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Stack Free by '53" Strategic Solutions for Phosphogypsum in both the Developed and the Developing World, with Special Emphasis on Safe, Affordable Uses in Agriculture

presented by

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About the IFA Technical Committee

The IFA Technical Committee encourages the development and adoption of technology improvements that can lead to greater production efficiencies and reduced emissions, as well as better health and safety standards throughout the fertilizer industry. Our mission is to actively promote the sustainable development of efficient and responsible production, storage and transportation of all plant nutrients. The Technical Committee accomplishes these objectives through a variety of channels, including:

- Technical and policy-oriented information materials. The committee regularly conducts surveys and produces reports on key industry metrics, including the IFA Energy Efficiency and CO_2 Emissions Report, the IFA Safety Report, and the IFA Emissions Report. This work enables member companies to assess their operations over time, make comparisons with similar facilities on an established level of performance, determine the need for technology improvements and identify good industrial and management practices.
- Regular exchange of information on technology developments and industrial practices. A key role of the IFA Technical Committee is to encourage ongoing technical innovation in the fertilizer industry through the development, compilation and exchange of technical information between members, researchers, engineers, equipment suppliers and other industry associations. To this end, the committee organizes a Technical Symposium every other year to examine progress in the production technology of fertilizers. Each Symposium traditionally features the presentation of 30-40 new technical papers from member companies worldwide, providing members with information on the latest technological developments. In the intervening years, the committee holds a variety of meetings to assess current industrial practices and standards, with an eye toward identifying key developments of interest to members.
- Technical and educational workshops and special events. The IFA Technical Committee provides workshops designed for engineers working in the fertilizer industry, particularly those who have recently assumed new responsibilities, and for new engineers to increase their technical knowledge. These workshops (e.g. concentrating on nitrogen and/or phosphate fertilizer production) are designed to improve the participants' skills and broaden their vision and understanding of the entire industry, including technology, economics, energy use, safety and environmental stewardship. Workshops also provide engineers with an opportunity to exchange ideas, solve specific problems and improve plant operations and profitability.
- Education and advocacy. The IFA Technical Committee recognizes that customers, markets and regulatory environments are best served by clear and concise information on the fertilizer industry and its practices and products. Because the knowledge and expertise found within the fertilizer industry is the best source for this information, the Technical Committee endeavours to educate policymakers, standardization bodies, customers and the public on industry achievements, technological advances, voluntary initiatives and best practices. The committee also encourages universities and development centres to conduct research on fertilizer product development and production processes.

(as provided by the author for distribution in Alexandria)

Stack Free by '53"

Strategic Solutions for Phosphogypsum in both the Developed and the Developing World, with Special Emphasis on Safe, Affordable Uses in Agriculture

Abstract *(1/2)*

For commercial, technical and regulatory reasons, the key challenges that face the phosphate industry going forward are convergent in the management and use of phosphogypsum (PG). Strategically, the end-of-life closure liability to cover and environmentally isolate the PG stacks and to also remediate and dispose of the vast quantities of process wastewater will be a very significant burden to the industry and the environment. A beneficial, commercially appropriate use for PG, based on objective data, sensitivity to stakeholder requirements and best available practices, must surely be a more appropriate outcome than dumping or perpetual storage. The goal is to define whether or not a safe, cost-effective, high volume use of phosphogypsum can be found, especially in agriculture as a soil amendment. The potential benefit to the industry is a significant cost saving on PG handling and storage. For example: the Florida industry is estimated to generate 22,000,000 tons of PG per year at an approximate handling and storage cost of $1.50 per ton. This equates to an annual legacy cost of $59m per year in one production center alone. In addition, there is now growing pressure from regulators to look at underwriting lifetime costs for stacks at an estimated "bond" value of $50-100m. In the more extreme case of the Piney Point stack, the closure costs are estimated at $200m.

Work Effort

The project itself consists of 8 interwoven work packages to be conducted over 5 years, at a total cost of $4.1m, with a break point after year 2. The global position will be studied in greater detail by means of a sector-wide survey, coupled with literature review; the technical feasibility of modifying the production process will be considered, from both "upstream" and "downstream" perspectives. A reverse engineering methodology will be applied to the specification on an acceptable PG based soil amendment, to test the "in principle" feasibility of a solution based on use, not stacking. And a market study will determine the prospects for the industry in regard to a commercially sustainable outcome. A pivotal activity is the development of reference data for the safe and efficacious use of PG in soil amendment and crop or forage production.

