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A study of the settlement of slimes

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"A STUDY OF THE SETTLEMENT OF SLIMES"

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A STUDY OF THE SETTLEMENT OF SLIMES

PREFACE

The purpose of this thesis, as originally planned, was to determine the effect produced by certain substances called electrolytes upon the mill product known as " slimes".

The subject presented an ever increasing number of new problems as it progressed and some work along the line of several of these branches is embodied in the following pages.

Reports of investigation and behavoir of slimes when treated for quick settlement are few and unsatisfactory. Our results may prove nothing already unknown , but the fact that so little data is easily accesible has been the motive for this thesis.

DEFINITION OF SLIMES.

Mr A.W. Warwick defines slimes as "West. Chem. & Met. Vol. No.2w p 51.
" That portion of the crushed ore which, owing to its containing combined water , possesses the property of forming colloid hydrates when mixed with water."

An unsigned note from the reference given " M.&S.P. May t 5, 1908.
defines the term "slickens" as follows;

" Slickens is that portion of anslime which packs and will form a bottom in a running stream that will resist scour. In modern parlance slime has superseded fine and means only finely comminuted ore."

Buttersays, " In slimes we found a substance M.& S.P. April 1898.
which could not be leached or thru which solution would not percolate but which had to be washed by decantation."

DEFINITION OF ELECTROLYTES.

An electrolyte is any substance which on going into solution, is subject to ionic dissociation.

EXPERIMENTS ON PURE MINERALS.

An attempt was made at the beginning of the investigation covered by this thesis to determine the relative differences in the rate of sudsidence of particles of comminuted ore or minerals when constituting a pulp of medium density.

The ratio of solid to liquid taken was 1 to 12, this ratio being about an average mill pulp sent to the settling vats. This average was obtained from flow sheets of mills in various localities.

The minerals selected for the test were those which could be obtained in well defined crystals or masses free from gangue material. The substances available were galena, sphalerite, quartz, calcite, and pyrite.

REDUCTION.

The reduction of the minerals offered the first problem.

The methods used were, a power triturating crusher, a battery of gravity stamps, a power muller, and a mortar and pestle.

In addition to these machines which were available it was advocated that we also try tube mill grinding since this machine is recognized as the most efficient fine grinder.

The ore-dressing equipment of the school includes no tube mill hence the construction of such a machine became a necessity.

A piece of six inch cast iron soil pipe twenty-two inches log long was attached to a face plate which carried a gearing,; the open end of the tube was then stopped by a plug operating on a shaft which was in turn supported on a rest attached to the base.

A small motor was used for power, being belter to the pulley of the gear driving the tube.

This machine gave very satisfactory results. The rate of drive was about thirty revolutions per minute. With dry grinding this device gave a 200 mesh product, the finest screen at our disposal.

Mr. M.P. Boss states that " Aeration in process of crushing greatly increases the visual evidence of slimes." M.& S. P. Oct. 1906. He further gives a case from his own experience, comparing the products of stamps with fine grinders, stating that the stamps produced slimes while Chilean mills produced none at all.

In accordance with this suggestion the stamps were next utilized. The mortar and screen were made water-tight and the stamps run without the addition of any more water after the pulp had reached the proper consistency for good work.

The triturating crusher was next employed. It was found to work well on the calcite but the quartz was too hard and the sulphide minerals were ignited by the mechanical heat generated.

The muller wworked satisfactorily on all the minerals but was too slow to be of any use other than on small quantities at a time.

The mortar and pestle were occasionally used to reduce the pulp to the finest possible condition for small quantities for experimental purposes.

The results of the reduction and settling tests are given in the following tables.

Machine	Mineral	Time Pulp Clearing hrs	minutes
Tube Mill	Galena	000	10
"	Sphalerite	000	10-12
"	Pyrite	000	8-10
"	Quartz	1	30
"	Calcite	000	30
Stamps	Galena	000	10-15
"	Sphalerite	000	"
"	Pyrite	000	"
"	Quartz	1	30
"	Calcite	000	45
Triturating	Galena	Could not be reduced	
Crusher	Sphalerite	" " " "	
"	Pyrite	" " " "	
"	Quartz	" " " "	
"	Calcite	000	30

The muller and mortar show about the same results as the stamps but the small quantities used could not be considered representative.

In the settling tests a 500 cubic centimeter graduated cylinder was used. The pulp was diluted, thoroughly shaken and allowed to stand in a good light. Observations were taken and the rate of settlement noted.

