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OLIVINE BENEFICIATION
RML Project No. 14

Minerals Research Laboratory April 1970 Progress Report

by

Robert M. Lewis

Abstract

The usefulness of olivine as a foundry sand is reduced when the sands are contaminated with minerals containing water of crystallization, such as serpentine, talc and others. Analyses for loss on ignition are used to determine the extent of these contaminants. Various methods of removing contaminants were investigated to develop processing data for the olivine industry.

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Introduction

Olivine is a natural mineral consisting of a solid solution of magnesium orthosilicate (forsterite) and iron orthosilicate (fayalite). Olivine possesses several characteristics which make it ideal as a foundry sand. One of the outstanding features is its hygienic value. Medical research has indicated that olivine dust will not cause silicosis or any similar condition. Other desirable characteristics include high fusion point, low uniform thermal expansion, and the ability to resist fracture from thermal shock.

There is one full-time producer of olivine in the State and several minor producers which operate intermittently. There are a number of dunite deposits throughout western North Carolina with sufficient reserves to qualify as minable properties. Olivine has established itself in industry as a good material for foundry sand. It is contemplated that these deposits will be tapped in the future as the market expands and new uses are found for olivine products.

Objective

The object of this project was to investigate and develop procedures which could be employed to produce a high grade olivine product. The primary consideration was the removal of minerals containing water of crystallization, such as serpentine and talc. The foundry industry requires a sand containing less than 1.0 percent loss on ignition.

Procedure

Description of Ore - The ore came from the Frank deposit located in Mitchell County and consisted of 64.0 percent olivine, 29.0 percent serpentine, and 7.0 percent talc as determined by microscopic analysis. A representative sample of the ore, obtained by riffling, assayed 3.98 percent loss on ignition. Two representative samples were separated into sinks and floats by heavy liquid (sp. gr. 2.95). The first sample was treated as received. In the second sample, the minus 200 mesh slime was removed and heavy liquid separation performed on the plus 200 mesh material. The data derived from these tests (see Table B) were useful in substantiating the mineral distribution. The calculated loss on ignition, based on mineral distribution determined from microscopic analysis, compared favorably with the loss on ignition determined by assay.

Sample Preparation - The ore was given a size reduction by jaw crushing followed by rolls crushing at 3/8" roll spacing. Subsequent treatment of feed is described on the attached test data sheets.

Special feed preparation was used for the reagent series. The ore was ground in a 12" x 24" rod mill for five minutes at 40 percent solids using 5,670 grams of feed and eight rods. The mill discharge was screened on 35 mesh and deslimed on 100 mesh. The plus 35 mesh was given an additional grind until all material was minus 35 mesh. The minus 35 plus 100 mesh material was divided into 500 gram samples. Each sample was scrubbed for ten minutes in a Wemco scrubber at 75 percent solids including 4.0 pounds per ton of NaOH. The sample was allowed to settle for one minute in a full bucket of water and then deslimed on 100 mesh. The samples thus prepared constituted 79.8 percent of the original feed and assayed 2.52 percent loss on ignition. Considerable care was taken in the preparation of these samples so that comparison of flotation results using various reagents would be governed by the reagents used and flotation techniques employed and would not be influenced by the preparation phase.

Testing General - Several series of tests were conducted involving processing without scrubbing, scrubbing, grinding, acid treatment, tabling and flotation.

Process Control - Quality and recovery of products are based on percent loss on ignition. The theoretical percent loss on ignition for the primary minerals are zero percent for olivine, 12.8 percent for serpentine, and 4.8 percent for talc.

Several graphs were developed to assist in the evaluation of ore bodies and products (Figures B, C, D). Figure B is a graph from which loss on ignition analyses can be projected to arrive at the percent olivine present in the ore. The curves take into account the analyses and distribution of gangue minerals. Figure C is a graph for estimating loss on ignition by use of specific gravity. Figure D is a graph for determining the approximate percent olivine present in a sample by using a rapid specific gravity determination.[1]

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[1] Pycnometer Project, April 1969 Progress Report
Minerals Research Laboratory
Asheville, North Carolina

Results

The tests are summarized in Table A for quick reference and are also attached in Tables 1-6 for more detailed information. A beneficiation graph (Figure A) shows the relative merits of the tests.

