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**In 1982, the name of the International Superphosphate Manufacturers' Associations (ISMA) was changed to International Fertilizer Industry Association (IFA).*

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# PRESENT TRENDS IN THE DESIGN OF FLORIDA PHOSPHATE BENEFICIATION PLANTS

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Since 1938 about 700 million tons of phosphate rock have been mined from a small area in central Florida. (See Fig. 1.) This deposit has been so rich and uniform that a standard mining and beneficiation flow sheet developed in the 1930's is still being used. There are variations in detail but all the current plants in central Florida follow this same basic flow sheet. (See Fig. 2.)

Current practice in Florida is to remove overburden with 30-65 cubic yard, long boom draglines. The draglines can cast the overburden across the exposed matrix into a previously mined cut. The dragline is then used to dig the matrix and place it in a slurry well on the bank.

From the well the matrix is pumped several miles to a central beneficiation plant. This plant consists of a washer which breaks down and separates the matrix into three components. The first is a finished +16 mesh pebble product, second is -16 flotation feed, and third is clay tailings.

The flotation feed is usually sized into plus and minus 35 mesh fractions and treated in parallel coarse and fine flotation circuits to increase recovery of the phosphate values. Flotation is accomplished in two stages -- an anionic rougher and a cationic cleaner.

The products are usually dried at the mine or shipped wet and dried at the port before loading.

While this "standard" flow sheet has served the Florida phosphate industry well for more than forty years, a new era is rapidly approaching.

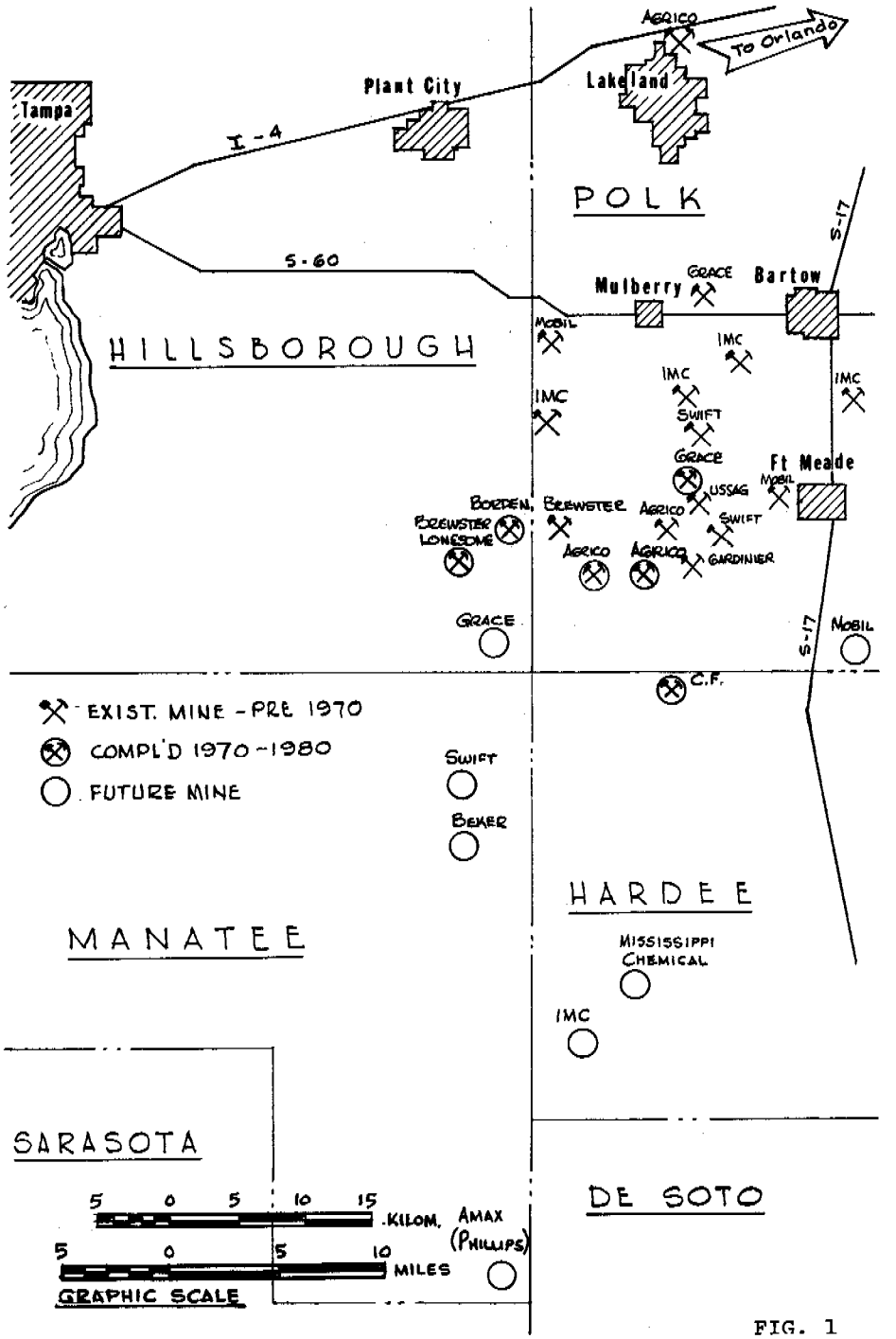
Many factors which demand change seem to be converging during this decade. First, the rich north-central region is being mined out and the reserves to the south have different ore body characteristics. Second, environmental and conservation regulations are becoming much more stringent. Third, the cost of energy has risen abruptly.

