OLIVINE USES AND BENEFICIATION METHODS

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Summary

Olivine, the magnesium, iron orthosilicate - $(Mg,Fe)_2 SiO_4$ - has a variety of uses based either on its refractory properties or magnesium content. Crude block or crushed olivine has been used for years in its natural form or mixed with various binders in the basic refractory industry.

A growing use, and potentially one of the largest tonnage wise, is in the manufacture of a synthetic molding sand for the foundry industry. This usage originated in Norway where several large foundries have installed olivine in preference to silica sand to overcome the silicosis hazard. One West Coast producer is offering olivine sand on the American market and technical reports indicate encouraging results in manganese steel and non-ferrous metals castings.

The North Carolina State College Minerals Research Laboratory at Asheville North Carolina has conducted four pilot plant scale investigations into the beneficiation of olivine from several of the North Carolina ore bodies. The feed for these pilot plant tests was obtained from two active quarries and represented the type of material likely to be encountered in large scale mining of the deposits. The object of the studies was to show the possibility of producing a synthetic molding sand, and to produce enough material to sample the foundry industry. The projects were carried through to a successful conclusion, and the information supplied by participating foundries indicates that sand produced by flotation methods from the North Carolina olivine deposits compares favorably with sands from Washington State and Norway presently employed in this country and in Europe.

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Most of the uses of olivine are based on one or more of its particular properties. For instance, olivine is a highly refractory material with a sinter point of 2850-2900°F and a fusion point in excess of 3000°F. This property of the material gives rise to numerous uses in the refractory industry such as block olivine for furnace linings, crushed olivine mixed with a binder for refractory brick manufacture, ladle linings, patching compounds and ramming mixes. Another use of olivine with a direct relation to the refractoriness, and potentially the most important in terms of tonnage usage, is in the field of foundry molding sands. Considerable research effort, both in this country and in Europe, is being applied in an effort to delineate the advantages and limitations of a manufactured olivine foundry sand. An analysis of the literature would indicate that heavy steel castings, such as manganese steel, and the non-ferrous metal industry offer the most promise for olivine sand today. However, due to the continuing research by the foundry industry, this picture might well be enlarged to include various other types of metal castings. One American producer of olivine on the West Coast has recently begun to offer commercial quantities of olivine foundry sand to the foundry industry. Another producer in the East has offered experimental lots of sand of probable North Carolina origin to the industry.

The beneficiation methods employed by producers of North Carolina olivine are quite crude and simple and consist primarily of selective mining, hand cobbing and hand picking. Since all the operators produce either a crude lump or crude crushed product, these methods are satisfactory. However, if it is desirable to produce a high grade olivine sand for foundry purposes, more elaborate methods must be employed.

In August, 1953, the North Carolina State College Minerals Research Laboratory in Asheville, North Carolina undertook a project involving the production of an olivine foundry sand from two North Carolina deposits. This project required the use of low grade ore such as could be produced on a large scale and specified that a low ignition loss on the final product was essential (Note I). Approximately 35 tons of ore was handled by the Laboratory and processed according to Flowsheet I shown in the appendix. Basically, the material was ground to pass 14 mesh in a rod mill, passed over a Humphreys spiral where the slimes and "flaky" or elongated "needle-like" deleterious minerals were removed. From the spiral the olivine went to a screw classifier where additional fines were removed and the sand was thickened before drying. Approximately 25 tons of sand were prepared in this manner and delivered to the project sponsor for evaluation. The recovery of olivine sand assaying 0.9 to 1.4 percent ignition loss ranged from 70 to 73 percent by weight of the original feed.

The sponsor reported to the Laboratory that the sand did not respond satisfactorily when used for steel castings. The information provided was quite limited, but it was suggested that fusion of the sand caused by the fluxing effect of deleterious minerals remaining was a prime factor in the failure. Since olivine, theoretically, has no ignition loss, it is obvious that either some of the olivine surfaces have been partially altered to serpentine or some talcose minerals remained in the sand fraction. After checking into the matter of ignition loss, it was found that both conditions existed.

