CARNEGIE-MELLON UNIVERSITY
MELLON INSTITUTE

FINAL REPORT

on

X-RAY DETECTION OF DISORDERED ORTHOPYROXENES IN METEORITES

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by

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INTRODUCTION

This final report consists of a section summarizing the past four years work and a section covering the new work, quantitative analysis of olivine in meteorites and other rocks.

The summary part consists of two earlier publications, "Disordered Pyroxene in Chondrites", and "Enstatite Produced by a Megabar Shock Event", an earlier semi-annual report showing the relationship between x-ray single-crystal photographs and shock in chondrites, two tables summarizing the occurrence of disordered pyroxene in mesosiderites, eucrites and howadites. The new work contains the % olivine and Mole % forsterite in 64 meteorites.

Quantitative Analysis of Olivine

In Table I the chondrites are grouped according to the Von Schmus and Wood petrologic classification. There is some overlap, but in general, the L group chondrites have less olivine than the LL group and more than the H group. Knyahinya with an L group olivine composition has a much higher olivine content. Guarena and Selma also have higher olivine content than the other members of the H group. Most of the H group contains between 24 and 37% olivine. In the L group, most fall between 40 and 52% and in the LL group, between 45 and 61% olivine. The estimated probable error in the x-ray measurements is 5% of the olivine determination. The table below shows the average olivine content of the LL, L and H petrologic types. The olivine percentages in L4, L5 and L6 are almost

Average % Olivine

	3	4	5	6
LL				51
L		46	46	45
H	32	30	31	31

identical, and those in H3, H4, H5 and H6 are very similar. The uniform olivine composition within these groups suggests that the mineralogy within the L and H groups has always been the same.

Total quantitative mineralogical analysis of the chondrites should show more definitely whether or not they have changed since crystallization. The differences in mineralogy within the H and L groups probably are due to variations in temperature pressure or composition at the time of chondrite or chondrite formation.

Table II lists the olivine content of some terrestrial and oceanic rocks.

SSP:vab

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TABLE I

OLIVINE CONTENT AND MOLE % FORSTERITE (Fo) IN CHONDRITES

	Meteorite	% Olivine	Museum Spec No.	Mole % Fo This Work	Mole % Fo Mason
L3	Barratta	40	USNM 289	79.5	75
L4	Bjurbole	45	---	75.5	74
	Goodland	46	ASU 425.1	77.5	75
L5	Arapahoe	41	ASU 465.1X	77.7	77
	Knyahinya	47	USNM 464	76.0	75
	Roy (1933)	52	ASU 234.110	74.6	75
	Taiban	45	ASU 541.1	76.8	75
L6	Abernathy	44	ASU 476.1X	76.4	77
	Brewster	46	ASU 483.1X	76.2	76
	Bruderheim	43	ASU 705	76.5	76
	Coon Butte	47	ASU 533.1	76.1	76
	Densmore	49	---	76.0	77
	Dwight	44	ASU 468.5	76.6	75
	Harrisonville	42	ASU 176.20	76.4	76
	Holbrook	50	ASU H52	76.2	75
	Leedey	41	ASU 498.1	76.9	76
	Marion Iowa	48	ASU 244a	75.7	76
	Modoc	47	USNM 360	76.5	77 & 78
	Ness County (1894)	44	ASU 87.8	75.7	75
	New Concord	41	ASU 202.1	76.0	76
	Otis	48	ASU 467.5	77.2	76
	Peetz	49	ASU 422.1	76.4	74
	Rush Creek	41	ASU 276.1X	78.1	74
	Utrecht	44	GMI	77.1	76
	Walters	46	ASU 655.1	75.7	75
Untyped L Chondrites					
	Akron #3 (1961)	45	ASU H2.8	77.5	75
	Calliham	49	ASU C70.16	76.2	77
	Cashion	36	---	75.0	82
	New Almelo	38	ASU 144.10	76.1	76
LL3	Chainpur	55	USNM 1251	71.7	--
LL4	Kelly	61	ASU 398.1X	72.5	71

TABLE I (CONTINUED)

