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Dear Stan:

EVALUATION OF LETTER REPORT, FEBRUARY 8, 1980

MITSUI MINING & SMELTING CO. LTD.

During the conference which I attended with Messrs. L. P. Taggart, P. J. Brown and J. F. Olk at the Cyprus Anvil office in Vancouver on May 5, 1980, I was given a copy of the Mitsui Report for my further study. Since this report contains some very interesting and useful new data, I have analyzed it as a supplement to my earlier report to you of April 25, 1980. As Mr. Taggart commented, Mitsui recommendations, with the exception of one or two insignificant differences in numbers, agree completely with my own conclusions.

The Mitsui Report presents the flotation response of Anvil ores by types. It shows that a grind of 80% minus 200 mesh, i.e., a 74 micron grind, is optimum for buckshot, pyritic, graphitic quartzite, and zone II ore and that a 37 micron grind is required for pyrrhotitic ore. In order to produce the optimum grind of 74 microns for the 4 types, excluding pyrrhotitic ore, the grinding time in the laboratory mill was varied from 13 to 20 minutes.

The laboratory tests of two-stage grinding with interstage flotation were made with a first-stage grind with a multiple screening at 65 mesh. Such a procedure greatly reduces the selective grinding of galena as compared to a ball mill-cyclone classification circuit. Thus, with the possible exception of the buckshot tests, the two stage tests were probably not as indicative as were expected due to inadequate liberation. This would be improved with cyclone classification instead of multiple screening.

The analyses presented in Table I, page 11, Mitsui Report are significant in that, for all types except graphitic, the lead recovery is less in the minus 400 mesh fractions than it is in the -325 +400 mesh fraction. For pyritic ore, the dominant type expected in Faro III ore, the recovery differential is 17%. For buckshot ore it amounts to 10%. These are rather large losses and thus, emphasize the potential problem of overgrinding. If the sizing analysis could be extended to less than 10 microns, the picture would be even clearer.

The sequential removel of concentrates as shown on pp 42-43 resulted in the cumulative grade and recovery figures of the tabulation of individual tests. These are plotted as grade-recovery curves. Such curves cannot be used in the same way as the usual grade-recovery curves are in a normal flotation operation since these include the effect of varying grinds. For example, in the Anvil mill zinc flotation circuit, a grade-recovery curve will show readily how much of a penalty in grade will ensue by an incremental increase in recovery.

A cursory glance at the curves for the pyritic ore on page 46 might lead to the faulty conclusion that curve 2 might represent a better practice than curve 4. This is not a valid conclusion because the effects of concentrate regrind and concentrate cleaning have not been taken into effect. The total recovery as represented by curve 4 was actually higher than that of curve 2 as shown on pages 24 and 26. Since rougher recovery is the key to final recovery and since essentially very little loss in lead recovery occurs during the regrind and cleaning stages as shown by the Lakefield tests (pages 6 and 13-A, Spedden report, 4/25/80), the Mitsui results should be analyzed on the basis of recovery alone.

MITSUI 3A		Pb RECOVERY %	
REF. PAGE	ORE TYPE	1-STAGE FINE FLOTATION	2-STAGE FINE FLOTATION
24,36	Pyritic	75.8	76.6
16,18	Buckshot	70.7	86.2
20,22	Pyrrhotitic	87.3	86.7
28,30	Zone Two	74.6	75.2

As noted before, the Mitsui tests with multiple screening at 65 mesh undoubtedly did not produce as well a liberated galena fraction as would be experienced with a ball mill cyclone circuit operating at a nominal P_{80} 100 micron grind. Thus, with an ore predominantly pyritic interspersed with occasional lots of high grade buckshot and some lots of pyrrhotitic or perhaps zone two, the Mitsui tests indicate an advantage for the two-stage fine grind as the Japanese concluded. Also, to be noted (pp 2, 15 and 17) is the fact that 2-stage coarse flotation of buckshot yielded the same recovery as 1-stage and that the buckshot was more difficult to grind than the pyritic. This means that a two-stage flotation and grinding circuit set for pyritic ore would produce the coarser, more optimum grind for buckshot if the feed rate were held constant or perhaps even increased. The Mitsui tests confirm once again, the long held adage of galena flotation, namely, remove the galena from the grinding circuit as soon as it has reached its size of liberation.

