COMPOSITIONAL AND MECHANICAL PROPERTIES OF CARBONATE ROCKS

by

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THE COMPOSITIONAL AND MECHANICAL PROPERTIES OF SOME CARBONATE ROCKS USED FOR AGGREGATE

The research project, HR-110, was begun in the fall of 1964 to further investigate the compositional and mechanical properties of some of the carbonate rocks used as aggregate in portland cement concrete. Under this project, rocks from the following quarries have been examined.

TABLE I. Quarries Sampled

NAME	COUNTY	LOCATION
DeWees-Potthoff Paralta	Linn	NE¼ SW¼, Sec. 6, T83N, R5W
County Quarry	Linn	NW¼ NW¼, Sec. 8, T85N, R7W
Weaver's Quimby	Cerro Gordo	NW¼, Sec. 27, T8N, R20W
Schildberg's Crescent	Pottawattamie	NE¼ NE¼, Sec. 34, T76N, R44W
Hopper's South	Cass (Neb.)	SE¼ SE¼, Sec. 34, T11N, R11W
Clark's North Logan	Harrison	NE¼ NE¼, Sec. 19, T77N, R42W
Lewis and Wallace	Appanoose	NE¼ NE¼, Sec. 32, T70N, R19W
Raid's Comanche	Van Buren	NE¼ NW¼, Sec. 5, T67N, R8W
Raid's Prospect Hill	Des Moines	NE¼, Sec. 27, T69N, R3W
Linwood Stone Products	Scott	SW¼, Sec. 13, T77N, R5W
Pint's	Black Hawk	NE¼ SE¼, Sec. 36, T89N, R12W
Beau and Son's Newton	Black Hawk	NE¼ NE¼, Sec. 13, T87N, R13W
Schildberg's Atlantic	Cass	NE¼, Sec. 34, T76N, R36W

Samples from these quarries were taken for study in cooperation with personnel of the Iowa State Highway Commission during the month of September, 1964 and the summer of 1965. Samples were taken only from those portions of the quarries that are used as aggregate in portland cement concrete by the Iowa State Highway Commission except where designated by commission personnel for purposes of evaluation of potential aggregate sources. Where practical, the samples were taken from each bed recognized by the Highway Commission geologists, and in most instances, the thicker beds were sampled at the top, middle, and bottom to detect any lithologic changes that escaped megascopic observation.

The samples as taken from the quarry were of sufficient size for laboratory testing. Sample sizes ranged from a minimum of three pounds to a maximum of twenty pounds, depending on the projected testing to be done.

LABORATORY OPERATIONS

In the laboratory, the samples were reduced to subsamples, an aliquot was ground to pass 200 mesh sieves and used for X-ray and chemical procedures, another aliquot was cored with a one inch core bit and the sample thus obtained was used for thin section blanks and other bulk testing, another portion was removed from the field sample with a half-inch core bit for use in specific surface, permability, density bulk and porosity testing. The sub-sampling was accomplished in such a manner as to be most representative of the bulk rock in the estimation of the project personnel. After the completion of sub-sampling, the remaining portions of the rock were replaced in the field bags and stored.

<u>X-ray Procedures</u>: Samples prepared for the X-ray diffraction analysis were first used as whole rock samples. That is to say, the samples were subject to no treatment beyond grinding. The samples were irradiated from 20° to 76° 2θ, and from this the rock was characterized as to mineralogy. The X-ray diffraction method is capable of determining mineral species present in amounts less than 4% if there is no interference between the patterns of the minerals present. The purpose of this analysis was to secure a knowledge of the bulk mineralogy of the rock to guide other investigation. Those samples that were shown by whole rock X-ray analysis to contain both dolomite and calcite were leached in 5% acetic acid to remove the calcite and were again subjected to the diffraction experiment to determine the type and crystallinity of the dolomite. Based on the results of this analysis, some samples were selected for analysis by the counting rate computer attached to the diffractometer. The counting rate computer is a very precise instrument, enabling the operator to accurately locate the peak of a diffraction maximum within a tolerance of $\pm 5 \times 10^{-3\circ}$ 2θ. This accuracy is achieved by causing the goniometer of the diffractometer to remain stationary until the counting circuits have received a predetermined number of signals from the detector. When

the predetermined number of signals, or counts as they are called, has been received by counting circuits, the time required to accumulate the count is measured by the computer and the mean value of the counts accumulated per second is plotted on a strip chart. The diffractometer goniometer then moves 0.01° 2θ where the cycle is repeated. The result of this sort of operation is a step-wise curve of the diffraction maximum from background through the peak and down to background on the other side. The instrument can be used as a quantitative tool by integrating the area under a diffraction maximum and comparing it to the area under another taken under the same experimental conditions. Because this latter technique is quite time consuming due to the extraordinary care required in duplicating conditions, it was not used in this investigation but the computer was used only to acquire accurately located diffraction peaks. Another advantage of the step-wise curve obtained by the counting rate computer is that resolution of diffraction maxima having almost the same 2θ value can be observed easily. In this investigation, much use was made of this feature.

<u>Chemical Procedures:</u> In this investitation the chemical procedure consisted of leaching part of the powdered sample with 1N HCl to derive the insoluble residue. Such common minerals as pyrite, quartz, gypsum anhydrite, and iron oxide are common in carbonate rocks and can usually be best isolated by means of taking the insoluble residue. The mineralogy of the insoluble residue from the rocks was determined by microscopy of X-ray diffraction as was

needed. In all cases the insoluble residue was quartz, pyrite, or iron oxide or some mixture of these crystals. In no case where the insoluble residue was over 5% was quartz not the main phase with subordinate amounts of the others intermixed.

<u>Microscopic Observations</u>: Standard thin sections were prepared from the samples and examined with the polarizing microscope. In this investigation, the textural and mineralogical classification of rocks in thin section was based on the same criteria as were used in HR-70 and HR-78. For convenient reference, the classification is restated here:

I. Essentially Homegeneous Texture

- A. Coarsely crystalline
- B. Medium crystalline
- C. Finely crystalline
- D. Microcrystalline

II. Polymodal Texture

- A. Breccia
    1. Aggregates or polycrystalline elements lacking well defined internal structure, occurring with surrounded by other aggregates of different particle size, shape or arrangement.
    2. Large, angular or rounded monocrystalline ele-

ments lying in a matrix of notably smaller monocrystalline elements.

The large monocrystalline elements commonly show overgrowths and other replacement phenomena.

B. Ovoid Texture

1. Rounded or subrounded aggregates of crystals that may or may not be radially and concentrically structured but are separated either completely or in part from like aggregates by a matrix of notably different crystal size lacking radial or concentric structure. These rounded aggregates are called ovoid bodies. They may contain single large crystals of any mineralogy or an aggregate of such crystals. Such contained crystals or aggregates thereof are not, in general, located at the center of "core" of the ovoid body.

C. Poikilitic Texture

1. Small crystals randomly scattered without common orientation within large crystals. The contained and host crystals may or may not be of the same type.

For the purpose of this investigation the terms used as size indicators have been assigned values as follows:

DESCRIPTIVE TERM	SIZE RANGE (in microns)
Microcrystalline	All crystals below the resolution limit of the microscope in thin section. This is usually less than thirty microns.
Finely crystalline	+30 u, -100 u
Medium crystalline	+100 u, -250 u
Coarsely crystalline	+250 u

By far the most common textural type found in the samples for this study are the microcrystalline rocks, most of them are both brecciated to some extent and definitely characterized by poikilitic intergrowth. Those rocks that contain both dolomite and calcite have crystals of both types that include the other mineral. In monomineralic rocks, the poikilitic enclosure of fine crystals by coarser ones of the same type is almost universally observed. The most abundantly observed texture consists of primarily microcrystalline calcite (or dolomite) with veins, irregular masses and/or interconnected veins and masses of coarser carbonate breaking up the microcrystalline mosaic into small domains ranging from a few microns to a few tens of millimeters in diameter. The difference between a microcrystalline mosaic and a microcrystalline breccia is then, a subjective judgment on the part of the observer as to whether the domains of coarser material do indeed divide the microcrystalline material into isolated domains. Most of the samples used in this study fall into one of these two classes and it does not appear significant if another observer would alter the two classifications. Few observers would confuse most of these rocks with any of the other mentioned types.

The samples for thin section were taken so that the section includes the vertical plane. They were first studied on a reconnaissance basis to select samples for other studies and to give a general classification to the rock. Later the sections were described with reference to composition, relative grain size and any other pertinent relationships. This study was carried out using the routine X-ray studies as a guide to the mineralogy. The impossibility of reliably differentiating between calcite and dolomite, or quartz and gypsum in thin section makes X-ray evidence by far the most reliable guide in this sort of study.

After the reconnaissance study, and classification, the thin sections were then analyzed by means of a five drum integrating stage. Two traverses, one parallel to the length of the section and the other normal to it were made on the few homogeneous rocks. The polymodal rocks were subjected to two traverses in each direction. The traverses were forty millimeters in length. The values presented in the accompanying tables and thin section descriptions are volume percentages of the minerals present in the rock.

Samples were prepared for use with polished specimens in reflected light, but the large amount of microcrystalline calcite and dolomite found in these rocks made such a study impossible. In former studies, operating with coarsely crystalline rocks, formic acid performed as a suitable etchant. When the percentage of the rock that is microcrystalline is greater than about twenty-five percent, however, formic acid acts too rapidly on the microcrystalline material with the result that so much relief is created that no clear microscopic image can be formed. A search is continuing for a suitable etchant for rocks of such fine crystal size. To date, hydrochloric acid, in numerous concentrations, acetic acid of various strengths, and two ferrocyanide solutions have been tried but in all cases, the large crystal boundary area renders the surface too susceptable to attack.

Method for Determination of Specific Surface Area: The specific surface was determined by the method of Brunauer, et al (1938). In this method, the necessary things to determine are that the total surface of all crystals in the specimen have been saturated with nitogen gas, N_2, and the number of moles of nitrogen in the process. Because it is considered that the nitrogen in a chemisorbed monolayer, and the cross sectional area of a molecule of N_2 is known, it is then possible to calculate the total surface area over which the absorption occurs. In our laboratory this is accomplished by use of a vacuum apparatus equipped with appropriate reservoir tanks for nitrogen and helium, a sample finger, and a mercury manometer for reading the gas pressure before and after allowing it to expand onto the sample. The reservoirs and sample chamber are separated by valves that permit an unknown amount of gas to be measured in a known volume at a measured pressure before it is supplied to the sample chamber. After the gas is expanded onto the sample, the pressure is determined again under known volume conditions. Nitrogen is supplied to the sample until saturation can be considered complete. Raw data from these operations are then used with a computer program to calculate the specific surface area. The determinations are made by a least squares calculation for slope and intercept, and the program prints out the specific surface area and the number of readings used in the calculation.

<u>Method for Determining Bulk Density:</u> The specimens were weighed accurately to three decimal places, and placed in a Beckman Air Comparison Pycometer for volume determination. This instrument depends on the equal compressability of air in two identical cylinders. If a sample of some volume be placed in one cylinder, then equal pressure will result only for different applied compression. The difference in the applied compression is proportional to the volume of the sample that has been inserted in one of the cylinders. In actual practice, the difference is read on the calibrated scale as cubic centimeters of sample volume. The sample displaces whatever fluid is present in the chamber; in design of the instrument this is air, and because most of the pores of a rock are permeable to air, a reasonably close measurement of the actual crystal density of the specimen can be obtained. In order to better this measurement, the instrument was modified so that both the sample and reference chambers could be evacuated and one atmosphere of N_2 applied to each. Because pores are more per-

meable to nitogen than to atmosphere, better values were obtained.

Method for Determining Porosity: If the crystal volume of a rock specimen is known and the apparent volume can be measured, the volume of the voids can be calculated and from this the porosity is easily determined. The apparent volume is easily obtained by filling the pores, or sealing them off. In this investigation, the sample core was sprayed with a plastic coating to seal the surface so that no penetration of the rock by nitrogen occurred.

Method of Determining Permeability: In this examination, the specimens were placed in a permeameter that forces air through the specimen and measures the flow rate of the effluent air. We found that the rocks tested were all below 45 millidarcys in permeability.

LABORATORY RESULTS

Dolomite Crystallinity Studies: Preliminary X-ray and thin section studies indicated that some of the dolomitic rocks had dolomite of more than two compositions present. Dolomites are known to differ significantly from the ideal composition of $Ca_{.5}Mg_{.5}CO_3$. The limits observed to date are $Ca_{.44}Mg_{.56}CO_3$ to $Ca_{.54}Mg_{.46}CO_3$. It is known that dolomites of differing composition have different X-ray patterns in general and that reflections from planes normal to the c axis and normal to the plane of the a axis have maximum differences in spacings. The spacings from d(00.6) and d(00.12), having no a axis component make the determination of the c axis length (c_o) quite simple and these peaks are composition sensitive. Similarly, the maxima from D(11.0) and d(03.0) having no c axis component are easy to treat for the determination of the length of the a axis (a_o). These diffraction maxima and the one from d(01.5) were examined for the selected dolomites by means of the counting rate computer.

It was expected that if two dolomites were present in the rock, whether zoning of crystals showed optically or not, there would be interference of the maxima from the two compositions and each maximum would have more than one peak, and that the peak shape itself would be asymmetrical. For comparison of peak shape between specimens of little and great mixing, the d(10.4) maxima were run for two of the dolomites, they are presented as figures 1 and 2 below. Note that figure 1, from R-4169 is very symmetrical and single valued. There is a slight asymmetry at the lower left end but the rest of the maximum is almost equivalent step for step. Figure 2, on the other hand, is multipeaked, asymmetrical and has a much higher background than does figure 1. It is difficult to analyze these peaks because of the multi-axis components, they are presented for illustrative purposes only.

The data from the counting rate computer was quite good for the reflections from d(00.6) and d(11.0), but from the other reflections, the intensities are in general too weak for use. Curves obtained from these experiments are presented as figures 3 through 20 and the peaks recorded therefrom and the departure from the values of c_o and a_o for ideal dolomite are recorded in Table II.

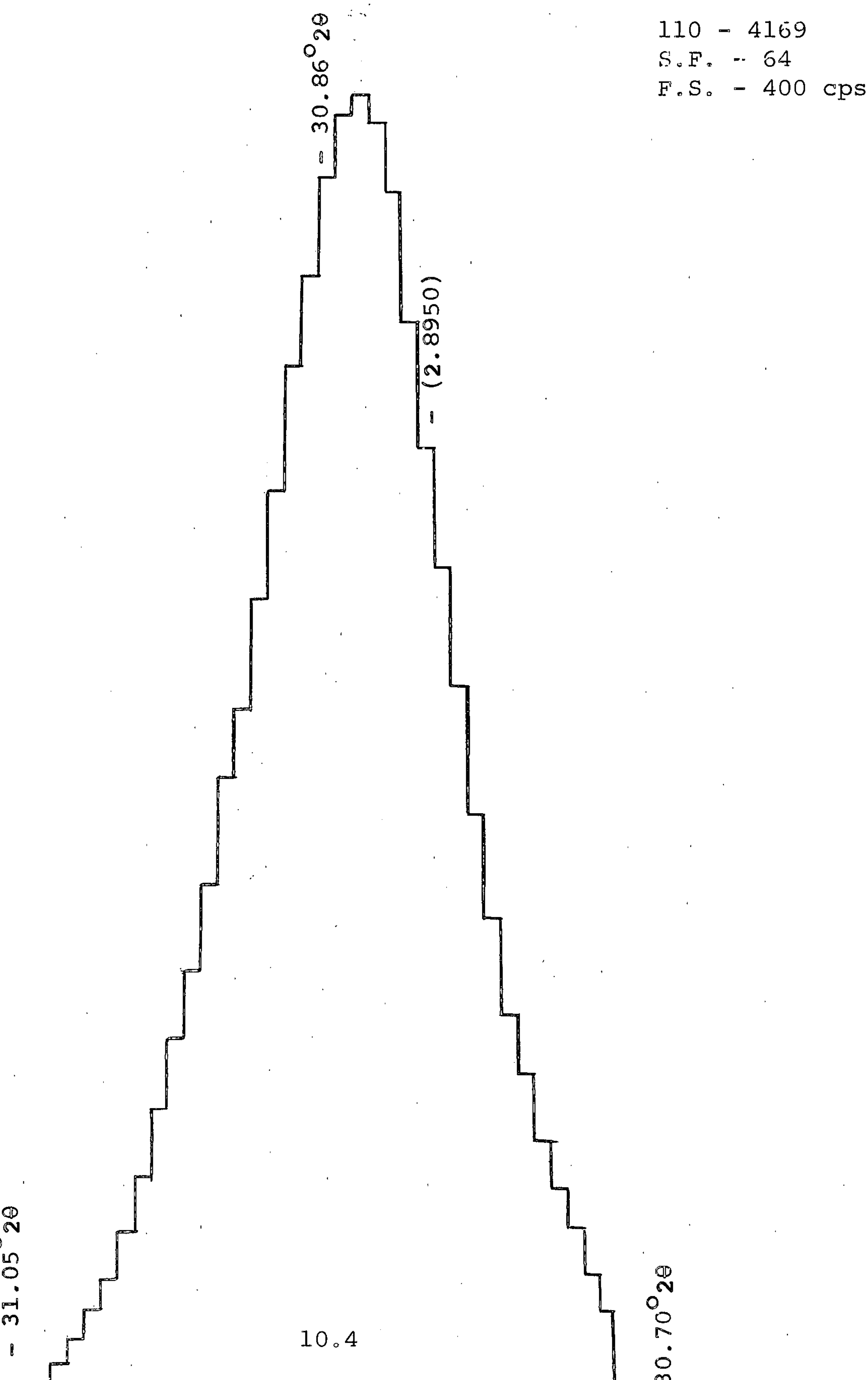
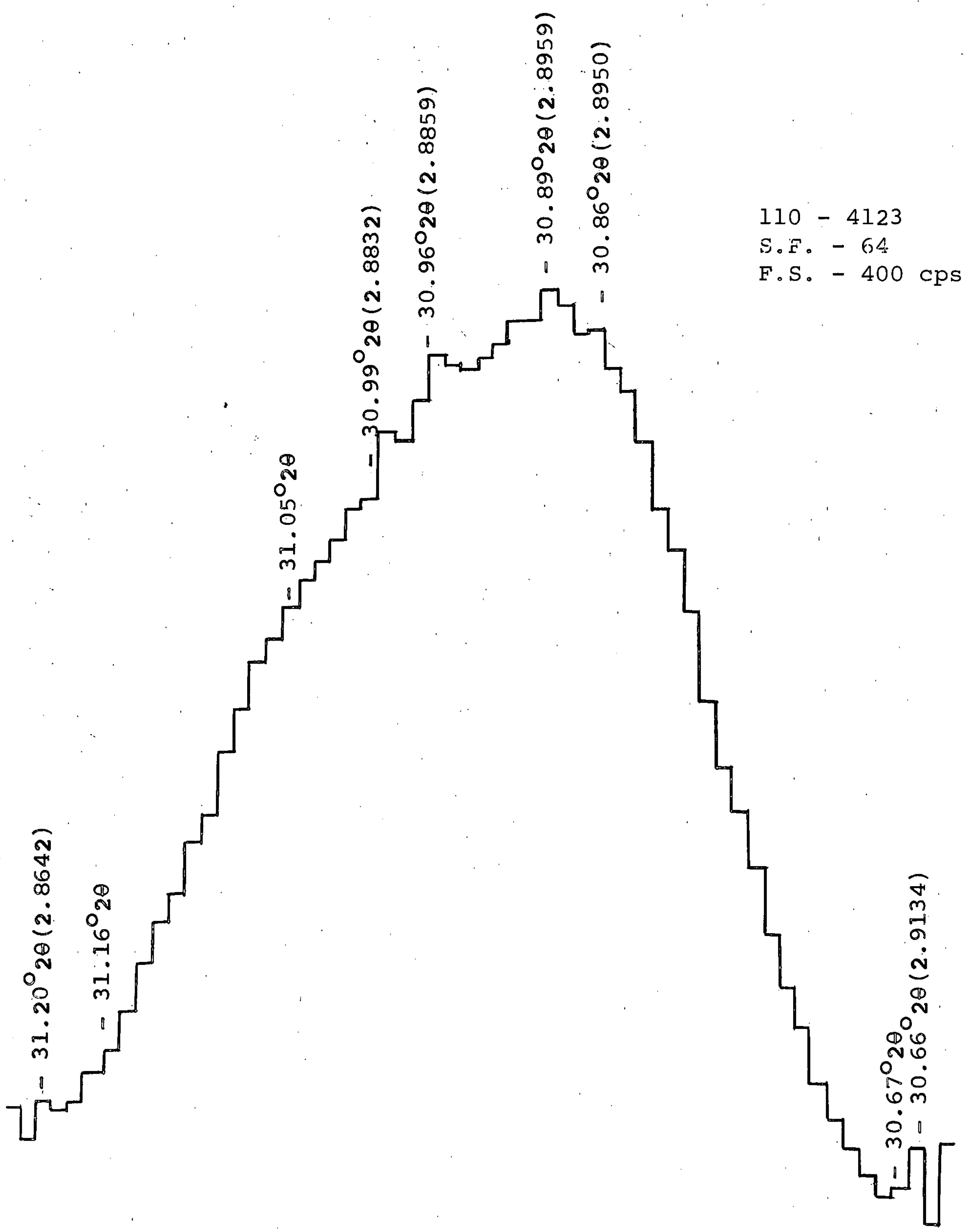


Figure 1


110 - 4123
S.F. - 64
F.S. - 400 cps
31.20°2θ(2.8642)
31.16°2θ
31.05°2θ
30.99°2θ(2.8832)
30.96°2θ(2.8859)
30.89°2θ(2.8959)
30.86°2θ(2.8950)
30.67°2θ
30.66°2θ(2.9134)

