Below the horizon of extinction of *D. pentaradiatus* and *D. surculus*, the coiling direction of the *Globorotalia menardii* complex is predominantly dextral. This complex includes *G. menardii miocenica, G. menardii multicamerata*, and a small biconvex form. Above this horizon the coiling direction is predominantly sinistral, and the complex is reduced to a single, larger form, the typical *Globorotalia menardii* of modern seas. *Globoquadrina altispira sensu lato* does not occur above this horizon, and abundant *Globorotalia truncatulinoides* occur only above the horizon (*9*). The former resembles *Globoquadrina altispira globosa*, which was described from the Upper Miocene of Trinidad. Typical *Globigerina nepenthes* is found in Pliocene-Miocene beds below this marked "faunal break."

From my observations I draw the following conclusions: (i) In view of the number of taxa involved, the small size of individuals, and the planktonic habit of these organisms, the horizon in question appears to be synchronous throughout the Atlantic Ocean, the Pacific Ocean, and the Gulf of Mexico. Stratigraphic evidence from numerous closely spaced wells supports this conclusion, at least for the northern Gulf of Mexico. The changes must have occurred abruptly and at approximately the same geologic time. (ii) Although Ericson *et al.* (*1*) claim that the extinctions and evolutionary changes were caused by a marked and abrupt climatic change, it is felt that too little is known of the controlling factors of life on this planet for an unequivocal conclusion to be drawn on this point. Riedel *et al.* (*2*) have pointed out that "more pronounced faunal changes have occurred at intervals through geologic time, but many of them are not clearly attributable to marked climatic change, and fewer are attributable to the onset of glacial periods." (iii) Even if the extinctions and evolutionary changes were caused by abrupt cooling of much of the earth's surface, the "faunal break" may have been Late Aftonian instead of Late Pliocene. The idea that there were alternating cooling and warming trends during the Pleistocene is not new, and it may well have been the onset of a subsequent glacial period rather than the first glacial period that resulted in the changes described. On the basis of the correlation of neritic sediments containing the horizon in question with alluvial terrace formations (*6*), which in turn have been related to Pleistocene events (*3, 4*), the "faunal break" probably occurred during the Late Nebraskan glaciation or the Aftonian interglaciation, or possibly later, rather than during the latest Pliocene. This analysis, it must be pointed out, cannot be substantiated (or disproved) paleontologically. Geochemical dating methods have confirmed the Late Quaternary age of the uppermost alluvial formations and their down-dip marine equivalents (*10*), but the older formations and marine correlatives exceed the range of the radiocarbon method. Thus, it may be argued that the exact age of lower alluvial terrace formations has not been determined.

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Ureyite, $NaCrSi_2O_6$: A New Meteoritic Pyroxene

Abstract. *The new mineral $NaCrSi_2O_6$ (ureyite) has been found as rare emerald-green grains in the iron meteorites Coahuila, Toluca, and Hex River Mountains. X-ray studies of the natural and synthetic material have established that the mineral is isostructural with jadeite, $NaAlSi_2O_6$. Indexed data for powder patterns obtained by x-ray diffraction and precise cell dimensions are given for the Cr, Fe, and Al members of the jadeite group. Unlike jadeite, a high-pressure phase, ureyite can be synthesized from melts at 1-atmosphere pressure.*

An emerald-green mineral found as an accessory constituent in the iron meteorites Coahuila, Toluca, and Hex River Mountains has been identified as a new chromium member of the jadeite group. Quantitative analyses by the electron-microprobe technique established the composition of the "ureyite" as $NaCrSi_2O_6$ (Table 1).

To establish the isostructural relation of the new mineral to clinopyroxene, we determined, by x-ray analysis of single crystals, the unit cell and space group of the Coahuila material and of aegirine from Narssarssuaq, Greenland. An analysis of the aegirine from this locality is reported by Böggild (*1*). The powder diffraction patterns of this material, of synthetic $NaAlSi_2O_6$ (*2*), and of synthetic $NaCrSi_2O_6$ prepared by us were indexed. The refined unit cell dimensions, obtained by the least-squares computer program of Burnham (*3*), are cited in Table 2 together with the data of Nolan and Edgar (*4*) on synthetic $NaFeSi_2O_6$. Indexed powder patterns are available for aegirine, ureyite, and synthetic $NaCrSi_2O_6$ (Table 3), jadeite (*5*), and synthetic $NaFeSi_2O_6$ (*4*). The space group of all members of the group is $C2/c$.

