Overview of the Agrium Kapuskasing Phosphate Operation.

Reno Pressacco, Geologist, Agrium - Kapuskasing Phosphate Operations
P.O. Box 92, Kapuskasing, Ontario P5N 2Y1
Phone: (705)337-4201, Fax: (705)335-3404

Introduction

Agrium•s history in fertilizer production and marketing goes back to 1931. Today, Agrium Inc. is a world leader in the production, distribution, and marketing of fertilizers and related products to the agricultural industry. Agrium is the largest North American producer of nitrogen fertilizers, a major producer of phosphate and potash fertilizers, and a world leader in fertilizer wholesale distribution and retail marketing. The mine at Kapuskasing is located some 40 kilometers southwest of Kapuskasing, Ontario (Figure 1). It has been developed to supply high-quality, low cost phosphate rock to the company•s Redwater, Alberta facility, where it is an ingredient in ammonium phosphate fertilizer production. The Kapuskasing mine is the only phosphate mine in Canada and will rank as one of the highest grade phosphate mines in the world (Clark and Duncan, 1999). Apatite is the principle ore mineral mined at the Kapuskasing Phosphate Operations.

Geology

The first record of exploration in the area was from a program executed by Continental Copper Mines in 1955 who evaluated the magnetic anomaly located in Cargill and Cumming Townships for it•s base metal potential. Intermittent exploration of the base metal potential of this magnetic anomaly continued in the following years, until the phosphate potential of the area was first examined in 1974 by International Minerals Corporation who recognized the presence of a layer of apatite sands overlying the carbonatite host rocks.

The local geology consists of a core complex of multi-phased carbonatite rocks which are surrounded by a ring of pyroxenite, and have provided a U-Pb age date of 1907 Ma +/- 4 (Sage, 1988). These two rock types are in turn situated within quartz diorite gneisses that form a large portion of the Kapuskasing Structural Zone (Figure 2). The carbonatite host rock is sub-divided into two sub-types: sovite and rauhaugite. The sovite is a medium to coarse grained, white, banded rock in which calcite is the dominant carbonate species and it includes accessory minerals such as phlogopite, magnetite, clinohumite, apatite, olivine, pyrrhotite, and amphibole. Apatite can reach 15% abundance in this rock type (Sage, 1988). In sharp contrast to the sovite, the rauhaugite appears as a massive, fine grained, dense, beige to tan coloured rock in which dolomite is the dominant carbonate species. Phosphate values can range to 14% P_2O_5 in the rauhaugite.

The high grade ore at the Kapuskasing Phosphate Operations is derived from the weathering and dissolution of the soluble minerals in the host carbonatite rock (eg. phlogopite). This process has left behind a residue of the insoluble minerals, largely apatite crystals, which is termed residuum. This residuum is formed above the host carbonatite, and is in turn covered by glacial deposits of lacustrine clays, and boulder tills of the Pleistocene age. Limited data suggest that this weathering took place during the late Cretaceous period (Sage, 1988).

