, the electromagnetic separator and/or other methods (e.g. Faultabel), when necessary. Sieve it to make three fractions: 400-500 µm, 300-400 µm and 250-300 µm. The former is easier to hand-pick, while the latter is easier to recognize under the microscope.
- Study the finest fraction (250-300 µm) under the stereomicroscope using the white surface or, preferably, under the petrographic microscope. In any case, pour the sample on a transparent tray and add acetone. If possible, locate a tracing paper below

the tray. Kaersutite and clinopyroxene should appear as brown and green crystals, respectively (Fig. 1c). If the studied fraction contains a high proportion of the desirable mineral (kaersutite or clinopyroxene), go ahead to the next point. If not, study fine fractions of different densities or magnetic susceptibilities to identify the most suitable one.

- Once the right density and magnetic susceptibility is identified on the finest fraction, start the hand-picking on the corresponding coarsest one (400-500 µm), in order to isolate the desirable mineral. This step has to be also carried out under a stereomicroscope using the white surface or, preferably, under the petrographic microscope. In any case, pour the sample on a transparent tray. To make the picking easier, do not add any liquid. Using high magnification objectives, pay attention to the thinnest areas of each crystal (e.g. the rims), where the brown (kaersutite) or light-green (clinopyroxene) colours can be identified (Fig. 1a).

If the phases to separate displayed small crystal sizes, finer fractions would have to be sieved to obtain homogeneous mineral fragments. In that case, the colour differentiation would be easier (smaller size allows better transmission of light, Fig. 1c) and both mineral recognition and hand-picking would be done in the same fraction, although hand-picking would be harder due to the small particle size.

Our method is as simple as effective. It represents a quick and cheap alternative to XRD or microprobe analyses when the separated fraction cannot be assured to be clinopyroxene or kaersutite by the classical physical or optical methods.

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