Zeitschrift: Schweizerische mineralogische und petrographische Mitteilungen = Bulletin suisse de minéralogie et pétrographie

Band: 41 (1961)

Heft: 1

Artikel: The application of the zonal method for the distinction between low- and high-temperature plagioclase feldspars

Autor: Rittmann, Alfred / El-Hinnawi, Essam E.

DOI: https://doi.org/10.5169/seals-31890

The Application of the Zonal Method for the Distinction between Low- and High-Temperature Plagioclase Feldspars

By *Alfred Rittmann* (Catania[1]) and *Essam E. El-Hinnawi* (Cairo[2]))

With 4 figures in the text

Summary

The authors propose a supplementary operation to the zonal method which, with the aid of two nomograms, permits the rapid distinction between low- and high-temperature plagioclases.

Zusammenfassung

Die Autoren schlagen eine zusätzliche Methode zur Zonenmethode vor, die mit Hilfe von zwei neuen Nomogrammen erlaubt, Hoch- und Tieftemperatur-Plagioklase zu unterscheiden.

Introduction

Optical differences between low- and high-temperature plagioclase feldspars have been recorded by several authors so by Spencer (1937), Köhler (1941a, b), Tuttle and Bowen (1950, 1958), Schwarzmann (1956), Burri (1956a, b) and Smith (1958). Kaaden (1951) carried out rather extensive optical studies on natural plagioclases with high- and low-temperature optics.

As shown by Burri (1956b) the distinction between the low- and high-temperature states, by precise optical measurements and their evaluation to the Euler angles for stereographical constructions may become an important method of identification. Later on, Smith (1958) and Tuttle and Bowen (1958) found that the optical axial angle can serve as a distinctive property, provided that the composition of the

[1]) Istituto di Vulcanologia, Catania (Sicilia).
[2]) National Research Centre, Dokki, Cairo.

plagioclase has first been determined by the aid of the immersion method using the determinative curves of CHAYES (1950). SMITH (1958) showed that the limits of distinction by this method lie within the ranges of An 0—40% and An 60—90%.

Using universal stage methods, a determination of low- and high-temperature plagioclase feldspars can be carried out by the Fedoroff method (MARFUNIN, 1958). Both the Fedoroff method, and the dihedral angle method introduced by DEBENEDETTI (1960) have certain limitations because they cannot be used in the case of microlites or strongly zoned crystals. Only the zonal method introduced by RITTMANN in 1929 is applicable in such cases as well. Although this method was not accepted by some authors e. g. BARBER (1936), yet most others e. g. TURNER (1947), EMMONS (1943), POLDERVAART (1950) etc. have admitted its rapidity and convenience as compared to the Fedoroff method. On the other hand it had hitherto the disadvantage of not permitting the distinction between high- and low-temperature optics.

The aim of the present paper is to present a supplementary procedure to the zonal method which permits a rapid distinction between the low- and high-temperature plagioclase feldspars.

Procedure for the distinction between low- and high-temperature plagioclase feldspars