We have synthesized ureyite by fus-

Table 1. Chemical composition of ureyite, as determined by electron-microprobe analysis (*9*).

Compound	Coahuila			Toluca			Hex River Mtns.
	Wt. (%)	Atoms per 6 atoms oxygen		Wt. (%)	Atoms per 6 atoms oxygen		Wt. (%)
SiO_2	55.5	1.99		56.0	2.06		
Al_2O_3	n.d.*			n.d.*			
Fe_2O_3	0.2	0.00	0.90	0.4	0.01	0.97	~ 0.9
Cr_2O_3	30.6	0.86		22.6	0.66		~26.4
MgO	0.8	0.04		5.4	0.30		~ 1.2
Na_2O	11.6	0.81	0.88	11.6	0.83	0.98	~11.0
CaO	1.7	0.07		3.7	0.15		~ 2.1

* None detected.

ing a nonstoichiometric mixture of 45 percent by weight SiO_2, 45 percent by weight Na_2SiO_3, and 10 percent by weight Cr_2O_3 at 1100°C and cooling the mixture to 700°C over a 2-day period. Well-formed crystals up to 0.1 mm in size also were obtained by fusing 1 g of stoichiometric $NaCrSi_2O_6$ mix with 0.1 g of Na_2SiO_3 at 1100°C. Fusions with the composition $NaCrSi_2O_6$ without extra SiO_2 and Na_2O yielded a product containing Cr_2O_3, with much glass and none of the desired phase. The phase relations in the system Cr_2O_3-SiO_2-Na_2O to this extent, at least, appear to be similar to those obtaining in the system Fe_2O_3-SiO_2-Na_2O, described by Bowen, Schairer, and Willems (*6*). We also have synthesized $NaCrSi_2O_6$ in an opposed-anvil press at 10 kbar and 600°C. Unlike jadeite, $NaAlSi_2O_6$, which is stable only at high pressures (*7*), the fields at which both $NaFeSi_2O_6$ and $NaCrSi_2O_6$ are stable extend down to ordinary pressures.

$NaCrSi_2O_6$ was found in the hexahedrite Coahuila as a smooth lenticle, about 0.5 mm in size, embedded in the surface of a nodular aggregation of daubreelite, $FeCr_2S_4$. An identical occurrence was found in the hexahedrite Hex River Mountains. The ureyite is a polycrystalline aggregate from which prismatic cleavage fragments up to 200 μ in size could be isolated. The ureyite and the daubreelite apparently consolidated from two immiscible liquids. A third occurrence was noticed in the acid-insoluble residue of a mass of the medium octahedrite Toluca. Here the ureyite, amounting to a few milligrams, occurred embedded in the cliftonite rims of troilite nodules that contained feldspars, pyroxenes, zircon, and quartz.

A study of two such nodules by metallographic techniques revealed a complex assemblage of accessory minerals, including daubreelite, chromite, pentlandite, heazlewoodite, several Cu-Fe sulfides, native copper, sphalerite, alabandite, and various as yet unidentified minerals.

Ureyite is monoclinic, optically negative, and strongly pleochroic. The optical properties of the three meteoritic occurrences of ureyite are similar but not identical, and the indices of refraction are somewhat lower than those of synthetic $NaCrSi_2O_6$ (Table 4). The reason for this is found in the presence of small and variable amounts of Ca, Mg, and possibly Fe^{2+} (Table 1), indicating a compositional variation analogous to that extending from

Table 2. Unit-cell dimensions and calculated density (d_{calc}) values for members of the jadeite group (space group $C2/c$).

Mineral	Unit cell parameters (Å)			β (deg.)	Volume	d_{calc}
	a_0	b_0	c_0			
$NaAlSi_2O_6$ (synthetic)	9.418±.006	8.563±.004	5.211±.006	107.57±.05	400.7±.6	3.35
$NaCrSi_2O_6$ (synthetic)	9.550±.016	8.712±.007	5.273±.008	107.44±.16	418.6±1.4	3.60
Ureyite (Coahuila)	9.560±.016	8.746±.008	5.270±.006	107.38±.10	420.6±1.1	
$NaFeSi_2O_6$ (synthetic)	9.658	8.795	5.294	107.42	429.1	3.58
Aegirine (Greenland)	9.657±.014	8.801±.006	5.291±.011	107.43±.11	429.0±1.0	