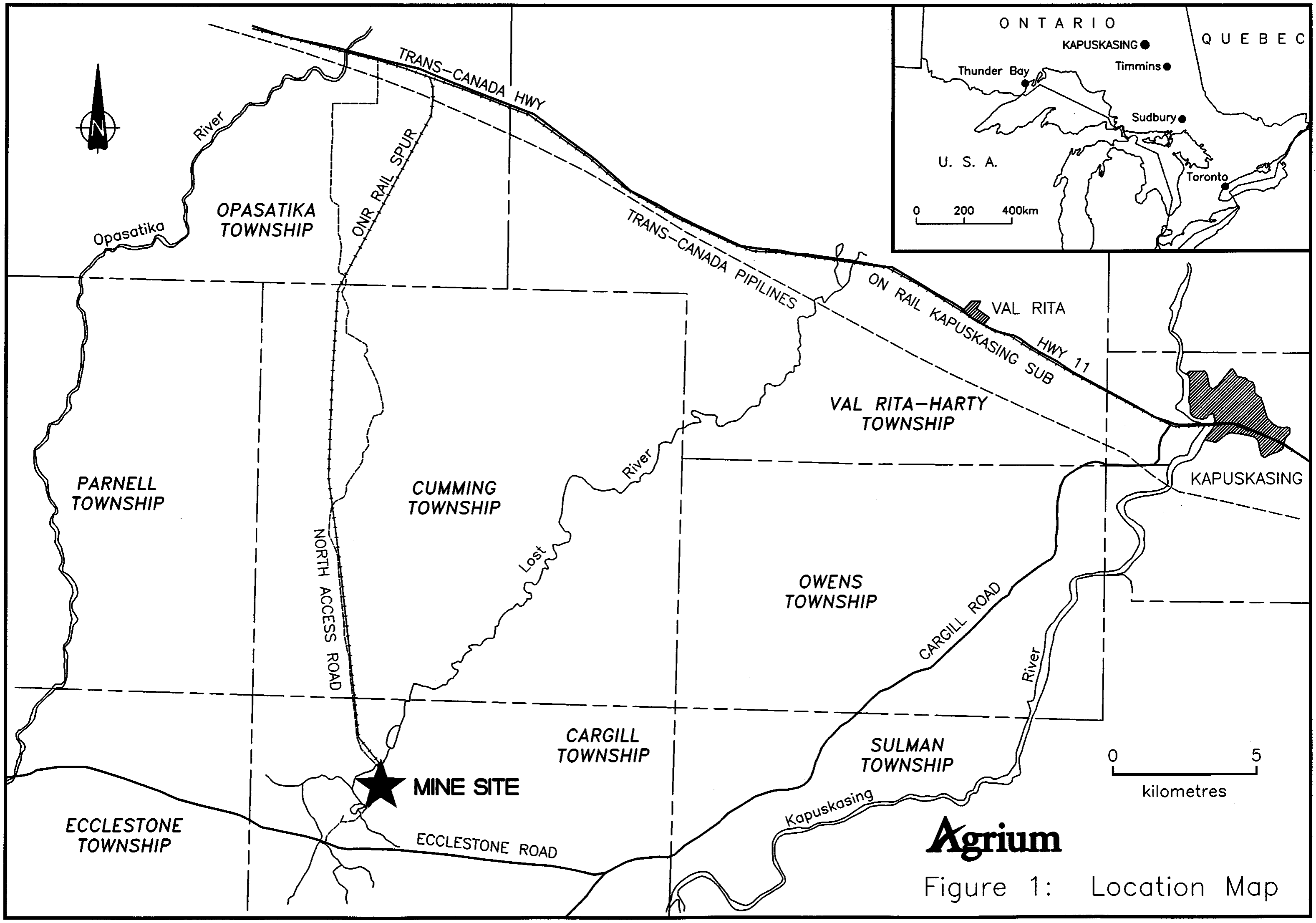
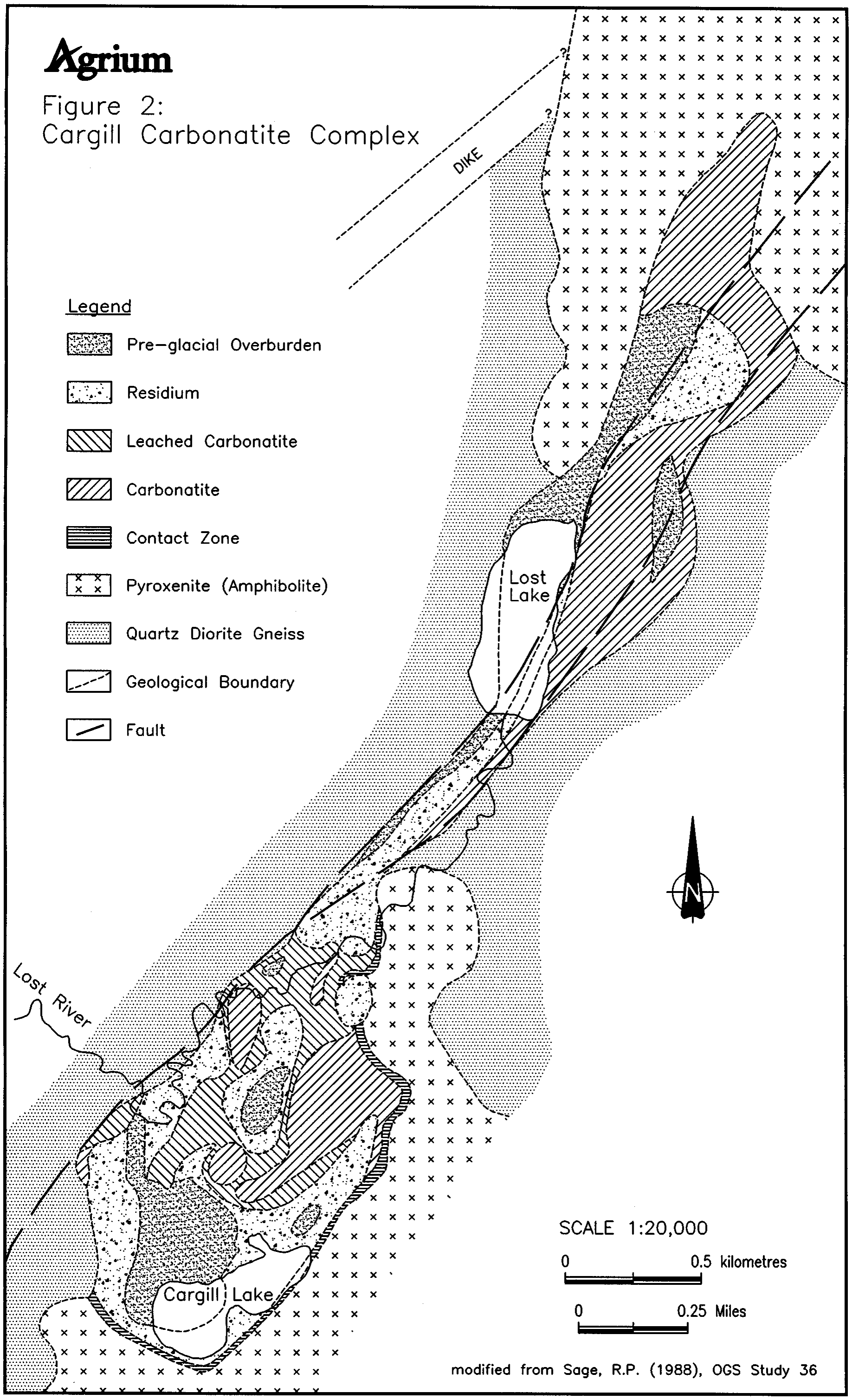