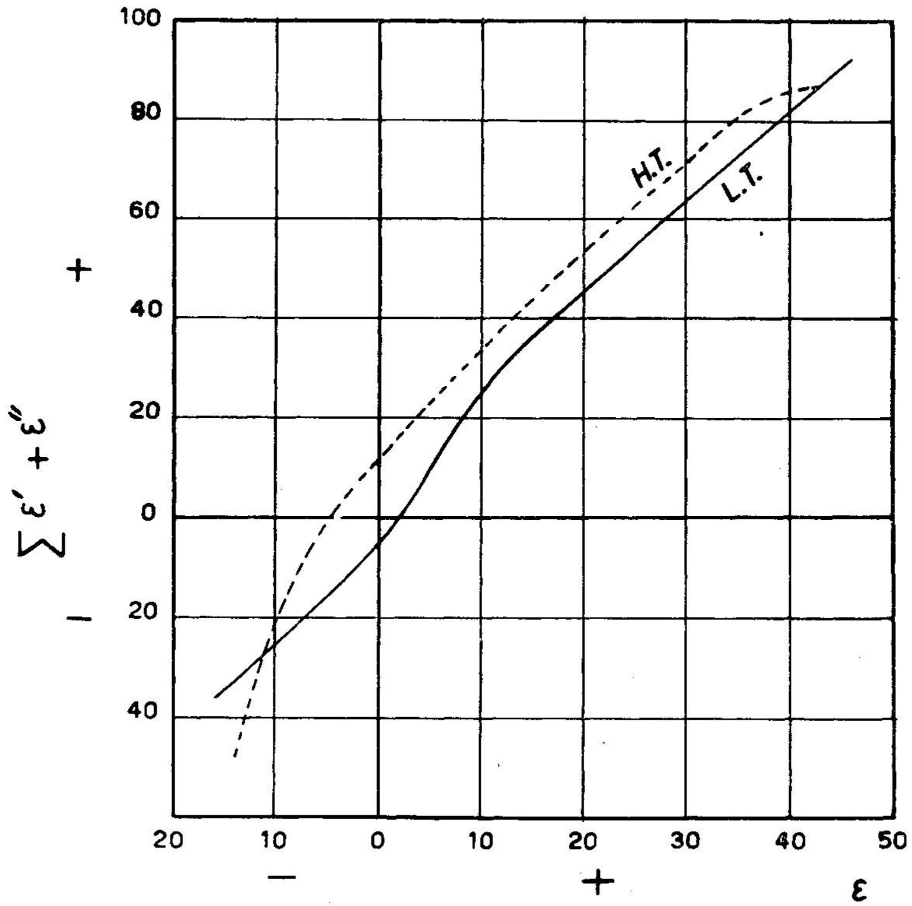
In connection with the zonal method, the distinction between the high- and low-temperature plagioclase feldspars can very easily be effected by measuring two additional extinction angles: Chosing a section of a plagioclase in which the plane of twinning is (010) and which permits the direction [100] being put parallel to the axis of the microscope, one proceeds in the following manner:

1. Rotate the slide about the axis "n"[3] till the trace of (010) is strictly parallel to the N–S wire of the eye-piece.
2. Incline the slide about the axis "h" till the trace of (010), or small lamellae of the albite twins respectively, appear as thin and sharp as possible. The plane (010) then lies perpendicular to the control axis C.

[3]) n axis perpendicular to the section
h N-S axis
C E-W control axis
M axis of the microscope

3. Rotate about the axis C till the trace of the cleavage plane (001) appears sharpest. The direction [100] then coincides with the axis M of the microscope.
4. Rotate the stage about M to the nearest position of extinction (which is X′) and read the extinction angle ϵ.
5. Turn back to the position of 3, incline 20° to the right about the axis "h" and determine the extinction angle ϵ' for this new direction of observation.
6. Repeat No. 5 but this time inclining 20° to the left about "h" from the position 3 and there after determining the extinction angle ϵ''.

Concerning the signs of ϵ, ϵ' and ϵ'', it should be noted that they are positive if the vibration direction of X′ (n_α') lies within the acute angle formed by the traces of (010) and (001), and negative if X′ (n_α') lies in the obtuse angle. ϵ' and ϵ'' have opposite signs in acid oligoclases,



NOMOGRAM I

Fig. 1

in albites both are negative, and in all intermediate and basic plagioclases both are positive like ϵ itself.

In small sections it may become difficult to distinguish between the acute and the obtuse angle, both being near to 90°. In this case the refractive index may be used for determining the sign of ϵ, ϵ' and ϵ'', which is negative if the refraction of the plagioclase is less than that of the Canada Balsam.

