THERMAL STUDIES OF ORTHOCLASE AND MICROCLINE

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ABSTRACT

Thermal studies were conducted on crystallographically oriented sections of orthoclase and microcline from 0° to 1000° C. Coefficients of linear expansion are given for microcline parallel to each axis. Mean values parallel to a increase from 14.97×10^{-6} to 17.85×10^{-6}. The maximum mean coefficient parallel to b is 1.18×10^{-6} and is 1.30×10^{-6} parallel to c. A series of eleven abrupt volume changes are listed for orthoclase and twenty for microcline. A comparison of adularia, orthoclase and microcline is presented.

INTRODUCTORY

The thermal study of orthoclase and microcline is of considerable interest because of the similarity in many of their properties and the controversial nature of their relationship. The status of the orthoclase-microcline problem has been presented succinctly by Alling (1). Much valuable data is available as a result of a number of investigations on changes in optic angle, refractive indices and density. The results of this investigation may be of further aid in the clarification of the relationship of the potash feldspars.

The microcline selected was a large, flesh-colored crystal from Bedford, New York. Its density is $d_{20}=2.544$ and the refractive indices are: $\alpha=1.518$, $\beta=1.522$, $\gamma=1.525$. The chemical analysis is given in Table 1. This corresponds to the composition $Or_{83.5}Ab_{16.5}$. Three sections, approximately $4\times4\times10$ mm. were cut parallel to each crystallographic axis and these sections were studied from 0° to 1000° C. by the methods previously

TABLE 1.* ANALYSIS OF MICROCLINE FROM BEDFORD, NEW YORK

SiO_2	65.10
Al_2O_3	18.80
Fe_2O_3 } FeO	0.10
MgO	0.09
CaO	0.02
Na_2O	1.99
K_2O	14.14
TiO_2	0.01
H_2O+	0.11
H_2O-	0.01
	100.37

* Analysis by Laboratory for Rock Analysis, University of Minnesota.

described by the authors (2). Observations were made at intervals of 10° for all sections and at intermediate points where abrupt volume changes occurred.

Similar studies were made on oriented sections of orthoclase cut from flesh-colored crystals from Good Springs, Nevada. This material, in the aggregate, has the composition $Or_{71.8}Ab_{23.8}An_{2.4}$. Since the crystals were slightly altered, only the volume changes will be reported in detail at this time.

Experimental Results

The mean coefficients of linear expansion for microcline are given in Table 2. In general, the values parallel to *a* closely approximate similar values for adularia (3). The coefficients parallel to *b* and *c* are somewhat more divergent. A comparison of corresponding sets of data reveals one very striking difference, namely, that all values for microcline increase for each orientation from 800° to 1000°, while all values for adularia decrease from 900° to 1000°. The expansion values obtained for the

Table 2. Mean Coefficients of Linear Thermal Expansion for Microcline

0°C. to	Parallel to *a* $10^6\delta_m$	Parallel to *b* $10^6\delta_m$	Parallel to *c* $10^6\delta_m$
100°	14.97	0.49	0.49
200°	16.19	0.23	0.45
300°	16.34	0.02	0.50
400°	16.46	0.03	0.65
500°	16.77	−0.04	0.85
600°	16.82	0.02	1.00
700°	17.05	0.09	1.06
800°	17.09	0.18	1.22
900°	17.29	0.56	1.29
1000°	17.85	1.18	1.30

Good Springs orthoclase all decreased from 900° to 1000° as did those for adularia. It is concluded, therefore, that there is a distinct difference in behavior during expansion between these monoclinic and triclinic potash feldspars. The curves shown in Fig. 1 display this difference.

Numerous sudden volume changes, made evident by abrupt changes in the rate of expansion, were observed for both orthoclase and microcline. These are given in Table 3, and the previously reported (3) values for adularia are included for comparison, all temperatures being ±5° C. Kôzu and Saiki (4) reported fewer volume changes than were observed in these investigations. A full comparison, including their results, may be obtained from Fig. 2.

