Table 3. Possible composition of the Martian atmosphere calculated from the ultraviolet reflectivity.

Amount (m-atm at 0°C, 1 atm)			Surface pressure (mb)
Pure CO_2	Pure N_2	N_2 (with 45 m-atm CO_2)*	
66	104	32	5 lowest limit
132	208	136	10 most probable
198	312	240	15
274	416	344	20 highest limit

* Data from ref. *8–10*.

would apply to the surface of Mars (*8*, *9*, *10*, *24*). The determination of pressure by Kaplan, Munch, and Spinrad (*10*) is based on photographic infrared spectrograms, and thus can be attributed to the surface since the atmosphere is transparent in that spectral region.

The spectrum of Mars can be divided into several regions where different effects are important in producing the reflectivity of the entire planet. Below 3000 Å, Rayleigh scattering, large-particle scattering, and reflection from the surface are all important, with Rayleigh scattering beginning to predominate at shorter wavelengths. In the 3000- to 4000-Å range, Rayleigh scattering should contribute about 0.01 to the total reflectivity, large-particle scattering 0.01 to 0.02, and surface reflectivity about 0.01 to 0.02. The reflectivity of the polar cap should be approximately constant at all wavelengths at about 0.15 to 0.25 (that is, slightly higher than the light areas in the red region of the spectrum). The contrast of surface features should be reduced essentially to zero in the 3000- to 4000-Å range. Maximum limb brightening should occur at 4500 to 5000 Å owing to Rayleigh scattering. Between 4000 and 5000 Å, the increasing reflectivity of the surface should begin to predominate in determining the total reflectivity. The contrast of surface features should rapidly become apparent. Above 5000 Å, where the reflectivity of the surface predominates, limb darkening should become apparent. All of these effects can be observed in photographs of the planet Mars.

The appearance of the planet in different colors can be satisfactorily described without postulating atmospheric absorbers in the blue and ultraviolet. The 10-mb model can be used to determine the ultraviolet flux at the surface of Mars. If there is a ten times larger than possible oxygen concentration of 70 cm-atm (*8*), the model permits inference that the transmission of direct solar radiation to the surface, at 60° solar zenith angle, will be about 70 percent at 2000 Å (correcting for both scattering and oxygen absorption). Between 2000 and 3000 Å, approximately 90 percent of the direct solar radiation should reach the surface. There will be serious biological effects caused by such high-intensity radiation. Studies of the germicidal effects of ultraviolet radiation (*25*) indicate that a lethal exposure to the radiation would be accumulated in 1 or 2 days for almost all types of bacteria, spores, fungi, viruses, protozoans, and so forth found on earth.

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Merrihueite, A New Alkali-Ferromagnesian Silicate from the Mezö-Madaras Chondrite

Abstract. *Merrihueite, a new mineral with the approximate chemical composition* $(K,Na)_2(Fe,Mg)_5Si_{12}O_{30}$, *occurs with iron-rich olivine, iron-poor pyroxene, and nickel-iron in a few chondrules of the Mezö-Madaras chondrite. The refractive index lies between 1.559 and 1.592; the birefringence for each composition is low to moderate. X-ray powder data for merrihueite are nearly identical to those for osumilite,* $(K,Na,Ca)(Mg,Fe)_2(Al,Fe)_3(Si,Al)_{12}O_{30}{\cdot}H_2O$, *and very similar to those for synthetic* $K_2Mg_5\,Si_{12}\,O_{30}$. *Merrihueite is interpreted as an alkali-ferromagnesian silicate mineral of the osumilite type. It is named in honor of the late Craig M. Merrihue, meteoriticist, of the Smithsonian Astrophysical Observatory.*

The Mezö-Madaras chondrite, an unequilibrated, low-iron, ordinary chondrite (*1*), contains a few chondrules made up of the unusual mineral assemblage: clinoenstatite, fayalitic olivine, nickel-iron, and a new alkali-ferromagnesian silicate mineral. This assemblage will be described and discussed in detail elsewhere. The purpose of this report is to announce the new mineral, for which we propose the name *merrihueite* in honor of Craig M. Merrihue, of the Smithsonian Astrophysical Observatory, who died in March 1965.

