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Argus FMB Strategy Report: World Phosphate Rock Outlook to 2029

April 2015
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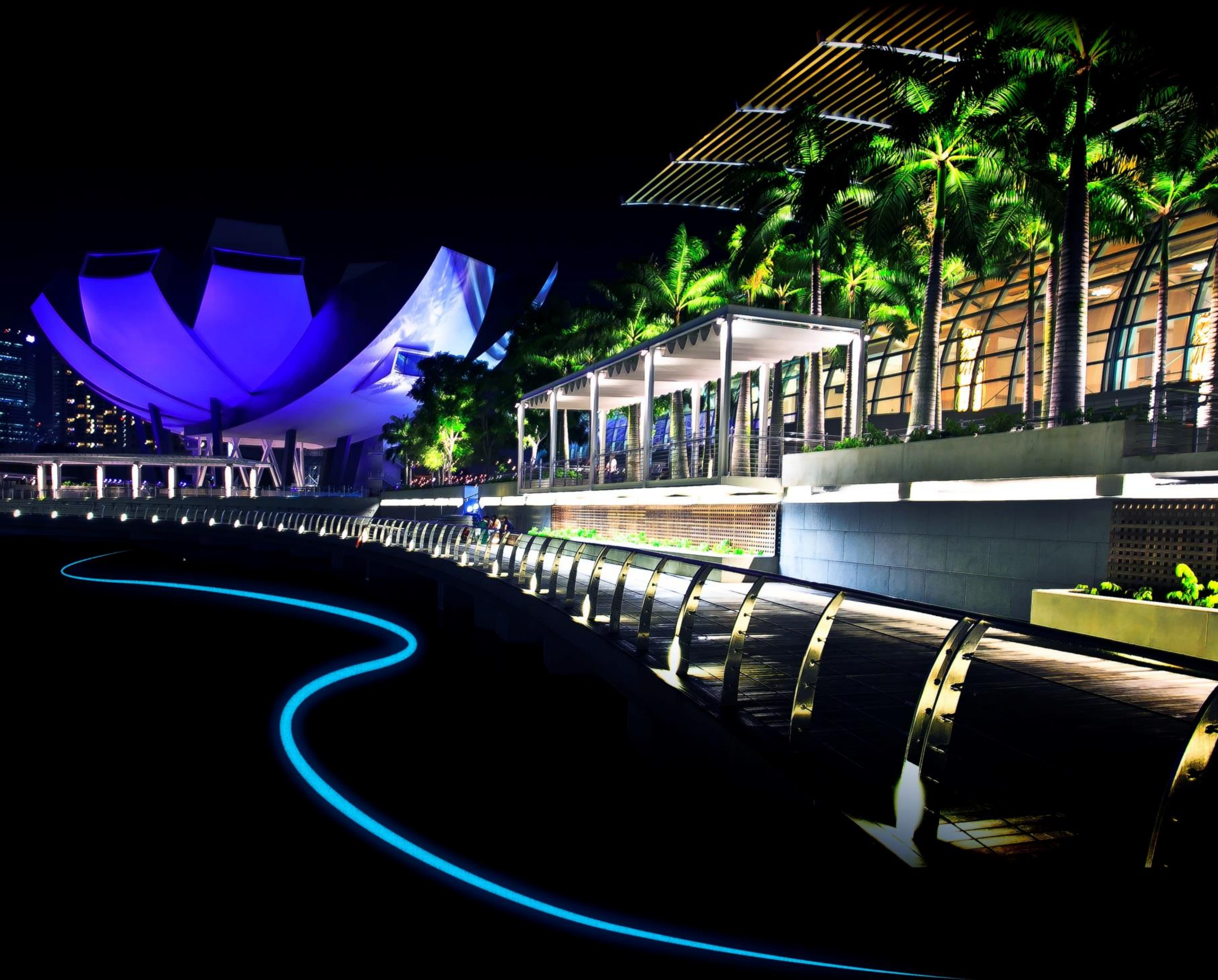

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Rock Resources and Reserves

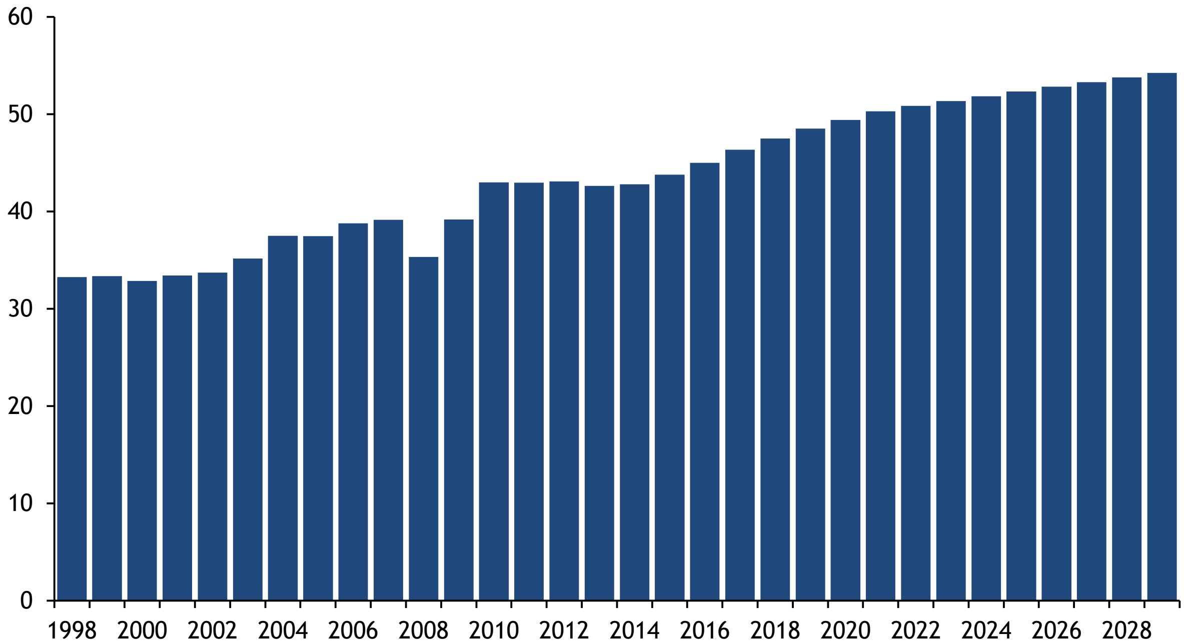
This report demonstrates that:

- There are substantial resources of phosphate-containing minerals remaining, many as yet untapped;
- The overwhelming majority of these resources are neither as conveniently located nor of such good quality as the rock which has been exploited historically and is still being mined at existing operations. The most significant of these "new" costs involve logistical infrastructure rather than the mining operation. In most cases, other factors add to costs such as the availability of water, the need for expensive beneficiation and a general increase in the capital costs of projects whether mining or processing into plant-available form, which can be significant;
- Any constraint on the supply of phosphate will therefore be determined not by resource availability but by the cost of exploitation, conversion into plant-available P_2O_5 and delivery to market.

Phosphate Rock Demand

Total phosphate fertilizer consumption is projected to grow from 42.8mn t P_2O_5 in 2014 to 54.2mn t P_2O_5 in 2029. This 11.4mn t P_2O_5 increase is 2mn t higher than the 9.4mn t increment seen in the previous 15 years. The forecast growth is equivalent to 40mn-42mn t of rock.

Figure 1: World Phosphate Fertilizer Consumption 1998-2029 *mn t P_2O_5*



— IFA, Argus FMB

Strategic implications

Phosphate Rock Supply

- Among the more important producers in volume terms, output has been gradually declining in North America and, for political reasons, in Tunisia and Syria. Output has been growing strongly in China, and more recently in Saudi Arabia. In both cases, incremental tonnage is being processed captively. Egypt has seen a rise in the production and export of rock, as companies seek to take advantage of the decline in Syrian exports. Peru has emerged as an important new merchant rock industry which is export-orientated and likely to remain so for the foreseeable future.

- The majority of long-standing industries have gradually increased processing capacity against a background of static or slow-growing production and generally at the expense of merchant rock availability.

- The only major change of which we can be certain is the expansion of OCP's mining capacity in Morocco, principally at Khouribga. Financing is in place and work on the mining, beneficiation and logistical infrastructure is well advanced. The additional 20mn t of capacity will be brought on stream in increments throughout the medium term, as and when expansions at processing facilities at Jorf Lasfar and offshore joint ventures come on stream and merchant demand requires it.

- Jordan is also increasing rock production in line with requirements for processing joint ventures.

- Acron's new mine at Oleniy Ruchey is building up to full utilisation. The second phase was planned for 2017 but seems unlikely to meet this target. The first phase has yet to achieve a full year's output of 1mn t/yr and production costs are believed to be higher than Apatit's in the first years of operation. This is mainly because of the company's inability to fully exploit the value of the mine under the terms of the licence i.e. also extracting the nepheline present in the deposit.

- New mines in China will open over the short term. But increasingly, new capacity will be replacing old and inefficient mines.

- The decline in US production will continue over the long term. While the industry has developed plans to manage the decline, environmental lobbying threatens to disrupt the smooth transition to new mining areas, and the consolidation of remaining operations.

- Eurochem's Kazakhstan mine launched production in July 2014. Production capacity for Phase 1 will be 650,000 t/yr and full commissioning is expected in 2016, mainly to feed Eurochem's downstream needs. The second phase involves a fertilizer complex which will require an expansion of the mine to a capacity of 1.5mn t/yr. This phase of the project will take five years to complete and is not expected to materialise before 2018.

- The new Ma'aden/Mosaic/Sabic mine and processing project is expected to come on stream by 2018. The joint venture mine will produce 5mn t/yr of rock to support fertilizer processing.

- Scope for the development of major new phosphate rock production by newcomers to the industry is limited. A great deal of exploratory work and project scoping is being undertaken by junior mining companies, spurred on by the 2007-08 price boom and the peak phosphate debate. Many of these embryonic projects face problems in respect of infrastructural requirements and costs. In addition, the grade and quality of much of the rock available suggests it would be better suited to an integrated operation. The rock from most of these projects would be at a disadvantage in the merchant trade, as it would incur price penalties compared with higher grade and higher quality rocks. The only medium-term exception may be the FosPac project in Peru, near the existing Bayovar mine, with a total capacity of 2.5mn t/yr. This project has the advantage of producing an acid-grade rock that is also suited for single superphosphate and direct application, as well as guaranteed offtake and powerful shareholders.

We expect no shortage of phosphate rock in the foreseeable future. Equally, any significant or long-lasting oversupply appears unlikely. This in part reflects the growing market power of a number of key exporters of P_2O_5, which have shown their willingness to curtail supply of rock and finished product in order to manage the market.

Rock Grades and Quality

This report defines rock grade solely in terms of its P_2O_5-content and quality in terms of its chemical composition, mainly reactivity and impurities.

- The average grade of phosphate rock produced is gradually falling. In 1988, the output of rock below 69pc BPL represented 51pc of the total. By 2013 this proportion had risen to 80pc of total production.
- This trend was even more extreme in the case of merchant rock deliveries. In 1988, exports of rock with 69pc BPL or more accounted for 84pc of trade. By 2013 these higher grades of rock accounted for only 44pc of international trade.
- The main acid grade of export rock is now 66-68pc BPL material. In 1988, rock in the 69-72pc BPL range was most widely traded.
- A drop in the P_2O_5 content of rock leads to higher costs, particularly for importers. Up to 10pc more rock per tonne of P_2O_5 needs to be handled and transported and the throughput of a phosphoric acid plant falls correspondingly.
- Generally speaking, high-grade ore bodies with low impurities have been cherry-picked. As poorer ore bodies are mined, the content of P_2O_5 falls and the content of unwelcome constituents increases. Lower grade rocks with unwelcome impurities such as magnesium, chloride, cadmium or silicates will be less saleable on the merchant market and attract a correspondingly lower price.
- The non-phosphate content of the ore mined will influence its processing potential. The impurities, rather than the grade of the rock, determine its suitability as a feedstock for phosphoric acid or superphosphate manufacture. Adjustments to beneficiation and processing can mitigate problems to an extent, but this requirement generally demands that the rock be consumed captively in a purpose-built acid plant and not traded on the merchant market. This is likely to be the case for the two most developed projects in Kazakhstan. Both will mainly serve captive acid plants, or in the case of the Eurochem project, a proportion of material will be used in its own existing plants.
- Few of the rocks under study at new mining ventures are well-suited for export to the phosphoric acid sector, and certainly not as the sole source of raw material.

Strategic implications

Merchant Rock

Trade in rock has remained static over the past 10 years at ±30mn t/yr product. However, there have been fundamental and on-going shifts in the characteristics of the rock traded:

- Trade in higher grades of rock (69% BPL or 31.5% P_2O_5 has declined steadily;
- Trade in lower grade rocks has grown, for direct application purposes or use in NPKs. We expect this growth to continue in line with the expansion of plantations in tropical southeast Asia and Africa. We are also seeing reactive rock demand growing in many regions, especially where organic agriculture has taken a foothold. In other instances it is used for reasons of economy rather than agronomy;
- Low-grade rocks and rocks with higher levels of impurities are increasingly being blended with other concentrates to provide a lower-cost feed for phosphoric acid manufacture.

The main points which emerge from the trade analysis are as follows:

- We see no evidence to suggest that there will be a return to constructing phosphoric acid or nitrophosphate complexes of large scale based on imported rock. The only exceptions will be complexes built as joint ventures between a mining company and a processing company — a form of arm's length vertical integration. The most recent of these was the PT Petro Jordan Abadi joint venture acid plant in Indonesia, which will take about 800,000 t/yr of rock from JPMC, the first of three similar joint venture plants between state-owned PT Pupuk Indonesia Holding Company and JPMC. A further example is the Zuari-Mitsubishi FosPac consortium;

- The main driver for the trade of merchant rock will continue to be phosphoric acid production. Many of the existing non-captive acid plants are over 30 years old and face threats to their long-term survival — economic, environmental and socio-political. The most recent development was the closure of the MissPhos plant in Pascagoula amid rising costs, removing a further 800,000-1mn t/yr of rock import demand going forward;

- We expect growth in the export of rock for use in single superphosphate. This trade will continue in Latin America and Oceania and is developing in India in order to take advantage of rock not suited to acid manufacture and available at discounted prices. Increased production of single superphosphate will develop in order to exploit local rock which, given the small scale of reserves and/or impurities, would be unsuited to feed a large-scale phosphoric acid complex;

- Acron, which started production at its Oleniy Ruchey mine in 2013, has now achieved self-sufficiency in rock concentrate. A home will have to be found for its 300,000 t/yr rock sales availability, which will grow into 1.3mn t/yr, as and when the second phase of the Oleniy Ruchey mine is completed.

This essentially adds up to a static overall picture for rock trade, with adjustments to the market share of grades and qualities on the one hand and end-uses on the other hand. The large-scale increments to rock production occurring in Morocco, Saudi Arabia and China will all be captively processed, as will half the production of the FosPac project if it proceeds. Growth in shipments will occur largely in the non-acid sector.

Strategic implications

Price Outlook

The analysis of phosphate rock pricing demonstrates that:

- Moroccan producer OCP is the dominant supplier of rock for use in phosphoric acid manufacture (acid-grade rock). We believe that it will be OCP's objective to protect its remaining customer base by enabling them to continue to produce economically for sales to their own market. Acid-grade rock pricing will therefore take account of:

    - OCP's need to keep its phosphoric acid and nitrophosphate producing customers viable;
    - Its desire to make new merchant rock projects unattractive investments;
    - The maintenance of a rational relationship between the unit cost of P_2O_5 in rock, merchant acid and solid phosphate fertilizers.

- Rock importers will continue to adapt phosphoric acid plants to lower qualities of rock and to blended feed in order to maintain market leverage;

- As the major build-up of new processing capacity will occur in Morocco and Saudi Arabia, the timing of incremental output so as to stabilise the international market price will be driven largely by OCP and Saudi mining company Ma'aden. In the medium term, OCP will expand rock production only to serve the requirements of its four new ammonium phosphate complexes planned under the Jorf Phosphate Hub programme. The next tranche of new mining and processing capacity will come on stream post-2019 and the precise timing will be driven by market realities;

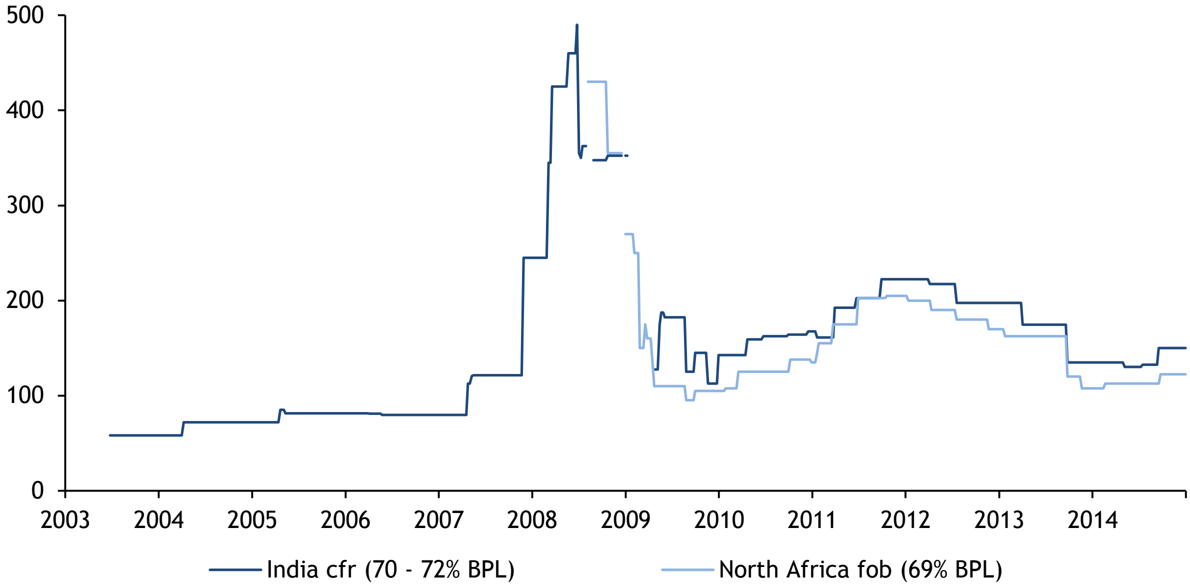
- The introduction of acid-grade rock by newcomers to the industry appears to be academic in the short term. The quality of rock is not available and the cost of bringing it to market prohibitive. The only medium-term exception may be new Peruvian export availability from the FosPac project;

- Lower-grade rock or rock with difficult impurities will be sold at a discount to OCP benchmark rock. This applies, for example, to Bayovar, Algerian, Syrian and Egyptian rock. OCP 31-32pc P_2O_5 rock will remain the benchmark against which discounts for poorer grades and qualities and premiums for higher grade of rock will generally be calculated. The discount takes account of a BPL adjustment and a quality adjustment which is determined by unwelcome impurities;

- For the foreseeable future, it appears that Egyptian material will set the pace for low-grade rock of lower/unreliable quality, but again within the general parameters of OCP acid-grade rock prices. This will only change with a major reorganisation of the Egyptian industry and the construction of additional processing facilities. Neither of these developments appears to be imminent and new major processing capacity looks at least five years away. The recent surge in Egyptian production and exports reflects the dislocation of government and industrial policy. It has been fuelled by short-term licences to exploit outcrops of higher grade material which can be sold without beneficiation. This additional output has been very variable in quality and the need to cherry-pick resources to generate revenue undermines a rational approach to exploiting reserves.

Strategic implications

Figure 2: Phosphate Rock Prices $/t



— Argus FMB

Note: Since end-March 2010 Argus FMB reports fob North Africa 68-70pc BPL, previous North Africa prices refer to 68-72pc BPL.

After the current market softness unwinds, the long-term objective of OCP will be to establish a floor price for its benchmark grade as close as possible to $150/t — albeit accepting a lower absolute floor of $120/t when its market control margin is assumed to come under more significant pressure in 2018— but still not greatly in excess of $200/t for short periods, a level which could conceivably revive interest in new projects for merchant rock. Our trend forecast is for phosphate rock prices to rise to $230-236/t cfr India and $177-184/t fob Morocco by 2029.

Section 1: Phosphate Rock Resources and Reserves
Chapter 1: Phosphate Rock Resources

There are three main primary forms of phosphate reserves: apatites of igneous origin, sedimentary marine phosphorites (the major form), and guano, formed from sea-fowl or bat droppings. These three primary forms of phosphatic mineralisation may be altered and concentrated by secondary chemical and physical processes such as weathering or leaching. Phosphate is associated with many and various minerals: sedimentary phosphates are generally associated with black shale and chert; igneous phosphates may be associated with carbonatite, nepheline-syenite or other alkali rocks. From a practical viewpoint, this means that the term phosphate rock is little more than a generalisation for phosphate-containing mineralisation of diverse origin and character and chemical and physical characteristics. The very diversity of phosphatic mineralisation is important, as it determines the suitability and cost of processing of any specific resource into plant-available P_2O_5.

The diversity of phosphatic mineralisation makes it difficult to generalise about the availability of potential supply. Significant media interest in the notion of peak phosphates (akin to the concept of peak oil) emerged during the agricultural commodity price spike in 2007-8, with some commentators even claiming that global phosphate rock reserves would be depleted within 50 years. The short-lived panic was produced in part by non-experts referring to figures produced by government agencies such as the US Geological Survey (USGS) and the US Bureau of Mines (USBM), which has been regarded as the main source of information on global phosphate rock reserves and whose data have not been systematically revised for many years. In response the USBM hurriedly revised reserves figure in January 2011 but not its reserve base figure (*see below*). The use of the term reserve base is one of the many and diverse definitions used in assessing potential minerals supply. The term reserve base as used by the USBM is defined as:

“... part of identified resources which meet minimum physical and chemical criteria related to current mining and processing practices, including those for grade, quality, thickness and depth. The resource base includes resources currently deemed to be economic, marginal reserves and currently sub-economic resources. Excluded from the reserve base are the large phosphates resources that have been identified on the continental shelves and on seamounts in the Atlantic and Pacific Oceans: these cannot be recovered economically with current technology.”

The slightly differing definitions which are applied to estimates of reserves all make reference to prevailing economic considerations and technology. At this point, economics takes the lead from geological analysis.

As the foundation for this report, we will first focus on the resources of phosphatic mineralisation which have been identified and — although not in all cases — thoroughly researched. One of the basic flaws in the argument of those warning of resource depletion in the coming 50-100 years is that they fail to give weight to the dynamic nature of mineral resource investigation:

- Geological surveying is a continuing process. The probability is that new work will result in a net addition to known resources and reserves, even accounting for areas where mining is leading to the gradual depletion of currently worked deposits;

- Definitions which rely on either historical or current economic realities will naturally represent a very incomplete view of total potential supply and will be superseded as new processes and market realities emerge;

- The proving of reserves occurs mainly when planning for the mining of new blocks of land commences — it is a continuing process even where mining is established.

The USGS data, which helped spark the “peak phosphate scare”, covers only a limited number of producing countries. It does not purport to be a comprehensive and detailed global assessment of all resources and is not intended as a tool for investment planning. The 2008-09 data on reserves had not been reviewed for some years, and was based on the technological and pricing norms of the 1990s. By 2008, the economics of fertilizers looked very different. This resulted in a number of fundamental revisions to resource and reserve forecasts:

Table 1: Phosphate Resource Estimates *mn t*

Country	USGS Jan 2009 Estimate*	IFDC Jan 2011 Estimate**
Australia	1,200	3,500
Brazil	370	2,800
Canada	200	130
China	10,000	16,800
Egypt	760	3,400
Israel	800	1,600
Jordan	1,700	1,800
Morocco	21,000	170,000
Russia	1,000	4,300
Senegal	160	250
South Africa	2,500	7,700
Syria	800	2,000
Togo	60	1,000
Tunisia	600	1,200
USA	3,400	49,000
Others	2,200	22,000
Total	**47,000**	**290,000**

**Definition as in text above, **In terms of tonnes of recoverable concentrate*

— IFDC, USGS

The countries which make up the others category in the IFDC estimate are Algeria, Angola, Finland, Kazakhstan, Peru and Saudi Arabia, which underlines the fact that we are talking primarily about producing countries — the exception being Angola. The major changes in the reserve status of a number of key players illustrate the rather different approach taken by the IFDC. For example, the uplift in Moroccan reserves indicates that IFDC is looking at national reserves, whether currently being worked or not. The increase in the US reserves are based on the recognition that the large reserves of lower-quality ore can be utilised if the economics are not skewed by current environmental and permitting arguments which may or may not be temporary.

Section 1: Phosphate Rock Resources and Reserves
Chapter 1: Phosphate Rock Resources

A more broad-brush approach was taken in the last comprehensive geological survey of resources "World Phosphate Deposits of the World" (1989), in which known deposits of all types and grade were estimated to be at least 163bn t[1]. This appraisal was undertaken before the opening up of China, where reserve information was not readily available in 1989. The following table has been derived from this work by Steven J Van Kauwenbergh of IFDC[2].

Table 2: Estimate of World Phosphate Rock Resources as of 1989 *mn t*

Region	Estimated Resources	Average P_2O_5
North America	34,999	24pc
South America	5,243	18pc
Africa	67,016	26pc
Middle East	15,642	21pc
Europe	1,168	7pc
Asia	13,947	24pc
FSU and Mongolia	21,269	12pc
Oceania	3,955	18pc
Total	**163,239**	**22.5pc**

The results of this very comprehensive 1989 study give a further indication of the dynamic nature of reserve estimates. In the 25 years since this report was compiled, the 2011 IFDC estimate has increased resource estimates by some 80pc. As we noted above, the estimate does not include marine deposits — much of which is located in relatively shallow, coastal waters. Modern dredging techniques should allow the exploitation of the easier deposits when economics permit. The 163mn t estimated in 1989 can also be compared with an assessment by Cathcart in 1980 and cited in the IFDC report which posited resources of 91bn t of rock containing at least 30pc P_2O_5.

In order to illustrate the scope for further increases in assessments of phosphate rock resources, we list the number of countries holding known resources which have been the subject of geological investigation. Within the framework of available research we find many lesser deposits, which have been partially depleted or are of relatively small scale — for example, deposits in Tennessee, California, Utah or Alaska in the US, as well as in Italy, France and the UK. These resources have generally been more thoroughly researched than occurrences in the developing world, and do not add significantly to global resource potential. We include them in the listing of resources and will comment on potential in terms of volume and timing in other sections of the report.