The tabulated results show that pure metallic or crystalline minerals do not form slimes under any conditions of reduction. That the earthy or crystalline minerals do not form a true slime as defined in current literature on the subject. That stamp mill reduction tends toward the production of a material more nearly resembling slime than any other form of grinding.

The reason for the rapid rate of subsidence is explained by the microphotographs in plates 1. 2. & 3. These plates show that the metallic minerals break in angular particles with sharp edges even when ground to pass 200 mesh. They may be classed as fine sands and while slime treatment might be advantageous

tageous, they do not partake of the nature of slimes as far as concerns speed of settling.

EXPERIMENTS ON CLAYS.

The previous set of experiments on the metallic and crystallin minerals led to the work on clays reported below.

Two clays of entirely different character were used. The first one was a fire-clay from the Denver Fire-Clay Company. The second a calcareous clay of local origin.

These clays were mixed with water in varying propostions from 1% to 4% solids, mixedm agitated and settled in the same manner as in the previous experiments. In no case was the solution cleared in less than 48 hours.

The colloid appearance of the pulp, the time required for settlement and the dense nature of the precipitate all show that the argillaceous substance is, in this instance the cause of slimes.

Water of Hydration.

To determine what effect the elemination of water of hydration would have upon the formation of slimes, a series of roasting tests were carried out as follows.

In shallow roasting dishes were placed small quantities of the various clays. One set of these samples was then subjected to a heat of 150 degrees for a period of two hours.

The other set of samples was heated for a corresponding length of time at 1100 degrees (Centigrade).

The samples were then weighed out in 10 gram portions and placed with 500 cubic centimeters of water in a graduated cylinder shaken and allowed to settle. After the coarse portions of the clay had settled out, the remaining pulp was allowed to settle for four hours and this substance treated as slime.

The lower temperature is sufficient to drive off the water of hydration and the higher the combined water which latter was effectually accomplished since the fire clay lost its plasticity.

In both cases an abundance of slimes resulted, the slimes being heavy, gelatinous substance which remained suspended after 48 hours had elapsed.

This set of results indicates that the formation of slimes is due to some other cause than water of hydration or combined water.

Sizing Tests.

The dried and burned clays were next put through a series of screens and as a comparison a sample of the raw clays was run simultaneously. The results are shown in the table below.

Mesh	Raw Clays	After Heating to 150 deg. C	to 1100 C.
On 20	Clear	Clear	Clear
On 40	Slime	"	"
On 60	"	Slime	"
On 80	"	"	Slime
Thru 100	"	"	"

The results of this screen test suggest that the production of slimes is a function of the fineness of grinding the clayey material of the ores.

TESTS ON ORES.

The ores used were of widely varying character in order to differentiate the results as much as possible. No attempt to run a large number of ores was made since the results for a given ore are true for that ore alone and the data obtained would be of no value other than for the individual sample.

Three ores were used.

(1) An ore from the Homestake, S.D. mines. A hard pyritic ore composed of Copper, Arsenic, Iron, Alumina, Silica. No clayey gangue was present to macroscopic examination.

(2) A South Dakota ore, a highly silicious ore containing a small quantity of gold, some iron, large quantities of alumina and silica.

(3) A manganese ore from Colorado. Contained Manganesem silica, alumina, iron, copper and lead.

(4) A clayey lead ore from the vicinity of Rolla with lead-sulphide, clay and barium sulphate present.

These ores were first broken dry to pass 20 mesh, a sample of 200 grams placed in 500 C.C. of water, well shaken and allowed to settle for four hours. At the expiration of this time the solution and suspended matter were siphoned off, dried over a water bath and weighed. This process was repeated with the settled portion crushing to pass 40 and 60 mesh in turn. The results are here tabulated.

Ore	Mesh	Wt slimes produced.
No.1	Thru 20	1.6 gms
"	" 40	1.65 "
"	" 60	1.8 "
No.2	" 20	2.0 "
"	" 40	2.6 "
"	" 60	2.7 "
No.3	" 20	1.0 "
"	" 40	1.3 "
"	" 60	1.6 "
No.4	" 20	5.0 "
"	" 40	5.0 "
"	" 60	5.4 "

Here the results indicate that the fineness of reduction is only of minor importance and that the production of slimes is a characteristic of an ore due to some contained substance.

