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THE EFFECT OF HEAT TREATMENT ON THE SUPERSTRUCTURE IN THE PLAGIOCLASES IN RELATION TO CHANGES IN LATTICE ANGLES

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A baffling feature in the structure of the low-temperature plagioclases of intermediate composition is the presence of a superstructure of complex nature. Subsidiary reflections occurring in pairs in non-Bragg positions were first found by Chao and Taylor (1940) on rotation photographs. The study of the position of these reflections as a function of composition and thermal state was begun by Cole, Sörum and Taylor (1951) and continued systematically by Gay (1956). The effect of heat treatment was investigated by Gay and Bown (1956), but attention was focussed on the mode and rate of disappearance of these reflections and not on the changes in the lattice constants evidenced by the main reflections. The pairs of subsidiary reflections approximate to type-(*b*) reflections (Laves and Goldsmith, 1951; Gay, 1953) and normally merge to form such in the compositional range An_{70-75}. Various theories (Chao and Taylor; Megaw, 1957; Chayes, 1958) have been advanced to account for these "split" reflections, but, at present, none seems to be satisfactory, though it is possible that the work of Chayes may lead to a solution of the problem.

Two crystals containing respectively 35 and 50% anorthite by weight were selected for the study of the relation of the changes in the split type-(*b*) reflections and in the lattice angles on heat treatment. Split type-(*b*) reflections were present in the unheated materials; those for the labradorite with 50% anorthite were sharp and almost as strong as type-(*a*) reflections, whereas those for the andesine with 35% anorthite were slightly diffuse and weaker. The crystals were then heated at 1140° C., removed from the oven after given periods of time and *x*-rayed at room temperature. The results are given in Table 1. A rapid but small change occurs in the angles γ^* and $(010)/(\bar{1}01)$ in the first 1–2 days; no further change occurs even on heating for 70 days at this high temperature. The final value of γ^* for both specimens corresponds to that of high albite, i.e. to the point B in figure 6 in Brown (1959).

The split type-(*b*) reflections gradually disappear with increase in heating time. Those for the andesine were no longer visible on *a*-axis pre-

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TABLE 1. RECIPROCAL LATTICE ANGLES OF HEATED SPECIMENS
Temperature—1140° C.

Andesine, An_{36}, S349[1]				Labrodorite, An_{50}, S113[1]			
Number of days	α^*	γ^*	(010)/($\bar{1}$01)	Number of days	α^*	γ^*	(010)/($\bar{1}$01)
0	86°04′	88°29′	87°20′	0	86°06′	88°18′	87°30′
0.25	86°00′	88°26′	87°22′	0.25	86°05′	88°18′	87°36′
2.25	86°03′	88°02′	87°44′	2.25	86°02′	88°03′	87°50′
5	86°07′	88°05′	87°40′	5	86°02′	87°54′	87°51′
15	86°13′	88°07′	87°49′	15	86°07′	87°49′	87°53′
20	86°03′	88°05′	87°46′	20	86°04′	87°50′	87°51′
25	86°08′	88°02′	87°44′	25	86°02′	87°50′	87°53′
50	86°10′	88°03′	87°51′	50	86°07′	87°54′	87°54′
70	86°12′	88°08′	87°56′	70	86°09′	88°00′	87°58′

[1] The angles were measured on the Buerger precession camera and are accurate to ±5′. The S numbers are the specimen numbers in Brown (1959).

cession photographs of very long exposure after only 5 days at 1140° C. The labradorite required much more time, since the type-(*b*) reflections disappeared only after heating for 70 days at 1140° C. This time is much greater than those found by Gay and Bown. With progressive heating the pairs of spots became progressively weaker relative to the type-(*a*) reflections. The relative intensities of spots in the pairs did not change, but they became gradually more diffuse and finally merged to form a dumb-bell-shaped area of blackening on *a*-axis precession photographs, before becoming too weak to detect. The sequence of stages with time on heating is very similar to the sequence found with decreasing anorthite content in plagioclases of low-temperature origin in the range An_{50-25}. The very diffuse type-(*b*) reflections in low-temperature plagioclases in the range An_{27-30} disappear in a few hours at high temperature, so the rate was not studied. Though no plagioclase more basic than An_{50} was studied, it is probable that the time required to effect the disappearance of the split type-(*b*) reflections would be greater in such plagioclases. Prolonged heating results in the disappearance of the single type-(*b*) reflections in bytownites (Gay, 1953, 1954).

There appears to be no connection between the changes in the lattice angles and the disappearance of the type-(*b*) reflections on heat treatment in the plagioclases. On the other hand, there is a connection between the anorthite content and the time required to produce the disappearance of the split type-(*b*) reflections. It is probable that the lattice constants of the plagioclases are determined by the short-range Si/Al order, whereas the split type-(b) reflections are probably connected with longer-range Si/Al and Ca/Na order with the resultant presence of domains. Reference is made here to the electron-microscope photograph published by Baier and Pense (1957) of a replica of a face ground on labradorite in which evenly spaced linear traces of separation 0.3 μ (about 250 unit cells) are seen. The nature of these lamellae and the effect of heat treatment on them is being studied.

References

Baier, E. and Pense, J. (1957), Elektronenmikroskopische Untersuchungen an Labradoren: *Naturwiss.*, **44,** 110–111.

Brown, W. L. (1959), Lattice changes in heat-treated plagioclases—the existence of monalbite at room temperature: *Z. Krist.*, in press.

Chao, S. H. and Taylor, W. H. (1940), Isomorphous replacement and superlattice structures in the plagioclase feldspars: *Proc. Roy. Soc.* (*London*), **176**A, 76–87.

Chayes, F. (1958), A possible explanation of the δ_c separations in intermediate plagioclases: *Acta Cryst.*, **11,** 323–324.

Cole, W. F., Sörum, H. and Taylor, W. H. (1951), The structures of the plagioclase felspars: *Acta Cryst.*, **4,** 20–29.

Gay, P. (1953), The structure of the plagioclase felspars: III An X-ray study of anorthites and bytownites: *Min. Mag.*, **30,** 169–177.

——— (1954), The structure of the plagioclase felspars: V The heat treatment of lime-rich plagioclases: *Min. Mag.*, **30,** 428–438.

——— (1956), The structure of the plagioclase felspars: VI Natural intermediate plagioclases: *Min. Mag.*, **31,** 21–40.

Gay, P. and Bown, M. G. (1956) The structure of the plagioclase felspars: VII The heat treatment of the intermediate plagioclases: *Min. Mag.*, **31,** 306–313.

Laves, F. and Goldsmith, J. R. (1951), Short-range order in anorthite: A.C.A. Meeting, Chicago, October 1951. (Abstract p. 10). Compare *Acta Crysts.*, (1954), **7,** 131–132.

Megaw, H. (1957), Structure and disorder in plagioclase felspars: *Acta Cryst.* **10,** 761.

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DIFFERENCES IN THE MONTMORILLONITE SOLVATING ABILITY OF POLAR LIQUIDS

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The polar organic liquids which are most commonly employed to demonstrate the expandable nature of montmorillonite units are ethylene glycol and glycerol (Bradley, 1945; MacEwan, 1948). Heretofore, it has been generally assumed that these two organic liquids exhibit nearly the