1 Editors A.J.G/Notholt, R.P.Sheldon and D.F. Davidson, Cambridge University Press, 1989

2 S.J.Van Kauwenbergh, 'World Phosphate Rock Reserves and Resources', IFDC, September 2010

Section 1: Phosphate Rock Resources and Reserves

Chapter 1: Phosphate Rock Resources

Table 3: Known Phosphate Resources	
Country	**Notes**
Europe	
Belgium	Deposits in Mons Basin. Once worked
Bulgaria	Reserves investigated in Eastern Rhodope mountains
Finland	Currently producing
France	Small deposits of various types throughout France. Some worked in the past.
Germany	Largest deposits in East (Mecklenburg/Brandenburg). Associated with iron ore in Salzgitter area and once worked.
Greece	Significant reserves in Northeast and smaller deposit in Southwest.
Greenland	Deposits of apatite-rich carbonatite in Southwest.
Irish Republic	Thin seams over large area of County Clare. Once worked
Norway	Significant deposits mostly associated with iron ore. Once worked
Poland	Small deposits close to Lublin. Once worked.
Portugal	Small veins of apatite and small occurrences of sedimentary rock.
Serbia	Significant deposits in Eastern Serbia.
Spain	Small deposits of apatite in Caceres Province. Once worked.
Sweden	Deposits of apatite associated with iron ore. Once worked.
UK	Small deposits widely distributed. Most significant mine Northern Scotland.
EECA	
Kazakhstan	Five main deposits of significant size. Currently producing.
Russia	Both igneous and sedimentary deposits throughout Russia once worked. Currently production focused on igneous rock.
Turkey	Several deposits. Small scale mining in past.
Turkmenistan	Deposits in Northwest. (Tuarky Field)
Uzbekistan	Deposits Central Kiziliums. Being worked
Africa	
Algeria	Currently producing
Angola	Significant sedimentary deposits plus some igneous carbonatite structures.
Atlantic Islands	Deposits of guano especially on Ascension Island. Apatite identified on Cape Verde Islands
Benin	Small deposits at Mckrou Bend identified.
Burkina Faso	Several occurrences of which Kodjari deposit appears the most important.
Burundi	Igneous Matongo deposit has been surveyed.
Cameroon	Small deposits.
Central African Rep.	Deposits at Bakouma
Congo	A number of small deposits identified
Egypt	Currently producing
Gabon	Sedimentary deposits from a belt close to coast.
Guinea Bissau	Farim-Saliquinhe deposits identified and surveyed. Significant volumes
Kenya	Igneous deposits identified at Mrima Hill
Liberia	Guano deposits identified
Malawi	Small deposits of carbonatite and apatite. Small-scale working
Malagasi Rep.	Small guano and phosphate-carbonate deposits. Once worked
Mali	Three main areas containing phosphates of varying types and richness
Mauritania	Significant deposits of high-grade apatite
Morocco	Currently producing

Section 1: Phosphate Rock Resources and Reserves

Chapter 1: Phosphate Rock Resources

Table 3: Known Phosphate Resources	
Country	**Notes**
Mozambique	Significant chlor-apatite plugs
Namibia	Significant marine deposits and guano on islands
Niger	Small deposit at Tapoa
Nigeria	Deposits in Oshosun and Seriki Oko plateau.
Senegal	Currently producing
Seychelles	Guano. Once worked
South Africa	Currently producing. Significant marine deposits
Tanzania	Apatite and calcium phosphate deposits. Small-scale working in the past
Togo	Currently producing
Tunisia	Currently producing
Uganda	A number of apatite deposits. Once worked
Zaire	A number of carbonatite complexes known
Zambia	Carbonatite and apatite occurrences have need surveyed
Zimbabwe	Production currently disrupted
North America	
Canada	Production stopped in 2013 with the closure of the Kapuskasing mine. Deposits in most states with some under active investigation.
USA	Deposits in many states. Current production in Florida, North Carolina and Northwest states. Potential for marine deposits
Central America	
Caribbean	Small deposits of guano derived minerals
Mexico	Currently producing. Significant marine deposits
Surinam	Significant potential in upper Nickerie area
Venezuela	Currently producing at Receite
South America	
Argentina	18 Marine/sedimentary basins identified. Potential for marine deposits
Bolivia	2 deposits identified
Brazil	Current production of apatite and sedimentary rock
Chile	Known deposits on Mejillones Peninsula and Bahia Tongoy-Guanaqueros
Colombia	Small-scale production. Significant deposits in a number of areas
Peru	Currently producing. Significant on-shore and marine deposits
Uruguay	Deposit identified at Grita y Cerro Arrequita
West Asia	
Jordan	Currently producing
Iran	Several deposits. Currently producing
Iraq	Major deposits. Previous mining curtailed by military conflict
Israel	Currently producing
Lebanon	Small deposits in the Jebel Bir ad Dahr area. Well surveyed and tested
Saudi Arabia	Major deposits. Now producing
Syria	Currently producing
South Asia	
India	Currently producing at a number of small-scale mining operations
Pakistan	Previous production at Kakul. Deposits in Northwest astride Afghan border
Sri Lanka	Producing small volumes at Epawala. Significant deposits of chlor-apatite
East Asia	
China	Numerous deposits, many currently exploited

Table 3: Known Phosphate Resources

Country	Notes
Christmas Island	Currently producing
Indonesia	Small-scale mainly guano-based production
Kampuchea	Small-scale mainly guano-based production
North Korea	Small-scale mining has been undertaken
Malaysia	Small-scale mainly guano-based production
Mongolia	Major reserves
Nauru	Currently producing
Philippines	Small-scale mainly guano-based production
Thailand	Small-scale mainly guano-based production
Vietnam	Lao Cai deposits currently producing
Oceania	
Australia	Currently producing. Major unexploited deposits
Pacific Islands	Small-scale mainly guano deposits

The above tabulation seeks only to establish the limited geographical scope of the USBM estimates, which focus mainly on countries with existing production and generally within the areas of current mining activity. This approach reflects the relative stagnation of the phosphate sector during the 30 years following the Opec crisis. Even during the 1990s and into the present century, the international price for phosphate rock (72pc BPL) was in the $45-50/t fob range. Only a handful of grassroots projects were likely to be economically viable at such price levels.

In the following chapter we look at the impact of economic assumptions on reserve assessments, and in a later chapter at specific projects and potential supply sources.

Section 1: Phosphate Rock Resources and Reserves

Chapter 2: Phosphate Rock Reserves

While the following figures from the latest US Geological Survey (which includes implied figures for reserve life) should still be treated with caution, it is clear that there are sufficient global reserves of useable phosphate rock to ensure a supply of P_2O_5 for the foreseeable future. Excluded from the figures are the large phosphates resources that would only be viable at significantly higher prices than the historical norm. These include reserves which have been identified on the continental shelves and on seamounts in the Atlantic and Pacific Oceans: the US Geological Survey clearly considered that such deposits cannot be recovered economically with current technology, although the price spike of 2008 created interest and has led to development work on offshore deposits in Namibia and New Zealand waters.

Table 4: Phosphate Rock Reserves, 2013 *'000t*

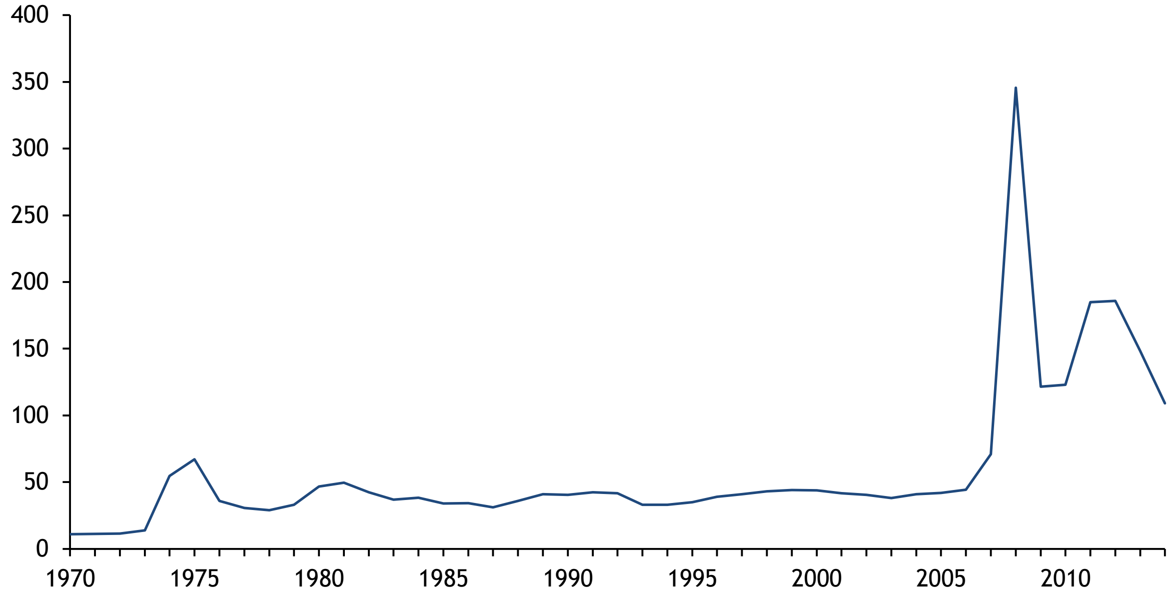
	Production 2013	Reserves	Reserve Life (Years)
US	30,548	1,100,000	36
Algeria	1,151	2,200,000	1,911
Australia	1,919	870,000	453
Brazil	5,939	270,000	45
Canada	316	2,000	6
China[1]	77,000	3,700,000	48
Egypt	5,315	100,000	19
India	1,211	35,000	29
Iraq	360	430,000	1,194
Israel	3,437	130,000	38
Jordan	5,399	1,300,000	241
Mexico	1,910	30,000	16
Morocco	25,489	50,000,000	1,962
Peru	3,547	820,000	231
Russia	10,743	1,300,000	121
Saudi Arabia	3,055	211,000	69
Senegal	1,128	50,000	44
South Africa	1,925	1,500,000	779
Syria	898	1,800,000	2,004
Togo	1,214	30,000	25
Tunisia	3,284	100,000	30
Others	7,504	520,000	69
Total (rounded)	**193,292**	**67,000,000**	**347**

[1] *Production data for large mines only. See note on Chinese rock figures*

— US Geological Survey, Mineral Commodity Summaries, February 2014; 2013 Production - IFA

The key issue for forecasting phosphate supply in this report boils down to the economic tests for new or expanded production. Despite the continuing commentary from peak phosphate exponents, the industry is not resource-constrained. Development of new resources was economically constrained for a period of 30 years by oversupply and low phosphate prices, which curtailed interest in investment in new deposits, except where development was driven by government policy rather than private investment.

Figure 3: Phosphate Rock Prices since 1970 *$/t*



— World Bank Pink Sheet; October 2014

The impact of 30 years of depressed prices between 1975 and 2005 has been to discourage new greenfield projects, alongside a substantial industry restructuring. The following tables show not only how sluggish the market was for 35 years, but also how the comparative fortunes of the major players have changed. The figures for 2012 and 2013 include sizeable gains in China, Egypt, Saudi Arabia and Peru.

Table 5: Peaks and Troughs in Global Phosphate Rock Production *mn t*

Peak 1984	Trough 1986	Peak 1989	Trough 1992	Peak 1998	Trough 2000	Peak 2005	Trough 2006	Peak 2007	Trough 2009	Peak 2012-2013
152.4	143.8	162.3	120.7	144.5	131.7	172.1	167.6	176.2	162.7	196.7-193.3

— IFA

Table 6: Output by Major Producers *mn t*

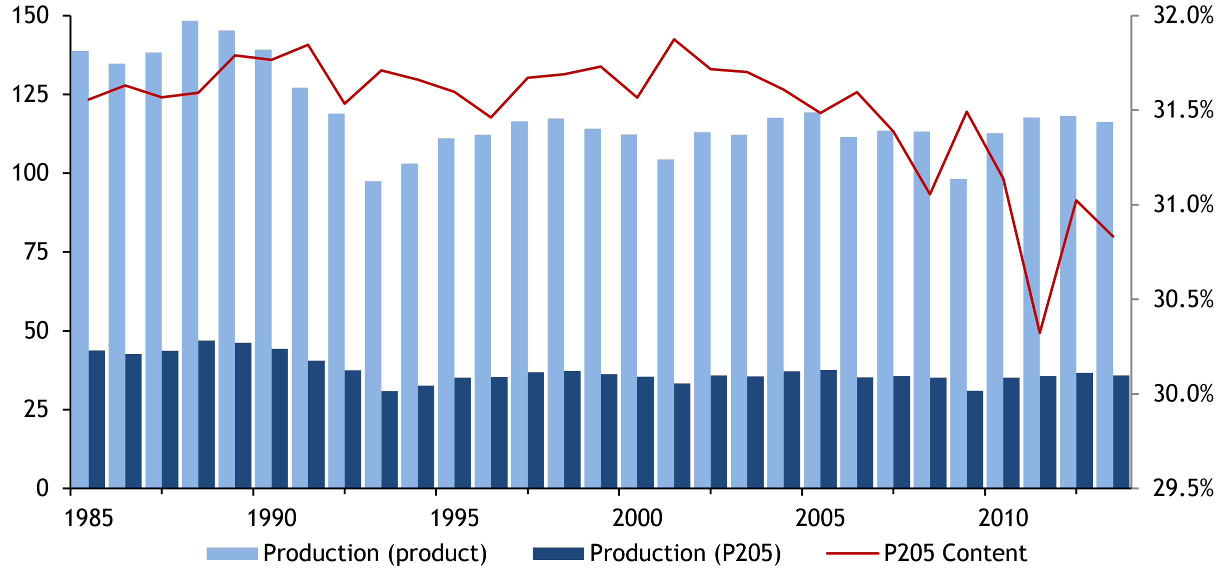
	1984 Peak	2007 Peak	2013 Peak
World Production	**152.4**	**176.2**	**193.3**
Of which			
FSU	31.3	13.3	13.3
USA	49.2	30.9	30.5
Morocco	21.1	27.6	25.5
China	14.2	62.7	77.0
Subtotal	**115.8**	**133.8**	**146.3**

— IFA

While the bulk of production comes from the countries with an established industry, the balance of power has shifted significantly — away from the US and the FSU industries (particularly Kazakhstan) and towards China in particular. It is also important to note that overall production saw neither substantial nor regular increases until the rapid emergence of the Chinese industry over the last 10 years. Production in the 1984 "peak year" was only 10mn t below the depressed year of 2009.

The need for substantial new capacity was constantly thrown into doubt during 2004-05 by the short-lived peaks in prices and production and the regular troughs. Since then, the enormous growth in Chinese rock production has impacted on the global market through phosphate fertilizer output and exports (but not directly on rock trade). The production trend for producers outside China was steadily downwards until the recent boom years stimulated a small revival, as the following chart illustrates:

Figure 4: Phosphate Rock Production (excluding China) *mn t*



— IFA

Relatively few entirely new operations of any size were added to the supply base between 1975 and 2005:

- Australia (2mn-2.5mn t/yr);
- Canada (now closed down);
- Iraq (in the first stages of reconstruction after serious war damage).

A tipping-point came in 2004-05, with a surge of new demand from Asia and South America. It affected not just phosphate rock, but potash, oil and metals — all of which had experienced reserve depletion during the many years of low commodity prices. The industry struggled to turn up production at existing operations and suitable opportunities for new investment were thin on the ground and unattractive at the price levels which had been the norm for several decades. In short, we reached an economic, rather than a resource watershed. The existing industry was developed to exploit the best rock in the most convenient locations, and the depletion of reserves at many of these operations means that production expansions have been limited. The search was on for new reserves, but most of these come at a cost which demands prices many times higher than the $30-50 fob level — which was the norm in 1975-2005.

Section 1: Phosphate Rock Resources and Reserves
Chapter 2: Phosphate Rock Reserves

Since 2005 we have seen four new entrants: the Bayovar project in Peru, Ma'aden in Saudi Arabia, Acron in Russia and Eurochem in Kazakhstan.

All of these projects had long been under discussion but the change in industry dynamics — which was becoming evident in the years following the turn of the current century — finally provided the impetus to invest. Neither of the projects looked viable at the prices prevailing in the 1990s and into the first years of this century. Bayovar has brought 3.5mn t/yr of merchant rock to the international market. But all of the output from the Ma'aden mine is consumed internally.

Section 1: Phosphate Rock Resources and Reserves
Chapter 2: Phosphate Rock Reserves

2.1 Changing Project Economics

In this introductory section we will examine in general terms the key issues which add to the cost of developing a grassroots mine. We will look at which of these factors apply to specific projects in the chapter dealing with the outlook for supply. In some of the countries, which have long been producers of phosphate rock, expansion at existing mines may not be feasible and future growth will depend on establishing new mines bearing the heavier costs associated with grassroots projects.

Logistics: Reserves within 100km of the coast and deep water ports were among the first to be developed, for example, the Bone Valley deposits in Florida, the Red Sea deposits in Egypt, the Gafsa Basin in Tunisia or the Moroccan reserves in Khouribga, Youssoufia and Ben Guerir. Of the new reserves opened up, only the Sechura deposit in Peru is conveniently placed for exports. For many large-scale reserves, the problem lies not in the mining and processing of ore but in moving it to market. No project is likely to be viable if it has to bear the cost of constructing 1,000km of railway line and/or port facilities. On the other hand, governments are neither willing nor, in many cases, able to finance the infrastructure required to develop inland deposits and move product to the market. The only recent exception to this general rule has been the Ma'aden project which has benefited from both a railway and a port connection provided outside the scope of the project itself.

Associated investments: New mines, particularly those in remote locations, often require offsite facilities such as townships, schools and clinics for the workforce. These substantially add to both the capital costs of a project and the total employment costs.

Water: The operation of both mines and downstream processing facilities depends on a supply of sweet water. The majority of phosphate rock deposits are found in arid areas where water, if available, may need to be drilled and piped-in over considerable distances or where the construction of dams or desalination units is needed. In some instances only water with high salinity is available. Providing water in such circumstances adds to both capital and operating costs.

Politics: Political considerations are playing an ever-greater role in the planning of new mines and the operation of existing mines and processing complexes. Additionally, the requirement for land-locked plants, for example in central Asia, not only to transport product over long distances but in some instances to pay transit charges levied by countries through which the rock must be moved, substantially adds to costs. Product moved in this way also risks being a target in any bilateral dispute between the country of origin and the country of passage as we have seen in the past, in respect of both gas and nitrogen fertilizers.

Quite apart from environmental considerations, in some countries there are problems in respect of obtaining mining permits or the terms of available permits. A recent spate of political unrest in north Africa and the Middle East raises questions as to the future ownership of phosphate rock deposits and mines. In most cases, the rock reserves are owned and mined by the state. In many cases, the state may be unable or unwilling to finance the development of the industry, or provide the basic logistical infrastructure to encourage private-sector investment in the mining and processing operations.

Environmental impact: Environmental impact is of great importance in the developed world. It has long been the case that existing operations — undertaking routine development of a mine as areas become exhausted — and new projects in the developed world have been beset by expensive conflicts and delays. We cite the US industry which faces well-organised lobbying in most aspects of its activities, but also the new mine proposed in Finnish Lapland, where the preservation of a natural wilderness area makes any industrial development extremely complicated. In the developing world, we are seeing a greater focus on the disposal of slimes and the use of water and the impact on the supply and quality of drinking water and destruction of wilderness areas and agricultural land becoming issues in the development of projects. As a rule of thumb where external finance is required, whether private-sector or through multinational agencies, environmental impact becomes a routine part of the "tick-list" in project approval.

Escalation of Capital Costs: There has been a significant increase in the capital cost of projects throughout the fertilizer sector, and this applies equally to phosphate rock mines and beneficiation. The impact of the increase in costs is magnified by the fact that most new mining developments will be as part of a larger, integrated phosphate fertilizer complex, which substantially increases the capital required. The Ma'aden project (not including the railroad) is reported to have cost in excess of $5.5bn. The increase in capital costs combined with the continuing global banking and financial crises are blighting the prospects of venture projects in their efforts to raise money. Even prior to 2008, the internal mechanisms of investment banks militated against lending, since it was general procedure to base decisions on as long a series of historical prices and market statistics as was available. Investment in a commodity industry with a 30-year history of low prices often did not appear particularly attractive.

These are factors which are of varying significance from one country to another, and one project to another. They are not readily subsumed into a simple equation that can be applied by geological organisations in establishing criteria for reserve assessment. The tightening of the market is real but refers less to the availability of rock than its availability in the quality and at production cost levels that have long been the basis of reserve calculations. Rock will become available as and when price levels allow its economic exploitation and downstream processing. It may be that the recovery of phosphate values from waste products and the development of higher cost fertilizers that control the release of P_2O_5 and provide it to plants more efficiently will become viable approaches as the costs of producing phosphate rock increases — especially if politically motivated environmental incentives are on offer. Newly mined rock or recovered P_2O_5 will be available for the foreseeable future, but at prices much higher than historical levels. The rock will generally be of lower grade and quality and therefore more difficult and expensive to beneficiate and process.

2.2 Technology Developments

The peak phosphate argument neglects the ingenuity of engineering faced with the opportunities offered by higher price levels. Already we are seeing developments which are looking to take advantage of tightening supply and rising prices. We offer this brief overview, as an illustration of what can be expected in the way of technical developments but not as an endorsement of any specific project or process.

2.2.1 Alternative Acid Processes

Great interest is being shown in the development of modern kiln processes. We take as an example JDC's Improved Hard Process. The process uses phosphate rock, petroleum coke and silica in a furnace to produce a pure phosphoric acid of higher concentration than the traditional wet process route. The driver behind the development work was a decline in the availability of Florida rock suitable as a feed for the wet process route on the one hand, and the avoidance of phosphogypsum generation in phosphoric acid manufacture, which together threaten the terminal decline of the Florida industry. The key points of the process relevant to this part of the analysis are as follows:

- It allows the use of low-grade ore (~15pc P_2O_5). This effectively adds about 1bn t to rock reserves in Florida, mainly for the lower zone rock seam which is not suited to the wet process due to lower P_2O_5 content and high magnesium content;
- Allows the use of ore with high silica, organics, iron and magnesium content which restrict the use of the wet process route;
- Produces a commercially acceptable aggregate for use as a road-building material instead of phosphogypsum, the co-production of which is constraining the operations of processing plants in Florida.

JDC Phosphate (JDCP) is currently building a pilot plant in Fort Meade, Florida in order to test the viability of the IHP technology. In June 2013, JDCP indicated that it was experiencing construction-related issues which were delaying the startup of the pilot plant. At the time of writing, the JDC pilot plant has still not started.

In China work on furnace processes to treat low P_2O_5/high magnesium ores was instigated some years ago, but the pilot plant has recently been closed down. As resources of high-grade ore are exhausted, development work is likely to be resumed on this and other ways of making P_2O_5 available to plants without recourse to acid attack. We do not consider such processes to be a wholesale replacement for the wet process, but an adjunct to traditional production.

While we point to no specific development other than the interest in kiln processes to deal with low-grade rock containing significant impurities which affect processing, we note the development of processes and techniques over the last 30 years that enable rock to be produced and processed which would have been regarded as uneconomical 40 years ago. During the 1970s, those estimating reserves tended to have a cut-off point of 30pc P_2O_5 for screened and washed ore. Since then, phosphoric acid processes have been adapted to use much lower-grade rock and flotation techniques have developed to upgrade ore not amenable to simple physical beneficiation plus washing. Flotation has now largely replaced calcining to produce high P_2O_5

concentrate and is making feasible the beneficiation of relatively low-grade ores.

As ore grades at existing operations deteriorate, technology and novel processes will be introduced to allow fertilizer production, albeit at an increased cost. The ability to use low-grade rock will logically lead to an up-grading of reserve levels — seams of ore which have remained unmined and ore which has been mined and discarded will come into play as they become commercially viable. We have already noted the impact which this would have on reserves in Florida. OCP indicates that its reserves would be effectively doubled if it were to expend an additional $10/t on the mining and beneficiation of rock which has traditionally been, and is still being, discarded.

2.2.2 Marine Reserves

Dredging technology initially developed for diamond mining at about a 150m depth is being adapted to deeper water mining. It seems likely that the next 10 years will see the development of a dredging operation on one of the continental shelves which will recover rock from two or three times the depth of the existing seabed diamond recovery. The system will use a dredging vessel employing a suction cutter head and a floating pipeline to shore through which the dredger or shuttle vessel will deliver the slurry to settling ponds, reclaim, beneficiation and washing. The key modifications will permit the dredging of deeper deposits located at a greater distance from the shore. When market economics encourage the development and implementation of the dredging process, it could unlock substantial phosphate deposits which are generally omitted from any reserve calculation.

We conclude this section with the following remarks:

- Phosphate is not resource-limited for the foreseeable future. Conveniently located, high-quality rock in many existing mining areas is being gradually exhausted;
- New mining operations will open up as and when the market price for P_2O_5 justifies the investment;
- New mining, beneficiation and processing technologies will be developed when the market price for P_2O_5 justifies the investment and higher costs of production and/or delivery to market;
- The recovery of P_2O_5 from human and animal waste will increase, when the market price justifies the cost and/or when environmental regulation dictates;
- More sophisticated delivery systems to crops and more sophisticated fertilizers and techniques will develop as the price of P_2O_5 increases.

While the supply of phosphate to agriculture is not at risk this century, the supply of low-cost phosphate is gradually coming to an end. Over the last century, the most easily accessed and highest quality phosphate resources were the first to be exploited. Often this exploitation took the form of cherry-picking (selective mining) leaving seams of lower grade rock which, in the light of the technology available at the time, were not economical to mine and/or impossible to beneficiate to a point that was acceptable to the market. Until the last 30 years, it was the market which dictated the acceptable specification for rock, as such a large part was exported to non-basic processing plants. This aspect of the industry continues to see rapid change:

- The exhaustion of higher grade ore was first seen on a large scale in the case of Florida pebble phosphate and Christmas Island A and B grades. These grades disappeared from the market and the US industry has focused entirely on processing lower grade rock captively;

- The reduction in the P_2O_5 content of ore and concentrate will inevitably result in an ever greater proportion of rock being processed in situ. Vertical-integration is already the norm.

We are entering an age of lower grade, lower quality and more expensive rock.

Section 2: Phosphate Rock Supply

In this section we will look at where we are today and developments under construction that will affect medium-term supply and the supply outlook beyond the medium term. The focus of this report is merchant phosphate rock, but this cannot be considered without taking account of the interface with rock fed directly or at arm's length into an integrated processing complex. We will therefore consider how changing economics will impact the structure of the processing industry and the mines serving these industries.

Section 2: Phosphate Rock Supply
Chapter 1: Supply Developments

Until the early years of this century, the phosphate rock sector was relatively static, especially outside China. The following table outlines the development of supply during this period. We do not focus on mine capacity as, unlike urea or phosphoric acid plants, it is more easily increased by small-scale investment in machinery or beneficiation as long as the base infrastructure is in place. Production in years of peak demand is a much better guide to the current capabilities of a mining operation. We do not include China in this table as official statistics were incomplete and unreliable during the years to 2005. Even today, there are issues about the quality of the rock produced, the output of small mining operations and a clear differentiation between run-of-mine ore and upgraded concentrate production.

Table 7: Phosphate Rock Production By Major Country (Excluding China) *mn t rock*

	2000	2008	2009	2010	2011	2012	2013
Total	**112.3**	**113.8**	**98.3**	**113.0**	**117.3**	**118.3**	**116.3**
Of which:							
Russia	10.1	9.8	9.5	10.8	10.3	10.3	10.7
Other FSU	0.6	2.4	2.0	2.5	2.4	2.6	2.5
USA	39.2	30.9	26.6	25.2	27.6	29.5	30.5
Brazil	4.7	6.3	6.0	5.7	6.1	6.1	5.9
Peru	0	0	0	0.8	2.5	3.2	3.5
Egypt	1.1	3.2	3.7	3.4	4.7	5.7	5.3
Morocco	21.6	24.2	18.2	25.7	27.8	26.8	25.5
Tunisia	8.3	7.6	7.3	8.1	2.5	2.6	3.3
South Africa	2.8	2.3	2.2	2.5	2.5	2.1	1.9
Israel	4.1	3.0	2.5	3.1	3.1	2.9	3.4
Jordan	6.0	6.2	5.3	6.5	7.6	6.4	5.4
Syria	2.2	3.2	2.2	3.8	3.5	1.8	0.9
Australia	1.0	2.5	2.1	2.1	2.5	2.1	1.9
Others	10.8	12.3	10.7	13.6	16.2	19.3	19.1

— IFA

Outside China, production has declined in the US, Tunisia, South Africa, Israel, Jordan and Syria since 2000, while Moroccan production has increased by almost 4mn t during this period. The following table shows the development of Chinese rock production since more consistent data became available. The full-year IFA figures now encapsulate all production, while in the past, only large-scale mines were included in the statistics.

