CONTINUATION OF RESEARCH ON MILLING, SCRUBBING AND SULFONATE FLOTATION OF OLIVINE

December 1968 Progress Report

Lab Nos. 3258, 3274, 3283, & 3289 - Book 227

by

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Background and Scope

This block of research and evaluation is a continuation of the work described in Report D of the April 1968 Progress Report. Its principal emphasis was on a more representative sample from Frank (No. 3258), replacing a smaller one collected earlier (No. 3249, April 1968 Progress Report). However, ore samples from other locations were also tested to determine their general response to beneficiation procedures found effective on No. 3258. Those samples were:

Lab. No.	General Location
3274	Daybook, Yancey County
3283	Balsam Gap, Jackson County
3289	Dark Ridge, Jackson County
3290	Addie, Jackson County

Lab No. 3258 - Collection

In February, 1968, J. P. Neal and R. M. Lewis from the Minerals Research Laboratory, together with Messrs. J. E. Bundy and A. C. Carpenter of the Division of Mineral Resources, met at the Frank olivine deposit with Messrs. C. P. Rogers Jr. and P. C. Coletta of the Feldspar Corporation and gathered 1180 pounds of olivine ore by continuous sampling of the rock pile along the full extent of the 200-foot face. This was judged by all persons mentioned above to be as representative as possible of the mine run of this deposit, as presently exposed.

Lab No. 3258 - Primary Dry Reduction and Splitting

The entire sample was jaw-crushed and then passed through a rolls crusher set at a ¼-inch gap. Table 1 gives the screen analysis of an aliquot of the sample thus prepared, plus pertinent ignition loss figures. Table 1,and all other tables, will be found at the end of this report, beginning page 14.

Lab No. 3258 - Wet Rod-Milling and Desliming

After some discussion among the staff of Minerals Research Laboratory, a standard procedure for wet rod-milling and desliming was established, involving use of a small batch rod mill with shell and rods made of stainless steel. Full description of the procedure can be read in Lab Notebook No. 227, Test No. 3258-30N; also in the Minerals Research Laboratory files, N. C. III section, under Olivine Beneficiation. Briefly, the procedure calls for a two-minute grind at 40 percent solids, plus two agitation-desliming cycles in a ten-quart bucket. Each desliming step includes a one-minute settling, followed by a ten-second pour-off across a 200 mesh screen, the plus 200 then being returned to the settled solids. In most tests following, variations of this procedure were employed which achieved equal or better end results, but several reference tests, using this standard procedure, served to indicate that all tests following were within essentially the same parameters, and could be related to tests starting with this standard milling-desliming procedure.

To save effort in preparation of No. 3258 for scrubbing and flotation, a milling-desliming procedure using a larger rod-mill was worked out, wherein a 5670-gram (12.5 lb) batch of head sample was milled at 40 percent solids, with the oversize (plus 35 mesh) then milled in a small rod mill and combined with the other milled feed. This gave more assurance of uniform feed for a series of scrubbing and flotation tests. It was found that use of this large mill resulted in slightly coarser milled product, as well as slightly higher recovery of plus 200 mesh material. Desliming of this large batch was carried out in a large pot permitting about the same degree of dilution as in the case of the small batch. Details of this large scale procedure are entered in Lab Notebook No. 277, Test No. 3258-76N.

Table 2 shows results of the standard milling-desliming procedure compared to results employing the large batch rod-mill on 5670 grams, followed by desliming in the large pot.

From the figures of Table 2, then, it can be seen that the use of a large batch grind, in the manner described, is slightly advantageous so far as grade, average mesh size, and recovery are concerned.

Several tests were also run involving a quicker, and thus coarser, deslime. In Test No. 3258-4N, a 500-gram batch was given a standard grind in a small mill, but then was deslimed once as follows: After dilution and agitation, a five-second settling time was allowed, followed by a ten-second pour-off across 100 mesh, with the plus 100 mesh returned to the settled solids. On a large scale, a 5670-gram sample was milled as Test No. 3258-76N (Table 2), but then was given a quick deslime across 100 mesh. Table 3 indicates results from these two tests, with standard Test No. 30N, from Table 2, again included for comparison.

From Table 3, it can be seen that a slightly larger percentage of deslimed material remains in Test No. 30N than in Tests No. 4N and No. 16N. However, the amount of olivine present, as opposed to serpentine, does not vary as much. Assuming zero ignition loss for olivine, and an empirical figure of 13 percent for the ignition loss of this serpentine, it can be calculated that pure olivine present in the scrub feed is close to 65 percent of original head feed weight in Test No. 30N, 64 percent in Test No. 4N, & 63 percent in Test No. 16N. Thus, so far as loss of values is concerned, the three tests do not differ greatly. In addition, the average mesh size of the scrub feed is considerably coarser in Tests No. 4N and 16N, with the screen fractions at the same time showing lower ignition loss. These findings further indicate the advantages of using the larger rod mill and of performing a coarser deslime.

With the exception of Test No. 76N (Table 2), the test batches cited up to this point were screened, after milling and desliming, on 20 mesh. It can be observed in Tables 2 and 3 that the coarser screen fractions of the scrub feed have a high ignition loss, which diminishes in the intermediate sizes. In an effort to better this situation, a 5670-gram sample was milled for a slightly longer time, and screened on 35 mesh. Desliming was the same as in Test No. 16N (Table 3). Table 4 indicates the results of this milling test (No. 3258-47N). Test No. 16N is again tabulated for comparison.

Using the same method of calculation as previously, the amount of olivine present in the scrub feed is 65.3 percent of head feed weight for Test No. 3258-47N. The data thus shows that finer grinding caused little or no additional loss of values. The screen analysis of the scrub feed from Test No. 47N is slightly finer than that from 16N, but still considerably coarser than from the standard milling test (No. 3258-30N, Table 2). Further, it is rendered more amenable to removal of more serpentine by scrubbing, as shown by data following. The milling and desliming technique employed in Test No. 3258-47N (Table 4) is the one employed in the most successful scrubbing and flotation tests on Sample No. 3258.