Abstract *(2/2)*

Of particular interest, in view of regulatory sensitivity concerning the radioactivity of PG, will be the measurement of its impact on the naturally occurring radioactivity of soils and the crops grown on them. Remote participation in the research process, and publication of interim and final results, will be facilitated by a part closed, part open website, which will be created from the outset. Through this website, access will also be available to selected components of the MiLo system as a resource for all participants and stakeholders. This resource comprises a unique repository of knowledge on PG and process water issues.

Research Activity and Management

Research is to be conducted in the US, UK and at field centers in a range of participating countries worldwide, led and managed by an international committee of highly experienced, widely published scientists and analysts, chosen to reflect a balanced, multidisciplinary approach to the problem. Reference dose and use regimens, based on contemporary data, will be proposed and validated in field studies, for use of phosphogypsum on a range of crops, including pasture, in a range of climates and soils. The co-Principal Investigators are Dr. Vaughn Astley, with 40 years of experience in the industry, and an experienced and long-serving member of both the Chemical and Process Water Technical Advisory Committees of FIPR and the Technical Sub-Committee of IFA. Professor Julian Hilton is Principal Investigator of the MiLo Project (FIPR) an Expert of the European Commission in Informatics and a Consultant to the Food and Agriculture Organization (Rome) since 1992.

Funding

Funding is planned from between four and six contributing organizations, including FIPR, International Fertilizer Association (IFA), industry, IMPHOS, IFDC and OCP.

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All papers and presentations prepared for the IFA Technical Committee Meeting in Alexandria will be compiled on a cd-rom to be released in May 2005.

Can we be?
"Stack Free by '53"

Strategic Solutions for Phosphogypsum in both the Developed and the Developing World, with Special Emphasis on Safe, Affordable Uses in Agriculture

Overview – Position Analysis of the Phosphate Industry

There is growing consensus in the phosphate industry that it is at a turning point, however it is not yet clear where it might best turn. Phosphogypsum (PG) is identified in this proposed research project as pivotal to that decision, both locally and world-wide. For a combination of commercial, technical and regulatory reasons, the key challenges that face the industry going forward are convergent in the phosphogypsum issue.

So what might it take to be "Stack free by '53"? Strategically, the end-of-life closure liability to cover and environmentally isolate the PG stacks and to also remediate and dispose of the vast quantities of process waste water will be a very significant burden to the industry and the environment. Tactically, the large quantities of PG, and the large associated volumes of process pond water that accumulate day by day, are causing the industry to be perceived to be intrinsically hostile to environmental health and bio-security, a perception that is beginning to impact the cost of operation and may ultimately threaten the industry's very existence. At best, it will greatly increase its cost.

The Project

The point of departure for the research project briefly outlined in this summary document is that a beneficial, commercially appropriate, use for PG, based on objective data, sensitivity to stakeholder requirements and best available practices, must surely be a more appropriate outcome than perpetual storage or dumping. This is the basis of the proposition: "stack free by '53". Given that the availability of phosphate fertilizers significantly determines the world's food production capacity, if this issue is not tackled successfully the penalty to be paid will levied well beyond the industry itself.

Because the PG question is held to be strategic, the proposal sets out a comprehensive, strategic approach to managing existing and future phosphogypsum production and use; to a lesser extent it also addresses the concomitant water inventory issues. The goal is to define whether or not a safe, cost-effective, high volume use of phosphogypsum can be found, especially in agriculture as a soil amendment. If so, reference dose and use regimens, based on contemporary data, will be proposed and validated in field studies, for use of phosphogypsum on a range of crops, including pasture, in a range of climates and soils.

Goal
To analyze the potential for using phosphogypsum (PG) for commercially viable agronomic purposes, achieving a stack free production process by 2053, within the context of demonstrating an acceptable public health and environmental safety profile to the regulatory authorities of the United States, Europe, Asia and other potential markets, such as North Africa and China.

Brief Project Outline
The project itself consists of 8 interwoven work packages to be conducted over 5 years, with a break point after year 2.