Early in 1956, the subject of producing a foundry sand from olivine was again revived, and it was decided that the Laboratory would undertake, as an unsponsored project, the task of producing a very low ignition loss sand by flotation methods. Accordingly, samples were obtained from nine olivine bodies found in the Western part of North Carolina. All of the bodies sampled contained sizeable tonnages of reserves and three were actively producing refractory grade material. Subsequent batch testing proved that a product of low ignition loss (less than 0.5 percent) and fair recovery could be produced from six of the ores. The process developed during the batch testing involved grinding to 48 mesh, removing talcose minerals with a frother, and floating the clean olivine grains with a fatty acid. The table below lists the deposit name, ignition loss, and

<u>NOTE I</u> - The basis for using ignition loss as a measure of quality is this - pure, unaltered olivine has no water of crystallization, therefore, little or no weight loss on ignition. On the other hand talc, chlorite, vermiculite, ocherous clay, serpentine, bronzite, asbestos, in fact, nearly all the accessory minerals in crude olivine, have water of crystallization and consequently show from 5 to 15 percent weight loss on ignition. Therefore, determination of ignition loss on the various pilot plant products serves as an index to the amount of accessory minerals contained therein.

recovery obtained when the standard process was applied to the nine samples.

Name of Deposit	% Ignition Loss	% Wt. Recovery
Dark Ridge	0.30	61.9
Balsam Gap	0.31	59.9
Day Book	0.20	53.1
Doe Bag	0.42	43.8
Webster	1.37	73.1
Addie Dump	0.98	31.7
Buck Creek	0.53	33.2
Number Nine	0.42	54.0
Newdale	0.44	53.3

The results of batch testing indicated the possibility of producing a high grade olivine foundry sand by flotation methods. Subsequently, a pilot plant investigation was conducted during the summer of 1956. Since three deposits were being worked for refractory grade material, and mining and crushing facilities were available at each, one of these ores, the Day Book deposit, was chosen as feed for the pilot plant. The ore represented a material of considerably lower grade than that being mined and one that would probably be encountered when handling large tonnages from the deposit.

A series of continuous tests was conducted on 21 tons of Day Book low grade ore. The table below shows the conditions and results obtained when this ore was processed according to Flowsheet II as shown in the appendix.

Olivine Pilot Plant

Conditions:

Mill Feed

1. New Feed -------------------------------- 233 #/hour - 1/2" crude.
2. Circulating load ----------------------- 800 #/hour

Total 1033 #/hour

Percent solids in mill = 50%

Reagents	Amount #/ton	Where Added to Circuit
Sodium Silicate	0.13	Talc conditioner
Pine Oil	0.15	Talc conditioner
Pine Oil	0.26	Olivine conditioner
Pine Oil	0.13	First olivine cleaner
Aliphat 44-B	0.70	Olivine conditioner
H_2SO_4	0.0 to 0.02	Olivine conditioner
H_2SO_4	1.7	De-oiling conditioner

Distribution of Products:

Product	% Weight	% Ign. Loss
Talc	8.1	-
Cyclone Product 2nd Class. O'flow	18.9	-
Tails	5.6	1.65
1st Mids	8.2	1.39
2nd Mids	2.6	0.82
Olivine Concentrate	56.6	0.33
Total	100.0	

Screen Analysis of Olivine Concentrates:

Size	% Weight	Cumulative % Weight
+48	1.0	1.0
-48+70	21.0	22.0
-70+100	36.8	58.8
-100+140	17.8	76.6
-140+200	15.5	92.1
-200+325	5.2	97.3
-325	2.7	100.0
Total	100.0	

Air Classifier Results

	Distribution
Product	% Wt.
Sand	83.0
Flour	17.0
Total	100.0

Screen Analyses

Sand			Flour		
Size	% Weight	Cum. % Wt.	Size	% Weight	Cum. % Wt.
+50	2.4	2.4	+50	0.2	0.2
-50+70	19.4	21.8	-50+70	0.7	0.9
-70+100	35.7	57.5	-70+100	8.0	8.9
-100+150	13.2	70.7	-100+150	6.8	15.7
-150+200	24.5	95.2	-150+200	38.3	54.0
-200+325	3.8	99.0	-200+325	28.1	82.1
-325	1.0	100.0	-325	17.9	100.0
Total	100.0		Total	100.0	