Lab No. 3258 - Scrubbing and Desliming

The standard scrub procedure is as follows: A 500-gram dried sample of milled and deslimed scrub feed was scrubbed at 75 percent solids with four pounds per ton of N_aOH for 10 minues, using a Wemco-type assembly consisting of an octagonal, 500-gram pot and a three-tiered impeller set, running at 1750 RPM. Following scrubbing, the usual deslime in the tests of this report consisted of dilution with agitation to about seven percent solids, followed by decanting through a funnel with an 11/32 inch i.d. stem, within 5 seconds, across 100 mesh; the plus 100 mesh being returned to the settled solids. This was performed twice. Suspended minus 100 mesh fines from both decants were combined and flocculated for evaluation.

The scrubbing technique just described was applied to deslimed scrub feeds from several large-batch milling tests cited in Tables 2, 3 and 4. Products from these scrubbing tests are described in Table 5.

Results shown in Table 5 can be summarized as follows: Preceding a standard scrub-deslime, a finer grind-deslime results in slightly higher theoretical olivine recovery, but also results in more residual serpentine in the scrubbed product. Comparing the second and third tests of Table 5, it can be seen that use of a slightly longer grind with finer screening still causes no greater values loss after scrubbing than when a batch is milled for a shorter time and screened on coarser mesh. To review, scrub Test No. 17N was run on minus 20 mesh, coarsely deslimed feed, while Test No. 47B-N was milled 25 percent longer and screened on 35 mesh. The longer milling and finer screening created a slightly finer scrub feed, but eliminated the small plus 35 mesh fraction having an ignition loss above 3 percent (Test No. 17N). This plus 35 mesh fraction apparently was distributed down throughout all screen fractions when finer grinding was carried out (Test No. 47B-N).

Lab No. 3258 - Comparative Flotations

Previous research indicated that a good serpentine flotation could be accomplished with a combination of H_2SO_4, petroleum sulfonate, fuel oil & pine oil (April 1968 Progress Report, Report D, p. 6 and 7). Based on this previous experience, the following conditioning and flotation procedure was carried out on the tests about to be cited (Table No. 6).

After the scrub and deslime procedure mentioned in the section preceding, the remaining sample was conditioned at 65 percent solids for three minutes, with reagent levels based on 500 grams of scrub feed. The conditioning pulp density was controlled on the basis of prior knowledge of solids loss from scrubbing and desliming.

Standard reagent schedule was as follows:

H_2SO_4 - 3 lbs/T
M-70 petroleum sulfonate - varied
No. 2 fuel oil - 2 lbs/T
Pine oil - 0.2 lb/T

Conditioning was performed in a 1000 cc glass beaker, using a four-bladed impeller running at 700rpm. Liquid from the conditioned pulp had a pH within one point of 3.3. Cell water, following flotation, had a pH of 4.0. Flotation was carried out in a Denver D-1 Lab flotation machine with a 1000-gram glass cell and with the impeller operating at 1200 rpm.

Lab No. 3258 - Evaluation of Flotation Tests

About seventy flotation tests were run on No. 3258, many varying in one way or another from the procedure just described. Forty-nine of these are outlined in Table No. 6. To evaluate them further, a graph was laid out with co-ordinates of weight recovery, based on head feed, and grade (ignition loss). When all tests had been located as points on this, certain points (tests) stood nearer the edges of the field, indicating that, for that particular concentrate weight, the grade produced was of higher quality. It was possible to plot a curve relative to these peripheral points, and to continue that curve by including points taken from tests involving simply milling, scrubbing and desliming, or milling and desliming only - terminating curve at zero processing and 100 percent recovery at 3.97 percent ignition loss.

It is not claimed that such a plotted curve represents maximum possible up-grading or efficiency. It does serve as an index of beneficiation efficiency to date on Lab No. 3258. The curve can be changed when a test point is plotted at a significant distance outside the existing curve to prove higher attainable efficiency.

This curve, showing some of the points that represent more successful beneficiation efforts, is shown in Figure 1, page 13. Also on the graph of Figure 1 is a straight broken line indicating the theoretical maximum weight recovery of various grades of concentrate ranging from 4.0 percent to 0.0 percent ignition loss, assuming 13.0 percent average ignition loss for all hydrated minerals in the head sample.

Conclusions regarding the data set forth on Table No. 6 are stated further on, following conclusions regarding Tables No. 7 and 8, since it is desired to discuss flotation results last.

Lab No. 3258 - Additional Test Data, and Comments

Grinding and Desliming Variables - The standard grinding and desliming procedure referred to earlier (Test No. 3258-30N, in the "Wet Rod-Milling and Desliming" section) yielded results which were good enough for use as a research base. However, variations from this procedure yielded slight improvements which are observable in terms of screen analysis as already mentioned, and also in terms of greater recovery efficiency. The curve (Figure 1) derived from recovery vs. grade of various test concentrates can be used in evaluating tests in this manner: Taking the point location of the beneficiated product of any test, on the graph of Figure 1, the percent recovery of that test is set down as a ratio against the percent recovery shown by the reading of the empirical curve at that grade. For example: Test No. 55N, with 67.3 percent weight recovery at 1.2 percent ignition loss, is compared to the curve, which shows an ideal of close to 70 percent recovery at that grade. Dividing 67.3 by 70 , a recovery efficiency figure of 96.2 percent is derived. Table No. 7 makes comparison of various grinding-desliming techniques on the above basis.