Section 2: Phosphate Rock Supply

Chapter 1: Supply Developments

Table 8: Chinese Phosphate Rock Production	*mn t rock*
2005	52.8
2006	56.9
2007	62.3
2008	61.8
2009	63
2010	71.0
2011	76.0
2012	78.5
2013	77

— IFA, readjusted in 2013

In the past, statistics for the more than 400 smaller mines have been lacking. It is even worth asking whether some of the poor-quality rock produced would classify as commercial phosphate rock in other countries. An average P_2O_5 content of Chinese rock of 30pc is used in IFA statistics. However, research conducted at a provincial level estimates output of about 116mn t in 2013, which tallies in with the number announced by the National Bureau of Statistics in China for the same year (108.5mn t). We assume that the IFA production figure is based on a back-calculation from the P_2O_5 content of fertilizer and technical products manufactured.

Outside of China, new supply has been limited. A major feature of the recovering market in 2011-13 has been efforts by a number of established producers to squeeze out more tonnage from their operations. Most significant were:

- US output rose by 1mn t year on year in 2013 to 30.5mn t — the highest level for the last five years — as the permitting issue at Mosaic's South Fort Meade mine in Florida has been resolved and production is back to planned levels;

- Peruvian production reached 3.5mn t in 2013 as the Bayovar mine ramped up to its full capacity of 3.9mn t/yr of rock;

- Egypt maintained its production above 5mn t, with 5.3mn t produced in 2013, by working the existing mines and exploiting surface and shallow resources of weathered rock of relatively high grade. Statistical reporting in Egypt has become less reliable since the onset of political change and turmoil and it is difficult to reconcile this output with delivery figures;

- Saudi Arabian output remained flat at 3.1mn t in 2013 but should build up in the coming years as processing performance improves. Ma'aden rock is unlikely to enter the merchant market;

- In contrast JPMC, Jordan, decreased output by 1mn t in 2013 to 5.4mn t as the capacity of the new export terminal and changing market conditions restricted exports.

Section 2: Phosphate Rock Supply
Chapter 1: Supply Developments

In 2014, the main capacity developments were:

- Eurochem launched operations at its Kok-Jon phosphate rock deposit in the Jambyl region of Kazakhstan in the second half of 2013, and ore production started in July 2014. At the time of writing, Eurochem expects total production to have reached over 150,000 t/yr of phosphate last year;

- JPMC has completed a 2mn t/yr capacity expansion at the Eshidiya mine in Jordan in order to meet the requirements of two new joint ventures supplied with Jordanian phosphate rock, and commissioned it in the second half of 2014. Overall phosphate rock production rose to 7.1mn t in 2014 from 5.4mn t in 2013;

- Acron, which launched production at its Oleniy Ruchey mine in Russia in 2013 with a total annual rock production of 642,000t, was ramping up to full production in 2014. The Russian producer has now achieved self-sufficiency in rock concentrate;

- In the US, the Hookers Prairie mine has reached exhaustion and was closed by Mosaic in June 2014.

External Disruptions in Rock Producing Countries

In contrast, rock output has been affected by external events in a number of countries over the past few years. Political turmoil in north Africa and the Middle East impacted mining in a number of countries, in particular Tunisia, Syria and Iraq:

- There is no fundamental damage at mining operations in Tunisia, and no damage to processing plants in Tunisia. The main problem appears to be regular disruption to production at the Gafsa mine caused by strike action, as the country attempts to regain political stability. Production fell by 5.6mn t to 2.5mn t in 2011 and remained at this level in 2012, before recovering to 3.3mn t in 2013. There was hope that the strike action would ease after the Tunisian elections in October 2014. However, given that the processing plant at Gabes is still running at only 50pc, this does not appear to be the case yet;

- Syrian rock production halved for the second consecutive year since 2011 to just 900,000t in 2013 because of political turmoil and fighting in the region. The operating rate of the small Homs triple superphosphate plant is unknown as the town has endured intense military action since the beginning of the civil war. But domestic supplies dwindled to some 77,000t in 2013 down from 460,000t in 2011, and just 800,000t of rock was exported, compared with 2.7mn t in 2011. It is also highly likely that damage has occurred to infrastructure, including road and rail links. On the other hand, Lebanon Chemical still produced triple superphosphate, partly based on Syrian rock which suggests that movement of phosphate rock has been possible by truck. In 2013 imports from Morocco were required to support production which indicates far more serious supply disruption. The mines lie well away from large urban populations and can be expected to remain intact during the conflict;

- The resumption of mining in Iraq is on a very limited scale. The 360,000t produced in 2013 were consumed domestically, suggesting that some production has resumed at the Al Qaim complex;

- The various and continuing civil disturbances in Egypt have apparently not affected the phosphate industry. Production stood at 5.3mn t in 2013, down by 400,000t in comparison with 2012 levels.

Section 2: Phosphate Rock Supply
Chapter 1: Supply Developments

Disturbances have centered on major urban areas and the factional disputes between elements in Egyptian society have not led to the sort of industrial disruption seen in Tunisia;

- A downturn in production caused by the permitting process for a mining extension at Mosaic's South Fort Meade mine in Florida is now over. The issue was settled in early 2012, allowing a ramp-up of production during the remainder of the year and in 2013. Such disruptions at major mines in the US are not uncommon. And as each routine extension comes up for official approval, there is a risk that legal action will affect production, in a worst case scenario by making further mining impossible.

Generally speaking, there is a relatively low risk of a phosphate mine suffering an unexpected and lengthy outage for internal, technical reasons. But in a few countries, natural influences such as flooding and earthquakes do periodically affect production. Fertinal's fertilizer complex was idled in 2001-06, when the phosphate rock mine flooded in the aftermath of hurricane Juliette in 2001. The vast majority of global production comes from open-pit mines where there is no risk of roof falls. The Chinese industry generally slows down or shuts down during the peak of the rainy season, but flooding problems do not affect the majority of producers. Planning in the phosphate rock mining sector is long-term, so the terminal problem of exhaustion of reserves is planned for well in advance. The closure date may shift if the mining of the last of the reserves proves to be unviable in the market conditions pertaining at that time.

Output from the majority of existing mines has globally plateaued. The following table outlines the key producers that are likely to see static production, until a major investment in a new mine is made feasible. We assume that the external disruptions to production mentioned above are a temporary phenomenon and discount them in this assessment. The impact of new investment will be discussed later in the report. Over recent years, output in the following major producing countries has remained steady:

Table 9: Producers with Static Production*	***mn t rock***
Russia	+10.0
Brazil	+ 6.0
Algeria	±1.5
Senegal	±1.5
South Africa	2
Israel	±3.0
India	±2.0
Vietnam	+2.0
Australia	±2.0
**Producers with +1mn t/yr output*	

— IFA

In addition to these operations, which have seen virtually unchanged production in recent years, there are operations which face closure or a decline in production. For example, the Canadian mine at Kapuskasing was closed in the second quarter of 2013. Agrium has signed a long-term supply agreement with OCP to supply 1mn t/yr of rock for its Redwater complex (345,000 t/yr P_2O_5) up to 2020. In the US, the Hookers Prairie mine has reached exhaustion and was closed by Mosaic in June 2014.

A forecast decline in US rock production, which partly prompted the construction of the Jorf Lasfar platform in

Morocco, has become a reality. It is this anticipation of decline which drove investment in North Africa and the Middle East. The acceleration in the decline of US output since 2000 has helped increase the market tightness which now sees rock prices moving well above pre-2000 levels. On the other hand, there has been a tendency to overstate the speed at which the decline in rock production will occur. Following the most recent closures, US production capacity has stabilized at 28mn-30mn t/yr and we expect a production level in excess of 25mn t/yr to be maintained over the next 10 years, environmental and permitting issues allowing.

Section 2: Phosphate Rock Supply
Chapter 2: The Outlook for Supply

The supply outlook is not simply defined by reserve strength as we argued in the first section of this report. A number of economic and political issues affect project viability over and above the mere existence of phosphate rock and its quantity and quality. Rather than list these factors in a generalised way, we will look at countries and areas of potential activity and comment on the various constraints that will influence production and project development. We will summarise the main factors at play at the end of the analysis. The focus of this chapter is those projects which are furthest advanced. For grassroots developments, there is often a pre-project phase during which specialist or junior mining companies develop the data, acquire mining licences, undertake small-scale preliminary drilling, test environmental requirements and generally scope out a project. Generally, the intention is to sell on this work to a more substantial player, saving the eventual project sponsor considerable time and effort. We will list such embryonic projects in this chapter, as such a project may well leapfrog a less practical project which appears to be approaching the financing stage. We also look at existing players that may expand or reduce production during the period to 2018.

2.1 Europe

2.1.1 Finland

The main potential development in Europe, which has been under discussion for decades, is the Sokli project in Finnish Lapland. This project would mine and beneficiate igneous rock, which is expensive relative to operations based on sedimentary rock, but may be economically feasible at current relatively high price levels. The project is located in an environmentally-protected Arctic area which makes permitting difficult and involves substantial additional costs. The cost of the expansion to Yara's existing Finnish mine equated to more than $750 per capacity ton. Despite the fact that the price of rock has risen considerably from historical levels, the project remains difficult to justify.

2.1.2 Serbia

The Victoria Group has been investigating the exploitation of a rock deposit in Serbia. The company is now actively developing a project, which is at the stage of feasibility study drafting. The Lisina site would have a maximum capacity of 1mn t/yr of concentrate, and initially the company would transform the rock to single superphosphate for local/regional sale.

2.1.3 Russia

Figure 5: Russian Phosphate Rock Mines and Process Units, Summary Map

The Russian rock now being exploited is igneous apatite. There are now three major producers of apatite in Russia, two of which (Phosagro and Acron) have a surplus to sell on the domestic or export market. Both Eurochem and Phosagro co-produce other minerals, in the case of Eurochem iron ore and baddeleyite and in the case of Apatit (Phosagro), nepheline. Overall, the three operations differ in a number of respects:

- **Eurochem** operates the Kovdor mine, with a capacity of 2.7mn t/yr. **Eurochem**'s co-products are of equal economic significance to rock and largely determine the rate of ore extraction. In addition, P_2O_5 extracted from tailing for processing into rock is being exhausted. Production of about 2.7mn t/yr from the Kovdor mining operation meets only 75pc of the company's raw material requirements at its Russian, Lithuanian and Belgian operations (namely Phosphorit Kingisepp, Belorechensk, Lifosa and Antwerp). In order to cover this deficit — or at least part of it — Eurochem is developing a rock project in Kazakhstan, which started production in mid-2014. But the grade of the rock is unlikely to be suitable for its existing ammonium phosphates operations as a sole feed, and reports indicate that Eurochem has opted for vertically-integrated processing in its planning for the Kazakh project, although processing appears to have been relegated to a second phase. A first phase of 600,000 t/yr of rock is moving forward in 2014-15, and its output will be used largely in its Belorechensk plant to produce monoammonium phosphate and other NP fertilizers;

- **Phosagro** produces 7.5mn-8mn t/yr of rock, of which 5mn t/yr are used captively and the remainder sold to other Russian companies and for export. It now owns 100pc of mining company Apatit's shares, following its acquisition at auction of the state's remaining stake and voluntary acquisition of other minor shareholdings. Having reached the 95pc mark, the company has enforced a shareholder squeeze out — a compulsory buy-out of the remaining shares. Furthermore, Phosagro has been in a perpetual stand-off with Russian competitors in respect of pricing. Until the commissioning of the Acron mine, Phosagro was the exclusive source of merchant rock within Russia. This meant that it was required to sell up to 80pc of its output within Russia at prices fixed by the competition authorities on a cost/plus basis, on the grounds that its own rock processing units competed with other non-basic phosphate fertilizer units in Russia, the largest of which are Uralchem, Acron and Minudobrenia Rossosh. The price set was low, often less than half of what the high-quality apatite would have netted on the export market. As a result Phosagro's output fell for some time, as the company was unwilling to sell to Russian competitors in the phosphate fertilizers sector. The reduction in output over recent years appears to have had more to do with marketing and price issues, but it is also the case that major investment was required in additional underground mining to maintain production at about 7.5mn t/yr. This investment is now underway with the construction of a second shaft for the underground operation. The investment will raise the ore production of the underground mines from 17.6mn t/yr to 19mn t/yr while the output of the open pit mines will fall from 8mn t/yr to 4.6mn t/yr ore once it is completed in 2017. This will result in a loss of 400,000t of rock production in 2014-17, as highlighted by Phosagro in its recent Capital Markets Day (down to 7.1mn t from 7.5mn t expected in 2014). Such is the depth and difficulty of the open-pit operations that the cost of underground extraction is reckoned to be more than half that of open pit production.

  The investment go-ahead was triggered by the government's announcement at the end of May 2012 that market pricing would be introduced as of 2013, in light of the commissioning of Acron's Oleniy Ruchey phosphate rock mine, which launched operations at the beginning of 2013. Since the commissioning of Oleniy Ruchey, Phosagro has set prices on the basis of an export-value related formula based on OCP exports prices with adjustments for rock quality, proposed by the Competition Authorities:

  - In 2012, the internal rock price ex-mine was about $135/t, but bulk discounts for the three major consumers resulted in prices of $115-120/t. Uralchem's agreement with Phosagro, which ended in 2013, provided a rock price of about $130/t;

  - Post-2013, Phosagro raised the price to $195/t, using the formula suggested by the Federal Antimonopoly Service (FAS). This severely disadvantages Uralchem and Rossosh and court cases have been on-going ever since, with Uralchem appearing to give up the legal fight in early 2014. Uralchem effectively shut down the Voskresensk plant in the first quarter of 2014, and is threatening to make the closure permanent unless it receives a price at which it can operate profitably. In January 2015, Russia's Supreme Court reportedly refused Uralchem's request to extend its phosphate rock supply contract with Phosagro/Apatit under the older agreement on the grounds that it was economically unjustified. The court additionally concluded that suppliers should be guided by the recommendations of the Federal Antimonopoly Service, published in 2012.

Phosagro is planning on increasing its capacity for NPK production, while replacing some of the ammonium phosphates it now exports. Ammonia capacity is under construction but no new phosphoric acid capacity. We assume that the rate of increase in NPK granulation will run in parallel with the curtailment in ammonium phosphates production, as plants are switched from one product to the other, so that the internal acid requirement does not alter but the volume of end-product will increase substantially.

Phosagro is gradually increasing its own rock consumption at the expense of merchant sales. The acquisition of Metachem, and an increase in output at its existing units (+500,000t DAP/MAP/NPK/NPS at Cherepovets by 2017-20) will see its internal rock requirements rise from the current 68pc to 77pc of its concentrate output over the next five years, indicating an own-use of 5.5mn t and a merchant availability of 1.6mn t down from the 2.4mn t sold externally in 2014, including both Russian sales and exports;

- **Acron** opened its first mine in the Kola peninsula at the beginning of 2013, with a design capacity of 1mn t/yr. Acron's 2013 investor presentation states that in June 2013 it achieved self-sufficiency in rock concentrate (60,000 t/month) and total rock production was 642,000t in 2013. The company also stated that it sold 12,000t to third parties, indicating that it produced surplus rock. Full production was expected by mid-2014. We also expect NPK capacity to increase over the next few years, although this is more difficult for Acron than the other two majors as it operates nitrophosphate units, whereas Phosagro and Eurochem are phosphoric acid-based which allows for easier expansion or cheaper additional capacity. In short, assuming that Acron's in-house requirements are about 650,000-700,000 t/yr, there is a possibility that sales availability from the first phase of the mine will increase to ±300,000 t/yr. There has been demand for this rock in Russia from companies such as Uralchem and Rossosh which produce NPKs but have no captive rock. At capacity, the requirements of these two purchasers of rock amount to 1.4mn t/yr. There is also the opportunity for Acron to export rock in competition to or co-operation with Phosagro, which was previously the monopoly supplier of rock, both domestically and for export. Acron is planning to open the second phase of its mine in 2017 (1mn t/yr).

  The audited reserves of the deposit total 255bn t averaging about 15pc P_2O_5. While the mining and beneficiation of the Kola ore is more expensive than for sedimentary rock, the quality of the resultant apatite concentrate is unique in respect of concentration (37-38pc P_2O_5) and low impurities, including cadmium. While we expect no technical problems in the mining and production of concentrate — other than as a first venture for Acron in this field — there are issues in respect of Russian mining regulations. The regulations insist that all minerals in the ore should be processed and in the case of Oleniy Ruchey this includes 1.7mn t of nepheline over the two phases of the project. As we understand, Phosagro is supplying all the requirements of the Russian market (about 600,000-700,000 t/yr) and has taken major shareholdings in the two companies which consume nepheline. The Kola nepheline appears not to be export quality, restricting merchant volumes, although the export market is small and dominated by high-quality Norwegian and Canadian product. We also understand that the required equipment to process nepheline will not be in place until 2015, which may increase the cost of production of the concentrate by around $30/t over the course of 2014-15. As it stands, the development of phase two of the project must include the processing of nepheline produced as a by-product by both phases of the phosphate mining operation;

- **Uralchem** has a requirement of about 800,000-900,000 t/yr and Rossosh of about 500,000 t/yr. In 2014, Uralchem decided to shut down its Voskresensk plant, citing a rock supply dispute with Phosagro. The plant is old and inefficient and was originally sold to Uralchem by Phosagro, so a re-purchase seems unlikely. A permanent closure could potentially free up to 900,000 t/yr of concentrate for the export market and would make room for Phosagro monoammonium phosphate and NPKs on the domestic and exports markets. Besides Uralchem and Rossosh, smaller customers take to up to 400,000 t/yr in aggregate. Phosagro export prices are relatively high as a result of the high grade and quality of the rock, although this high-quality material is used by the three major producers in their production of standard ammonium phosphates and NPKs.

  Uralchem developed plans to construct mines in two areas which would free them of dependence on Apatite rock. The Sordinsky mine in the sedimentary Vyatsko-Kamskoe deposit was to produce 1.8mn t of concentrate for shipment to its processing unit in Voskresensk, some 1,400km away, but also to its Kirovo-Chepetsk complex, 250km away. Its cost in 2007 was put at $700mn. The Yegoryevsk mine, close to Moscow (and to the Voskresensk complex) was idled in 1998, when the upper layers of the deposit were exhausted. The acquisition of the mining rights for the lower seam included all of the surface infrastructure which still stands. The open pits have been conserved. The particular area for which mining was planned (the Semislavksy area) has some 44mn t of proven sedimentary reserves and a further 22mn t of inferred reserves. The whole deposit contains some 250mn t of proven reserves — second in size only to Vyatsko-Kamoskoe in terms of sedimentary rock. On the downside, there appear to be problems with the regulations pertaining to mining the lower layer of the deposit. Regulations and costs in relation to the Sordinsky mine was probably not the only factor inhibiting the development of these two mines. The price imposed on Apatite for domestic sales of rock was low enough to make new investment unattractive. The rise in rock prices following the liberalisation of the market encouraged Uralchem to revisit projects in 2007-08. But current international prices are too low to permit economic production at projected mines and both are indefinitely on hold.

It is clear that in three out of the four Russian locations discussed, there is either existing infrastructure which may need extending or refurbishing or, in the case of Oleniy Ruchey, is being constructed. Over and above the first 1mn t tranche of Oleniy Ruchey, there is theoretical scope for a further 4mn t/yr of capacity to be constructed in short order, or up to 6mn t if the Sordinsky project were ever to be revived. The downside is that the international price of rock would have to return to the $400/t level to make the Uralchem projects viable.

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2.2 Central Asia

2.2.1 Kazakhstan

Figure 6: Kazakhstan Phosphate Rock Mines, Summary Map

The Karatau deposits located in southern Kazakhstan have been the major source of Kazakh phosphate rock since the 1960s. The reserves in the area are estimated to contain more than 13bn t of ore. Six mines were developed during the Soviet era (four open-pit and two underground) with a total capacity of 13mn t/yr, although production has since declined.

Following the break-up of the Soviet Union, Kazakh production fell to negligible quantities from an estimated 10mn t/yr. In 1999, most of the existing facilities in Karatau were acquired by Kazphosphate which is slowly rebuilding the business. The old industry was based on the production of yellow phosphorus for which the rock is suitable. Production today is focused at two locations: Karatau Zhanatas and Chulaktau Jambyl. After reaching a peak of 2.5mn t in 2008, of which 2.1mn t was delivered domestically, production has been ranging between 1.7mn and 1.8mn t since 2010 (reported at 1.83mn t in 2013).

There are two major projects being progressed in Kazakhstan — the recently commissioned Eurochem mine in the Karatau deposit and the Sunkar Resources project in the Chilisai deposit.

Eurochem mine

The Eurochem Sary-Tas factory was closed shortly after the break-up of the Soviet Union and has been idle for close to 20 years.

Work on the Eurochem mine at the Kok-Jon phosphate rock deposit in the Jambyl region (near the town of Zhanatas) began in autumn 2013, and ore production started in July 2014. Eurochem expects total production to have reached over 150,000 t/yr of phosphate ore by the end of 2014. Production capacity for Phase 1 will be 650,000 t/yr and full commissioning is expected in 2016, which the company claims will make Eurochem self-sufficient in rock.

We expect the majority of the rock to be delivered to the Belorechensk fertilizer complex on the Black Sea, and blended with Kovdor material to achieve an optimal acid-feed for the manufacture of monoammonium phosphate and NPKs. This should free up Kovdor material for its Lithuanian and Belgian assets. The second phase involves a fertilizer complex which will produce 1.4mn t/yr of finished product (600,000 t/yr of ammonium nitrate and 800,000 t/yr of NPs) and an expansion of the mine to 1.5mn t/yr capacity. This phase of the project will take five years to complete, following finalisation of the natural gas supply to support ammonia production.

Chilisai Project

The Chilisai deposit is part of the deposits found in the Aktybinsk area in northwest Kazahkstan, which also appear in the adjoining parts of Russia and Uzbekistan. In the 1980s, reserves in the Kazakh portion of the formation were estimated at 840mn t, of which Chilisai accounted for 270mn t. Sunkar reports that recent drilling results show that the 836km² covered by its licence contains 1.1bn t of phosphatic resources averaging 10.3pc P_2O_5. This suggests that the licence extends over the whole Aktybinsk formation and that the initial project will exploit only the Chilisai portion of the total deposit. The mineral rights have been signed initially for a 25-year period (up to 2030), with an option to extend them for a further 25 years.

The Sunkar project is currently confined to a small rock mine, which needed to have a capacity of 1mn t in 2011 to meet the terms of its mining licence. The company reported in July 2011 that production of ore was running at 300,000 t/yr and that, using dry beneficiation, it had produced 236,000t of concentrate with a P_2O_5 content of 17pc — which is being sold locally as a direct application phosphate fertilizer. The company requested and successfully received approval for changes to its licence, which have adjusted its mining programme to allow for the delays occurring in its original schedule. It is now committed to produce just 300,000t of ore in 2014 and 2015, rising to 5mn t by 2018 and to 10mn t over the following five years. In the final stage, the majority of the 10mn t/yr of 17pc concentrate will be used as acid feed and a smaller volume of ore will be sold as a direct application fertilizer.

Processing is an important element in this project. While the 17pc P_2O_5 concentrate is very reactive (8-10pc P_2O_5 is plant-available) and suited to direct application, the ore cannot easily be concentrated, and therefore is not suited to merchant sales for fertilizer processing. The Sunkar plant's reactor and filtration sections will need to be scaled up to accommodate the 17pc P_2O_5 feed. The rock will produce 10-50-0 with 75pc water-solubility and 98pc citric solubility and 17-49-0 with 80pc water solubility and 98pc citric solubility. The feasibility of the rock mine is entirely dependent on the viability of ammonium phosphate production in situ. Sunkar estimates that the cost ex plant to produce the 17pc concentrate will be lower than $12/t and reports that land-locked sulphur is available at minimal cost. The current schedule is to develop a two-stage project:

- Phase 1 will include 430,000 t/yr P_2O_5 Phosphoric acid, 412,000 t/yr DAP, 388,000 t/yr MAP;
- Phase 2 will add an additional 430,000 t/yr P_2O_5 Phosphoric acid, 412,000 t/yr DAP, 388,000 t/yr MAP.

The capital cost of the first phase is put at $1bn. The revised plan is looking at production by 2018 for Phase 1.

The two main problems facing export projects in Kazakhstan are the quality of rock and logistics. In terms of end-product — and from the perspective of the Kazakh government — the processing of rock domestically is preferable. In terms of export logistics, China could be an outlet though it is important to note that it is currently an exporter of P_2O_5 rather than an importer. Logistical costs through Russia to the Baltic and Black Sea ports are high and eroding revenues with every hike in Russian rail tariffs.

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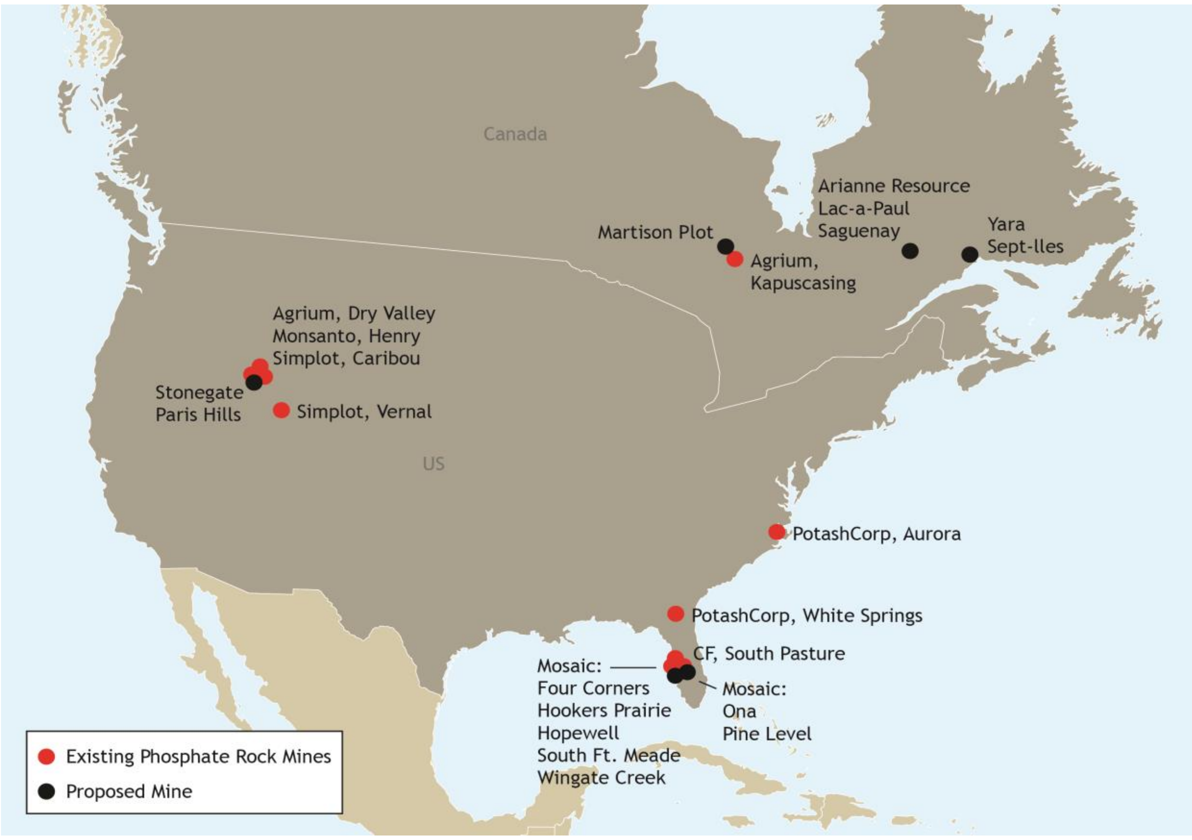
2.3 North America

Figure 7: North America Phosphate Rock Mines, Summary Map



2.3.1 Canada

Agrium's Kapuskasing mine closed in 2013, though there are several projects in the early stage of development in consideration:

- The Martison Project in Ontario developed by PhosCan is in close proximity to the ex-Kapuskasing mine. While initially a phosphoric acid project, the planned closure of Kapuskasing is likely to have prompted a switch to a stand-alone rock project in 2010, with an output of 2mn t/yr apatite concentrate at 37pc P_2O_5 content. Commercial production of niobium (4,000 kg/yr) is also being considered and work is continuing on devising a process which economically separates the niobium from the run-of-mine ore. In addition, exploitation of rare earths in the deposit is being considered. The reserve contains 65mn t of ore, with an average content of 22pc P_2O_5. The cost of the mine and beneficiation operation plus a 70km slurry pipeline to the rail-head at Hearst, Ontario, is estimated to be in excess of $700mn. This project seems to have lost Agrium's interest since the latter has signed a long-term supply agreement with OCP (from 2013 to 2020) to replace the 1mn t/yr of rock which is required by its Redwater complex (345,000 t/yr P_2O_5);

- The Sept-Iles project in Quebec (also known as Mine Arnaud) is a joint venture between the provincial government and Yara. It intends to produce 1.2mn t of apatite with a P_2O_5 content of above 40pc. The chlor-apatite deposit contains a number of other minerals, the most significant of which is magnetite. The project has filed an environmental impact study and received all the necessary permits during summer 2013. The mine will extract 8mn t/yr of ore, from which 1.2mn t/yr of ~40pc P_2O_5 concentrate will be produced. The capital cost of the venture is estimated at C$500mn ($460.2mn);

- The Lac-a-Paul project in Quebec is being developed by Arianne Resources. The company released the results of the project's feasibility study in October 2013, and the highlights of this are summarised below:

    - The measured and indicated reserves of apatite are currently estimated at 472mn t, with an average grade of 6.9pc P_2O_5.
    - The total initial capital costs for the production of 3mn t/yr concentrate are estimated at $1.2 bn ($982.5mn for the mine and $232.2mn for the rock transport system) and the cash operating cost (fob Port of Saguenay) at close to $100/t. The ore-body may also provide a commercial source of titanium.

