

it seems that no greater reliability of the distances in these iron garnets has been established by having done several structure refinements than as given by the individual error limits.

The results of EULER and BRUCE on the gallium garnets do not bear out my earlier reasoning²⁵ as to why the Ga³⁺ ions should have a preference at least equal to that of Al³⁺ ions for tetrahedral sites when substituted for Fe³⁺ ions in yttrium iron garnet. In my paper²⁵ on β -Ga₂O₃, I had shown that the ratio of the average tetrahedral to average octahedral Ga³⁺-O²⁻ distance in β -Ga₂O₃ was equal to the analogous ratio in yttrium aluminum garnet, the values in the latter having been taken from the results of PRINCE's neutron-diffraction investigation²⁶ of YAl garnet powder. However, according to the results of EULER and BRUCE, this ratio of the Ga³⁺-O²⁻ distances is greater than that for the Al³⁺-O²⁻ distances in the garnets. A recent investigation²⁷ of the site distribution of Ga³⁺ ions in Y₃Fe_{5-x}Ga_xO₁₂ confirms the greater preference of Ga³⁺ than Al³⁺ ions for the tetrahedral sites, at least to $x = 2.75$. However, it appears that for $x > 2.75$, the situation could be reversed. According to the results of EULER and BRUCE the ratios, referred to above, are the same in both YFe and YGa garnet and smaller in YAl garnet. If the results obtained by other investigators on YFe and GdFe garnet are compared with those of EULER and BRUCE on the gallium garnets, the ratio in the Ga garnets is smaller than that in the two iron garnets. Thus the relative site preference of the Al³⁺ and Ga³⁺ ions in the systems Y₃Fe_{5-x}Al_xO₁₂ and Y₃Fe_{5-x}Ga_xO₁₂ cannot now be explained on simple structural grounds. It might still be possible, however, if the distances were determined more accurately.

Garnet survey and ionic site preference

In the present paper, I hope not only to bring the previous survey up to date, but also give more detail on the garnets and garnet systems that have been made.

In subsequent tables, I shall give lists of simple end-member garnets, namely the silicates, the germanates and the yttrium and

²⁵ S. GELLER, Crystal structure of β -Ga₂O₃. J. Chem. Physics 33 (1960) 676-684.

²⁶ E. PRINCE, Neutron diffraction measurements on yttrium-iron and yttrium-aluminum garnets. Acta Crystallogr. 10 (1957) 787-788.

²⁷ S. GELLER, J. A. CAPE, G. P. ESPINOSA and D. H. LESLIE, Gallium substituted yttrium iron garnet. Physic. Rev. 148 (1966) 522-524.

rare earth aluminum, iron and gallium garnets. Then I shall give a list of garnets and garnet systems to exemplify the ions which enter garnets and, when known, the sites they occupy. I also intend to discuss various aspects that have arisen in connection with these garnets.

Table 3. End-member silicate garnets

A ²⁺	B ³⁺	a [Å]	A ²⁺	B ³⁺	a [Å]
Mg	Al	11.459 ^{18,19,28}	Mn	Al	11.621 ^{28,36}
	Cr	Not reported ¹⁹		Fe	11.82 ^{19,37}
	Fe	Not reported ¹⁹		Fe	Al
Ca	Al	11.851 ²⁸	Co	Al	11.471 ³⁸
	Se	12.27 ²⁹		Al	11.82 ³⁹
	V	12.09 ²⁹ , 12.070 ³⁰ , 12.068 ³¹	V	12.09 ²⁹	
	Cr	12.00 ³² , 11.999 ³³			
	Fe	12.048 ²⁸ , 12.059 ³⁴ , 12.067 ³⁵			
	Ga	12.00 ³⁵			
	In	12.35 ²⁹			

²⁸ B. J. SKINNER, Physical properties of end-members of the garnet group. Amer. Mineral. 41 (1956) 428-436.

²⁹ B. V. MILL', Hydrothermal synthesis of garnets containing V³⁺, In³⁺, and Se³⁺. Dokl. Akad. Nauk. [USSR] 156 (1964) 814-816.

³⁰ R. G. STRENS, Synthesis and properties of calcium vanadium garnet (goldmanite). Amer. Mineral. 50 (1965) 269.

³¹ S. GELLER and G. P. ESPINOSA, data not published previously. The specimen was prepared at 900°C and 20 kbar from constituent oxides mixed with CaCl₂.

³² S. GELLER and C. E. MILLER, The synthesis of uvarovite. Amer. Mineral. 44 (1959) 445-446.

³³ H. E. SWANSON, M. I. COOK, E. H. EVANS and J. H. DE GROOT, Standard x-ray diffraction powder patterns. NBS Circular 539, Vol. 10 (1960) pp. 17-18.

³⁴ H. E. SWANSON, M. I. COOK, T. ISAACS, and E. H. EVANS, NBS Circular 539, Vol. 9 (1960) pp. 22-23.

³⁵ B. V. MILL', Hydrothermal synthesis of silicates and germanates with garnet structure type. Zhur. Neorg. Khim. (1966) 1533-1538.

³⁶ S. GELLER and C. E. MILLER, Silicate garnet-yttrium iron garnet solid solutions. Amer. Mineral. 44 (1959) 1115-1120.

³⁷ S. GELLER and C. E. MILLER, Substitution of Fe³⁺ for Al³⁺ in synthetic spessartite. Amer. Mineral. 44 (1959) 665-667.

³⁸ J. A. KOHN and D. W. ECKART, X-ray study of synthetic diamond and associated phases. Amer. Mineral. 47 (1962) 1422-1430. The authors stated incorrectly, however, that this garnet represented the first successful introduction of the Co²⁺ cation into a garnet.

³⁹ A. L. GENTILE and R. ROY, Isomorphism and crystalline solubility in the garnet family. Amer. Mineral. 45 (1960) 701-711.