Conclusions from Grinding - Desliming Data, Tables No. 2, 3, 4, and 7 - Based on the grinding and desliming tests on Lab No. 3258, as shown in Tables 2, 3, 4, and 7, the following conclusions can be drawn:

1. A desliming operation performed after removal of most of the coarser solids may be more efficient (Table No. 7, Test No. 1N vs. Test No. 30N), although practicability is questionable for a large-scale operation.

2. The apparatus and procedure used to grind and deslime large batches (5670 grams) of this sample as compared to grinding 500 grams, is of about equal efficiency in saving values (Table 7), and in addition yields a beneficiated product of coarser average mesh size (Test No. 4N vs. No. 16N, Tables 3 and 4). The mesh differences in the product from the large versus the small batch may be caused by the fact that the rods in the large rod-mill (Test No. 16N) cascade very little, whereas in the case of the small mill (Test No. 4N) the rods cascade very actively.

3. Grinding to minus 35 mesh instead of minus 20 mesh does not cause loss of more olivine (Test No. 16N vs. No. 47N, Table 7). It can also be seen from the data in Tables 3 and 4 on these two tests that the finer grind did not reduce substantially the average mesh size of the milled product. Further, the plus 35 mesh fraction of the milled product in Test No. 16N, which has an ignition loss about equal to that of head feed, is eliminated by milling to minus 35 mesh, thus allowing for improved beneficiation in steps following.

4. Desliming on a finer mesh (200) after a brief settling time retains slightly more olivine than a quick deslime on 100 mesh (Test No. 47N vs. Test No. 76N, Table 7); however, it will be seen from data on subsequent tests (scrubbing & flotation) that the yield of final concentrate, for any given grade, is not increased.

Scrubbing and Desliming Variables - Several different scrub-deslime techniques were used. Table 8 provides pertinent data.

Conclusions from Scrubbing - Desliming Data, Tables 5 and 8 - Based on the scrubbing and desliming tests on Lab No. 3258, as shown on Tables 5 and 8, the following conclusions can be drawn:

1. Use of acid in scrubbing does not improve the scrubbed product as compared with use of caustic (Test No. 17N vs. No. 18N, Table 8).

2. Desliming on 200 mesh after agitation and one-minute settling does save additional olivine as compared to immediate desliming on 100 mesh. Comparative tests here are No. 17N vs. No. 31N, Table 8. These scrub tests were preceded by different milling, but it will be seen from Table No. 7 that Test No. 16N which preceded No. 17N had a relative efficiency of 92 percent, and this figure did not rise; whereas Test No. 30N, with a 94 percent relative efficiency, yielded a scrubbed product (No. 31N), showing a relative efficiency of 97 percent. However, with respect to the small additional olivine values saved by finer and slower desliming, data from flotation tests indicate that these values are lost in the scavenger froth product, even in float tests of high relative efficiency (See Table 6, Test Group E vs. Test Group J).

3. The favorable effects of milling to slightly finer mesh size (Test No. 47N vs. No. 16N, Table 7) remain apparent when comparing Tests No. 17N and No. 47B-N, (Table 8).

4. The finer desliming technique following milling in Test No. 76N (Table 7) carries through its higher relative efficiency compared to Test No. 47N (Table 7) when both these milled products are scrubbed and deslimed the same (Test No. 77-N vs No. 47B-N, Table 8).

5. A two-stage scrub and deslime (Test No. 87N, Table 8) shows no immediate improvement over single-stage (No. 77N). However results of comparative flotation tests following these two techniques indicate possible advantage of two stages (Test Group K vs. Test Group J, Table 6). It is of interest that total duration of scrub is less in No. 87N (2 stages) than in No. 77N (1 stage).

6. A single scrub stage of only five minutes appears to yield grade and recovery about equal to one of ten minutes (No. 83-84N vs. No. 77N, Table 8), thus indicating that a ten-minute scrub may not be necessary. This point (No. 6), and No. 5 preceding, tend to show that more research into optimum scrubbing conditions is probably worth while.

<u>Lab No. 3258 - Conclusions from Flotation Data, Table 6</u> - The sum total of data from flotation tests points to these conclusions:

1. When it is desired to secure an olivine concentrate with an ignition loss of 0.6 percent or less from an ore such as No. 3258, using the acid-sulfonate flotation system, it appears that (a) little or no additional values are lost by comminution to 35 mesh rather than to 20 mesh, and (b) desliming or hydroclassification techniques which remove a fine waste product at 200 mesh size, rather than 100 mesh, do not in the end cause any substantial increase in grade or recovery. The foregoing points are illustrated by comparison of Test Group A (20 mesh grind, 100 mesh deslime) with Test Group B (20 mesh grind but 200 mesh deslime); or Test Group A with Test Group E (35 mesh grind, 100 mesh deslime); or Test Group E with Test Group J (35 mesh grind but 200 mesh deslime).

2. Scrubbing in an acid circuit prior to desliming and flotation does not appear to yield any improvement. See Test Group C compared to Test Group B.

3. The use of petroleum sulfonate as a serpentine collector on this scrubbed olivine ore appears possible over a wide pH range (Test Group D). However, best results seem to be obtained with a conditioner pH of about 3.5 or less. This can be seen from data of Test Group E vs. Test Groups D and A.

4. The relative sensitivity of this float at various pH levels has not been established. In Test Groups A and E, there are apparently optimum levels of collector. Below optimum level, the collector may pull more froth product rather than less. This phenomenon is worthy of investigation in future research. In both Test Groups A and E there appears to be a plateau of optimum product concentration caused by a range of collector level varying from the minimum upward to about 1.25 times that minimum in Test Group A (Tests 25N - 29N), and to about 1.39 times in Test Group E (Tests 57N - 61N).

5. Besides petroleum sulfonate (mahogany soap), dodecylbenzene sulfonate can also be employed as collector in this type flotation. However, as seen from Test Group F, this flotation, while achieving equally good results, appears to be considerably more sensitive regarding variations in collector level. One, test, not tabulated, employed 10% more dodecylbenzene sulfonate and floated almost the entire sample. However, future research into this type collector may be worthwhile.

