LINEAR THERMAL EXPANSION OF ADULARIA

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ABSTRACT

Adularia from Grisons, Switzerland, was studied from 0° to 1000° C. parallel to the three crystallographic directions for linear thermal expansion and other thermal changes. The results indicate a large expansion parallel to *a*, a very small negative value parallel to *b*, and a very small positive value parallel to *c*. Abrupt changes in the rate of expansion or contraction occurred at twelve temperature regions, beginning at 120° and ending at 950°.

INTRODUCTORY

In planning the program of thermal expansion studies of the feldspars, it seemed best to begin with adularia because it most closely approaches the composition of pure potash feldspar. In subsequent investigations, it is proposed to work with other members of the alkali series, this to be followed by the plagioclase sequence.

All sections were cut from a single crystal of milky adularia from Val Cristallina, Grisons, Switzerland. The density is $d_{20}=2.559$ and the refractive indices are: $\alpha=1.519$, $\beta=1.523$, $\gamma=1.525$. From its chemical analysis,* given in Table 1, it may be computed that the crystal consists of 93.2 per cent potash feldspar and 6.3 per cent soda feldspar, all other constituents amounting to 0.5 per cent.

TABLE 1. ANALYSIS OF ADULARIA FROM GRISONS, SWITZERLAND

SiO_2	64.69
Al_2O_3	18.69
Fe_2O_3, FeO	0.04
MgO	0.07
CaO	0.03
Na_2O	0.74
K_2O	15.78
TiO_2	0.00
H_2O+	0.07
H_2O-	0.03
	100.14

Three sections, approximately 4×4×10 mm. were cut parallel to each crystallographic axis, all of them being almost clear and transparent. These sections were studied from 0° to 1000° C. by the method described in a previous paper.[1] After cooling from 1000° to room temperature every

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

[1] Rosenholtz, J. L., and Smith, D. T., Linear thermal expansion and inversions of quartz, var. rock crystal: *Am. Mineral.*, **26**, 103–109 (1941).

section displayed a marked pearly opalescence which was not visible in the unheated samples.

Experimental Results

The total expansions for the crystallographic orientations are shown in Fig. 1. All curves, if unobscured by the abrupt changes in rate of ex-

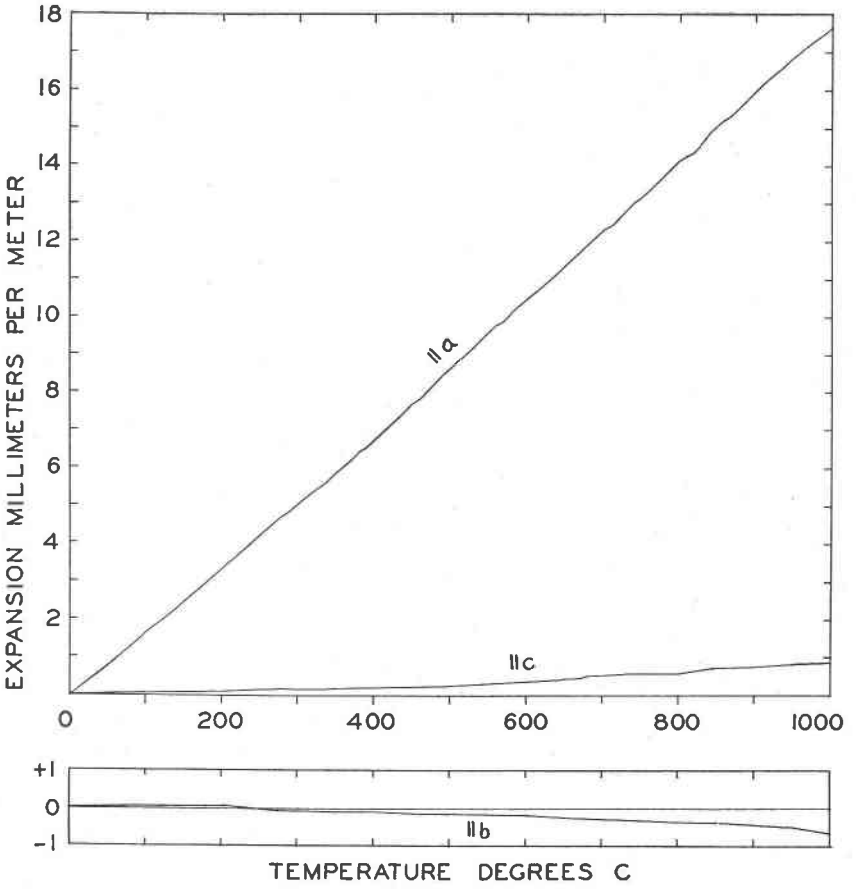

Fig. 1. Linear thermal expansion of adularia.

pansion, show changes in flexure which give them the shape of a flat, open *S*. The mean coefficients of linear thermal expansion for each crystallographic direction are given in Table 2.