Merrihueite occurs as inclusions in

twinned clinoenstatite and clinobronzite ($\mathrm{En}_{80\text{-}95}$). In most cases, it is separated from the pyroxene by narrow selvages of very fine-grained fayalitic olivine ($\mathrm{Fo}_{10\text{-}30}$); this mineral also rims some of the merrihueite-bearing chondrules. Minute, irregular grains of nickel-iron occur in the olivine, commonly at the olivine-pyroxene interfaces.

Merrihueite is greenish blue and is pleochroic from colorless to greenish blue. It occurs in masses up to 150 μ in diameter, which are aggregates of smaller individuals and show patchy variations of color and extinction. The small size, aggregate character, and low abundance of merrihueite in Mezö-Madaras (five thin sections and about 10 g of crushed sample have yielded only a few micrograms of the mineral) make optical determinations very difficult, but several poor interference figures indicate that the mineral is either uniaxial or biaxial, with optic angle 5° to 10°. The lowest refractive index measured on any grain is 1.559; the highest index measured is 1.592. In view of observed variations in composition from chondrule to chondrule (notably in Fe : Mg), this range certainly exceeds the birefringence for any one composition. The interference colors are anomalous blues and purples in thin sections of normal thickness, suggesting a low to moderate birefringence.

X-ray powder-diffraction patterns for merrihueite, osumilite (*2*), and synthetic $K_2Mg_5Si_{12}O_{30}$ (*3*) are reported in Table 1. All three patterns are similar; those for merrihueite and osumilite are nearly identical (merrihueite gives one reflection—($40\bar{4}2$)—which is not present in the osumilite pattern). There is good agreement between the observed *d* spacings for merrihueite and spacings calculated for the mineral by using the Miller indices for osumilite. It thus appears that these two minerals, and perhaps $K_2Mg_5Si_{12}O_{30}$ as well, are isostructural. Proof of this would require single-crystal x-ray measurements which are impossible with the finely polycrystalline material available in Mezö-Madaras.

We calculated the unit cells of merrihueite and $K_2Mg_5Si_{12}O_{30}$, assuming a cell configuration identical to that in osumilite (that is, dihexagonal-dipyramidal). The results (Table 2) indicate that the cell dimensions of the three minerals are very similar and that those of osumilite and merrihueite

Table 1. X-ray powder data for merrihueite, osumilite, and synthetic $K_2Mg_5Si_{12}O_{30}$.

Indices*	Merrihueite			Osumilite (*2*)		$K_2Mg_5Si_{12}O_{30}$ (*3*)	
	Intensity†	d(Å) observed	d(Å) calc.	Intensity†	d(Å)	Intensity†	d(Å)
$10\bar{1}0$				VW	8.8		
$000\bar{2}$	80	7.13	7.16	S	7.17	70	7.12
$10\bar{1}2$	10	5.50	5.55	W	5.55	10	5.54
$11\bar{2}0$	30	5.03	5.08	S	5.08	70	5.13
$20\bar{2}0$	5	4.40	4.40	M	4.41	80	4.43
$11\bar{2}2$	10	4.13	4.14	S	4.15	70	4.14
$20\bar{2}2$	100	3.73	3.75	M	3.74	80	3.74
$00\bar{0}4$	5	3.60	3.58	W	3.58	70	3.53
$12\bar{3}0,10\bar{1}4$	5	3.33	3.33	W	3.34		
$12\bar{3}1$	90	3.23	3.24	VS	3.24	100	3.25
$12\bar{3}2$	10D	3.01	3.02	W	3.02		
$11\bar{2}4,30\bar{3}0$	60	2.92	2.93	S	2.930	85	2.90
$20\bar{2}4$	100	2.774	2.777	M	2.776	85	2.76
$42\bar{2}0$	50	2.530	2.540	W	2.543	70	2.55
$31\bar{4}0$						30D	2.456
$31\bar{4}1$						30D	2.415
$00\bar{0}6$	10D	2.380	2.386	S	2.390		
$30\bar{3}4$						20D	2.266
$31\bar{4}3$	20D	2.166	2.173	W	2.170	40D	2.175
$20\bar{2}6$						30	2.113
$40\bar{4}2$	10D	2.097	2.102				
$22\bar{4}4$						20	2.072
$23\bar{5}0,31\bar{4}4$	20D	2.010	2.018	W	2.016	50D	2.016
$11\bar{2}7$						30D	1.914
$14\bar{5}2,20\bar{2}7$	10D	1.852	1.855	M	1.855	50D	1.852
$50\bar{5}0$						40	1.765
$23\bar{5}4$	5	1.737	1.758	W	1.737		
$22\bar{4}6$						40	1.731
$41\bar{5}4$						20	1.696
$42\bar{6}0$						20	1.669
$20\bar{2}8$						10	1.640
$21\bar{3}8$						40D	1.578
$33\bar{6}4$						30	1.533
$42\bar{6}4$						20	1.513
$60\bar{6}0$						10	1.472
$60\bar{6}1$	10D	1.465	1.458	VW	1.462		
$43\bar{7}0$						60D	1.451
$60\bar{6}2$	10D	1.440	1.437	W	1.437	10	1.440
$52\bar{7}0$						60D	1.415
$60\bar{6}3$				W	1.406		
$55\bar{7}2$						20D	1.386