    Recent testing has established that the ore can be concentrated to 38.6pc P_2O_5 end-product and achieve a P_2O_5 recovery rate of almost 90pc. In respect of the minor element (MER) ratio and CaO/P_2O_5 ratio, the concentrate is acceptable and it can be successfully processed into phosphoric acid.

    In 2014, Arianne announced that it was considering processing Lac-a-Paul's phosphate rock into purified phosphoric acid, MAP/DAP and nitro phosphate fertilizer product. The project has filed its environmental impact report and is expecting to start production in 2018 if financing can be raised;

- Glen Eagle Resources has several projects based in Quebec, one of which is the Lac Lisette phosphate project it is currently drilling on. The Lac Lisette property is 40km away from Arianne Resources' Lac a Paul property, and shares the same main road. Glen Eagle Resources has also instigated a drilling programme based on previous industry ministry exploration results at the Moose lake project in Chicoutimi, Quebec. The initial study reported P_2O_5 values of 5-6pc and current drilling programme results are being analysed;

- Jourdan Resources has undertaken early reconnaissance work on the Dissimieux Lake property, similar to Glen Eagle Resources on the Lac Lisette property, both located in Eastern Canada. Following a drilling programme in 2012, the phosphate property has been increased to 24,500 hectares (245km^2) from an original 831 hectares. Following the staking of new claims in March 2013, several have shown to have values up to 5.6pc P_2O_5.

Even though there are a large number of junior mining projects being considered in Canada, the likelihood of them all reaching fruition is minimal, as the market would not be able to absorb this much supply and current rock prices are not high enough to justify investment in these projects.

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2.3.2 US

Until the mid-1980s, the US industry could supply sufficient rock to maintain both a processing and export business. By the mid-1990s, increases in vertically integrated processing and a decrease in mine output resulted in a decline in the export business. Rock production has since fallen more steeply, resulting in a decrease in domestic rock deliveries of about 10mn t and this has only partially been compensated by imports from OCP and more recently Bayovar. The absorption of domestic supply by domestic processing is a global phenomenon as demonstrated in the following comparison:

Table 10: Global Phosphate Rock Production and Trade 1985-2012			*mn t*
	1985	**2013**	**Change**
Production	146.5	193.2	+48.8
Trade	46.5	26	-16.3
			— IFA

The key question is not whether US production of both rock and processed P_2O_5 will decline, but the pace at which the decline will occur. The US has long been out of the merchant rock business, and as such regularly imported rock from OCP for phosphoric acid production at the Pascagoula and Geismar plants. Previous experience suggests that we should treat the outlook for US rock supply with a degree of caution. Reserves sufficient to sustain mining well into the medium term remain at many of the existing mining operations, but the problem facing the US industry is twofold:

- The gradual exhaustion of acceptable quality reserves, particularly in Florida;
- Difficulty gaining permits for any extension of mining area or new mines, whether in Florida, North Carolina or the Northwest States.

Published figures for current phosphate rock mining capacity indicate the following totals by company. Mosaic is the largest rock producer and processor in the US, followed by PotashCorp (PCS). Unlike Mosaic, whose reserves are concentrated in central Florida, PCS operates mines in both Florida and North Carolina.

Table 11: Reported US Mine Capacity			*mn t/yr*
Company	**Mine**	**Capacity 2013**	**Permitted Mine Life (years)***
Mosaic	Four Corners Mine, FL	7	8
	Hookers Prairie, FL	2	Closed in June 2014
	South Ft. Meade, FL	5.5	9
	Wingate Creek, FL	1.5	27
	Hardee County Mine, FL (ex CF Industries)	3.5	11
	Total	*19.5*	
PCS Phosphates	Aurora, NC	6	27
	White Springs (Swift Creek), FL	3.6	16
	Total	*9.6*	
Monsanto	Henry,ID	0.9	16
Agrium	North Rasmussen Ridge, ID	2	9
J.R. Simplot	Smokey Canyon,WY	2.5	16
	Vernal, UT	4	13
	Total	*6.5*	
Total US		38.5	

**Permitted mine life estimates as of end-2013, based on current exploitation rates and under current environmental permits*

— Interchem 'Blue Book' 2013, Argus research

Mining capacity should always be treated with a degree of caution as compared with that for an acid or ammonia plants — and especially in an industry which has conservation of reserves as one of its major priorities. In addition, there is often some leeway in deciding what is effective capacity and potential capacity, which tend to include capacity that can be brought on stream relatively quickly and at low cost.

Mosaic/CF

The following table describes the rock production of Mosaic, the largest US producer by capacity, in fiscal year 2007-08 through to calendar year 2013:

Table 12: Mosaic Rock Production, 2007/8-11/12							*fiscal year ending 31 May, mn t*
	2007-08	**2008-09**	**2009-2010**	**2010-11**	**2011-12**	**2012-13**	**Calendar 2013**
Four Corners	5.6	5.1	5.6	6.7	7.4	6.4	6
South Fort Meade	6.4	5.1	4.3	1.8	1.2	5.5	5
Hookers Prairie	2.3	1.6	1.8	1.8	2.1	2	1.9
Wingate	1	0.9	1.1	1	1.4	1.5	1.3
Hopewell	0.5	0.5	0.5	0.2	-	-	-
Total	**15.8**	**13.2**	**13.3**	**11.5**	**12.1**	**15.4**	**14.2**

— company reports and submissions

Since 2007-08, a number of factors have impacted on Mosaic's production. The most significant was a legal stalemate about extending the mining area at South Fort Meade. As the above table shows, a production peak was achieved in 2007-08, which reflected the demand/price spike in that year. After the spike, production levels settled down to what appears to be the base requirement for the operation of the company's processing units — plus 13mn t of 29.8pc P_2O_5 concentrate. The closure of the Hopewell operation was planned, as was the extension of mining at Fort Meade into Hardee County. The requirements resulting from the disruption caused by the temporary closure of South Fort Meade were able to be covered by extending production at other mines — most significantly Four Corners — drawing down stocks and by importing the company's allocation of rock from Bayovar, Peru. The legal process involving the Fort Meade mining extensions permit was finally brought to a conclusion in early 2012, but created significant additional costs for Mosaic.

The inability of Mosaic to push through its plans for Fort Meade illustrates some of the risks in forecasting US supply, even through the medium term. The reserve situation is more important than the current mining statistics. In addition, we ask the question as to whether reserves designated to serve the company's processing complexes for the next 30-40 years will in fact be available for exploitation. The following table shows the reserves available at existing operations and at two potential new mining areas in Florida as presented in statutory submissions between 2008 and 2013. Mosaic emphasised its definition of proven reserves:

"Proven (measured reserves) are those resources of sufficient concentration to meet minimum physical, chemical and economic criteria related to our current product standards and mining and production practices."

Probable or indicated reserves have been less intensively drilled than proven reserves, but in all other respects offer a similar certainty in respect of mining potential.

Table 13: Mosaic Phosphate Rock Reserves — *mn t, average P_2O_5- content in brackets*

	2008	2009	2010	2011	2012	2013
Active Mines						
Four Corners	110.6	113.3	57.5	53.6	60.3	46.8
South Fort Meade	53.9	54	48.3	53.8	52.3	46.5
Hookers Prairie	25.5	29.6	22.8	5.7	3.8	1.7
Wingate	25.4	35.7	35.9	36.5	37.9	34.8
Hopewell	1.4	0.8	0.2	-	-	-
Total Existing	**216.8 (28.9pc)**	**233.4 (28.9pc)**	**164.7 (29.4pc)**	**149.6 (29.6pc)**	**154.3 (29.4pc)**	**129.8 (29pc)**
Planned Mining						
Ona	167.8	183.3	245.5	245.5	245.5	245.9
DeSoto	148	148	148	148	148	149.6
Total New Areas	**315.8 (29.4pc)**	**331.3 (29.6pc)**	**393.5 (29.3pc)**	**393.5 (29.3pc)**	**393.5 (29.3pc)**	**395.5 (29.5pc)**

— company reports and submissions

We make the following notes on the reserves estimates:

a) The reserve total figure of 525.3mn t include 493.2 of proven reserves and 32.1mn t of probable reserves of which 1.6mn t are at Ona and 26.2mn t at the DeSoto (Pine Level) mine;

b) The Hookers Prairie mine has reached exhaustion and was closed in June 2014;

c) The changing estimates illustrate the point made in Section 1 of this report that reserves estimation is a dynamic process. More detailed work is undertaken as required by the development of a mining plan. For example:

- The reserve position at the Four Corners Mines has been recalibrated and almost halved in 2010. It stood at 46.8mn tin December 2013. At current enhanced exploitation rates, current reserves equate with about 7-8 years of productive life;

- Testing of the reserves at Ona has resulted in an upgrading of the deposit in terms of volume (by 78mn t);

- Minor changes occur annually in existing mines, as data from current excavation and testing for short-term planning are fed into the calculation;

d) Various legal agreements influence future mining:

- The lease on the South Fort Meade reserves expires by 2025 or when mining is completed and the land rehabilitated, whichever is the earlier.

- The reserves at the Four Corners mine are held under a lease whereby the rights extend to 2015 with the right to extend to 2022. The rights to the Ona reserve extend in the first instance to 2022.

The production and reserve figures hold some significant messages for the industry. The existing mines at Mosaic will run down over the course of the next 9-10 years, if Mosaic consumption remains static at about 14mn t/yr and is supplied entirely internally. Our assumption is that Mosaic will continue to import rock from Bayovar and reduce its in-house requirement to 12.5mn-13mn t/yr, which would extend the life of the existing mines to at least 11 years, providing that economics and environmental pressure allow 100pc of reserves to be exploited. The introduction of MicroEssential products also allows the company to use less P_2O_5 per tonne of granulation capacity as MicroEssential formulation currently ranges between 30-40 pc P_2O_5 vs. 46-52pc P_2O_5 for DAP and MAP. We also note the success of the US industry in managing its BPL levels over a long period of time and into the future, if the permitting of new mines is successful. The existing mines will continue to exploit the Undifferentiated Peace River Formation, which currently supplies the Wingate and Four Corner mines. The rock is unlikely to present any unexpected problems. The two new mine sites are, on the other hand, some distance to the south of the current processing plants at Bartow and New Wales, which suggests a major investment in processing facilities or transportation, raising all the environmental issues which mining and processing create.

Most of the legal disputes have been connected to extensions, including the recent South Fort Meade dispute. By extensions we mean the progressive need to move mining areas forward when each tract is mined out. New areas for which the full range of permitting is required, we refer to as projects. As the best reserves have been depleted, there are few new projects in areas for which no mining permit is held. The following extension permits are being requested:

Mosaic is proposing an extension at the Wingate mine which would allow a further five years of mining in the immediate future. The company has been mining a 7,300 acre (29.5km²) tract since the 1970s. The expansion involves an area of 600 acres upon which there are no federal designated wetlands. The company has agreed to pay $103,000/acre to compensate for the destruction of this wetland and the application for the extension has been passed by the Manatee County Commissioners. The US Army Corps of Engineers issued the final AEIS (environmental impact statement) on April 2013 and will rely on it to consider the pending federal wetlands permits for the Wingate extension, as well as the Ona and DeSoto phosphate rock reserves.

An extension permit at the Four Corners mine (the "Altman Extension") was also the subject of litigation, as non-governmental organisations filled a lawsuit against the US Army Corps of Engineers in September 2013. The lawsuit was subsequently dismissed. Mining on the mine extension commenced on approximately 600 acres. According to Mosaic, the remaining 1,200 acres of the Altman extension is not currently in its near-term mining plan.

Mosaic has also made applications to the US Army Corps of Engineers in respect of the Ona (250mn t reserves) and Desoto (150mn t reserves) projects, upon which its long-term future in the phosphate business depends. In 2011 the US Army Corps of Engineers decided to conduct an environmental impact statement (AEIS) for the central Florida phosphate district, which was released in April 2013 and which will be used to consider the pending federal wetlands permits for the Ona and DeSoto mines.

In late 2013, Mosaic announced the acquisition of CF Industries' phosphate assets, which included a rock mine and processing complex in Florida. The capacity of the Hardee County mine is 3.5mn t/yr and production peaked in 2013 at 3.6mn t, and the rock has a P_2O_5 content of 29pc. An ammonium phosphate complex at Plant City generally requires about 3.2mn t/yr. The reserve situation for the properties serving the mine is as follows:

Table 14: CF/Mosaic Phosphate Rock Reserves, Hardee County mine *mn t as of end-2013*

	Recoverable tonnes	P_2O_5	$Fe_2O_3 + Al_2O_3$	MgO
Permitted	38.5	29.84pc	2.37pc	0.75pc
Unpermitted	35.3	29.58pc	2.38pc	0.78pc
Total	**73.8**	**29.72pc**	**2.38pc**	**0.76pc**

— 2013 company reports

Exploitation of the permitted reserves will allow for a further 11 years of production at current operating rates as of end-2013. CF and now Mosaic has been actively working for the permitting of further tracts containing 35mn t of reserves, which would allow for a further 10 years of production. As the previous analysis of Mosaic has illustrated, the involvement from local community participation, environmental pressure groups and the federal structure of the legal system makes permitting both expensive and uncertain. We will take Hardee County mine property as an example of how regulatory requirements and costs weigh heavily on all aspects of the US phosphate sector, from permitting through to operation, closure and post-closure activities:

Historical Clean-up: CF faces a lawsuit in respect of the Georgetown Canyon Mine in Idaho which operated in the 1950s and 1960 in respect of a contribution to the remediation of the property. Negotiations are on-going.

Regulatory Costs: Regulations in respect of the environment and health and safety change frequently and expensively for the mines and plants affected. In 2014, CF budgeted $38.3mn for capital expenditures needed to comply with regulatory changes compared with only $10mn in 2010. Such costs may influence the timing of the closure of mines and processing units, if it looks as though they will be substantial.

Downstream Issues: The mining of phosphate rock in the US is highly dependent on integrated downstream processing operations. Practically all of the rock currently mined would not be suited to the merchant trade in current market circumstances — with the possible exception of the highly-reactive North Carolina rock. CF faced enforcement notices at its Plant City site in respect of a number of issues, including the re-use of process water from its phosphoric acid unit in ammonium phosphates production and the alleged in-house treatment of sulphuric acid. Again we make no comment on the merit of these allegations, but point out that the broadening and tightening of environmental regulation affects processing as much as mining. Both the legal process of dealing with these matters and the need for remedy procedures adds to the cost of production, and ultimately to the uncertainty of an operation.

Permitting: The permitting requirement to extend the Hardee County Mine has already been discussed. In the worst case scenario of permits not being granted, the mine has a maximum of 11 years life. However, permitting also affects the stacking of phosphogypsum and this in turn impacts on the whole mining and processing operation. Hardee County mine has now completed an expansion of the gypsum stack until 2026 (at current operating rates). Including additional expansion phases, the stack capacity is expected to meet Hardee County mine requirements until 2040 — six years beyond the reserve life of the mine — subject to securing the corresponding operating permits.

Closure Obligations: Regulations affecting the closure, maintenance and rehabilitation of industrial sites affect all sectors in the USA, but are particularly onerous for phosphate producers, owing to the need to deal with a combination of mines and gypsum stacks. As an indication of the long-term planning and liabilities which apply, we have summarized the cost estimates for Hardee County as from 2013. The costs envisaged for the Bartow site which was closed in 1999, are estimated as follows:

- Closure of cooling ponds and channels: $5mn in 2014-16;
- Water treatment: $10mn to 2056;
- Post-closure care: $48mn in 2013-62.

The costs for Plant City are estimated to be the following:

- Closure of gypstack currently in use: $115mn in 2038-42 and a further $61mn in 2092;
- Closure of cooling pond: $61mn in 2092;
- Water treatment expenses: $6mn in 2018, $80mn in 2038-42 and a further $198mn to 2092.

Of course, all these amounts are subject to changing circumstances and conditions. The estimates need to be made and agreed as it is a requirement to cover such future obligations by payments into an escrow account in favour of the Florida Department of Environmental Protection.

PotashCorp (PCS)

The following table describes the rock production of PCS in 2008-13:

Table 15: PCS Rock Mining *mn t*

	Capacity	2013 Output	2012 Output	2011 Output	2010 Output	2009 Output	2008 Output
Aurora, NC	6	4.9	4.1	4.62	4.07	4.2	4.03
White Springs, FL	3.6	2.8	2.7	2.7	1.78	2.5	3.03

— Company Reports

PCS operates two mines in the US. The older mine in White Springs, Florida, has permitted reserves sufficient to support mining at an average rate of extraction of 2.7mn t/yr for about 11 years, assuming that they can be mined in their entirety. However, the closure of the Suwanee River phosphoric acid plant in the second half of 2014 will reduce internal demand by 215,000 t/yr P_2O_5, equivalent to about 750,000 t/yr of phosphate rock, thereby extending White Spring mine life by an additional 5 years. The larger Aurora mine in North Carolina has permitted reserves that would support mining at an average rate of extraction of 4mn t/yr for about 27 years. As with Mosaic, BPL values vary marginally from year to year. The North Carolina rock has averaged about 27pc P_2O_5 in recent years and White Springs ~30pc P_2O_5.

Table 16: PCS Phosphates Rock Reserves, as of End 2013 *mn t*

	Proven Reserves	Probable Reserves
Aurora, NC		
Permitted Reserves	45	1
Unpermitted Reserves	53.8	6.8
White Springs, FL		
Permitted Reserves	29	-
Unpermitted Reserves	1.5	-
Total (average grade 30.66pc P_2O_5)	**129.3**	**7.8**

— company reports

The assessment of PCS reserves over recent years illustrates the volatility of results, given changing assumptions. North Carolina is a young mining area as compared with Florida, and this is reflected in the resource and reserve situation. As of end-2013, the total resource estimate for Aurora was put at 177mn t and that for White Springs at 73mn t. The figures in the table below reflect the historical evolution of measured resource estimates:

Table 17: PCS Development of Resource Estimates *mn t, nominal 30.66pc P_2O_5-content*

Measured Resource	As of End-2008	As of End-2009	As of End-2010	As of End-2011	As of End-2012	As of End-2013
Aurora	340	127	121	172.6	172.6	172.6
White Springs	49	43	40	76.3	76.3	73.2
Total	**389**	**170**	**161**	**249**	**249**	**249**

— company reports

The major amendment in reserve size which occurred in 2009 resulted from an independent audit that was triggered by the granting of a new permit for the sequence of mining granted by the US Army Corps of Engineers in June of that year. PCS stated in their statutory submissions for 2009 that it was the methodology of the audit that caused the drastic re-evaluation.

> *"In contrast to previous reports on phosphate ore reserves for the company, Marston (the company undertaking the survey) confined its analysis to lands owned or controlled by the company within a cut-off mining ratio boundary or meeting minimal recovery criteria, and excluded buffer areas, utility corridors, dikes, settling ponds, backfill support plugs and reserves sterilised or to be sterilised in connection with mining permitting, and distinguished between mineral deposits qualifying as reserves and as resources."*

The rise in the resource figure in 2011 is not explained, but we suspect that it is the result of continuing drilling and appraisal programmes.

As with Mosaic, the uncertainty over future output at PCS mines is less in respect of reserves and more in respect of permitting and tightening regulations. PCS was involved in a similar process for replacing mined-out reserves at its Aurora mine in 2010. The approval process took about eight years and when a permit to extend mining was granted in 2010, the permitted mining area was sufficient for just four more years of production. In April 2010, PCS announced that as a result of delays, mining would be curtailed and personnel would be redeployed and contract labour eliminated. The threat resulted in a Record of Decision which offered a permit to expand the mine — although the permit entailed redesigning the mine so that substantial reserves will remain undeveloped.

The Mountain States Mines

Simplot, Agrium and Monsanto operate phosphate rock mines in the Mountain States, although these operations are smaller and less transparent. Simplot is a private company and not bound by the same reporting regulations as publicly listed companies. Agrium is a Canadian company and Monsanto produces phosphate rock for non-fertilizer uses, such as glyphosphate manufacture.

These companies only supply the domestic market and are wholly vertically integrated. Our estimate of output from the western state mines is 5mn-5.5mn t/yr.

Permitting issues are also a key concern in this region. The main problems are created by changing attitudes to National Parks and forests, wetlands and wilderness areas:

- Simplot operates two mines in the US. The Smokey Canyon mine near the Idaho-Wyoming border supplies over 2mn t/yr of rock by a 87-mile slurry pipeline to Simplot's Don phosphoric acid plant in Pocatello which produces about 400,000 t/yr of P_2O_5. For the past 10 years the company has been working on the planning and permitting of replacement reserves, as its current mine was due to be exhausted in 2010. Having gained approvals from the US Forest Service and Bureau of Land Management, clearing, road construction and other infrastructure was well in hand. But work was halted in 2010 by the US Circuit Court of Appeals, following objections from a coalition of environmental groups in the Greater Yellowstone area. In response, Simplot gave notice of the layoff of 78 employees at the Pocatello complex and 36 at the mine. Simplot warned that both sites would have to be closed by the end of 2010 unless the situation could be resolved with severe repercussions on the local economy. This threat resulted in the lifting of the stay on preparatory work to prepare the new mine site. A definitive decision is still awaited and will be based on the findings of an environmental impact study released in August 2013. The new working would extend the life of the phosphates operation by about 14 years;

Simplot's other mine in Vernal, Utah is still operating. It originally had a capacity of 4mn t/yr, but now supplies the Rocks Springs phosphoric acid unit (370,000 t/yr of P_2O_5) by a 96-mile slurry pipeline commissioned by the then owners Chevron in 1986. This implies a requirement of up to 1.5mn t/yr of rock production. In 2014, Simplot started construction of a new ammonia plant adjacent to its existing Rock Springs phosphate facility, in order to implement the next phase of phosphate expansion plans at the same plant. Such an expansion implies that the Vernal mine will be expanded in the near future to supply the additional rock requirement for the processing plant;

- Agrium has operated the existing North Rasmussen Ridge and Dry Valley Mines in Caribou County, Idaho, since 2003 to supply about 2mn t/yr of concentrate to its Conda processing plant producing MAP, SPA and MGA (Soda Springs, Idaho). In 2011, the Dry Valley mine was closed. Proven and probable reserves at Rasmussen Ridge stood at 17.8mn t in December 2013, equating to about eight to nine years of remaining mine life at current exploitation rates;

- Monsanto operates a small mine at South Rasmussen Ridge (Blackfoot Bridge mine) with a capacity of about 1mn t/yr of rock for its technical phosphate operations. The plant, which opened in 1991, is halfway through its expected life and has received approval, without a great deal of opposition, for the mining expansions required to mine out the reserves;

- Stonegate Agricom is developing the Paris Hills Phosphate Project located in Bear Lake County, Idaho, located 73km south of the Smokey Canyon and Pocatello operations. The project area comprises 1,010 hectares. The majority of the mineralisation occurs in two horizontal limbs comprising an Upper and a Lower zone, with seams of 3-5m and 1.5-3m, respectively. The mineralisation has a strike length of about 3km and extends from the surface to a depth of over 1,000m. Resource estimates for the Lower Zone and the Upper Zone are as follows:

Table 18: Paris Hills Project - Resources Estimate (Lower Zone)

	Tonnes (mn)	P_2O_5 (wt pc)
Measured	15.4	30.4
Indicated	14.4	29.6
Total	**29.8**	**30**
Inferred	**4.6**	**29.9**

— company releases

Table 19: Paris Hills Project - Resources Estimate (Upper Zone)		
	Tonnes (mn)	**P_2O_5 (wt pc)**
Measured	28.4	22.8
Indicated	31.8	22.6
Total	**60.3**	**22.7**
Inferred	**9.4**	**22.6**
		— company releases

In laboratory tests, un-beneficiated ore from the Lower Zone successfully produced merchant phosphoric acid, diammonium phosphate and monoammonium phosphate;

Initial plans are to develop underground mining of the Lower Zone, which will produce close to 1mn t/yr of concentrate quality rock over 15-20 years. The full feasibility study for the project was completed in December 2012, and the licensing process has been under way since then. Stonegate Agricom was initially hoping to have permitting completed by the second quarter of 2015, at which point mine construction would commence. However, the company decided to halt work on the project permitting in January 2015 because of financial constraints. The initial capital costs are put at $121mn and subsequent sustaining capital over the mine life at $134mn. The cash operating cost to ex-mine would be about $70/t and $165/t is the base netback ex-mine used in its financial projections. There is no data available on specific impurities such as magnesium and selenium, although the laboratory production of diammonium phosphate might suggest that these will not create a problem. On a positive note, the deposits contain significant amounts of vanadium which may eventually enhance project economics.

Section 2: Phosphate Rock Supply
Chapter 2: The Outlook for Supply

2.4 Latin America

Figure 8: Phosphate Rock in Latin America, Summary Map

2.4.1 Mexico

Following the rehabilitation of the Rofomex mine in San Juan de la Costa, Baja California, there are no definitive plans for new production by the present owners, Fertinal. An expansion programme between 1993 and 2000 increased its annual production capacity to 2.1mn t/yr, although in 2001 production was suspended as a result of flooding caused by hurricane Juliette. Production recommenced in 2007, and stabilized at around 1.9mn t/yr since 2011. At the time or writing, Fertinal's phosphate rock mine is operating at 80pc of capacity, following last December's fire which affected one of three conveyor belts at the facility. The fire occurred shortly after phosphate rock production at the mine was knocked off line by Hurricane Odile in September 2014. Production resumed in mid-October of 2014.

Fertinal has spent recent years acquiring mining rights on various properties in Baja California Sur. The primary intention may have been to increase the attractiveness of the company to potential purchasers, although the company has reported no intention of investing in a new mine.