MICROSCOPIC INVESTIGATION.

With the object of determining the nature of the material forming slimes in the ores a series of microscopic examinations were made.

A scale of 200 lines to the millimeter was made by means of the dividing engine. A drop of the liquid containing the suspended material was placed on this scale, allowed to dry without heating in order to prevent flocculation. The slides were then plased under a high power petrographical microscope. The particles were too small to give any definite results with the polarizer and the determination is only thought to be grains of silica with possibly some particles of amorphous aliminium-silicate. The series of photographs shown in plates 3,4, & 5 are the results of these examinations.

The particles as shown by the lines on the ruled scale vary between 0.002 mm and 0.006 mm and finer.

Prof. Richards, in determining the settling velocities of very fine particles in water found that particles as fine as 0.0025 mm would descend at a rate of 0.09 mm per second and that the rate of descent of such particles varies as the square of their linear dimensions. These particles are then not caused to remain in suspension by their minute size. That they do remain suspended and that the particles are not of uniform size indicates that there must be some chemical or physical change in the suspending medium.

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EFFECT OF ELECTROLYTES.

The next step was the determination of the relative values of the different electrolytes in aiding the settlement of the suspended material.

For this purpose were used only the generally recognized slime making materials, viz. clay, chlorite and talc.

The solids were ground to pass 200 mesh, mixed with water, agitated and allowed to settle as in the preceding experiments. The slimes were not washed since it was desired to obtain as heavy a pulp as possible.

A small quantity of polishing rouge was added to the pulp to give a clearer line of demarcation between pulp and clear solution. Experiment proved that the rouge had no effect on the settling.

The results of this series of tests are shown in the curves in plate 6. These curves represent a large number of determinations under identical conditions.

Results of experiments of like nature are shown for the calcareous clay in plate 7.

The first series of curves for the fire clay are fairly uniform. The calcareous clay showed some remarkable eccentricities when different conditions were used. CaO, for example produced rapid settlement and left a clear solution, while NaOH acted more slowly but otherwise equally well. Alum and H_2SO_4 failed to accomplish settlement in 70 hours. The roasted clay through 100 mesh gave only a small percentage of slimes which settled so rapidly upon the addition of CaO and NaOH that no curve could be obtained. Alum and sulphuric acid, however had the same effect as before.

Microscopic Examination.

The series of microphotographs, plates 8 et seq. show the clays both previous to and subsequent to the precipitation by electrolytes. Representative slides were made from a large number prepared.

The granular character of the suspended particles and the flocculent character of the same after precipitation are well shown in the photographs.

Mr. H.S.Nichols describes a series of tests on a granitic clay under varying conditions. Our results so conform to his in the matter of the effects of temperature that the curves are not presented here.

M. & S.P.
July,11m, 1905.

On the contrary, our results concerning the effect of electrolutes are so greatly contrasted with his that it seems only reasonable to suppose that the chemical composition of the clay is an important factor in the use of an electrolyte.

CaO in every instance gave a clearer solution after settlement, the other electrolytes giving an opalescent appearance to the supernatant liquid.

Freshly broken samples of talc and chlorite when ground to pass 200 mesh gave a cloudy solution which cleared after a period of less than two hours or less hence could not be called slimes nor classed with the slime making material.

The amounts of electrolyte to be added were determined after a wide range of experiment. The constant amount finally determined was 50 C.C. of 4% solution.

CONCLUSIONS.

From the foregoing experiments the following conclusions are deduced.

(1) That pure metallic or crystalline minerals do not form slimes under any conditions of reduction.

(2) That neither water of hydration nor water of composition are responsible for the formation of slimes in a clayey substance.

(3) That suspension of fine particles is not due to the linear dimensions of the particles but to some chemical or physical change in the suspending medium such as increased viscosity, density or molecular attraction.

(4) That the presence of alumina and silica in all the substances examined and experimented upon would indicate that one or both are responsible for the occurrence of slimes since their presence probably means the exiztence of clay as a result of decomposition by weathering. This theory is confirmed by the action of NaOH according to the well known reaction from qualitative analysis.

(5) That fine grinding is, in a measure responsible for slimes since it would set free more of the clayey material.

(6) That no general rules for the addition of electrolytes may be deduced since an action is not duplicated in any two substances.

(7) That the effect of an electrolyte does not increase with increase in amount after a certain point, a small percentage acting as promptly and well as an excess.