OLIVINE CONTENT AND MOLE % FORSTERITE (Fo) IN CHONDRITES

	Meteorite	% Olivine	Museum Spec. No.	Mole % Fo This Work	Mole % Fo Mason
LL5	Oberlin	49	ASU 293ax	73.7	73
LL6	Arcadia	45	ASU 390.2	73.3	71
	Lake Labyrinth	55	ASU 369.2	72.2	72
	St. Severin	52	USNM 2608	73.0	71
H3	Clovis	35	USNM 2170	81.5	81
	Grady #2 (1937)	29	ASU 373.4X	85.5	85
H4	Bath	29	USNM 201	82.5	81
	Gruver, Texas	33	---	80.3	81
	Selma	31	USNM 3422	82.0	80
	Seminole, Texas	29	---	80.3	81
H(3,4)	Dimmitt	30	ASU 49.13	83.0	80
H(4,5)	Yonozu	30	USNM 1434	82.5	82
H5	Hugoton	24	---	81.4	84
	Pultusk	37	---	80.3	82
	Scurry	32	---	80.7	81
H6	Cedar, Kansas	28	ASU 408.1X	80.3	82
	Estacado	24	ASU 44.3	81.7	81
	Gladstone	32	ASU 315.1	81.1	83
	Guarena	36	USNM 1469	82.5	81
	Morland	32	ASU 282d	81.5	81
	Oakley	26	ASU 152a	81.0	79
Untyped H Chondrites					
	Lakewood	30	---	81.3	--
	Plains, Texas	34	---	81.0	--
	Portales #3	27	---	83.3	--
	Tell	34	---	82.0	82
	Wellman	33	---	82.5	82
	Wellman #3	33	---	84.5	--
C2	Murchison	< 5	---	---	--

TABLE I (CONTINUED)

OLIVINE CONTENT AND MOLE % FORSTERITE (Fo) IN CHONDRITES

	Meteorite	% Olivine	Museum Spec. No.	Mole % Fo This Work	Mole % Fo Mason
C3	Allende	87	---	58.3	--
	Efremovka	31 }60 29	USNM 2348	56.7 94.0	-- --
	Karoonda	72	USNM 5281	69.5	--
Unclassified					
	Cumberland Falls	18	ASU 26a	99.0	--
	Winona	17	USNM 854	94.5	95

ASU Arizona State University

USNM U.S. National Museum

GMI Geological-Mineralogical Institute, Utrecht

TABLE II

OLIVINE CONTENT AND MOLE % FORSTERITE (Fo) IN OCEANIC BASALTS AND TERRESTRIAL ROCKS

Sample	% Olivine	Mole % Forsterite
Olivine bomb San Carlos, New Mexico	44	87.5
Gabbro, Wichita Mts., Oklahoma	24	78.5
Shonkinite, near Butte, Montana	23	56.7
Leg III Oceanic Basalts		
3-14-10-1 near base	9	86
3-15-10-1	Less than 5	
3-18-7-1 15-16 cm	2-5	86
3-19-12-1	Less than 5	
3-19-12-2 12-13 cm	Less than 5	
3-20A-4-1	Less than 5	
Basalts dredged by Chain		
Chain 1-2 "glassy portion"	16.6	90.5
Chain 1-2 "crystalline portion"	20.6	68.5
Chain 36-5-12	Less than 5	
Chain 36-5-41	Less than 5	
Chain 43-107-3	14.6	90
Chain 43-104-16	15.3	77

SUMMARY OF PAST WORK

TABLE III

MESOSIDERITES WHICH HAVE BEEN STUDIED USING SINGLE-CRYSTAL X-RAY TECHNIQUES

Mesosiderites
Bondoc
Clover Springs
Crab Orchard
Enon
Estherville
Hainholz
Morristown
Mt. Padbury
Patwar
Vaca Muerte
Veramin

Ordered orthopyroxene was found in all of the above mesosiderites except crab orchard which contained ordered clinopyroxene.

TABLE IV

TYPE OF PYROXENE FOUND IN EUCRITES AND HOWARDITES

Achondrite		Type of single-crystal pattern produced by pyroxenes
Bereba	Eu	Disordered ortho & twinned clino
Bununu	Ho	Twinned clino & disordered ortho; untwinned clino, ordered ortho
Bholgati	Ho	ordered ortho; disordered ortho
Frankfort	Ho	ordered ortho
Haraiya	Eu	untwinned clino
Jonzac	Eu	twinned clino
Juvinas	Eu	clino
Luotolax	Ho	ordered ortho
Pasamonte	Eu	untwinned clino
Peramiho	Eu	ordered ortho; disordered ortho; untwinned clino
Sioux County	Eu	disordered ortho