Looking at each of these factors in more detail....First, the reserve deposit characteristics:

1) More variable
2) Deeper matrix
3) Less pebble (washer product)
4) Lower I & A and higher carbonates
5) Lower grade flotation feed.

Second, environmental and conservation regulations:

1) Rapid land reclamation
2) Clay tailings disposal at higher concentration


AGRICO
To Orlando
Lakeland
Plant City
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I - 4
POLK
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SWIFT
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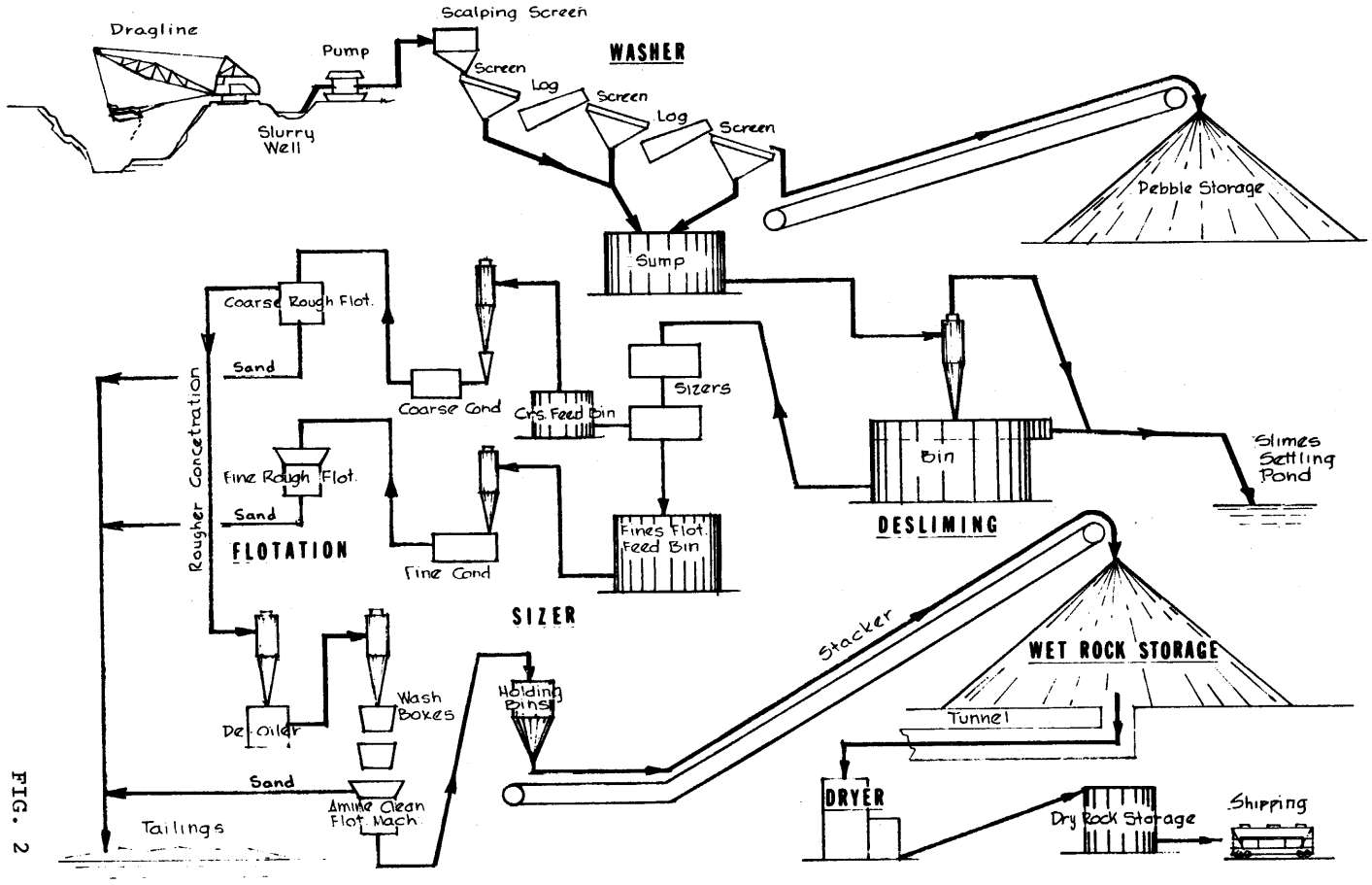
Ft Meade
MOBIL
USSAG
BORDEN
BREWSTER
AGRICO
SWIFT
FORMSTER
LONESOME
AGRICO
AGRICO
GARDINER
HILLSBOROUGH
GRACE
S-17
MOBIL
C.F.
EXIST. MINE - PRE 1970
COMPL'D 1970-1980
FUTURE MINE
SWIFT
BEKER
HARDEE
MANATEE
MISSISSIPPI CHEMICAL
IMC
SARASOTA
DE SOTO
5 0 5 10 15 KILOM.
5 0 5 10 MILES
GRAPHIC SCALE
AMAX (PHILLIPS)

