values listed by Slemmons (Table 3, 1962a). It seems most probable that the difference between the values listed here and those reported by Slemmons reflect the greater purity and high degree of ordering of albite formed in a relatively low temperature metamorphic environment and that these values are characteristic of metamorphic An_0.

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DIMENSIONAL AND COMPOSITIONAL CONTROL OF GARNET GROWTH BY MINERALOGICAL ENVIRONMENT

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OCCURRENCE AND CRYSTAL MORPHOLOGY OF GARNET

During the course of a geochemical study of the Kiawa pegmatite group, Las Tablas Quadrangle, Rio Arriba County, New Mexico (Gresens, 1964), attention was called to the dual nature of the occurrence of spessartite garnet in the pegmatites. Large irregular anhedral spessartite masses (10 cm or more in diameter) are present in albite concentrations. These masses are weak and commonly crumble when handled. Smaller (1 cm or less) clear euhedral tablets are found within large muscovite books. These crystals are "flattened" in the *c*-axis direction of the muscovite crystals and are hard with no tendency to crumble. Jahns (1946) noted these relationships in an earlier study. The "flattened" garnets show dodecahedral faces. These faces are commonly distorted, that is, the polygonal outline of the face does not have the perfect bilateral symmetry of the polygonal face of a perfect dodecahedron. The large "flattened" face is not necessarily a dodecahedral face. (The angle between the "flattened" face and an adjacent face is usually not the dodecahedral angle.) It seems instead to be merely the termination of the garnet against the muscovite layer structure, truncating the dodecahedral faces.

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MINERALOGICAL ENVIRONMENT AS A CONTROL ON CRYSTAL MORPHOLOGY

The occurrence of the "flattened" crystals in particular argues against growth of the surrounding mineral around pre-existing garnet. If the garnet had been formed prior to the muscovite, the enclosed garnet should be more equidimensional. Also, the "flattened" garnets are found *only* in muscovite books. The control exerted by the muscovite crystal lattice on the dimensional growth of the garnet implies that the two minerals either grew simultaneously or that the "flattened" garnets grew within pre-existing muscovite crystals.

The age relationship between albite and the large garnet masses is not as clear. As pointed out by Jahns (1946), the albite is a late replacement feature in the pegmatite. The garnet could have been formed either before or after the albite. However, even if the albite is later than the garnet, the garnet would probably have been originally surrounded by perthite or quartz rather than muscovite before the replacement of these minerals by albite. Another possibility, if the pegmatite is of magmatic origin, is that the garnet was a very early mineral surrounded by a fluid. Jahns (1946) observed that in the Kiawa deposits, spessartite garnet is abundant in albite-rich zones and border zones. This suggests a genetic relationship and implies that at least some of the garnet grew simultaneously with or later than the albite. For example, Jahns (1946), considered that the association of most of the mica with albite indicated that the mica formed during the albite stage of pegmatite development. The garnet-albite association could also indicate growth of garnet during the albite stage. On the other hand, albitzed portions of the pegmatite and border zones could have been favored sites for a later replacement by garnet.

The exact age relationship is not necessary for the discussion that follows. What is important is that the medium (albite, perthite, quartz, or fluid) surrounding the large garnet masses during growth was different from the medium (muscovite) surrounding the "flattened" garnets during their growth.

DeVore (1959) discussed minimum interfacial free energy as a control on certain features of mineral assemblages, including grain form. The "flattened" garnets may be an example of this kind of control. The "flattened" form presents a large garnet surface area to the (001) face of the surrounding muscovite and a minimum interfacial garnet surface to other planes in the muscovite crystal. This suggests that the interface between garnet and the (001) plane in muscovite is the interface of lowest free energy.

CHEMICAL COMPOSITION OF GARNET

Spectrochemical analyses by the author of the two types of garnet are presented in Table 1. Sodium and potassium were not determined, and manganese fell above the upper limit of the working curve. Both of the analysed garnets came from the South Kiawa deposit, and they were located about 8 meters apart. The analyses show compositional differences between the two modes of occurrence. The most pronounced differences are the higher iron, beryllium, yttrium and magnesium content of the "flattened" garnet and the higher titanium and nickel content of the anhedral massive garnet. Although this comparison is based on only two analyses and additional work should be performed, certain tentative conclusions can be drawn.