The global position will be studied in greater detail by means of a sector-wide survey, coupled with literature review; the technical feasibility of modifying the production process will be considered, from both "upstream" and "downstream" perspectives. A reverse engineering methodology will be applied to the specification on an acceptable PG based soil amendment, to test the "in principle" feasibility of a solution based on use, not stacking. And a market study will determine the prospects for the industry in regard to a commercially sustainable outcome. A pivotal activity is the development of reference data for the safe and efficacious use of PG in soil amendment and crop or forage production. Of particular interest, in view of regulatory sensitivity concerning the radioactivity of PG, will be the measurement of its impact on the naturally occurring radioactivity of soils and the crops grown on them. Remote participation in the research process, and publication of interim and final results, will be facilitated by a part closed, part open website, which will be created from the outset. Through this website, access will also be available to selected components of the **MiLo**[1] system as a resource for all participants and stakeholders. This resource comprises a unique repository of knowledge on PG and process water issues.

Research is to be conducted in the US, UK and at field centers in a range of participating countries worldwide, led and managed by an international committee of highly experienced, widely published scientists and analysts, chosen to reflect a balanced, multidisciplinary approach to the problem. Organizations having a commercial interest in the outcome will be active participants at all levels; but pivotal elements of the research required are delegated to centers of international excellence, which are neither for nor against the use of PG and which have no vested interest in the outcome.

In the same spirit of objectivity, project financing comes from a balanced spread of sources, and project management will be undertaken by a company with no ties or obligations to the phosphate or wider fertilizer industry. International, national and regional regulatory bodies will be invited to participate in the project from the very outset, being significantly involved in both the planning and the technical assessment phases.

The research methodology proposed in respect of testing safe and efficacious use of PG consciously imitates the three-stage process of developing a new pharmaceutical product. If at any stage, compelling data emerges that clearly indicates that PG is not safe, according to international standards, or unlikely to achieve a cost-effective place in the market, the project will be wound down.

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[1] MiLo. A FIPR computer searchable repository of knowledge related to phosphate industry.

The issue of testing for safe, efficacious use of PG is embedded in an approach that looks at the market and regulatory drivers that might condition the likely uptake of PG as a soil amendment in the future, and at the options for "upstream" process change in the industry that might lead to a better defined, reduced flow of PG from phosphoric acid production, or reduced radionuclide or heavy metal content. It will also look for technically feasible, economically viable modifications to production techniques that might deliver a more saleable PG product, perhaps by "reverse engineering" the process from what would be deemed to be an acceptable specification for PG based product(s).

Such a comprehensive approach would enable industry to plan for a future in which regulatory concerns have been anticipated and met, and in which an "end to end" solution for PG will have been found. This in turn may assist in solving the long-term risk management problem now on the top of the regulatory agenda in respect of PG stacks, while at the same time restoring public confidence in the industry's good intentions. The mitigation of the process water inventory environmental impact will be concurrently addressed as an integral component of the overall PG issue. It would also perhaps signal some options for the industry to embrace a business model that is perhaps broader based than its current commodity focus, especially on diammonium phosphate (DAP).

If the industry can replace either stacking or dumping with a safe, commercially appropriate, long-term solution, which in effect returns to the ground what came from the ground, the outcome is highly desirable.

Research Methodology

The methodology proposed comprises three, linked approaches, designed to facilitate the translation of technical and scientific conclusions from the study into new practices. The three, linked, components are: 1. empirical, 2. "grounded hypothesis" and 3. "blue ribbon".

1. In the **empirical** approach, a sequence of laboratory, glasshouse and field experiments will generate contemporary reference data for PG as a soil amendment; as a preliminary, basic safety data will be taken from both soil and crop samples, based on a structured series of laboratory and glasshouse experiments.

2. In the "**grounded hypothesis**", a reverse engineering approach will be taken, defining in advance an idealized spec sheet and application regimen for what an acceptable, likely viable PG based product would need to achieve to be given marketing approval.

3. In the "**blue ribbon**" approach, led by the oversight and review groups defined in this proposal, a multidisciplinary expert team will by direct consultation and risk assessment, sector wide survey, review of literature and best practices set out the basis for a workable solution to the PG problem.

The Challenges: Technical and Perceptual

The challenges concerning the safe and efficacious use of PG focus on two key issues:

Radioactivity

Heavy metals/ inorganic pollutants.

These challenges may be defined as both technical and perceptual:

The **technical** risk to phosphoric acid production is that a, currently fashionable, "zero tolerance" approach to both sources of potential risk be applied, with the consequence for many types of source rock, and in many radiation safety regimes, it will simply be banned. A ban could be disastrous for food production world wide. It could also be judged ridiculous if the naturally occurring radioactivity of typical soils exceeds that of soils amended with PG.