FIG. 1


Dragline
Pump
Scalping Screen
WASHER
Screen
Log
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Slurry Well
Pebble Storage
Sump
Coarse Rough Flot.
Sand
Coarse Cond
Crs. Feed Bin
Sizers
Fine Rough Flot.
Sand
FLOTATION
Fine Cond
Fines Flot. Feed Bin
Rougher Concetration
SIZER
Bin
DESLIMING
Slimes Settling Pond
Stacker
WET ROCK STORAGE
Tunnel
Holding Bins
Wash Boxes
De-Oiler
Sand
Amine Clean Flot. Mach.
Tailings
DRYER
Dry Rock Storage
Shipping

FIG. 2

3) Water conservation
4) Wet lands restrictions
5) Elimination of drying in many situations.

Third, energy cost and availability.

Taking the "standard" Florida flow sheet as a structure, we will work our way through the flow to illustrate how these new conditions may influence changes in the mine and beneficiation plant.

Starting at the pit, the large draglines have served the industry well and are highly energy efficient. However, as the matrix deepens below 50-60 feet, it becomes difficult to dig the overburden and cast it far enough beyond the exposed matrix so contamination can be controlled. Also, more exacting and rapid land reclamation means moving the overburden longer distances.

Other mining methods are now being considered. These include dredge removal of overburden and matrix, and wheel excavator removal of overburden with dredge or dragline mining the matrix.

The dredge is of interest because it can mine deeper deposits without lowering the surrounding ground water table. The wheel excavator is unique in that it can dig matrix and feed it directly on a belt conveyor for low cost transport to land reclamation areas.

The high velocity slurry pipeline which has been the standard method for conveying matrix several miles to the plant is also being reexamined. Conventional slurry pumping is a high maintenance and energy method. At the same time the phosphate content of the matrix is lower in the reserves so much more material has to be handled all the way from the pit through the plant. Together these factors form a great incentive to seek a more efficient method. Brewster Phosphates has recently placed an innovative continuous belt conveyor system in operation at their new Ft. Lonesome Mine. Another contender being studied is reduction in size of the larger matrix particles at the pit to allow pumping the slurry at a lower velocity and higher density through plastic pipe.

After mining land reclamation is required to be done more exactly and quickly so mining and reclamation are beginning to be studied as a single system. The best mining method and the best reclamation method may not be the optimum when considered as one system. Mining and reclamation are complicated further by clay and sand tailings disposal and water recirculation. All of these considerations are presently coming under more restrictive governmental regulations and will require more meticulous planning and control.

After the matrix is conveyed to the plant it enters the washer. Here the matrix is subject to several stages of screening and scrubbing to break it apart so the +16 mesh pebble fraction can be freed from the clay and washed clean. This pebble has been a salable product with no further beneficiation. The reserve

deposits are less weathered and contain more carbonate contaminants. It may prove possible to remove most of these contaminants by adding crushing, screens, and gravity separation to treat a select portion of the pebble at the washer.