Figure 1: Location Map


Agrium
Figure 2:
Cargill Carbonatite Complex
DIKE
Legend
Pre–glacial Overburden
Residium
Leached Carbonatite
Carbonatite
Contact Zone
Pyroxenite (Amphibolite)
Quartz Diorite Gneiss
Geological Boundary
Fault
Lost Lake
Lost River
Cargill Lake
N
SCALE 1:20,000
0
0.5 kilometres
0
0.25 Miles
modified from Sage, R.P. (1988), OGS Study 36

Mining is currently being carried out in the Stage 0 open pit, where two principal types of residuum are found: A / Grey and B types. The A / Grey type ore is characterized by its low iron content and relatively high phosphate content (0 - 8% total iron, and >30 % P_2O_5). The A ores can vary in colour from white (essentially pure apatite sands) through tan / sandy brown to grey and dark grey to black. Pyrite and pyrrhotite are believed to be the dominant iron minerals in this ore. The B ores are characterized by their higher iron content and relatively lower phosphate content (8-30% total iron, and 15 - 30% P_2O_5). The colour of the B ores vary depending upon the dominant iron minerals and can be earthy brown, chocolate brown, wine red, tan, and rusty in colour. The principal iron minerals found in the B ores are magnetite, hematite, limonite / goethite, and ilmenite. The B ores are subdivided into a B1 and B2 sub-type based upon their iron content (B1, <20% total iron; B2, 20 - 30% total iron), however visual distinction between these two sub-types is often difficult.