It is essential to present the technical risks of phosphoric acid production, including potential occupational exposure through phosphoric acid production or PG handling and use, in the context of a reasoned, data driven approach to risk. Having regard to the risk management principles of ALARA, the justification principle and of the intrinsic value of "solving" the PG problem rather than "stacking" it, the research proposal outlined in this document considers PG in such a data-driven context. It recognizes that a precondition for considering a long-term solution to the PG challenge is a set of property and activity benchmarks, and equivalent data derived from normalized use, on the basis of which "real world" applications, such as in agriculture, can be studied.

By these means, it is anticipated that the "zero tolerance" position, where adopted, can be replaced by one, based on the precautionary principle, that weighs objectively the relative merits of a precautionary outcome that results in stacking as compared with a precautionary outcome that modifies both the phosphoric acid production process and the subsequent uses of PG in a manner that meets regulatory requirements, is compliant with environmental and agronomic best practices, is conducive to a sustainable food production process, and is consistent with the global biosecurity objective.

The **perceptual** risk focuses on relations between key stakeholders, the phosphoric acid producers (the industry), the regulators and the public. The most conflicted relationship between these stakeholders groups is perhaps to be found in south Central Florida, around and south of the I-4 corridor between Tampa and Orlando, one of the fastest growing areas of the US. The encroachment of very significant numbers of retirees and the arrival of new style industries, such as biotechnology, in traditional phosphate operational areas, and the resultant competition for available water resources and land, is causing sustained conflict within the local populace, county authorities environmental groups and the State regulators. The debate is centered on the question of whether or not to issue new mining permits. Given how vital Florida's reserves are to the US and the global economy it is not just of concern to Floridians how this conflict may be defused, or resolved. What may be learned from conflict resolution in this area may be applicable elsewhere when, as may be predicted, similar difficulties arise.

Questions Addressed

Among the questions addressed by the project are:

1. By what benchmarks, standards and metrics should the potential use of PG be measured?
2. Is contemporary data available referenced to the approved benchmarks, standards and metrics, especially in regard to PG as a potential soil amendment in both productive and exhausted soils?
3. Is PG inherently safe as a soil amendment according to established international standards and norms, in both normal and extreme conditions, having regard also to its impact on naturally occurring levels of radioactivity and toxic metals?
4. In what climates and soils, with what crops, and at what dose regimens is PG likely to be efficacious?
5. In which markets is PG application cost-effective?
6. What health and safety factors might determine the selection of best available technologies and best available practices for PG storage, transportation, application?
7. What regulatory or market drivers might incent an "end to end" solution for PG that results in a "stack free" outcome?
8. Why should this research proceed now?
9. How does resolution of the PG issue impact the process water inventory and acidity issue?
10. Is there an economic synergy to the resolution of both the PG and process water issues?
11. Are there possible modifications in the production process that might make PG a more viable soil amendment for use, for example, in exhausted soils?
12. Can a standardized specification be devised for PG which would permit secure access to global markets? And can such modifications be made without prejudice to existing manufacturing practices and to allow commercial viability?

The consensus that change is imminent is driven by both positive and negative factors:

- After a period of slow down and depressed prices, margins have recovered and the phosphate industry is growing again; there is some latitude for reflection
- New markets are opening and demand is likely to continue to accelerate; but the characteristics of the market are not clear
- Regulatory pressure is growing, especially in the management and mitigation of long-term risk, at both national and international levels
- Public pressure on industries perceived to be polluting or unsafe is growing throughout the food production-consumption continuum.
- The recent releases of the acidic process water from the PG stacks during recent strong hurricanes impacted west and central Florida counties where several phosphoric acid production facilities are located.