The heavy liquid separation and ignition loss analysis data (see Table B) show 54.7 percent of the head feed assaying 1.14 percent loss on ignition, with an additional 15.5 percent assaying 2.71 percent loss on ignition.

Flotation without scrubbing (Tests 1, 2 and 3 - Table 1) results in good recovery but poor grade. The grade can be improved by scrubbing the concentrate followed by flotation as shown in Tests 3 and 4 - Table 1.

The use of caustic in the grind was found to be beneficial as shown by the increased recovery in Test 4, Table 1. The series of tests using a high solids (65 percent) grind showed a definite improvement in grade, while maintaining recovery (see Tests 4, 5 and 6, Tables 1 and 2). A further improvement in grade can be made by following the high solids grind and flotation procedure with high density scrubbing, or acid scrubbing the concentrate at high density and re-floating (Tests 8, 9, 10, and 11 - Tables 2 and 3). Acid scrubbing before flotation is also a method for improving the grade (see Test 12, Table 3).

Tests 13, 15, 19, 22, 23, 25 (see Tables 4, 5), in the reagent series, are the best tests (over 40 percent yield and less than 1.0 percent loss on ignition) of a total of nineteen tests. This series was run to study the effects of sulfonated oil, amine, and fatty acid collectors under a standard set of conditions. The fatty acid did not perform as well as the other two reagents. The results are inconclusive as to which of the two reagents, sulfonated oil or amine, is most effective. The anionic system has the advantage of floating the smaller amount of material as gangue. The amine system has an advantage of floating in a neutral pH.

The ore responded very well to table separation. The ore that had not been scrubbed before tabling gave a higher recovery and ignition loss than the ore that was scrubbed before tabling. This probably reflects more on the operation of the table than on the preparation of the feed. Flotation of the concentrate from these tests resulted in low ignition loss products (see Tests 28, 29 - Table 6). An additional gravity test (see Test 30 - Table 6) was performed in which a rougher concentrate was made on a shaking table, and the table tails were returned to the rod mill for additional grinding and desliming, and were then treated again on the table in a scavenger separation. The concentrates were cleaned with two stages. The results show a good recovery and grade.

The acid scrub test (Test 31 - Table 7) compares the ignition losses of products which were leached with various strengths of acid. Ten percent acid was found to be the ideal strength for acid scrubbing from the standpoint of effectiveness and economy.

Conclusions

There are a variety of ways by which olivine can be concentrated and refined. Some of these methods may be more readily adaptable than others to certain ore bodies. A simple gravity-type process may be sufficient for products requiring percent loss on ignition in the range of 0.5-1.0 percent. A more elaborate flowsheet can be used if a 0.1-0.5 percent loss on ignition product is desirable. High solids scrubbing is beneficial for removing serpentinized surface coatings.