After having thus determined the three extinction angles ϵ, ϵ' and ϵ'', one forms the arithmetic sum $(\epsilon' + \epsilon'')$ and plots it, as also the value of ϵ on the nomogram fig. 1 which, for the rest, is self explanatory. For

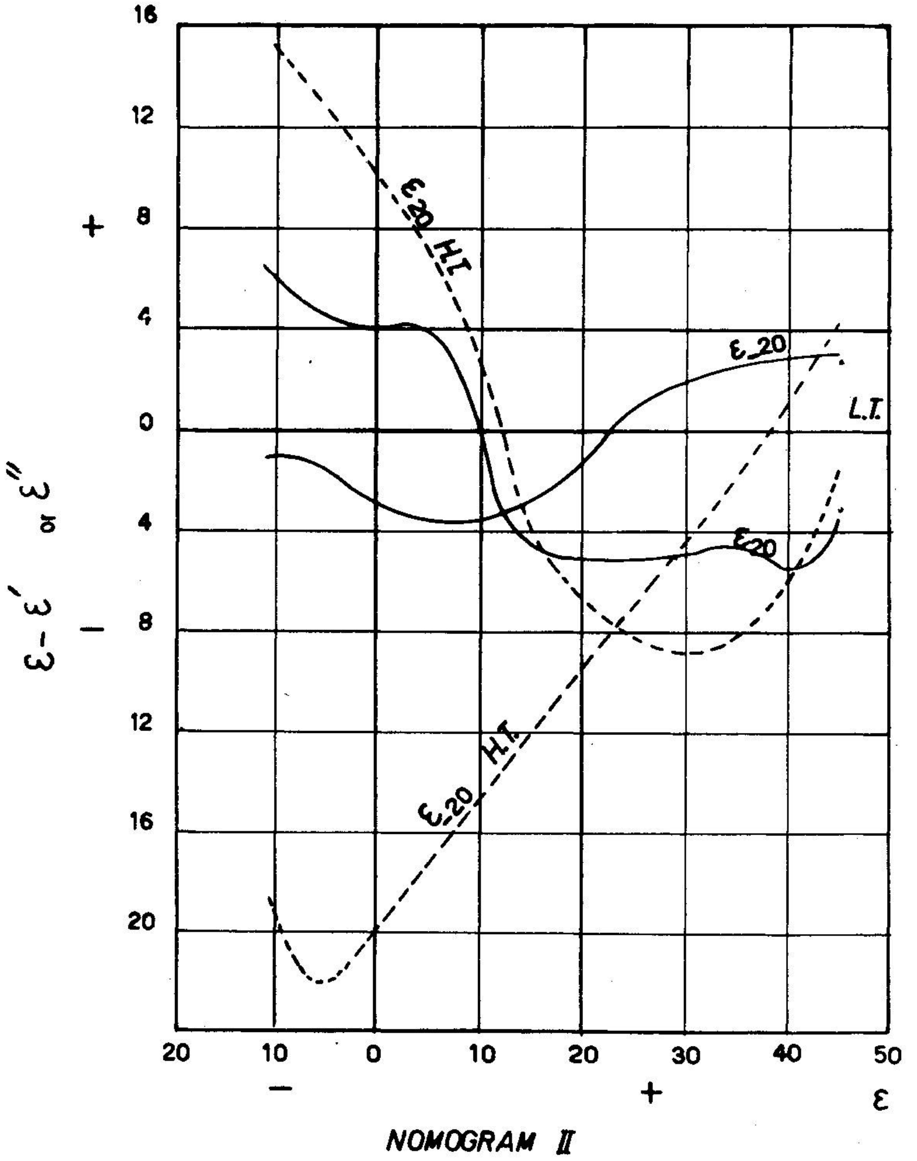


Fig. 2

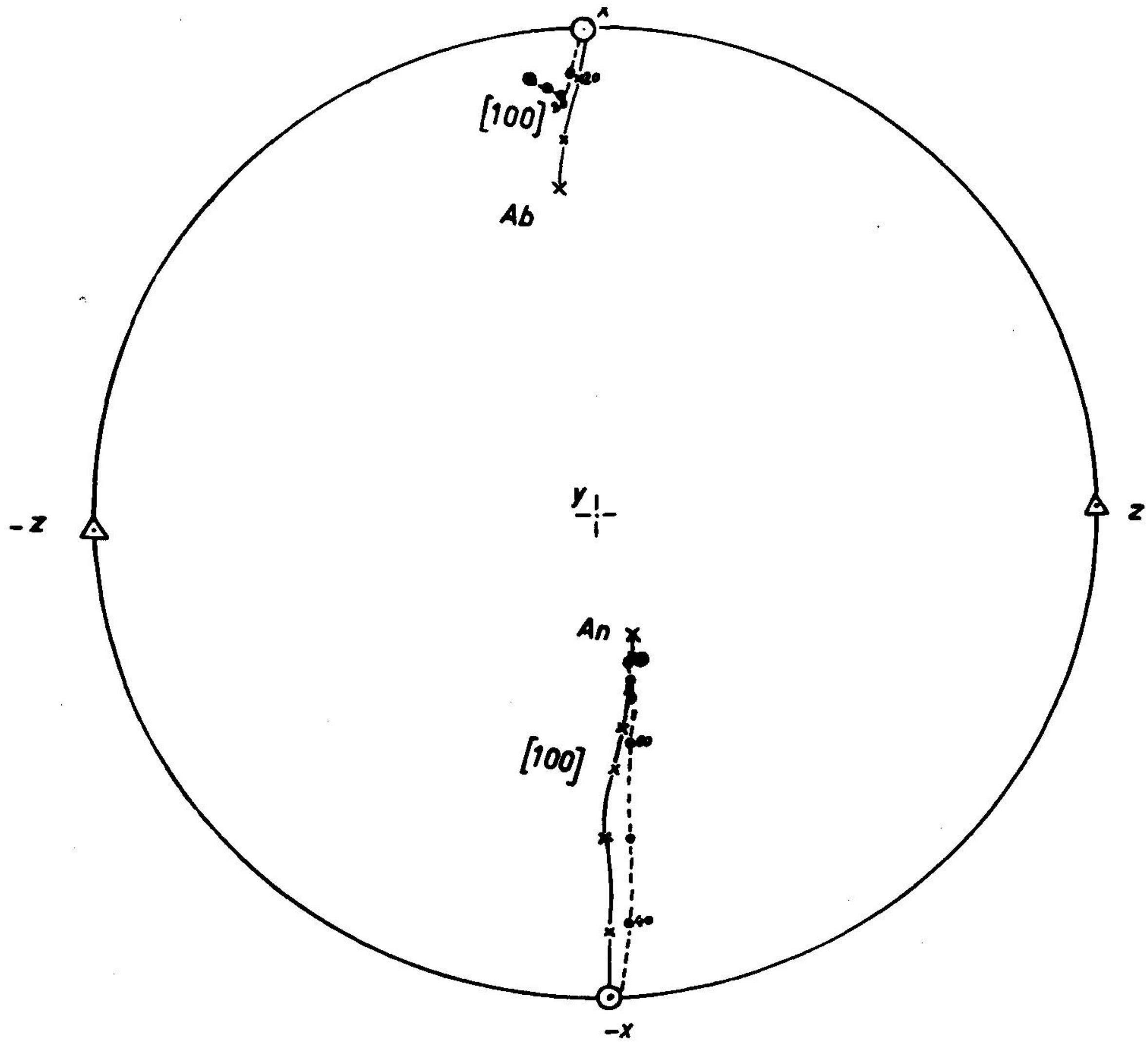


Fig. 3

further control it is advisable to calculate the two differences ($\epsilon - \epsilon'$) and ($\epsilon - \epsilon''$), and plot them and the value of ϵ in the second nomogram shown in fig. 2. It is easy to decide from these nomograms, whether one is dealing with high- or low-temperature optics or with a transitional state. In the latter case the An% can be obtained by interpolation.