There are certain seminal processes and events which may be seen as both symptom and cause of the need for change:

- IAEA has established a working party to report on radiation safety issues (occupational exposure, public and environmental health risk) in phosphate production and in by-product use, especially phosphogypsum.
- The governments of Japan and South Africa are actively considering banning phosphate production because of radiation safety fears.
- US Congress, through Congressman Adam Putnam (Polk County, Florida) is pressing for review of the EPA Phosphogypsum Rule (1992).
- The Florida Department of Environmental Protection (FDEP) is seeking long-term solutions to the management of phosphogypsum stacks and their associated quantities of process pond water, as a result of the significant challenges and the costs realized by the State as a result of the Tampa Bay, Piney Point bankruptcy.
- The European Technical Centre of the OECD Nuclear Energy Agency is working on occupational exposure issues in the phosphate industry, and is holding a Workshop on the topic in 2005/06

It is vital to safeguard a sector that is essential to the security of the world's supply of food, and one that is by most scientific standards, fundamentally safe. Yet, as the examples of nuclear energy and genetically modified crops have amply demonstrated, the power of the public and the policy-maker to intervene in, and even close down, unpopular industries cannot be underestimated. The risk is perhaps greatest to the industry in the developed world; but in an era of globalization, and of the strong global commodity-based business model the industry has adopted for the past twenty years, there is ever less distinction between the developed and developing world's attitudes.

Pivotal to the future context within which the industry will be permitted to operate is its willingness to take leadership in fronting regulatory concerns. That suggests that the reactive posture that has characterized the past twenty years of dealings with regulators may now need to give way to a proactive one, and one that involves joint efforts to solve the issues to the benefit of both the environment and the sustainability of agricultural production.

Such an approach would align the phosphate sector with both the pharmaceutical and food industries. The pharmaceutical industry has been pursing, under the umbrella of the International Conference on Harmonization (ICH) a successful policy of collaboration with regulators worldwide in bringing the management of clinical trials towards a single, unified standard, based on the centrality of protection the rights and safety of human subjects. The food industry has just passed a new ISO 22000 standard bringing to food safety management systems for the first time a single global standard. Even the nuclear industry, as evidenced by changes of attitude in Finland and Germany, that will permit new generation power-plants, is starting to see a more positive perspective; but this comes after twenty years of patient, proactive education of regulators, policy-makers and public opinion.

The opportunity is there for the phosphate industry now to take a lead; by doing so, it can demonstrate that it can realign its own interests to those of regulators, proponents of sustainable environmental systems and the wider public. In the process, it will create a more conducive climate for a long-term stable business.

Project Description

Investigative Remit

At an acceptable level of risk to public, soil and environmental health, and against the background of a need for an “end to end” solution to managing PG as a by-product from phosphoric acid production, is there cost-effective agronomic benefit and commercial value in uses of phosphogypsum in agriculture, in both the developed and the developing worlds?

Phosphogypsum may offer agronomic benefit as a soil amendment for improving soil fertility and supplying sulfur (S) and calcium (Ca), together with small amounts of phosphorus (P) in both the developed and developing worlds. There is also a potential use of PG to be investigated as an emergency remediation tool for dealing with severely nutrient depleted soils, or soils damaged by natural disasters (such as in Haiti September 2004, by Hurricane Jeanne, or the Indian Ocean Tsunami, December 26, 2004).

Underlying Methodology

Given the significance of public and environmental health concerns in the evaluation of phosphogypsum, the underlying methodology of the evaluation process will be derived from standard practice in pharmaceutical research and development, splitting activity into three phases, and proceeding from one phase to the next only if the case to do so is adequately made.

Phase 1 (Year 1) is targeted at gathering reference data from laboratory and glasshouse experiments on the behavior of PG in soil, enabling both a *prima facie* investigation of its likely contribution to agriculture and its likely commercial acceptability in the context of answering fundamental questions of safety. The question to be answered is: can PG in principle work beneficially in agriculture according to internationally accepted standards, metrics and norms, and are there any environmental or public health concerns that would render its use wholly unacceptable, however viable agriculturally? Particular attention will be given to analysis of possible radiation impact on soil and plant matter treated with PG, analysis to be conducted according to protocols defined by [Senes Consulting], [the IAEA] and the [UKAEA laboratories at Harwell].

Phase 2 (Year 2) is targeted at differentiating potential dose regimens by crop, climate and soil, including “tuning” these regimens in the light of other biological indicators. It will define what residual acidity and moisture content of the PG is required for acceptable use in “normal” soils, and explore various extreme conditions ranging from soil depletion and exhaustion, to “hundred year” weather events such as extreme rainfall.

Phase 2 must be completed to be able to carry out the pathway analyses of the preceding phase. Phases one and two, when combined, function as a screening opportunity, thus allowing a refinement of the project after this stage, or even termination.