Chemical Analyses

	Percent		
	Sand	Flour	Heads
SiO_2	41.4	41.0	42.0
R_2O_3 ($-Fe_2O_3$)	0.6	0.7	1.0
Fe_2O_3	8.7	8.7	8.6
CaO	Tr.	Tr.	0.1
MgO	49.1	49.1	46.5
Ign. Loss	0.35	0.75	1.90
Total	100.15	100.15	100.10

After drying, the olivine sand was run through an air classifier to remove the -200 mesh fraction. This step was necessary to meet sand size specifications as well as to produce a fine olivine flour for dusting and partings.

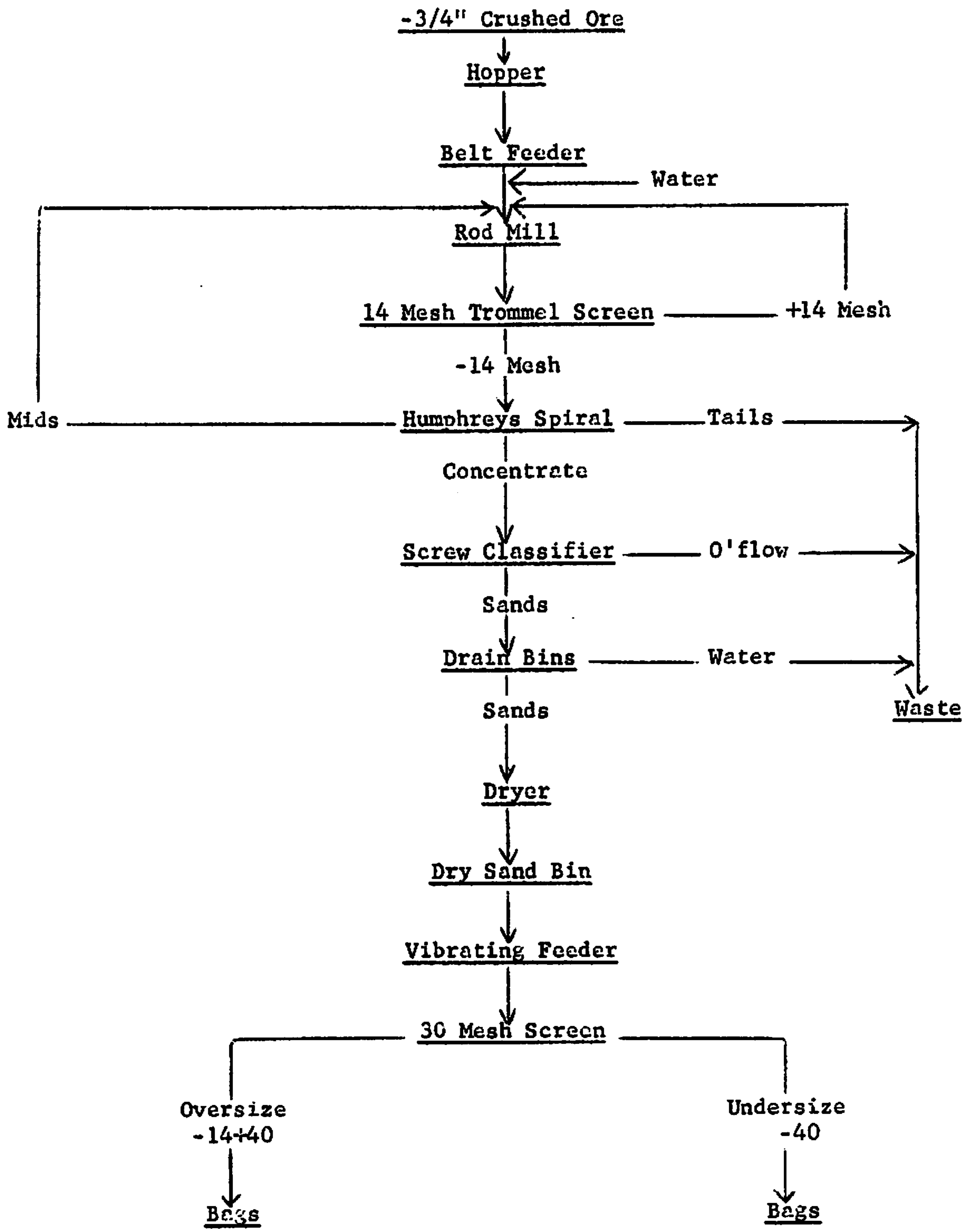
This operation proved that it was possible to continuously produce an olivine sand meeting foundry sand size specifications showing less than 0.5 ignition loss, and yielding a recovery of 55-60 percent of the feed weight from the Day Book olivine deposit.