10.4

Figure 2

110 - 4105
S.F. - 32
F.S. - 50 cps

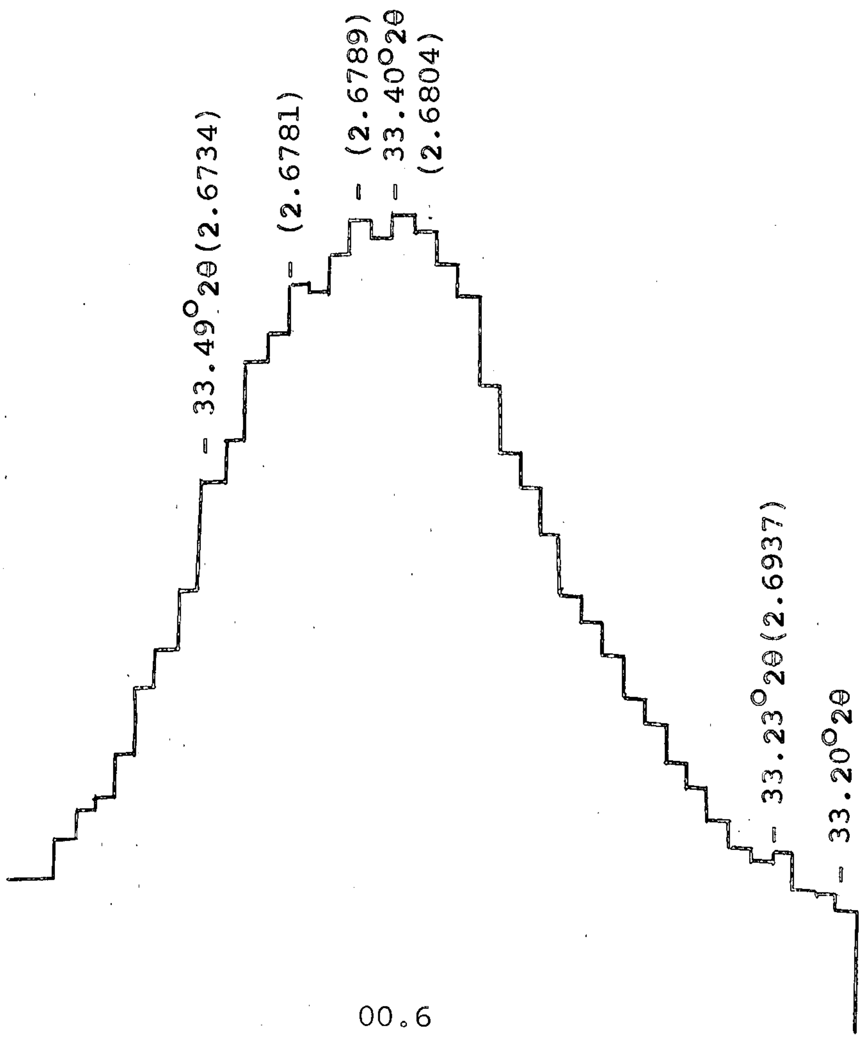


Figure 3

110 - 4105 Dol.
S.F. - 32
F.S. - 50 cps

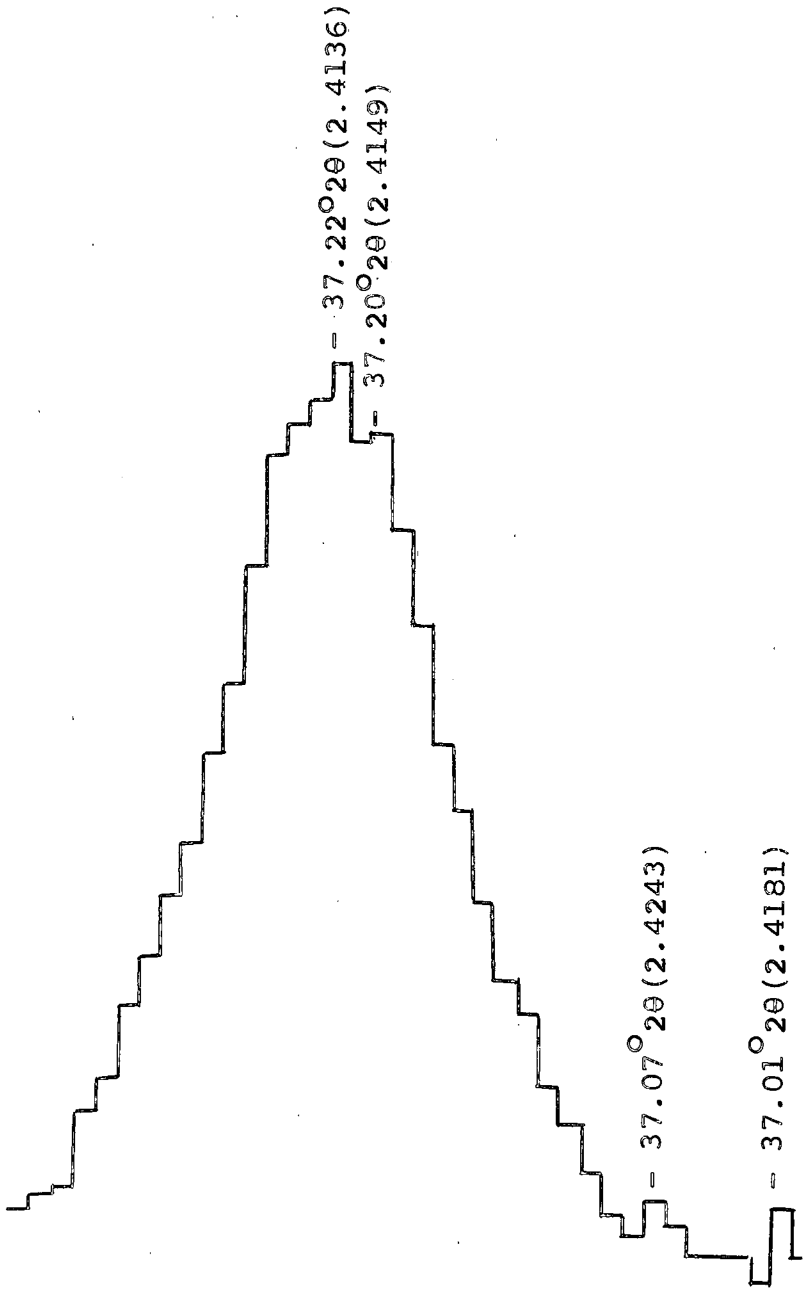


Figure 4

110 - 4106
S.F. - 32
F.S. - 50 cps

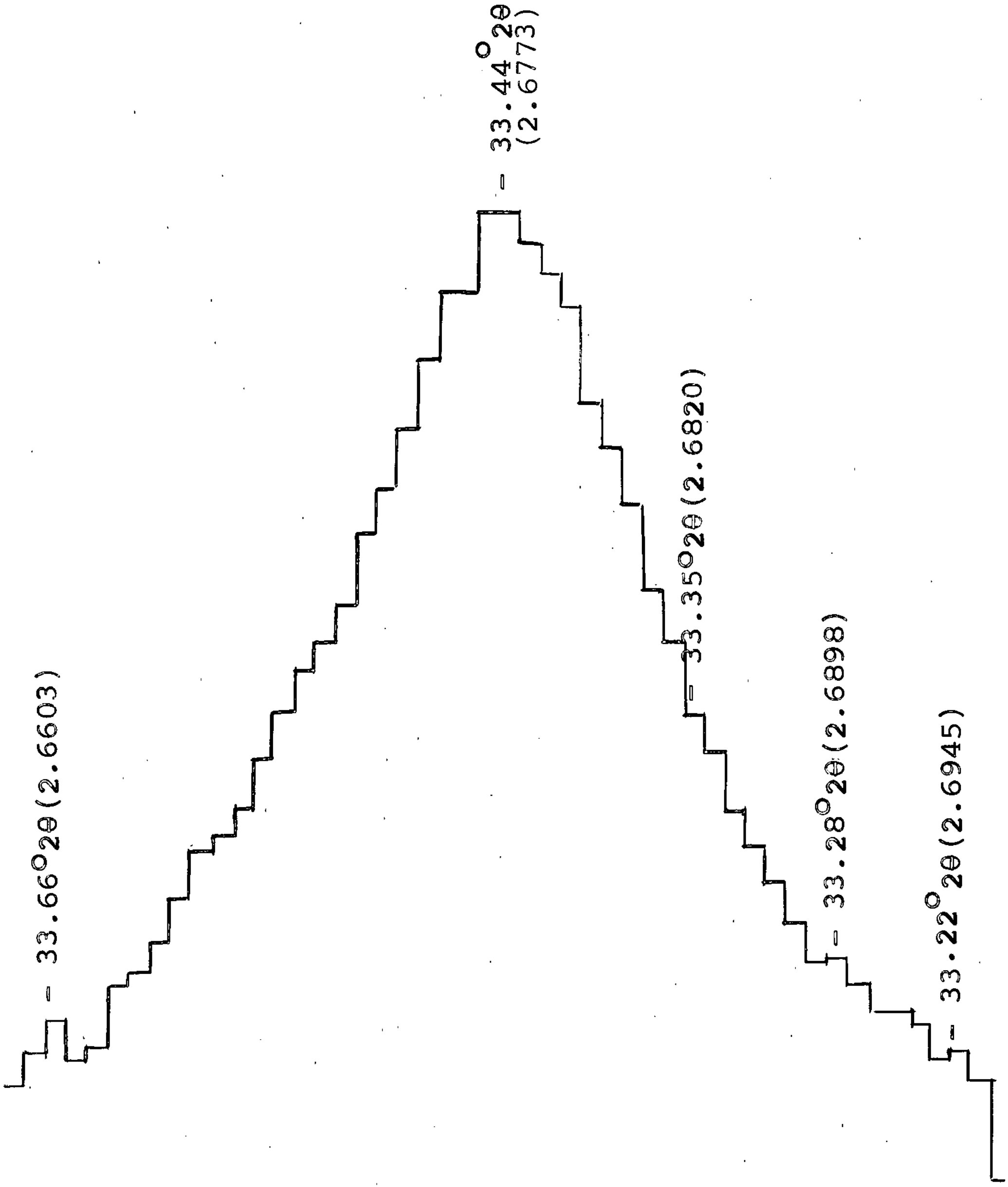


Figure 5

110 - 4106
S.F. - 32
F.S. - 50 cps

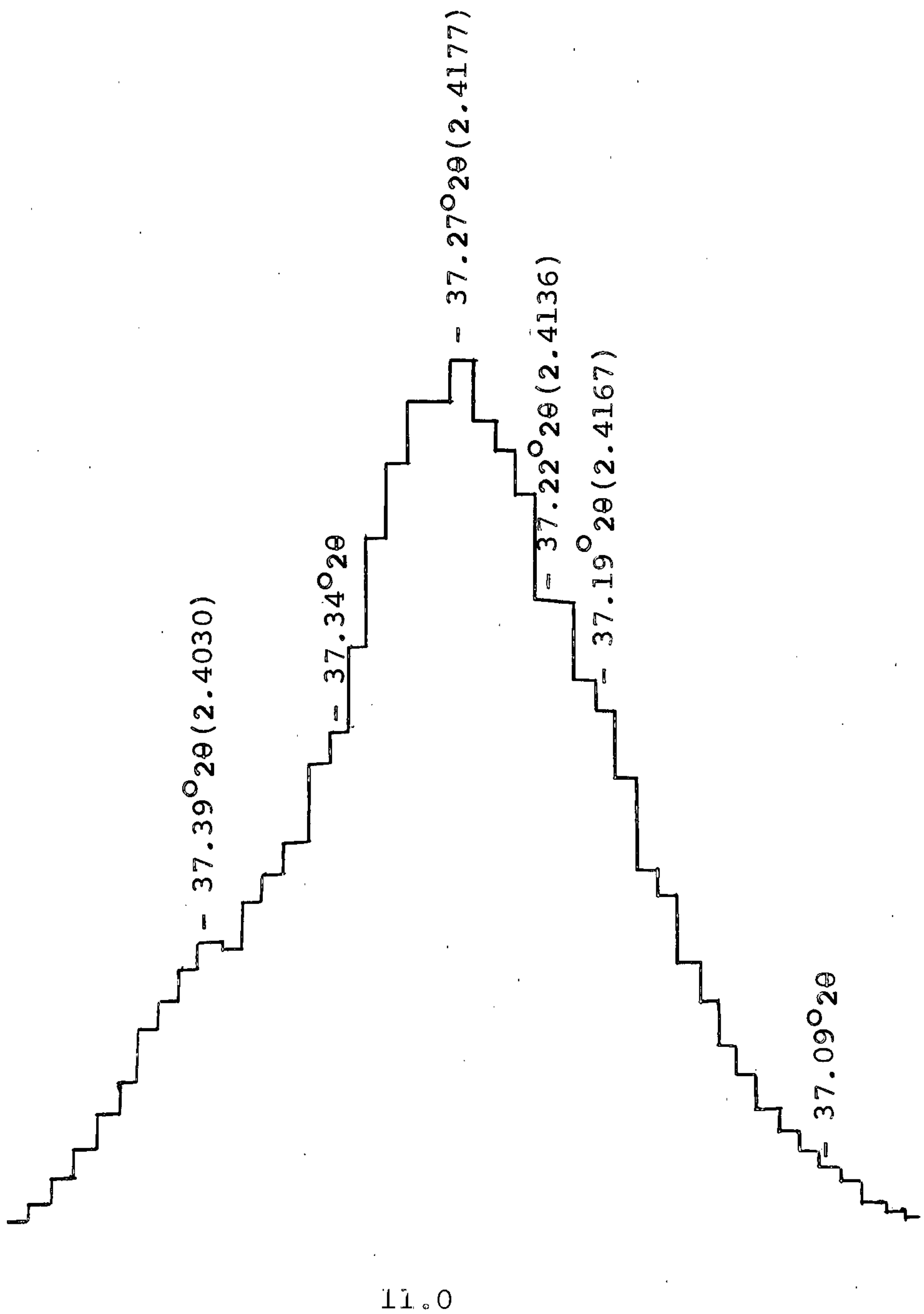
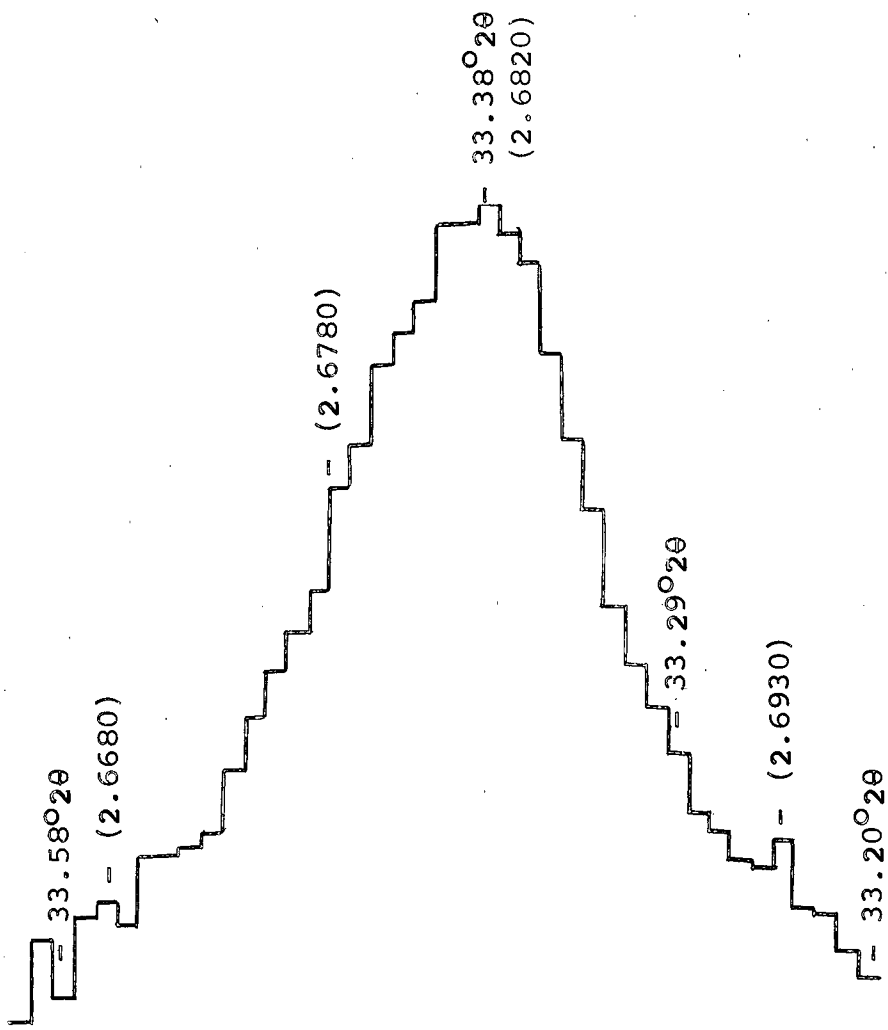