The lead recoveries by ore type as shown on page 2 of the Mitsui Report also are interesting when compared with Anvil mill daily and annual average lead recoveries. For example, the laboratory Pb recovery on buckshot at the one-stage coarse flotation of 80% minus 200 mesh was 90.8% as compared to 91.1% at 70% minus 200 mesh which is presented as present grind practice. The Anvil mill on October 12, 1978 yielded a 90% recovery on buckshot type ore. As noted previously, final concentrate recovery is very close to rougher, including scavanger, recovery.

Since, for present grind practice, Mitsui reported 77.4% recovery on pyritic ore and 80.2% recovery on pyrrhotitic ore, we must assume that in order for the Anvil mill to have made an average recovery of 83.7% Pb during 1979, the Faro I ore treated was significantly more amenable to treatment than would be the case with a predominantly pyritic type. In fact, it would have to have contained about half of material with liberation characteristics similar to buckshot. With this indication then, if the expanded Anvil mill is built as now designed and produces a primary grind of P_{80} 37 microns, substantial losses would occur about half the time. Note that the Pb recovery was only 70.7% at a one-stage grind of P_{80} 37 microns but was 90.5% at a grind of P_{80} 74 microns for the buckshot ore.

Although laboratory flotation tests normally yield better recoveries than can be obtained in a mill, the Mitsui tests would appear to be closely comparable to Anvil results. The Mitsui one-stage grind at 80% minus 200 mesh, without classification, would produce a slightly finer grind of the galena. It would, in fact, be almost the same size as Mitsui reports (pg. 38) for the size of the Anvil rougher froth at 87% minus 200 mesh. The Mitsui one-stage tests, thus, would appear to have been designed to match current Anvil practice which, with a nominal grind of 65% minus 200 mesh, produces a galena fraction of 87% minus 200 mesh. Comparing then, the one-stage coarse grinds on buckshot and pyritic (pp 15 & 23), the average rougher recovery at a 50:50 blend would be 84.5% vs. 83.7% for the Anvil mill 1979 average into final concentrates. This is a reasonable ratio from rougher to cleaner.

At the finer grind of 80% minus 400 mesh which, by similar analogy, corresponds to the planned Anvil practice, the Mitsui recoveries of 70.7% and 75.8% respectively for buckshot and pyritic ores would average 73.3%. Thus, if the expanded Anvil mill is operated as planned, the lead recovery might be as low as 72.5% instead of the 87.5% recovery projected which would amount to about C$30.38 million per year, based on 1979 returns. This is undoubtedly overly pessimistic, however, additional test work and analysis obviously is required.

Since the combined Pb-Zn grade of Anvil mill feed exceeded 10% for 28 days out of the 64 days from September

22 to November 24, 1978, it would appear that ores having an amenability for concentration somewhat similar to buckshot ore are more common than has been indicated. This leads to the suggestion that the identified buckshot ore represents only the most coarsely crystallized fraction and that a significant part of Faro I ore was somewhat more finely crystallized and of lower grade than the identified buckshot ore and therefore not identified as "buckshot" but still quite different from "pyritic." The pyritic ore sample supplied to Mitsui, apparently as an example of the predominant ore type, was lower in lead grade than the Faro III ore projected as mill feed.

	GRIND	GRADE		Pb RECOVERY	
Sample	P_{80} Microns	Pb	Zn	Rougher	Cleaner
Faro III AFE Projection	50	2.9	4.6		87.5
Anvil Mill - 1979	130	3.26	5.28		83.7
Anvil Mill - Nov. 13, 1978	87	4.01	5.88		86.2
Mitsui "Pyritic" No. 82	74	2.64	5.45	78.6	
Mitsui "Pyritic" No. 83	37	2.56	5.43	75.8	
Mitsui "Buckshot" No. 74	74	5.73	9.18	90.5	
Mitsui "Buckshot" No. 77	37	5.51	8.95	70.7	
Mitsui "Pyrrhotitic" No. 79	37	5.00	7.47	87.3	
Lakefield Sample No. 2, Test 35	50	2.36	4.32	82.3	82.3
Lakefield Sample No. 2, Test 31	69	2.45	4.36	82.5	82.2