* Hexagonal indices, in part after Miyashiro (*2*), were used to calculate *d* spacings for merrihueite. Those indices not given by Miyashiro were calculated from measured *d* spacings for the three minerals.
† Intensity data for merrihueite and $K_2Mg_5Si_{12}O_{30}$ are given on a scale of 0 to 100, the strongest lines being given a value of 100; D = double. The intensities of osumilite lines are expressed by: W, weak; M, moderate; S, strong; VW, very weak; VS, very strong.

Table 2. Cell dimensions for merrihueite, osumilite, and $K_2Mg_5Si_{12}O_{30}$. Cell dimensions for the first and third were calculated from the *d* spacings on the assumption that these minerals are isostructural with osumilite.

Merrihueite	Osumilite (*2*)	$K_2Mg_5Si_{12}O_{30}$ (*3*)
Calculated cell	*Measured cell*	*Calculated cell*
$a_0 = 10.16 \pm 0.06$ Å	$a_0 = 10.17$Å	$a_0 = 10.18$ Å
$c_0 = 14.32 \pm 0.06$ Å	$c_0 = 14.34$ Å	$c_0 = 14.29$ Å
$a_0 : c_0 = 1 : 1.409$	$a_0 : c_0 = 1 : 1.410$	$a_0 : c_0 = 1 : 1.404$
Calculated density	*Measured density*	*Calculated density*
$\rho = 2.87$ g/cm^3	$\rho = 2.64$ g/cm^3	$\rho = 2.63$ g/cm^3

Table 3. Microprobe analysis of merrihueite from the Mezö-Madaras chondrite.

Element	Percent by weight	Oxide	Percent by weight	Moles of oxide*	
Si	28.9	SiO_2	61.8	12.00	12.00
Al	0.09	Al_2O_3	0.2	0.02	
Fe	18.4	FeO†	23.7	3.85	5.20
Mg	2.63	MgO	4.4	1.27	
Mn	0.40	MnO	0.5	0.08	
Ca	0.21	CaO	0.3	0.06	
K	3.13	K_2O	3.8	0.47	0.85
Na	1.50	Na_2O	2.0	0.38	

* Data normalized to $SiO_2 = 12.00$ moles. † All Fe assumed to be divalent. See text.

are identical within the limits of error. The specific gravity of merrihueite, based on the cell and chemical analysis, is 2.87.

Five grains of merrihueite in a single chondrule were analyzed with an Applied Research Laboratories microprobe at the Smithsonian Institution of Washington (*4*), with the results presented in Table 3. The grains showed minor variations in K and Na, but are otherwise homogeneous. Partial analyses of merrihueite from several chondrules, made with a Philips-type microprobe at the Advanced Metals Research Corporation, Burlington, Mass., indicate that Fe varies widely from chondrule to chondrule and, in some instances, within chondrules.

The observed range is 10.5 to 24.8 percent Fe by weight, corresponding to a variation of FeO/(FeO + MgO) (molecular ratio) from about 0.4 to unity. Spectral scans of two grains of merrihueite indicated no significant amounts of elements with atomic numbers greater than 8, other than those reported in Table 3.