There has been long-standing interest in developing an offshore mine to exploit the low-grade phosphatic sands which extend for at least 72km offshore southwest Baja California. The resources have not been fully measured, but estimates exceed 1bn t of high-grade concentrate. The Mexican government established Rofomex in 1975 to investigate and exploit phosphate deposits in Baja California, including these sands, and a number of US companies examined the deposit and processes were developed to produce a 31pc P_2O_5 concentrate. Rofomex originally planned to exploit the San Hilario area but hit problems in respect of beneficiation, mining and onshore logistics. The company abandoned the project in favour of an open-cast mine onshore — the San Juan de la Costa mine which had a capacity of 450,000 t/yr — but which gradually fell into disuse until it was privatised in 1992, when the first rehabilitation and expansion project was launched.

In 2007, PhosMex was granted a 50-year concession, ending in 2056, on 100km^2 of ocean bed, some 20km west of San Juanico, Baja California Sur. The aim was to develop resources estimated at 250mn t of ore at a grade of 5-20pc P_2O_5. We are aware of no recent news about a potential investment, but the project points to the long-term promise of these marine reserves.

The phosphate resources which reside in the Pacific also outcrop on the peninsula and off the east coast. The onshore resources are reported to be generally sub-commercial because of a “high degree of contamination”, which we take to mean low P_2O_5 content.

2.4.2 Brazil

Brazil has significant existing production of phosphate rock, mainly carbonatite with a relatively low P_2O_5 content and which, like all apatites, can be concentrated up to produce a high-grade concentrate (35-38pc P_2O_5).

The country remains a major importer of P_2O_5, and it is for this reason that the Brazilian government consolidated the majority of the basic phosphate industry under Vale, with the acquisition of assets from Fosfertil and Bunge. The objective was to drive forward a process of investment which would increase self-sufficiency. Something that had proven difficult for private-sector companies to achieve. Tax regimes for imports and for the movement of products between federal states are complex and changing, and often favour imports. Internal transportation is difficult in terms of distance, road standards and traffic congestion — which is reflected in extremely high costs. For these reasons, processing and mining generally take place close together. The main existing mines are listed below:

Table 20: Existing Brazilian Phosphate Rock Capacity

Company	Mine	Rock Type	Reserves (mn t)	Av. Grade (P_2O_5)	Conc. Grade (P_2O_5)	Capacity ('000 t/yr)
Anglo American	Ouvidor, GO	Carbonatite	118	12.8pc	35.0pc	1,350
Vale	Tapira, MG	Carbonatite	1,309	7.69pc	35.5pc	2,170
Vale	Araxa, MG	Carbonatite	89	11.12pc	35/33pc	1,650
Vale	Catalao , GO	Carbonatite	224	8.96pc	36/34pc	1,000
Vale	Cajati, SP	Carbonatite	85	5.45pc	36pc	550
Vale	Patos de Minas, MG	Metasediments	305	12.36	24pc	70
Galvani	Lagamar (MG), Angico dos Dias (Piaui) and Irece (BA)	Carbonatite				500

— company reports, Aguia Resources

These mines are essentially designed to feed downstream operations as their sizes indicate.

Vale

Vale operates five mines in Brazil, with a total capacity of 5.4mn t/yr and one in Peru (Bayovar, 3.9mn t/yr capacity), to feed its downstream processing units at the following sites:

Table 21: Vale's processing units in operation

Processing Unit	Products manufactured	Capacity ('000 t/yr)
Cubatao, SP	Phosphoric acid	165
	DAP/MAP	340
	SSP Powder	640
	SSP Granular	560
Guara, SP	SSP Powder	400
	Granulation (SSP/TSP)	375
Cajati, SP	Phosphoric acid	225
	DCP	635
Uberaba, MG	Phosphoric acid	910
	TSP Powder	929
	SSP Powder	630
	Granulation (SSP/TSP)	895
	MAP Powder	150
	MAP Granular	845
	DCP	120
Araxa, MG	SSP Powder	1,350
	SSP Granular	1,210
Patos de Minas, MG	SSP Powder	250
	SSP Granular	130
Catalao, GO	SSP Powder	350
	Granulation (TSP/SSP)	325

— company reports

A major development still under study is Vale's rock mine and processing complex at Salitre in Patrocinio, Minas Gerais, which was initiated by Fosfertil. The first phase of the project includes the production of 1.1mn t/yr of rock and 500,000 of SSP. A second phase would expand the mine capacity to 2.2mn t/yr of rock and would produce higher analysis fertilizers. This project will mine carbonatite from a resource estimated at plus 800mn t. Initial estimates for run-of-mine ore are 10.2pc P_2O_5. Vale has undertaken technical and financial feasibility work but the project has not been put up for approval by the board. It appears that Vale's interest in the fertilizer sector has diminished over the last couple of years, and all fertilizer projects have been put on hold. Given that Vale's Araxa mine is approaching exhaustion, the investment required in the Salitre project to replace Araxa will be decisive in Vale's potential decision to exit the fertilizer sector. Vale is currently sourcing rock from the Bayovar mine in Peru to feed its Cubatao plant as rock from Catalao is limited and the Araxa mine depletes.

Another project is at an earlier stage of development. In 2010 Vale acquired Fosfertil's 50pc and Yara's 50pc stake in the Anitapolis, Santa Catarina, project which at one stage included a mine, as well as processing and ammonia plants. A single superphosphate plant was to be added during a planned later stage. At the time of the acquisition, the project was at an early stage and showed little indication of being expedited. In order to accelerate investment in fertilizers the government had threatened to cancel all mining licences granted unless projects were developed. Yara was not willing to be pressured into a large and possibly questionable project. When its project showed little sign of being developed, the government proceeded to buy out the private interests and consolidate large-scale production under Vale — with the exception of the wholly-owned Copebras/Anglo American operation. Under the new government, the policy is no longer as straightforward. There have been no recent announcements from Vale in respect of the Anitapolis project and we suspect that the Salitre project has taken precedent. It is also possible that the lobby groups against the project may be having some success, as concerns have been raised about the area of Atlantic rainforest that will be destroyed (up to 360 hectares) in developing the phosphate rock mine.

Anglo American

The Anglo American open-pit mine at Ouvidor in the south east of Goias state, is the second largest phosphate mine in Brazil and currently has a capacity of 1.35mn t/yr of 35pc P_2O_5 concentrate. Actual production approached 1.4mn t in 2013. About half the output of the mine is processed into high analysis fertilizers at the nearby Catalao complex and the remainder is shipped to its production facility in Cubatao to produce low analysis fertilizers. Anglo American is planning on doubling the capacity of the Ouvidor mine to produce an additional 800-900,000 t/yr of MAP/TSP at the Catalao complex (the Goias project). The start-up of this expansion has been delayed to 2020-21, should the project proceed.

Galvani

Galvani has two phosphate rock mines in Lagamar (Minas Gerais) and Angico dos Dias (Piaui) and a leased mine in Irece (Bahia), with a total production of around 500,000 t/yr of rock. This rock is used to produce SSP in two processing sites, Paulinia (700,000 t/yr) and Luis Eduardo Magalhaes (400,000 t/yr).

The company was selected by state-run Brazilian nuclear industry group INB as a partner to develop the Santa Quiteria, Ceara, uranium/phosphate project in 2008, although no firm announcements have been made since. Galvani also has two greenfield and one brownfield phosphate rock mining project under development for an additional 2.15mn t/yr of rock. Salitre and Santa Quiteria, are expected to add up to 1.2mn t/yr and 800,000t/yr of phosphate rock capacity respectively, and brownfield project Angico a further 150,000 t/yr.

The Salitre mine, which is part of the Serra do Salitre project in minas Gerais, is expected to be completed by 2020-21 along with new downstream capacities (1.2mn t/yr of 34pc P_2O_5 rock, 130,000 t/yr of MAP, 410,000 t/yr of SSP and 200,000 t/yr of TSP). The capex estimate for the mine development is put at $400mn. The recent acquisition of a 60pc stake by Yara International should provide the financial capacity to develop this project.

MBAC

MBAC Fertilizer Corp started production at the Itafos Arraias mine in August 2013. It currently exploits deposits put at about 70mn t of roughly 5pc P_2O_5 content. The new beneficiation plant should produce 330,000 t/yr of 28pc P_2O_5 concentrate to support SSP production of 500,000 t/yr.

MBAC is in the early stage of investigating two further resources in Brazil. The Santana deposit is located in southern Minas Gerais state, over 2,000km away from the main import terminal at Paranagua, and initial work indicates reserves of 45mn t of 12.9pc P_2O_5. The project's development includes the production of 500,000 t/yr of SSP in phase 1, while phase 2 would produce TSP and DCP. A feasibility study was completed in October 2013, and the company is carrying out additional work in order to define new drilling targets. MBAC is also investigating a high-grade Rare Earth/Niobium/Phosphate Project located in the state of Minas Gerais, the Araxa project. Both projects are at an early stage of development.

In March 25015, MBAC announced that it had entered into default after failing to file annual audited results. The company suspended production in November 2014 and reported that it produced 86,902 t of SSP in the first three quarters of 2014.

Aguia Resources

Aguia Resources, an Australian junior mining company, is developing three embryonic projects in Brazil. At the time of writing, drilling and testing work was most advanced at the Tres Estradas project in the Rio Grande do Sul area. The company also has exploration rights to a second area (Joca Tavares) 42km south east. Both areas are within the 150km Brazilian border zone, and any ensuing project must have Brazilian majority control. Initial drilling results at Tres Estradas and Joca Tavares have been promising. The company is also looking at the possibility of developing the Lucena phosphate project in the north eastern Paraiba State, as well as the Mata de Corda project in Minas Gerais State, which is located close to other major phosphate sites operated by Vale (Araxa, Tapira and Catalao)

Aguia is prioritising the Tres Estradas project. The resource estimate and metallurgical test work completed to date indicate that the ore body is similar to that being mined by Vale. The project also has the advantage of being located in a major consuming area with no existing rock mines.

2.4.3 Peru

The Bayovar Phosphate Mine (Vale 40pc/Mosaic 35pc/Mitsui 25pc) at Piura in the Sechura Desert in northwest Peru is currently ramping up to its full capacity of 3.9mn t/yr of phosphate concentrate (2013 production was reported at 3.55mn t). The rock produced is of relatively low-grade, in terms of the merchant market for acid-grade material. The deposit being worked has a reserve base of 238mn t of phosphate ore. Vale has put plans to its board for the Bayovar project to increase production by 1.9mn t/yr by utilising layers 6 and 7 of the resource. The Fe_2O_3 + AL_2O_3 levels in these layers are much higher than the rock now being mined and would require a complete flotation circuit to beneficiate into a commercial concentrate. The initial objective was to eventually produce a volume of rock sufficient to feed a major processing unit. In 2013, Vale was understood to be reassessing its fertilizer strategy and this expansion, along with all of Vale's other fertilizer projects, was put on hold. Last updates indicate that the Bayovar expansion studies are advancing with Vale's current partners. But minority shareholder Mosaic is unlikely to be in favour of a move into processing, as it would most likely prefer to have access to rock and not create new competition for ammonium phosphates in some of its important export markets.

Bayovar rock has a P_2O_5 content of about 30pc, but has a number of other characteristics which make it unsuitable as a sole feed for phosphoric acid production. These include:

- A high chloride content emanating from lattice-bound chloride and chloride from the residual wash water. The desalination plant built for the project is not operating to the original specification (600ppm chloride);
- The creation of stable foam in the phosphoric acid reactor;
- Fluorosilicate build-up;
- Poor phosphogysum crystal structure.

As a result, Bayovar rock has to be blended with other rocks when used for acid production.

A new project in the Bayovar area is being developed by Peruvian mining company Fosfatos del Pacifico (FosPac). In 2012, Zuari and Mitsubishi Corp acquired a 30pc stake in the project for $46mn. The project has a reserve base of 540mn t/yr of 18.5pc P_2O_5 ore and involves construction of a first phase for the production of 2.5mn t/yr of concentrate. Mitsubishi has signed an offtake agreement for the total output and a back-to-back agreement with Zuari for half of production — 1.25mn t/yr concentrate. The project is intended to invest in an effective water desalination unit and calcine some or all of the rock which will reduce both the chlorine and organics content of the rock, allowing for the production of a 30-31pc P_2O_5 concentrate. Tests indicate that it is well suited as a sole feed for phosphoric acid production, as well as being highly reactive. The concentrate will have a cadmium content of 60ppm, which is not currently a concern in major target markets such as India and Brazil, but might affect its potential in the North American market. As infrastructure has to be provided, this project is expected to come on stream in 2018.

A number of other projects are at an earlier stage of development:

- Stonegate Agricom, a Canadian junior mining company, is investigating the Mantaro Phosphate property, 250km east of Lima, near the city of Huancayo. The exploration area has some 40mn t of measured and inferred resources with an average P_2O_5 content of 10pc. The project is at the scoping stage and Stonegate Agricom is looking for joint venture partners to develop it further;

- Focus Ventures, another Canadian junior mining company, has three phosphate projects in Peru: Bayovar 12, Quebranta and Machay. The company's main project is the Bayovar 12 deposit located in the Sechura basin in Northern Peru, about 15-20 km north of Vale's Bayovar mine. The project has a reserve base of around 200mn t/yr of 12.4pc P_2O_5 phosphate rock. Drilling started in 2014 and Focus Ventures announced the selection of three consulting engineering companies to prepare the Preliminary Economic Analysis (PEA) for the project. The two other projects are at the scoping stage;

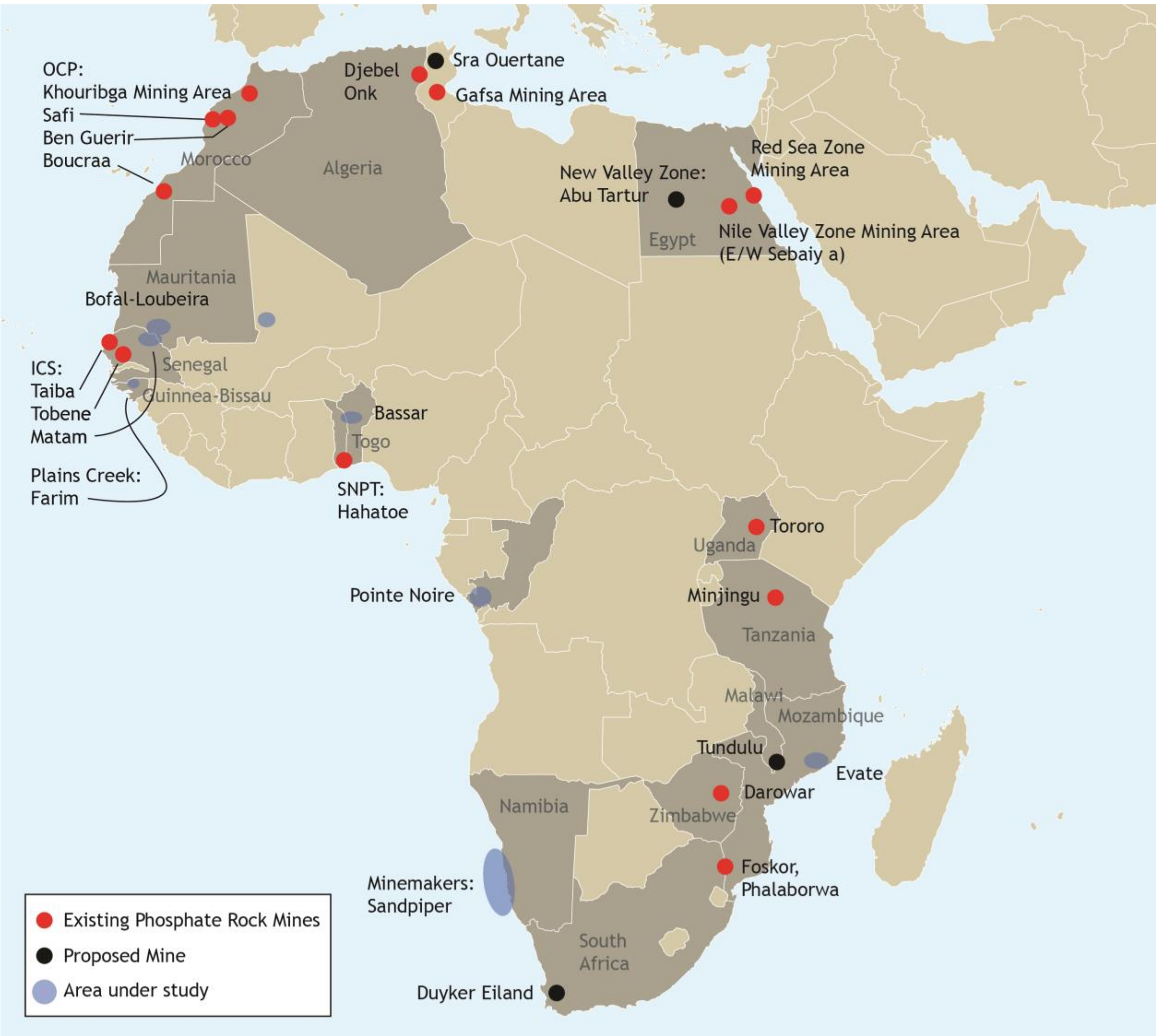
- GrowMax Agri Corp is also investigating a phosphate deposit in the Sechura Desert near the Bayovar mine. An 80pc stake is held by Canadian oil and gas exploration company Americas Petrogas, while IFFCO (Indian Farmers Fertilizer Co-operative Limited) owns the remaining 20pc. This project is also at the scoping stage.

2.4.4 Venezuela

The Riecito mine is operated by Pequiven in the Falcon state of Venezuela, serving small-scale phosphoric acid and NPK facilities at the Moron processing site. Production in recent years has peaked at around 360,000 t/yr, while the mine only produced 106,000t in 2013. The rock concentrate has a content of 29pc P_2O_5 and 24pc SiO_2, which makes it suitable for phosphoric acid manufacture. There have been numerous plans to expand both the mine and processing, but none has reached the implementation stage to date.

2. 5 Africa

Figure 9: Phosphate Rock in Africa – Summary Map



Africa is rich in phosphate resources which have, in the past, been exploited primarily for the export market. Rising prices and a new interest and urgency in addressing population and food security concerns in Africa have resulted in a fresh focus on project development, particularly from non-African companies, including firms from China and Israel. But it remains to be seen whether this will result in the completion of new operations. The continuing economic slowdown may alter plans and priorities developed by the global political community during a more prosperous period. On the other hand, some older industries which have been major producers and exporters in the past, are reaching a point where expansions at existing mines are no longer feasible and substantial expenditure is required to develop new available reserves. Africa is most certainly one of the main focuses for a maintenance and increase in P_2O_5 supply during the medium term.

Section 2: Phosphate Rock Supply
Chapter 2: The Outlook for Supply

In the following analysis of supply prospects, our main focus will be practical economics. Political issues cannot be entirely ignored, whether in relation to external interest in investing in Africa and supporting development, or in respect of local political difficulties, which have blighted some countries for generations. If nothing else they affect the timing of investment and industrial development.

We start our analysis with an overview of the main producing countries, to establish which show growth potential. In general, the mines in southern and western Africa are static or in decline, while growth is being seen in the north of the continent. We will add more detailed comments on trends in each of the countries reviewed. The following table provides an overview of production in Africa:

Table 22: Overview of Production in Africa *mn t product*

	1995	2005	2010	2011	2013
Total	**33.95**	**45.79**	**43.22**	**41.28**	**39.5**
Of which:					
Algeria	0.76	0.90	1.53	1.28	1.15
Tunisia	7.24	8.20	8.13	2.51	3.28
Egypt	0.77	2.62	3.43	4.75	5.31
Senegal	1.50	1.54	1.19	1.52	1.13
Togo	2.57	1.02	0.72	0.87	1.21
South Africa	2.79	2.64	2.50	2.47	1.92
Zimbabwe	0.13	0.08	0.06	0.05	0.02
Morocco	18.19	28.79	25.66	27.82	25.49

— IFA

Much of the recent fluctuation in annual production is the result of political disturbance in the north of the region, especially in Tunisia. To this should be added the willingness of Morocco's OCP to adjust rock production to accommodate swings in demand.

The following analysis of phosphate rock supply in Africa will be subdivided into three regions — north and northwest Africa, the Central African Belt and southern Africa.

Section 2: Phosphate Rock Supply
Chapter 2: The Outlook for Supply

2.5.1 North and Northwest Africa

Algeria

The Algerian rock reserves lie inland close to the Tunisian border region to the northwest of the Gafsa operations on the Algerian side of the border. The many plans announced for new projects between 2007 and 2008 involved expansions and extensions to the existing mined area around Djebel Onk, around 100km south of Tebessa, rather than greenfield projects exploiting new resources further to the north. Production there almost doubled in 2000-08 to about 1.8mn t/yr, and has ranged from 1.1mn-1.3mn t/yr over the past four years. This volume would be sufficient to support maximum production of about 350,000 t/yr P_2O_5 fertilizers at current ore grades. As part of the Ferphos project documentation, a geological survey and development of a mining plan have been undertaken. There is no doubt that sufficient reserves of rock are available in the area, currently put at 2.2bn t by the Algerian authorities. Projects have been floated in periods of market-boom over the past 40 years, going back to the Marubeni joint venture at Tebessa in the 1970s. It appears that the constraints which caused that project to fail are still present today, despite a much healthier market outlook for P_2O_5:

- The state-owned industrial companies suffer from chronic under-financing and politically, rather than economically-driven management and administration. The stagnation of the phosphate sector is mirrored in the larger domestic nitrogen industry (Sonatrach) and the gas sector;

- The establishment of joint ventures in the fertilizer sector as a whole has been fraught with difficulty. Ultimately, the OCI nitrogen joint venture started production in 2013, although foreign investment in Algeria still remains difficult, with changes to conditions (such as majority-ownership by non-Algerian partners) likely at any time;

- The Djebel Onk phosphate mine is 350km from the port city of Annaba. The existing rail network has never been upgraded since the mines were opened. It has the capacity to haul a maximum of 1.2mn t/yr of rock. Ferphos has established its own road freight subsidiary to move up to 800,000 t/yr to the coast. The port of Annaba can cope with the current export volume, but without a major upgrade it will not achieve the 4mn t/yr cited in government forecasts, or the volume which would be required to supply an export processing unit located at the coast;

- The open-cast mining envisaged is straightforward with the overburden:ore ratios expected to be 1:7 or less. The lower-grade rock is essentially physically separated and dried. It has a magnesium content of about 1.4pc. In the past, rock was calcined to produce a 34pc P_2O_5 grade which reduced MgO to 0.7-1.0pc. The rock has an iron content of about 4pc. This suggests that significant investment in beneficiation would be required to provide a satisfactory feed for processing into phosphoric acid. The original Annaba phosphoric acid unit, built in the 1970s, never produced satisfactorily, although the extent to which this was caused by rock quality is not documented;

- Announced plans to establish a new processing complex at Bouchegouf, 450km East of Algiers, are questionable, as how the rock will be transported there remains unclear.

Section 2: Phosphate Rock Supply
Chapter 2: The Outlook for Supply

A major medium-term expansion of rock production looks unlikely until logistical infrastructure to port and local infrastructure in the mining area is installed. It is likely that such expenditure could not be absorbed into a foreign joint-venture project, nor does there seem to be any movement on the part of the government to provide the investment that would facilitate an expansion of rock mining and downstream processing. The rock is not of a quality to encourage expansion for the purpose of increasing exports — existing rock sales are made at a discount to standard acid-grade rocks. Despite these perceived problems and the failed tentative joint venture with Fertiberia and Engro Chemical, it is reported that the Algerian government remains intent on pushing ahead with a major P_2O_5 project, and is again in discussion with potential joint-venture partners.

Tunisia

Tunisia's phosphate rock deposits are located in the regions of Gafsa, Tozeur and in the northern region of Kef. The Gafsa mines are operated by CPG (Compagnie des Phosphates de Gafsa) and have reached a production ceiling of about 8mn t/yr, although they are not currently producing at this level. In 2014, CPG announced a production target of 5.5mn t, but this goal proved far too optimistic as the prime minister recently announced that 2014 production stood at 3.7mn t, less than half the 2008 production level. Any future expansion of output will be based on new reserves to the northwest of the Gafsa Basin. Some of these outliers of Eocenen rocks in the north of the country have been exploited and worked out.

While proven reserves of phosphate with commercial potential have been located, the Tunisian industry faces even greater pre-project expenditure than its Algerian counterparts. This is illustrated by the Sra Ouertane project which evolved during 2006-08.

a. Sra Ouertane

This project was first launched in 2006 through a tender calling for international parties to invest in the development. The project was conceived as a joint venture to include all the infrastructures for a new, inland mining area. Prior to signing a formal joint-venture agreement, a concession agreement must be negotiated. There is no certainty that the government can finance its part of the development as it was initially conceived — essentially covering the rail line and port dredging. It was also never clear that the Tunisian government's "participation" in the project involved an equity stake. The original document states:

"The Tunisian Government is considering equity participation in the Project, either directly or through state enterprises like CPG and GCT."

On the other hand the Investor was obliged to:

"Allow Tunisian government (state or state-owned companies CPG-GCT) to be partner in the project at a suitable level".

The nature of eventual ownership also remained unclear:

"The owner in association with the eventual Tunisian partner shall build, own and manage and ensure the operation and maintenance of the project during the concession period for the mines and port and during the whole period life of the fertilizer chemical complex."

There is also no clarity in respect of the concession period, "period" of mine life and financial input.

This makes it hardly surprising that there is currently no sign of an external joint venture partner emerging. The cost was originally put at $3bn, with no clear split between government and joint-venture contributions. As mentioned above, the division of responsibilities envisaged that the Tunisian government would be responsible for the railway link and the port deepening.

The joint-venture partner would undertake to finance water pipes to plant, liquid products pipes to and from ports and the construction of berths and railway equipment.

Since the invitation to outside parties to invest in the development, we understand that a number of changes have been made. The most significant is a decision to put the processing units for triple superphosphate and diammonium phosphate at the mine, rather than at a coastal processing unit.

We list below the key factors which will impact on the development's economic viability and attractiveness for an outside investor:

In respect of phosphate rock:

- The new rock mine is 200km north of Gafsa, and 40 km south of Kef, in northwest Tunisia. It will share no facilities with the existing mining operation;
- The run-of-mine ore will have 13pc P_2O_5 and will be beneficiated using flotation to 30pc P_2O_5; The concentrate will be typical of Tunisian quality:
  30pc P_2O_5
  0.9pc MgO
  4pc SiO_2
  0.1 Cl;
- The invitation to invest stipulates that the mine shall be state-of-the-art with full reclaim facilities of the mined area for return to agriculture use and wastes should be returned to back-fill the mine site. Production of 4mn-5mn t/yr is foreseen (one or two phases), presumably providing up to a 1mn t/yr surplus for sale to other operations or export.

In respect of water-supply, the original plan stated a preference for sea-water desalination in the processing units: "Due to some limitations in water resources, sea-water desalination is the preferred option, especially for sea-adjacent facilities. Nevertheless some resources from dams are available in northwest Tunisia and can be used for on-site beneficiation of the ore."

Relocating the plant inland puts into question the cost of and availability of water. It was always the responsibility of the investor to mobilize water requirements for the project. Currently there is mention of water availability from the Oued Mallegue River.

In respect of logistics, all infrastructure is to be built by the potential investor, with the exception of rail-line construction and dredging. Such investment would be substantial, especially as there is no clarity on which port is to be used by the project. The options appear to be:

- Port of Bizerte (200km);
- Port of Skhira (300km);
- Port of Enfidha (200km).