Waste material is found both within the ores and stratigraphically overlying them. Within the ore in the Stage 0 open pit, waste products consist principally of white silica sands mixed with kaolin clays, and black organic material mixed with fine sand. The black organic material often contains fossilized tree material, and is suspected to be a swamp deposit of Cretaceous age. The overlying waste consists of a layer of boulder till that contains rounded boulders of granitic gneiss and assorted country rocks, and often is in direct contact with the orebody. This is in turn overlain by homogenous grey-blue clay and varved brown clay of suspected Pleistocene age.

Mining

The phosphate ores are found in three deposits (Main, A, and B Zones), all of which will be mined using conventional open pit mining techniques. Using a 15% P_2O_5 cut off grade, the total mineral inventory currently stands at 49 078 000 tonnes at an average grade of 24.4 % P_2O_5. Due to the unconsolidated nature of the ores, essentially no blasting will be required during the mining operation, as the ores can be dug directly. Some blasting will be done in waste rock along the final limits of the open pits and in some sections of cemented ore. Mining of the orebody is currently being accomplished under a 4 year contract with Leo Alarie & Sons Limited. A range of excavators are employed and include a Komatsu PC-1100, a Hitachi EX-700, and 1, Caterpillar 350. These excavators feed a fleet of 5, 50-tonne Caterpillar 773 haul trucks, and 2, 100-tonne Komatsu 330 haul trucks. Assorted support equipment such as bulldozers, grader, and various service vehicles are also present on site.

The Main and A zones are contiguous, and will be mined in stages which conform to physical and economic constraints while, the B zone will be mined separately. An initial open pit is currently in operation (Stage 0) and was designed to take advantage of the pre-existing excavations from earlier test work to provide access to high grade, low strip-ratio ore for commissioning of the new operation. The initial pit will be expanded in 1999/2000 to the Stage 1 open pit. This will allow maximum exploitation of the reserves in the Main Zone as constrained by the Lost River to the north, and Cargill Creek to the south. The Lost River will be diverted in 2001 to allow expansion to the ultimate northern limit of the Stage 1 open pit. A final southward expansion to the limits of the A Zone will commence in 2006 and will form the ultimate outline of the Main Pit (Figure 3). The production rate from the mine is tailored to provide the mill with a consistent feed of 5 000 dry tonnes per day. The reserves are sufficient for a planned mine life of 13 years, following which mining of the B Zone is expected to extend the mine life to 20 years. The overall life-of-mine stripping ratio is 2.0 waste : 1.0 ore.

The various pit stages are designed to either 5 or 10 metre benches depending on the proximity to final ore contacts. Generally, 10 metre wide berms are left every two full benches although single-benching occurs in the less competent material types. The shallow, 5 metre benches are designed at ore/waste contacts to improve mining selectivity and reduce dilution. Wall slopes vary depending on material types. In the eastern side of the pit, inter-ramp walls as steep as 53° will be cut into the fresh carbonatite rock. The main haul road is located along this wall to take advantage of the steeper walls from an economic perspective, but also due to the higher competency of the rock in this area. The rock along the north and west walls is less competent and requires inter-ramp slopes of 39° The overburden situated at the top of the deposit consists of low-strength, high-moisture clay which require slopes as shallow as 6:1 (Clark and Duncan, 1999)