The calculated oxide analysis in Table 3 is based on the assumption that all iron in merrihueite is divalent, an assumption which is consistent with the reduced nature of the chondrite as a whole and with the presence of metallic iron in the mineral assemblage. Failure of the analysis to total 100 percent may be due to underestimation of Na, to the presence of undetected water, or to other limitations of quantitative microprobe analysis. Refinement of the chemical analysis of merrihueite must await the location of a more abundant source for the mineral.

When the calculated oxide analysis is recast to moles and normalized to 12 SiO_2 (Table 3), it is evident that the ratio of alkali oxides to ferromagnesian oxides to silica is approximately 1 : 5 : 12. The formula of merrihueite thus appears to be essentially $(K,Na)_2(Fe,Mg)_5Si_{12}O_{30}$. The small amounts of Ca and Al present may proxy for the alkalies and silicon respectively.

Both the x-ray data and the chemical analysis of merrihueite indicate that it resembles the synthetic compounds $K_2Mg_5Si_{12}O_{30}$ (*3*) and $Na_2Mg_5Si_{12}O_{30}$ (*5*). It can be regarded as a solid solution of these components and their K-Fe and Na-Fe analogues. Merrihueite differs from all other osumilite-type minerals—osumilite (*2*), armenite (*6*), and milarite (*7*)—in lacking essential aluminum. It is of interest for this reason and because it is the only known meteoritic mineral which contains essential potassium.

Inasmuch as merrihueite contains variable amounts of Fe, Mg, Na, and K, it raises a problem of terminology. This problem is compounded by the facts that Al may substitute for Si in some environments to a theoretical upper limit of $Al : (Al + Si) = 0.4$ (atomic) in osumilite, and that Ca can proxy for K and Na (*2*). We propose that the name merrihueite be restricted to minerals with the osumilite structure in which (i) $K > (Na + Ca)$ (atomic), (ii) $(Fe + Mn) > Mg$, and (iii) $Al : (Al + Si) \leqq 0.2$.

Although our iron data include some grains in which $Mg > Fe$, the data for these grains are too meager to justify extending the name on this basis.

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Saturn's Ring and the Satellites of Jupiter: Interpretations of Infrared Spectra

Abstract. *Infrared spectra of Saturn's ring correspond closely with the reflection spectrum of water ice. This result supports Kuiper's suggestion for the composition of the ring. The absence of the strong absorption at 8873 Å in spectra of Io, Ganymede, and Callisto leads to a new upper limit for the abundance of methane in possible atmospheres of these satellites.*

Low-dispersion infrared spectra of Saturn and the Galilean satellites of Jupiter have been published by Kuiper (*1*). The object of my investigation was to extend the study of the spectra of these bodies to longer wavelengths: 11,100 Å in the case of Saturn and 9700 Å for the Jovian satellites. Both projects were carried out at the Kitt Peak National Observatory with the Cassegrain spectrograph of the 36-inch (90-cm) reflector. Eastman I-M and I-Z spectrographic plates were used after hypersensitization with an ammonia solution. The observations were made in the autumns of 1963 and 1964.

The spectra of Saturn were compared with those of Jupiter obtained at the same dispersion (250 Å/mm) to determine whether any new features were present. The spectrum of Jupiter has been analyzed at higher resolution in this region (*2*) and thus serves as a reliable standard for line identifications. No new absorptions were found. The most interesting feature, first pointed out by Fredrick (*3*), in these spectra was the low reflectivity of Saturn's ring in the region 10,400 to 10,900 Å. In this wavelength region, the sensitivity of the I-Z emulsion rises to its maximum and then drops steeply toward longer wavelengths. This behavior is well illustrated by the spectra of Jupiter and the disk of Saturn, but the ring exhibits a nearly uniform brightness across the plate, indicating a definite drop in reflectivity in the region referred to.

Kuiper (*1*) has suggested that the particles making up the ring are covered by frost (if not composed of ice) on the basis of the low reflectivity of the ring near 1.5 μ. To test whether this deduction might also explain the present observation, spectra of sunlight, reflected by blocks of H_2O ice and CO_2 ice and by H_2O ice crystals,