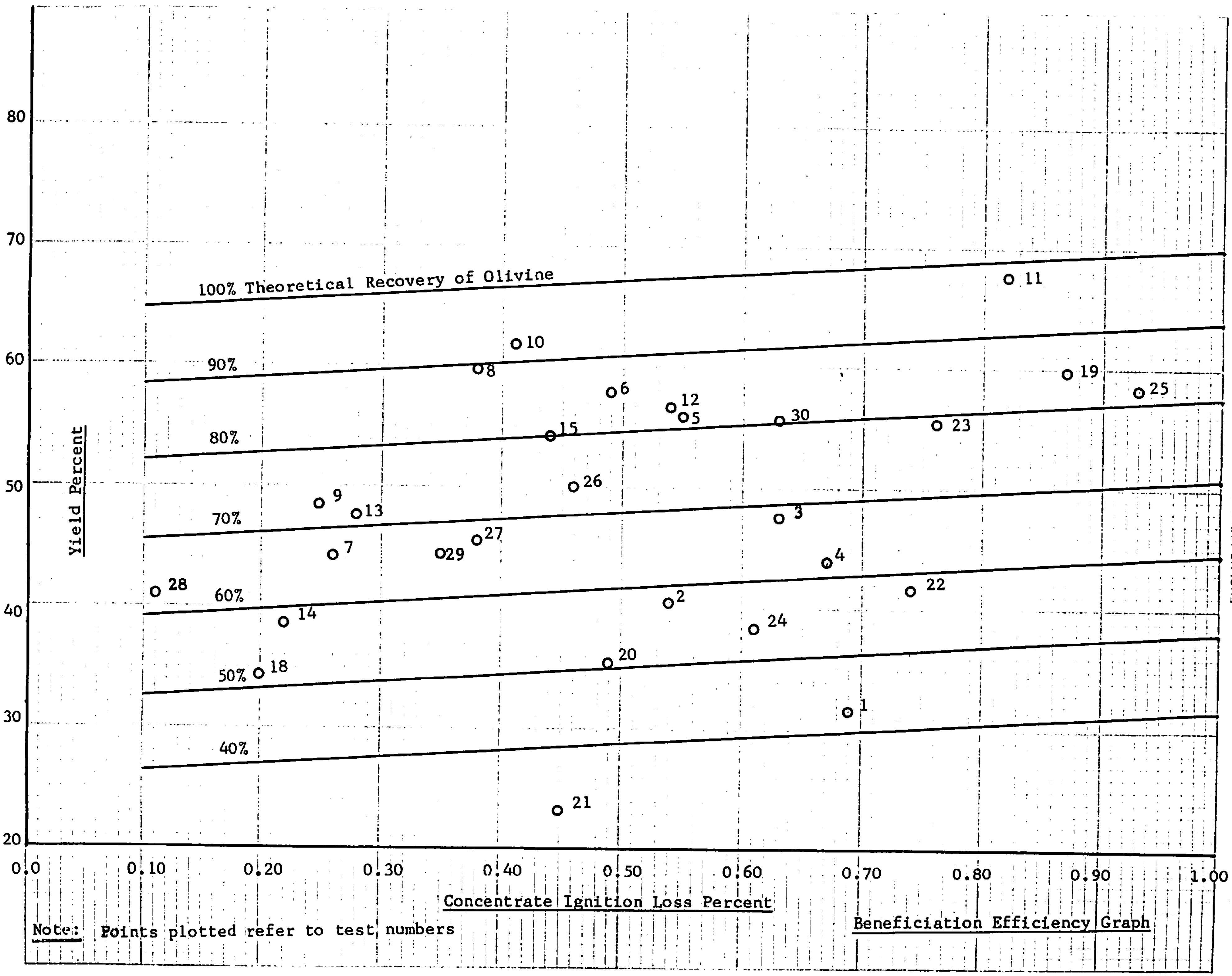

Figure A

Beneficiation Efficiency Graph

Note: Points plotted refer to test numbers

Table A

Summary

Test No.	Test Series	Stage	Ign. Loss	% Yield*	% Rec.**
1	No scrubbing before flotation	Cleaner	0.69	31.6	42.5
2	" " " "	"	0.54	40.4	58.5
3	" " " "	"	0.63	47.7	69.0
4	" " " "	"	0.67	44.0	62.0
5	High solids grind	Cleaner	0.55	55.9	82.0
6	" " "	"	0.49	57.8	85.5
7	" " "	"	0.26	44.2	67.0
8	" " "	"	0.38	59.9	89.8
9	Acid scrub	Cleaner	0.25	48.4	73.5
10	" "	"	0.41	61.7	93.0
11	" "	"	0.82	67.5	98.0
12	" "	"	0.54	56.6	83.5
13	Anionic flotation	Cleaner	0.28	47.6	72.0
14	" "	"	0.22	38.9	58.5
15	" "	"	0.44	54.1	80.0
16	" "	"	0.20	12.5	-
17	" "	"	0.24	16.8	-
18	" "	"	0.20	34.3	51.5
19	Cationic flotation	Cleaner	0.87	59.9	85.0
20	" "	"	0.49	35.5	50.5
21	" "	"	0.45	23.2	32.0
22	" "	"	0.74	41.4	58.5
23	" "	"	0.76	55.3	79.5
24	" "	"	0.61	38.3	54.0
25	" "	"	0.93	58.1	82.0
26	Tabling	Conc.	0.46	50.0	74.0
27	"	"	0.38	45.5	68.0
28	"	"	0.11	41.0	63.0
29	"	"	0.35	44.5	66.0
30	"	"	0.63	55.6	80.5

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* % Yield = % weight of head feed recovered as product.

