the xonotlite crystals parallel to the slickensides strongly suggests a genetic relationship between the mineral crystallization and the displacement along the contact. Possibly the heat generated by this movement was sufficient to alter a pre-existing calcite vein into the hydrous calcium silicate, xonotlite, in the presence of siliceous emanations from the serpentine. The calcite may have been deposited at the contact in a pre-movement stage. A possible alternative to this hypothesis is that the xonotlite formed prior to the movement along the contact but that this movement caused recrystallization of the original xonotlite into the parallel-fibrous variety. The massive xonotlite described above would thus be relict from the pre-movement deposit. In any event, the origin of the xonotlite apparently is related to emanations from the serpentine. The fact that the xonotlite is confined to the contact plane and does not penetrate the wallrock indicates, however, that conditions at the contact were critical to its formation.

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CUMMINGTONITE FROM THE MIKONUI RIVER, WESTLAND, NEW ZEALAND

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Cummingtonite has not been recorded from New Zealand, although a considerable part of the South Island is made up of metamorphic rocks of various kinds. However, large areas of these rocks are situated in the geologically little explored region of the Southern Alps. Some years ago I collected a number of boulders of unusual appearance from the rivers draining the Southern Alps in Westland. Recent examination has shown the presence of abundant cummingtonite in some of these.

The cummingtonite-bearing boulders were collected from the Mikonui River where the main road crosses it just south of the town of Ross. The boulders were well rounded and ranged up to two feet in diameter, a not uncommon size in these swift mountain torrents. These boulders have a typically rusty surface, evidently due to the partial decomposition of the iron-bearing minerals. On breaking them with a ham-

mer, they split comparatively easily along cummingtonite-rich surfaces. Other minerals visible to the unaided eye are quartz, dark-red garnet, and small amounts of pyrrhotite and a black bladed mineral, later identified as ilmenite. The rock can best be described as a quartz-rich cummingtonite-garnet schist. In some specimens the schistose structure is not pronounced, and the rock could be called a cummingtonite-garnet quartzite.

The cummingtonite occurs as fibrous radiating aggregates of crystals, the individual crystals being up to 20 mm. long. Its color is pale clove brown. The hardness is about 5. The density (measured by suspension in Clerici solution)is 3.27.

In thin sections under the microscope the cummingtonite appears as long fibrous crystals containing numerous inclusions of quartz crystals elongated in the c direction of the cummingtonite. The color is pale yellowish-gray, and the mineral shows feeble pleochroism, the intensity of color being greatest in the Z direction. Some crystals show polysynthetic twinning. The extinction is oblique, the extinction angle ($Z \wedge c$) being 16°. The interference figure indicated a high axial angle, and this was confirmed by universal stage measurements, which showed that the sign is positive and that $2V = 86°$. Refractive indices (measured in sodium light by the immersion method) are $\alpha = 1.651$, $\gamma = 1.678$; $\gamma - \alpha$ 0.027. From the axial angle and the measured values of α and γ, the calculated value of β is 1.664. From the data given by Bowen and Schairer (1935) this indicates a cummingtonite with almost 50% of the $Mg_7(Si_4O_{11})_2(OH)_2$ component, a figure which was confirmed by chemical analysis.

A pure sample of cummingtonite for chemical analysis was readily separated from the crushed rock by centrifuging the 140–400 mesh fraction in methylene iodide-acetone mixtures. The separated material was examined under the microscope and found to be 99%+cummingtonite, the only impurity being tiny quartz inclusions. The analysis (Table 1) was made by Mr. M. Coller, analyst in the Department of Geology of Indiana University, to whom I would express my appreciation for his careful work. Fluorine was tested for and not found. The first determination of H_2O+ by the Penfield method, with ignition at red heat for five minutes, gave 0.66%, clearly a low figure in view of the accepted amphibole formula. Redetermination with ignition for 30 minutes raised this figure to 1.04%, still below the theoretical quantity ($\pm 2\%$). This experience confirms the belief held by some chemists and mineralogists that Penfield method fails to drive off all the combined water in minerals which hold this water very tenaciously, such as the amphiboles. Rabbitt (1948) mentions a similar experience in his study of the anthophyllite series.

