NOTES AND NEWS

CRYSTAL GROWTH AND SOLUTION UNDER LOCAL STRESS

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It has often been stated that crystals dissolve where intensely strained and grow where the strain is less[1] but the idea that a schistosity may result from such oriented growth has been questioned. Riecke's principle,[2] based on his theoretical analysis indicates that a crystal under uniform stress is not in equilibrium with a solution that was saturated before the stress was applied: it will begin to dissolve. If another crystal in the solution is not stressed it will grow as the stressed crystal dissolves. Nevertheless, such an experiment and such a principle cannot be used to explain a development of elongated grains. It is emphatically stated that such an attempt would be based on a misunderstanding of the principle—it would be a misapplication of the idea.[3] This leaves some question whether such changes in relative length and thickness as occur during metamorphism can be attributed to solution under stress and resultant changes in index of elongation. A search of the literature revealed no definite experiment, although the suggestive statements are numerous.[4] This paper reports some simple experiments that can readily be repeated almost anywhere.

[1] Harker, A., Metamorphism, pp. 145, 171, 1932.

Van Hise, C. R., Treatise on Metamorphism: *U. S. Geol. Survey, Mon.* **46,** p. 693. 1904.

Grout, F. F., Petrography and Petrology, pp. 398–400, 1932.

Taber, S., Growth of Crystals Under External Pressure: *Am. J. Sci.,* 4th Series, vol. **41,** pp. 532–556, 1916.

[2] Riecke, E., Zur Erniedrigung des Schmeltzpunktes durch einseitigen Zug oder Druck; *Centralbl. für Min., Geol., Pal.,* pp. 97–104, **1912.**

[3] Schwinner, R., Scherung, der Zentralbegriff der Tektonik: *Centralbl. für Min., Geol., Pal.,* pp. 474–475, **1924.**

Knopf, E. B., Petrotectonics: *Am. J. Sci.,* vol. **25,** pp. 460–461, June, 1933.

[4] Sorby, H. C., Devonian Limestones: *Proc. Quart. Jour. Geol. Soc.,* vol. **35,** pp. 87–89, 1879.

Harker, A., *op. cit.*

Wright, F. E., and Hostetter, J. C., The thermodynamic reversibility of the equilibrium relations between a strained solid and its liquid: *Jour. Wash. Acad. Sc.,* vol. **7,** pp. 405–417, 1917.

Wright, F. E., Schistosity by Crystallization: *Am. J. Sci.,* 4th Series, vol. **22,** pp. 224–230, July, 1906.

Van Hise, C. R., The pre-Cambrian rocks of the Black Hills: *Bull. Geol. Soc. Am.,* vol. **1,** p. 224, 1890.

The Optical Determination of Local Strains

(A) In Pyralin and Glass.

The phenomena termed photoelasticity were observed by Sir David Brewster in 1814. About a hundred years later the idea was applied by Groth,[5] and by Rinne[6] to determinations of the loci of stresses. Recently Coker[7] has applied the methods to metallurgical and engineering problems and Nadai[8] to geological problems. The interference colors of a stressed block of pyralin move progressively into the block from the points of application of stress. Figure 1-A shows two stages in the deformation of a pyralin block, the increase in stress being indicated by the large arrow.
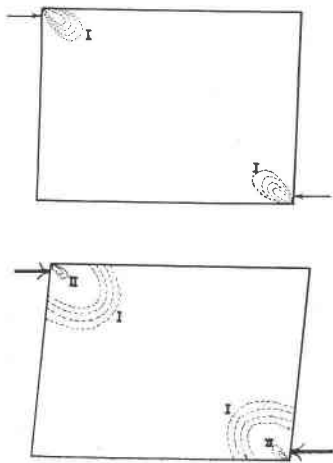

Fig. 1A

(B) In Crystals.

Rinne[9] showed by using garnet that the same localization of strain occurs in crystals. If stress is applied at a point or on a very small surface the interference color rings expand regularly with increasing stress. The writer agrees with these results in every way

[5] Groth, P., Optical Properties of Crystals, pp. 261–282, 1910.

[6] Rinne, F., Beitrag zur Kenntnis von Spannungdiagramen: *Centralbl. für Min., Geol., Pal.*, pp. 121–134 and 209–216, 1926.

[7] Coker, E. G., *Metallurgia Magazine*, April, 1932.

[8] Nadai, A., Plasticity, 1931.

[9] Rinne, F., *op. cit.*

and can only offer a simplified verification that will be available in any petrographic laboratory. If a cleavage block of halite about $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{8}$ inch is stressed by a small clamp (even a pinch cock for rubber tubing will serve) the colors can be developed on a petrographic microscope between crossed nicols. They can be watched spreading from the point of application as the screw is tightened, (Fig. 1-B). A small nail or wire serves to localize the pressure of the clamp.
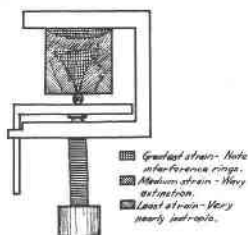

FIG. 1B

It seemed perfectly evident that strains can be developed in a small part of the crystal (as in a small part of a glass or pyralin block) long before such strains reached all through the crystal. The strains may not be absolutely nil in the parts showing no interference color, but they must be very small.