Figure 6

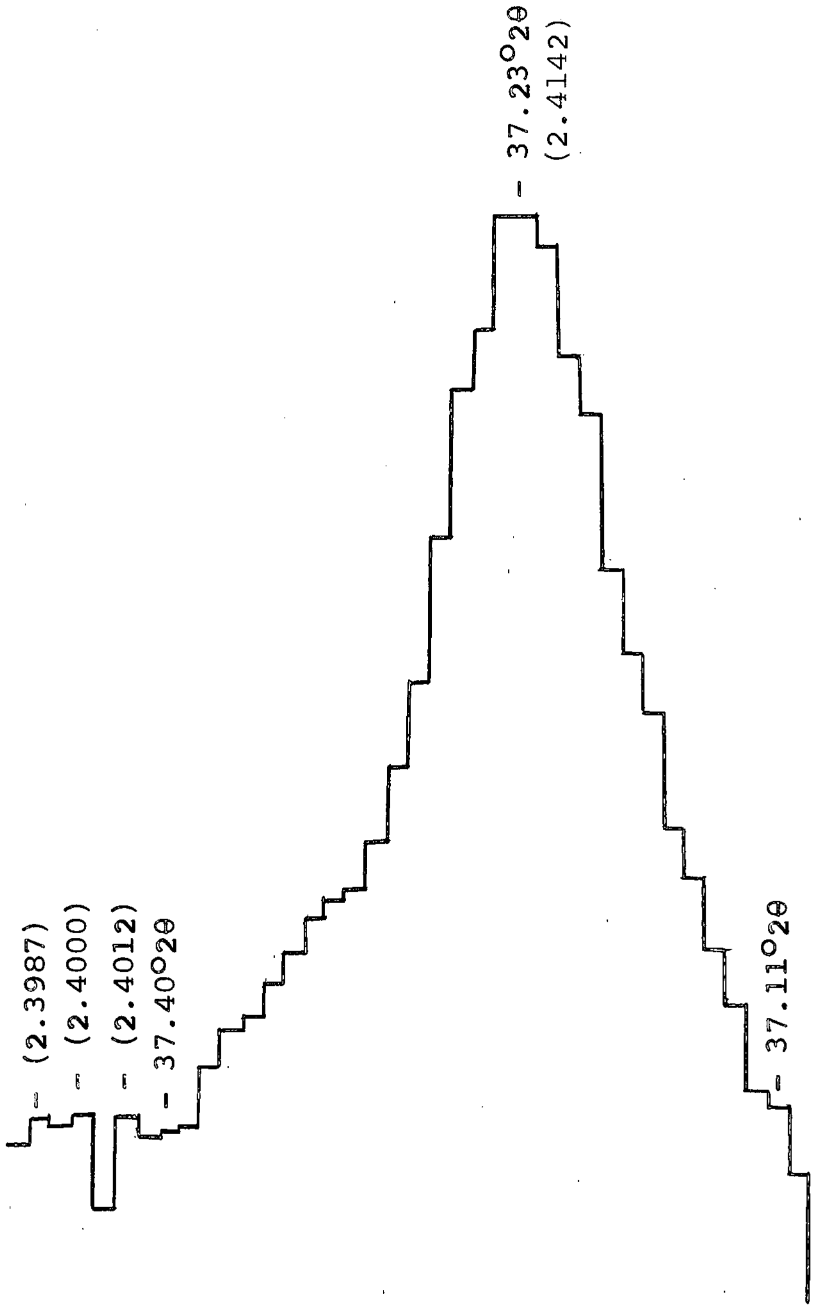
110 - 4107
S.F. - 32
F.S. - 50 cps



00.6

Figure 7

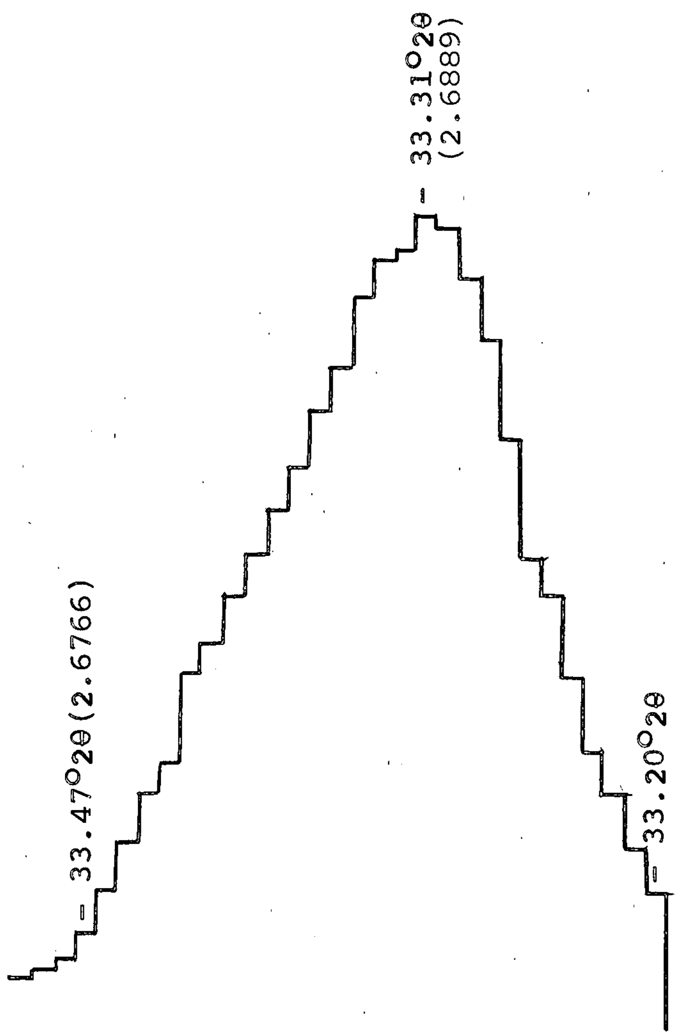
110 - 4107
S.F. - 32
F.S. - 50 cps



11.0

Figure 8

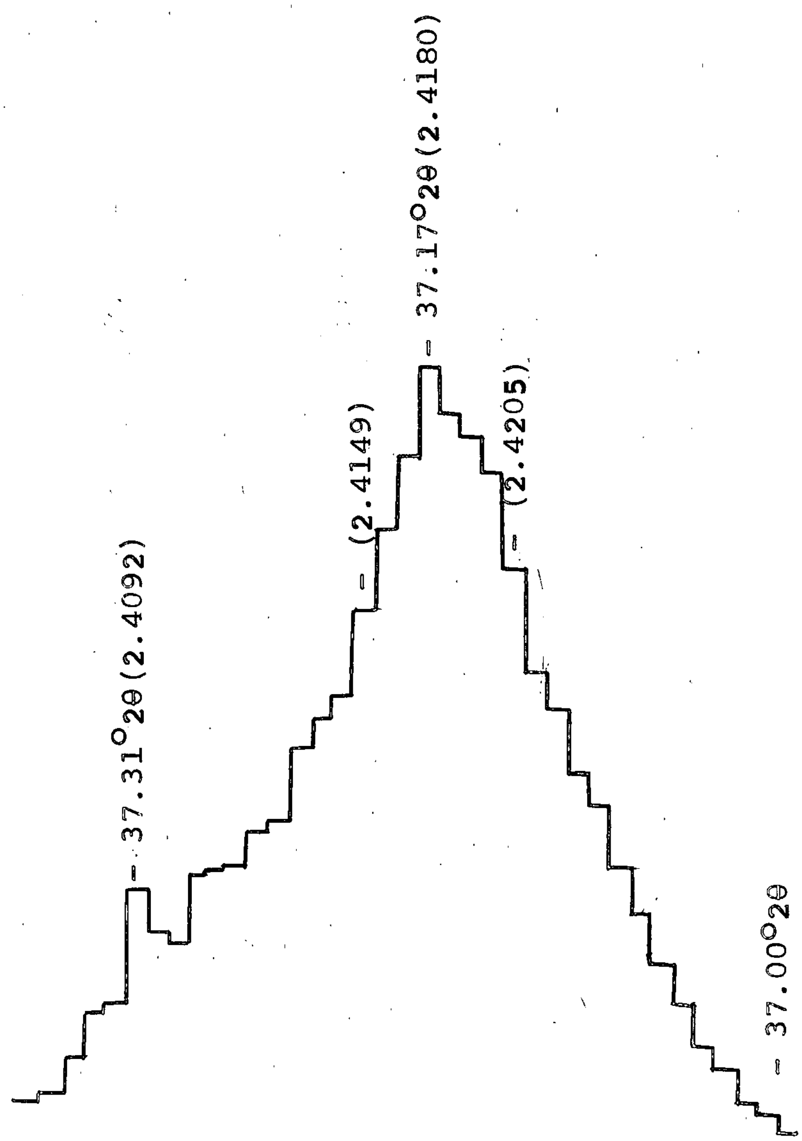
110 - 4109
S.F. - 32
F.S. - 50 cps



00.6

Figure 9

110 - 4109
S.F. - 32
F.S. - 50 cps



11.0

Figure 10

110 - 4110
S.F. - 32
F.S. - 50 cps

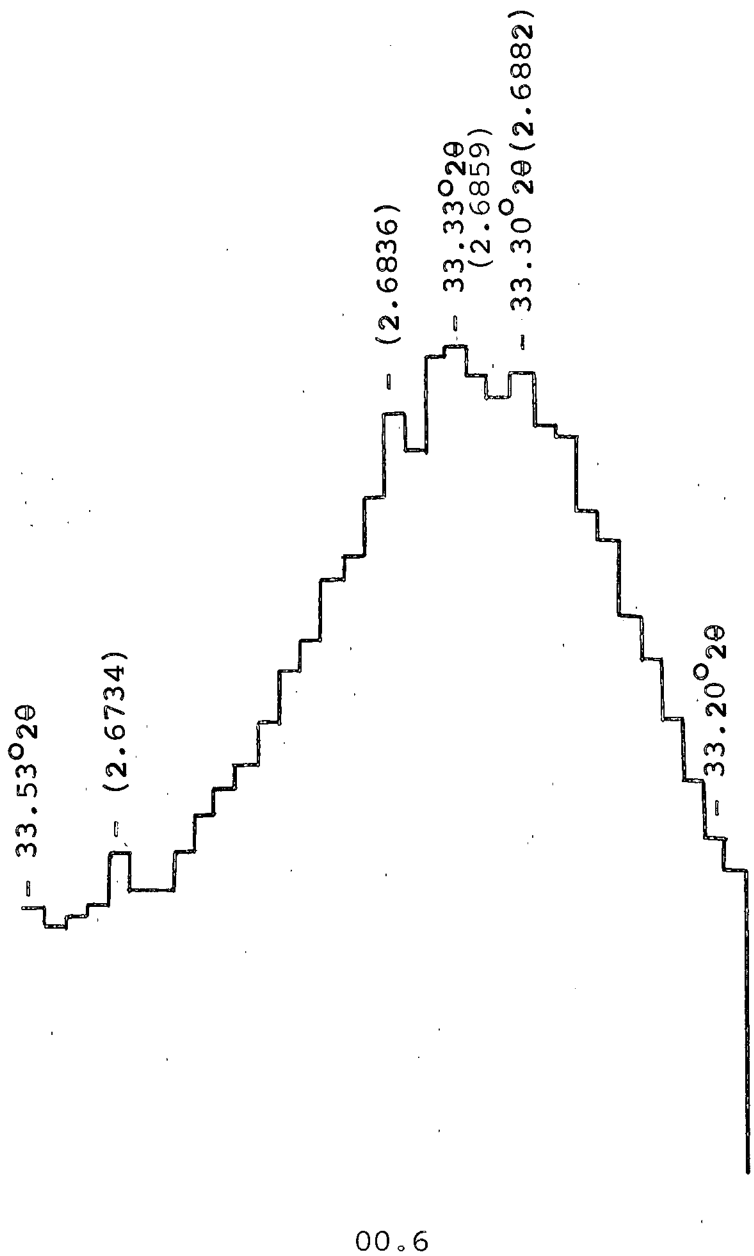
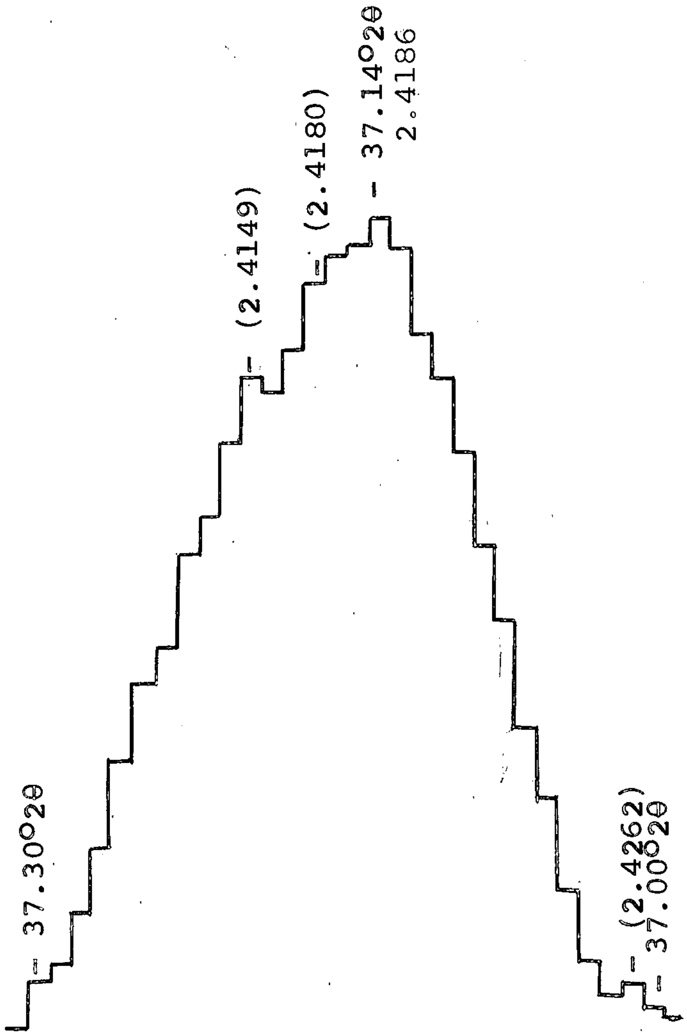


Figure 11

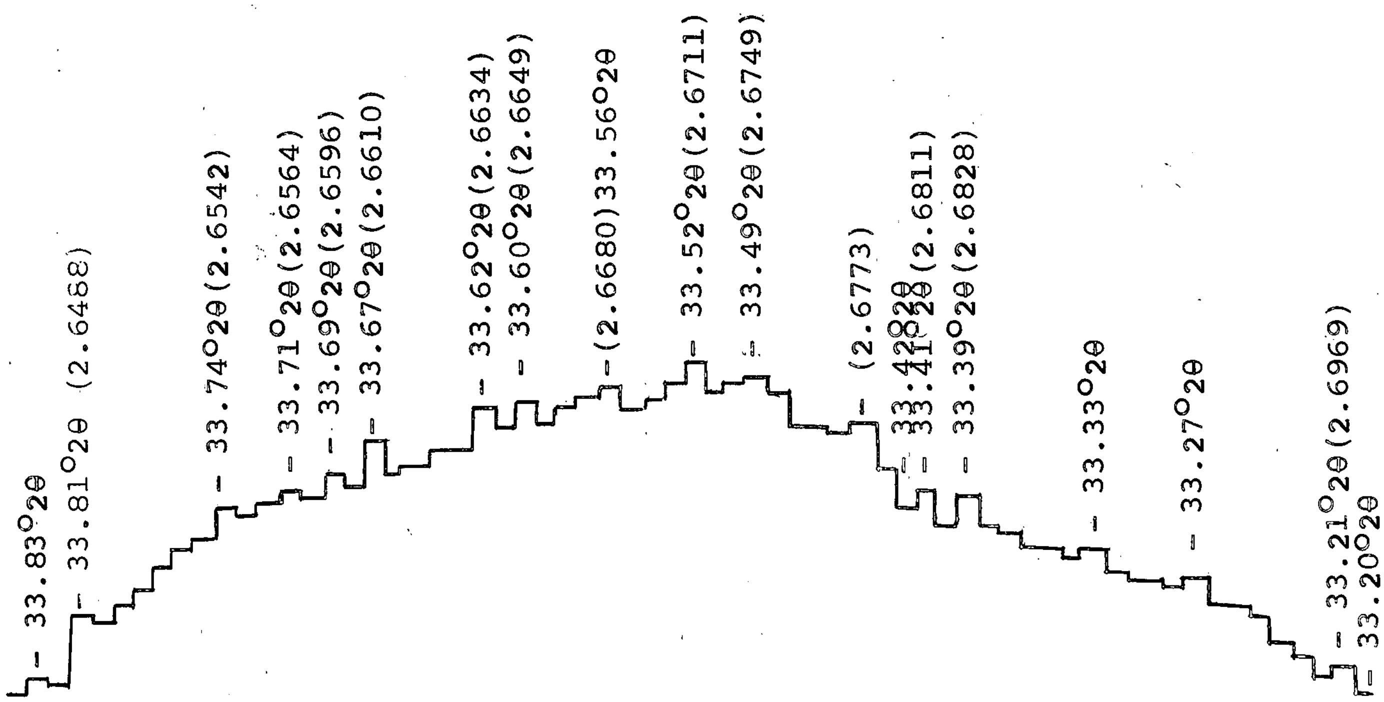
110 - 4110
S.F. - 32
F.S. - 50 cps



11.0

Figure 12

110 - 4123
S.F. - 32
F.S. - 25 cps



00.6

Figure 13

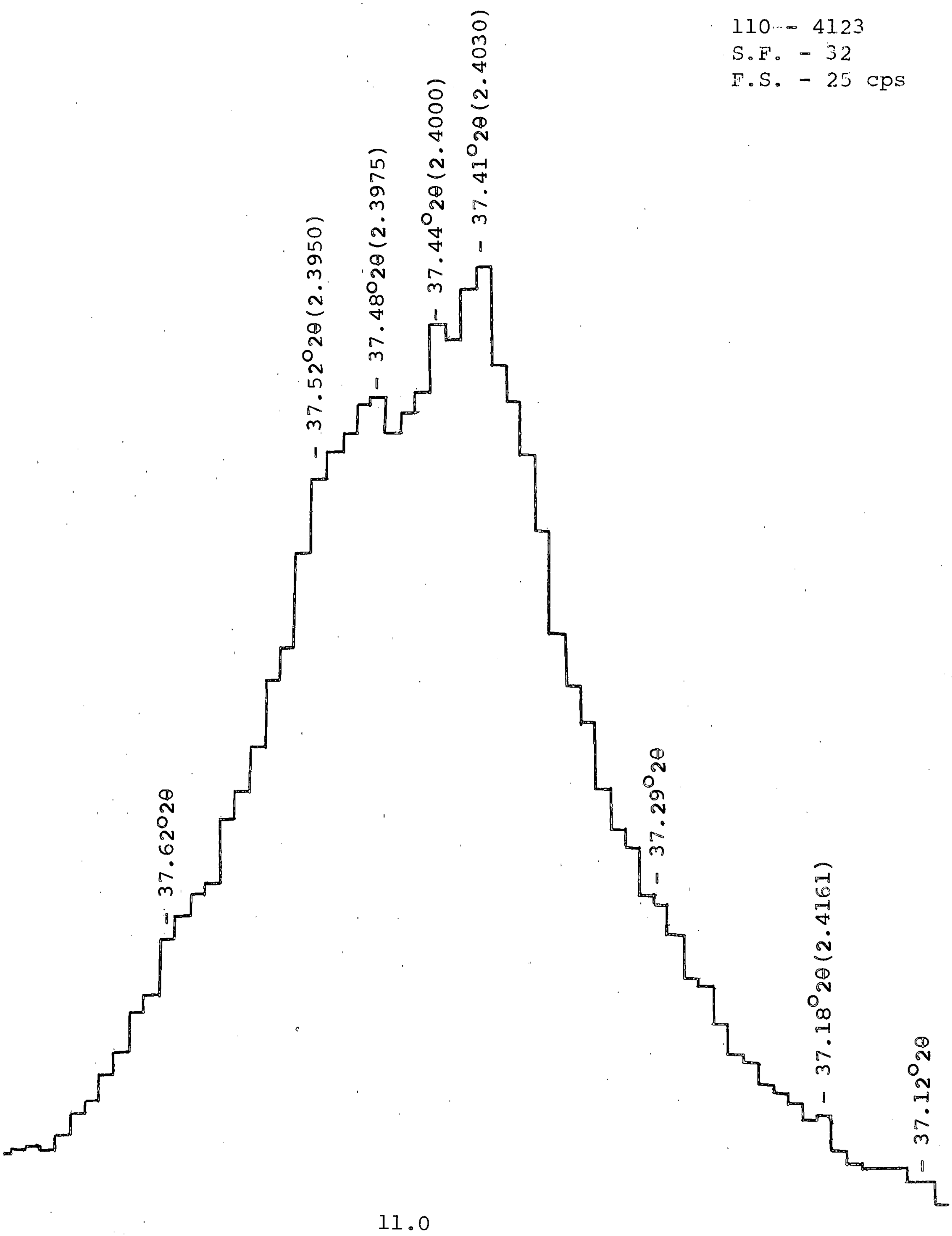

110 -- 4123
S.F. - 32
F.S. - 25 cps
- 37.62°2θ
- 37.52°2θ(2.3950)
- 37.48°2θ(2.3975)
- 37.44°2θ(2.4000)
- 37.41°2θ(2.4030)
- 37.29°2θ
- 37.18°2θ(2.4161)
- 37.12°2θ
11.0

Figure 14

110 - 4124 Dol.
S.F. - 32
F.S. - 25 cps

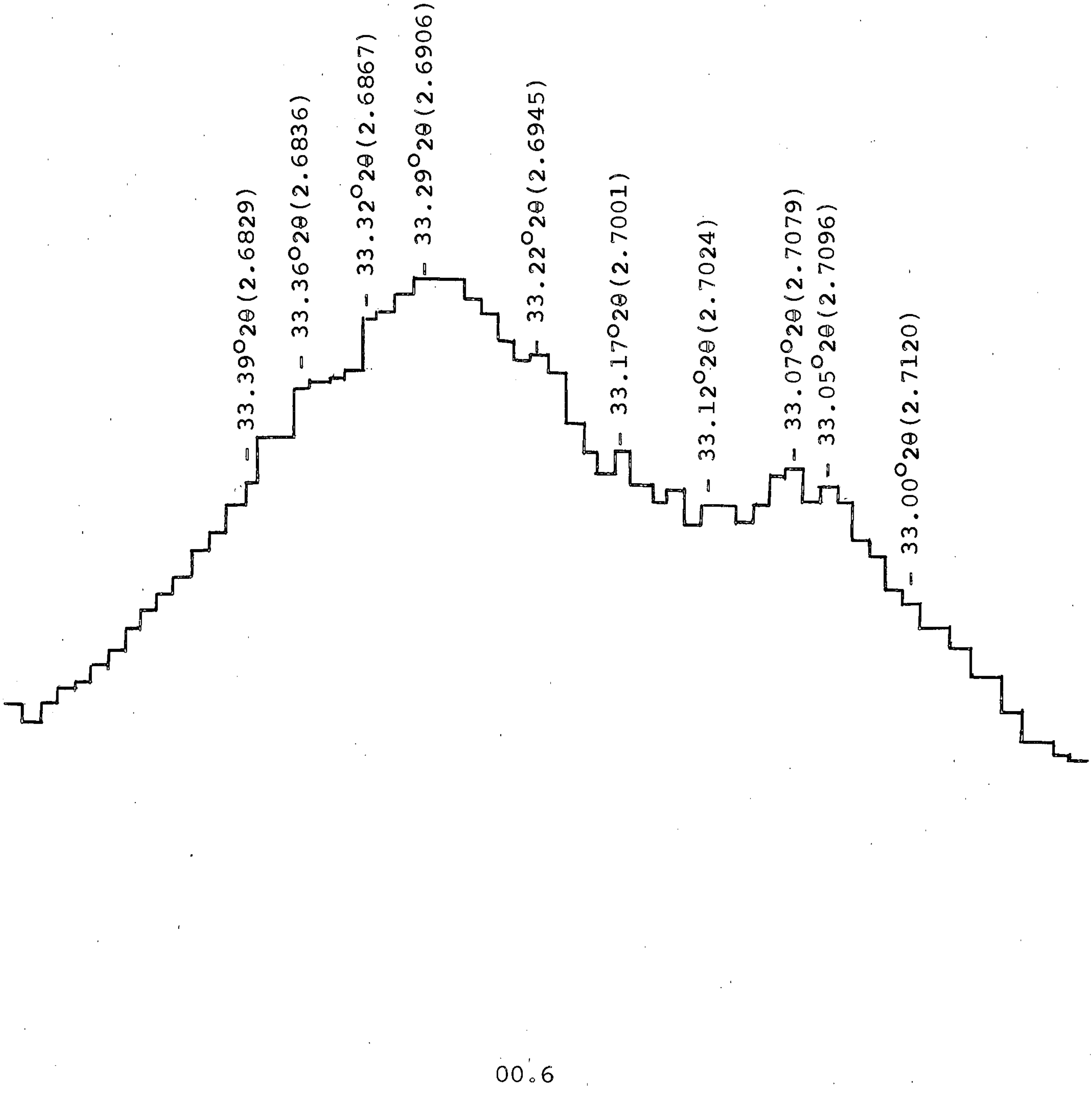
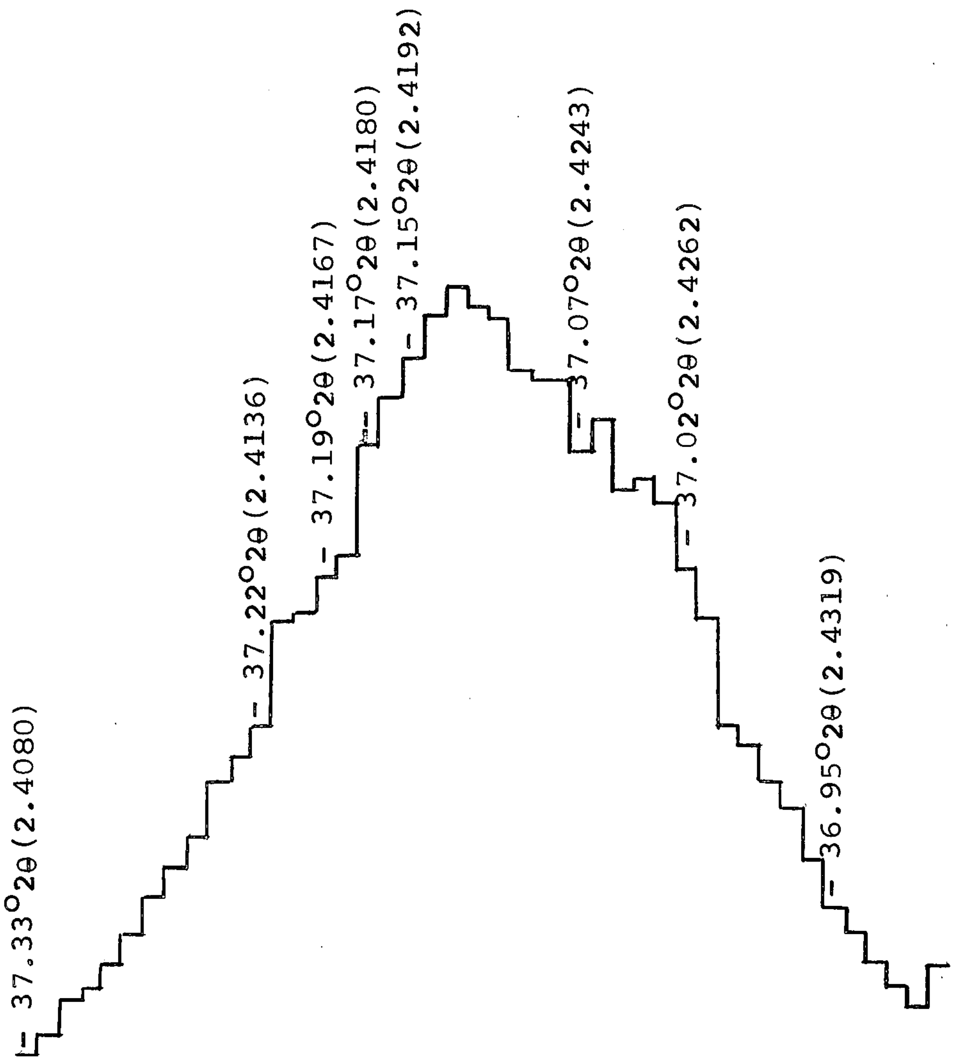