The relocation of the plant brings additional logistical responsibilities and costs for the investor. On the positive side, it reduces the need to transport rock to plant and, eventually phosphogypsum back for mine back-fill. There is no clarity as to whether there will be charges for use of the rail line and what is involved in "railway equipment" traction units, signalling etc.

This project, as originally defined, has a limited prospect of implementation in the changed global economic climate. We must also recognise the political and economic uncertainties that would affect any investment in Tunisia. It appears unlikely that the government would be in a position to fund any substantial portion of the project.

b. Other Projects

There are two projects in Tunisia at a preliminary project scoping stage — gaining permits, undertaking initial geological surveys, sampling and testing and scoping. As previously discussed, there are an increasing number of junior mining companies that aim to develop a project to a stage where it can be sold on to a bigger company with the means to implement it. While a useful preliminary activity, these activities should not be confused with developments at either the project or pre-project stage.

Celamin Holdings and its local partner Tunisian Mining Services (TMS) have investigated two areas of phosphatic mineralisation in northwest Tunisia:

- **The Chaketma Phosphate Project** is the most advanced, having reached the point where a formal Bankable feasibility Study (BFS) was launched in August 2014. Celamin holds a 51pc interest in the Chaketma project and TMS owns the remaining 49pc. Testing continues but the following landmarks have now been reached:
  - The project covers an area of 56km^2. Target potential 175mn-280mn t/yr of 17-22pc P_2O_5 ore at six potential prospects, two of which are currently under investigation by Celamin;
  - The initial focus is the Gasaa El Kebira resource. Work has already shown that the resource has inferred reserves of 93mn t of ore containing an average of 20.3pc P_2O_5. Drilling undertaken across Kef El Louz North resource adds a further 37mn t, averaging 21pc P_2O_5. Drilling undertaken so far therefore indicates that the Chaketma area shows an inventory of 130mn t P_2O_5 with an average of 20.5pc P_2O_5;
  - Independent bench tests on ore from Gasaa El Kebira have shown that rock can be concentrated up to 31pc P_2O_5 with a magnesium content of 0.7pc MgO, and all other minor elements in acceptable ranges for acid manufacture. At ambient temperature the P_2O_5 recovery rate was 68pc;
  - Bench tests on ore from Kef El Louz North could be concentrated to 30.5pc P_2O_5, with 0.77pc MgO and a recovery of up to 77pc;
  - A sample tested as part of the project's testing programme gave the following results:

P_2O_5	31.7pc
Al_2O_3 + Fe_2O_3	1.2pc
MgO	0.8pc
SiO_2	2.2pc

These values fall within the accepted parameters for acid production. Work continues on the use of selective mining and adjustments to the beneficiation process. All the test work has used conventional technology.

- **The Bir El Afou Phosphate Project:** The salient details of the research programme to date are:
  - At the current stage of drilling, the resource potential stands at 29mn t of 11.1pc P_2O_5 rock; Drilling and trenching has been completed at Salsala, Zebouzi and Bir El Afou Blocks A, B and C. Less than 5pc of the area has been drilled;
  - Tests show the ore can be concentrated up to 30pc P_2O_5. Base-case production target is 750,000 t/yr concentrate, with a second phase expansion to 1.5mn t/yr. The concentrate meets the accepted norms as feed for acid production;
  - Rail access has been agreed, a short siding required;
  - Existing export facilities available at the Port of Tunis;
  - A dedicated water supply has been allocated to the project;
  - Since October 2013, Tunisian Mining Services owns 100pc of this project.

The future prospects for these junior mining projects will be determined by the policies and decisions of a new government, and the general state of the economy. As it stands, civil unrest has significantly affected rock deliveries to downstream plants and rock exports. There was hope that logistics difficulties would ease after the government election in October 2014, but this has not been the case. And the situation is unlikely to improve in the near term. Therefore even if the mines are built, logistic difficulties may prevent the rock from being sold domestically, or internationally.

Egypt

The Egyptian phosphate rock mines are state-owned through two major holding companies:

- EL Nasr Mining Company (ENMC) which owns and operates mines in the Aswan governorate (east and west Sebaiya) and the Red Sea area;
- Misr Phosphates which owns the Abu Tartour deposit in the New Valley Plateau (southeast).

During the boom years, the government encouraged the private sector to propose projects to upgrade rock into fertilizers, but limited the investment options to processing plants for single and triple superphosphate production. There were a number of projects set in motion but all failed as a result of the unacceptable terms of rock supply or mining licences.

When it became clear that there would be no private-sector investment under the terms proposed by the government, Misr Phosphates, a new state-owned entity with some private-sector interest, was set up in early 2009. It is led by the Egyptian Mineral Resources Authority (EMRA) and the National Investment Bank. Misr Phosphate's first task was to take control of developing rock mining in the New Valley mining zone (Abu Tartour).

Egyptian reserves are distributed as follows:

- The Red Sea Zone has been in production for over 100 years. Three small underground mines operate, producing low-grade rock (25pc P_2O_5 run of mine, and maximum 28pc P_2O_5 after beneficiation). It is generally sold for direct application use. Reserves are depleting:

  - El-Quosir, 4mn t
  - Safaga, 6mn t
  - Hamrawein, 8mn t

- The Nile Valley Zone is divided into two sectors. The west Sebaiya sector is depleting and has reserves of 5mn t. The east Sebaiya sector has reserves of about 20mn t, and is largely responsible for the up-tick in production in recent years;

  Practically all the downstream projects floated during the recent boom intended to use rock from east Sebaiya. If the official reserve figures of 22mn t with a run-of-mine grade range of 22-28pc P_2O_5 are correct, then there is sufficient rock for one small processing project with a life of 15-20 years. This suggests that the first step in developing a new project would be a detailed survey to identify new resources. This in turn suggests that the timetable for such a project would be lengthy;

- Abu Tartour, located on the New Valley Plateau, is further inland — over 600km from the Red Sea and about 1,000km from the Mediterranean. It has total resources of 1.5bn t of phosphatic mineralisation, according to government figures. The zone has a long and very expensive history as an object of study. The first work on the potential of the zone was undertaken in the late 1960s and a joint venture agreed with Russia in 1972. Since then, the project has been revived about once every 10 years. By the late 1990s, over $3bn of costs, including a 600km rail link, were on the books of the project. The rail-link, a number of buildings scattered over a large area and a small underground pilot mine were all that could be seen for this expenditure. In the 30 years that the project was under the control of the ministry of industry (prior to the Misr Phosphates take-over), the small pilot mine produced just 300,000t of rock. Between 2009 and 2012 it produced 1.3mn t of rock. The sections of the deposit which have shown most promise — recent announcements suggest 750mn t — have an average rock content of 24-36pc P_2O_5. Research work is being undertaken in Egypt to see if a 32pc P_2O_5 concentrate can be produced;

  It has been difficult to persuade either Egyptian or foreign partners to become involved with the New Valley project, if only because the enormous sum of money already sunk in the venture would need to be written off first. Past governments were unwilling to do this. If this historical hurdle were to be overcome, other problems remain to be solved:

  - Ore quality: the contamination of the rock by pyrites which affects its processing qualities;
  - A mining licence on acceptable terms;
  - Poor mining conditions: the overwhelming majority of the reserves lie over 100m below the surface and are therefore difficult and expensive to mine. The original equipment purchased was designed to mine at a depth of 40m. There are some reserves amenable to open-pit mining — some 30mn-40mn t — but no equipment suited to its extraction has been purchased. Bottom line, a deep open-pit operation may be feasible but would also be expensive;

- Removal of the condition that single superphosphate and triple superphosphate are the only designated products;
- Distance from seaports: the 400km of dedicated line that connects with the rail track to the port city of Safaga on the Red Sea is run down — over 40km of railroad ties have been removed by thieves. The Port of Safaga has found new customers for the warehousing and handling facilities intended for use by Abu Tartour, so new warehousing would be required if the port were to be used as the export terminal for merchant rock. Export rock is currently being trucked to Damietta and Suez.

In October 2012, a new scheme to exploit the Abu Tartour deposits was announced by the government, again fronted by state-owned nitrogen company Abu Qir Fertilizers. A protocol of co-operation was signed by the government and Abu Qir to invest $1.7bn in two phases — the first ($750mn) presumably intended to construct a mine, while the second ($950mn) a processing complex. In February 2015, Kuwaiti and Egyptian firms signed several initial agreements for four projects, including a fertilizer complex worth an estimated $1.2bn, with the capacity to produce 500,000 t/yr of phosphoric acid, 350,000 t/yr of triple superphosphate and 350,000 t/yr of diammonium phosphate by 2018.No further announcements have been made, although the fundamental problems associated with exploiting Abu Tartour rock and the impact of these problems on project viability remain the same as before.

The situation in respect of phosphate rock production has evolved over the last five years and mining has expanded to fill the gap left in the market by Syrian rock. Egypt has increased phosphate rock production in recent years, from 2.2mn t in 2006 to 5.3mn t in 2013. Reported production reached 5.7mn t in 2012, although the quality of some of the rock was dubious. Exports totalled 2.4mn t in 2013, after reaching a historical high of 4.1mn t in 2012 (of which almost 1mn t was shipped to unspecified destinations which are difficult to establish, as shipments to all traditional markets are included in the export statistics). Home deliveries in 2013 are reported to be 2.26mn t, more than double the 900,000t reported in 2012, with the majority consumed in the production of low-grade single superphosphate.

We understand that a number of licences to cherry-pick outcrops of richer material have been granted over recent years. This is reportedly damaging the future prospects of the resource, as at least a quarter of the reserves being left behind are low grade. No figures are available but Abu Tartour has contributed to the significant increase in exports of rock. With 28-30pc P_2O_5 content, it is sold mainly for single superphosphate production and direct application customers, but generally not for acid production.

At the time of writing, we understand that there is a general concern among Egyptian phosphate exporters about an imminent regulation that would ban or complicate (via export taxes) phosphate rock exports, with a view to encouraging local valorisation of the raw material and exports of finished product.

Senegal

Senegal's phosphate rock producer ICS is in the process of replacing the exhausted Taiba mine with the new Tobene mine which is producing 250-300,000 t/yr of rock with a P_2O_5 content of about 30pc. From a peak of around 2mn t/yr in the mid-1980s, total production declined to 600,000 t/yr in 2006-08. The new mine has enabled a recovery to over 1.5 mn t in 2012 before declining again to 1.1mn t in 2013.

Throughout the history of the ICS joint venture (66pc Indorama since August 2014, 18.54pc IFFCO, 15pc government of Senegal, 0.46pc government of India), the company has suffered from a shortage of investment and disputes between the partners. It is reported to be unlikely that the new mine will produce sufficient rock to serve the needs of the associated phosphoric acid plants.

There are two others resources readily available in Senegal:

- Aluminium phosphate is available from the Theis mine, but there is no market demand for it. A better quality of ore found beneath that deposit is apparently being exploited and output exported in small volumes, totalling 150,000t in 2012;

- In excess of 55mn t of “slimes” have accumulated in the tailing ponds at Taiba and have naturally dried. They have a P_2O_5-content of 22-23pc but a very high Al+Fe and are extremely fine if recovered by flotation. These slime pools represent a significant environmental problem but also a potential source of low-cost phosphate rock for in situ processing.

Exploration for new resources has been focused both close to and beyond the existing mining areas. Three licences were issued in 2008 for phosphate research permits close to the Taiba mine. Significant deposits of rock have been discovered and studied in the Matam region. Proven resources are about 40mn t of ore with 28.5pc P_2O_5 content and low cadmium (5ppm). The area has a weak overburden, which will keep mining costs low. The intention is to proceed with a small mining operation in the southwest of the deposits which has 4mn t of resources. Research permits have also been issued for the area between Kanel and Thilogne. Grupo Azoty Police has also started to invest in Senegal, following acquisition of a 55pc stake in AIG (African Investment Group) in 2013. The aim of the investment is to obtain a secure supply of rock and Police aims to import up to 1mn t/yr from Senegal.

The development of actual projects is clearly some way off, as is shown in the wide range of resource estimates. On the basis of research undertaken, resources in the areas under study are put in the 500mn-1bn t range.

Togo

Although Togolese rock has a high P_2O_5 content (36-37pc P_2O_5 content), it also has a high cadmium level (60ppm). This limits interest either in investing in the mining operation or developing processing facilities. The state-owned Societe Nouvelles des Phosphates (SNPT) mining facility at Hahotoe itself is relatively simple, using bucket wheel excavators. The overburden:ore ratio is low at 2:1. The run-of-mine ore is transported by rail 30km to Kpeme where it is scrubbed, screened and hydrocycloned to remove clays. The beneficiation unit has a capacity of 3.5mn t/yr.

From a peak of around 3.5mn t/yr in 1988, production declined to 725,000 t/yr in 2009-10, mainly due to a lack of investment and overall economic instability in the country. But investment in infrastructure from 2010 onward has enabled production to recover to 1.1mn t in 2013.

A tender for the rights to develop carbonated phosphate resources containing an estimated 2bn t of phosphatic mineralisation was launched in 2012. The tender was won by the Elenilto/Wengfu consortium at the end of 2013. The limited details of the project available are:

- 2bn t of phosphatic mineralization;
- The development of the project will be done in two phases of 5mn t/yr of rock each (31.5pc P_2O_5);
- The “major part” of the rock produced is to be processed via the acid route;
- The project includes construction of a wharf, a power plant and transportation facilities to the port;
- The project is located adjacent to the existing Hahotoe mine;
- The total cost would be “over $1bn”.

Early indications are that the P_2O_5 content of the resource is in the 14.5-15.5pc range, with discrete zones containing 80mn-100mn t containing 18pc-20pc P_2O_5. Based on old drillings from French geological agencies, rock from three zones could be up-graded to +30pc P_2O_5. However, there appears to be insufficient exploration to support these facts. The project is clearly at the pre-development stage.

Mauritania

There is a degree of optimism in Mauritania that it will develop a significant phosphate industry. Interest is focused primarily on the Bofal-Loubeira area neighbouring Senegal’s Matam deposits. A licence was granted to Bofal Indo Mining in late 2010 to conduct commercial survey work and an agreement was signed in 2007 between the Mauritanian government and China’s Transtech Engineering to construct a 430km rail link between Bofal and Nouakchott. Clearly, the global economic climate has delayed progress on opening up the phosphate area, and we are not likely to see commercial production in the medium term. But the resource, estimated at 90mn t/yr of 20pc P_2O_5 content ore, will be of interest as and when transport links are in place.

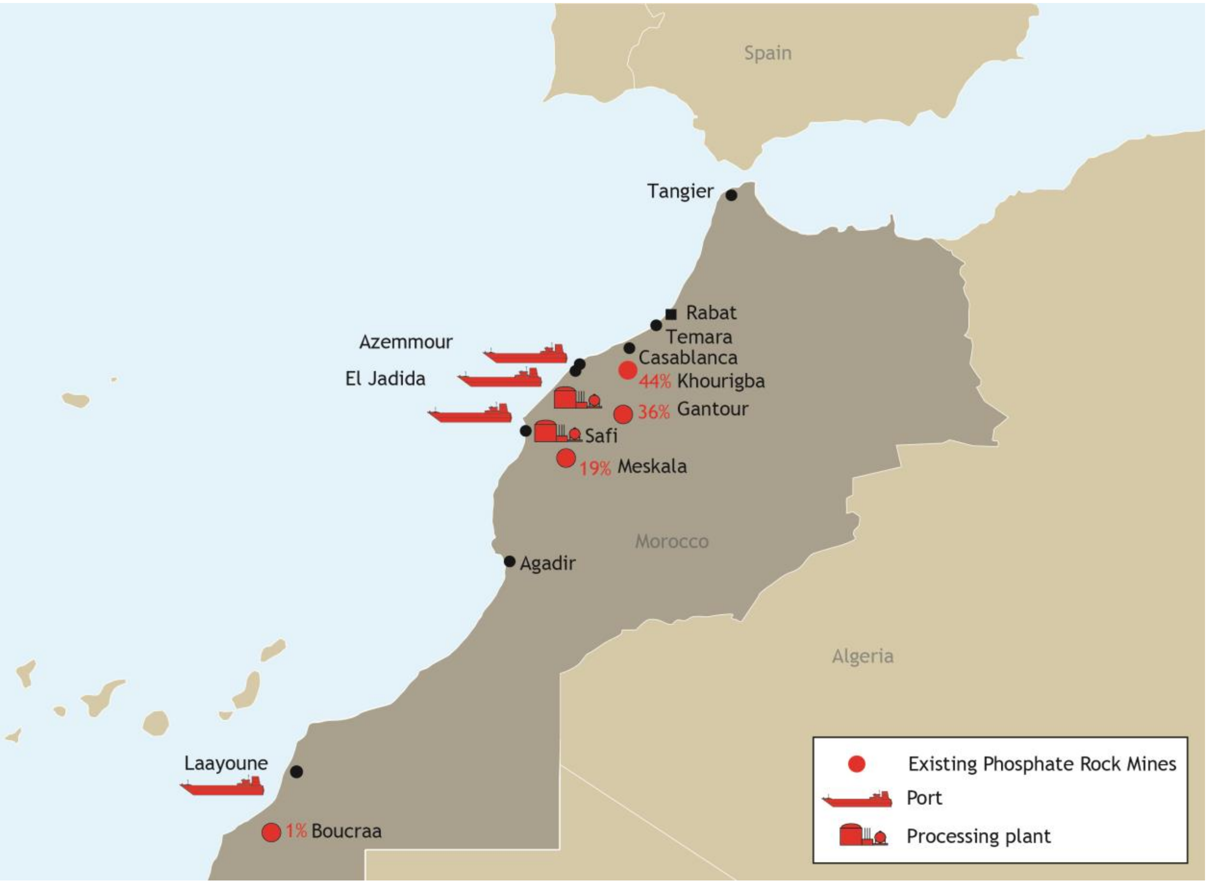
Morocco

The Moroccan phosphate rock industry is an exception to most of the general trends so far described in this report:

- Morocco possesses the largest reserves of high-grade phosphate rock. The average P_2O_5 content of the rock currently mined by OCP is 31pc;
- The reserves lie within easy reach of deep-water ports;
- OCP has exclusive access to Morocco’s phosphate rock reserves;
- All phosphate rock mining activities are conducted at open-pit mines;
- OCP is investing in the infrastructure to increase production from existing reserves and bring it to market, as both merchant rock and processed products;
- OCP has become a Societe Anonyme (SA) and has a strong financial position allowing it to raise financing to progress its development plans. The most recent development was the issuance of a $1bn offering in April 2015, with a BBB- Investment Grade rating, one year after the Group’s inaugural bond.
- The country has been relatively stable during a period of regional turmoil, and political risk is not currently a major issue.

In respect of reserves, the following chart shows their distribution:

Figure 10: OCP Phosphate Rock Reserves



— *OCP documentation*

OCP currently operates ten phosphate rock mines, at three different locations in Morocco, with a combined maximum production capacity of 32.4mn t/yr of rock:

- Six mines at Khouribga;
- Three mines at Gantour (Ben Guerir and Youssoufia);
- One mine in the Southern Provinces (Boucraa).

The growth in Moroccan production of both rock and processed products is a rolling process supported by the development of a large-scale infrastructural platform. As such, OCP is currently undertaking a number of industrial projects including:

- The opening of three new mines and four beneficiation plants in Khouribga and Ben Guerir to increase the mining capacity by approximately 26mn t/yr. OCP may also consider opening a new mining front in Meskala to address long term demand;
- The construction of two slurry pipelines to transport up to 55mn t/yr of rock: one pipeline linking Khouribga to Jorf Lasfar (with a length of 234km and a capacity of 38mn t/yr in 2015) and a second

slurry pipeline between Gantour and Safi (with a length of 155km and a capacity of 10mn t/yr when operational in 2019). A third slurry pipeline linking the potential Meskala mine to the processing platforms is currently under study;

- The expansion of fertilizer and phosphoric acid capacity at the Jorf Phosphate Hub;
- The expansion of the port and storage facilities and water-related infrastructures at Jorf Lasfar to accommodate such increased production.

OCP has structured its capital expenditure program in various phases to 2025. The Khouribga area was developed to support the first phase of the Jorf Lasfar platform and production is now effectively being doubled as OCP realises the second half of the Jorf Lasfar development for a major expansion of its processing capacity.

The development of rock-related investments to service the new processing platform has been divided into three phases: the first phase will be completed in 2016, the second phase will be completed by 2020 and the third phase by 2025. The status of OCP's capital expenditure program is as follows:

Financing: The total estimated cost of the industrial projects since their launch in 2008 to 2025 is around Dh189bn ($21bn), with Dh37.1bn — around 20pc — having already been spent between 2008 and 2014, out of the Dh54.7 bn committed so far. The total capital costs of mining, beneficiation and rock delivery to Jorf and Safi in this investment programme is estimated at approximately Dh63bn (around one third of the total capital expenditure program). This is an approximation as some of the investments (for example in port expansion) serve both the rock and processing operations. The investment in mining, beneficiation of the incremental rock and the pipeline transportation system represents a capex per capacity tonne of concentrate of around $100-120/t. This compares with about $600/capacity tonne for an apatite mining and beneficiation complex at the top of the range and of $150-200/capacity tonne for the best-placed projects exploiting shallow sedimentary deposits. These investments will also result in a reduction in costs for the existing mining and processing capacity as well as providing a low-cost base for the expansion. The investment programme will bring savings in respect to drying prior to shipment from mine, in direct access to pipeline at each mine eliminating the need to have trucks move ore around the site and in the scale of operation;

Mining: The programme includes the construction of three new mines located at Khouribga:

- The El Halassa mine at Khouribga was the first to be completed in the end of 2014. In 2015, 3.8mn t/yr of rock concentrate will come on stream and a further 2.6mn t/yr in 2016;
- The second mine at Khouribga will be the Oulad Fares mine which will produce up to 6mn t/yr concentrate and be on stream in 2017;
- The third development at Khouribga will be an extension to an existing mining (the EZCN development) with approximately 5mn t/yr of concentrate capacity, on stream in 2019.

In addition OCP will be upgrading their existing mines:

- Sidi Chennane (1994) is the largest of OCP's existing mines with 10mn t/yr concentrate (merchant grade) capacity. It produces 14mn t/yr of run-of-mine ore;
- Merah Lahrach (1964): produces 11mn t/yr concentrate;
- The Boucraa mine will not be expanded but will continue to produce up to 2.7mn t/yr of high-quality concentrate. Investments will be made in maintenance and flotation in order to improve mining operations. Mining of the second layer of phosphate, which is less rich in BPL and contains more silica commenced in 2014.

Based on its current plans and estimates OCP expects its annual production capacity of phosphate rock to increase from 32.4mn t in 2014 to 57mn t in 2025.

Beneficiation: Four new beneficiation plants using advanced flotation techniques are being/will be constructed, three in Khouribga and one in Ben Guerir:

- At Merah El Ahrach a beneficiation unit with a capacity of 7.2mn t/yr has been completed. The plant's capacity will be expanded to 12mn t/yr in 2016. It will treat ore from the Khouribga mines. Two lines are being constructed at El Halassa, the first with a capacity of 6.5 mn t/yr of concentrate, the second with 5.5mn t/yr capacity. The first unit will be operational in 2015. Half of the ore will come from the Sidi Chenanne mine and the remaining 50pc will come from the El Halassa mine. They are being built simultaneously for reasons of construction economics;
- A beneficiation unit will be built at the Oulad Fares mine with a capacity of 14mn t/yr. It will consist of two streams. The first will have a capacity of 8mn t/yr and will come on stream in 2017. The second stream will have a capacity of 6mn t/yr and will be commissioned in 2019;
- At Ben Guerir, a beneficiation unit with a capacity of 6mn t/yr will be constructed in two streams. The first 3mn t/yr will come on stream in 2015, the second in 2019;
- At Layoune the beneficiation plant is being upgraded to allow an extended mine life at the existing capacity;
- The old beneficiation complex at Ben Idir has been closed;
- Beneficiation capacity at Youssoufia will remain at 4.2mn t/yr. Calcining capacity of 3mn t/yr will also be maintained.

At the end of the investment programme there will be 44mn t/yr of beneficiation capacity at Khouribga and 10mn t/yr beneficiation capacity at Gantour;

Water supply: Two pipeline supply systems are being constructed to feed water from existing dams to the beneficiation operations at Khouribga and Gantour:

- The Maroc Central project will pipe water from the Ait Massoud Dam to serve Khouribga. Construction commenced in November 2010 and was completed in 2014;

- The Al Massira pipeline project, which is linked to the Al Massira Dam, will serve Gantour. It will be completed in 2015.

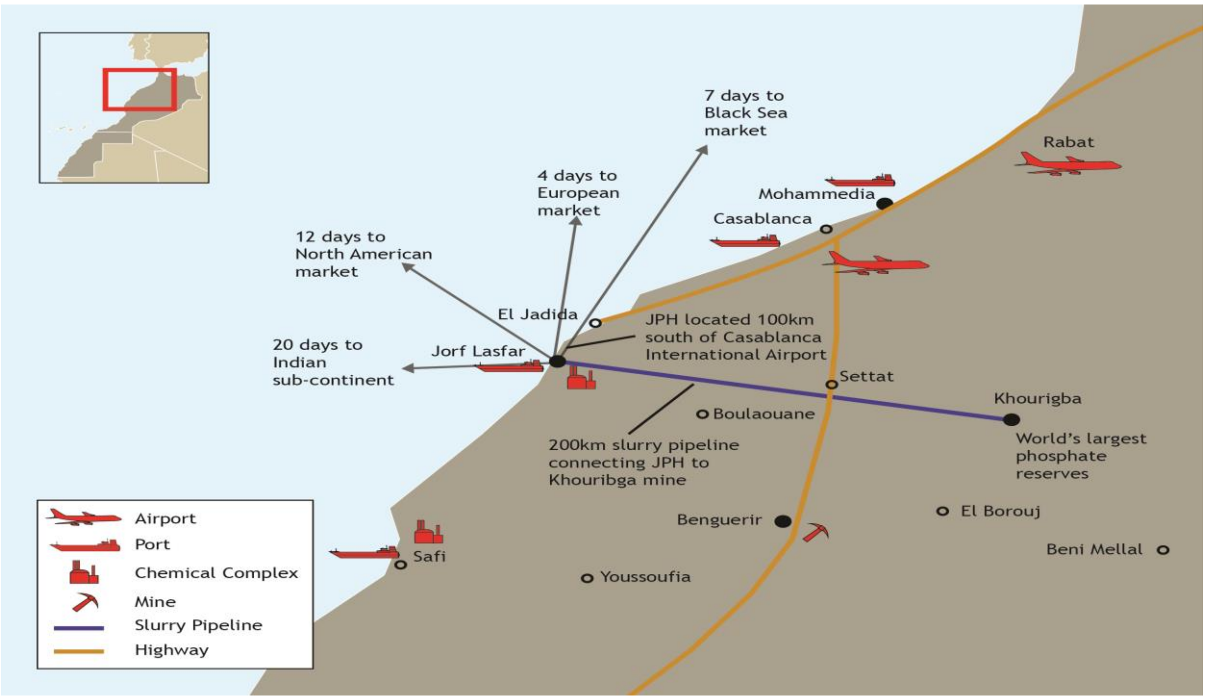
The water requirements at Jorf lasfar and Safi will be wholly supplied by water carried by slurry pipelines and desalination units, relieving demand on water sources in the coastal area.

Slurry pipelines: Two slurry pipelines are planned. In the first phase, a slurry pipeline connecting Khouribga to Jorf and in the second phase a pipeline will connect Gantour with Safi. Construction of the Khouribga-Jorf pipeline is now complete and the pipeline has been operational since April 2014. A third slurry pipeline linking the potential Meskala mine to the processing platforms is currently under study.