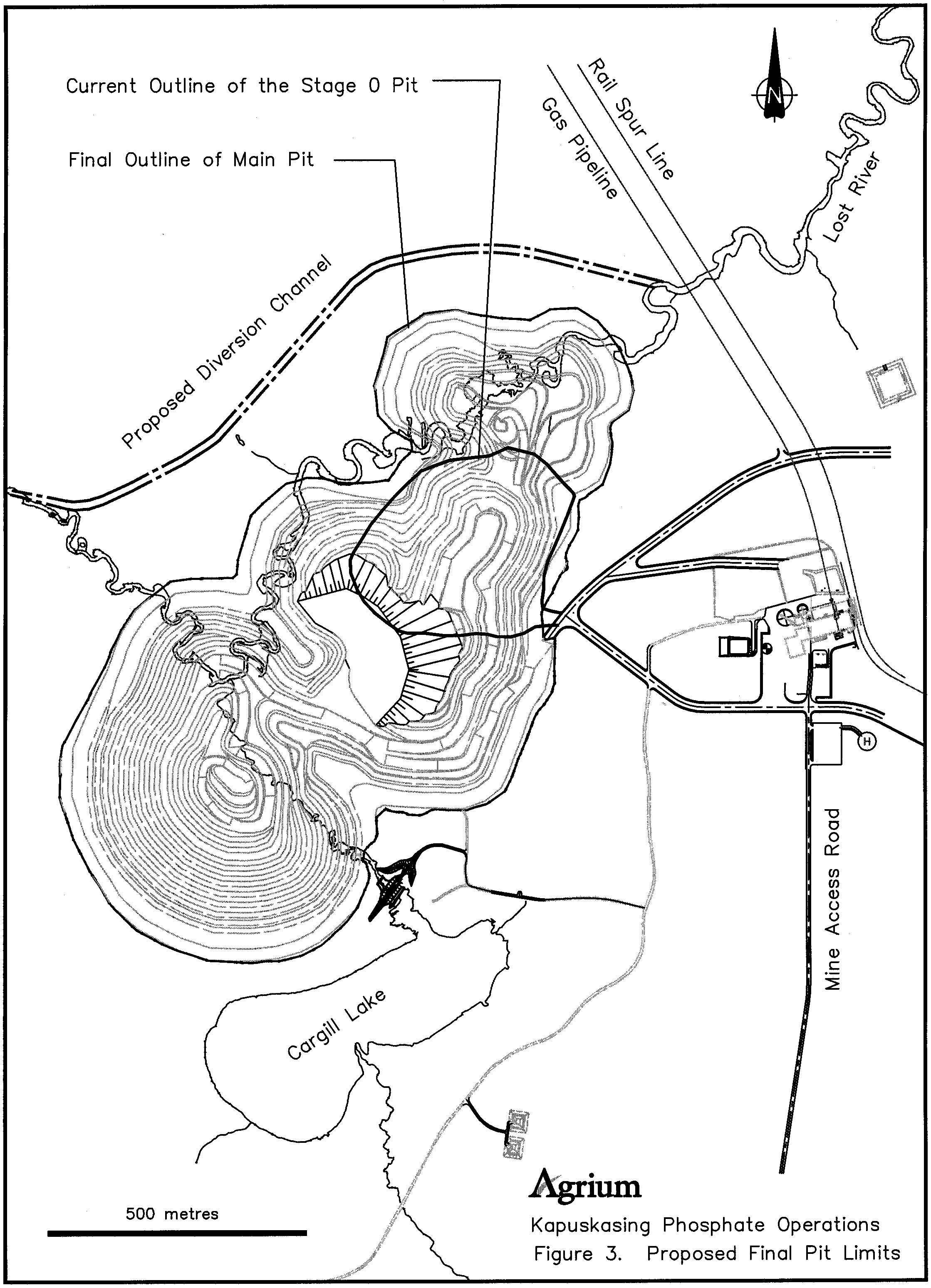
Two main waste dump areas have been designated for the project. One dump will be dedicated solely to the deposition of the large amounts of clay that will be generated from pre-stripping activities. The second dump will accommodate a combination of waste rock and assorted unconsolidated waste materials (Figure 4).

Milling

During the feasibility studies, run-of-mine ore was felt to be mainly loosely consolidated earthy type material with very little contained rock. The majority of this rock was determined to be very low in compressive strength and could be handled by the two Long-Airdox reclaim feeder/breakers. However upon start-up hard granitic glacial boulders contained in the upper areas of the ore body caused undue stress on the breakers which resulted in the addition of a static grizzley ahead of the units.

The milling circuit consists of grinding/desliming, flotation, magnetic separation, filtering/drying, and loadout.