Figure 15

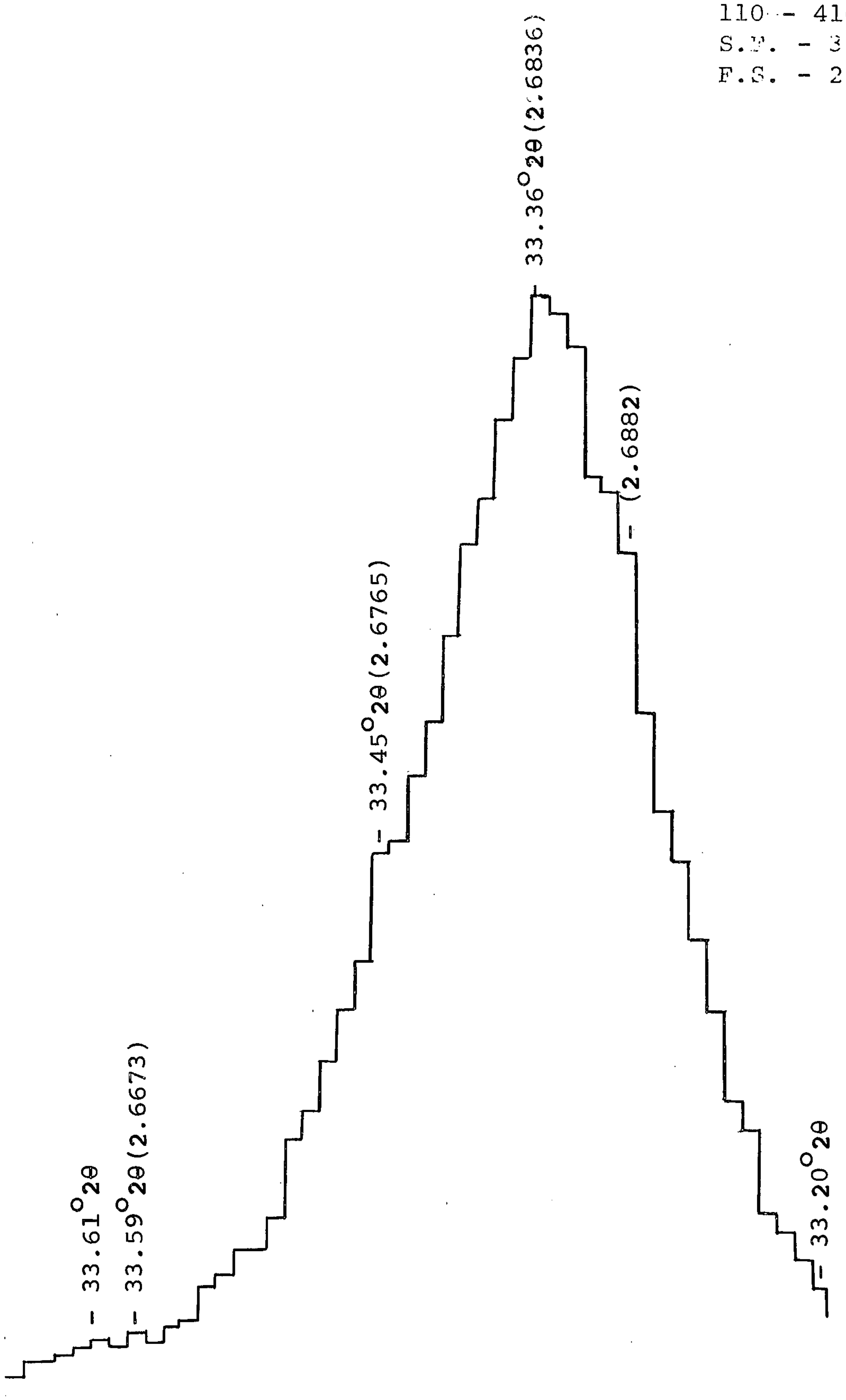
110 - 4124 Dol.
S.F. - 32
F.S. - 25 cps



11.0

Figure 16

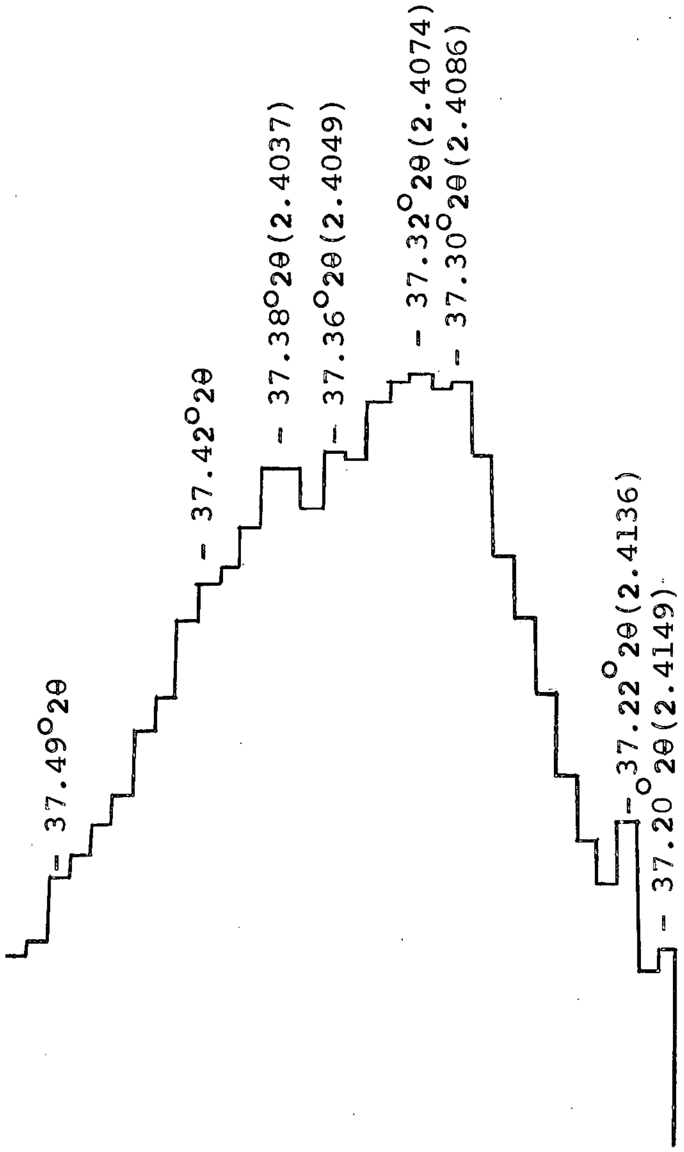
110 - 4169
S.F. - 32
F.S. - 25 cps



00.6

Figure 17

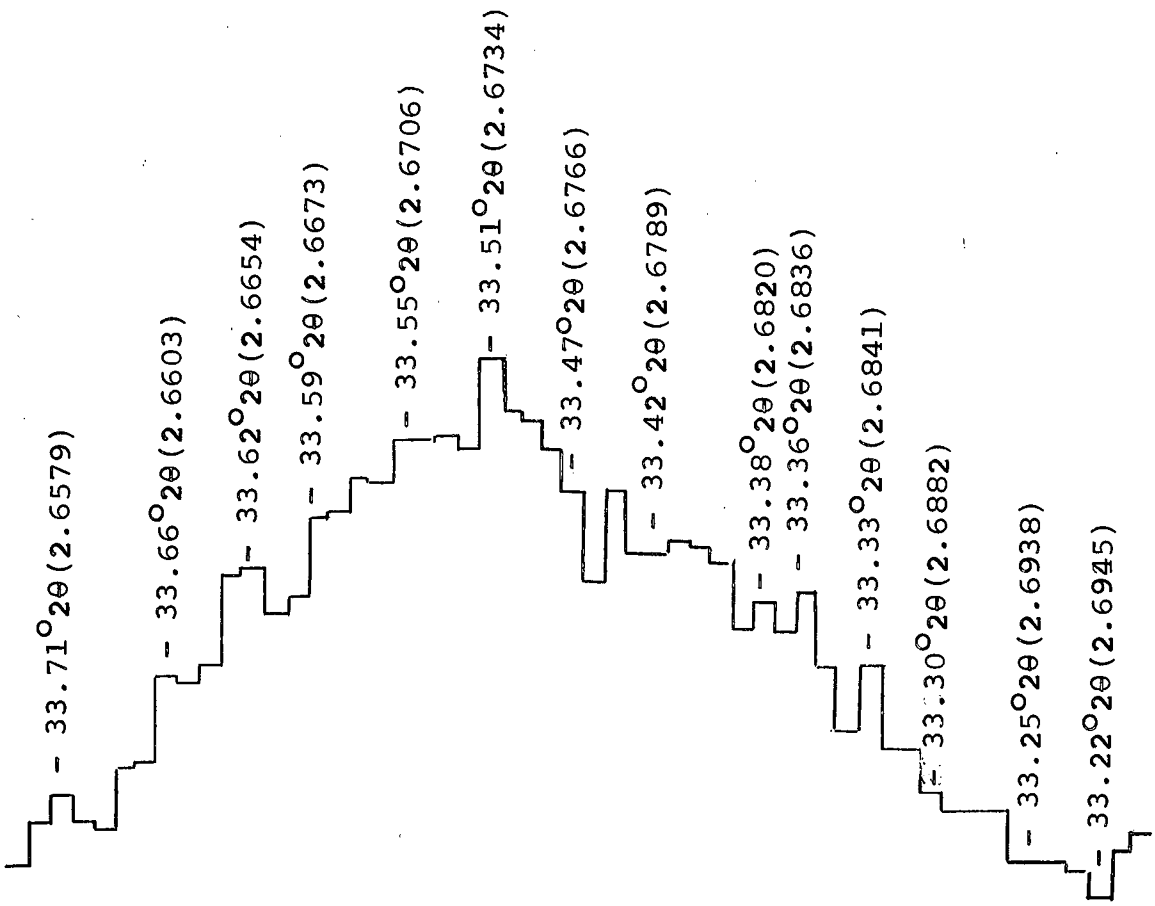
110-4169
S.F. - 32
F.S. - 50 cps



11.0

Figure 18

110-4172
S.F.-32
F.S.-25 cps



00.6

Figure 19

110-4172
S.F. - 64
F.S. - 50 cps

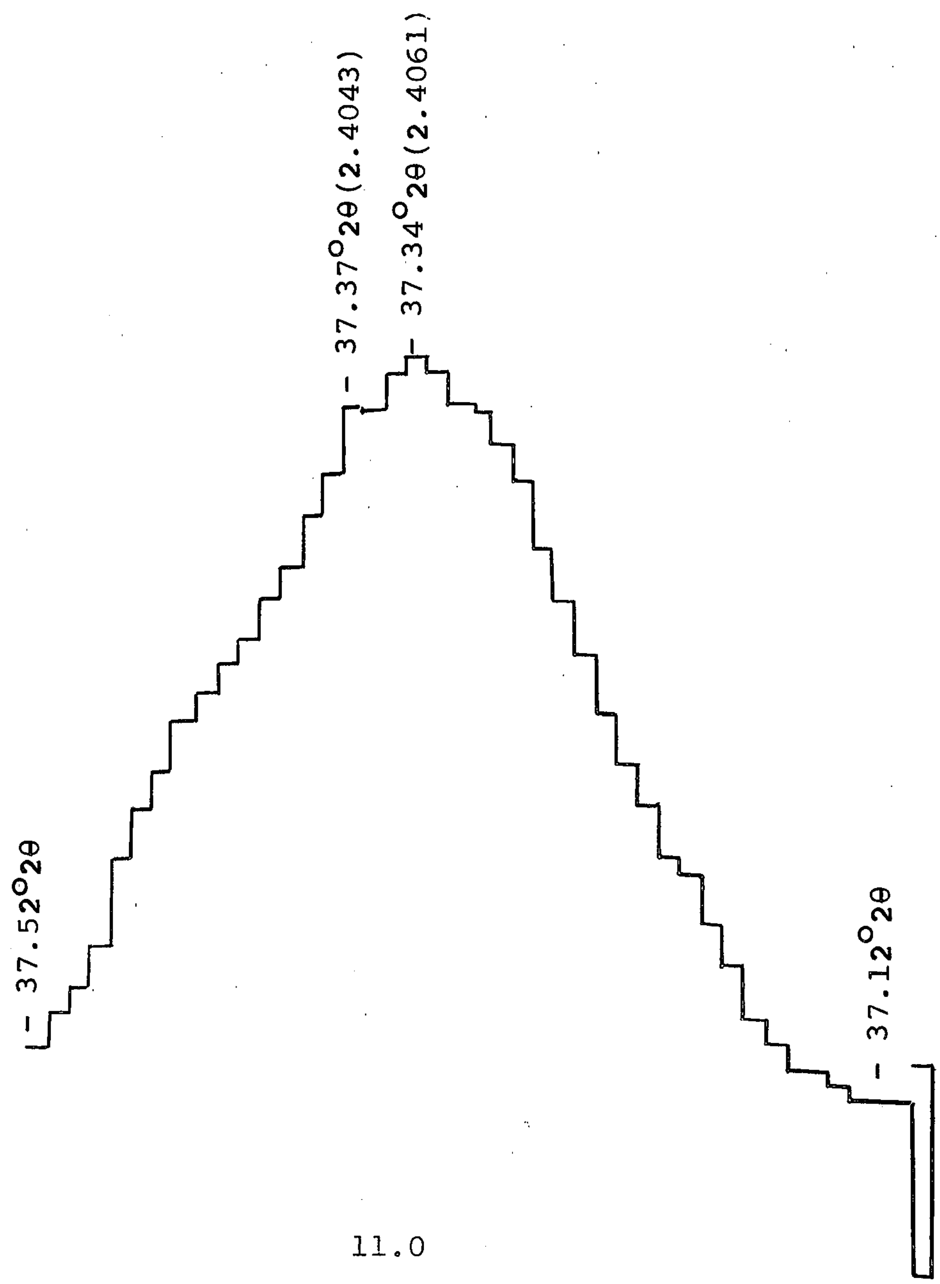


Figure 20

TABLE II. Cell constants from HR-110 dolomites and their departure from constants for ideal dolomite.

Sample	°2θ	d(00.6)Å	c_o	Departure from c_o ideal Å	2θ	d(11.0)Å	a_oÅ	Departure from a_o ideal
R-4105	33.40*	2.6804	16.8024	0.072+	37.20	2.4149	4.8298	0.0219+
	33.42	2.6789	16.0734	0.063+	37.22*	2.4136	4.8272	0.0193+
	33.45	2.6781	16.0686	0.058+				
R-4106	33.44	2.6713	16.0278	0.018+	37.27*	2.4177	4.8354	0.0275+
					37.39	2.4030	4.8060	0.0019-
					37.23	2.4142	4.8284	0.0205
R-4107	33.38*	2.6820	16.0920	0.082+				
	33.45	2.6780	16.0680	0.052+				
R-4109	33.31*	2.6889	16.1334	0.123+	37.13	2.4205	4.8410	0.0331+
	33.42	2.6789	16.0734	0.063+	37.17	2.4108	4.8630	0.0281+
					37.20	2.4149	4.8298	0.0219+
					37.31	2.4902	4.8184	0.0105+
R-4110	33.30	2.6882	16.1292	0.119+	37.14*	2.4816	4.8372	0.0293+
	33.33*	2.6859	16.1154	0.105+	37.20	2.4149	4.8298	0.0219+
	33.36	2.6836	16.1016	0.091+				
R-4123	33.49	2.6749	16.0494	0.039+	37.41*	2.4030	4.8060	0.0019-
	33.52*	2.6711	16.0266	0.016	37.44	2.4000	4.8000	0.0079-
	33.56	2.6680	16.0080	0.002-	37.48	2.3975	4.7950	0.0129-
	33.60	2.6649	15.9894	0.011-				
	33.62	2.6634	15.9804	0.030-				
	33.67	2.6610	15.9660	0.044-				

continued, next page

Table II (Cont'd.)

R-4124	33.07	2.7079	16.2474	0.237+	37.06	2.4237	4.8474	0.0395+
	33.29*	2.6906	16.1436	0.133+	37.13*	2.4192	4.8384	0.0305+
R-4169	33.32	2.6867	16.1202	0.110+	37.32*	2.4074	4.81848	0.0069+
	33.36*	2.6836	16.1016	0.091+	37.38	2.4037	4.8074	0.0005+
R-4172	33.41	2.6789	16.0734	0.063+	37.34*	2.4061	4.8122	0.0043+
	33.51*	2.6719	16.0314	0.021+	37.37	2.4043	4.8086	0.0007+
	33.62	2.6634	15.9804	0.030-				

* maximum intensity

\+ unit cell parameter greater than that for the ideal composition of dolomite

\- unit cell parameter less than that for the ideal composition of dolomite

The data of Table II indicate that most of the dolomite from these rocks has unit cell parameters in excess of those for the ideal dolomite composition. Some cell parameters found here are less than those for ideal dolomite, but none are equal to it. The crystallinity of the rhombohedral carbonates is such that the larger unit cell parameters might be accounted for by disordering in a structure of near ideal composition, but the values less than those for ideal composition may be assumed to come only from major departures in composition from the ideal. It is to be expected that crystals having unit cells smaller than the ideal dolomite contain an excess of magnesium and probably iron in solid solution whereas those having unit cells larger than ideal dolomite are probably rich in calcium.

Other Laboratory Data: Data from the other laboratory experiments are summarized on Table III. The data presented here are for a convenient reference so that rocks can be characterized by individuals working in the field. The correlation of the sample number scheme and the Iowa State Highway Commission bed numbers is given here.

Microscopic Observations: Microscopic description of the samples is given following Table III.