Samples of the sand and flour produced during the pilot plant investigation have been distributed to various foundries throughout the United States. The information received from these foundries has been encouraging. See the appendix for samples of the reports on North Carolina olivine sand in the foundry. In two similar pilot runs, one in 1958 and one in 1959, a total of 40 tons of concentrate was produced for full scale foundry investigations.

It is probable that two by-products could be recovered while processing these olivine ore bodies for foundry sands. The presence of from 0.5-2 percent chromite in most of the ore bodies was observed but no efforts were made to separate this mineral from the olivine sand. It is conceivable that this chromite might be recovered by some simple step during the flotation process. All of the samples investigated carried up to 10 percent talc or talcose minerals which were removed during the flotation process. This material could probably be sold as is for mineral filler or cleaned to yield a medium grade talc product.

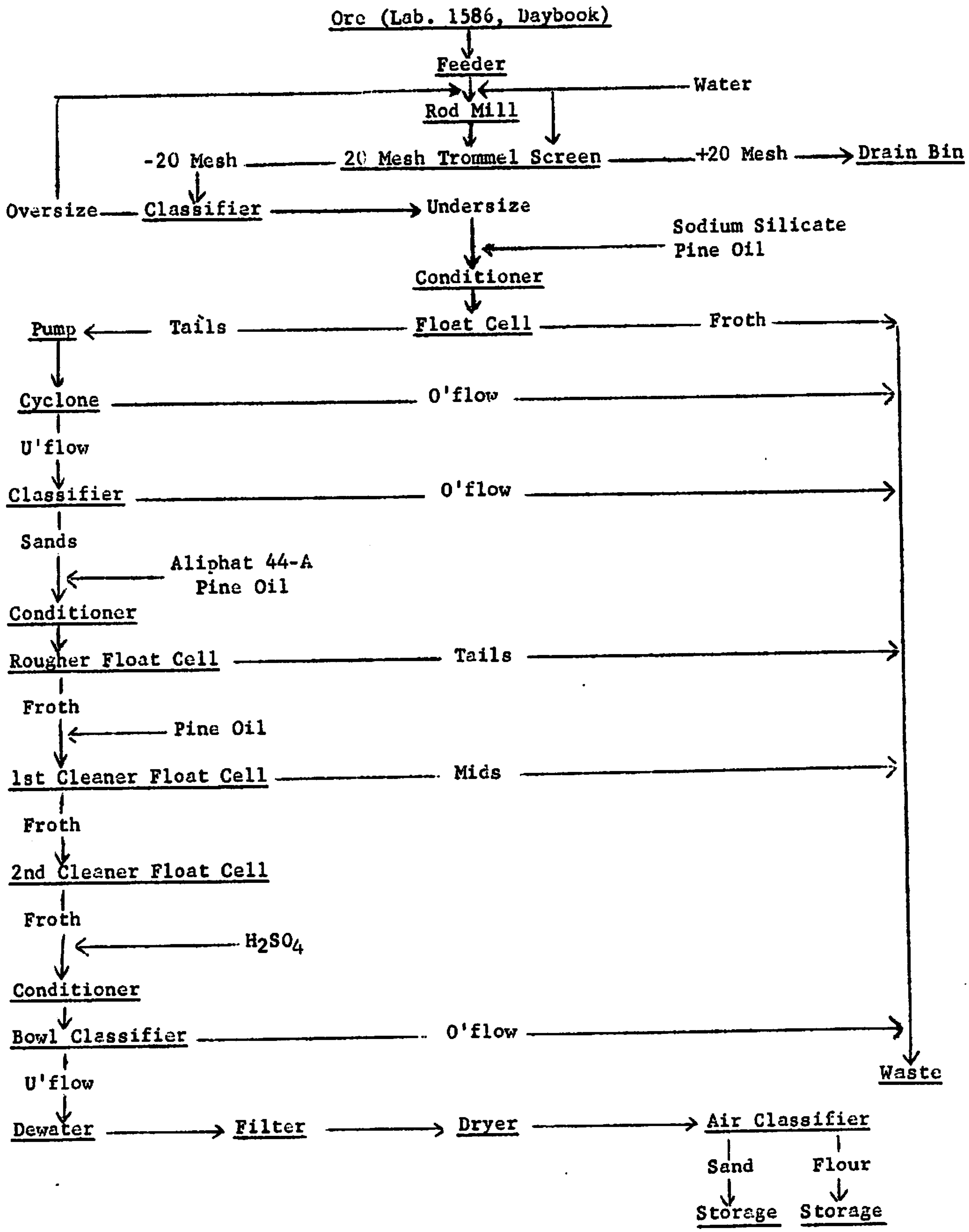
APPENDIX

Pilot Plant Flowsheet I - Humphreys Spiral Method



Appendix - Cont'd

Pilot Plant Flowsheet II - Olivine Flotation



Appendix - Cont'd

Foundry Analysis of Olivine Sand

To compare the mineralogy of commercial olivines, an operating foundry made chemical analyses of North Carolina flotation concentrates, fine sand from Aheim, Norway, and fine sand from Twin Sisters, Washington. The sands were dehydrated without oxidation before assay, metallic iron was removed, and the chemical laboratory was warned that the FeO in olivine will oxidize to Fe_2O_3 at temperatures above 1300°F, with an increase in weight. Assays were made for MgO, SiO_2, and total Fe as FeO.