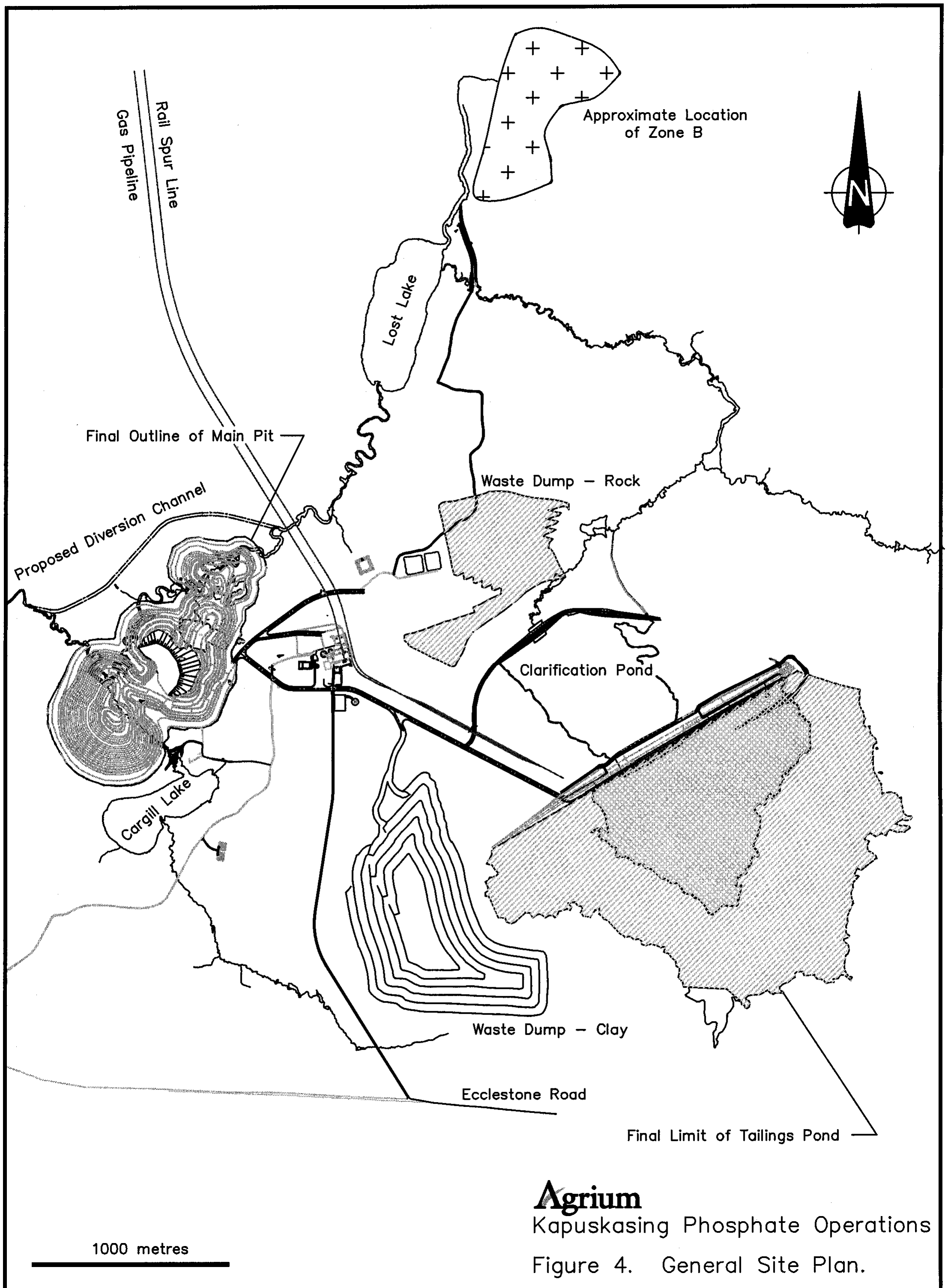
Grinding and Desliming: Minus 200 mm broken ore is fed at approximately 350 to 300 tph to a 5 486 mm diameter by 3 200 mm long variable speed SAG mill charged with 100 mm balls. The main purpose of the SAG mill is mainly to slurry the solids and helps to break up any clay or chunks of hard ore in the feed. The clay and fines are detrimental to the efficient operation of the flotation circuit and must be removed prior to reagent addition. SAG discharge is separated in a cyclone into a fine fraction “FF1” and coarse fraction “CF1”. “CF1” is scrubbed (to further assist in clay and slimes removal) and then separated into a fines fraction “FF2” and coarse fraction “CF2”. “FF2” is recombined with “FF1” which is pumped to the primary desliming cyclones which discard the minus 10 micron fraction to tailings in the overflow. The cyclone underflow is further scrubbed and deslimed again prior to flotation.