TABLE III

PROPERTIES OF CARBONATE ROCKS

IHC Bed #	HR-110 Sample No	R- No.	CALCITE Fine	CALCITE Medium	CALCITE Coarse	DOLOMITE Fine	DOLOMITE Medium	DOLOMITE Coarse	Micro-xln Carbonate	Insol	m^2/gm S.S.A.	Bulk Density	Total Porosity	Texture
DeWees-Potthof Peralta Quarry, Linn Co.														
5	1-1	R-4104												
6	1-2	R-4105							99.9	0.1				Microcrystalline mosaic
7	1-3	R-4106				10.5			89.5					Microcrystalline mosaic
8	1-4	R-4107				84.7			15.3					Microcrystalline mosaic
8	1-5	R-4108				74.06	1.3	2.0	22.6					Microcrystalline mosaic
9	1-6	R-4109				33.7			66.3					Microcrystalline mosaic
9	1-7	R-4110												
6-B	1-8	R-4111												
10	1-9	R-4112												
11	1-10	R-4113												
County Quarry Linn Co.														
14	2-1	R-4114				60.4	28.0	11.6						Medium crystalline mosaic
15	2-2	R 4115												
16	2-3	R-4116												
Weaver's Quimby Quarry, Cerro Gordo Co.														
9	3-6	R-4122				7.65	58.05	34.28						Medium crystalline poikilitic mosaic
10	3-7	R-4123				40.4	44.7	14.9						Medium crystalline poikilitic mosaic
10	3-8	R-4124				19.9	67.7	23.4						Medium crystalline poikilitic mosaic
Schildberg's Crescent Quarry														
5	5-1	R-4027	36.83	3.74	3.78				51.8	3.9	1.21	2.73	3.2	Microcrystalline mosaic
5(b)	5-2	R-4028	25.90	4.94	7.12				55.1	4.8	1.13	2.66	3.3	Microcrystalline mosaic
6	5-3	R-4029	1.0		2.0				9.1	59.3				Microcrystalline mosaic
7	5-4	R-4030	23.64	3.56	4.98				64.0	3.8	0.79	2.74	1.9	Microcrystalline mosaic
9	5-5	R-4031	18.65	1.88	1.12				74.9	3.5	0.99	2.73	2.8	Microcrystalline mosaic
9	5-6	R-4032	25.25	8.87	8.43				31.6	25.8	0.60	2.77	4.9	Microcrystalline mosaic
10	5-7	R-4033	30.07	4.18	4.1				57.3	3.4	0.53	2.73	1.6	Microcrystalline mosaic
12	5-8	R-4034	12.9	0.7	6.7				63.1	16.0	1.27	2.73	7.8	Microcrystalline mosaic
7	5-9	R 4035	32.1	5.0	10.3				47.3	5.3	0.22	2.75	1.9	Microcrystalline mosaic
Hopper's South Quarry, Cass County, Weeping Water, Nebraska														
3	6-1	R-4036	20.0	4.8	4.9				68.0	2.3	0.33	2.73	1.2	Microcrystalline mosaic
3	6-2	R-4037	23.0	3.7	6.5				63.5	3.3	0.44	2.71	2.7	Microcrystalline mosaic
3	6-3	R-4038	12.1	2.1	1.6				82.3	1.9	0.14	2.71	1.0	Microcrystalline mosaic
3	6-4	R-4039	15.7	1.6	4.1				77.1	1.5	0.45	2.72	1.8	Microcrystalline mosaic
3	6-5	R 4040	18.6	4.7	7.2				68.0	1.5	0.29	2.73	1.7	Microcrystalline mosaic
4	6-6	R-4041	18.1	4.5	31.8				44.0	1.6	0.49	2.71	1.4	Poikilitic breccia
4	6-7	R-4042	21.0	5.2	5.5				64.5	3.8	0.39	2.74	2.2	Microcrystalline mosaic
5	6-8	R-4043	29.4	2.4	18.4				48.6	1.2	0.14	2.74	2.4	Finely crystalline breccia
Clark's North Logan Quarry, Harrison Co.														
5	7-1	R-4044	22.3	1.1	3.8				70.8	2.0	0.18			Microcrystalline mosaic
5	7-2	R-4045	10.5	1.5					85.4	2.6	0.38			Microcrystalline mosaic
6	7-3	R-4046		7.8	2.2				86.2	3.8	0.75			Microcrystalline mosaic
7	7-4	R-4047				15.1	2.2	1.7	76.7	4.3	0.14			Microcrystalline mosaic
7	7-5	R-4048	27.4	1.7	1.2				67.5	2.2	0.24			Microcrystalline mosaic
8	7-6	R-4049				7.7	1.0	1.0	82.4	7.8	0.33			Microcrystalline mosaic
8	7-7	R-4950	3.0						36.2	60.8	0.42			Microcrystalline mosaic
9	7-8	R-4051	15.8	1.0	1.7				80.3	1.2				Microcrystalline mosaic
9	7-9	R-4052								1.8				

IHC Bed #	HR-110 Sample No.	R- No.	CALCITE Fine	Medium	Coarse	DOLOMITE Fine	Medium	Coarse	Micro-xln Carbonate	Insol	m^2/gm S.S.A.	Bulk Density	Total Porosity	Texture
Clark's North Logan Quarry (cont'd.)														
10	7-10	R-4053	23.1	2.7	7.2				65.2	1.8				Microcrystalline breccia
10	7-11	R-4054	14.6	6.4	20.1				55.4	3.4				Microcrystalline breccia
10	7-12	R-4055	23.2	2.4	1.5				68.5	4.4	0.19			Microcrystalline mosaic
11	7-13	R-4056	13.3	1.5					85.2		0.12			Microcrystalline mosaic
12	7-14	R-4057	9.4		7.3				64.3	18.9	0.14			Microcrystalline mosaic
L. and W. Stone Quarry, Appanoose Co.														
11	8-1	R 4058	20.6	3.1	3.1				71.2	2.0	0.34	2.74	2.2	Microcrystalline breccia
11	8-2	R-4059	5.3	4.4	9.4				77.3	3.0	0.54	2.71	2.3	Microcryst alline mosaic
10	8-3	R-4060	6.5	5.0	23.5				60.2	4.8	0.36	2.72	2.8	Microcrystalline breccia
10	8-4	R-4061	8.1	7.1	13.5				69.2	2.1	0.58	2.73	1.4	Microcrystalline breccia
9c	8-5	R-4062	18.4	7.7	5.2				66.6	1.1	0.50	2.77	2.1	Microcrystalline mosaic
9c	8-6	R-4063	17.0	7.4	13.4				59.7	2.5	0.34	2.76	2.5	Microcrystalline breccia
9c	8-7	R-4064	15.5	8.5	20.7				53.7	1.6	0.14	2.74	1.4	Microcrystalline breccia
9b	8-8	R-4065	9.8	7.3	7.1				72.0	3.8	0.49	2.75	2.0	Microcrystalline breccia
Raid Brothers Comanche Quarry														
3a	9-1	R-4066	6.0						87.9	6.1	0.40			Microcrystalline breccia
3a	9-2	R-4067	3.7						92.0	4.3	0.23			Microcrystalline breccia
3c	9-3	R-4068	4.5						91.7	3.8				Microcrystalline mosaic
3c	9-4	R-4069	1.3						91.0	6.5	0.03			Microcrystalline mosaic
3c	9-5	R-4070	7.0						83.8	7.4	1.25			Microcrystalline mosaic
3e	9-6	R-4071	14.7						78.1	7.2	1.36			Microcrystalline breccia
3g	9-7	R-4072	13.4						78.6	6.7	1.33			Microcrystalline breccia
Prospect Hill Quarry, Des Moines Co.														
2' below	10-1	R-4073				21.9			60.7	17.4	2.64			Poikilitic microcrystalline mosaic
top of	10-2	R-4074				35.4	1.2		59.2	4.2	1.45			Poikilitic microcrystalline mosaic
McCraney	10-3	R 4075				3.3			95.2	1.5	0.43			Poikilitic microcrystalline mosaic
fm to														
bottom	10-4	R-4076				3.3			95.5	1.2	1.29			Poikilitic microcrystalline mosaic
of	10-5	R-4977				4.2			95.3	0.5	1.29			Poikilitic microcrystalline mosaic
quarry	10-6	R-4078				75.5			21.4	3.1	0.47			Poikilitic microcrystalline mosaic
	10-7	R-4079	1.4						98.6	3.2	0.55			Poikilitic microcrystalline mosaic
Linwood Stone Products Quarry, Scott Co.														
30	11-9	R-4135	19.9		1.6				77.1	1.0				Microcrystalline breccia
30	11-10	R-4136	37.0	18.2	6.5				37.3	1.0				Poikilitic finely crystalline mosaic
30b	11-11	R-4137	34.3	12.8					52.2	0.7				Poikilitic finely crystalline mosaic
29	11-5	R-4138	43.3	9.0					47.3	0.4				Ovoid
29	11-6	R-4139	23.5	7.0	1.0				67.7	0.8				Microcrystalline breccia
29	11-7	R-4140	12.3						87.4	0.3				Microcrystalline mosaic
28	11-3	R-4141	25.7	2.3	1.4				69.9	0.7				Ovoid
28	11-4	R-4142	25.2	4.3	1.2				69.3	21.9				Microcrystalline mosaic
27	11-1	R-4143	8.0	1.3	3.0				86.0	1.7				Microcrystalline breccia
27	11-2	R-4144	1.3	7.5	8.5				81.6	2.1				Microcrystalline breccia
25	11-16	R-4145	32.5	6.4	5.8				53.9	1.4				Finely crystalline mosaic
24	11-13	R-4146	10.2	1.7	1.2				86.4					Microcrystalline breccia

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24	11-14	R-4147	18.3	3.9	1.2				75.9	0.7				Poikilitic finely crystalline breccia
24	11-15	R-4148	32.1	3.0					64.8	1.1				Poikilitic finely crystalline breccia
23	11-12	R-4149	8.7						98.8	0.5				Microcrystalline breccia
22*	11-13	R-4150	0.9						99.1					Microcrystalline mosaic
23	11-17	R-4151	8.0						91.6	0.3				Ovoid
20	11-18	R-4153	24.1	10.3	11.1				49.3	2.6				Finely crystalline breccia
21*	11-19	R-4152	8.6	1.1					90.3	0.9				Microcrystalline mosaic
19*	11-23	R-4154		0.1					98.4	1.5				Microcrystalline mosaic
19*	11-22	R-4155		4.4					94.9	0.7				Microcrystalline mosaic
19*	11-21	R-4156		10.6					88.4	1.0				Microcrystalline mosaic
19*	11-20	R-4157	10.9	1.7	1.8				84.3	1.3				Microcrystalline mosaic
18*	11-24	R-4158	27.9	5.2					64.9	1.9				Microcrystalline breccia
17*	11-24a	R-4159	5.9	3.0	5.2				80.8	5.1				Microcrystalline breccia
16*	11-25	R-4160		0.1					98.8	1.1				Microcrystalline breccia
15*	11-26	R-4161		0.1					97.6	2.3				Microcrystalline mosaic
13*	11-27	R-4162	36.4						61.4	2.2				Ovoid
12*	11-30	R-4163	5.8						93.7	0.5				Microcrystalline mosaic
12*	11-29	R-4164	5.0						93.0	2.0				Microcrystalline breccia
12*	11-28	R-4165	99.1						0.9	6.7				Finely crystalline mosaic
* Samples taken from Dewey Portland Cement Quarry adjoining Linwood Stone Products.														
Pint's Quarry, Black Hawk Co.														
5a	12-1	R-4166		5.4			92.5		1.1	1.0				Poikilitic medium crystalline mosaic
5a	12-2	R-4167				56.0		43.2		0.8				Poikilitic coarse mosaic
5a	12-3	R-4168				90.3		9.0		0.7				Poikilitic coarse mosaic
5b	12-4	R-4169				90.5		7.8		1.7				Poikilitic coarse mosaic
6	12-5	R-4170				94.6	2.0		2.3	1.17				Fine poikilitic mosaic
6	12-6	R-4171				6.4			91.4	2.20				Microcrystalline mosaic
6	12-7	R-4172				29.6			68.3	2.1				Microcrystalline mosaic
7	12-8	R-4173				6.2		1.2	90.1	2.5				Microcrystalline mosaic
8	12-9	R-4174				7.9			89.0	3.1				Microcrystalline breccia
9	12-10	R-4175				80.3			17.3	2.4				Fine poikilitic mosaic
9	12-11	R-4176		4.1			8.3		85.8	1.80				Microcrystalline mosaic
9	12-12	R-4177				26.6	10.4	7.1	53.3	2.6				Breccia
10	12-13	R-4178				78.6	4.4	8.7	6.3	2.0				Coarse poikilitic mosaic
10	12-14	R-4179				92.9		3.5	1.9	1.7				Fine poikilitic mosaic
10	12-15	R-4180				71.5		9.7	9.8	3.0				Fine poikilitic mosaic
Newton Quarry, Black Hawk Co.														
17	13-1	R-4181			1.7		83.4		12.9	2.0				Fine poikilitic mosaic
18	13-2	R-4182				67.5		29.2		3.3				Coarse poikilitic mosaic
18	13-3	R-4183				59.1		9.7	29.9	1.3				Fine poikilitic mosaic
18	13-4	R-4184				73.2			25.4	1.4				Fine crystalline mosaic

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Schildberg's Atlantic Quarry, Cass Co.														
4c	15-1	R-4186	17.2	4.8	9.5				68.5					Microcrystalline mosaic
4c	15-2	R-4187	4.6	0.7	0.7				94.0					Microcrystalline mosaic
4c	15-3	R-4188	8.2	0.7	0.6				90.5					Microcrystalline mosaic
4d	15-4	R-4189	5.0	1.3	3.5				90.2					Microcrystalline mosaic
4d	15-5	R-4190	15.6	4.2	5.2				75.0					Microcrystalline mosaic
4d	15-6	R-4191	12.9	1.7	0.6				84.8					Microcrystalline breccia
4e	15-7	R-4192	12.2	2.1	0.9				84.8					Microcrystalline breccia

DeWees-Potthoff Paralta Quarry, Linn County, Iowa, NE SW 6 83N, 5W

R-4105, Bed 6

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline dolomite	99.9%
	Insoluble residue	0.1%

Thin section description: The rock is composed of a mosaic of microcrystalline dolomite crystals. Few of these show subhedral outlines against voids. Where the crystals are impingent against other dolomite, rhombohedral outlines are lacking. Narrow iron stained zones occur. Veins filled with calcite containing dolomite crystals in poikilitic intergrowth are noted but they are rare.

R-4106, Bed 7

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline dolomite	89.5%
	Finely crystalline dolomite	10.5%

Thin section description: The rock is predominantly anhedral dolomite crystals. Most of these are microcrystalline but there are finely crystalline dolomite bodies randomly distributed throughout the specimen. There are many voids ranging from less than thirty to greater than 100 microns in diameter. Some of these are rhombic in shape but most are irregular. A few scattered small areas of dark iron oxide staining were noted. There seems to be a concentration of the larger crystals near voids.

R-4107, Top of Bed 8

Texture: Finely crystalline

Mineralogy:	Microcrystalline dolomite	15.3%
	Finely crystalline dolomite	84.7%

Thin section description: Finely crystalline dolomite makes up most of the rock with some microcrystalline dolomite occurring in bands approximately parallel to the bedding. A few crystals are euhedral to subhedral but most are of irregular outline in a mosaic fabric. Poikilitic enclosure of microcrystalline material within the larger crystals of dolomite is common. The bands noted above are well developed and of sharp contacts. Some of the bands seem to be controlled by very large carbonate crystals.

R-4108, Bottom of Bed 8

Texture: Finely crystalline

Mineralogy:	Microcrystalline dolomite	22.6%
	Finely crystalline dolomite	74.1%
	Medium crystalline dolomite	1.3%
	Coarsely crystalline dolomite	2.0%

Thin section description: Though the most of the rock is composed of fine dolomite crystals, there are irregular regions of microcrystalline dolomite, and more or less isolated medium and coarse crystals occur in a random fashion. A few crystals are euhedral in outline and subhedral crystals are rather common. Poikilitic enclosure of smaller crystals is common in all cases. The rock is marked by a few vugs surrounded by subhedral crystals. Some iron oxide staining of crystal boundaries is noted.

R-4109, Top of Bed 9

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline dolomite	66.3%
	Finely crystalline dolomite	33.7%

Thin section description: Dolomite crystals ranging up to 100 μ comprise the bulk of the specimen. Larger dolomite crystals occur in narrow, elongate regions and near vugs. The larger crystals poikilitically enclose the finer ones. Iron oxide staining marks the microcrystalline areas; a few aggregations of opaque crystals occur in the specimens. These are pyrite or marcasite, but the amount present is so slight that isolation of a sample for determination is impractical.

County Quarry, Linn County, Iowa

R-4114, Bed 14

Texture: Finely crystalline mosaic

Mineralogy:	Finely crystalline dolomite	60.4%
	Medium crystalline dolomite	28.0%
	Coarsely crystalline dolomite	11.6%

Thin section description: Dolomite crystals of the fine to medium size range make up most of the rock. For the most part it is an interlocked mosaic of anhedral crystals. A few rhombohedral crystals occur. The rock is marked by microfractures and small solution voids. These are bounded and in some cases filled by larger crystals, some of which are quite coarse. Poikiltic enclosure of smaller crystals is present throughout the specimen.

Weaver's Quimby Quarry, Cerro Gordo County, Iowa, NW 27, 97N, 20W

R-4122, Bed 9

Texture: Medium crystalline poikilitic mosaic

Mineralogy:	Finely crystalline dolomite	7.7%
	Medium crystalline dolomite	58.0%
	Coarsely crystalline dolomite	34.3%

Thin section description: In thin section, the texture would be described as a poikilitic intergrowth. Most of the crystals fall into the size range of medium crystalline dolomite, but relatively large numbers of coarse crystals are observed. Perhaps the most remarkable petrologic feature of the rock is the clear borders of the crystals contrasted to their cores, clouded by poikilitically enclosed microcrystalline dolomite. Many of the core areas are of rhombohedral outline and commonly the host crystal is subhedral. The interlocking between crystals is not perfect, and the specimen displays much void space because of it. Some of the crystals have borders that are crenulated and fit closely against other crystals except at the corners. The finely divided crystals not poikilitically contained within larger ones commonly occupy spaces at the corners between larger crystals.

R-4123, Top of Bed 10

Texture: Medium crystalline poikilitic mosaic

Mineralogy:	Finely crystalline dolomite	40.4%
	Medium crystalline dolomite	44.7%
	Coarsely crystalline dolomite	14.9%

Thin section description: The medium-sized crystals of dolomite characteristically include finely crystalline dolomite as poikilitic intergrowth. The coarse crystals, though not free of poikilitic enclosure, are not so crowded with the small crystals as are the others. The medium-sized crystals occur as a mosaic of interlocking grains with some microcrystalline dolomite between them. The coarsely crystalline dolomite occurs as isolated regions of anhedral crystals. These regions are of random and irregular shape. They do not parallel bedding, nor is there any feature to which they bear constant relationship. The rock has a few voids of greater than 100 μ diameter.

R-4124, Lowest exposure of Bed 10

Texture: Medium crystalline poikilitic mosaic

Mineralogy:	Finely crystalline dolomite	19.9%
	Medium crystalline dolomite	67.7%
	Coarsely crystalline dolomite	12.4%

Thin section description: This rock is much like R-4123, indicating a rather unusual constancy of rock type in bed 10. In this specimen, the coarse dolomite is more poikilitic than in the above specimen. The isolated regions filled with coarse crystals are less abundant and smaller. Otherwise, the rocks are identical.

Schildberg's Crescent Quarry, Pottawattamie County, Iowa, NE, NE, 34, 76N, 44W

R-4027, Bed 5 (top)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	51.8%
	Finely crystalline calcite	36.8%
	Medium crystalline calcite	3.7%
	Coarsely crystalline calcite	3.8%

Thin section description: The rock is a mosaic of microcrystalline calcite containing scattered zones of more coarsely crystalline calcite. These zones range in size from a few to many individual crystals. Some of the larger crystals occur completely isolated from others. These crystals in the isolated situation have very irregular boundaries and give evidence of being invaded by the microcrystalline carbonate. One such crystal, over two mm long is deeply embayed by the calcite of finer size and in some instances actually truncated by the mosaic of finer crystals. Poikilitic enclosure of calcite within calcite is common in all size ranges but is less marked in the large isolated crystals than in the aggregates of coarse ones. Some quartz replacement of carbonate has occurred, but is of such minor extent as to be negligible.

R-4028, Bed 5 (bottom)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	55.1%
	Finely crystalline calcite	27.9%
	Medium crystalline calcite	4.9%
	Coarsely crystalline calcite	7.1%

Thin section description: The rock closely resembles R-4027, the top of the same bed, except for the fact that the isolcated large crystals are slightly less abundant, though they have the same form and habit. Bryozoan fragments occur in a poor state of preservation. Some unidentified circular bodies of microcrystalline calcite occur. It is probable that these structures represent the two dimensional expression of a spherical body because they are rarely observed to be other than circular in thin section. Microfractures associated with the coarser portions of the rock. The paragenesis in this and in R-4027 appears to be that the finely and microcrystalline calcite have recently replaced a coarser texture.

R-4029, Bed 6

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	9.7%
	Finely crystalline calcite	1.0%
	Coarsely crystalline calcite	2.1%
	Quartz	87.9%
	Insoluble residue	59.3%

Thin section description: The specimen is a chert. Some chalcedonic variety of quartz occurs but it is mostly in association with voids. Most of the quartz is present as a microcrystalline mosaic containing more or less carbonate as individual crystals of all sizes and as aggregates more or less embayed by the quartz. There is a rather large concentration of opaque crystals in the chert which is red in reflected light and is interpreted as being iron oxide occurring after pyrite.

R-4030, Bed 7

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	64.0%
	Finely crystalline calcite	23.6%
	Medium crystalline calcite	3.6%
	Coarsely crystalline calcite	5.0%
	Insoluble residue	3.03%

Thin section description: The rock is predominantly a microcrystalline mosaic but zones of coarser calcite crystals occur. These are present as individual crystals and aggregates of appreciable size, some being 5 mm in maximum diameter. Some of the coarser crystals have regular boundaries against the finer mosaic and others are much embayed by the finer carbonate. Poikilitic enclosure of smaller calcite crystals by larger ones is common. The larger crystals are predominantly associated with voids interpreted as solution channels. When microcrystalline aggregates of ovoid or circular outline occur in parts of the section of the rock takes on a texture approaching that of an oolite.

R-4031, Bed 9 (top)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	78.3%
	Finely crystalline calcite	18.7%
	Medium crystalline calcite	1.9%
	Coarsely crystalline calcite	1.1%
	Insoluble residue	3.5%

Thin section description: This specimen, though predominantly composed of microcrystalline calcite, is almost an ovoid texture. The microcrystalline carbonate occurs as nearly to completely isolated aggregates with coarser calcity crystals between aggregates. There is no well developed structure that would fit the definition of an oolite, and the microcrystalline aggregates are highly variable as to size. The coarser crystals of all sizes poikilitically enclose calcite of finer sizes. Some of the coarse crystals have been replaced by quartz mosaics in part.

R-4032, Bed 9 (middle)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	57.4%
	Finely crystalline calcite	25.3%
	Medium crystalline calcite	8.9%

Coarsely crystalline calcite	8.4%
Insoluble residue	25.8%

Thin section description: The rock is quite similar to R-4031 but for the increase in coarser calcite than the microcrystalline variety. Much of the coarser material is associated with what appears to be a fossil fragment.