These results suggest that the Lakefield Sample No. 2 was a relatively poor grade of pyritic ore (stated to be "representative of the ore type known as 4E - a predominately pyritic specie") which has been shown to benefit by finer grinding. It was obviously deficient in the higher grade type of more coarsely crystallized ore which, by the Mitsui tests, loses recovery from fine grinding. The AFE assumption that higher recoveries in the pilot plant would have been possible with a higher grade ore at the 50 micron grind does not appear to be substantiated.

Since the Faro III ore, as mill feed, will vary by type in a manner similar to that experienced with Faro I, the mill will have to produce acceptable results on both extremes as well as on any intermediate blends or types. This is a different condition than that of the Lakefield Research tests which were all made on a uniform blend. The Mitsui results can be analyzed on a recovery vs. time of flotation basis to compare the two-stage fine flotation with the one-stage fine flotation. This gives an indication of what might be expected by employing the proposed Spedden flowsheet as opposed to the proposed Anvil flowsheet. The attached graphs show the Mitsui data for lead recovery by time. Note that the total flotation time of the Mitsui tests was 13 minutes as contrasted to 27 minutes provided in the lead rougher and scavenger circuits in the AFE for the Anvil expansion. For pyritic ore, the flotation rate is less for the two-stage case at the intermediate time period only, however, final recovery is slightly higher. For the buckshot ore, the two-stage flotation is substantially better over the whole time range. Thus, a mill being fed at times pyritic ore and at other times a buckshot type would yield recoveries at an intermediate point.

The optimum grinding times by ore type given on page 2 of the Mitsui Report suggest that a method of grinding control other than particle size be studied. For example, since the pyritic ore requires less grinding time (i.e., 13 minutes) than buckshot ore (i.e., 20 minutes) a constant feed rate set for optimizing the grind on pyritic ore would give a coarser, more suitable grind for buckshot. This would not, however, work for pyrrhotitic ore. A simple magnetometer, measuring the pyrrhotite content, might be a very effective control strategy to reduce tonnage for the finer grind required when pyrrhotitic ores are encountered. Some simple magnetic response tests of the various ore types would show if this control strategy is feasible.

The Mitsui mineragraphic studies pp 37-41 present some very useful information for flowsheet design. For example, the Anvil mill lead scavenger froth (p. 39) has a galena liberation of 61.2% and the scavenger tail, a liberation of 62.9%. In addition to flotation studies suggested by Mitsui, the potential improvement of regrinding the scavenger froth before reflotation is obvious. The potential of a fine grind before scavenger flotation is also apparent. This feature is provided in the Spedden alternate flowsheet.

The Mitsui tests also show that the first rougher concentrates made in their two-stage flotation tests should be reground for acceptable Pb-Zn liberation before a cleaner float. The suggested alternate flowsheet fulfills this function by regrinding the lead cleaner tailing. A variation would be to cyclone the rougher concentrate and regrind the cyclone undersize before the Pb first cleaner. Full plant tests would enable a precise evaluation to be made of this minor flowsheet variation.

Conclusions:

1. The use of grade-recovery curves from the Mitsui data in the usual manner that flotation grade recovery curves are applied is a misapplication of data.

2. Flotation rate curves for an ore feed varying by time and type are useful for predicting mill metallurgy and support the Mitsui conclusions.

3. The Mitsui report contains a wealth of information providing guides to further mill improvements. It also employs techniques which should be adopted for further studies of Vangorda and Grum ores.