Agrium

Kapuskasing Phosphate Operations

Figure 3. Proposed Final Pit Limits



Agrium
Kapuskasing Phosphate Operations

Figure 4. General Site Plan.

"CF2" is fed to a closed circuit 3 962 mm diameter by 6 400 mm long ball mill charged with 65 mm balls which grinds the ore to flotation feed size of 80% passing 100 mesh.

Flotation: Ground ore in slurry form is pumped to 3 mechanically agitated conditioner tanks where collector, sodium hydroxide, fuel oil, soda ash, and starch are added prior to eight 17 cubic meter rougher flotation cells. The rougher concentrate is cleaned in two additional stages of same size cells. Flotation concentrate represents approximately 60% of the weight of total mill feed. Flotation rougher tailings is combined with the slimes fraction and is pumped to a 27 430 mm diameter tailings thickener for water recovery. Tailings thickener underflow is pumped at 40% solids to the tailings dam area.

Magnetic Separation: The re-cleaner flotation concentrate is pumped to a reconditioned High Gradient Magnetic Separator (HGMS) purchased from the Iron Ore Company of Canada. The HGMS reduces the iron content from approximately 5% to less than 2%. HGMS product is pumped to a 15 240 mm diameter concentrate thickener.

Filtering/Drying: Thickened concentrate is pumped to two 4 115 mm diameter rotary drum filters. The filter cake is conveyed into a natural gas fired 2 743 mm diameter fluidized bed dryer. The product is classified into a fines fraction which is collected in a bag house and a coarse fraction which is conveyed to the product loadout bin. The fines fraction is agglomerated with sodium silicate and is recombined with the coarse fraction.

Loadout: Dried product is discharged into a 600 tonne product silo. The product is gravity fed into 100 tonne closed hopper rail cars at a rate of approximately 30 cars per day. These rail cars are shipped to Redwater Agrium plant in Alberta for further processing.

Processing

Kapuskasing concentrate is received by rail at Redwater, treated to improve handling characteristics, and stored in 2 enclosed storage buildings.

From storage, the material is fed by conveyor to the first compartment of a multi-compartment reactor called an attack tank. 93-98% sulphuric acid is blended with recycle acid from the filter section and added to the attack tank. Sulphuric acid attacks the concentrate in the first 3-4 compartments and dissolves the phosphate from the rock matrix. As the reactor slurry moves through compartments 4 to 11, gypsum crystals are formed.

The reactor slurry containing a 26-28% concentration of phosphoric acid, gypsum crystals and impurities is fed to 4 belt filters where the gypsum is separated from the solution. The filtrate is delivered to a settling tank for aging and settling. The bottoms from the settling tank are returned to the attack tank while the clarified 28% phosphoric acid is sent to a holding tank. From the holding tank the acid is delivered to 8 evaporators, concentrated to 42-45% phosphoric acid and sent to final settling tank. From the final settler the clarified 42% acid is sent to granulation for Monoammonium Phosphate (MAP) production while the bottoms are either blended back for grade control or returned to the attack tank for eventual disposal on the filters.

The 42% acid sent to granulation reports to a preneutralizer, where ammonia is added in a ratio greater than 1:1. The ammoniated slurry is sent to a granulator, where it is sprayed onto a rotating bed of recycled MAP. A 42% acid solution is also sprayed on to the granulator bed to back titrate the product to a 1:1 ratio. The material is dried on a rotating drum dryer, screened for the appropriate size product, then sent on to a rotary drum cooler and off to storage. The oversize product is crushed, combined with fines, and sent back to the recycle stream and the granulator.

The finished MAP is coated with a de-dusting agent, kept for a minimum of 3 days, and is inventoried or sold.

Environmental Summary

The unique nature of the project has presented a number of environmental challenges. During the project permitting phase, a significant effort was put forth in order to assess the pre-development, environmental baseline conditions. As the project progresses into the operational phase, additional environmental challenges will be to monitor, assess, and mitigate potential environmental impacts. The mine site closure phase will provide opportunities for enhancement of the local environment, including an approximate two fold increase in fisheries habitat.

