This find suggests that the Spot claim pegmatites deserve a detailed mineralogical study, since the occurrence of pollucite usually indicates ultimately differentiated pegmatites rich in minerals of rare elements.

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PRELIMINARY INVESTIGATION OF ALMANDINE-SULPHUR-WATER AT 700°C AND 1 KB

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Almandine garnet rarely occurs in contact metasomatic rocks, whether or not it is present in the adjacent rocks, even though it is stable within the P/T range of thermal metamorphism. The present study was initiated largely to examine to what extent the sulphur content of an aqueous fluid could be responsible for breakdown of almandine.

The natural garnet which we used as our starting material was separated from a sample of garnet anorthosite in the Parry Sound area of Ontario. The composition is shown in Table 1. Examination optically and with the electron microprobe revealed the presence of a very few inclusions (mainly quartz). Weighed amounts of garnet were mixed with pure sulphur and distilled water, sealed in gold capsules, and held at approximately 700°C and 1 kb confining pressure in "cold seal" pressure vessels and vertical resistance furnaces for periods up to one month.

After 30 days a maximum of 60 per cent of the garnet (*i.e.* a proportion roughly equivalent to the almandine end-member content) had reacted to give Mg-cordierite (80-85 per cent of the product), Fe-sulphide (10-15 per cent), anhydrite (3-4 per cent), and dravite, the Mg-tourmaline (1 per cent or less). Excess fluid of approximately 4.5 pH, as determined by litmus paper, remained in the tubes. Unreacted sulphur was present in several charges. Many of the garnet grains showed strong recrystallization to larger grains with several crystal faces. Probe analyses of the recrystallized garnet showed no significant differences in chemical content from the starting material.

We tested the tendency of garnet to recrystallize in an aqueous solution by preparing several tubes containing only garnet and water. After 2 weeks at 700°C and 1 kb approximately 20 per cent of the grains showed significant recrystallization and no new products were noted. It is well known that the rate of nucleation of one phase using certain components as opposed to the rate of crystal growth of a second phase using the same components is slow. Crystal growth of a phase in an aqueous medium, which permits rapid migration of particles and complexes, may be a rapid rate phenomenon even under P/T conditions unsuitable for stable growth of the phase (*i.e.* metastable crystal growth). The garnet of our experiments grew metastably by this process.

The Fe-sulphide produced was dependent on the initial ratio of garnet to sulphur in the charge. In rough form, the experiments indicate that a molecular weight ratio of end-member almandine to sulphur less than $1/2$ resulted in pyrrhotite crystallization, between $1/2$ and $1/3$ yielded both pyrrhotite and pyrite, and greater than $1/3$ produced pyrite only.

To test the coexistence of pyrite, pyrrhotite and anhydrite at 700°C and 1 kb several charges of previously equilibrated pyrite and pyrrhotite were mixed with anhydrite and water and run in sealed gold tubes for one month. The three phases remained in coexistence without development of CaS or isolation of one phase by rimming, although development of the crystal habits of anhydrite, pyrrhotite and pyrite indicated movement of components. This is taken as proof that the anhydrite produced in our reactions was not a metastable phase.

The tourmaline crystals which were produced are acicular, rarely more than 0.3 mm in length and 15 microns thick. Perfect terminations could be seen on the larger crystals. Production of phases such as tourmaline point up a danger in using natural starting materials. Since tourmaline contains boron, it could not have formed had the garnet not contained a small quantity of this element. While boron-containing inclusions are to be expected in the garnet, no such inclusions were located.

Magnetite was produced only in those charges which leaked during the run. Obviously, the pS_2 was too high, relative to the pO_2, to permit formation of an oxide phase in the experiments of constant bulk composition.

Kullerud & Yoder (1962) reacted almandine with sulphur at 750°C and 2 kb in the dry system to form pyrrhotite + quartz + cordierite + pyroxene. The discrepancy in silicate products between their experiments and ours may be due in part to the presence or absence of an aqueous fluid and the consequent increase or decrease of ionic mobility, but perhaps also to the incompleteness of our reactions.

Two charges were prepared to test the reaction rates in the dry system at 700°C and 1 kb. After 30 days, approximately 5 to 10 per cent of the garnet had reacted. Very small crystals of pyrite were easily identified, but it required an electron probe scan to identify cordierite as a narrow selvage on most garnet grains. None of the garnet grains showed evidence of recrystallization.

In thermally metamorphosed rocks, almandine + cordierite is not a common mineral assemblage; in regionally metamorphosed rocks it is common only to the granulite facies. In the Lochnager aureole in the Scottish Grampians garnetiferous hornfels contains both almandine and cordierite (Chinner 1962). It is apparent from textural evidence that the garnet has partially broken down to cordierite. Chinner suggests that the assemblage at Lochnager represents an arrested reaction from the regionally metamorphosed assemblage of sillimanite + biotite + muscovite + almandine to quartz + cordierite + orthoclase + biotite + sillimanite. Schreyer & Yoder (1960) also report a number of possible reactions of silicates which could produce cordierite, some of them involving almandine, but they conclude that hidden metasomatic changes are often probable and that much more is yet to be learned about reactions involving cordierite.

Our experiments at 700°C and 1 kb confining pressure conclusively confirm that Fe is readily removed from almandine garnet by a sulphur-containing aqueous solution. Presumably, the results may be extrapolated somewhat to temperatures and pressures above and below the limits of our experiments. We note that proportionately very small amounts of sulphur are required to break down the garnet. Since sulphur has the capacity of drastically altering a silicate mineral assemblage, more attention must be paid to the presence or absence of accessory sulphide minerals in metasomatic rock suites and to the mobility of metal-sulphide ions.

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TABLE 1. ANALYSES OF STARTING MATERIAL AND SILICATE PRODUCTS

	Garnet LO-67	Cordierite	Tourmaline
SiO_2	38.70	49.41	35.96
TiO_2	0.11	0.00	0.82
Al_2O_3	20.93	34.06	34.02
Fe_2O_3	1.16		
FeO	24.40	0.63 [1]	0.30 [1]
MnO	0.64	1.55	0.08
MgO	5.19	12.44	10.50
CaO	8.83	0.26	1.80
Na_2O	0.04	0.01	1.13
K_2O	0.03	0.01	
B_2O_3			4.0 [2]
H_2O		1.8 [2]	10.5 [2]
	100.03	100.2	99.1
Almandine	53.5		
Grossular	21.0		
Pyrope	20.4		
Andradite	3.8		
Spessartine	1.3		

[1] Total Fe expressed as FeO.

[2] Estimated content from reported analyses (Deer, Howie & Zussman 1962: Table 47, p. 276 and Table 50, p. 304).