The pipeline will transport rock that is ground to the specification of the acid units. The slurry will be thickened for introduction to the reactors at Jorf. Different grades of rock for export will be prepared accordingly and dispatched in separate charges to Jorf for drying and conditioning at port facilities. The pipeline creates the bulk of the savings in production costs for both existing and new rock production. Not only does it eliminate the need for expensive handling and shipment by rail, it also obviates the need to dry material at mine for use in the phosphoric acid units at Jorf, and thereby the need for water to prepare the dry rock for the phosphoric acid reactors. Moreover, thanks to a naturally occurring slope between Khouribga and Jorf (the mine is 800m above sea level) the amount of water and energy needed to get the phosphate rock slurry moving will be minimised.

According to OCP, integration between the upstream and downstream operations of the value chain through the slurry pipeline reduces the costs of delivering phosphates to Jorf Lasfar from the current \$8/t to less than \$1/t of rock transported. After a transition period during which OCP will keep the flexibility to ship rock by train from Khouribga to Casablanca in case it needs to do so, phosphate rock exports will no longer be shipped from Casablanca, which had led to problems of phosphate rock dust in the atmosphere in the area surrounding the port facility. The new arrangement centres all phosphate activities at Jorf Lasfar.

Figure 11: OCP Logistics



— *OCP documentation*

Excluded from the above map is the proposed slurry pipeline from Benguerir/Youssoufia to Safi with a length of

155 km and an annual capacity of up to 10mn t. Construction of this pipeline has not yet commenced and the start-up is planned for 2019. The cost of the pipeline is estimated at Dh2.7bn.

Facilities at port: Drying and conditioning facilities are being constructed at Jorf Lasfar to treat the merchant rock (filtration, drying and screening). Equipment was ordered in July 2011 and construction will be completed by 2015. A quay is being rehabilitated at Jorf Lasfar to handle the additional tonnage which is still shipped out of Casablanca. Its draught will be increased so that Cape-size vessels can be loaded (110,000dwt). Today the berth is limited to Panamax vessels (65,000dwt). By 2015, OCP will have the capacity to export about 15mn t/yr of rock from Jorf Lasfar, Safi and Boucraa, with the possibility to go beyond 15mn t/yr by means of low-cost and easy investments to infrastructure.

The following table summarises the build-up of beneficiation capacity:

Table 23: Build-up of OCP Beneficiation Capacity		*mn t/yr concentrate*
Existing capacity		
Sidi Daoui	6.4	Operational
Merah El Ahrach	7.2	Operational
Youssoufia	4.2	Operational
Layounne	3.2	Operational
New capacity		
Al Halassa	12.0	On-stream 2015/2016
Oulad Fares	14.0	On-stream 2018/2019
Merah El Ahrach expansion	2.0	On-stream 2016
Benguerir	6.0	On-stream 2015/2019

—OCP documentation

2.5.2 The Central African Belt

Although there are no major phosphate mines in the Central Belt of Africa, there are known deposits of phosphate rock that have commercial promise both locally and for export. A number of projects are looking at the production of 2mn t/yr or more, although none is well advanced. The following analysis summarises the projects' status, most of which are at an early stage, and the few small-scale mining operations now working:

Tanzania

Four main phosphate rock deposits have been identified and tested in Tanzania. The Sangu-Ikola deposit is the most extensive, at 14km long and 1.5km wide. In places, the P_2O_5 concentration is 10-15pc. But the phosphate is not available to plants without treatment. The Minjingu reserves, on the other hand, are very reactive and the soft ore contains 22-25pc P_2O_5. Total reserves of hard and soft rock are estimated at about 10mn t. The Minjingu mines were originally the supply source for the now idled Tanzanian Fertilizer's (TFC) mini-plant production of single and triple superphosphate. Minjingu Mining, which replaced TFC, now produces powder and granular hyperphosphate (ground rock phosphate) for sale locally and in the surrounding area, where soils tend to be acidic. The rock is beneficiated up to 30pc P_2O_5 by a system of drying, sieving and sorting. Minjingu Mines & Fertilizer Ltd claims that the total rock mined is about 165,000 t/yr, of which 65,000t is the soft rock used in the manufacture of hyperphosphate, and 100,000t of rock is beneficiated. However, IFA data indicate that rock production has been ranging between 8,500-17,000 t/yr of rock in the last 3 years. The current installed granulation and blending capacity is about 30,000 t/yr.

Although there are no commercial projects under advanced development in Tanzania, illegal mining does occur and involves exploiting rich outcrops of phosphatic mineralisation. Exports of this product are concerning the government, which has announced that it will tackle illegal mining because of the lost revenue and illegal trade it involves. The removal of rich outcrops may adversely affect the economics of exploiting the small, fragmented reserves found in Tanzania.

Malawi

Trial mining has been conducted by Optichem at the Tundulu reserves in Malawi, since mid-2008. The deposit is estimated to contain 1.5mn t of ore with an average 17.5pc P_2O_5 content. When mixed with ammonium sulphate, ground rock from Tundulu reportedly gives goods results.

Mali

Great Quest Metals, a Canadian junior mining company, is developing a project to exploit the Tilemsi deposit in eastern Mali and is in the process of fully drilling and testing the resources. Rock has been mined in Tilemsi — mainly during the 1980s and into the first half of the 1990s. The rock was medium reactive and had a P_2O_5 content of 20pc. The rock is low in cadmium and uranium but has a significant iron content and is not calcareous. The Tilemsi phosphate project is composed of three concessions covering an area of 1,206km^2: Tilemsi, Tarkint Est and Ader Foul. The company reported an inferred mineral resource estimate of 50mn t grading 24.3pc P_2O_5.

Great Quest Metal made two announcements in September 2014:

- The renewal of its phosphate exploration permits for the Tarkint Est and Tilemsi concessions;
- The conclusion of an off-take agreement with Mali-based Societe Africaine de Developpement Agricole S.A (SADA Group) for 95pc of the projected annual production of 35,000t of direct application phosphate rock, which will comprise of 25,000t of high-grade 35pc P_2O_5 and 10,000t of medium-grade 27pc P_2O_5, targeting the Malian market.

Congo

Congo has substantial resources of phosphate containing mineralisation which are also rich in uranium. The resources lie in a belt roughly 400-700m wide over a 100km strike. Cominco Resources Ltd, a privately held company, owns 100pc of the Hinda project and has licences for both phosphate and uranium.

The Hinda mining project lies 37km north of Pointe Noire port and has connections by tarred road and rail. The first objective of the project is to develop a mine with a capacity of 4mn t/yr of 32pc P_2O_5 beneficiated rock. The project includes an open pit mine, beneficiation plant, slurry pipeline to the coast, drying, storage and ship loading facilities. Preliminary drilling established the presence of 433mn t of 10.65pc P_2O_5 content ore, supporting a 26 year mine life with production of 4mn t/yr of 32pc P_2O_5 phosphate rock.
Cominco is currently undertaking a definitive feasibility study due for completion in the second half of 2015 and is planning on starting construction in 2015. Thereafter the company will study the feasibility of constructing a fertilizer complex close to Pointe Noire which would produce 1mn t/yr of fertilizers.

Angola

Angola's mineral resources have been surveyed over many years and numerous occurrences of phosphate-containing rocks have been identified. The most significant reserves have been identified in the Cabinda Province to the North of the Congo River Delta. Less significant reserves have been found in the Lucunga River area to the south of the Congo River Delta. Numerous other and less extensive deposits have been found throughout the country.

The following are two key analyses of the composition of ores from Angolan reserves:

- Weathered ore from the upper zone of the uppermost bed (3m) in an old quarry in the Mongo Matande area in Cabinda province had the following composition:

P_2O_5	37.5pc
CaO	51.57pc
Fe_2O_3	0.94pc
SiO_2	1.62pc
F	3.84pc

- Weathered ore from the Lueshe area of the Lucunga deposit showed the following composition:

P_2O_5	41.3pc
CaO	55.0pc
SiO_2	0.9pc
F	4.1pc
Cl	0.05pc

One of the most significant feature of these analyses is the iron content, which indicates that we are dealing with a pyrochlore ore, while the Lucunga sample also contained 1.34pc Nb_2O_5 and 0.8pc SrO. However, indications suggest that the Lucunga reserves contained about 30mn t of phosphate ore and are therefore not likely to be suited to large-scale production.

The Cabinda resources are believed to be considerably larger and are the location of the only active project. Cabinda Province is an exclave of Angola bordered to the north by Congo, to the east by the Democratic Republic of Congo, to the south by the Congo Delta and to the west by the Atlantic Ocean. There is no land link with Angola, which lies to the south of the Congo River Delta. The main port is Cabinda on the Bele River. Data available indicate that the channel depth is 4.6m with a 1m tide.

The project is being developed as a joint venture between Australian company Minbos Resources and the Israeli Mitrelli Group. The focus is on the Cacata deposit, one of five resources in the Cabinda concession:

Table 24: Angola Resource Overview			
Deposit	**Tonnes (mt)**	**Grade (pc P_2O_5)**	**Category**
Cacata	5.0	23	Measured
	10.2	25.3	Indicated
	11.8	8.8	Inferred
Chivovo	6.5	20.5	Indicated
Mongo Tando	24.8	13.6	Indicated
	184	8.0	Inferred
Chibuete	149	8.3	Inferred
Total	**391.3**	**9.2pc**	
			— company reports

The initial objective is to selectively mine the high-grade sections of the Cacata deposit to produce 800,000 t/yr of “relatively high” concentrate with 32-33pc. Based on owner-operated mining, beneficiation, road haulage and ship loading, the company claims that the full cost of the Cacata project is $157mn and the operating cost $54/t concentrate.

Uganda

Mining took place at Sukulu, in the eastern Ugandan district of Tororo, between 1962-78, and weathered products of carbonatite mined at the time were beneficiated by grinding, magnetic separation and flotation into a 40pc-42pc P_2O_5 concentrate, which was then transformed into SSP. Earlier testing of the Sukulu resource indicated a deposit of 230mn t of ore with about 13pc P_2O_5. However, political unrest and military action effectively destroyed the mining, beneficiation and single superphosphate facilities.

Belgian technical phosphate producer Nilephos, a subsidiary of the Madhavani Group, investigated the reactivation of mining at Tororo in the eastern region of Uganda. The proposed project, first floated in 2008, has met with protest and resistance from the local population who fear displacement. An injunction to stop mining was dismissed by the High Court in 2012, which opened the way to the eviction of 4,000 people living within 26km of the Osukuru Hills.

In 2014, the Sukulu phosphate project changed hands as the government of Uganda entered into a joint venture agreement with the Chinese Guangzhou Dongsong Energy Group to develop the mine and build a processing plant. The most recent announcements indicate that the Madhavani family decided to go to court to claim back its rights over the Sukulu mining licence. This will most certainly further delay the development of this project.

Guinea Bissau

GB Minerals Ltd is a junior mining company based in Canada, which is developing the Farim phosphate project in Guinea Bissau, in the northern part of central Guinea-Bissau, some 25 km south of the Senegal border. The phosphate resource has undergone preliminary testing and produced the following results:

Table 25: Farim Resource Base		
Classification	***mn t***	**Grade (P_2O_5)**
Measured Resource	65	29.11pc
Indicated Resource	28	27.68pc
Inferred Resource	18	28.66pc

—company reports

The high P_2O_5 seam is covered by an overburden of about 40m and underlying it is a further seam with an average of 10-15pc P_2O_5. Analysis of the rock shows it to be low in impurities such as cadmium. Selective mining will produce a 30.4pc P_2O_5 run-of-mine ore.

As a result of a feasibility study undertaken in 2012, a project plan has been developed to produce 1mn t/yr of phosphate rock for export. Beneficiation of the ore is to be undertaken by washing and magnetic separation resulting in an 80pc recovery of P_2O_5 values, and a concentrate with a 33.1pc P_2O_5 and 3.0pc Fe+Al. The disposal of tailings will be in ponds some 3km from the mine. The concentrate will be piped 80km as a slurry to a dedicated seaport capable of handling 30,000-40,000 t/d.

The investment cost for the first phase of 1mn t/yr concentrate is an estimated $238mn and the company estimates an operating cost fob of $77/t concentrate. The strategy is to expand production to 2mn t/yr, for which the project has a 25-year licence. There has been no apparent exploration activity since 2012 and no record of any marketing investigation.

2.5.3 Southern Africa

The phosphate rock deposits found in the Republic of South Africa (RSA), Zimbabwe and Mozambique are mainly igneous, and as such, require significant beneficiation in order to produce high-quality and low-impurity concentrate. Only the RSA and Zimbabwe have operated mines and processing facilities in the past, and in the case of Namibia, interest is centered on marine sands.

Republic of South Africa (RSA)

The RSA is the leading producer of phosphate rock in southern Africa. The country's output has remained stable over many years at around 2.5mn t/yr, produced from about 35mn t of run-of-mine ore, although this fell to below 2mn t/yr in 2013. Rock is currently railed to the Richards Bay processing plant for phosphoric acid production or exported. Richards Bay has had a number of production difficulties in recent years, mainly due to old production equipment, which may explain the drop in rock production observed in 2013.

Since the upturn in the fortunes of the phosphate sector in the mid-2000s, Foskor has been considering expanding its production by opening up a new mine. It is not constrained by reserve status — they are approaching 2bn t of proven reserves with an average 7pc P_2O_5 content. No expansion has been observed so far, although its operations have undergone changes which result from the evolving requirements of mining operations exploiting other minerals and metals in the complex apatite plug in Phalaborwa. The rights to the copper content of carbonatite and phoscorite ore bodies are owned by Phalaborwa, Foskor's mining division. In the past, Foskor depended heavily on processing the tailings from the copper production. Increasingly, Foskor is processing pyroxenite for its P_2O_5 content. The company has recently invested in a new pyroxenite mine from which P_2O_5 values will be available to maintain production levels. Expansion has therefore depended as much on the internal synergies of the company as on changes in the phosphate market.

Foskor has also looked for joint venture partners to engage in such an expansion, but there is no recent report of positive developments. Coromandel Fertilizer (India) holds a 14pc stake in Foskor but the majority holding still lies with the South African state.

In addition, two junior mining companies are currently exploring phosphate deposits in South Africa:

- Montero Mining, a Canadian company specialising in rare earths, is testing four phosphate prospects in South Africa. The most advanced is at Duyker Eiland and a resource of 33mn t/yr of phosphate-bearing ores has been identified. The ore is reportedly capable of producing a 33-35pc P_2O_5 concentrate;

- Elandsfontein Exploration and Mining Ltd is developing a phosphate project on the west coast of South Africa, some 95km north of Cape Town. Initial plans are for sedimentary phosphates to be mined and upgraded on site, to produce a saleable concentrate grade for export. Elandsfontein has completed its definitive feasibility study and has awarded an EPCM contract to an engineering firm.

Zimbabwe

A small-scale mining operation has been operating in Zimbabwe since 1970, although the Dorowa facility has struggled to maintain production in recent years. At best, it has produced 100,000-150,000 t/yr of 37pc P_2O_5 concentrate produced from an apatite ore averaging 6.5pc P_2O_5. 2013 phosphate rock production was reported at 18,000t. The output is used in the production of phosphate fertilizer (TSP and SSP) at a mini-complex in Harare (ZimPhos).

Even before the recent troubles, there were no plans to increase production at the mine significantly, and there are none reported at present.

Mozambique

The Evate deposit is the largest known phosphate rock resource in Mozambique, and also contains magnetite, graphite and other minerals. The phosphate-bearing minerals in the deposit occur in two separate marble horizons. Preliminary reserve estimates indicate the presence of some 155mn t of ore containing 9.32pc P_2O_5, 5.76pc Fe and 1.12pc TiO_2.

Brazilian mining giant Vale has undertaken early technical and feasibility work to the sum of $20mn on the development of a 2mn t/yr project. Beneficiation of the apatite would result in a high-grade concentrate. The phosphate project would benefit from, and help justify the construction of, a rail corridor that would serve the proposed Moatize coal mine expansion and also allow Vale to transport copper from its mine in Zambia. Although Vale announced in late 2012 that it was looking to meet its deadline to commence production by 2014, it appears that the company's interest in the fertilizer sector has diminished over the last couple of years, and all fertilizer projects have been put on hold.

Namibia

Two offshore projects are currently being developed in Namibia and are intended to harvest phosphate-rich sands from the seabed. If they were to progress, those projects could become an important development, in as much as they would provide an opportunity to test modern sub-sea mining techniques in the phosphate sector, thereby opening up rich resources which have hitherto been inaccessible.

- Namibian Marine Phosphate (NMP), which is a joint venture between Australian junior mining company UCL Resources, Oman-based Mawarid Mining and Namibian company Tungeni Investments is developing the Sandpiper Marine phosphate project, which involves exploiting seabed mineralisation in the Walvis Bay area, some 60km offshore Namibia and at depths of 180-300m. Initial exploration has indicated reserves of 133mn t containing 20.41pc P_2O_5. Inferred resources have been identified in excess of 1.6bn t, with an average P_2O_5 content of 18.9pc P_2O_5. The preliminary mining plan envisages dredging at less than 225m, and transferring the slurry to the coast where the dredger will discharge into buffer ponds via a sea-to-shore slurry pipeline. Oversize material will be stockpiled, while undersize material will be piped to a tailing pond and the phosphate sands will be washed, dried and trucked or railed to Walvis Port for export. The concentrate will have ±28pc P_2O_5. The objective is to produce an initial output of 1mn t/yr, ramping up to 3mn t/yr. A subsequent stage envisages converting some of the rock to super-phosphoric acid, using the novel IHP process described briefly above — as port capacity increases — if the pilot plant, currently in start-up, is successful. Until “in situ” processing becomes feasible, the output of the project will be targeted mainly at the direct application and single superphosphate markets, as the rock is very reactive in suitable soils and climatic conditions and impurities such as chloride, which adversely affect acid manufacture, are less significant.

- Another offshore project is being developed by the Israeli-led Lev Leviev Namibia Phosphates Ltd. (LLNP) which is planning to produce 2mn t/yr of phosphate rock at Luderitz Bay. Initial plans were to build a $20mn pilot plant before scaling up to industrial production due to start in 2018.

The latest updates indicate that both projects have been put on hold because of resistance from Namibian environmentalists and the fishing industry, leading the Namibian government to place an 18 months moratorium on marine phosphate mining in September 2013, until an environmental impact study has shown that mining will not destroy the fishing industry.

2.6 Middle East

Figure 12: Phosphate Rock in the Middle East, Summary Map

The Middle East is the location of a number of significant producers of phosphate rock and downstream fertilizers. Iraq has been affected for more than two decades by armed conflict which has effectively removed it from world trade or even significant production for domestic use. The industry in Syria is now also seriously disrupted. As this section looks beyond the medium term, we discount temporary disruptions to supply and look at the potential contribution of all countries in the region to global phosphate supply in the long term.

2.6.1 Iraq

Iraq has known resources of rock of 9.5bn t, mainly located in the western parts of the country. A mining and processing operation was built in the early years of the 1980s. The open pit mine at Akashat started production in 1983 and had a design capacity of 3.4mn t/yr of run-of-mine ore on a 12hr/d operating basis. Peak annual production of run-of-mine (21pc P_2O_5) was 2.4mn t/yr in 1988 but concentrate production never greatly exceeded 1mn t/yr after the 1990s. The mine consists of five main quarries within a 50km² area.

The Akashat mine is located close to the Syrian border some 1,300km from the port of Basra. There was a rail link which has probably been affected by the various hostilities. The rock produced supplied the Al Qaim processing complex. The rock contains some awkward impurities in respect to downstream processing. After some physical separation at mine the grade of the rock shipped from Akashat was as follows:

P_2O_5	21.47pc
CaO	50.98pc
MgO	0.60pc
CO_2	17.26pc
SiO_2	2.24pc
R_2O_3	0.67pc
SO_3	1.70pc
F	2.88pc
Cl	0.13pc

The run-of-mine rock is subjected to crushing and grinding, calcination and then washing to remove the CaO produced during calcination. The beneficiated concentrate has a P_2O_5 content of 31-33pc, but the beneficiation has the effect of concentrating undesirable impurities:

- MgO is concentrated to 1pc and impedes filtration at the acid plant;
- Chlorine causes significant corrosion;
- Strontium remains in the concentrate after calcination and washing and the majority is precipitated as $SrSO_4$ in the graphite tubes used to heat the phosphoric acid causing energy losses;
- Uranium, vanadium and yttrium were removed in the purification (uranium recovery unit) which was destroyed in 1991 during the First Gulf War.

The 1mn t/yr maximum historical output of concentrate ties in with the actual requirements of the 400,000 t/yr P_2O_5 capacity of the acid plant at Al Qaim, which sustained heavy damage in allied attacks triggered by the associated uranium recovery plant.

Reinvestment in the mine began in 2001, and new equipment was installed that allowed the mine to be operated at 25pc of capacity. Renewed operation was terminated by a fresh bout of hostilities. As we understand it, both the mine and processing complex were in a degraded state and stopped production between 2004 and 2009. Phosphate rock production at the Akashat mine seems to have been reactivated in 2010 with an annual output of 150,000t of rock, gradually ramping up to 360,000t in 2013.

Proposals and invitations for reinstating the phosphate industry have been circulating for a few years. The probability was that efforts would be made to resuscitate production at both Akashat and Al Qaim in the medium term — there is little merit in refurbishing the mine without the associated processing plants. Once financing is available, this is not likely to take much less time than new construction, especially in respect of the downstream plant.

However, recent tensions in Iraq have once again disrupted production. In 2014 terrorist groups took control of the processing facility at Al Qaim and are reported to be displacing phosphate rock to Syria for explosives use.
Regardless of current disruptions, a question mark remains in respect of rock quality. The mining operation was originally planned to use high-uranium rock. This was extracted from the rock at the Al Qaim acid complex

— none of the rock was sold as such. The high uranium content of the rock would not be welcome in fertilizer use and would pass through to finished fertilizer, if not removed.

2.6.2 Syria

Syria has become a more significant player in respect of phosphate rock and especially merchant rock over the course of the present century, during which production has practically doubled to peak at 3.7mn t in 2010. Since then, production has been decreasing by 50pc every year, and was last reported at 900,000t of phosphate rock in 2013 because of the current political turmoil.

There are two mining areas being operated — Khneifiss and Eastern (Alsharqia). The Khneifiss mine is the smaller operation producing less than 1mn t/yr. Rock is mechanically separated and dried. Concentrate from the Khneifiss mine averages 30.5-31pc P_2O_5. The concentrate from Eastern mine A averages 28.5-29pc P_2O_5, and that from Eastern mine B 29.5pc P_2O_5, and production capacity at these mines has been increased in recent years to about 3.5mn t. Future development is likely to be focused on the Eastern mine where reserves exceed 1.5bn t. By some washing and the blending of rocks, Gecopham, the state-owned rock producer, is able to produce small quantities of low-chlorine rock (less than 0.01pc) but generally speaking Syrian rock contains chemically-bound chlorine often in excess of 1pc Cl. This impurity tends to limit marketing, both in respect of target markets and prices.

There has long been a policy to increase nominal production capacity from its current level of 4mn t/yr, an ambition supported by estimated known resources of 1.7bn t. Clearly, joint-venture investments are currently out of the question, but many proposals have been put forward in the past. The most recent initial agreements have been between the Syrian government and the governments of Qatar and India. The joint venture would have had to consider investment in logistical infrastructure (road, rail and port) plus mines and processing units. The baseline for the expansion was an increase in rock mining capacity to 10mn t/yr. The industry is on hold until the current political problems are resolved.

2.6.3 Saudi Arabia

A survey in 1992 identified several areas of potential interest in the areas of northern Saudi Arabia, around the city of Turaif. One of these was the Al Jalamid deposit, 140km south east with estimated reserves of 213mn t. There were three phosphate-bearing horizons, of which the upper horizon was shown to have commercial potential with a P_2O_5 content of about 25pc and stripping ratio of 2:1. The average thickness of the upper horizon was 6.5m, whereas the stripping ratios for the lower two horizons was above 5:1. A core sample showed the following analysis:

- P_2O_5 25.86pc
- CaO 52.91pc
- SiO_2 1.17pc
- FeAl 0.31pc
- Mgo 0.84pc
- NaCl 0.21pc
- Co_2 9.24pc
- F 0.10pc
- Cl 0.03pc

A more detailed survey of the whole ore-body in 2004 produced the follow results:

Table 26: Al Jalamid - Resource Potential

	Mn t	P_2O_5	MgO	CaO
Measured resources	502	19.8pc	4.7pc	48.9pc
Indicated resources	22	18.1pc	8.5pc	44.6pc
Total resources	524	19.7pc	4.9pc	48.3pc

— IFA Dubai Conference 2004. Future Phosphate Developments in Saudi Arabia, C. Neser, Ma'aden,

The Ma'aden mine (Al Jalamid) and processing units have yet to reach full commercial production, although at full capacity they could produce 4.5mn t/yr of 32.5pc P_2O_5 concentrate. The high magnesium content of the run-of-mine ore suggests that the concentrate will be primarily of interest for captive processing designed to cope with the rock.

For reasons of mining economics, only the upper layer will be mined during the first 7-8 years of operation, and thereafter the first two layers. Overburden removal will grow to 12.9mn t/yr from 4.9mn t/yr during the mine life. The water required for the flotation process will amount to about 13mn m^3/yr and be supplied from nearby aquifers. The beneficiation system has been installed by Wengfu using technology from China Bluestar Lehigh Engineering.

Since the licensing of the Al Jalamid mine, other project promoters in the private sector have been encouraged by the government to develop further blocs of the Al Jalamid resources. Such a project was announced in 2013 with Ma'aden to form a joint venture with Mosaic and Sabic. The Umm Wu'al Phosphate Project will involve the exploitation and processing of the Umm Wu'al phosphate deposit (also known as Al Khabra mine), taking advantage of existing and future railway infrastructure linking the phosphate deposits with the processing site of Ras Al Khair on the Arabian Gulf. The Al Khabra deposit is located northeast of Turaif and has measured resources of 210mn t of 17-19.6pc P_2O_5 ore. The project includes the construction of a mine and beneficiation capacity to produce about 5mn t/yr of concentrate (1.5mn t/yr P_2O_5) containing around 34pc P_2O_5. This rock is believed to have much lower magnesium values (max 0.3 MgO) than the rock currently mined at Al Jalamid, which should make it more amenable to acid production. The joint-venture partner in the project, Mosaic, brings considerable experience in the processing of a variety of rocks.

Overall, all rock produced in Saudi Arabia is and will be focused towards downstream production because of the country's ban on exporting raw materials.

2.6.4 Israel

Phosphate resources in the various deposits of the Negev desert are estimated at 1.6bn t. The Geological Survey of Israel has identified about 20 phosphate deposits in various parts of the Negev desert, of which three are currently being mined (Oron, Zin and Arad). Zin is the largest of these mines (approaching 3mn t/yr concentrate capacity) and Arad and Oron smaller (± 1mn t/yr concentrate capacity).
Publicly-listed phosphate and potash producer ICL operates a number of mining sites in the Negev Desert, although its high-grade rock reserves are slowly depleting. Production tends to fluctuate around 3mn t/yr and the primary objective is to feed the company's various processing units, for both fertilizer and non-fertilizer products in Israel and offshore. 2013 rock production was reported at 3.4mn t. The Mishor Rotem phosphoric

acid plant also recovers uranium from the processed rock, as rock from all three mines contains the element. A strategic export surplus of merchant rock is maintained which tends to represent about a quarter of output.

ICL's strategy of focusing the company on high-value specialty products provides little incentive for its phosphate division, Amfert Rotem Negev, to significantly increase output and especially output for the merchant market. The rock has impurities which limit its suitability for standard phosphoric acid units, most importantly a high chlorine level. A higher quality rock was produced at Zin using calcination, but this unit has been closed for economic reasons. Currently, the focus is on the sale of reactive rock for direct application from the Arad mine — which circumvents any problems in respect of suitability for acid units. This rock has 31.7pc P_2O_5 and minimum 30pc solubility in citric acid/55pc solubility in formic acid.