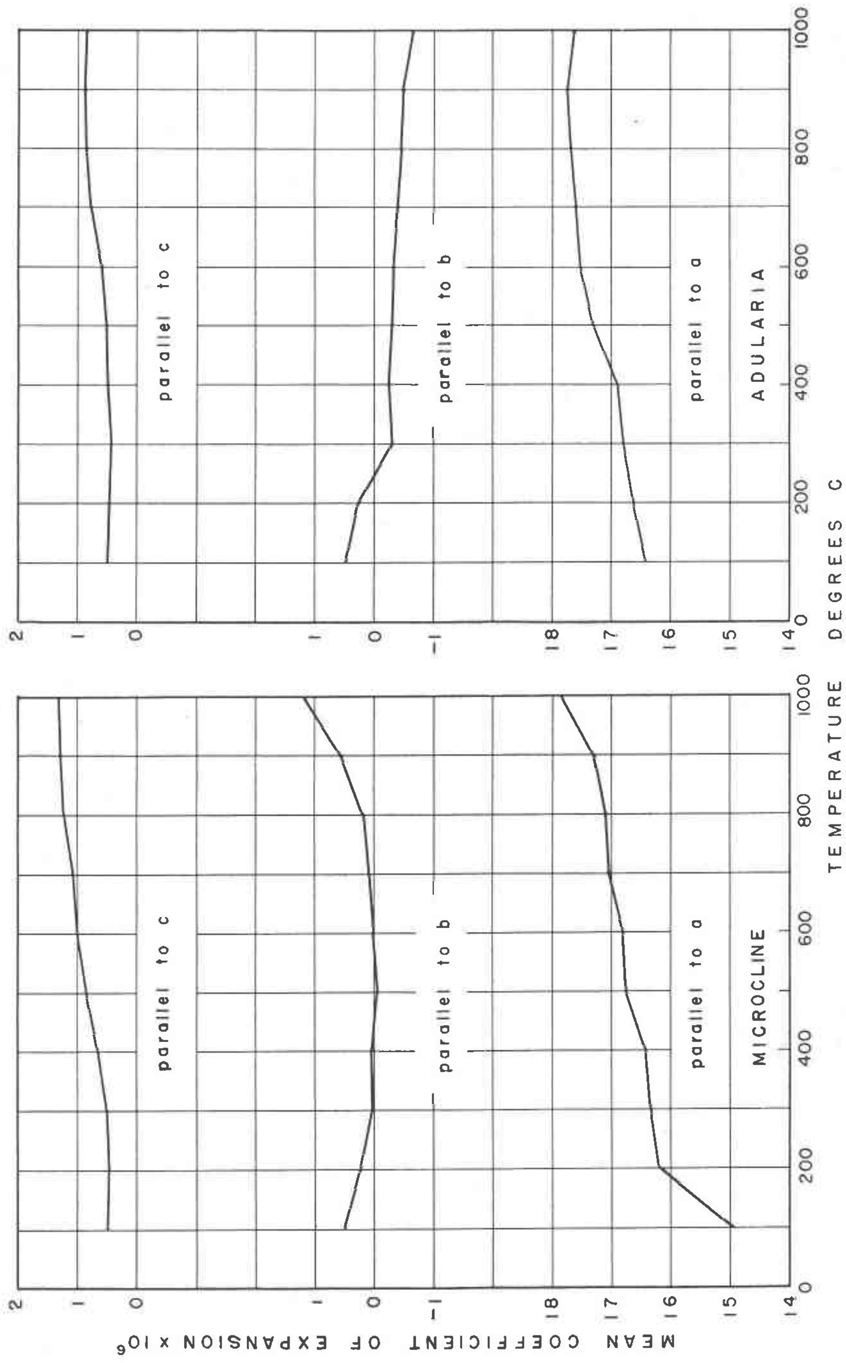

FIG. 1. Mean coefficients of linear expansion (from 0°) for microcline and adularia.

