Using the maximum and minimum hardness values, quartz has an anisotropy of 0.25 for the [01·0] disk, 0.24 for the disk of general orientation, and 0.11 for the [00·1] disk. As a comparison, the anisotropy of relative grinding hardness of diamond (4) is two which is, of course, the theoretical maximum anisotropy defined by the above equation. The anisotropy of hardness of strontium titanate is 0.70 (1) and of silicon 0.26 (2). No single crystal as yet studied has displayed isotropic grinding hardness (anisotropy of zero).

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TEPHROITE FROM CLARK PENINSULA, WILKES LAND, ANTARCTICA

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In January 1957 a United States base (Wilkes Station) was established on Clark Peninsula (about 66° S, 110° E), in Wilkes Land, in connection with the International Geophysical Year. Mr. Walter Sullivan accompanied the expedition as a reporter for the *New York Times*, and while ashore at Wilkes Station he noticed a vein of black rock with a metallic sheen in the light-colored gneisses forming the bedrock of this region. He observed that the vein outcropped at several points on a ridge near the site of Wilkes Station, and that where it was exposed it was less than a yard wide. He also noticed green stains of malachite along joints in the country rocks. Mr. Sullivan collected a number of specimens and on his return to New York he gave them to the museum. Laboratory examination showed that the black vein material consisted largely of the manganese silicate tephroite. Since tephroite is not a common mineral and has not been previously recorded from Antarctica the material has been investigated in some detail.

The specimens as collected are coated with a black iridescent film with a metallic luster, evidently a manganese oxide. On fresh fracture, however, the material has a dark ash-gray color typical of tephroite; small grains of yellow spessartite are scattered through the tephroite, and occasional small patches of white barite and pink rhodonite are present.

The tephroite is granular, the individual grains being up to 3 mm. in diameter.

In thin section the rock is seen to be a granoblastic aggregate of tephroite, spessartite, rhodonite, and barite, of which tephroite makes up more than 90%. A small amount of black and reddish-brown alteration products is present along cracks. The spessartite has a very faint yellowish tinge and is completely isotropic. The tephroite and the rhodonite have a somewhat grayish tint in comparison to the spessartite; they are very similar in appearance, but the more pronounced cleavage and the much lower birefringence of the rhodonite aid in distinguishing it. The tephroite and the rhodonite contain numerous very small opaque inclusions. A few grains of a brown anisotropic mineral with very high refractive index and straight extinction were seen in the thin section, generally in association with the spessartite; they are probably rutile.

The rhodonite has refractive indices $\alpha=1.721$, $\beta=1.725$, $\gamma=1.732$, very similar to those of a rhodonite from Harstigen, Sweden, described by Sundius (1931). These indices suggest a composition in which about 20% of the manganese is replaced by calcium, iron, and magnesium. The spessartite has refractive index $n=1.804$ and unit cell dimension $a=11.68$ Å. The diagrams of Sriramadas (1957) show that these properties correspond to a composition of 84% spessartite component, 9% andradite, and 7% grossularite.

In immersion liquids the grains of tephroite are generally colorless and transparent, but a few are stained yellow or brown by alteration products. Thick grains show weak pleochroism, X=pale yellow, Z=pale blue. The refractive indices are $\alpha=1.770$, $\beta=1.803$, $\gamma=1.819$. It is optically negative, $2V=71°$ (determined on the universal stage). The density of the tephroite is 4.08, and its hardness is $6\frac{1}{2}$. The luster is vitreous, inclining to greasy, and the streak is pale gray-brown.

A sample of the purest material was carefully crushed and the tephroite selected by hand-picking. Rhodonite and barite were readily removed in this way, but it was not possible to prepare a sample completely free from spessartite. The analyzed material contains about 2% of spessartite. The chemical analysis was made by Dr. H. B. Wiik, and the results are as follows: SiO_2 29.31, TiO_2 0.05, Al_2O_3 0.48, Fe_2O_3 1.21, FeO 1.67, MnO 65.62, MgO 0.71, CaO 0.70, Na_2O 0.07, K_2O 0.C0, P_2O_5 0.07, H_2O+ 0.19, H_2O- 0.02, CO_2 0.00, total 100.10. The Al_2O_3 percentage corresponds to the amount of spessartite observed in the analyzed material. If allowance is made for this, the molecular proportions of $MnO+MgO+FeO+CaO:SiO_2$ is 0.9643:0.4720, or 2.00:0.98, in agreement with the formula Mn_2SiO_4 for tephroite. In this tephroite there is little replacement of manganese by other elements, it containing over 94% of the Mn_2SiO_4 component. In this respect it is comparable to the tephroite from Franklin, New Jersey, described by Palache (1928).

The lack of information regarding the local geology at Clark Peninsula makes it difficult to discuss the paragenesis of these manganese silicate minerals. The country rock, judging from the specimens which Mr. Sullivan collected, is a coarse-grained quartz-andesine-biotite-almandine-cordierite-sillimanite gneiss. This association is typical of high-grade regional metamorphism. The assemblage tephroite-spessartite-rhodonite is compatible with crystallization at medium to high temperatures; this assemblage is stable at the liquidus in the system $MnO\text{-}Al_2O_3\text{-}SiO_2$ (Snow, 1943). Mr. Sullivan describes the occurrence of the manganese silicates as a vein; it is also conceivable that it may be a narrow band of originally manganese-rich material which has been subjected to regional metamorphism along with the country rock. The association of tephroite, spessartite, and rhodonite is one that has been recorded at a number of places, for example, Altarnun, Cornwall (Russell, 1946); Kaso Mine, Japan (Yosimura, 1939); and Broken Hill, Australia (personal observation). At Altarnun the mineral association probably represents a rhodochrosite deposit which has been subjected to contact metamorphism by a neighboring granite intrusion. The Kaso Mine deposit appears to be similar in origin. At Broken Hill the ore deposit containing the manganese silicates is located in an area of high-grade regional metamorphism, also characterized by almandine-cordierite-sillimanite gneisses.

It is tempting to speculate on the possibility of the tephroite at Clark Peninsula being associated with economic minerals. Most other occurrences of tephroite have been in ore deposits, as at Langban, Sweden (iron-manganese), Franklin, New Jersey (zinc), and Broken Hill, Australia (lead-zinc). Mr. Sullivan's observations of malachite staining in the country rock on Clark Peninsula may be significant in this respect. It is to be hoped that further geological information will be obtained from this region.

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