The other washer component which is a -16 mesh mixture of clay, silica sand, and phosphate is pumped through high efficiency wet cyclones to separate the -150 mesh waste material from the -16, +150 mesh material.

This -16, +150 mesh material is a mixture of silica sand and phosphate. Since the sand and phosphate particles are about the same size and specific gravity, selective froth flotation is used to separate them. In most plants this feed is first sized into two or three fractions to increase recovery in the flotation process. The fine (-35 mesh) fraction is universally treated in a two-stage flotation circuit. Anionic (fatty acid) reagents are used to float the phosphate first. This rougher concentrate is then scrubbed with sulfuric acid to strip the reagents before being cleaned in a cationic (amine) stage which floats the remaining silica from the phosphate. This two-stage reverse flotation circuit has also served the industry well for many years. It is very forgiving when the object is to produce a high grade product from a high BPL feed. As feed grades go below 15 BPL*, the chart on the following page (Fig. 3) shows how recovery of the phosphatic values rapidly drops. Study of this relationship shows that as feed grades below 15 BPL are encountered, the "standard" reverse flow sheet has reached the limit of its usefulness. Several possible variations or additions may help. In 1965 Minerals Recovery built a plant designed to process an average 13 BPL feed. This plant employed an amine flotation first stage which removed most of the -28 silica with very low losses. Amine reagents can be highly selective and this feature may be the basis for an improved circuit designed to handle low grade feed with high recovery.

Several different methods have been used to upgrade the coarse (+35 mesh) fraction of the feed. However, recovery has been poor except where the more complex skin flotation circuits are employed.

One interesting development has emerged from the present situation. Designers and operators of the mines and designers and operators of the chemical plants have been learning to communicate and cooperate. The demands for low energy consumption, pollution control regulations, and changes in the

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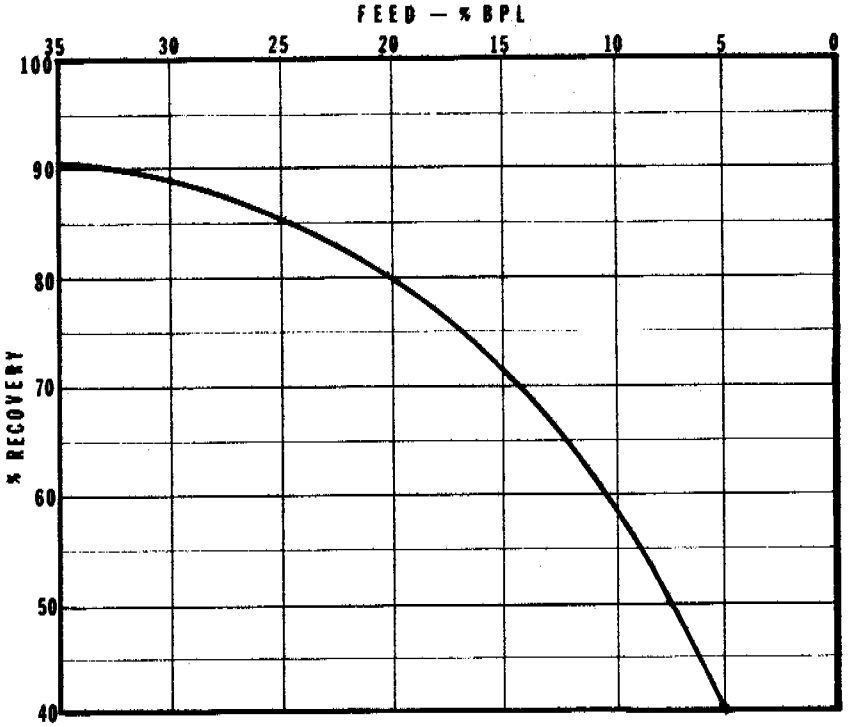
*While the fertilizer industry expresses phosphate content as $\%P_2O_5$ or P, the traditional term in phosphate mining and beneficiation is BPL (Bone Phosphate of Lime) which chemically is Tri-Calcium Phosphate.

$$\%BPL \times 0.46 = \% P_2O_5; \quad \%BPL \times 0.20 = \% P.$$




TYPICAL FEED GRADE VS. METALLURGICAL RECOVERY

FIG. 3

nature of the deposits are forcing a new evaluation of the overall mine, beneficiation, acid plant system. Local Florida processing of wet rock and elimination of grinding concentrates are subjects for discussion between the two operations. Separation and recovery in the coarse (+35 mesh) flotation circuit has always been a problem. If crushing of this coarse material to -35 mesh can take place in the beneficiation process, then excellent metallurgical results can be obtained in a simpler process. At the same time a suitable acid plant feed is produced that requires no further drying or grinding when used in modified local plants. Also being discussed is in which plant certain contaminants can best be removed. Some of the solutions that emerge from this more active cooperation will in time spread beyond Florida.