Table 3. Indexed x-ray powder data. Unit-cell dimensions given in Table 2. FeKα 1.93728 Å, Mn filter, camera diameter 114.59 mm (f, faint; b, broad; bb, very broad).

hkl	Aegirine, Greenland			Ureyite, Coahuila			$NaCrSi_2O_6$, synthetic		
	I	d_{obs}	d_{calc}	I	d_{obs}	d_{calc}	I	d_{obs}	d_{calc}
110	9b	6.369	6.364	5	6.316	6.314	5	6.294	6.297
020	8b	4.416	4.400	6	4.381	4.373	5	4.357	4.356
111	1	3.614	3.608				3	3.621	3.585
220	5	3.188	3.182				2	3.137	3.148
22$\bar{1}$	7b	2.983	2.985	10	2.961	2.964	10	2.956	2.958
310	10b	2.900	2.900	7	2.8768	2.8724	10	2.8670	2.8678
31$\bar{1}$			2.893			2.8669			2.8644
130	f	2.7920	2.7954						
13$\bar{1}$	5b	2.5408	2.5455						
11$\bar{2}$			2.5327						
002			2.5240	6	2.5172	2.5147	7	2.5166	2.5155
221	6b	2.4701	2.4710	6	2.4548	2.4549	7	2.4476	2.4503
311	1	2.2530	2.2540				2	2.2293	2.2343
31$\bar{2}$			2.2439						2.2294
040	1	2.1995	2.2002						
112			2.1956	7	2.1806	2.1860	5	2.1783	2.1852
022						2.1800			2.1784
33$\bar{1}$	3	2.1200	2.1185	3	2.1008	2.1023	7	2.0985	2.0989
330			2.1213			2.1045			2.0989
42$\bar{1}$	2	2.0943	2.0950				3	2.0748	2.0733
041	2	2.0162	2.0169				2	1.9962	1.9987
240	f	1.9840	1.9854						
24$\bar{1}$	1	1.9350	1.9350				2	1.9140	1.9162
51$\bar{1}$	1	1.8818	1.8823						
42$\bar{2}$				2	1.8320	1.8304			
331	f	1.8263	1.8263						
510	1	1.8052	1.8036						
150	6b	1.7293	1.7289				5	1.7107	1.7114
042	f	1.6590	1.6585						
22$\bar{3}$	f	1.6341	1.6337	3	1.6259	1.6264			
44$\bar{1}$	5	1.6120	1.6164	3	1.5997	1.6037	7	1.5957	1.5997
151						1.5984			1.5931
440	5	1.5920	1.5910				5	1.5752	1.5742
60$\bar{2}$	1bb	1.5377	1.5313				2	1.5209	1.5165
600			1.5356						1.5185
35$\bar{1}$	1bb	1.5290	1.5261						
350			1.5271						
53$\bar{2}$				1	1.4968	1.4976			
13$\bar{3}$						1.4967			
060	2	1.4671	1.4668				2	1.4519	1.4502
260	6bb	1.3975	1.3977	1	1.3866	1.3885	6	1.3802	1.3834
531			1.3943			1.3832			1.3806
53$\bar{3}$	2	1.3283	1.3240	1	1.3161	1.3148	3	1.3170	1.3139
71$\bar{2}$			1.3283			1.3158			1.3148
313	4	1.3021	1.3040						
710			1.3017						
31$\bar{4}$				1	1.2920	1.2937	2	1.2881	1.2943
11$\bar{4}$									1.2855
004				1	1.2589	1.2573	3	1.2560	1.2577
22$\bar{4}$	3	1.2687	1.2663						
062			1.2682						
352	2	1.2289	1.2281						
42$\bar{4}$			1.2292						
	1	1.2212		f	1.2204		3	1.2170	
	2	1.1992		1bb	1.0464		2	1.0510	
	1	1.1622					3	1.0436	
	f	1.1540							
	1bb	1.0691							
	2bb	1.0621							
	3bb	1.0550							
	1	1.0401							
	2bb	1.0043							

Table 4. Optical properties of ureyite. Indices for Na light: strongly pleochroic, with X, dark green; Y, yellow-green to yellow; Z, emerald-green to dark emerald-green. Optically negative, 2V 60°–70° (Toluca).

