TABLE 2. UNIT-CELL DATA FOR MOOREITE

	1	2
a	11.18	11.18
b	20.25	20.28
c	19.52 Kx	8.23 Å
β	122°23′	92°55′

1. Prewitt-Hopkins (1949)
2. This paper

tations. The transformation matrix, new to old is $100/010,\bar{1}0\bar{2}$ and old to new is $100/010/\bar{\tfrac{1}{2}}0\bar{\tfrac{1}{2}}$.

The space group is $P2_1/a$ with reflections obeying the systematic absences hkl: none; $h0l: h=2n$; $0k0: k=2n$. For the present cell $Z=4$ and the cell formula $(Mg, Zn, Mn)_{32}(SO_4)_4(OH)_{56}\cdot 12H_2O$ is compatible with space group requirements. The calculated density, based upon the present analysis, is 2.52.

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SILLIMANITE FROM TWO CONTACT AUREOLES

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ABSTRACT

"Fibrolite" from two contact aureoles is proved by X-ray diffraction to be sillimanite; mullite in such occurrences now seems unlikely.

In the contact metamorphism of pelitic rocks, andalusite is typically produced in spotted slates and hornfels of low grade, being accompanied (or, infrequently, entirely supplanted) by a fibrous aluminosilicate near the igneous body. This "fibrolite" is commonly in the form of fine acicular prisms which, at first appearance with increasing grade, compose mats with biotite and quartz, independent of andalusite; mantling of andalusite by fibrolite is much less common. It cannot be said with certainty that the two aluminosilicates coexist metastably; partition of ferric iron or manganese, for example, may be sufficient to produce a two-phase stability field in p-T space (as demonstrated by the thermochemical calculations of Strens, 1968). Alternatively, it may be assumed that the two minerals constitute a univariant pair, and coexist throughout a wide zone as a result of slow transformation rate.

Another question concerns the identity of most of the fibrolite reported. It is mainly too fine to permit optical distinction between sillimanite and mullite. Recently, Waldbaum (1965), on the basis of synthesis and thermochemical data in the system Al_2O_3-SiO_2, suggested (p. 194) that mullite might "be more common in highly aluminous metamorphic rocks than presently supposed." Because the composition of natural mullite is highly variable (Agrell and Smith, 1960), the coexistence of mullite with andalusite and/or sillimanite could be a possibility over a wide range of conditions, were Waldbaum's assertion correct.

For this reason, we examined fibrolite from hornfels of the Isabella area, southern Sierra Nevada (Best and Weiss, 1964) and from Onawa, Maine (Moore, 1960). Mineral assemblages indicate the pyroxene hornfels facies of contact metamorphism. The samples are described below, and the textural relations of the aluminosilicates shown in Figure 1. Sample B-94 was of particular interest because all three: andalusite,

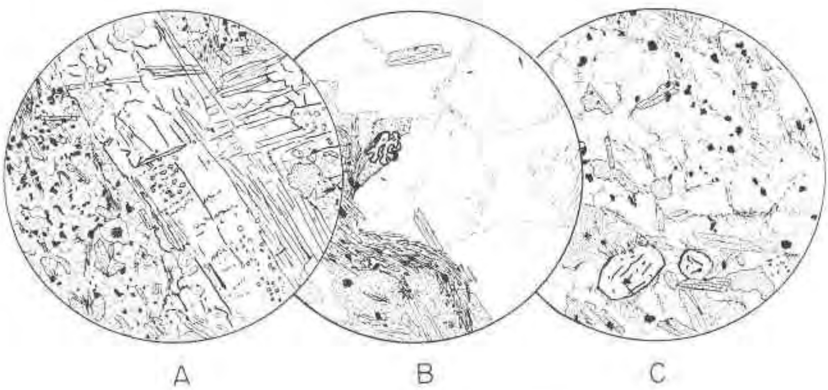

FIG. 1. A: B-94. Note two habits of sillimanite, as prismatic crystals apparently replacing andalusite, and fibrous sprays in matrix. B: B-145. Aggregates and single prisms of acicular sillimanite; skeletal crystal at centre is andalusite. Large crystals with stippled borders are slightly pinitized cordierite. C: 0–7. Mats and sprays of fibrolite run around grains of quartz, perthite, and cordierite. Rounded andalusite crystals at bottom are rimmed by fibrolite. Field diameters: 1.3 mm.

prismatic sillimanite, and fibrolite, are present. Small amounts of aluminosilicate were separated magnetically, with heavy liquids, and by hand picking. Sample O–7 yielded a mixture of fibrolite and quartz, in which the necessary X-ray reflections (see below) could be read without interference; the other concentrates were substantially pure. A mixture of fibrolite and sillimanite was obtained from B-94.

The most satisfactory way of distinguishing sillimanite from mullite is by careful measurement of the unit cell. The *a*-dimension of all natural and synthetic mullites studied (Agrell and Smith, 1960) is larger by 0.06–0.1 Å. than that of sillimanite; this dimension varies with Fe and

TABLE 1. CELL DIMENSIONS OF ALUMINOSILICATES

No.	Sample	*a* Å	*b* Å	*c* Å	V Å^3
1	B-94	7.4822	7.6689	5.7689	331.02
2	B-145	7.4840	7.6724	5.7672	331.16
3	O-7	7.4828	7.6716	5.7655	330.97
4	Brandywine[a]	7.4820	7.6710	5.7684	331.07
	Brandywine[b]	7.4806	7.6709	5.7678	330.97
5	Mullite[c]	7.5458	7.6884	5.7710	334.80

[a] Sillimanite Brandywine Spring, Del., U.S. Nat. Mus. 79748.
[b] Same, cell dimensions determined by Skinner *et al.* (1961).
[c] Synthetic mullite furnace tube.