In some deposits it may also be necessary to remove carbonates from the flotation concentrates. IMC has developed an additional cleaner stage to accomplish this removal after conventional flotation. This process is the subject of another paper being presented by J. E. Lawver at the ISMA October Technical Meeting

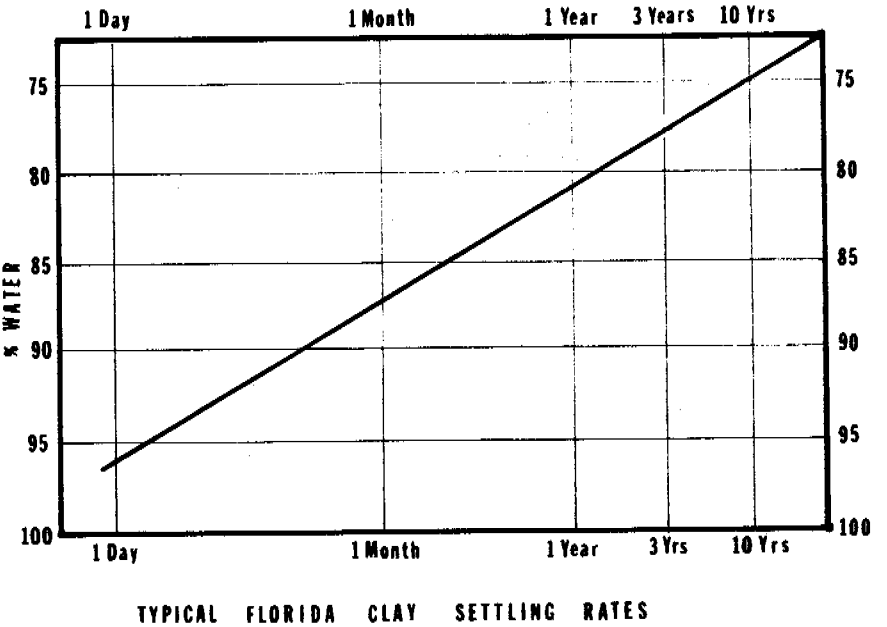



FIG. 4

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Disposal of the large quantities of difficult to settle clay tailings encountered in Florida matrix has always been a problem. Current practice is to settle the clay and clarify the water in large above ground settling areas. The clay settles very slowly in the form of a floc which includes huge quantities of water. A typical consolidation curve (Figure 4) shows that years after deposition the clay still contains 80% water. With increasing pressure from governmental agencies to minimize the above ground settling ponds and to maximize the recovery of water, it is fortunate that several years ago several of the operating companies as well as the Florida Phosphate Council began work to solve this problem. At the present time there are three methods that have received extensive field testing, the Brewster sand spray method, the IMC dredge mix, and the Phosphate Council flocculant enhanced thickener.

Looking toward 1980, we must realize that effective plant design is not the complete story. As operations become more complex, the Florida mine operator will be forced to plan in more careful detail further ahead. He is going to have to train and manage his personnel more effectively and maintain

the plant more methodically. In many cases, design, operations and maintenance merge.

A plant can be designed to be easy to operate or difficult to operate. It can be designed to be simple to maintain or difficult to maintain. A good example of this interrelationship occurs in the design specifications of materials of construction. As more and more tons of feed material must be handled throughout the process in order to produce a ton of product, the reduction of maintenance costs and downtime from abrasive failure becomes critical. One of the most effective means to reduce maintenance has been the use of highly abrasive resistant elastomers such as rubber or urethane. These elastomers are finding wide use as liners in slurry pipe, launders, and the wetted parts of machinery such as pumps, cyclones, and agitators. Even more extensive specification of these abrasive resistant materials in the original plant design can drastically reduce maintenance and increase plant utilization.

How long can Florida maintain a production rate of 40 million tons per year? To help answer this question the United States Bureau of Mines has recently funded a study to determine Florida phosphate economic reserves and resources. This study should be completed in 1978 and when published should form the basis on which a more exact picture of the future of Florida phosphate operations can be developed.

In review, Florida phosphate rock producers are indeed confronted with many new challenges. We are confident that creative design and effective management will allow the extensive Florida phosphate reserves and resources to be mined and processed in a way which will enable Florida to remain a major supplier of high grade phosphate rock for many more years.