Pre-production environmental baseline data collection and government agency consultations were initiated in 1996. Anticipating an environmental screening of the project, as per the requirements of the *Canadian Environmental Assessment Act (CEAA)*, an Environmental Impact Statement (EIS) was prepared and released in December 1997 for public and government agency review and comment. Based on the results of the screening process, potential environmental impacts associated with the project are mainly related to water quantities, water quality, and minor losses of fisheries habitat.

The surrounding water courses were found to have naturally high background levels of aluminum, iron and total phosphorus. Due to the fact that phosphate is a component of fertilizer, one of the biggest environmental concerns is the potential for over loading of the downstream receiving areas with nutrients. A combination of the above factors has resulted in the current environmental monitoring programs being more comprehensive than most other mines in Canada. These programs include chemical monitoring of the hydrogeology, effluent discharges and surface receiving waters. Also included are biological monitoring programs for upstream, downstream and receiving surface waters. In addition, two modeling studies are underway to quantitatively predict the effects of effluent discharges on the receiving waters.

A site water balance and site water management plan has been prepared as part of the project development phase and was sufficient to conduct the initial environmental impact assessment studies. A significant mandate of site environmental personnel is to oversee the development of a long term site water management plan, including the development of the tailings management system. The purpose of such an undertaking will be to ensure that acceptable water quality standards continue to be achieved on and off site, and minimize impacts on current and future mining/milling operations and the environment.

A significant environmental challenge related to the long term development of the project involves the diversion of two water courses: the Cargill Lake outflow, and a 2 600 metre section of the Lost River. The major challenge revolves around the expected loss of fish habitat as a result of the Lost River diversion. Additional preliminary studies to fully understand the impacts of the diversion have already been initiated. Upon completion of the diversion project, it is expected that a net increase in fisheries habitat will result.

Generation of additional fisheries habitat by filling of the completed open pit mine will be integrated within the closure phase of the project. It is proposed that the open pit will be flooded, creating a man made basin of approximately 78 hectares. Filling of this proposed lake will be initiated by re-directing the Cargill Lake outflow into the pit via a spill way. Prior to the completion of filling however, the upper benches of the pit will be re-graded to improve slope stability and provide a shallow littoral zone to assist the development of a vibrant fish population in the pit lake. This completed pit lake will also provide a net increase in the amount of fisheries habitat over pre-development conditions.

Conclusion

Over the years, Agrium has worked diligently to establish and maintain good relationships with local governments and community organizations. The positive impact of the Kapuskasing Phosphate Operations has already been felt in the Kapuskasing area in the form of local employment at the mine, a positive impact on the housing market, and the creation of numerous spin-off jobs in the local service and supply companies.

Agrium is a public company, with its shares listed on the Toronto and New York Stock Exchanges under symbol AGU. It employs more than 4,000 people and has its corporate headquarters in Calgary, Alberta.

Acknowledgements

The author wishes to thank Agrium for their support and consent to prepare and present this paper. Thanks also go to Alex Watson (Site Manager), Jacques Gagné (Mine Superintendent), Klaus Tietz (Mill Superintendent), Alex Giovannelli (Acid Co-ordinator, Redwater, Alberta), Colin Webster (Environmental Co-ordinator), and Ron Ross for their participation and encouragement.

References

Clark, D.R., and Duncan, D., 1999, The Development of Agrium•s Phosphate Mine in Kapuskasing, Ontario: *in* CD ROM proceedings volume of the 101st Annual General Meeting of the Canadian Institute of Mining, Metallurgy, and Petroleum.

Fenco MacLaren Inc., 1998, Kapuskasing Phosphate Project - Environmental Impact Statement. Ref. No. 011529, Unpublished Internal Document.

Sage, R.P., 1988, Geology of Carbonatite-Alkalic Rock Complexes in Ontario: Cargill Township Carbonatite Complex, District of Cochrane: Ontario Geological Survey Study 36, 92 p.

Sandvik, P.O., and Erdosh, G., 1984, Geology of the Cargill phosphate deposit in Northern Ontario: *in* The Geology of Industrial Minerals in Canada, CIMM Special Volume 29, p. 129-13.