Chemical Analyses

	Flotation Conc. North Carolina	Norway	Washington
MgO	51.65%*	50.73%	49.40%
SiO_2	40.62	41.94	40.18
FeO	7.56	6.83	7.86
Cr_2O_3	neg.	neg.	1.00 (estimated)

From these assays, the following mineralogical compositions are determined. The forsterite content is indicative of the refractoriness.

Mineralogical Compositions

	Flotation Conc. North Carolina	Norway	Washington
Forsterite	87.76%**	85.36%	85.49%
Magnesia	1.35		
Chromite			1.47
Fayalite	10.72	9.68	10.48
Enstatite		4.46	1.00
Other	0.17	0.50	1.56
Ign. Loss	0.336%	0.529%	0.297%
Sinter Point	(all between 2850° and 2900°F)		
Fusion Point	(all above 3000°F)		

The sinter point tests indicated the Washington and Norwegian olivines to be equal in refractoriness. The North Carolina flotation concentrates were slightly superior.

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* Slightly high due probably to error in chemical analysis.

** Forsterite content slightly high due to high MgO analysis.

Appendix - Cont'd

Core Mixtures

Olivine Sand
Cereal (corn)
W. Bentonite
Iron Oxide
Core Oil
Fuel Oil
Water

Mull sand and dry additives 1 min; add water, mull 2 min. add oil, mull 1 - 1½ min. add fuel oil, mull 30 sec.

Properties

Cores baked at 420 degrees F for 30 min.
Green Permeability - 32.
Dry Permeability - 50.
Surface Hardness 100 plus
Tensile Strength (psi) 235, 240, 245, 265
Normal tensile strength for above mixture using a # 60 New Jersey silica sand would be 200-225 psi.

Shell Molding and/or Core Mixtures

20 lbs. olivine sand, 1 lb. (5%) of dry phenolic resin, mull together for 10 minutes.

Properties

Tensile strength (psi) - 340, 330, 360, 310, 340, 350.
This is slightly higher than other angular or subangular sands of comparable finenesses.