6. Although an unreported group of tests, involving no scrubbing, indicated that some scrubbing is necessary, decreasing scrub time or intensity may be possible without significant loss of grade or recovery. Test Group G shows several tests run with less scrubbing but yielding acceptable results.

7. Less desliming may be possible after scrubbing (See Test Group H).

8. A double-stage scrub of shorter total duration (five minutes total vs. ten minutes), each stage followed by a deslime, is of equal or greater benefit to grade and recovery. Comparison is made between Test Groups K (stage scrubbing) and J or E (single scrub).

Summary and Conclusions on Milling, Desliming, Scrubbing, and Flotation of Lab Sample No. 3258 - Principal conclusions drawn from all beneficiation tests can be briefly stated thus:

1. A sliding-rod grinding technique, as opposed to cascading rods, may yield higher grade and recovery on ore of this type.

2. For this sample, a grind to minus 35 mesh and deslime on 100 mesh appear to be optimum. Grinding to 35 mesh need not increase loss of values.

3. A two-stage scrub may permit shorter total scrub duration.

4. The standard scrub duration of this test series (10 minutes) is possibly longer than necessary.

5. Acid-circuit scrubbing (as opposed to caustic scrubbing) is of no perceptible benefit to either scrubbing or flotation in this application.

6. Petroleum sulfonate collector in this application will operate fairly well over a wide pH range, although sensitivity is not well established.

7. At a low pH (about 3.3) there appears to be an optimum range of quantity of petroleum sulfonate within which sensitivity is reasonably low.

8. At least one other anionic reagent (dodecylbenzene sulfonate) can be substituted for petroleum sulfonate in this application, although that particular anionic appears very sensitive as a collector.

Beneficiation of Other Ore Samples

Since the scrub and flotation techniques previously described accomplished an exceptionally high level of beneficiation on a head feed of quite high average ignition loss, the question arose as to how these techniques would work with other olivine ores. Those ores mentioned on the first page were selected for laboratory tests of the same type.

Lab Sample No. 3274 - Beneficiation and Conclusions - This sample was collected from the area of the olivine mine at Daybook, North Carolina, and is considered fairly representative of the ore of that area. A portion of Sample No. 3274 was crushed to minus 1/4 inch, then rod-milled to minus 35 mesh and deslimed by a procedure close to the "standard" one described for Sample No. 3258. This was followed by a ten-minute scrub and double deslime as performed on No. 3258, followed by an acid flotation with petroleum sulfonate collector. This processing of Sample No. 3274 yielded the results shown in Table 9.

Following up the tests described in Table 9, a portion of olivine concentrate from Test No. 10-N was passed through a Frantz Isodynamic Magnetic Separator to remove a portion of relatively lower magnetic susceptibility. Feed for this test was only the size range of 48-65 mesh, having an initial ignition loss of 0.49 percent, compared to 0.51 percent for the entire sample. This test (No. 10-B-N) concentrated 91.2 percent of the throughput as a magnetic fraction having an ignition loss of 0.36 percent. If this percentage is reckoned in terms of head feed, then there is a theoretical recovery of 44.2 percent of that grade from head feed.

The following conclusions are drawn from the beneficiation data just preceding:

1. This sample does not contain the same serpentine-type, slime-producing ingredient as No. 3258. It does contain a substantial amount of talc, which can be floated easily along with a relatively small amount of serpentine.

2. In addition to other means of beneficiation, one possible way to attain fair grade and good recovery with this ore is by intensive scrubbing alone, followed by desliming.

3. The few flotation tests carried out on this sample indicate that, while a concentrate ignition loss about 0.65 percent is obtainable with a recovery of 64 percent of head feed, any higher grade than that would probably be at the expense of considerable recovery, and it seems unlikely that a grade better than 0.5 percent ignition loss could be attained by any wet separation method.

Thus, so long as the trade accepts a grade of 0.6 percent to 1.0 percent ignition loss, the Daybook deposit can be used. Should a tighter standard than this be imposed in the future, a deposit such as Frank (Sample No. 3258) might be more attractive.

Lab Samples No. 3283 and 3289 - Preliminary Beneficiation - Sample No. 3283 was a 25 pound sample obtained from the old Balsam Gap mine of International Minerals and Chemicals Corporation, and No. 3289 was a sample of about 100 lbs. from the Dark Ridge deposit. Both samples were gathered by the Minerals Research Laboratory, assisted by Geologist Jerry Bundy and Al Carpenter of North Carolina Department of Mineral Resources. Both samples were relatively fresh and unweathered. The ignition loss of Sample No. 3283 was 1.16 percent and that of No. 3289 was 1.49 percent. Milling and desliming alone brought the ground samples to fair grade: No. 3283 reached 0.71 percent ignition loss with 85 percent recovery of head feed and No. 3289 was beneficiated to 1.08 percent ignition loss, with recovery of 83.1 percent. A standard scrub and deslime of the type used in No. 3258 produced a concentrate from No. 3283 having 0.51 percent ignition loss and with 78.8 percent recovery of head feed. Similar treatment of No. 3289 yielded a concentrate with 0.76 percent ignition loss, 74.7 percent of head feed. The appearance, mineralogy, and reaction to beneficiation of these samples suggest they are similar to the Daybook sample, No. 3274. Future investigation should include trials of the acid-sulfonate collector flotation system on them. Figures just quoted can be compared to results on Sample No. 3274, Table 9, preceding.

Lab Sample No. 3290 - Beneficiation and Conclusions - A sample of ore weighing about 100 lbs. was gathered from the mine face and ore pile at the Addie mine, which is presently inoperative. This material bore a closer physical resemblance to the Frank deposit (No. 3258) than it did to samples from Daybook (No. 3274), Balsam Gap (No. 3283), or Dark Ridge (No. 3289). Treated as the others, it responded as shown in Table 10.