Meteorite	α	β	γ	$\alpha \wedge c$
Coahuila	1.748±.001	1.756±.001	1.765±.001	14°±1°
Toluca	1.740±.001	1.756±.002	1.762±.001	22°±1°
Hex River Mountains	Mean index about 1.760			
$NaCrSi_2O_6$ (synthetic)	1.766±.002		1.781±.002	8°

aegirine, $NaFeSi_2O_6$, to aegirine-augite, $(Na,Ca)(Fe^{3+},Mg,Fe^{2+},Al)Si_2O_6$. The largest variation in properties and composition was found in the Toluca material. The aegirine-augite series, as in the series extending from $NaCrSi_2O_6$, is accompanied by an increase in a_0 and b_0, by a decrease in the indices of refraction, and an increase in the extinction angle $\alpha \wedge c$. Crushed grains of ureyite exhibit a well-defined cleavage on (110) and a pronounced parting on (001). The cleavage angle was measured on a reflecting goniometer as 87°23′ ± 10′. The hardness and density could not be determined; the density for synthetic $NaCrSi_2O_6$, calculated with the cell dimensions of Table 2, is 3.60. Calculated density values for other synthetic members of the jadeite group are given in Table 2.

The mineral here described recalls an ill-defined emerald-green chromium mineral found in Toluca and described under the name kosmochlor by Laspeyres (*8*) in 1897. His analysis of a sample stated to contain a few percent of impurities gave: MgO, 4.55; CaO, 6.06; Fe_2O_3, 9.09; Al_2O_3, 9.09; Cr_2O_3, 39.39; SiO_2, 31.82; total, 100.00. The determinations were made with the greatest care, but the total sample weighed only 3.3 mg and the analysis, based on gravimetric methods, must be considered doubtful. Sodium, if present, would not have been detected since the sample was brought into solution by fusion in Na_2CO_3. Laspeyres described the mineral as forming cleavage laths bounded by a perfect cleavage on (010), a less-perfect cleavage at right angles on (100), and a third cleavage, observed as a single surface, in the same zone at about 105° to (010). On (010), the mineral exhibited inclined extinction with $\alpha \wedge c$ about 12°. The absorption of X is light yellow-green, and at right angles thereto, dark blue-green to emerald-green. The chemical and other characters of this mineral do not immediately indicate an identity with or relation to $NaCrSi_2O_6$. The optical behavior, however, suggests that the measurements may have been made on a cleavage flake of a clinopyroxene resting on (110) [with $110 \wedge 110 \sim 87°$]. We observed a green variety of diopside in the residues of Toluca, but the Cr_2O_3 content was only about 1 percent.

Acting with the approval of the Commission on New Minerals and Mineral Names of the International Mineralogical Association, we have set aside Laspeyres's name "kosmochlor," insofar as it may relate to this matter, since its identity with $NaCrSi_2O_6$ could only be fortuitous. The name itself is undesirable because of the ambiguity deriving from the suffix *chlor*, which can mean chlorine-containing or, as was here the intent, green. The name ureyite, after Harold Clayton Urey, Nobel Laureate in chemistry and noted investigator of meteorites, is here proposed for $NaCrSi_2O_6$.

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Subbottom Profile of Abyssal Sediments in the Central Equatorial Pacific

Abstract. *A north-south subbottom acoustic profile made in the central Pacific Ocean shows that the first layer (unconsolidated and semiconsolidated sediments) increases in thickness from less than 200 meters at about 14°N to more than 600 meters near the equator. Two major faults, one of which lies on the extension of the Clipperton fracture zone, have produced vertical separations of about 400 meters in the base of the first layer.*

During the recent WAHINE expedition we ran a subbottom acoustic profile (*1*) along longitudes 153° and 148°W from almost 14°N to the equator (Fig. 1). This profile yielded a detailed picture of the north-south variations in thickness of the first layer (*2*), as well as information on its internal structure.

The area surveyed is floored by a diverse suite of abyssal sediments made up of biogenous, authigenic, volcanic, and terrigenous components. Distribution of these various fractions is influenced by many physical and biological factors which, in terms of geologically significant time intervals, are far from constant.

Studies of bottom cores from the central and eastern Pacific led Arrhenius (*3*) and Riedel (*4*) to conclude that the equatorial belt of high organic productivity became narrower and narrower throughout the Tertiary period. Shor (*5*) used seismic reflection data from the eastern equatorial Pacific to show that the thickness of sediments above the "second layer" decreases with distance from the equator; this layer is generally assumed to consist of volcanic material or indurated sediments (*6*).