** % Recovery = % of olivine recovered in product determined from Figure A.

Table B

Heavy Liquid Separation of Head Feed Samples

Sample		% Wt.	Ign.Loss
(1) -14 Mesh as rec'd.	Sinks	54.7	1.14
	Mids	15.5	2.71
	Floats	29.8	11.80
	Total	100.0	4.56
(2) Deslimed +200 Mesh	Sinks	67.4	1.23
	Mids	4.3	3.71
	Floats	28.3	8.65
	Total	100.0	3.44
(3) As Rec'd.	+200	92.6	3.00
	-200	7.4	10.30
	Total	100.0	4.14
(4) Head Feed Analysis			3.98

Heavy Liquid = 2.95 specific gravity

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(1) As received sample was roll crushed to minus 14 mesh.

(2) Deslimed sample was deslimed two times on 200 mesh with one-minute settling in full bucket.

(3) Sample as received was deslimed on 200 mesh and both screen fractions assayed.

(4) Sample as received was assayed.

Table 1

No Scrubbing Before Flotation

Process - Rod mill (caustic variable), deslime, amine float, scrub conc. (variable), amine float (variable).

Test No.	Main Variable	Stage	Ign. Loss	% Yield	% Rec.
1	No caustic in rod mill,	Ro.	1.47	66.6	100.0
	one cleaner stage	Clean.	0.69	31.6	42.5
2	No caustic in rod mill,	1st Cl.	0.81	50.6	70.5
	two cleaner stages	2nd Cl.	0.54	40.4	58.5
3	No caustic in rod mill,				
	one cleaner stage,	1st Cl.	0.84	49.4	69.5
	scrub conc., deslime,	Scr.Conc.	0.66	48.5	70.0
	amine float	2nd Cl.	0.63	47.7	69.0
4	Caustic in rod mill,				
	one cleaner stage,	1st Cl.	1.18	58.8	-
	scrub conc., deslime,	Scr.Conc.	0.89	56.6	80.0
	amine float	2nd Cl.	0.67	44.0	62.0

Table 2

High Solids (65-70 Percent) Grind

Process - Rod mill, deslime, scrub (variable), amine float, scrub conc. (variable), deslime, amine float.

Test No.	Main Variable	Stage	Ign. Loss	% Yield	% Rec.
5	Scrub flotation feed,	Ro.	0.80	59.0	84.0
	one cleaner stage	Clean.	0.55	55.9	82.0
6	No scrub before flotation,	1st Cl.	0.86	60.7	86.0
	two cleaner stages,	2nd Cl.	0.61	58.2	86.0
	scrub conc., deslime	Scr.Conc.	0.49	57.8	85.5
7	No scrub before flotation,	Ro.	1.88	71.9	100.0
	two cleaner stages,	1st Cl.	1.33	56.6	-
	scrub conc., deslime,	Scr.Conc.	0.39	51.7	77.0
	amine float	2nd Cl.	0.26	44.2	67.0
8	Scrub flotation feed,	Ro.	2.18	73.8	-
	two cleaner stages,	1st Cl.	1.08	65.1	-
	scrub conc. and deslime	2nd Cl.	0.58	60.3	90.0
		Scr.Conc.	0.38	59.9	89.8

Table 3

Process - Rod mill, deslime, acid scrub, flotation.