No extensive flotation test series was run on this sample, but the single test cited gave some indication that it might be amenable to the same sort of beneficiation as No. 3258 (Frank). It was brought to higher grade than appeared possible for No. 3274 (Daybook).

The serpentine in Sample No. 3290 seemed harder than that in No. 3258. Milling of No. 3290 yielded a slime product which was 15.7 percent of the head feed, with an ignition loss of 6.44 percent, while No. 3258 produced a mill slime of 17.6 percent of head feed, with an ignition loss of 9.40 percent. The scrub operation yielded, for No. 3290, a slime product which was 7.0 percent of the scrubbed sample with ignition loss of 6.65 percent, while the same product from No. 3258 was 9.9 percent with a 9.29 percent ignition loss. Following flotation in Test No. 3290-3N (Table 10), the physical appearance of the machine discharge concentrate indicated strongly the remnant of dark-colored serpentine. A mitigating factor is the apparent lower ignition loss of this type serpentine which is not scrubbed off or floated off as froth product.

In conclusion, it seems unlikely that the ore from Addie could be beneficiated to match the grade and recovery attained from the Frank deposit, although it might be treated by flotation to attain a grade higher than possible with ores of the type of No. 3274 (Daybook).

Final Conclusions

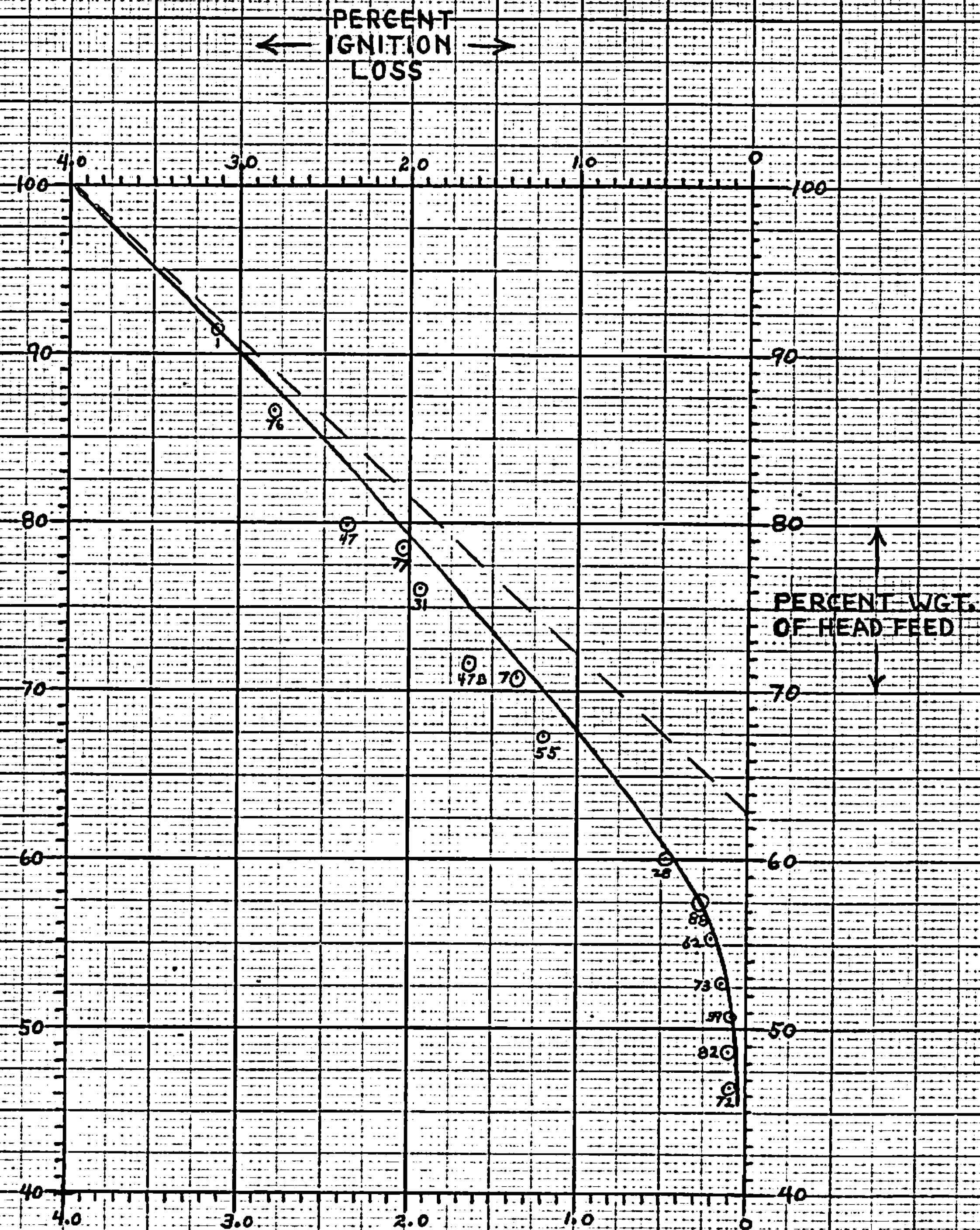
With regard to the minerals olivine, serpentine, and talc present in potential olivine orebodies, the research here described dealt with two different types of ore. One, exemplified by Samples No. 3258 (Frank) and No. 3290 (Addie) has discrete olivine particles of quite low ignition loss surrounded mainly by softer serpentine of high ignition loss, plus some talc. Another type, of which Samples No. 3274 (Daybook), No. 3283 (Balsam Gap), and No. 3290 (Dark Ridge) are examples, is a harder ore with little or no discrete serpentine, but with a higher talc content.