TABLE I. SPECTROCHEMICAL ANALYSES OF GARNETS FROM SOUTH KIAWA DEPOSIT

Element	Euhedral "Flattened" Garnet	Anhedral Massive Garnet
$SiO_2\%$	43	43
TiO_2	<0.1	0.25
Al_2O_3	22	22
Fe	7.5	3.9
MnO	High	High
MgO	0.40	<0.1
CaO	1.1	0.7
ZrO_2 PPM	49	67
Cr_2O_3	25	31
Sc_2O_3	7	10
V_2O_3	92	87
Y_2O_3	1200	530
BeO	140	6
SrO	13	27
BaO	not detect.	13
CuO	9	8
NiO	330	460

MINERALOGICAL ENVIRONMENT AS A CONTROL ON CHEMICAL COMPOSITION

In addition to the dimensional control exerted by the mineralogical environment, a compositional control may also have been present. Suppose that the garnets represent growth simultaneous with that of the enclosing minerals. Because growth takes place by additions to the surface, the surface energy difference between the feldspar (?)-garnet interface and the muscovite-garnet interface could lead to compositional differences between the garnets of the two environments. Additions to the mineral are controlled in part by the state of the mineral surface. When two mineral surfaces are in contact, there are mutual interactions between their force fields. Mutual polarization of the surface atoms can occur. The surface of a garnet in contact with muscovite is thus energetically different from the surface of the same garnet in contact with feldspar, quartz, or even a fluid. The differences, however small, could lead to discrimination with respect to certain atoms during crystal growth.

If the "flattened" garnets grew by replacement within a pre-existing muscovite crystal, the above argument still holds, but an additional factor may be considered. At least some of the elements composing the garnet must then have reached the site of growth by intracrystalline diffusion through the muscovite. The muscovite could have a "sieve" effect with respect to ionic diffusion, allowing some elements to diffuse more freely than others. This could also result in compositional differences. Similarly, if the large garnets are later than the feldspar (microcline or albite) or quartz, growth must have taken place by diffusion along feldspar/quartz grain boundaries or through feldspar/quartz crystals. A "sieve" effect could also be present in this situation.

Compositional differences could also result from incorporation of some of the components of the host mineral in the guest mineral during replacement. This would also be a compositional control because of mineralogical environment.

The postulated reasons for the compositional differences between the two garnets have been of a very general nature and somewhat speculative. An attempt to be more specific would be even more speculative. For example, the higher iron content of the "flattened" garnet could be attributed to at least three mechanisms:

(1) Iron was available in about equal amounts at both sites, but the surface conditions controlling the crystal growth resulted in a higher iron content in the "flattened" garnets. (2) The muscovite crystal lattice exerted a "sieve" effect, allowing iron to diffuse more freely than manganese (Fe^{2+} has a smaller ionic radius than $Mn^{2.+}$). (3) The higher iron content of the "flattened" garnet is simply due to the higher iron content of the muscovite (usually about 4.5% Fe) as opposed to that of feldspar (only a trace). The excess iron is therefore iron incorporated by the garnet from the host muscovite during replacement.

Another example is the higher yttrium and beryllium content of the "flattened" garnet. It might be argued that this means that yttrium and beryllium could diffuse freely through the muscovite crystal lattice. This is highly speculative to begin with, but is even further complicated by the fact that there is little similarity between yttrium and beryllium with respect to ionic size, charge, polarizing power, etc. Therefore, to assign *specific* differences in composition to a single mechanism is difficult. In the more general sense, either of the three mechanisms discussed above in relation to iron content are ultimately due to differences in the mineralogical environments of the two garnets.

Another possibility is that the "flattened" garnets formed by exsolution within the muscovite. However, as pointed out by DeVore (1964, pers. comm.), if the garnet grew by exsolution, almost all of the muscovite crystals should have a few. In the Kiawa deposits most mica books do not contain garnet inclusions.

It is also possible that the two occurrences of garnet were formed at different times from different chemical environments. Although the two analysed garnets were only 8 meters apart in the same pegmatite body, this remains a very real possibility. It does not, however, invalidate the possibility that the mineralogical environment also exerted a control on the crystal composition. The fact that one of the garnets is in a *distinctly* special mineralogical environment (a muscovite book) and that the environment exerted a definite dimensional control during crystal growth lends support to the possibility that the mineralogical environment also exerted a compositional control during crystal growth.

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