Phase 3 (Years 3-5) takes the experimental data from pots into the field and looks at defining a "best practice" methodology and data set that will define for given crop, soil and climate types what uses of PG bring the most agronomic benefit at the least risk to people, crops or the environment.

One of the world's most experienced and reputable centers of excellence for arable crops research, Rothamsted Research UK, is proposed to lead the experimental work. UK is chosen in part because it does not produce PG and is neutral in its approach to the acceptability of various storage and disposal methods for PG use.

The Eight Work Packages

To achieve a rounded answer, the team will undertake up to eight work packages, as follows:

1. A study of potential worldwide markets for PG, including feasibility analysis of marketing and distribution in restrictive regulatory environments. It will run in parallel with the overall project, but begin with a three month desk review of existing markets and uses, in parallel with a survey, conducted through IFA of the current practices of member countries and organizations. Particular attention will be paid to non-conventional uses of PG, especially regarding uses where significant changes have occurred in local and international agriculture due to abnormal climatic and geological events.

2. A scientific and technical literature review of phosphogypsum in agriculture, focused on phosphoric acid producing countries. It will build on the testimony already submitted by Dr. Sumner to the Congressional Hearing (Bartow, Florida, March 2004) but encompass other agronomic practices outside the US regulatory sphere.

3. A review of "upstream" techniques in mining, beneficiation and phosphoric acid production, including process water management, with a view to proposing changes with a beneficial impact on phosphogypsum production, storage and ultimate disposal. Thus what process changes and/or modifications could be implemented to produce a PG product without losing phosphoric acid production capacity or operational economics will be identified. This investigation will be coupled with a "reverse engineering" approach to PG use, defining from an idealized spec sheet and product requirement what, if any, PG-based formulation would be both acceptable and viable as a product for agronomic and other uses?

4. A survey of IFA phosphoric acid producing members to elicit their knowledge of the radionuclide and metals (including metalloids. e.g. arsenic, cadmium) contents of the rocks used, the acidulation processes used, the fate and distribution of the NORM nuclides and metals in the various product streams and byproducts, and issues concerning the enhanced activity of exposed metallic surfaces and scales in the reaction and filtration equipment. The data provided in the initial survey and results obtained from samples obtained from individual companies, as described below, will be coded to assure confidentially of the source, but will thus be invaluable to formulate a thorough understanding of the PG production fundamental quality issues.

For the first time, all major global rock production and processing sites will be analyzed for a comprehensive set of radionuclides, metals, and other parameters of interest according to a rigorous set of protocols. In this way, the data set will be complete and uncertainties stemming from differences in analytical techniques and sample handling will be avoided. We will use laboratories in the United States, European Union, and Asia for the analyses. All will use the same set of handling protocols and analysis techniques. Quality Assurance/Quality Control will be maintained using chain of custody, and cross-checking with standards and a statistically reliable subset of samples. Both the database and the analytical protocols used in its development will become the new benchmark for the twenty-first Century global phosphate industry.

With these data it should be possible to generate predictive equations of expected concentrations from beginning to end of processing based on the properties of the source material. Based upon our experience, it is likely that there will be enough variability that more "successful" specific processing sites could be easily identified. That is, successful sites would be those that are most efficient at partitioning radionuclides and metals in a way that has the least potential impact on consumers or the environment. An examination of techniques used in successful versus poorer-performing sites would be conducted.

5. As an extension of the survey in work package 4, a review of current practices worldwide of storage and handling practices for phosphogypsum, with an analysis of strengths and weaknesses of the various methodologies, including environmental impact of both the PG storage and the process water inventories will be carried out. This investigation will be coupled with a "reverse engineering" approach to PG use, defining from an idealized spec sheet and product requirement what, if any, PG-based formulation would be both acceptable and viable as a product for agronomic and other uses. By identifying through reverse engineering what the target PG product specification must be, it will be possible to assess the technical feasibility and economic viability of modified production procedures.

6. A sequence of laboratory-based and related glasshouse experiments to determine reference data and other benchmarks suited for subsequent testing of various aspects of the safety and beneficial effects of PG, followed by field experiments testing those benefits in practice. Among issues addressed will be:
    a. Regular use of phosphogypsum as a soil amendment
    b. Emergency/ remedial uses of phosphogypsum for nutrient depleted or severely damaged soils; the material is readily available and is free at point of sale.