Test No.	Main Variable	Stage	Ign. Loss	% Yield	% Rec.
9	Scrub, deslime,	Ro.	2.24	63.8	-
	one cleaner stage,	Clean.	0.61	56.2	81.0
	acid scrub, deslime	Scr.Conc.	0.25	48.4	73.5
10	Scrub, deslime,	Ro.	1.26	70.1	-
	two cleaner stages,	1st Cl.	0.93	67.3	97.0
	acid scrub, deslime,	Scr.Conc.	0.44	62.6	94.0
	cleaner float	2nd Cl.	0.41	61.7	93.0
11	Scrub, deslime,	Ro.	1.36	71.2	-
	one cleaner stage,	1st Cl.	1.11	69.0	-
	scrub conc., deslime	Scr.Conc.	0.82	67.5	98.0
12	Acid scrub, deslime,	Ro.	1.19	68.1	-
	one cleaner,	1st Cl.	0.75	57.7	84.0
	scrub conc. and deslime	Scr.Conc.	0.54	56.6	83.5

Table 4

Anionic Flotation*

Process - Reagent used: H_2SO_4, M-70 (petroleum sulfonate), fuel oil, pine oil.

Test No.	Main Variable	Stage	Ign. Loss	% Yield	% Rec.
13	NaOH used instead of H_2SO_4	Clean.	0.28	47.6	72.0
14	Standard test	Clean.	0.22	38.9	58.5
15	Reduced M-70	Clean.	0.44	54.1	80.0
16	Reduced M-70	Clean.	0.20	12.5	-
17	Increased M-70	Clean.	0.24	16.8	-
18	Reduced M-70	Clean.	0.20	34.3	51.5

*Procedure developed by Philip Neal, Minerals Research Laboratory.

Table 5

Cationic Flotation (Amine)

Process - Reagents used: Alamac 11-C (amine collector), MIBC (frother).

Test No.	Main Variable	Stage	Ign. Loss	% Yield	% Rec.
19	Standard	Clean.	0.87	59.9	85.0
20	Reduced amine	Clean.	0.49	35.5	50.5
21	Increased amine	Clean.	0.45	23.2	32.0
22	Standard	Clean.	0.74	41.4	58.5
23	Increased amine	Clean.	0.76	55.3	79.5
24	Standard	Clean.	0.61	38.3	54.0
25	Increased amine	Clean.	0.93	58.1	82.0

Table 6

Tabling

Process - Tabling and flotation

Test No.	Main Variable	Stage	Ign. Loss	% Yield	% Rec.
26	Rod mill, deslime, table	Conc.	0.46	50.0	74.0
27	Rod mill, deslime, scrub, deslime, table	Conc.	0.38	45.5	68.0
28	Scrub table conc. from test 26, deslime, amine float, cleaner float	Ro. Clean.	0.17 0.11	46.4 41.0	71.0 63.0
29	Scrub table conc. from test 27, deslime, amine float	Ro.	0.35	44.5	66.0
30	Table separation and scavenger table separation of tails	Ro. Scav. Combined	0.41 1.09 0.63	38.0 17.6 55.6	55.5 - 80.5

Table 7

Acid Scrub Tests (70 Mesh Olivine)

Product	% Wt.	H_2SO_4 %	H_2SO_4 lb/ton	Ign. Loss
Conc.	95.8	40	266	0.27
Slimes	4.2			
Total	100.0			
Conc.	95.5	20	133	0.26
Slimes	4.5			
Total	100.0			
Conc.	96.3	10	66.5	0.28
Slimes	3.7			
Total	100.0			
Conc.	96.8	5	33.2	0.33
Slimes	3.2			
Total	100.0			
Conc.	98.0	0	0	0.54
Slimes	2.0			
Total	100.0			
Head Feed				0.62

Remarks:

400 gram samples

Acid scrubbed (Wemco scrubber) 75% solids, 10 min., 1600 rpm

Deslime 2 X at 200 mesh, one-minute settling

The feed material for this test was obtained from a concentrate produced in a spiral pilot plant. The pilot plant recovered 70.8% of the head feed as a product which assayed 0.91% loss on ignition. The #70 product represented 68.8% of the spiral concentrate.