SOLUTION EXPERIMENTS ON SINGLE CRYSTALS.

The direct attack on the problem was made with cleavage pieces of salt and crystals of ammonium alum, ranging from $\frac{1}{2}$ to 1 inch in size. A number of experiments were tried and while all tended to indicate the same principle, the very soluble alum gave the clearest demonstration. A measured, weighed, smooth-surfaced alum crystal in a saturated alum solution at constant temperature suffers no appreciable change for several weeks when evaporation of the solution is prevented. It was desired to find out whether a local strain in such a crystal would cause solution of the strained part and practically simultaneous growth of the other parts of the crystal.

A pressure rod was applied to the upper horizontal face of a crystal near one corner. The rod had a diameter of 1.5 mm. and an alum crystal will commonly stand a load of three or more kilograms on such a surface without crushing. Around the crystal was

a solution saturated with alum at the temperature to be used. To facilitate the later determination of solution and growth, a little chrome alum was added. The growth from this solution was colored whereas the original was a nearly transparent white.

The temperature was kept constant within a degree Centigrade, by putting the container in a tank in which water was circulating under control by a toluene thermoregulator.

When all was set up the saturated solution around the crystal was covered with a layer of thick lubricating oil to prevent evaporation.
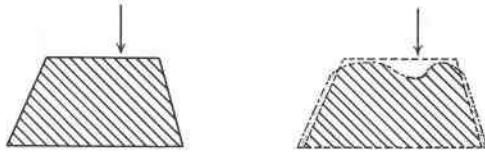
Fig. 2

In the most satisfactory experiment a solution and crystal were kept at 28°C. to 29°C. for 144 hours. The crystal which weighed 10.290 grams before, weighed 10.282 grams after treatment. It was corroded and remained white under and near the pressure rod, but had a growth of colored alum on all four sides in tiny parallel crystal faces. No other crystals had grown in the container. It is believed that the slight loss in weight (8 mgs.) may be a result of the pressure, or possibly of some imperfections in the apparatus. The volume lost from the top of the crystal was carefully estimated by restoring its original top dimensions with plasticene. This indicated the solution of over 0.6 gram from the top and a growth of nearly the same amount on the sides (Fig. 2).

SUMMARY AND DISCUSSION

It seems perfectly clear that stresses may be localized in crystals as well as in amorphous material and that the solubility of a part of the crystal is related to the local stress.

Material dissolved from one part of a crystal because of a local stress may be redeposited on another part of the same crystal where the stress is relatively less, thus changing the form of the crystal.

This is perhaps not a statement of the Riecke principle nor an application of it, but it seems none the less to be a valid idea.

It is still too little known to be applied very far in metamorphism. The crystals in schists are known to be oriented crystallographically as well as elongated, and these experiments have not explained such an orientation. Possibly the change in shape here obtained may be perfectly possible under laboratory conditions, but if such conditions are rare in nature, the applications may not be important. The questions remain: (1) whether during mountain making movements the stresses applied to crystals are localized at certain corners as in the experiments here described, and (2) what other forces acting during metamorphism orient the crystal axes as well as the greater dimensions of the crystal.

PIEDMONTITE FROM LOS ANGELES COUNTY, CALIFORNIA

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Petrographic studies of some of the metamorphic rocks of the Sierra Pelona schist series[1] have shown that piedmontite occurs as small euhedral crystals in quartz-sericite-biotite schist and in quartzite. The samples studied were obtained near the junction of Bouquet and Texas canyons in northern Los Angeles County.

Although manganiferous schists and quartzites are rather widespread in this region, the piedmontite is restricted to a zone about 300 feet wide and a half mile long adjacent to a quartz diorite dike which is three miles long and over 300 feet wide. The thermal effects and solutions from this intrusive aided the replacement of the laminae of biotite by piedmontite so commonly noted in the thin sections. Some of the quartzites show complete replacement; in such cases little or no biotite is found and parallel rows of pink crystals of piedmontite occupying former bands of biotite give the rocks a reddish cast.

Slides of several samples of the schist and quartzite showed that idiomorphic crystals of piedmontite less than 1 mm. long and 0.5 mm. wide were oriented parallel to the foliation; occasionally when an abnormal amount of the mineral is present radiating rosette-like masses are typical. Some of the crystals have been stretched and the interstitial cracks filled with secondary quartz while others nearby show no signs of deformation indicating several periods of piedmontite deposition. Pleochroic colors are: X = orange to lemon-yellow; Y = amethystine red; Z = carmine. A positive biaxial interference figure showed 2V to be large (70 to 80°). Extinction $X \wedge c$