TABLE 3. TEMPERATURES OF ABRUPT VOLUME CHANGES IN MICROCLINE, ORTHOCLASE AND ADULARIA

Microcline	Orthoclase	Adularia
100°C.		
120°		120°C.
150°		
190°	190°C.	
	245°	
265°		260°
		285°
300°		
400°	400°	400°
445°		
480°		475°
505°	500°	
570°	560°	560°
600°		
	615°	
645°		
	670°	680°
770°		
725°		
		740°
770°		
	800°	
825°		820°
		855°
	870°	
895°	895°	900°
950°		950°
	970°	
985°		

DISCUSSION

Kôzu and Saiki (4) studied flesh-colored orthoclase from Arendal, yellow orthoclase from Madagascar and amazonstone from Pikes Peak. An examination of the mean coefficients which they obtained for these feldspars shows that an increase occurred for all samples in all directions from 900° to 1000°, with the exception of a single sample of Arendal orthoclase parallel to *b*, which decreased in this temperature range. A comparison of the amazonstone with the microcline described above cannot be accurate because of possible differences in chemical composition. Their mean values (from 20°) for the amazonstone at 1000° are: $10^6\delta_{m\|a}=21.05$, $10^6\delta_{m\|b}=4.80$ and $10^6\delta_{m\perp base}=14.30$. Their *a* values, though high, are in the approximate range reported here for microcline; their *b* values appear extremely high; the divergences in the values of the several feldspars which they examined in the direction perpendicular to the base seem contradictory among themselves.

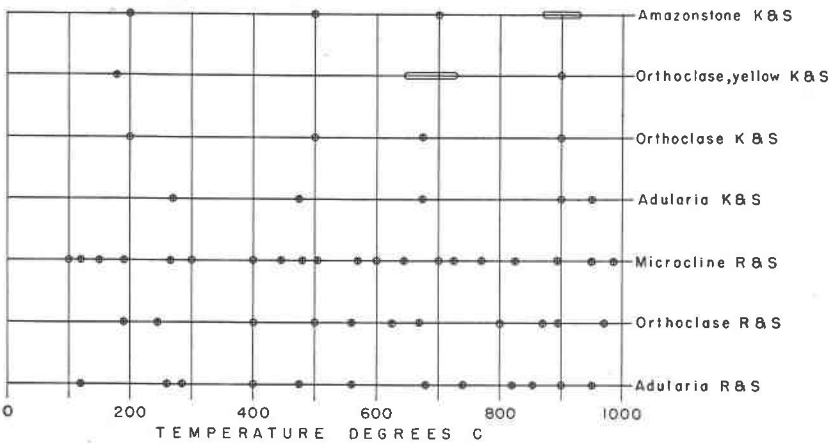

FIG. 2. Volume changes in adularia, orthoclase and microcline

There are some abrupt volume changes which are common to two of the three feldspars and other changes which appear to be characteristic of each separate feldspar. It is peculiar that there is a much greater similarity in points between microcline and adularia than between orthoclase and adularia. Spencer (5) found similar behavior in his heating studies as they related to changes in optical properties. It is apparent from Fig. 2 that the volume changes at 400° and 895°, and possibly at 560°, are common to the three feldspars studied, regardless of their composition or manner of origin. It is to be observed, particularly, that the change at 895° ($\pm 5°$) is common to all samples examined by both groups of investigators. It is suggested, therefore, that the above temperatures correspond to inversion points. Accordingly, if 895° is an inversion point, the assumed stability of microcline up to its melting point would no longer be valid. The authors, on the basis of this investigation, question such stability.

Kôzu and Saiki found no change at 950°, except for adularia. This point was observed not only for adularia but also for microcline; it did not occur for orthoclase.

It is clear that microcline displays almost twice as many volume changes as do either adularia or orthoclase, the numbers being 20, 12 and 11, respectively. This, together with the difference in behavior during expansion at high temperatures discussed above, seems sufficiently definite, *per se*, to establish the separate identities of orthoclase and microcline.

Acknowledgment

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