Ti substitution in mullite, whereas the *c*-axis varies with Al/Si ratio. Because of the paucity of sample, it was necessary to use a powder X-ray camera. Photographs were taken with a Norelco Guinier camera, using $CuK\alpha_1$ radiation and $KBrO_3$ internal standard, calibrated against quartz. In addition to the three unknowns, a synthetic mullite and a previously studied sillimanite were measured. Two independent measurements of the films were made, and cell dimensions calculated from each set, using least-squares computer refinement from *d* for the eight reflections: 400, 312, 240, 322, 420, 042, 402, and 332. Data are presented in Table 1. A single, sharp pattern was obtained from B-94. Departure of individual cell dimensions from the mean of the two values is up to 0.003, although generally less than 0.001; in no case can great confidence be attached to the fourth decimal place. Close agreement exists between our data and those of Skinner *et al.* (1961) for the sillimanite from Brandywine Spring. Cell volumes are plotted against *c* in Figure 2, after Agrell and Smith (1960), where they are compared with data for sillimanite taken from the literature.

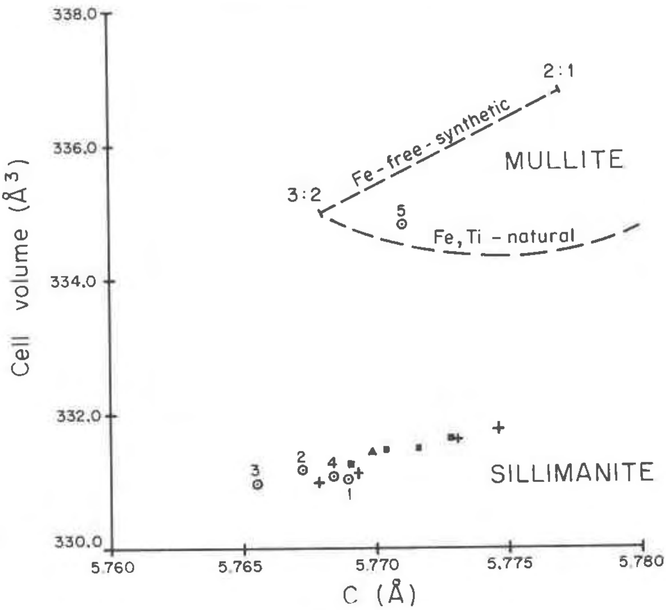

FIG. 2. Cell volume *vs* *c*-axis plot of sillimanite and mullite, after Agrell and Smith (1960). Numbered points correspond to Table 1; squares, to sillimanites from Agrell and Smith; crosses, sillimanites from Skinner *et al.* (1961); triangle, sillimanite from Labelle County, Quebec (Burnham, 1963).

It is clear that the fibrolite from the hornfelses is sillimanite, and that this mineral occurs in two habits in B-94. The samples being mineralogically and texturally representative, the occurrence of mullite in rocks of pyroxene hornfels facies is considered unlikely. The *c*-dimensions of the contact metamorphic sillimanites lie at the small end of the range of values reported to date, implying an environmental control of composition or structure that warrants further investigation.

The results reported here are consistent with the data of Holm and Kleppa (1966), who concluded on the basis of new thermochemical measurements in the system Al_2O_3-SiO_2 that mullite is not stable with quartz below about 1100°C at atmospheric pressure and higher temperature at elevated pressures. This value is compatible with the observation of mullite in aluminous rocks metamorphosed in Sanidinite facies, by intimate contact with basaltic magma near the surface of the earth, and with its absence in plutonic contact aureoles. The extent to which coexisting aluminosilicates depart from the system Al_2O_3-SiO_2 remains to be adequately evaluated.

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DESCRIPTION OF SAMPLES

B-94: Hornfels, Isabella area, collected 1000 feet from nearest exposed contact of Sierra Nevada batholith. Assemblage III, Best and Weiss (1964, Fig. 3). Prisms of andalusite are enclosed in a matrix of brown biotite and finer quartz, plagioclase (An_{29}), fibrolite, ilmenite, and possibly graphite. Andalusite contains inclusions of quartz and graphite (?), and appears to be partially replaced by single crystals and aggregates of prismatic sillimanite.

B-145: Isabella hornfels, Assemblage IV, 100 feet from igneous contact. The rock is principally composed of quartz, microcline perthite, plagioclase (An_{18-23}) and cordierite, with subordinate biotite, sillimanite, andalusite, and ilmenite. Acicular sillimanite is in isolated grains and sinuous aggregates, mixed with ilmenite; andalusite, rare sieved granules. For further data on this specimen, see Best and Weiss.

O-7: Fine hornfels with quartz-feldspar and quartz-fibrolite veinlets, 900 ft. from contact of Onawa pluton, Boarstone Mountain, nr. Onawa, Maine (Philbrick, 1936; Moore, 1960). Matrix of quartz, microcline perthite, and cordierite, with biotite and ilmenite, is traversed by quartz-microcline segregation veinlets and irregular, veinlike mats of fibrolite, mixed with quartz and biotite. Fibrolite also occupies grain boundaries between other minerals and sends sprays into them. Subordinate andalusite subhedra have a thin fibrolite mantle. Matrix is depleted in biotite adjacent to fibrolite veinlets.

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