

Howie (1960) have suggested that the serpentinization and garnetization of the peridotites of Pastoki, Hindubagh, West Pakistan, could have been brought about by the breakdown of the pyroxenes, CaO released and transported through the dolerite body by percolating hydrothermal solutions combining with the Al_2O_3 from the plagioclase to form hydrogrossular. This occurrence is markedly similar to the Naranji Sar rocks. No analyses of the Naranji Sar peridotites and gabbroic rocks are available, but it is considered that the chlorite and grossular were formed by hydrothermal alteration of diopsidic augite and anorthite.

Christophe Michel-Lévy (1956) has shown that grossular and wollastonite are formed from a 3:1:3 mixture of SiO_2 , Al_2O_3 , and Ca(OH)_2 or CaCO_3 , at 500 °C and $P_{\text{H}_2\text{O}} = 500$ bars. At 400 °C, garnets were rare and xonotlite and calcite were formed. These temperature–pressure conditions may give an indication of those prevailing in the formation of the Naranji Sar rodingite.

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REFERENCES

- BILGRAMI (S. A.) and HOWIE (R. A.), 1960. *Amer. Min.* **45**, 791.
 CHRISTOPHE MICHEL-LÉVY (M.), 1953. *Bull. Soc. franç. Min. Crist.* **76**, 275.
 DEER (W. A.), HOWIE (R. A.), and ZUSSMAN (J.), 1962. *Rock-forming Minerals*, **3**, 106. London (Longmans).
 FRANKEL (J. J.), 1959. *Amer. Min.* **44**, 565.
 PHILLIPS (W. R.), 1963. *Min. Mag.* **33**, 404.

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Hydrogrossular: $\text{Ca}_3\text{Al}_2(\text{H}_4\text{O}_4)_3$ versus $\text{Ca}_3[\text{Al}(\text{OH})_6]_2$

IN the above title two structural formulas are given for the same composition (i.e., for the composition of synthetic hydrogrossular, which also has been called tricalcium aluminate hexahydrate).¹ Questions immediately arise: Are both formulae acceptable? If both are not acceptable, why not, and which is preferable?

¹ From the viewpoint of comprehension of the structure, 'tricalcium aluminate hexahydrate' [$3\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot 6 \cdot \text{H}_2\text{O}$ or $\text{Ca}_3(\text{AlO}_3)_2 \cdot 6\text{H}_2\text{O}$] is misleading because it implies that protons are bonded to merely half of the oxygen atoms rather than to all of them.

One readily recognizes $\text{Ca}_3\text{Al}_2(\text{H}_4\text{O}_4)_3$ as the end member of $X_3Y_2(\text{ZO}_4)_{3-m}(\text{OH})_{4m}$, where $m = 3$. However, this convention implies the existence of a configuration (H_4O_4) that has been called 'tetrahedral hydroxyls', and another question arises: How real is a configuration of four oxygens (in tetrahedral array) that are *not* co-ordinated to a small, highly charged, central cation (such as Si, P, etc.)?

Pauling's rules, to be sure, make no provision for any such configuration, but it must be remembered that these 'rules' were propounded in 1929, and some of them cannot be accepted as rigorously quantitative.¹

The work of Cohen-Addad *et al.* (1967) is concerned with the co-ordination of Al and six OH groups; they concluded² that the general structural formula should be $\text{Ca}_3(\text{SiO}_4)_x(\text{Al}(\text{OH})_{6-2x})_2$. Why they ignored a considerable volume of literature on this topic, and arrived at a conclusion that is applicable only under special conditions, is not clear.

Foreman (1968) and Żabiński (1966), however, presented general conclusions applicable to structures that do not necessarily contain Al atoms or, indeed, any other cation with six-fold co-ordination. They recognized (H_4O_4) as the controlling structural group, without attempting to reconcile their conclusions with some imperfect generalizations presented in 1929.

Numerous examples, including the natural hydrogranets, griphite, etc., demonstrate that the interpretation of Cohen-Addad *et al.* is erroneous, and $\text{Al}(\text{OH})_6$ is quite unacceptable as an alternative to (ZO_4) even when Z becomes four protons.

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REFERENCES

- COHEN-ADDAD (C.), DUCROS (P.), and BERTAUT (E. F.), 1967. *Acta Cryst.* **23**, 220-30.
FOREMAN (D. W. Jr.), 1968. *Journ. Chem. Phys.* **48**, 3037-41.
PAULING (L.), 1929. *Journ. Amer. Chem. Soc.* **51**, 1010-26.
ŻABIŃSKI (W.), 1966. *Polska Akad. Nauk, Prace Mineral.* no. 3, 1-69.

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¹ The 'rule of parsimony', for example, was inconsistent with the chemical knowledge of minerals that existed in 1929, and the co-ordinated polyhedra of anions may not be sufficiently regular to produce a unique sum for all cation-anion radius pairs.

² In an earlier paper (*Journ. phys. radium*, **25**, 478-83 [1964]) they state: 'Les règles de Pauling sont vérifiées.' Also they state (p. 483): 'Les ions H^+ sont situés à l'intérieur du tétraèdre des ions oxygènes.' This error is corrected later (*ibid.* **25**, 656 [1964]).