The two nomograms have been constructed by making use of the high-temperature optical data reported by several authors and after slightly correcting the [100] position in one of the stereograms of KAADEN (1951), which was slightly erroneous. The corrected position is shown in fig. 3. The optic axial angle has been taken as being 46° for high temperature albite, as this agrees with many reported values e. g. the recent ones of SMITH (1958).

Having determined whether one is dealing with low- or high-temperature plagioclases the An% and the prevailing twinning laws can be determined by the usual procedure of the zonal method. Fig. 4 shows the relation between the An% and the extinction angle ϵ from which the An% can be determined. This diagram was originally published by Rittmann (1929) and is here completed with respect to the high-temperature curves.

It must be noted that in the present nomograms, the high-temperature curves are constructed on the basis of the migration curves for the "maximum" high temperature optics of natural plagioclases so far recorded.

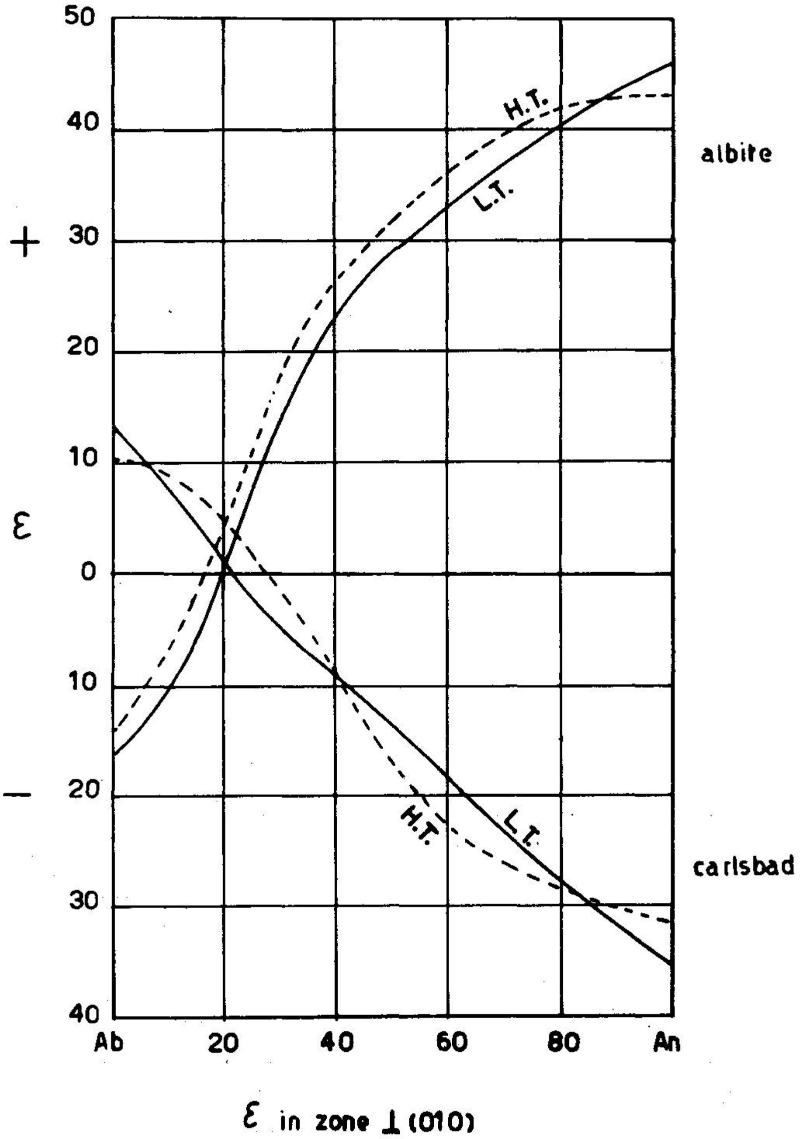


Fig. 4

As has been indicated by previous authors, e. g. LAVES (1960), DEBENEDETTI (1960) and some others, it is not correct to speak about exact optical properties of "maximum" high-temperature plagioclase feldspars, as in these a state of "disorder" exists. Attempts to attain a state of "order", i. e. to change to a low temperature state, cause the optical properties to vary, and so plagioclases are sometimes found that are in a "intermediate phase" or a "transitional state" and have optical properties lying between those of the low-temperature and the "maximum" high-temperature states.