R-4033, Bed 10 (bottom)

Texture: Microcrystalline mosaic

Mineralogy:		
	Microcrystalline calcite	57.3%
	Finely crystalline calcite	30.1%
	Medium crystalline calcite	4.2%
	Coarsely crystalline calcite	4.1%
	Insoluble residue	3.4%

Thin section description: The specimen is predominantly a poikilitic intergrowth of calcite of various sizes. The larger crystals occur both as individuals and in aggregates of various sizes up to 2 mm in diameter. Some replacement of quartz has occured, and the quartz is generally restricted to fossil structures. Opaque crystals in small amounts are observed in the chalcedonic variety of quartz.

R-4034, Bed 12

Texture: Microcrystalline mosaic

Mineralogy:		
	Microcrystalline calcite	63.7%

Finely crystalline calcite	12.9%
Medium crystalline calcite	0.7%
Coarsely crystalline calcite	6.7%
Insoluble residue	16.0%

Thin section description: Fine, medium and coarse calcite crystals are scattered throughout the microcrystalline mosaic both individually and in groups. All the larger calcite crystals poikilitically enclose finer ones. Individual larger crystals and the outer border crystals of aggregates are of irregular boundaries with respect to the finer mosaic. Some few individual quartz crystals of very fine to microcrystalline size occur. In some cases portions of the larger calcite crystals have been replaced by chalcedony which commonly contains opaque crystals thought to be pyrite. Echinoid fragments are common and randomly distributed through the rock.

R-4035, Bed 7 (bottom)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	47.3%
	Finely crystalline calcite	32.1%
	Medium crystalline calcite	5.0%
	Coarsely crystalline calcite	10.3%
	Insoluble residue	5.3%

Thin section description: The specimen has a microcrystalline texture with stringers and isolated masses of larger calcite crystals distributed randomly throughout the rock. Larger sized crystals poikilitically enclose those of smaller size. In some areas of medium and coarse calcite crystals, a distinctly lath-like appearance is present. These areas are characterized by crystals in a moderate state of strain showing undulating extinction and polygonization of the larger crystals. Twinning and deformed twining lamellae are missing from this specimen, for the most part. A few areas of twinned crystals were noted but they are rare. Some few calcite crystals have been partially replaced by quartz.

Hopper's South Quarry, Cass County, Nebraska, SE, SE, 34, 11N, 11W

R-4036, Bed 15 (2½ feet above quarry floor)

Texture: Fossiliferous microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	68.0%
	Finely crystalline calcite	20.0%
	Medium crystalline calcite	4.8%
	Coarsely crystalline calcite	4.9%
	Insoluble residue	2.3%

Thin section description: The rock is composed of a microcrystalline matrix with several zones (usually elongate) of fine, medium and coarse calcite crystal occuring throughout. Well preserved fusilinids occur in considerablue abundance. The larger crystals poikilitically enclose all finer sizes of calcite. The coarser crystals are almost exclusively associated with what appear to be solution phenomena. Fragmentation of fusilinid shells along these zones is common, though not abundant.

R-4037, Bed 15

Texture: Microcrystalline mosaic, very fossiliferous

Mineralogy:	Microcrystalline calcite	63.5%
	Finely crystalline calcite	23.0%
	Medium crystalline calcite	3.7%
	Coarsely crystalline carbonate	6.5%
	Insoluble residue	3.3%

Thin section description: The rock is a mosaic of fine and microcrystalline calcite with some zones of coarse and medium calcite crystallization. The coarser calcite is associated with the fusilinid shells. Most of the coarse crystals are of very irregular outline, and those outside the fusilinid shells are poikilitic with respect to the finer varieties of calcite. The coarser crystals within the fusilinid shells are relatively free of enclosure. In some instances the fusilinid shells have been deformed by being pressed against more resistant crystals. The paragenesis indicates that the order of age is directly from microcrystalline to coarsely crystalline calcite, with much of the material being in the intermediate stages.

R-4038, Bed 15 (4½ feet above quarry floor)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	82.3%
	Finely crystalline calcite	12.1%
	Medium crystalline calcite	2.1%

Coarsely crystalline calcite	1.6%
Insoluble residue	1.9%

Thin section description: Microcrystalline calcite predominates in the rock but fossil fragments and zones of larger crystals occur. Larger microcrystalline and very finely crystalline calcite make up differentiable zones in the rock. The zones containing the fine to coarse calcite crystals are commonly elongate. Larger crystals poikilitically enclose finer ones. In a few instances, small amounts of quartz have replaced calcite and there are a few quartz crystals that appear to be of detrital origin. The common fusilinid shells appear to have been rather severely modified since deposition. They have been penetrated by individual crystals and masses of crystals. The fusilinid walls have been separated in some instances. Some of the coarser carbonate crystals have been deformed to the extent of twinning and then the formation of new crystals across the old twins.

R-4039, Bed 15 (top)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	77.1%
	Finely crystalline calcite	15.7%
	Medium crystalline calcite	1.6%
	Coarsely crystalline calcite	4.1%
	Insoluble residue	1.5%

Thin section description: The rock is very similar to R-4038 except that in this specimen, some large voids are associated with medium and coarsely crystallized calcite. Brecciation of the rock has proceeded to a minor extent by the formation of microfractures and their later infilling by calcite of larger crystal size than the microcrystalline material that makes up the bulk of the rock.

R-4040, Bed 14

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	68.0%
	Finely crystalline calcite	18.6%
	Medium crystalline calcite	4.7%
	Coarsely crystalline calcite	7.27%
	Insoluble residue	1.5%

Thin section description: The rock is composed of a mosaic of microcrystalline calcite that contains zones of coarser crystals. The large crystals are poikilitic with respect to smaller ones. The coarse zones are particularly interesting in that they show much crystal twinning and repeated twinning. Examples of deformation twins that have been formed at some past time and been superseded by later deformation twins are common in this rock. Curved deformation lamellae, and deformation lamellae extending across crystal boundaries, and curved lamellae relieved of strain by new crystal formation are also present. The microcrystalline calcite that makes up the bulk of the rock occurs as an anhedral mosaic that is interrupted by the coarser regions and by stylolites. Some iron oxide enrichment is observed associated with the stylolites, and probably considerable calcite has been dissolved from these regions.

R-4041, Bed 14 (top)

Texture: Poikilitic breccia

Mineralogy:	Microcrystalline calcite	44.0%
	Finely crystalline calcite	18.1%
	Medium crystalline calcite	4.5%
	Coarsely crystalline calcite	31.8%
	Insoluble residue	1.6%

Thin section description: In this rock, where the bulk of the mass is composed of microcrystalline calcite mosaic, the matrix is interrupted by so many zones of coarser crystallization that the microcrystalline material is contained within and completely surrounded by coarser zones. Many of the fossils have been deformed and partially resorbed by both the coarsely crystalline calcite and by other fossils. Some of the large calcite crystals contain quite well preserved, and complete fossils. The large crystals are commonly overgrowths of previously existing crystals and in other cases they seem to be newly crystallized in a strained environment. In some single crystals, the strain of deformational twins has been relieved by neocrystallization occurring within the crystal, not at its boundaries. Some of these crystals and those showing bent twinning lamellae are sufficiently strained that they yield an interference figure that has a slight biaxial character.

R-4042, Bed 14 (middle)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcites	64.5%
	Finely crystalline calcite	21.0%
	Medium crystalline calcite	5.2%
	Coarsely crystalline calcite	5.5%
	Insoluble residue	3.8%

Thin section description: A microcrystalline calcite matrix occurs with rather well defined elongate zones, of fine, medium and coarse calcite. These zones are commonly sharply defined from the matrix. Several kinds of fossil fragments occur. Two stylolites cross the specimen and several solution cavities are present. The latter are associated with the zones of larger crystals. The larger crystals poikilitically enclose the finer ones in all parts of the specimen, and in some instances, opaque crystals, interpreted as pyrite, occur enclosed within the coarser crystals. Minor replacement of fossil fragments by quartz is observed.

R-4043, Beds 13 and 12

Texture: Finely crystalline breccia

Mineralogy:	Microcrystalline calcite	48.6%
	Finely crystalline calcite	29.4%

Medium crystalline calcite	2.4%
Coarsely crystalline calcite	18.4%
Insoluble residue	1.2%

Thin section description: The matrix of this rock is finely crystalline calcite. It forms a continuous framework separating regions of crystals of other sizes. The coarsely crystalline calcite poikilitically encloses much microcrystalline calcite but very little of the fine material. Moreover, poikilitic enclosure by finely crystalline calcite is not well developed. Many of the coarse aggregates are bounded by microcrystalline material or medium sized calcite.

Clark's North Logan Quarry, Harrison County, Iowa, NE, NE, 19, 77N, 42W

R-4044, Bed 5

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	70.8%
	Finely crystalline calcite	22.3%
	Medium crystalline calcite	1.1%
	Coarsely crystalline calcite	3.8%
	Insoluble residue	2.0%

Thin section description: The major constituent is microcrystalline calcite in a mosaic fabric that is somewhat interrupted by thin zones of finely crystalline calcite. These zones are connected in an irregular way to give to the whole rock an almost brecciated texture. Within this pattern medium and coarsely crystallized calcite masses occur. The coarsest crystals occur at the junctions of the thin zones and seem to be the result of lower pressure in these localities. The regions of the rock occupied by the coarser crystals are quite irregular in outline and widely variant in size. All crystals are poikilitic with respect to those of finer size, and all the larger crystals have very irregular borders against those of smaller sizes. Chert appears in very minor amounts, seemingly restricted to the partial replacement of individual large calcite crystals.

R-4045, Bed 5 (bottom)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	85.4%
	Finely crystalline calcite	10.5%
	Medium crystalline calcite	1.5%
	Insoluble residue	2.6%

Thin section description: The rock is predominantly a mosaic of microcrystalline calcite in which few regions of coarser calcite occur. The presence of finer crystals poikilitically enclosed by coarser calcite, indicates a greater age for the former type, but modest amounts of chert, which is always associated with the larger calcite render this paragenesis open to some question. The chert is observed to replace parts of individual crystals only.

R-4046, Bed 6

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	86.2%
	Finely crystalline calcite	7.8%
	Medium crystalline calcite	2.2%
	Insoluble residue	3.8%

Thin section description: The microcrystalline matrix contains both individual isolated coarser crystals and aggregates of them. The rock is pyritic and has a few small aggregates of chert. The bulk of the insoluble residue is pyrite, though some small amount of quartz is observed. The disposition of the finely crystalline calcite, though small in amount is such as to cause the microcrystalline calcite to appear as microbreccia. The pseudo-particles of the breccia texture are very small, less than 200 microns in diameter usually. The larger calcite crystals are very ragged at the borders where they impinge against the finer crystals. Poikilitic enclosure of finer crystals is common througout the rock.

R-4047, Bed 7 (top)

Texture: Brecciated

Mineralogy:	Microcrystalline dolomite	76.7%
	Finely crystalline dolomite	15.1%
	Medium crystalline dolomite	2.2%
	Coarsely crystalline dolomite	1.7%
	Insoluble residue	4.3%

Thin section description: The finest dolomite is crossed by a random network of fine to coarse vein-like zones of clear dolomite crystals. The effect of this is to render the rock of a brecciated appearance, and to probably control the mechanical properties of the rock. The medium and coarse dolomite are associated with these elongate zones of finely crystallized material. The microcrystalline aggregates are quite large, ranging up to several millimeters in diameter, and the vein-like masses that separate them are only a few tenths of a millimeter in thickness. The dolomite in this rock is an anhedral mosaic without any well developed euhedral crystals. Chert is associated with a few of the coarser crystals, but is of such minor amount not to be recorded by the X-ray diffraction diagram.

R-4048, Bed 7 (bottom)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	67.5%
	Finely crystalline calcite	27.4%
	Medium crystalline calcite	1.7%
	Coarsely crystalline calcite	1.2%
	Insoluble residue	2.2%

Thin section description: The microcrystalline mosaic contains scattered individual crystals and aggregates of coarser sized calcite. Some of the coarser aggregates are connected to form a partial network. The larger crystals all poikilitically enclose microcrystalline material. The coarse and medium crystals form straight boundaries between themselves and are ragged where impingent against the fine and microcrystalline material. Small aggregates of chert are noted, usually completely contained within one coarse calcite crystal. The rock contains a few fusilinids and fragments of other fossils. Some of the coarse crystals may well be echinoderm fragments.

R-4049, Bed 8 (top)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline dolomite	82.4%
	Finely crystalline dolomite	7.7%
	Medium crystalline dolomite	1.0%
	Coarsely crystalline dolomite	1.0%
	Insoluble residue	7.9%

Thin section description: In the main, microcrystalline dolomite is predominant. Some medium, fine, and coarse crystals occur throughout the rock, both are isolated individuals and as aggregates. All the larger crystals poikilitically enclose finer ones, and form irregular boundaries against the microcrystalline dolomite. In several instances, chert appears to have partially replaced coarse dolomite. Fossils include fusilinids and corals as well as fragments that are so nearly destroyed that their zoological affinities cannot be determined.

R-4050, Bed 8 (bottom)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	36.2%
	Finely crystalline calcite	3.0%
	Quartz	60.8%
	Insoluble residue	60.8%

Thin section description: The specimen is about half carbonate and half chert. The division is sharp and little of either rock type is observed contained within the other. There is some quartz present in the carbonate portion of the rock, because the thin section analysis yielded a quartz value of 54.3% though the insoluble residue taken from a matched sample was somewhat higher. Carbonate in the chert, was not observed, though it would be much easier to see than the other case. The carbonate part of the specimen is an almost completely microcrystalline mosaic with a few larger crystals contained within it. The chert is typical of the rock type. The quartz occurs as a diversely oriented mosaic of microcrystalline quartz containing small, irregular areas of chalcedonic material.

R-4051, Bed 9

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	80.3%
	Finely crystalline calcite	15.8%
	Medium crystalline calcite	1.0%

Coarsely crystalline calcite	1.7%
Quartz	1.2%

Thin section description: The coarser crystals are distributed as randomly occurring individuals and as zones of aggregates within the microcrystalline matrix. In part the interconnections of the coarser aggregates give to the rock a brecciated appearance. The quartz is present as chert masses associated with the coarser crystals. It is not observed to be replacing the microcrystalline calcite anywhere. Coral, fusilinid, and echinoderm fragments occur. These are associated with the finer calcite crystals, except in instances where they enclose coarse ones within the body chamber, or, as is true of the echinoderm fragments they are single coarse crystals.

R-4053, Bed 9 (bottom)

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	65.2%
	Finely crystalline calcite	23.1%
	Medium crystalline calcite	2.7%
	Coarsely crystalline calcite	7.2%
	Quartz	1.8%

Thin section description: The fine, medium and coarse calcite occur in a more or less complete network of vein-like zones of considerable length, though irregular shape, and comparatively small thickness. These features serve to divide the microcrystalline calcite up into small aggregates. Poikilitic enclosure of smaller crystals is common in crystals of all sizes. Some chert is observed, associated with the coarser calcite. Some iron oxide masses, probably replacing pyrite, are observed in the chert. Fossil debris is common, but well preserved forms are rare.

R-4054, Bed 10

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	55.4%
	Finely crystalline calcite	14.1%
	Medium crystalline calcite	6.4%
	Coarsely crystalline calcite	20.1%
	Insoluble residue	3.8%

Thin section description: The microcrystalline calcite, which comprises the bulk of the rock is divided into small domains in the rock by aggregates of fine, medium, and coarse calcite crystals, all of which poikilitically enclose finer sizes. The coarse crystals, ranging up to individuals greater than two millimeters in diameter, sometimes contain aggregates of finer crystals. The brecciated appearance of the rock is particularly prominent near the aggregates of coarser crystals. Some small segregations of quartz, as chert are noted.

R-4055, Bed 10 (bottom)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	68.5%
	Finely crystalline calcite	23.2%
	Medium crystalline calcite	2.4%
	Coarsely crystalline calcite	1.5%
	Insoluble residue	4.4%

Thin section description: The microcrystalline matrix contains aggregates of various shapes of fine, medium and coarse calcite. The aggregates are typically isolated, though some interconnections occur. The medium and coarse crystals form very irregular boundaries against finer crystals and straight ones between themselves. Chert is observed within individual coarse crystals. There are few opaque crystals in the rock, and these seem to be iron oxide after pyrite.

R-4056, Bed 11

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	85.2%
	Finely crystalline calcite	13.3%
	Medium crystalline calcite	1.5%

Thin section description: Microcrystalline calcite is the major constituent and is present in two easily recognized habits, one is very finely divided and stained brown, either by iron oxide or by light scattering at the many interfaces, the other is clear in thin section and of slightly larger size. These latter crystals occur in an anastomosing network of vein-like bodies that effectively divide the masses of smaller, darker microcrystalline calcite into sub-domains in the rock. The vein-like network contains most of the finely crystalline calcite, and some of the medium size. A few opaque crystals occur and are interpreted as pyrite.

R-4057, Bed 12

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline carbonate	64.3%
	Finely crystalline calcite	9.4%
	Coarsely crystalline calcite	7.3%
	Quartz	19.0%

Thin section description: The major constituent of the rock is microcrystalline calcite with some finely crystalline calcite veins which contain scattered coarse crystals. Poikilitic enclosure of finer crystals by those of coarser size is ubiquitous. Several ovoid bodies of radial and sometimes concentric crystallization appear scattered throughout the rock.

Lewis and Wallace Quarry, Appanoose County, Iowa, NE NE 32, 70N., 19W

R-4058, Bed 11

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	71.2%
	Finely crystalline calcite	20.6%
	Medium crystalline calcite	3.1%
	Coarsely crystalline calcite	3.0%
	Insoluble residue	2.0%

Thin section description: The microcrystalline matrix is interrupted by elongate regions of coarse to fine calcite aggregates. These are commonly interconnected, and usually sharply distinct from the microcrystalline material. They may well be reconstituted fossil debris, but if so they cannot be identified with any certainty. There are a few individual coarse crystals of very irregular outline in the matrix.

R-4059, Bed 11 (top)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	77.3%
	Finely crystalline calcite	5.3%
	Medium crystalline calcite	4.4%
	Coarsely crystalline calcite	9.4%
	Insoluble residue	3.0%

Thin section description: The microcrystalline matrix contains regions of more coarsely crystalline calcite throughout. All crystals coarser than microcrystalline size are poikilitic and contain smaller crystals. Many of the coarser regions are polycrystalline but individual crystals also occur. The fossils present, including echinoid fragments have been thoroughly reconstituted. The echinoid fragments which, in the organism are single crystal plates have been recrystallized to microcrystalline calcite. Some of the coarser crystals appear strained, showing undulatory extinction and polygonization.

R-4060

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	60.2%
	Finely crystalline calcite	6.5%
	Medium crystalline calcite	4.9%
	Coarsely crystalline calcite	23.6%
	Insoluble residue	4.8%

Thin section description: The microcrystalline mosaic is broken by vein-like masses of coarser calcite of all sizes, though the coarser crystals predominate. Some of the coarsely crystalline aggregates may be reconstituted fossils, but there is only the persistant curved outline to support such an hypothesis. Some of the coarse crystals are limpid, clear masses with sharply defined borders, others are ragged and display strain phenomena such as undulatory extinction and polygonization and one has evidence of recent fracture within it. Poikilitic enclosure of finer crystals is common in all parts of the rock.

R-4061, Bed 10 (top)

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	69.2%
	Finely crystalline calcite	8.1%
	Medium crystalline calcite	13.5%
	Insoluble residue	2.1%

Thin section description: This rock is identical to R-4060 above.

R-4062, Bed 9c (bottom)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	66.6%
	Finely crystalline calcite	18.5%
	Medium crystalline calcite	7.7%
	Coarsely crystalline calcite	5.2%
	Insoluble residue	1.1%

Thin section description: The major constituent is a microcrystalline mosaic, containing some scattered, and commonly disconnected regions of fine, medium and coarse calcite. Most of the zones are elongate, and the crystals are poikilitic. The borders of the coarser zones are gradational with respect to the microcrystalline matrix. Poikilitic crystals occur in all size ranges and all crystal habits. The calcite that makes up the elongate zones is commonly elongate in habit as is commonly observed in veins. The veins are usually marked by a centrally trending microfracture. A few ovoid bodies with both radial and concentric structure well developed are present.

R-4063, Bed 9c(middle)

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	59.7%
	Finely crystalline calcite	17.0%
	Medium crystalline calcite	7.4%
	Coarsely crystalline calcite	13.4%
	Insoluble residue	2.5%

Thin section description: The microcrystalline calcite matrix predominates. The larger crystals occur either independently or are grouped into zones. These large crystals are poikilitic with respect to all finer crystals. The boundaries between aggregates of coarse crystals and the matrix is quite irregular and gradational in character. Microcrystalline, opaque crystals, considered to be pyrite occur in all parts of the rock.

R-4064, Bed 9c (top)

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	53.7%
	Finely crystalline calcite	15.5%
	Medium crystalline calcite	8.5%

Coarsely crystalline calcite	20.7%
Insoluble residue	1.1%

Thin section description: The fine, medium and coarse calcite regions are interconnected to form an anastomozing vein-like network that subdivides the microcrystalline matrix into regions a few millimeters in diameter and smaller. Some of the veins are quite thick, and all are composed of poikilitic crystals. These veins lack any centrally trending fracture and any of the typical vein structure of elongate crystals extending from the wall to a central region.