When subjected to flotation with acid and petroleum sulfonate at the proper levels, some scrubbed and deslimed ores of the first type may be beneficiated to yield a product of very low ignition loss (0.1 percent or lower). The second type of ore can easily be beneficiated by various techniques to a fairly low ignition loss (0.5 - 0.6 percent), but it may not be amenable to further upgrading by wet methods of the usual sort. This may be due to a minor interlocked component of higher ignition loss: serpentine or talc.

So long as the trade finds an ignition loss of 0.5 percent to 1.0 percent acceptable, ores of the second type, which give high concentrate recovery at that grade, will be more desirable. Should new specifications demand an olivine concentrate of considerably lower ignition loss, the first type of ore will bear futher investigation.

Figure 1

RELATIVE EFFICIENCY OF RECOVERY, TESTS ON SAMPLE #3258



BROKEN LINE: Theoretical Maximum Weight Recovery of Concentrate of Given Ignition Loss.

SOLID CURVE: Probable Attainable Weight Recovery at Given Ignition Loss, Based on Tests So Far. Certain High-Recovery Tests Are Shown.

SEE ALSO ADDENDUM AT END OF THIS REPORT

Table 1

Screen Analysis of Sample No. 3258 After Primary Dry Crushing

Screen Size	Percent Weight	Ignition Loss
+20	56.4	4.33
-20+35	6.3	3.47
-35+48	5.8	2.18
-48+65	7.3	1.72
-65+100	7.9	1.89
-100+150	6.1	2.87
-150+200	3.3	4.57
-200	6.9	9.30
Total	100.0	4.03% (Calculated)

Actual I.L., Total-3.97%

Table 2

Comparison of Products from Milling & Desliming - Large vs. Small Batches, Sample No. 3258

Test No.	% O'Size	Slimes % Wt.	Slimes % I.L.	% Loss	Scrub Fd. % Wt.	Scrub Fd. % I.L.	Scrub Feed +35	35-48	48-65	65-100	100-150	150-200	-200
3258-30N	2.5	11.4	9.56	1.3	84.8	3.04	1.5(1)	7.5	20.9	28.0	20.8	11.0	10.3
(Standard)							4.67	3.65	2.42	2.35	2.67	4.55	4.62
3258-76N	0.4	9.7	9.87	3.2	86.7	2.80	-	9.8(2)	23.2	24.4	16.9	13.1	12.6
(Large Batch)							-	2.45	2.12	1.87	2.62	3.63	5.40

(1) Upper figure = Percent weight. Lower figure = Percent Ignition Loss.

(2) Test No. 3258-30N screened through 20 mesh. Test no. 3258-76N screened through 35 mesh.

Table 3

Comparison of Milled Products Following Varied Desliming, Sample No. 3258

3258-30N	2.5	11.4	9.56	1.3	84.8	3.04	1.5*	7.5	20.9	28.0	20.8	11.0	10.3
(Standard)							4.67	3.65	2.42	2.35	2.67	4.55	4.62
3258-4N	1.2	16.7	9.21	1.9	80.2	2.62	0.8	7.2	25.2	29.8	20.9	9.3	6.8
(Small batch, quick deslime)							5.68	3.70	2.17	2.25	2.40	2.87	4.72
3258-16N	2.6	17.2	8.89	2.9	77.3	2.39	11.0	17.0	20.2	22.6	17.0	7.5	4.7
(Large batch, quick deslime)							3.81	2.26	1.90	2.11	2.22	2.64	3.26

*Upper figure = Percent weight. Lower figure = Percent ignition loss.

Table 4

Effects of Longer Milling Plus Finer Screening

Test No.	% O'Size	Slimes % Wt.	Slimes % I.L.	% Loss	Scrub Fd. % Wt.	Scrub Fd. % I.L.	Scrub Feed +35	Scrub Feed 35-48	Scrub Feed 48-65	Scrub Feed 65-100	Scrub Feed 100-150	Scrub Feed 150-200	Scrub Feed -200
3258-16N (Milled 4 min, screened on 20)	2.6	17.2	8.89	2.9	77.3	2.39	11.0 3.81	17.0 2.26	20.2 1.90	22.6 2.11	17.0 2.22	7.5 2.64	4.7 3.26
3258-47N (Milled 5 min, screened on 35)	0.7	17.6	9.42	1.9	79.8	2.37	- -	15.4 2.54	26.8 2.22	25.2 1.88	18.4 2.38	8.3 2.79	5.9 4.02

*Upper figure = Percent weight. Lower figure = Percent ignition loss.

Table 5

Comparison of Scrubbed Products After Variable Grind - Deslime but Identical Scrub - Deslime[(1)]

A. General Data

Test No.	Description	Test & Table No.	Deslimed Scrubbed Product: % of Hd. Fd.	Deslimed Scrubbed Product: % of Scrub Fd.	Deslimed Scrubbed Product: % I.L. Total	Scrub Slimes: % of Hd. Fd.	Scrub Slimes: % I.L.	Theoretical Olivine in Scrubbed Fd. Wgt. % of Hd.Fd.
3258-77N	Fine grind, 200 mesh deslime.	3258-76N, T. #2	78.6	90.7	2.04	7.1	10.64	66.3
3258-17N	Coarse grind, 100 mesh deslime.	3258-16N, T. #3	68.2	88.2	1.57	8.6	9.66	60.0
3258-47B-N	Fine grind, 100 mesh deslime.	3258-47N, T. #4	71.6	89.6	1.65	7.9	9.29	62.5

B. Screen Fractions of Scrubbed Feed, with Ignition Losses

Scrub Test	+35	35-48	48-65	65-100	100-150	150-200	-200
77N	-	10.4[(2)]	24.6	25.8	16.9	12.4	9.9
	-	1.84	1.68	1.71	1.83	2.69	3.52
17N	7.9	15.4	20.7	23.7	18.8	8.4	5.1
	3.12	1.70	1.39	1.19	1.41	1.57	1.95
47B-N	-	11.9	24.8	26.7	20.4	10.0	6.2
	-	1.92	1.66	1.39	1.53	2.00	2.12

(1) See also Table 8 for additional scrubbing data, with conclusions.