Kôzu and Saiki[2] have made somewhat similar studies on adularia from St. Gotthard, the composition of which is given as $Or_{83}Ab_9An_3$. For the direction parallel to *a*, there is a reasonably good agreement with the coefficients given above. Their results parallel to the *b* axis, obtained from only one section, are completely different from those in Table 2. For example, they report no change at 100° and positive values from 150° upward. At 1000°, they found a coefficient of +1.40 as compared with −0.65 reported in this investigation. It is impossible to compare the *c*

TABLE 2. MEAN COEFFICIENTS OF LINEAR THERMAL EXPANSION FOR ADULARIA

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°	16.40	+0.49	0.49
200°	16.63	+0.27	0.46
300°	16.78	−0.30	0.44
400°	16.88	−0.24	0.50
500°	17.30	−0.30	0.51
600°	17.51	−0.31	0.60
700°	17.58	−0.38	0.78
800°	17.68	−0.43	0.86
900°	17.73	−0.47	0.88
1000°	17.62	−0.65	0.86

directions because their third sections were in the direction of the perpendicular to the base, rather than being parallel to the *c*-axis. It is of interest to observe, however, that they report values of 2.65 and 3.65 at 1000° on two such samples.

Several special sections were cut at various angles between *b* and *c* axial directions. Expansion studies of these sections showed the same mean coefficient of 0.49 at 100°, with intermediate values between $\delta_{m\parallel b}$ and $\delta_{m\parallel c}$ at higher temperatures. It is possible to obtain directional sections in which δ_m to 1000° is zero, although at lower temperatures a very small positive coefficient is obtained.

Abrupt changes in the rate of expansion or contraction were observed during the heating of all sections. Since none of these changes are large, it was necessary to make observations at intervals of not more than 10° throughout. The rate changes were observed at 120°, 260°, 285°, 400°, 475°, 560°, 680°, 740°, 820°, 855°, 900° and 950°. The temperature variation in each region is ±5°. Kôzu and Saiki (*loc. cit.*) reported five temperatures for changes in the expansion rate and two additional temperatures where change in the optic angle was observed. For the purpose of

[2] Kôzu, S., and Saiki, S., *Sci. Rep. Tôhoku Imp. Univ.*, Ser. III, 2, 203–238 (1925).

comparison, these are given in Table 3, together with the temperatures listed above.

Some sections showed a permanent change in length after cooling to room temperature. For the *a* direction, one showed no change, the second was 0.04 per cent longer, and the third 0.13 per cent longer. For the *b* direction, one showed no change but the other two were shorter by 0.04 and 0.05 per cent, respectively. Of the three *c* sections, only one showed a change, it being an elongation of 0.07 per cent.

TABLE 3. TEMPERATURES OF CHANGES IN ADULARIA

R. & S.	Kôzu and Saiki
120°	
260°	270°—Expansion change
285°	
400°	
475°	475°—Expansion change
560°	
680°	675°—Expansion change
	700°—Optic angle change
740°	
820°	
855°	850° to 900°—Optic angle change
900°	900°—Expansion change
950°	950°—Expansion change

The analysis of the above data presents a most intriguing problem. The 900° change may perhaps be eliminated from consideration since this is ascribed to the adularia→sanidine inversion. The other points of change are not to be disposed of so readily. It is conceivable that interdiffusion of the soda into the potash feldspar, as suggested by Bragg[3] for perthitic lamellar intergrowth, may be at least partially responsible for these changes in adularia. Why interdiffusion should occur intermittently at irregular temperature intervals is not clear. It is suggested here, therefore, that the thermal equilibrium diagram for the alkali feldspars is quite complex. Since such information is not currently available, the authors propose to defer consideration of this question until their study of other feldspars is completed.

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[3] Bragg, W. L., Atomic Structure of Minerals (**1937,** Cornell Univ. Press), p. 241.