R-4065, Bed 9b

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	72.0%
	Finely crystalline calcite	9.8%
	Medium crystalline calcite	7.3%
	Coarsely crystalline calcite	7.1%
	Insoluble residue	3.8%

Thin section description: The microcrystalline mosaic is interrupted by vein-like networks of more coarsely crystalline calcite. These veins are commonly connected in crystals that may be echinoid fragments. Microcrystalline calcite masses of tubular shape sometimes intrude into the veins, indicating a possible replacement of the veins by the microcrystalline material as well as an earlier emplacement of the veins in a microcrystalline mosaic.

Some ovoid bodies displaying both radial and concentric structure are observed. The rock gives evidence of microdeformation in the displacement of several linear features by amounts of 1/2 mm without trace of any shear zone being left.

Raid's Comanche Quarry, Van Buren County, Iowa, NE NW 5, 67N, 8W

R-4066, Bed 3a (top)

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	87.9%
	Finely crystalline calcite	6.0%
	Insoluble residue	6.8%

Thin section description: The microcrystalline calcite occurs in two habits, one is very finely divided and stained dark brown by iron oxide, the other is present as slightly larger crystals and lacking the brown stain. The second variety is present in a more or less interconnected network, separating irregular bodies of the dark brown calcite. The finely crystalline calcite occurs with the clear variety of microcrystalline material. The rock is highly fossiliferous, and the fossils vary from well preserved specimens to those that have been almost completely destroyed. Some microcrystalline quartz crystals were noted occurring as isolated individuals of irregular outline. The insoluble residue of the rock is composed of quartz and iron oxide.

R-4067, Bed 3a (bottom)

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	92.0%
	Finely crystalline calcite	3.7%
	Insoluble residue	4.3%

Thin section description: This specimen is very similar to R-4066 above, except that echinoid fragments occur and the total number of fossils observed is smaller than in R-4066.

R-4068, Bed 3c (top)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	91.7%
	Finely crystalline calcite	4.5%
	Insoluble residue	3.8%

Thin section description: The rock is an almost completely microcrystalline mosaic. The finely crystallized calcite is present as isolated masses that do not divide the mosaic into separate bodies. There is not as much iron oxide stain as noted in the specimen R-4066 and R-4067, and there are fewer fossils. Some of the fossils have chert associated with them. It commonly replaces the matrix and in some cases, the fossil.

R-4069

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	91.0%

Finely crystalline calcite	1.3%
Insoluble residue	7.7%

Thin section description: This specimen is, much like the others described from this quarry, a mosaic of microcrystalline calcite. The number of fossils is fewer here than in R-4066, but the number and size of pyrite crystals are increased. The pyrite crystals occur as well defined cubes reaching diameters of 50 μ. The insoluble residue is chiefly pyrite with subordinate quartz present. The finely crystalline calcite occurs as isolated single crystals and as polycrystalline masses of random occurrence and size.

R-4070, Bed 3c (bottom)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	83.8%
	Finely crystalline calcite	7.0%
	Quartz	0.8%
	Insoluble residue	7.4%

Thin section description: The specimen is a mosaic of brown stained microcrystalline calcite. The few coarser calcite crystals that occur in the rock are present in association with aggregates that may be fossil fragments. If these are indeed fragments of fossils, they have been so altered that the zoological affinities cannot be determined. The fine crystals poikilitically enclose microcrystals. A few fine quartz crystals are distributed randomly in the rock. They have irregular borders against the microcrystalline matrix. Fine and microcrystalline pyrite occur randomly throughout the specimen.

R-4071, Bed 3e

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	78.1%
	Medium crystalline calcite	14.7%
	Insoluble residue	7.25%

Thin section description: The medium calcite divides the microcrystalline matrix into disconnected regions that have the appearance of a breccia. Some of these domains are large, several millimeters across, and others only a few microns. Many fossil fragments are present and these are sometimes filled with coarsely crystalline calcite. All calcite coarser than the microcrystalline variety is poikilitic with respect to the finer sizes. Some irregular quartz crystals of microcrystalline size range are observed. They appear as isolated occurrence randomly distributed in the rock. A few identifiable pyrite crystals were observed.

R-4072, Bed 3g

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	78.6%
	Medium crystalline calcite	13.4%
	Insoluble residue	6.7%

Thin section description: Aggregates of medium (with some fine) crystalline calcite occur separated from the microcrystalline matrix by borders of brown calcite that is more finely divided than that of the matrix. The medium crystalline calcite is poikilitic with respect to the finer sizes. The aggregates of medium sized calcite are more or less rounded and their borders are well defined.

Prospect Hill Quarry, Des Moines County, Iowa, NE 27, 69N, 3W

R-4073, Two feet below the top of the quarry face

Texture: Poikilitic, microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	60.7%
	Finely crystalline dolomite	21.9%
	Quartz	17.4%

Thin section description: The rock is predominantly carbonate with quartz, as individual crystals and small masses of chert scattered throughout the rock. The carbonate is predominantly microcrystalline calcite, but appreciable concentrations of dolomite crystals occur. These are both as individual rhombs and as small aggregates. The quartz crystals are subangular to angular and some appear to have very fine to microcrystalline carbonate inclusions. Iron stain is concentrated at the grain boundaries of the quartz and is present in some few linear zones in the carbonate. Few voids occur and these are in the areas where quartz is abundant.

R-4074 Five feet below the top of the quarry face

Texture: Poikilitic microcrystalline mosaic calcite

Mineralogy:	Microcrystalline calcite	59.2%
	Finely crystalline dolomite	35.4%
	Medium crystalline dolomite	1.2%
	Quartz	4.2%

Thin section description: The specimen is predominantly carbonate with a few irregular quartz crystals scattered randomly in the rock. The larger dolomite rhombohedra poikilitically enclose microcrystalline carbonate and lie in a matrix of the same material, in most of the rock. In some randomly scattered portions of the rock, the dolomite rhombohedra occur as mosaics with the only microcrystalline carbonate present being poikilitically contained within the rhombohedra. Veins filled with larger calcite and dolomite crystals occur in the rock.

R-4075 Eight feet, six inches below the top of the quarry face

Texture: Poikilitic microcrystalline mosaic

Mineralogy:	Microcrystalline carbonate	95.2%
	Finely crystalline dolomite	3.3%
	Insoluble residue	1.5%

Thin section description: The rock is predominantly microcrystalline calcite with scattered fine dolomite rhombohdra and quartz crystals occurring randomly throughout the mass. The borders of the dolomite rhombohedra and the quartz crystals are somewhat irregular and embayed by the microcrystalline matrix, and the dolomite crystals poikilitically enclose microcrystalline carbonate of undetermined mineralogy. One vein filled with finely crystallized calcite occurs. The width of the vein is approximately 125 μ.

R-4076 Eleven feet, six inches below the top of the quarry face

Texture: Poikilitic microcrystalline mosaic

Mineralogy:	Microcrystalline carbonate	95.5%
	Finely crystalline dolomite	3.3%
	Insoluble residue	1.2%

Thin section description: This rock is mostly microcrystalline calcite with a few widely scattered dolomite rhombohedra of dolomite and irregular quartz crystals dispersed in it. In a few regions of rounded outline, the dolomite rhombohedra occur in greater concentration than throughout the rock. The quartz is probably present in greater amount than shown in thin section analysis because the insoluble residue, which is all quartz is very fine grained. Such finely divided quartz as this would be easily missed upon thin section examination.

R-4077 Eleven feet, six inches below top of the quarry face

Texture: Poikilitic microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	95.3%
	Finely crystalline dolomite	4.2%
	Insoluble residue	0.5%

Thin section description: The rock is predominantly microcrystalline calcite with scattered rhombohedra of finely crystalline dolomite present. The dolomite crystals are bounded by corroded to deeply embayed borders. They poikilitically enclose microcrystalline carbonate of undetermined mineralogy. A few quartz crystals occur in the rock; these are irregular in outline and are sometimes marked by iron staining at their borders. Some possible fossil fragments occur, and, like the quartz are marked by iron oxide concentrations. A few opaque crystals, probably pyrite, occur.

R-4078 Fourteen feet, six inches below the top of the quarry face

Texture: Poikilitic finely crystalline mosaic

Mineralogy:	Microcrystalline calcite	21.4%
	Finely crystalline dolomite	75.5%
	Insoluble residue	3.2%

Thin section description: The rock is predominantly finely crystalline dolomite. Most of the crystals poikilitically enclose microcrystalline calcite. The dolomite crystals are anhedral for the most part, though some show partial rhombohedral outlines. A few crystals of pyrite occur but they do not make up a significant portion of the rock. Discontinuous vein-like voids are apparent in thin section. These do not seem to be artifacts created during thin section preparation, but appear to be part of the rock structure.

R-4079 Bottom of the quarry face

Texture: Poikilitic microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	95.4%
	Finely crystalline dolomite	1.4%
	Insoluble residue	3.2%

Thin section description: Microcrystalline calcite comprises the most of the rock, with a few scattered crystals of dolomite occurring randomly. The dolomite occurs as poikilitic rhombohedra, containing crystals of the microcrystalline calcite. Circular bands of carbonate stained brown by iron oxide are common. There are concentrations of elongate, curved regions of iron stained carbonate that may be fossil fragments of undeterminable zoological affinities.

Linwood Stone Products Quarry, Scott County, Iowa, SW 13, 77N, 2E

R-4135, Bed 30 (middle)

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	77.1%
	Finely crystalline calcite	19.9%
	Coarsely crystalline calcite	1.6%
	Insoluble residue	1.0%

Thin section description: Brown stained microcrystalline calcite makes up most of the specimen but there are important regions of fine and coarsely crystalline calcite present. Most of the finely crystalline calcite is present as aggregates of rhombohedral outline. Some of the rhombohedra are completely bounded by straight borders and are sharply distinct from the microcrystalline matrix in which they occur. Others have irregular borders against matrix. Some of the rhombohedra are composed exclusively of the finely crystalline carbonate and others contain more or less coarsely crystalline calcite. Typically these rhombohedral aggregates measure about one half millimeter along a side. It is not expected that calcite should form euhedral crystals against other calcite crystals, though dolomite commonly does so because of the greater surface tension. For this reason, it is supposed that the rhombohedra observed in the specimen represent replacement of dolomite by calcite without complete destruction of the dolomite morphology.

R-4136, Bed 30 (bottom)

Texture: Poikilitic finely crystalline mosaic

Mineralogy:	Microcrystalline calcite	37.3%
	Finely crystalline calcite	37.0%
	Medium crystalline calcite	18.2%
	Coarsely crystalline calcite	6.5%
	Insoluble residue	1.0%

Thin section description: The dominant element of the texture is the finely crystalline calcite that is the most abundant calcite habit acting as a textural element. The microcrystalline calcite is, for the most part, contained within crystals of the fine habit.

Some of the microcrystalline material occurs as an independent part of the rock forming homogeneous bands of no great thickness, that alternate with similar bands of fine and medium calcite.

R-4137, Bed 30b

Texture: Poikilitic finely crystalline mosaic

Mineralogy:	Microcrystalline calcite	52.2%
	Finely crystalline calcite	34.3%
	Medium crystalline calcite	12.8%
	Insoluble residue	0.7%

Thin section description: The specimen is a mosaic of finely crystalline calcite, that contains aggregates of microcrystalline and medium crystalline calcite in random distribution. The coarser calcite contains finer crystals in poikilitic intergrowth. A few irregular quartz crystals of fine size are present.

R-4138, Bed 29 (top)

Texture: Ovoid

Mineralogy:	Microcrystalline calcite	47.3%
	Finely crystalline calcite	43.3%
	Medium crystalline calcite	9.0%
	Insoluble residue	0.4%

Thin section description: The rock is composed of rounded, subspherical bodies approximately ½ mm in diameter composed of microcrystalline calcite containing more or less coarsely crystalline calcite at their centers occurring in a matrix of fine and medium crystalline calcite. The ovoid bodies are randomly distributed throughout the rock. The ovoid bodies lack radial and/or concentric structure that is characteristic of oolites, and the included medium and coarse calcite crystals are not centrally located in the ovoid bodies. Most of the coarser calcite contained within the ovoids is present in polycrystalline masses, indicating some origin other than detrital for this habit of calcite.

R-4139, Bed 29 (middle)

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	67.7%
	Finely crystalline calcite	23.5%
	Medium crystalline calcite	7.0%
	Coarsely crystalline calcite	1.0%
	Insoluble residue	0.8%

Thin section description: The microcrystalline matrix, a mosaic of very small calcite crystals is interrupted by more or less well connected networks of vein-like occurrences of more coarsely crystalline calcite. In most portions of the rock, the microcrystalline regions are quite large but in regions of coarsely crystalline calcite, the microcrystalline aggregates are about two millimeters in diameter and of ovoid shape. These ovoids, in contrast to those in R-4138, have no coarser calcite contained within them.

R-4140, Bed 29 (bottom)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	87.4%
	Finely crystalline calcite	12.3%
	Insoluble residue	0.3%

Thin section description: The rock is a microcrystalline mosaic for the most part. There are vein-like bodies of finely crystalline calcite that disrupt the mosaic in some parts of the section. All crystals in this specimen are anhedral, and poikilitic intergrowth is common.

R-4141, Bed 28 (top)

Texture: Ovoid

Mineralogy:	Microcrystalline calcite	70.6%
	Finely crystalline calcite	25.7%
	Medium crystalline calcite	2.3%
	Coarsely crystalline calcite	1.4%
	Insoluble residue	0.7%

Thin section description: The ovoid bodies of this rock are mosaics of microcrystalline calcite set in a finely crystalline and coarser matrix. The ovoid bodies lack both radial and concentric structure and include no coarser calcite. Their borders against the finely crystalline matrix are not sharp, and poikilitic intergrowth of microcrystalline calcite in fine material is common in the border zones. The finely crystalline and coarser calcite that make up the matrix are nearly equant crystals having what appear to be voids at corners where three crystals meet. A few opaque crystals of very fine size were noted.

R-4142, Bed 28 (bottom)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	69.3%
	Finely crystalline calcite	25.2%
	Medium crystalline calcite	4.3%
	Coarsely crystalline calcite	1.2%
	Insoluble residue	21.9%

Thin section description: Most of the specimen is a mosaic of microcrystalline calcite, with a few vein-like masses of coarser carbonate transecting the mosaic. There are areas of predominantly finely crystalline calcite that contain much microcrystalline material as irregular masses with gradational borders. Some of these bodies seem to be relicts left of some former texture. In these zones, the incidence of poikilitic intergrowths is high.

The mineralogy of the rock is of interest in that the piece taken for residue analysis obviously differs from that taken for thin section preparation. The insoluble residue of 21.9% is all quartz, though no obvious chert nodule appeared in the sampling, and the insoluble residue aliquot ground normally. It can only be assumed that the quartz is present as a disconnected group of quartz crystals that are perhaps cemented by calcite.

R-4143, Bed 27 (bottom)

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	86.0%
	Finely crystalline calcite	8.0%
	Medium crystalline calcite	1.3%
	Coarsely crystalline calcite	3.0%
	Insoluble residue	1.7%

Thin section description: Throughout the specimen, the microcrystalline mosaic is disrupted by vein-like bodies of fine, medium and coarse calcite. The isolated bodies of microcrystalline calcite are of various shapes and sizes. A conspicuous feature is the rhombohedral outlines of some of the aggregates of coarsely crystalline calcite. Some of these are to be found in the finely crystalline material also, but there they are more irregular of outline than when present in the microcrystalline material. The rhombohedral bodies of medium and coarsely crystalline calcite occur in bodies of microcrystalline material as well. Sometimes they are associated with veins and sometimes they are completely isolated. If they are pseudomorphs after dolomite crystals, there is no dolomite left in the rock and this represents a cose of dedolomitization.

R-4144, Bed 27 (middle)

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	81.6%
	Finely crystalline calcite	1.3%
	Medium crystalline calcite	7.5%
	Coarsely crystalline calcite	8.5%
	Insoluble residue	2.1%

Thin section description: The microcrystalline calcite, that makes up most of the rock is divided into two types, that that comprises the general matrix of the rock is stained rather dark brown, probably by iron oxide, and that which occurs in the poikilitic intergrowths of which the rhombohedral bodies are composed. These rhombohedral bodies also contain fine, medium, and some coarse crystals. Other coarse crystals are found in the veins that cross the specimen in a random way. Some of these veins are filled by long thin crystals a fraction of a millimeter wide and six or seven millimeters long.

R-4145, Bed 25

Texture: Finely crystalline mosaic

Mineralogy:	Microcrystalline calcite	53.9%
	Finely crystalline calcite	32.5%
	Medium crystalline calcite	6.4%
	Coarsely crystalline calcite	5.8%
	Insoluble residue	1.4%

Thin section description: Though the microcrystalline calcite is the predominant mineral in the rock, the texture is dominated by the finely crystalline material. Most of the microcrystalline calcite is poikilitically contained in the coarser variety. There are coarse areas in the rock that exist at the junction of several finely crystalline elongate masses. Small amounts of pyrite occur as widely separated single crystals of good cubic outline, and in two regions, there are concentrations of pyrite.

R-4146, Bed 24 (top)

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	86.9%
	Finely crystalline calcite	10.2%
	Medium crystalline calcite	1.7%
	Coarsely crystalline calcite	1.2%
	Insoluble residue	0.5%

Thin section description: This rock is predominantly microcrystalline calcite, but the fine, medium and coarse material makes an interpenetrating matrix that divides the microcrystalline calcite into domains only a few millimeters in diameter. Some of the coarser crystals are irregular in outline where they impinge on the microcrystalline material, but their boundaries with others of their own textural class are straight. A few small styolites occur in the rock and they are heavily marked by iron oxide.

R-4147, Bed 24 (middle)

Texture: Poikilitic finely crystalline breccia

Mineralogy:	Microcrystalline calcite	75.9%
	Finely crystalline calcite	18.3%
	Medium crystalline calcite	3.9%
	Coarsely crystalline calcite	1.2%
	Insoluble residue	0.7%

Thin section description: Though microcrystalline calcite is the most abundant variety of mineral in this limestone, the texture is controlled by the coarser varieties which poikilitically enclose the microcrystalline material. Fine, medium, and coarse crystals seem to form a network, or a mosaic whose borders are difficult to follow because of the vast amount of included carbonate of microcrystalline size. There are prominant iron oxide stained styolites associated with the clear regions, and it is only here that the rock is free of poikilitic intergrowth. In some of these areas, coarse crystals showing polysynthetic twinning occur.

R-4148, Bed 24 (bottom)

Texture: Poikilitic finely crystalline breccia

Mineralogy:	Microcrystalline calcite	64.8%
	Finely crystalline calcite	32.1%
	Medium crystalline calcite	3.0%
	Insoluble residue	1.1%

Thin section description: This rock is identical to R-4147 except for more finely crystalline calcite being present. The texture is again dominated by the poikilitic enclosure of the microcrystalline calcite in the fine and medium carbonate. There seem to be more styolites in this portion of the bed and their amplitude is smaller than in the middle of the bed.

R-4149, Bed 23

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	90.8%
	Finely crystalline calcite	8.7%
	Insoluble residue	0.5%

Thin section description: The microcrystalline calcite is of two types. The first of these is very finely divided and stained brown by iron oxide, and the second is slightly larger in crystal size and clear in thin section. The first sort appears as isolated masses in a network of the second. The second class of microcrystalline calcite is associated with the finely crystalline carbonate, and in one or two cases, with veins that contain a few coarse crystals. Some of this latter calcite are twinned.

R-4150, Bed 22*

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	99.1%
	Finely crystalline calcite	0.9%

Thin section description: This is a microcrystalline mosaic interrupted by randomly oriented and spaced veins of finely crystalline calcite. There are a few small amplitude styolites, and a few opaque crystals interpreted to be pyrite.

R-4151, Bed 23 (weathered)

Texture: Ovoid

Mineralogy:	Microcrystalline calcite	91.5%
	Finely crystalline calcite	8.1%
	Insoluble residue	0.3%

Thin section description: This is the same rock as that taken for R-4149 but a weathered sample taken to determine whether weathering had caused any change in the mineralogy. No change was observed.

R-4152, Bed 21*

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	89.4%
	Finely crystalline calcite	8.6%
	Medium crystalline calcite	1.1%
	Insoluble residue	0.9%

Thin section description: The specimen is predominantly a microcrystalline mosaic with some variation of iron oxide staining.

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* Samples taken from Dewey Portland Cement Quarry adjoining Linwood Stone Products Quarry. Samples R-4152 through R-4165 were also taken from Dewey's Quarry.

Veins of fine and medium calcite occur randomly in the rock; these contain a few coarse crystals. The coarser crystals are commonly twinned and poikilitic, containing finer calcite crystals.

R-4153, Bed 20

Texture: Finely crystalline breccia

Mineralogy:	Microcrystalline calcite	49.3%
	Finely crystalline calcite	26.7%
	Medium crystalline calcite	10.3%
	Coarsely crystalline calcite	11.0%
	Insoluble residue	2.6%

Thin section description: The bulk of the rock, and the continuous phase, is a mosaic of microcrystalline calcite. Contained within the matrix are aggregates of fine, medium and coarse calcite in a randomly mixed state. Commonly the larger crystals are bordered by finer ones, so that the larger crystals do not impinge directly on each other. These bodies of coarser calcite reach dimensions of ten millimeters. Poikilitic intergrowth is common in all parts of the rock containing crystals coarser than microcrystalline calcite. Opaque crystals, probably pyrite, occur in association with the coarser crystals.

R-4154, Bed 19 (top)*

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	98.4%

Finely crystalline calcite	0.1%
Insoluble residue	1.5%

Thin section description: The specimen is a mosaic of very finely divided calcite crystals, relieved at widely and randomly distributed points by a few crystals of medium crystalline calcite. Some opaque crystals occur scattered over the specimen, but their occurrence is minor.