In Table 1 the analysis (after subtracting an estimated 1% SiO_2 as quartz impurity) is recalculated into atoms per unit cell, according to the procedure recommended by Hey (1939), using the measured density of 3.27 and a figure of 909 Å³ for the volume of the unit cell. The results show good agreement with the accepted formula of cummingtonite, $(Fe,Mg)_{14}(Si_4O_{11})_4(OH)_4$, except for the deficiency in OH, this being apparent rather than real, due to the incomplete removal of water by the Penfield method. The analysis shows the typical features of other analyzed cummingtonites, especially a low content of Al, which seems to be characteristic of this amphibole. Compared with other analyzed cummingtonites, the Mikonui material is closest in composition to one from Isopää, Finland, described by Eskola (1936).

TABLE 1. ANALYSIS OF CUMMINGTONITE

Analysis		atoms per unit cell			
SiO_2	52.9	Si	15.64	Si+Al	16.00
TiO_2	0.06	Al	0.84		
Fe_2O_3	0.0	Fe	7.08		
Al_2O_3	2.37	Mg	6.18	Al+Fe+Mg	
FeO	28.0	Ca	0.18	+Ca+Mn	14.17
MgO	13.71	Mn	0.25		
CaO	0.55	O	44.14		44.14
MnO	0.97	OH	2.10		2.10
$H_2O > 105°$	1.04				
Na_2O*	<0.1				
F	*not found*				
Total	99.60				

* By spectrographic analysis.

Some confusion exists in the naming of amphiboles of this composition, since the names cummingtonite and grünerite have been used by different mineralogists for what is actually a single phase. Sundius (1931) has suggested that the name cummingtonite be limited to material containing 50–70 mole per cent of the magnesium component, and that the varieties richer in iron be called grünerite. This proposal would have the curious result of requiring the original cummingtonite from Cummington, Massachusetts, to be called grünerite. Since one name is adequate for this amphibole species (or sub-species) and cummingtonite has clear priority (cummingtonite: Dewey, 1824; grünerite: Kenngott, 1853), the name cummingtonite should be accepted and grünerite relegated to the synonymy. If it is necessary to distinguish the magnesium-rich varieties this can be accomplished by the use of an adjectival prefix, i.e. magnesian cummingtonite.

Since the cummingtonite was collected in a stream boulder and not observed in place, little can be said about its geological occurrence. Morgan's description of the Mikonui Subdivision (1908) shows that the Mikonui River drains larger areas of schists of the Arahura Series. None of the rocks he describes resembles the material discussed in this paper and this probably means that it is of comparatively local occurrence. The essential minerals of the rock are cummingtonite, quartz, and garnet, the cummingtonite and garnet in sub-equal amounts and the quartz in excess of either. Feldspar is totally absent. The garnet has $n = 1.81$, $D = 4.09$, and lattice dimensions $a_0 = 11.59$ Å; a spectrographic analysis showed that the major elements are Fe, Si, and Al, with minor Ca and small amounts of Mg and Mn. These properties indicate that the garnet is essentially an almandite, with about 30% of the grossularite component. The mineralogical assemblage quartz-cummingtonite-almandite places this rock either in the amphibolite facies or the epidote—amphibolite facies. The general appearance of the rocks of the Arahura Series suggest that they belong to the lower rather than the higher of these two facies, although rocks belonging to the amphibolites facies may be developed around the granite intrusions which are common in the Mikonui Valley. Prior to metamorphism the quartz-garnet-almandite rock may have been a sandstone with clayey and ferruginous impurities; on the other hand the rock may be of metasomatic origin. This question can only be settled when the rock is found in situ. A small amount of later alteration is indicated by the beginning alteration of almandite to chlorite along cracks.

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