Respectfully submitted,

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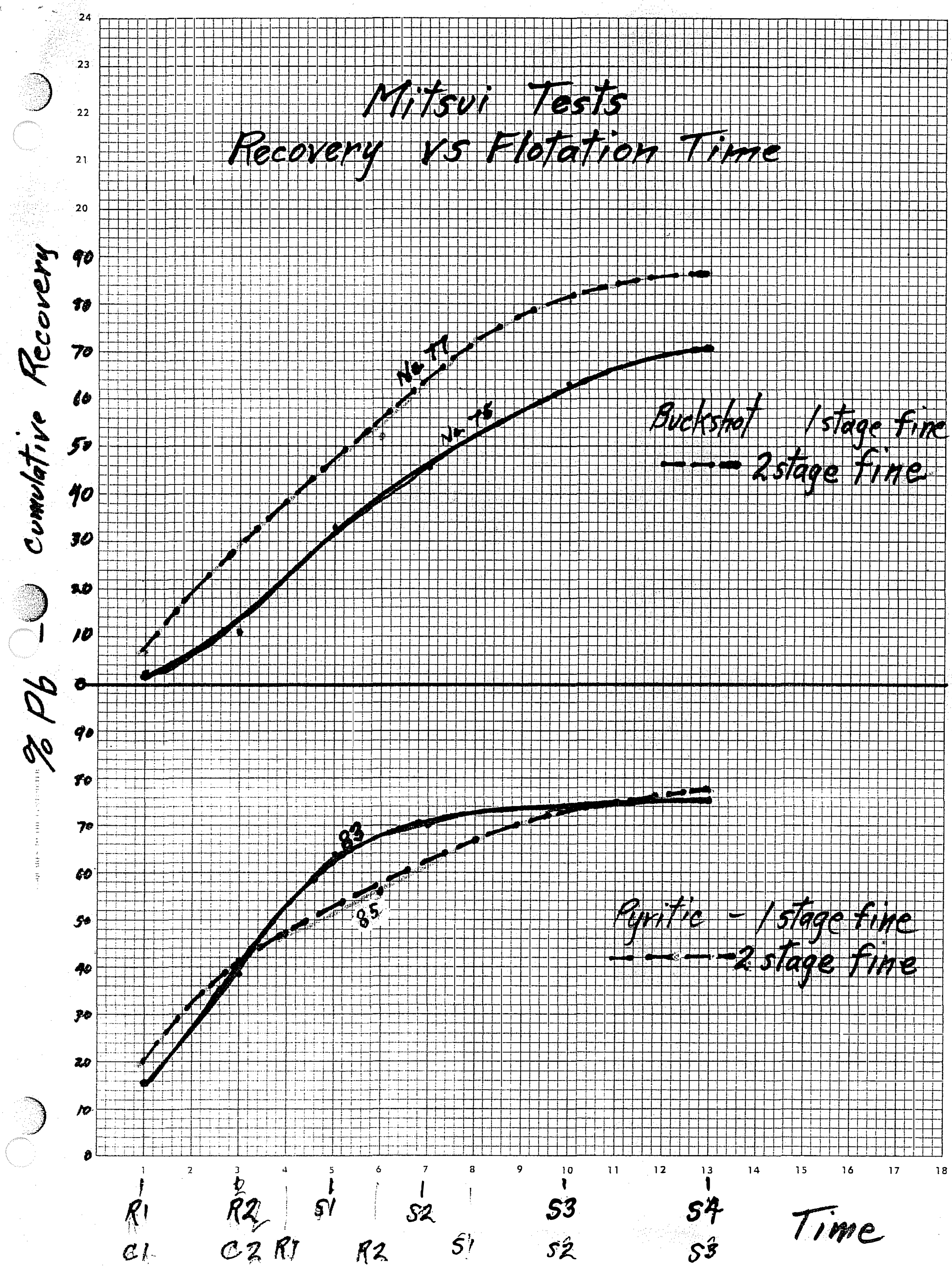
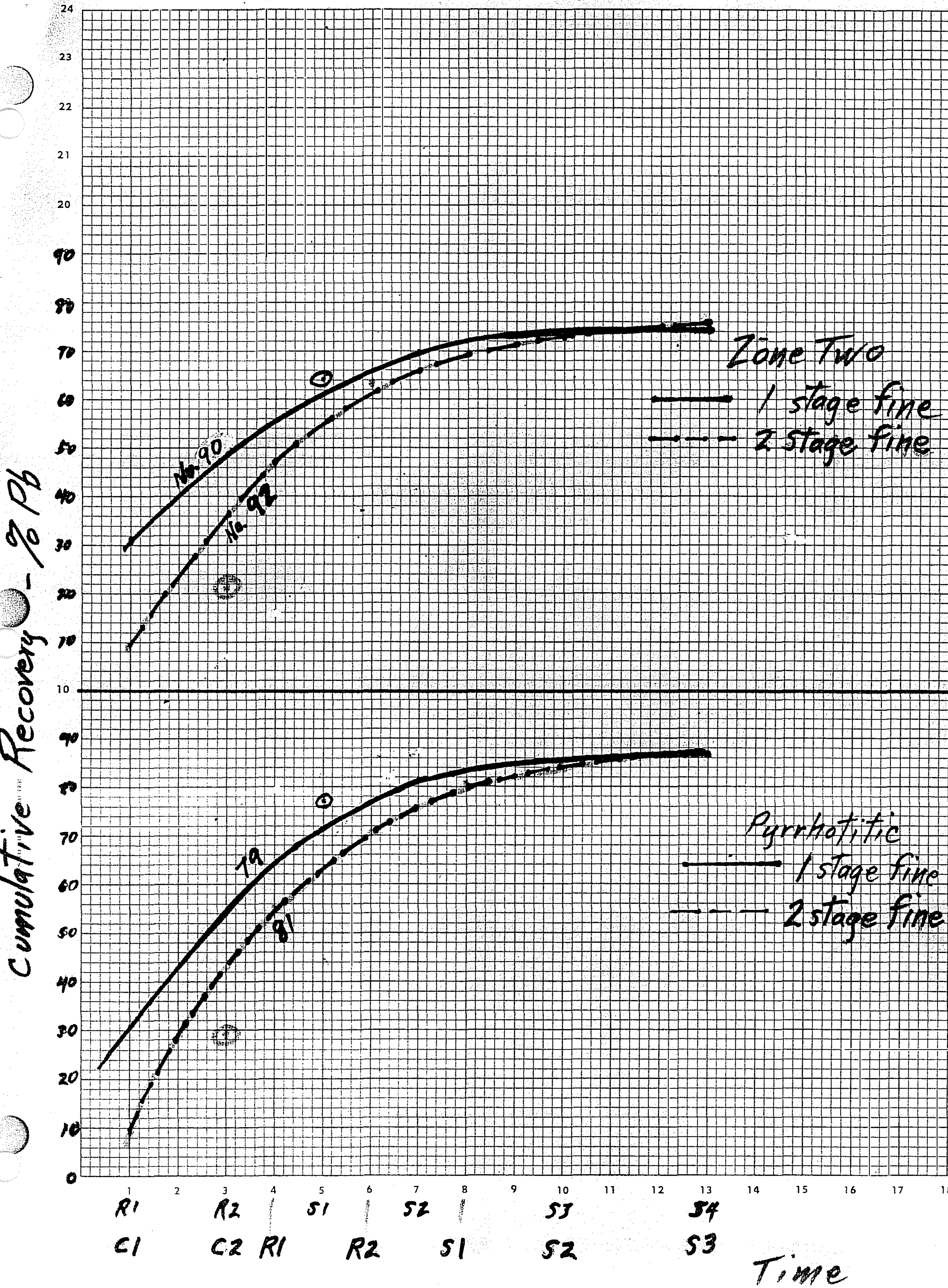
HRS:sgw


Mitsui Tests
Recovery vs Flotation Time
% Pb — Cumulative Recovery
No 77
No 78
Buckshot 1 stage fine
2 stage fine
83
85
Pyritic - 1 stage fine
2 stage fine
R1 R2 S1 S2 S3 S4
C1 C2 R1 R2 S1 S2 S3
Time


Cumulative Recovery - % Pb
Zone Two
1 stage fine
2 stage fine
No. 90
No. 92
Pyrrhotitic
1 stage fine
2 stage fine
79
81
R1 R2 S1 S2 S3 S4
C1 C2 R1 R2 S1 S2 S3
Time