R-4155, Bed 19 (upper one fourth)*

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	94.9%
	Finely crystalline calcite	4.4%
	Insoluble residue	0.7%

Thin section description: This rock closely resembles the previous specimen except that the amount of finely crystalline calcite has increased, and that there are a few seggregations of dark, extremely finely divided microcrystalline calcite.

R-4156, Bed 19 (middle)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	88.4%
	Finely crystalline calcite	10.6%
	Insoluble residue	1.0%

Thin section description: The specimen is predominantly a mosaic of microcrystalline calcite. Poorly defined structures of near circular habit are observed in some parts of the thin section. The microcrystalline matrix is divided by darker veins of very thin darker material so finely divided that its crystallinity cannot be determined. These veins resemble ghosts of grain boundaries. Minor aggregates of quartz occur randomly and widely separated in the rock. The quartz crystals are quite coarse, being over 100 μ in their longest dimension, they formed sutured mosaics that poikilitically include the microcrystalline calcite. The quartz is somewhat strained as indicated by undulatory extinction.

R-4157, Bed 19 (bottom)*

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	84.3%
	Finely crystalline calcite	10.9%
	Medium crystalline calcite	1.7%
	Coarsely crystalline calcite	1.8%
	Insoluble residue	1.3%

Thin section description: The specimen consists mostly of microcrystalline calcite in an interlocking mosaic. The fine, medium and coarse calcite are in veins for the most part. The veins are narrow and trend randomly over the specimen. Some of the veins are stained dark brown, while others are clear. A few opaque crystals and one small aggregate of coarse quartz occur.

R-4158, Bed 18 (bottom)*

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	64.9%
	Finely crystalline calcite	27.9%
	Medium crystalline calcite	5.2%
	Insoluble residue	2.0%

Thin section description: The rock is of brecciated texture with particles of microcrystalline texture occurring in a mass of finely crystalline calcite. In this thin section, the major part is microcrystalline material, with the matrix being present in a lesser amount. The microcrystalline fragment is marked by aggregations of dark, finely divided calcite of more or less rounded outline, separated by slightly coarser crystals of the same mineral that are clear in transmitted light. The boundary between the fragment and the matrix in which it occurs is marked in part by a styolite. The present styolite is later than the boundary. The rock contains widely separated quartz crystals that are of medium size and irregular outline. Most of the quartz occurs in the finely crystalline calcite.

R-4159, Bed 17*

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	80.8%
	Finely crystalline calcite	5.9%
	Medium crystalline calcite	3.0%

	Coarsely crystalline calcite	5.2%
	Insoluble residue	5.1%

Thin section description: The rock is composed of microcrystalline domains of varying sizes and shapes separated by veins of caorser calcite. Some veins contain fragments of microcrystalline rock within themselves, others are quite free of inclusions. Several veins were noted to be filled with long, thin single calcite crystals. Some of the large crystals are poikilitic with respect to both individual microcrystals of calcite and to microcrystalline aggregates. A small chert aggregate occurs, associted with one vein of coarsely crystalline calcite. The coarser crystals are polysynthetically twinned. Some pyrite crystals of finely crystalline and microcrystalline size occur in the finer portions of the rock, and to a lesser extent in the veins of coarser material.

R-4160, Bed 16*

Texture: Brecciated microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	98.8%
	Medium crystalline calcite	0.1%
	Insoluble residue	1.1%

Thin section description: The microcrystalline mosaic is broken by veins of calcite that range up to medium crystalline in size. A few coarse opaque crystals, probably pyrite, occur scattered randomly through the rock.

R-4161, Bed 15*

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	97.6%
	Finely crystalline calcite	0.1%
	Insoluble residue	2.3%

Thin section description: The microcrystalline mosaic includes a few veins of coarser microcrystalline and a few grains of larger calcite. A few finely crystalline calcite masses occur isolated in the mosaic.

R-4162, Bed 13*

Texture: Ovoid

Mineralogy:	Microcrystalline calcite	61.4%
	Finely crystalline calcite	36.4%
	Insoluble residue	2.2%

Thin section description: The rock is composed of ovoids ranging in size from 0.01 to 0.5 mm in diameter, set in a matrix of finely crystalline calcite. Some of the ovoid bodies have polycrystalline calcite masses at their centers that may comprise much or little of the volume of the body. These polycrystalline cores are quite irregular in shape, they are poikilitic with respect to the microcrystalline calcite, and they are invaribly surrounded by it. The better developed ovoids have borders of finely crystalline calcite of elongate habit. The calcite of these borders is radially arranged, with the long axes of the crystals pointing away from the ovoid body. In most instances, the ovoid bodies are in contact across these radial borders with the interstices between them filled with an anhedral mosaic of finely crystallized calcite. The insoluble residue of the specimen is considered to be made up of pyrite and quartz, both of which appear in thin section in subordinate amounts.

R-4163, Bed 12 (top)*

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	93.7%
	Finely crystalline calcite	5.8%
	Insoluble residue	0.5%

Thin section description: The rock appears as a mosaic of microcrystalline calcite with bands of finer material over parts of the rock. A few zones in the band are coarse enough to be called finely crystalline calcite, and in one small portion of the rock, a group of coarse crystals occurs. These coarse crystals form straight boundaries with each other in a typical mosaic pattern and irregular boundaries with the microcrystalline calcite. Poikilitic enclosure of both individual crystals and aggregates of the fine material are abundant.

R-4164, Bed 12 (middle)*

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	93.0%
	Finely crystalline calcite	5.0%
	Insoluble residue	2.0%

Thin section description: The microcrystalline calcite that comprises the bulk of the rock is present in two varieties, a finely divided, darkly stained material and a coarser, less stained and perhaps better crystallized one. The two occur throughout the rock as more or less well defined masses. The general impression is that the latter forms a matrix containing the latter. Both varieties contain isolated regions of finely crystalline calcite.

R-4165, Bed 12 (bottom)*

Texture: Finely crystalline mosaic

Mineralogy:	Finely crystalline calcite	92.4%
	Insoluble residue	6.7%

Thin section description: The rock is a mosaic of finely crystalline calcite containing scattered masses of quartz that replaces the carbonate. A few of the carbonate crystals of coarser size poikilitically include slightly smaller ones.

Pint's Quarry, Blackhawk County, Iowa, NE, SW, 36, 89N, 12W

R-4166, Bed 5a (top)

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*Indicates samples taken from the Dewey Portland Cement Quarry adjoining the Linwood Stone Products Quarry.

Texture: Medium crystalline poikilitic, subhedral mosaic

Mineralogy:	Microcrystalline calcite	1.1%
	Medium crystalline calcite	5.4%
	Medium crystalline dolomite	92.5%
	Insoluble residue	1.0%

Thin section description: The bulk of the rock is euhedral to subhedral dolomite crystals. These poikilitically enclose microcrystalline calcite and are, in part, cemented by medium crystalline calcite. The rock is very uniform in texture, though there are voids in it of irregular and rhombohedral shape. It is considered that the rhombohedral voids are artifacts produced in thin section manufacture, but the irregular ones are probably solution channels. The medium crystalline calcite is irregular in shape and in some instances, poikilitically includes dolomite. A few pyrite crystals occur.

R-4167, Bed 5a (middle)

Texture: Poikilitic coarse mosaic

Mineralogy:	Finely crystalline dolomite	56.0%
	Coarsely crystalline calcite	43.2%
	Insoluble residue	0.8%

Thin section description: The coarsely crystalline calcite forms an interlocking mosaic texture in which boundaries between the crystals are somewhat obscured by the poikilitically included finely crystalline dolomite. The dolomite is commonly euhedral, uniformly fine in size, and commonly more abundant at the borders of the large calcite crystals than within them.

R-4168, Bed 5a (bottom)

Texture: Poikilitic coarse mosaic

Mineralogy:	Finely crystalline dolomite	90.3%
	Coarsely crystalline dolomite	9.0%
	Insoluble residue	0.7%

Thin section description: The coarse dolomite crystals form an interlocking mosaic that is almost completely obscured by the very large number of poikilitically enclosed dolomite crystals. The fine dolomite crystals are predominantly euhedral to subhedral in habit. Only in instances where they mutually interfere do they lose this habit of straight boundaries.

R-4169, Bed 15b

Texture: Coarse, poikilitic mosaic

Mineralogy:	Finely crystalline dolomite	90.5%
	Coarsely crystalline dolomite	7.8%
	Insoluble residue	1.7%

Thin section description: The coarsely crystalline matrix forms a mosaic of interlocking crystals whose boundaries are difficult to discern because of the closely packed finely crystalline dolomite rhombohedra that are present everywhere in the rock but seem prevalent at the edges of the large crystals. The rhombohedral dolomite crystals are generally euhedral and diversely oriented. Some of them seem to be zoned, but they are so small that the zonation is not well resolved by the light microscope.

R-4170, Bed 6 (top)

Texture: Fine poikilitic mosaic

Mineralogy:	Microcrystalline dolomite	2.3%
	Finely crystalline dolomite	94.6%
	Medium crystalline dolomite	2.0%
	Insoluble residue	1.1%

Thin section description: The finely crystalline dolomite is present in this rock in sufficient amount to form an interlocking mosaic, poikilitically enclosing the microcrystalline dolomite. The finely crystalline material seems to have, at one time, had a predominantly euhedral habit but because of crystal growth and mutual interference between crystals of the same type, the crystals presently occurring in the rock are subhedral for the most part. The coarsely crystalline dolomite is completely anhedral and encloses both individual rhombohedra and aggregates of the finer crystals.

R-4171, Bed 6 (middle)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline dolomite	91.4%

Finely crystalline dolomite	6.4%
Insoluble residue	2.2%

Thin section description: Microcrystalline dolomite predominates as a mosaic of generally anhedral crystals. There are a few aggregates of finely crystalline dolomite present that are isolated from each other. Individual fine rhombohedra occur in a few instances. The rock is marked by voids that are not thought to represent artifacts due to thin section preparation but resemble solution cavities.

R-4172, Bed 6 (bottom)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline dolomite	68.3%
	Finely crystalline dolomite	29.6%
	Insoluble residue	2.1%

Thin section description: The microcrystalline matrix contains zones of finely crystalline dolomite that are gradational with the matrix. Some of these coarser zones in the rock are associated with solution cavities, and others contain isolated coarse crystals that appear as cavity fillings. The poikilitic enclosure of finer crystals is characteristic of all sizes of the dolomite in this rock.

R-4173, Bed 7

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline dolomite	90.1%
	Finely crystalline dolomite	6.2%
	Coarsely crystalline dolomite	1.2%
	Insoluble residue	2.5%

Thin section description: The microcrystalline dolomite contains isolated regions of fine and coarse dolomite that are gradational with the matrix and poikilitically enclose microcrystalline individuals and aggregates. Other coarsely crystalline particles fill solution cavities in elongate vein-like masses. In this mode of occurrence, the coarse carbonate fills the vein as single crystals extending all the way across the vein and for a distance of several millimeters along the vein. Microcrystalline pyrite occurs both as individual particles and as aggregates. This mineral is sparsely represented but present along the veins in sufficient quantity to be worthy of mention.

R-4174, Bed 8

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline dolomite	89.0%
	Finely crystalline dolomite	7.9%
	Insoluble residue	3.1%

Thin section description: The finely crystalline carbonate is present as a more or less continuous network of veins and aggregates that break up the microcrystalline mosaic so that aggregates of it appear as fragments on a breccia. The insoluble residue, which is quite high relative to most of the rocks of this quarry, is predominantly pyrite with subordinate quartz.

R-4175, Bed 9 (top)

Texture: Fine poikilitic mosaic

Mineralogy:	Microcrystalline dolomite	17.3%
	Finely crystalline dolomite	80.3%
	Insoluble residue	2.4%

Thin section description: The finely crystalline dolomite forms an anhedral mosaic sutured poikilitic crystal enclosing the microcrystalline dolomite. The boundaries of the larger dolomite crystals are difficult to study in detail because of the occurrence of the microcrystalline mineral across them.

R-4176, Bed 9 (middle)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline dolomite	85.8%
	Medium crystalline calcite	4.1%
	Medium crystalline dolomite	8.3%
	Insoluble residue	1.8%

Thin section description: The microcrystalline mosaic is interrupted by medium crystalline dolomite as isolated individuals and polycrystalline aggregates and by vein filling masses of medium crystalline calcite. Poikilitic enclosure of microcrystalline dolomite is ubiquitous. A few widely distributed opaque crystals occur in association with the coarser crystals. The insoluble residue is chiefly quartz with some pyrite.

R-4177, Bed 9 (bottom)

Mineralogy:	Microcrystalline dolomite	53.3%
	Finely crystalline dolomite	26.6%
	Medium crystalline dolomite	10.4%
	Coarsely crystalline dolomite	7.1%
	Insoluble residue	2.6%

Thin section description: The rock is composed of two primary zones. One is predominantly microcrystalline dolomite with finely crystallized dolomite occurring as a vein-like network that divides the microcrystalline matrix into regions like breccia fragments. The finely crystalline material poikilitically encloses the finer crystals of dolomite. Most of the opaque crystals noted in the rock occur in this portion as widely separated individuals. These are yellow in reflected light and appear to by pyrite. The second type os zone is composed of medium and coarse dolomite crystals. These crystal types form an interlocking mosaic of sutured crystals which is marked by poikilitic enclosure of finer dolomite crystals. The border between the two zones is not sharp, there is little evidence of solution along the contact. In all the rock, the crystals that occur completely surrounded by another are euhedral, except where, and to the extent that they interfere with other crystals similarily included within the same host.

R-4179, Bed 10 (middle)

Texture: Fine poikilitic mosaic

Mineralogy:	Microcrystalline dolomite	1.9%
	Finely crystalline dolomite	92.9%
	Coarsely crystalline dolomite	3.5%
	Insoluble residue	1.7%

Thin section description: The rock is very similar to R-4178. There is less coarsely crystalline carbonate and the whole rock has a finer textured appearance. The mosaic of coarser crystals poikilitically enclosing the micro and finely crystalline carbonate is finer and the crystals comprising it are more irregular in outline.

R-4180, Bed 10 (bottom)

Texture: Finely crystalline poikilitic mosaic

Mineralogy:	Microcrystalline dolomite	9.8%
	Finely crystalline dolomite	77.5%
	Coarsely crystalline dolomite	9.7%
	Insoluble residue	3.0%

Thin section description: The rock is a mosaic of euhedral and subhedral finely crystalline dolomite that poikilitically encloses the microcrystalline material. The coarsely crystalline dolomite occurs in isolated regions of the rock as irregular individuals that are poikilitic with respect to all finer sizes of dolomite. Some bands of predominantly microcrystalline dolomite occur but they are somewhat restricted in the rock.

Beau and Son's Newton Quarry, Black Hawk County, Iowa, NE, NE, 13, 87N, 13W

R-4181, Bed 17, (top)

Texture: Fine poikilitic mosaic

Mineralogy:	Microcrystalline calcite	12.9%
	Medium crystalline dolomite	83.4%
	Coarsely crystalline calcite	1.7%
	Insoluble residue	2.0%

Thin section description: Most of the rock is medium crystalline dolomite that encloses the microcrystalline calcite and is, in turn enclosed in poikilitic intergrowth with the coarsely crystallin calcite. The coarse calcite occurs as isolated polycrystalline masses. Rarely are these connected. There is a small amount of quartz present as fine, individual crystals. The rock has a very low void content that can be observed in thin section.

R-4182, Bed 18 (top)

Texture: Coarse poikilitic mosaic

Mineralogy:	Finely crystalline dolomite	67.5%
	Coarsely crystalline dolomite	29.2%
	Insoluble residue	3.3%

Thin section description: The coarsely crystalline dolomite forms an anhedral mosaic which contains the finely crystalline dolomite in poikilitic enclosure. The fine dolomite in turn is clouded with submicroscopic inclusions, some of which are perhaps calcite and some of which are opaque crystals. Some small amounts of quartz are present and they contain rhombohedra of fine dolomite.

R-4183, Bed 18 (middle)

Texture: Fine poikilitic mosaic

Mineralogy:	Microcrystalline dolomite	29.9%
	Finely crystalline dolomite	67.1%
	Coarsely crystalline dolomite	9.7%

Thin section description: The most prevalent phase, the finely crystalline dolomite occurs as a mosaic of subhedral crystals; these enclose the microcrystalline dolomite and are in turn enclosed by the coarser dolomite particles which are anhedral. There are solution cavities present, one of which is noticeably elongate, that have small amounts of quartz associated with them. Some crystal boundaries are stained brown, and in such areas, pyrite crystals of fine size are common.

R-4184, Bed 18 (bottom)

Texture: Fine crystalline mosaic

Mineralogy:	Microcrystalline dolomite	25.4%
	Finely crystalline dolomite	73.2%
	Insoluble residue	1.4%

Thin section description: The major constituent of the rock is the finely crystalline dolomite which sometimes contains inclusions of microcrystalline material. A few coarse crystals occur as isolated individuals, and there are quite large areas of microcrystalline dolomite that have gradational boundaries with other types of dolomite. Subhedral crystals of dolomite are common, but there is such dense packing of dolomite in this rock without any calcite or other accompanying mineral, that euhedral crystals are rare.

Schildberg's Atlantic Quarry, Cass County, NE, 34, 76N, 36W

R-4186, Bed 4c (top of bed, shot hole)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	68.5%
	Finely crystalline calcite	17.2%
	Medium crystalline calcite	4.8%
	Coarsely crystalline calcite	9.5%

Thin section description: The microcrystalline, fine and medium crystalline calcite occur in a mosaic that is almost randomly mixed between the three sizes. The coarsely crystalline calcite, large, irregular crystals that commonly display polysynthetic twinning, occurs as aggregates composed of several tens of crystals. These are not commonly connected. A few coarse crystals were observed to occur as individuals in the surrounding matrix of finer calcite. In all cases, the coarser carbonate is irregular in outline where it impinges on finer material. Fossil fragments are abundant, bryozoans, brachiopods, and gastropod ramains being among the more common types. Some of the fossil fragments have been sheared with attendant loss of structural detail in the sheared area. Other zones of similar appearance but affecting only the matrix appear in the rock. It is assumed that these indicate shearing also, but because no feature such as a fossil is affected, the point is controversial. Minor amounts of chert are present replacing parts of the fossils.

R-4187, Bed 4c (two feet east of R-4186 to avoid shot hole)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	94.0%
	Finely crystalline calcite	4.6%
	Medium crystalline calcite	0.7%
	Coarsely crystalline calcite	0.7%

Thin section description: The microcrystalline calcite forms a dense mosaic in which the other varieties occur randomly and widely spaced as individuals. There are a few aggregates of coarser crystals and some of the finely crystalline calcite forms veins and fills fossil fragments. The fossils observed are the same as those in R-4186. Microcrystalline pyrite occurs throughout the rock.

R-4188, Bed 4c (bottom)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	90.5%

Finely crystalline calcite	8.2%
Medium crystalline calcite	0.7%
Coarsely crystalline calcite	0.6%

Thin section description: The rock is identical in all aspects to R-4186 and R-4187 except that there are minor differences in the amounts of the several sizes of calcite crystals.

R-4189, Bed 4d (top)

Texture: Microcrystalline mosaic

Mineralogy:	Microcrystalline calcite	90.2%
	Finely crystalline calcite	5.0%
	Medium crystalline calcite	1.3%
	Coarsely crystalline calcite	3.5%

Thin section description: The microcrystalline calcite, the bulk of the rock, is present as a general matrix in which the larger species of carbonate occur both as individual cyrstals and as small aggregates composed of several tens of crystals. Commonly the aggregates are disconnected from each other, and though they are generally elongate, they are not aligned in any preferred direction. Brachiopod and bryozoan fragments are common and there is one unknown feature that may be organic in nature. This is a rounded aggregate of radial calcite crystals, containing a ring of microcrystalline calcite. Commonly there is a region of radial calcite outside the ring. The crystals enclosed by the ring are not acicular, but their crystallographic c axes are radially arranged, giving rise to a permanent cross of extinction as the stage is rotated between crossed polarizers. Sometimes these features occur in association with elongate features of the same kind but having a common wall along a part of the brown microcrystalline ring. In some instances, these features are partly replaced by quartz.

R-4190, Bed 4d (middle)

Texture: Microcrystalline mosaic, in part brecciated

Mineralogy:	Microcrystalline calcite	75.0%
	Finely crystalline calcite	15.6%
	Medium crystalline calcite	4.2%
	Coarsely crystalline calcite	5.2%

Thin section description: Irregular zones of larger crystals occur randomly spaced throughout the microcrystalline mosaic. Sometimes the larger crystals occur individually and are of irregular outline, and display deformation twinning. Fossil fragments are abundant, as are voids of various shapes that are interpreted as solution cavities. Some of the fossil fragments have been replaced in part by chert.

R-4191, Bed 4d (bottom)

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	84.8%
	Finely crystalline calcite	12.9%

Medium crystalline calcite	1.7%
Coarsely crystalline calcite	0.6%

Thin section description: The fine to coarse calcite occurs in a more or less interconnected network that divides the microcrystalline mosaic into breccia-like fragments. The fragments, though rounded are far from spherical, and are indeed quite irregular in shape. The fine, medium and coarse crystals form mosaics between themselves and are present as elongate regions. The crystals are subsequent to equant, elongate crystals are rare along the vein-like network. Microcrystalline pyrite is uniformly distributed over the rock but is present in very slight amount. Chert occurs as a very minor constituent of the rock where it has replaced single coarse crystals in part.

R-4192, Bed 4e (top)

Texture: Microcrystalline breccia

Mineralogy:	Microcrystalline calcite	84.8%
	Finely crystalline calcite	12.2%
	Medium crystalline calcite	2.3%
	Coarsely crystalline calcite	0.9%

Thin section description: The rock is similar to R-4191. The chief differences are in the amount of quartz replacing fossils and that the fossils are more abundant in this specimen.