(2) Upper figure = Percent. Lower figure = Percent ignition loss.

Table 6

Significant Flotation Test Groups on Sample No. 3258

Test Group and Description	Test No.(3285)	Collector Level	Float Fd.[1] % of Hd.Fd.	Machine Discharge (Concentrate) % of Float Fd.	Machine Discharge (Concentrate) % of Hd.Fd.	Relative % Efficiency (Figure 1)	% ign. Loss of Conc.
A Mill, scrub and deslime as Test 16N - 17N, Table 4 & 5. (Minus 20 grind, 100 mesh deslime). Conditioner pH, 5.7.	23N	M70 - 0.30#/T	68.2	96.4	66.6	91	1.50
	22N	M70 - 0.325#/T	68.2	84.2	58.2	91	0.70
	21N	M70 - 0.35#/T	68.2	82.6	57.2	93	0.52
	24N	M70 - 0.375#/T	68.2	79.8	55.0	91	0.44
	25N	M70 - 0.40#/T	68.2	73.2	50.3	85	0.38
	26N	M70 - 0.425#/T	68.2	77.1	53.8	90	0.43
	27N	M70 - 0.45#/T	68.2	78.6	54.5	91	0.42
	28N	M70 - 0.475#/T	68.2	79.4	60.0	98	0.48
	29N	M70 - 0.50#/T	68.2	60.6	42.3	71	0.38
B Mill and deslime as 30N, Table 3 (Standard grind-deslime of 500 g. batch). Standard scrub, deslime on 200. Cond. pH, 5.7 .	33N	M70 - 0.325#/T	76.1	75.4	57.0	92	0.53
	32N	M70 - 0.35#/T	76.1	69.1	52.8	92	0.28
	34N	M70 - 0.375#/T	76.1	70.5	53.7	93	0.30
	35N	M70 - 0.40#/T	76.1	70.5	53.6	93	0.30
	36N	M70 - 0.425#/T	76.1	67.5	51.7	86	0.43
C As B, but scrubbed with 10#/T conc. H_2SO_4, drop by drop, last 5 minutes. Cond. pH 3.1.	43N	M70 - 0.275#/T	76.1	72.7	50.9	87	0.33
	39N	M70 - 0.325#/T	76.1	68.1	47.5	82	0.29
	38N	M70 - 0.35#/T	76.1	67.8	47.7	80	0.39
	(pH)						
D Prepared as Group A. Conditioner pH varied as shown in next column.	40N-3.7	M70 - 0.45#/T	68.2	83.1	57.7	95	0.47
	41N-3.2	M70 - 0.50#/T	68.2	74.1	50.8	92	0.18
	42N-6.6	M70 - 0.325#/T	68.2	82.2	57.3	92	0.60
	44N-6.3	M70 - 0.375#/T	68.2	76.0	53.4	88	0.48
	45N-11.0	M70 - 0.50#/T	68.2	85.4	59.2	94	0.64
	46N-11.8	M70 - 0.80#/T	68.2	80.5	56.1	90	0.59

E Mill, scrub and deslime as Tests 47N -47B-N, Tables 4 & 5 (Minus 35 mesh grind, 100 mesh deslime). Conditioner pH 3.3.	52N	M70 - 0.45#/T	71.6	78.8	56.6	96	0.35
	53N	M70 - 0.475#/T	71.6	84.3	60.6	97	0.61
	54N	M70 - 0.50#/T	71.6	79.2	57.4	95	0.44
	55N	M70 - 0.525#/T	71.6	89.7	67.3	96	1.20
	56N	M70 - 0.55#/T	71.6	87.8	63.8	93	1.10
	57N	M70 - 0.575#/T	71.6	72.3	52.7	93	0.23
	58N	M70 - 0.65#/T	71.6	70.1	51.2	94	0.14
	59N	M70 - 0.70#/T	71.6	70.0	50.8	99	0.09
	60N	M70 - 0.75#/T	71.6	70.5	51.0	99	0.08
	61N	M70 - 0.80#/T	71.6	70.7	50.2	95	0.12
	64N	M70 - 0.85#/T	71.6	60.6	44.2	86	0.08
	(pH)						
F[2] As Group E but collecter was dodecylbenzene sulfonate ("ABS"). Cond.pH varied - see next column.	62N-3.3	ABS - 0.25#/T	71.6	75.3	54.8	94	0.22
	63N-3.3	ABS - 0.225#/T	71.6	83.3	60.2	96	0.64
	65N-3.6	ABS - 0.25#/T	71.6	72.8	51.5	98	0.10
	66N-5.4	ABS - 0.25#/T	71.6	66.9	48.3	83	0.34
G As Group E but shorter scrub(next col.).	69N-7min	M70 - 0.70#/T	73.6	72.4	53.4	91	0.36
	71N-5min	M70 - 0.70#/T	74.7	73.9	54.0	91	0.39
H As Group E but single deslime after scrub.	72N	M70 - 0.75#/T	72.3	65.4	47.5	91	0.10
	74N	M70 - 0.70#/T	72.3	72.6	52.7	92	0.25
J Mill, scrub and deslime as Tests 76N-77N, Tables 2 & 5(Minus 35 grind, 200 mesh deslime, large batch). Cond. pH 3.3.	78N	M70 - 0.60#/T	78.6	82.0	63.5	93	1.06
	79N	M70 - 0.65#/T	78.6	71.6	55.6	92	0.43
	80N	M70 - 0.70#/T	78.6	70.4	54.0	96	0.22
	81N	M70 - 0.75#/T	78.6	67.2	52.0	94	0.18
	82N	M70 - 0.80#/T	78.6	62.9	48.6	84	0.11
K Milled-deslimed as Group J, but scrubbed as follows: 1. 2 min.@75% solids, deslimed on 100 mesh, then 2. 3 min @80% solids, deslimed on 100 mesh.	87N	M70 - 0.65#/T	78.0	71.4	55.1	96	0.27
	88N	M70 - 0.56#/T	78.0	75.3	57.7	100	0.27

(1) Average total slimes plus losses plus oversize in each test group is 100 percent minus the percentage shown in "Float Feed" column. Minor variations in "slime plus loss" levels may cause some lack of exact correlation between increase or decrease of percent machine discharge vs. percent concentrate recovery. Example: Tests 59N-60N-61N, Group E.