Figure B

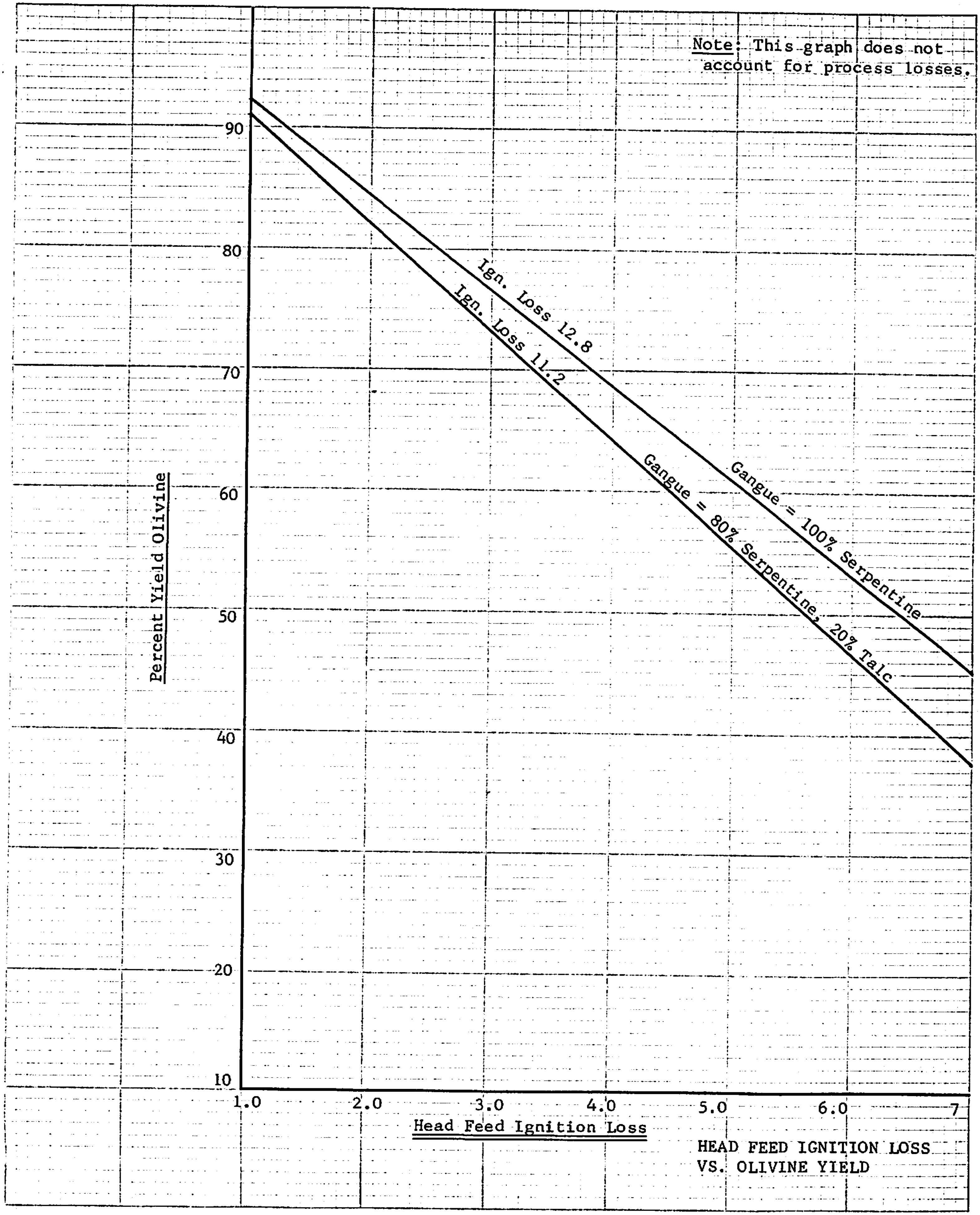

Note: This graph does not account for process losses.
Percent Yield Olivine
90
80
70
60
50
40
30
20
10
1.0
2.0
3.0
4.0
5.0
6.0
7
Head Feed Ignition Loss
Ign. Loss 12.8
Ign. Loss 11.2
Gangue = 100% Serpentine
Gangue = 80% Serpentine, 20% Talc
HEAD FEED IGNITION LOSS
VS. OLIVINE YIELD

