

## SHORT COMMUNICATIONS

*The birefringence of carbonate apatites.*

RECENTLY Trautz (1960) has made some interesting calculations on the contributions of  $\text{CO}_3$  groups to the birefringence of carbonate apatites, and concludes therefrom: 'We now can support with quantitative data our objection to McConnell's arrangement of the  $\text{CO}_3$  groups in francolite (1 horizontal and 3 [essentially] vertical around the [pseudo] threefold axis), which cannot be correct, as it should produce in our dahllite a birefringence that is about 0.005 more positive instead of the observed 0.012 more negative than that of carbonate-free apatite ( $-0.003$ ).'

In his attack on my proposal (McConnell, 1952, 1960*a*), Trautz based his argument on the optical isotropism of cubic crystals that are supposed to contain  $\text{CO}_3$  groups parallel with the principal planes (100), (110), (111), ( $hk0$ ), &c. He calculated the contribution of any particular  $\text{CO}_3$  group as a function of its angle of tilt (inclination) with respect to other symmetrical  $\text{CO}_3$  groups in such a way that their sum is zero for the cubic array. By these calculations he obtains the contribution of a  $\text{CO}_3$  group as a function of its orientation *within an isotropic medium*.

Careful reading of his paper suggests that Trautz may have been aware of some of the difficulties involved in the application of such data without correction to a solid that is already *anisotropic for other structural reasons*. Nevertheless, through the use of such data he claims to have disproved certain features of my structural theory, and proposes an alternative explanation which deserves our immediate consideration.

Rather than 4  $\text{CO}_3$  groups substituting for 3  $\text{PO}_4$  groups, with one horizontal and 3 of the  $\text{CO}_3$  groups essentially vertical (McConnell, 1952 and 1960*a*), Trautz assumes that the planar configuration of the  $\text{CO}_3$  group occupies a position equivalent to an inclined face of the  $\text{PO}_4$  tetrahedron, and is inclined about  $35^\circ$  from the basal plane. He gives no clue concerning what happens to the fourth tetrahedral oxygen: whether its position remains vacant, thus creating a large 'hole' in the structure, or whether its coordination significantly changes as a consequence of the absence of the phosphorus atom.

Several other consequences of his proposal are equally obscure, and they are not clarified by such statements as: 'The fact that the carbonate groups in the apatite are oriented is no reason not to consider them an impurity.' He seems to arrive at the paradoxical conclusion that the

$\text{CO}_3$  groups are an integral part of the structure and control its optical properties (birefringence), but are to be considered as an 'impurity' that need not be related to the structure as a whole.

Furthermore, the explanation by Trautz makes no attempt to explain certain data of fundamental significance, aside from the question of the fourth tetrahedral oxygen. On the basis of his explanation there should be a fairly simple relation between the carbon dioxide content and the Ca/P ratio. We have shown (McConnell, 1960b) that this is not true. In addition, his explanation completely fails to indicate why the combined water should appreciably exceed that of hydroxyapatite, whereas our theory accounts for additional increments of water in two ways, one of which is  $\text{Ca}^{++} + 3\text{PO}_4^{3-} \equiv \text{H}_3\text{O}^+ + 4\text{CO}_3^{2-}$ . It is to be recalled that francolite, besides adequate fluorine to fill all of the F positions of fluorapatite, contains a significant amount of water that is retained above 300° C.

In an attempt to evaluate the data and discussion by Trautz, we conclude that his results suggest that the  $\text{CO}_3$  groups which we have described as 'essentially perpendicular' to the basal plane may be somewhat inclined and may thereby alter the optical properties (birefringence) accordingly. To this extent the results of Trautz are not without interest. We regret, however, that Trautz somewhat befuddles other questions concerning the structure of carbonate apatites while considering their optical properties.

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#### References.

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 — 1960a. Amer. Min., vol. 45, p. 209.  
 — 1960b. Arch. Oral Biol., vol. 3, p. 28; see also Naturwiss., vol. 47, p. 227.  
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### *The identity of erionite and offretite.*

IN 1890, F. Gonnard<sup>1</sup> described a new zeolite, occurring very sparingly with much phillipsite in the basalt of Mt. Simouise, Montbrison, Loire, France, as small hexagonal prisms with basal plane; it is uniaxial

<sup>1</sup> F. Gonnard, Compt. Rend. Acad. Sci. Paris, 1890, vol. 111, p. 1002; Bull. Soc. franç. Min., 1891, vol. 14, p. 60. Gonnard's analysis shows a distinct excess of  $\text{Al}_2\text{O}_3$  over CaO and alkalis; it is possible that he failed to dehydrate  $\text{SiO}_2$  completely (the analysis was made on a very small sample).