(2) Higher pH in this series caused unselectivity. Precise ABS level appears critical even at low pH.

Table 7

Comparative Grinding - Desliming Efficiencies, Tests on No. 3258

Test No.	General Description	Wt. Recovered % of Head Feed	% I.L.	Relative Efficiency Re Curve, Fig.1
1-N	Ground as 30-N standard. Agitated and deslimed at once in 10 seconds. Repeat. Decanted solids settled 1 min. then poured across 200 mesh. (This test not reported elsewhere)	91.5	3.14	100%
4-N	Standard grind of 500 g. batch but 100 mesh deslime. (See also data on Table 3)	80.2	2.62	93%
16-N	Large batch ground to minus 20, deslimed on 100 mesh. (See also Table 3)	77.3	2.39	92%
30-N	Standard grind of small batch. (Table 2)	84.8	3.04	94%
47-N	Large batch ground to minus 35, deslimed on 100 mesh. (See also Table 4)	79.8	2.37	96%
76-N	As 47-N but deslimed on 200 mesh (See also Table 2)	86.7	2.80	98%

Table 8

Comparative Scrubbing - Desliming Efficiencies, Tests on No. 3258

Test No.	General Description	Weight Recovered % of H.F.	% I.L.	Relative Efficiency Re. Curve, Fig.1
17N	Milled and deslimed as 16N, Table 7. Standard scrub, 100 mesh deslime.	68.2	1.57	92%
18N	As 17N, above, but scrubbed with H_2SO_4 in gradual increments: total 10#/T. Same deslime. (Test not reported elsewhere)	69.7	1.72	92%
31N	Milled and deslimed as 30N, Table 7 (20 mesh grind, 100 mesh deslime). 200 mesh deslime after standard scrub.	76.1	1.94	97%
47B-N	Milled and deslimed as 47N, Table 7 (35mesh grind, 100 mesh deslime). 100 mesh deslime after standard scrub.	71.6	1.65	95%
77N	Milled and deslimed as 76N, Table 7 (35 mesh grind, 200 mesh deslime). Standard scrub, 100 mesh deslime.	78.6	2.04	99%
87N	Milled and deslimed as 76N, Table 7. Two scrub stages totaling only five minutes, each with deslime on 100 mesh. First scrub 75 percent solids; second, 80 percent solids.	77.2	2.03	97%
83N - 84N	Milled and deslimed as 76N, Table 7. Five minute scrub in one stage, 100 mesh deslime. These are float tests, but total scrub feed only is reported here.	78.9	2.05	99%

Table 9

Beneficiation of Sample No. 3274

Test No.	Material	% Ign. Loss	% of Head Feed
	Head feed	1.55	100.0
3274-5N	Milled head feed	1.21	91.2
3274-6N	Scrubbed head feed	0.82	84.2
3274-7N*	M.D. concentrate, 0.174#/T pet. sulf.	0.65	64.1
3274-10N*	M.D. concentrate, 0.225#/T pet. sulf.	0.51	48.4
3274-13N	M.D. concentrate from unscrubed feed, 0.75#/T pet. sulf.	0.92	64.9

* Intermediate tests gave intermediate results.

Table 10

Beneficiation of Sample No. 3290 (Addie)

Test No.	Material	% Ign. Loss	% of Head Feed
	Head feed	2.87	100.0
3290-1N	Milled head feed	1.93	82.1
3290-2N	Scrubbed head feed	1.40	75.5
3290-3N	M.D. flotation concentrate, 0.45#/T pet. sulf.	0.29	51.4

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CORRELATION OF DATA RELATING TO RESEARCH ON FRANK OLIVINE

December 1968 Progress Report

Lab No. 3258

by

J. Philip Neal

This addendum refers to two separate reports on beneficiation of olivine from Frank, N. C. by R. M. Lewis and J. P. Neal, respectively. These reports comprise Sections F and G, MRL Progress Report No. 19, Part I.

Table 1, attached, shows combined data from Table A of the Lewis report (Section F) and from Figure 1 of the Neal report (Section G). No data is submitted here on tests where concentrate ignition loss was over 1.0 percent. The Neal test points and curve from Figure 1 have been adjusted to the Lewis Table A scaling system.

Three Lewis tests (No. 9, 11, and 12) indicate that the theoretical maximum efficiency curve derived from all tests to date, and depicting probable optimum grade vs. yield (Figure 1, Neal) can be revised, as per the broken line shown on attached Table 1.

All tests are described in the respective reports. On attached Table 1, two levels of theoretical 100 percent recovery are shown by the two top inclined lines. The lower one (Lewis) is based on the calculation of average ignition loss of 11.2 percent from 100 percent of all gangue minerals present having measurable ignition loss. The higher line (Neal) is based on assumption that 13.5 percent ignition loss is nearer correct; an estimate founded on actual ignition loss figures on gangue products from certain Neal tests. Lower lines show recovery levels bases on both the stated figures.

TABLE 1

COMBINED DATA FROM TABLE A (LEWIS, SECTION F) AND FIGURE I (NEAL, SECTION G) : PROGRESS REPORT, APRIL 1969, PART I