This work package will have three main objectives:

1. To investigate, using laboratory techniques, what happens to the different components of phosphogypsum when the product is added to soil. This will encompass the fate of the radionuclides, heavy metals and phosphorus, calcium and sulphur. Increasing amounts of phosphogypsum will be added to a range of soils.

2. The second objective will be to determine, using pot experiments in controlled conditions in the glasshouse, the effect of phosphogypsum additions to a range of soils on the growth and nutrient content of a "standard" crop, ryegrass. Protocols for this are well established. Taking six harvests at monthly intervals will allow estimates of total yield and uptake (nutrients, heavy metals and radionuclides) and any change in yield or uptake over time to be measured.

3. Undertaking the third objective will depend on the results from objectives one and two. If there are no perceived short-term adverse environmental impacts from applying phosphogypsum to agriculturally managed soils and there are positive benefits in terms of yield, then the third component of this work package will be started, namely field experiments on a much wider range of soils growing different crops under various climatic conditions. The aim will be to more precisely define where it would be cost-effective and environmentally benign to use phosphogypsum either as a regular soil amendment or in very large amounts for remedial/restorative purposes.

These three objectives taken sequentially broadly equate to a clinical trial for a new pharmaceutical product.

7. Radiation and environmental monitoring of the investigative samples and resultant experimental applications. Samples generated in Work Package 6 will be studied to determine the measurable impacts, if any, of PG use. Radionuclide activity concentrations, even under aggressive application scenarios, are likely to be very low. In this case, the radionuclides of interest (Ra-226, Ra-228, Th-232, Pb-210, Po-210, U-238) are in “trace” quantities from a chemistry perspective. Once the activity concentrations of radionuclides and the metals concentrations are determined for all application scenarios, pathway modeling is conducted using peer reviewed computer models to determine endpoint concentrations and potential risk to the environment and human receptors.

8. A closed, secure website will be designed as the hub both of data capture and analysis, as well as project communications, web-conferencing and project management. The coordinating organisation, Aleff Group is highly experienced in web-based project management, and the facilitation of virtual communities on line, and will host the data capture process. The website will also provide means of access to selected resources from the **MiLo** system.

Project Management

Consistent with the “blue ribbon” approach, project management is vested in the management committee, which is constituted to double as a blue ribbon panel. Decision-making will be managed through regular quarterly meetings of the management committee, which are planned to take place face to face every second quarter, with telephone conferences acting as the mechanism for meeting on the remaining occasions.

There is a necessary cost attached to face to face meeting, but it is believed that in a project of this scale, using a blue ribbon methodology as part of its working practice, such meetings are essential on a regular basis.

Each work package is directed by an experienced manager with extensive project management experience in their own right. This enables each work package to function in a semi-autonomous manner, so reducing the administrative overhead to the efficient minimum.

A major technical and scientific meeting is planned for an early stage in the first year of the project, engaging the management group and the reviewer/ advisor panel together.

A closed website for on-line participation by the management committee, the funders, reviewers and key stakeholders will be established by the coordinating organisation, Aleff Group. Project documentation will be available on a restricted basis from this website throughout the life of the project. This website, subject to approval from FIPR, will include relevant sections of the **MiLo** knowledge tool both as an online resource for the project research team and as a vehicle for interim dissemination of working papers and drafts of reports around team members and advisors.

Other reporting requirements will be in line with the needs of funding organizations.

Independent Financial Management

To avoid the obvious charge of bias or influence, funding will be channeled through Aleff Group as project manager, an independent, privately held company with no ties to industry and no background investment interests that might constitute influence. Aleff Group has been actively working in the phosphate sector since 1999, and has been working, from the perspective of scientific communications, in the field of crop production since the mid 1980s.

Management Group

Professor Julian Hilton, Chairman, Aleff Group Inc. Lakeland, Florida. (Project Coordinator).
Dr. Vaughn Astley, Consultant, Dr Phosphate, Inc., Ex. Freeport McMoRan, Agrico, IMC, & Mosaic, Industry Liaison, Technical Sub-Committee, International Fertilizer Manufacturers' Association, Paris.
Dr. Brian Birky, Director of Public Health, Florida Institute for Phosphate Research, Bartow, Florida.
Professor Keith Goulding, Head, Agriculture and the Environment Division, Rothamsted Research, Harpenden, UK.
Johnny Johnston, Lawes Trust Senior Fellow, Rothamsted Research, UK.
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