The suitability of the present adaptation of the zonal method for distinguishing between high- and low-temperature plagioclases has been verified by its application to some Etnean lavas and some types of pegmatites.

References

BARBER, C. T. (1936): The Tertiary igneous rocks of the Pakokku district and the Salingyi Township of the lower Chindwin district Burma, with special reference to the determination of the felspars by the Fedoroff method. Mem. Geol. Surv. India 68, 2.

BURRI, C. (1956a): Charakterisierung der Plagioklasoptik durch drei Winkel und Neuentwurf des Stereogramms der optischen Orientierung für konstante Anorthit-Intervalle. Schweiz. Min. Petr. Mitt. 36/2, 539.

— (1956b): Optische Charakterisierung von zwischen Hoch- und Tieftemperaturform gelegenen Übergangsstadien bei Plagioklasen. Z. Krist., 108, 15.

CHAYES, F. (1950): On the relation between anorthite content and γ-index of natural plagioclases. J. Geol. 58, 593.

DEBENEDETTI, A. (1960): La misura diretta di angoli diedri tra piani principali all'indicatrice e piani cristallina per la determinazione dei plagioclasi. Period. Miner. XXIX, 1, 47.

EMMONS, R. C. (1943): Universal stage. Geol. Soc. America Mem. 8, 205 p.

VAN DER KAADEN, G. (1951): Optical studies on natural plagioclase felspars with high and low temperature optics. Diss. Utrecht.

KÖHLER, A. (1941a): Die Abhängigkeit der Plagioklasoptik vom vorangegangenen Wärmeverhalten. Tschermaks Min. Petr. Mitt. 53, 24.

— (1941b): Drehtischmessungen an Plagioklaszwillingen von Tief- und Hochtemperaturoptik. Tschermaks Min. Petr. Mitt. 53, 159.

LAVES, F. (1960): I feldspati e le loro relazioni di fase. Rend. Soc. Mineral. Italiana XVI, 69.

MARFUNIN, A. S. (1958): New diagram for the optical properties of acid and intermediate plagioclases. USSR Pr. Acad. Sci. Geol. Sci. Sec. 118, 211.

POLDERVAART, A. (1950): Correlation of physical properties and chemical compositions in the plagioclase, olivine and orthopyroxene series. Amer. Miner. 35, 1067.

RITTMANN, A. (1929): Die Zonenmethode. Ein Beitrag zur Methodik der Plagioklasbestimmung mit Hilfe des Theodolithtisches. Schweiz. Min. Petr. Mitt. 8, 1.

SCHWARZMANN, S. (1956): Über die Lichtbrechung und die Achsenwinkel von Hochtemperaturplagioklasen und ihre Entstehungsbedingungen. Heidelberger Beitr. z. Min. u. Petr. 5, 105.

SMITH, J. R. (1958): The optical properties of heated plagioclases. Amer. Miner. 43, 1179.

SPENCER, E. (1937): The potash-soda felspars I. Thermal stability. Miner. Mag. 24, 453.

TURNER, F. J. (1947): The determination of plagioclases with the four axis universal stage. Amer. Miner. 32, 389.

TUTTLE, O. F. and BOWEN, N. L. (1950): High temperature albite and contiguous feldspars. J. Geol. 58, 572.

— (1958): Origin of granite in light of the experimental studies. Mem. Geol. Soc. America No. 74.

Received 5th of November 1960.