Figure C

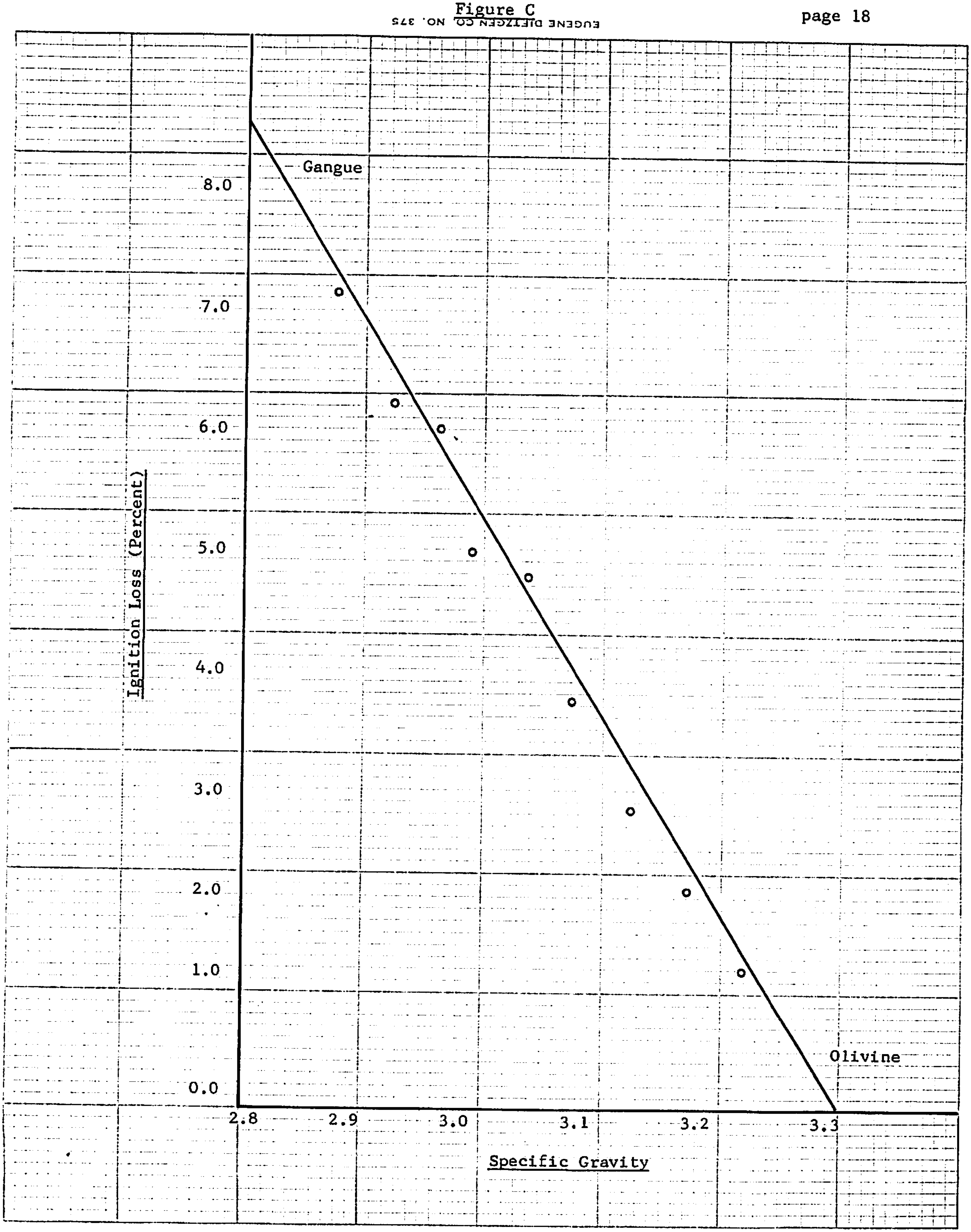
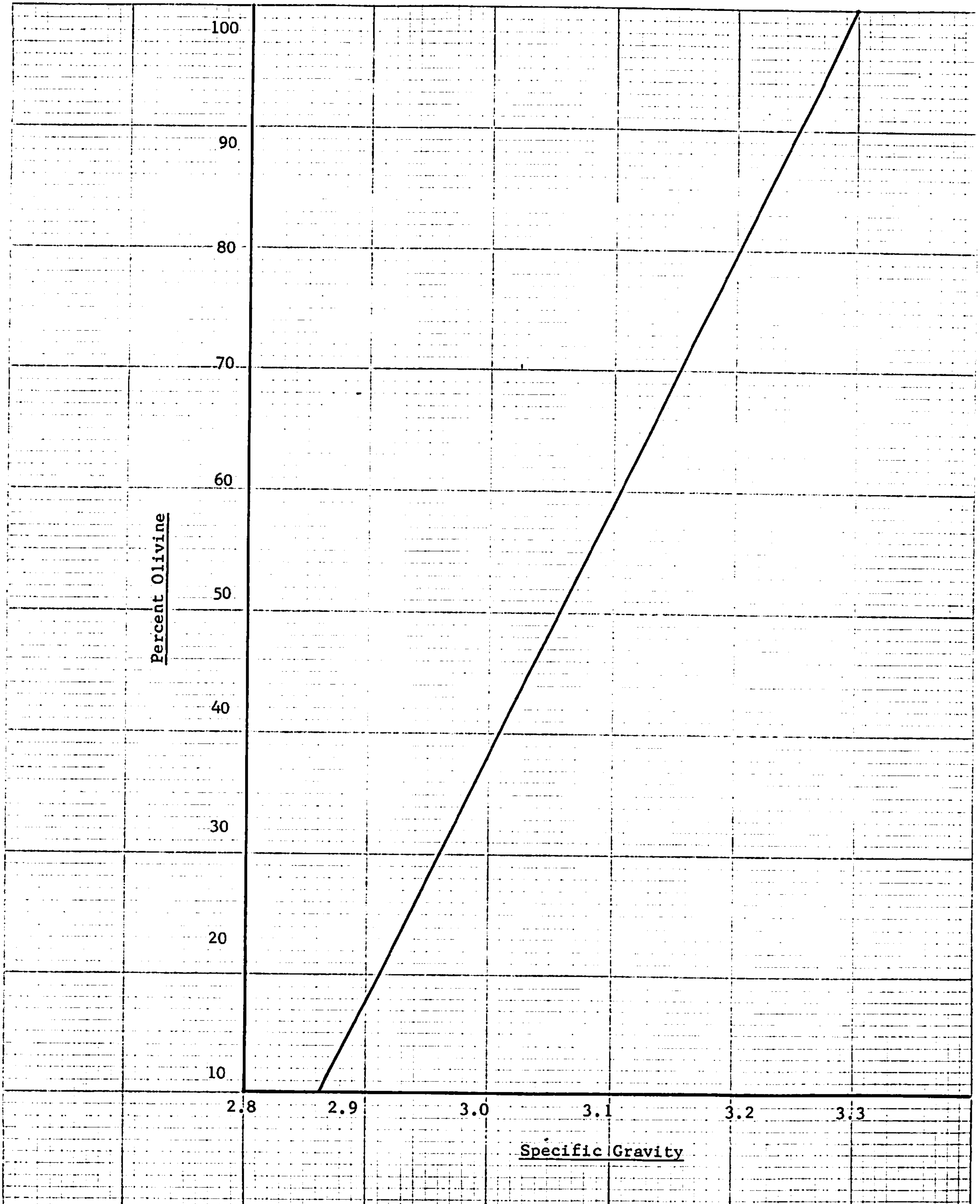

EUGENE DIETZGEN CO. NO. 375
Gangue
Olivine
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Ignition Loss (Percent)
2.8
2.9
3.0
3.1
3.2
3.3
Specific Gravity

Figure D


100
90
80
70
60
50
40
30
20
10
Percent Olivine
2.8
2.9
3.0
3.1
3.2
3.3
Specific Gravity