ICL is facing serous constraints. The Arad reserves are large but expansion at the site is constrained by environmental issues, which are being pursued by a vigorous group of lobbyists. The Israeli Health Ministry is currently objecting to the opening of a new mine at the Sde Barir field near Arad because of potential dust issues. And ICL's chief executive has threatened to close its phosphate division if the government does not allow it to mine at Sde Barir given that current mines are depleting. In addition, the government is in the process of reviewing royalty payments with the introduction of a higher tax rate and flat royalty structure. The proposal encourages the implementation of a progressive tax whereby companies are subject to 25-42pc depending on their return on investment and an extraction royalty of 5pc.

Many Israeli companies are now seeking overseas joint ventures as an alternative to exploiting Israeli assets. For instance ICL entered into a partnership with Allana Potash earlier this year to develop a potash mine in Ethiopia and LGC (Leviev Group) has outlined plans to exploit a marine phosphate bed off the coast of Namibia, as mentioned earlier in this report.

2.6.5 Jordan

The oldest Jordanian mine at Russeifa was closed in the 1980s. But until recently, small volumes were produced from remaining stockpiles (the company reported 44,000t of phosphate production there in 2008). Three mines remain operational in Jordan — Eshidya, Al-Hassa and Al-Abiad. The latter two mines are old and have been slated for eventual closure for many years. They both have an effective capacity of plus 1mn t/yr. But they offer employment to over 1,200 people in an area where alternative work is almost non-existent. The recent period of unrest has underlined the social role the mines play in the community, and this may well influence any timetable for closure. Both mines have rail links to Aqaba and export the majority of their joint output of about 2.5mn t/yr

Eshidya is the most modern of the mines, operational since 1988, and will eventually be the sole rock mine in Jordan. In 2013, its capacity stood at about 5mn t/yr, but it should have completed a 2.5mn t/yr expansion in 2014 to reach a total capacity of 7.5mn t/yr in order to accommodate the requirements of the new phosphoric acid joint ventures:

- PT Petro Jordan Abadi (PJA) is 50:50 joint venture between PT Petrokimia Gresik and JPMC located in Gresik, Java. The 200,000 t/yr phosphoric acid plant was brought on stream in the second half of 2014 and has a contract in place with JPMC to supply ~770,000 t/yr of rock for the next 20 years. The acid will be used as feedstock for a 1mn t/yr NPK plant.

This is the first of three similar joint-venture plants between the state-owned PT Pupuk Indonesia Holding Company and JPMC. All three of the plants are based on Jordanian rock and the acid will be used as a feedstock for 3mn t/yr NPK capacity. The construction of the second 200,000 t/yr phosphoric acid plant — Pupuk Kaltim (PKT) — is scheduled to start in the third quarter of 2015 for commissioning in 2017. The third 200,000 t/yr acid plant will be located in South Sumatra and is a joint venture between JPMC and PT Pupuk Sriwijaya (Pusri);

- JIFCO is a phosphoric acid plant owned by Indian fertilizer corporation IFFCO (52%) and JPMC (48%) and located in Eshidiya, Jordan. It started operation in December 2014 and will consume 1.6mn-1.7mn t/yr of rock to produce 500,000 t/yr of phosphoric acid.

In a recent filing with the Amman Stock Exchange (dated March 2015), JPMC reported higher phosphate rock production and exports in 2014. Overall phosphate rock production rose to 7.1mn t in 2014 from 5.4mn t in 2013, up by 31pc. Exports of phosphate rock rose by nearly 1.4mn t to 4.6mn t. At the same time, fertilizer production rose by almost 100,000t to 590,000t, up from 494,000t in 2013. Much of the increase can be attributed to higher exports of DAP to JPMC's key market of India.

In terms of reserves, Jordan is comfortably placed to expand production of rock. It is estimated that phosphate formations cover about 60pc of the total area of the country. Recently, a major new area of phosphatic mineralisation has been discovered in the north of the country. The estimated total reserves in the 52km² beneath the three operating mines amounts to about 1.5bn t. But there are two main constraints to a major expansion of the phosphate sector in Jordan: water supply and logistics. Jordan is one of the world’s most arid populated areas. This applies across the whole country:

- Supplies of water at the Eshidya mine and processing facilities have to be carefully managed and conserved — as they do everywhere else in the country. The scale of expansion currently being undertaken by Morocco could not be supported in Jordan through shortage of water;

- The port of Aqaba is the main export outlet for JPMC. Despite the ceding of a strip of land to the south of Aqaba by Saudi Arabia, which forms an industrial port area, logistics through and around Aqaba are limited, as is the port area. The old phosphate rock terminal has been replaced by a new terminal in the industrial port, which started operation in 2013. This terminal is believed to have a capacity of 4mn t/yr, although JPMC reported an increase of its rock exports to 4.6mn t in 2014, from 3.2mn t in 2013. Nevertheless, export activity is likely to be limited going forward, as the constraint on bulk handling is created not just by lack of space but by the proximity of one of the world’s finest coral reefs which runs along the Jordanian shore and attracts important tourist revenue.

Furthermore, JPMC signed a memorandum of understanding in September 2014 with China's Chongqing Minmetal and Machinery Import and Export Co, with plans to build a new fertilizer plant in Aqaba expected to consume 1.5mn-2mn t/yr of phosphate rock. According to the company, this project “is part of the company's strategy to optimally utilise raw phosphate and turn it into high value-added products instead of exporting it as raw materials”. If it were to materialise, this project would further reduce Jordan’s phosphate rock export availability. It is currently at the pre-feasibility stage. In early 2015, JPMC signed another memorandum of understanding with GNFC to build a phosphoric acid plant in India that will utilise 1mn t/yr of Jordanian phosphate rock. No further details are available.

2.7 South Asia

The phosphate resources of the Indian Sub-Continent are limited, both in quantity and quality. The hike in fertilizer prices we have seen since the beginning of this century is likely to encourage the more optimal use of the resources available in the region.

2.7.1. India

Total phosphate rock resources in India are about 200mn t, of which about 25mn t are apatite and the remainder sedimentary. In terms of grade, resource estimates put the highest "chemical fertilizer" grade at about 20mn t.

Most of the rock in India is currently mined in Rajasthan by state-owned mining company Rajasthan State Mines & Minerals Limited (RSMML). It currently operates two main mines: Jhamarkotra and the Kanpur Group of Mines. The main problem presented by the rock is the hard silica matrix (silica is chemically bound with the phosphate) content which inhibits filtration in the acid plant and causes significant abrasion in equipment in the reactor. RSMML produces the following grades:

Table 27: Rock Grades offered By RSMML

Grade	Use
31.5pc P_2O_5	SSP
31.5pc P_2O_5	Non SSP plants
31.54 P_2O_5	SSP, DCP, NP
18-20pc P_2O_5	Direct application

The flotation beneficiation process used can remove some of the magnesium lime carbonate from the rock, but not the silica. Attempts have been made — as early as the late 1970s — to produce phosphoric acid and triple superphosphate at Sindri, and a second attempt has been launched. The volumes involved are small — about 1.6mn-1.7mn t/yr of concentrate was produced by Rajasthan State Mines in 2011 and a further 250,000-300,000 t/yr by other mines. In 2013, total Indian output stood at 1.2mn t. These now include the first private-sector mining company, Krishana Phoschem, which has a production capacity of 200,000 t/yr, and has developed its own beneficiation process to produce a concentrate with the following specification:

- P_2O_5 30.2pc
- R_2O_5 2-2.5 pc
- SiO_2 10-12pc
- MgO 0.5-0.75pc
- CaO 45-46pc
- F 2.5-3pc
- $CO_2/CaCO_3$ 1.5-2pc
- Moisture 14-16pc
- Mesh 200 mesh

The high silicon content, high moisture and medium magnesium content suggest that this rock would not be preferentially used in phosphoric acid manufacture.

The Indian government has recently announced an initiative "to encourage the conversion of phosphate rock resources into reserves across three provinces" in order to supplement growing import supply. In 2009, a project was launched in Madhya Pradesh to develop a project at Meghna Nagar to produce 1.5mn t/yr of rock, although no positive announcement has since been made on the progress. Given the quality of rock in most of India, attention has switched to lower-analysis phosphate fertilizers, notably SSP, rather than high-analysis phosphoric acid-based products. The growing demand for sulphur means that SSP with 16pc P_2O_5, sulphate and calcium can be treated as a multinutrient fertilizer. Even for SSP with 16pc P_2O_5, some of the Indian rock needs to be boosted by imported material.

2.7.2 Pakistan

Exploration of the Hazara deposits in Pakistan commenced in 1975. Proven and probable reserves were recorded at 22mn t. A small mine at Kakul was developed with an intended capacity of 300,000 t/yr of 26pc P_2O_5 concentrate. It has produced small quantities of rock intermittently and in 2009 production reached a high of 110,000t. In 2013, output stood at 100,000t. The rock is understood to contain a number of undesirable impurities in respect of acid manufacture, including silica, magnesium oxide and iron oxide. A typical analysis is:

- P_2O_5	30pc
- CaO	43pc
- MgO	2pc
- SiO_2	16pc
- F	3pc

Recently, interest has been shown in developing the mine in tandem with SSP production. For the time being, the sole domestic DAP producer, Fauji, is based on imported acid from OCP rather than domestic rock.

2.7.3 Sri Lanka

The Eppawala deposits of chlor-apatite were discovered in 1971. The deposit is estimated at 60mn t. A small-scale mining operation was introduced, producing less than 50,000 t/yr and the rock sold as direct application material to local agriculture. In the late 1980s, Agrico-Overseas, a US company, launched a phosphate fertilizer project to produce phosphoric acid-based, high-analysis fertilizers. It failed to achieve approval as it would have exhausted the reserves over 30 years and exported the majority of the fertilizers produced. Internal fighting effectively isolated Eppawala from the official economy during the 20 years after the Agrico venture. The mine continued to operate under the control of state-owned Lanka Phosphate Ltd and produced 49,000t in 2013. Some interest is being shown in upgrading to single superphosphate for local consumption now that peace has been restored and reconstruction programmes are under way in the eastern regions.

2.8 East Asia

There is some small-scale production of guano-based direct application product in the countries of Southeast Asia, but the amounts are insignificant. There has also been some small-scale mining of apatite in North Korea. Reserves here were estimated at 88mn t in the 1970s, when five small mines were operational. There are currently no production statistics available and the IFA uses 100,000 t/yr as its estimate of the likely scale of production.

2.8.1 China

Figure 13: China provinces

Over the last three Five-Year Plan periods, China has set about achieving self-sufficiency in P_2O_5. Both the phosphate rock and P_2O_5 processing industries have succeeded in reaching this target and, indeed in overshooting it. The enthusiasm with which the development of the phosphate industry has been pursued by provincial governments, local authorities, publicly-owned and private-sector companies since the mid-1990s has created a wave of over-investment. As a result, reserves of naturally-occurring, higher-grade rock have been heavily "cherry-picked" in recent years, and the country is facing a serious and rapid deterioration in the average run-of-mine ore.

Proven reserves in China are estimated to be around 13bn t, of which less than 1bn t is of high-grade 30pc P_2O_5. In the late-1990s a countrywide survey was completed which identified 13bn t of which:

- 1.14bn t were of a grade equal to or above 30pc P_2O_5;

- 6.7bn t were of a grade equal to or above 18pc P_2O_5;
- 2.76bn t contained 12-18pc P_2O_5;
- 2.7bn t contained less than 12pc P_2O_5;
- Average P_2O_5-content across all grades was 18.45pc P_2O_5.

The China Chemical Mining Association reported in its submission for the current Five-Year Plan that only 330mn t of high-grade ore with a P_2O_5 content above 30pc remained. Although many of the association's reserve figures are difficult to reconcile, we would estimate that the 330mn t figure refers to nutrient content which would equate to about 1bn t of rock (as indicated above). Notwithstanding this uncertainty, the message is generally accepted — the lack of efficient beneficiation capacity means that higher-grade rock (mainly found in Yunnan, Guizhou and Hubei Provinces) is being rapidly depleted. In a paper issued by the fertilizer division of the Oil and Chemical Planning Institute, the director stated explicitly in 2009 that high-grade rock will be available for domestic processing for about 10 more years.

Overall, available data indicate that low-grade ores represent a large proportion of total phosphatic resources in China, with the average P_2O_5 content of rock in the main mining provinces put at around 17pc, reflecting the cherry-picking which has taken place, and giving concern for the future. Remaining high-grade reserves represent less than 9pc of total resources.

The nature of the reserves in China results in heavy losses of P_2O_5 for two main reasons:

- The old rock is very densely cemented making recovery of the phosphate values difficult;
- 75pc of the deposits are inclined and moderately thick.

Such characteristics create a series of technical problems in high-intensity mining and cause heavy losses in mining, a high dilution rate and low recovery rates of phosphate. From the data available, it is clear that high magnesium content is a serious and general problem in respect of the mineralization. To this should be added the wasteful processing of rock. There is growing pressure to use the remaining high-grade rock efficiently and especially for wet-process phosphoric acid production for which magnesium is a major problem, rather than products such as yellow phosphorus which should use low-grade rock. The government has made it clear that companies not beneficiating rock or doing so wastefully or in an environmentally unfriendly fashion will be closed down.

The five major provinces outlined below account for over 90pc of Chinese rock reserves. And in terms of higher-grade rock they account for over 95pc of reserves:

Table 28: Distribution of Chinese reserves

	Reserves	Higher-Grade reserves
Yunnan	21pc	29pc
Guizhou	26pc	26pc
Sichuan	7pc	12pc
Hubei	18pc	18pc
Hunan	21pc	12pc
Other	7pc	3pc

— LI Jun, Ying Jiankang, Zhong Benhe, Sichuan University, present at IFA Crossroads Conference, 2006

Section 2: Phosphate Rock Supply
Chapter 2: The Outlook for Supply

In terms of actual production, the phosphate rock sector in China is fragmented. The central government has, over the last two Five-Year Plan periods, driven a policy which will see the closure of small, inefficient mines and the consolidation of smaller mines which can be viable as a larger production unit, in order to adjust and correct the results of the over-investment stimulated by earlier central government policy objectives. However, the industry remains primitive in many provinces, both in terms of the scale of mines and quality of output. The table below gives an overview of the industry as a whole:

Table 29: Overview of China Rock Capacity, 2013 *'000 t/yr product*

	Mine capacity	Estimated Ore Output	Captive use 30pc P_2O_5 rock	Merchant Ore	Beneficiation Capacity
All mines	**115,900**	**107,000**	**54,700**	**50,900**	**41,000**
Of which:					
Large mines	87,900	83,300	48,700	33,300	39,200
Small mines	28,000	23,700	4,000	17,600	1,800

— Argus research

On the basis of the above data, we can make the following comments and assumptions:

- Wherever possible, the production figures are based on an extrapolation of eight months production rates. Where this is not the case, they use 2012 figures. Statistics for rock producers have been individually researched rather than taken from published compilations;
- The classification for large mines has a cut-off at about 300,000 t/yr;
- 24mn t/yr of ore is produced in the small mine category which is the primary target for rationalization. It represents nearly one quarter of total output;
- If we assume that the average output of these mines is in the range 100,000-150,000 t/yr, then we are looking at 160-240 small-scale operations;
- Given the fact that capacity will be lost in the rationalization, the industry will have to invest in new deposits if only to stand still;
- The dearth of beneficiation capacity is striking, and further explains some of the panic about the decline in ore quality. Beneficiation capacity at mine, or by mining companies at other sites, amounts to just 36pc of ore production capacity. In the case of small mines, beneficiation capacity is equal to less than 8pc of ore output;
- Much of the merchant rock available for sale in China is unbeneficiated — the higher-grade ore and the beneficiated concentrate is primarily going into vertically integrated operations. However, some rock is beneficiated at the chemical complex, or even at river port. The Chinese Chemical Mining Association stated in 2009 that only 13 companies in China had the technology to beneficiate low-grade ore in that year and that their combined capacity was 14.7mn t. This concern tallies with many other reports which claim that such beneficiation as does take place results in large losses of P_2O_5. Our latest research has uncovered about 41mn t/yr of beneficiation capacity. Looking at the production versus beneficiation capacity figures, we assume that in most cases the capacity refers to the throughput of ore through the beneficiation units. We think it probable that the discrepancy with the association's figures arises from the use of the term "low-grade ore". There is a considerable

amount of what is called "medium heavy dressing", which we take to be physical separation, crushing and washing. Dealing with the low-grade 17pc P_2O_5 ore is a different matter altogether as is described below, in a paper dealing with the problems encountered in beneficiating low-grade rock in Hubei Province. The paper makes it clear that the problems associated with concentrating many of the low-grade ores have not been solved. Some low-grade ores can be upgraded. We see from the provincial analysis that in Jiansu the phosphate seems to be an apatite (3-12pc P_2O_5) and this accounts for 1.3mn t/yr of beneficiation capacity. There are also low-grade rocks which do not display the complexities seen in many other ores. The National Bureau of Statistics puts total production of phosphate rock in 2013 at 108.5mn t. These statistics tally well with our recent research, while the IFA reports production levels of 77mn t.

Recent research conducted at a provincial level indicates the below distribution of phosphate rock production in China:

Table 30: Chinese phosphate rock capacities and production by province, 2013 *'000t product*

	Mine capacity	Estimated Ore Output	Captive use 30pc P_2O_5 rock	Merchant Ore	Beneficiation Capacity
All mines	**114,000**	**105,200**	**52,700**	**50,900**	**41,000**
Of which:					
Hubei	39,100	37,000	15,800	17,300	20,100
Yunnan	26,800	26,000	18,300	8,600	10,300
Guizhou	26,700	24,700	13,500	13,200	4,100
Sichuan	16,350	13,700	2,200	11,000	2,300
Anhui	1,400	1,300	1,950	0	2,300
Hebei	1,200	1,200	150	250	1,200
Jiangsu	1,200	400	100	100	112
Shaanxi	530	400	350	400	350
Chongqing	300	300	0	230	300
Hunan	300	100	200	0	0

— Argus research

The key findings of this provincial review are summarised below:

- **Hubei Province** is the largest producer of phosphate rock in China, accounting for an estimated 37mn t of ore in 2013 — more than twice the amount recorded in 2008 (16mn t), although some of the expansion will be accounted for by declining grades. It is a long-established production area which means that the highest-grade reserves are rapidly being exhausted, and the ore currently mined is mainly medium grade. We quote the following description from a paper prepared by the Wuhan Institute of Technology, Wuhan, Hubei:

  "Yichang phosphate ores have been mined for a long time and the rich ore reserves are dwindling and marketable phosphate ores are in high demand. The exploitation of middle/low grade phosphate rock has become the key issue of the sustainable development of the Yichang phosphate resource. Previous studies show that middle/low grade phosphate ores in Yichang areas were complex, containing variable amounts of silicates, magnesium, carbonates clay and so on. Although

magnesium, silica and aluminium for a certain type of phosphate rock can be reduced in a small processing plant, large-scale plants face two main problems. First, it is extremely difficult to determine a reasonable process which can lower magnesium, silicon and aluminium at the same time. Secondly, it is even more difficult to achieve room-temperature flotation."

The medium-grade ore demonstrates the complexity of beneficiation:

P_2O_5 27.17pc	Na_2O	0.66pc
CaO 33.51pc	Fe	2.60pc
MgO 2.45pc	Cl	0.05pc
MnO 0.03pc	Volatile Compounds	11.28pc
SiO_2 13.50pc	Acid Insoluble Compounds	22.23pc
$Fe2O_3$ 1.69pc		
AlO_3 3.00pc		
K_2O 1.20pc		

It is estimated that there are about 4bn t of reserves remaining in Hubei and that about 60pc are to be found in Yichang. This includes mostly medium/low grade rock. The nature of the reserve formation accounts for much of the fragmentation of the industry (10 separate identified deposits). Exploration for new reserves in Hubei is on-going as evidenced by a number of licences being issued. For an impression of how the industry has evolved over the last two Five-Year Plan periods, we compare two snapshots of the provincial phosphate industry — the first from 2008 and the second from 2012.

We included the following statistical data for Hubei Province in our 2009 Phosphate Rock Study:

- Production 2008: 16mn t;
- Number of mines: around 100 (as of end-2009 Hubei had 7 large producers producing plus 1mn t/yr, 19 medium-sized mines producing 0.3mn-1mn t/yr and many small mines);
- Average P_2O_5 content: 22.34pc;
- Beneficiation Capacity: 9.95mn t of run-of mine ore;
- Throughput 2008: 6mn t(indicating that 10mn t was run of mine);
- Concentrate output: 3.5mn t.

A further update was published for 2012:

- Mining Capacity 2012: 30mn t;
- Beneficiation Capacity: 20mn t of run-of mine ore;
- Concentrate production target 2015: 25mn t.

These statistics tally well with our recent research:

Table 31: Evolution of the mine sizes in China

Mine size	Number of mine, 2009	Number of mine, 2013
Large (1mn t/yr+)	7	11
Medium-sized (0.3mn-1mn t/yr)	19	16

It appears that four years of a policy of consolidation is paying dividends, albeit slowly. The big 11 mines have an aggregate capacity of about 21mn t/yr of extracted ore. The estimated production for

2013 shows significant growth from 2012, at 9mn t in terms of capacity or 7mn t if production is the benchmark. That being said, the phosphate rock industry in Hubei remains fragmented. The largest concentration of mines is in the Yichang district, which accounted for about 8mn t of production in 2008. We also note that there are many beneficiation units in the province not associated with a mine.

- **Yunan Province** is the second-largest producer of phosphate rock in China, accounting for an estimated 26mn t of ore in 2013. Run-of-mine rock grades are generally high (28-32pc P_2O_5). Only four companies operate beneficiation units. This backs up the report that cherry-picking of the higher grades of rock is the general rule. Yuntianhua Yunnan produces 60pc of the provincial rock output and has 83pc of beneficiation capacity. The remaining “medium-size” mines are small on a world-scale, and few beneficiate their ore.

- **Guizhou Province** is the third-largest producer of phosphate rock in China accounting for an estimated 24.7mn t of ore in 2013. Guizhou rock is richer than that in Yunnan and Hubei, with an average P_2O_5 content of 30-34pc. Beneficiation capacity aggregates only 4mn t/yr. This also means that extraction is focused on the depleting reserves of high-grade rock. An attempt to by-pass the wet-process acid route by developing a furnace process to process medium-grade rock (22pc P_2O_5 and 7pc MgO) and low-grade rock (17.1pc P_2O_5 and 9.6pc MgO) appears to have been abandoned. In any event, the pilot plant is no longer operational.

- **Sichuan Province** is the fourth-largest producer of phosphate rock in China, accounting for an estimated 13.7mn t of ore in 2013. Sichuan has a greater proportion of high-grade ore than the other main producing provinces (average P_2O_5 content of 28 pc). This is reflected in the limited number of beneficiation plants in the Province. Reduced beneficiation facilities also results from the large yellow phosphorus sector in the province, the production of which is based on a slagging process.

  Mining conditions are difficult in the province, which is mountainous. For example, the mines operated by holding company Asiaphos are at a height of over 2,000m above sea level.

  Sichuan rock capacity has been affected by the earthquake of 2008, which damaged mines and infrastructure. The Sichuan Jinhe mine was destroyed in 2008 and further seriously damaged by flooding in July 2013. The mine is also under attack from Greenpeace on the grounds of pollution and loss of habitat. In mountainous areas, the disposal/stacking of mining spoil is always problematic as there is little flat land to put it on which is not used for agriculture. Even worse, Greenpeace claims that mining is encroaching on the natural reserves which are home to the endangered great panda.

- Our analysis of phosphate rock in **Hebei** and **Jiangsu provinces** indicates an apatite ore-body (3-12pc P_2O_5) which can be upgraded to high-analysis concentrate (30-35pc P_2O_5), accounting for 1.3mn t/yr of China’s total beneficiation capacity. There are also low-grade rocks that do not display the complexities seen in many other ores.

We do not suggest that China will be short of rock in the foreseeable future. Recent reserve estimates show that exploration efforts are leading to an increase in proven resource and reserve size. It is estimated that total resources amount to about 13bn t. It is also the case that new reserves of high-quality rock are being proven in Guizhou, Sichuan and Hubei. For example, Kailin Group announced at the end of 2010 that it has discovered a resource of 782mn t of high-grade phosphates reserves in Kaiyang, Guizhou, with a P_2O_5 content averaging 33.78pc, without need for beneficiation. In 2013, Sichuan Province announced that it was exploring 24 phosphate rock deposits that could increase Sichuan Province's known phosphate rock reserves by 135mn t. How much of this resource can be economically mined is not known. There are projects being developed by Sichuan Chemical holdings (2.5mn t/yr of rock) and development work in Mabian County. These small projects will go some way to neutralizing the impact of small-mine closures. The high prices for high-grade rock seen in 2012 have attracted the interest of non-traditional mining interests.

The above provincial research identified the following firm projects for rock mining and beneficiation in China:

Table 32: Firm Mining and Beneficiation Projects in China with expected delivery between 2013 and 2016 *mn t*

	Mine Capacity	Beneficiation Capacity
All China	**13.6-15.6**	**12.1**
Of which		
Yunnan	0.9	-
Guizhou	5.2-7.2	1.5
Hubei	5	4.4
Sichuan	2.5	5.8
Others	-	0.4

— Argus research

Another 8mn t/yr of rock capacity has been identified as planned expansions/projects to be built beyond 2018. A number of capital funds, non-fertilizer companies and even an airline company are involved in merging companies or acquiring phosphate mines or mining rights. It is clear that these newcomers regard (or regarded) the hike in phosphate rock prices as a long-term trend, and the rationalization process as an opportunity to enter the industry.

The question arises as to how effectively existing plants and expansions under construction can be served with rock concentrate, as high-grade run-of-mine rock becomes less available. Although there is much written about the successes being achieved in beneficiating Chinese rock, there remain serious doubts, especially in respect of high-magnesia rocks such as those being tested in Guizhou.

The current Five-Year Plan addresses the issues of inefficiency and over-expansion created by the dash for self-sufficiency. The main themes of the strategy underlying national planning for phosphate rock in China may be summarised as follows:

- Both national and provincial plans stress that a new lower threshold for permitting of new mines will be imposed. Very small mines will be closed. Mining enterprises will be encouraged to consolidate operations into larger, more efficient units. A number of announcements have already been made in this respect, for example, Hubei Xingfu and Guizhou Wengfu have agreed on a combined phosphate resource development and fine phosphate chemical production. We expect the number of mines to be gradually reduced on grounds of size, efficiency, safety and environmental impact. In Hubei, for example, phosphate rock and beneficiation centres will be completed in the Yichang, Jingmen, Xianfan, Dawu and Wuxue areas. Presumably, ore from smaller mines will be stored and beneficiated at these centres before shipment to chemical and fine chemical processing centres. The rooting out of the small and inefficient operations has in fact been a feature of recent Five-Year Plans — the number of phosphate fertilizer manufacturing units has reduced from 590 in 1990 to 370 in 2010. The current Five-Year Plan will see the number of phosphate chemical enterprises reduce by 30pc;

- One of the major national constraints on industrial development is the overloading of the Chinese rail system. As far as is practicable, efforts are being made to favour development close to mine, although this may bring problems in respect of nitrogen and sulphur supply. From the viewpoint of the four major rock-producing provinces, the depletion of high-grade rock resources is making them less inclined to sell acid-grade rock to non-basic producers, which in turn will contribute to industry consolidation. The policy appears to be having an effect. In 2012 Hubei province processed 86.5pc of the rock mined within the province. This is an increase from 73.5pc in 2006. This does not mean that the processing took place at mine. It is often moved as run-of-mine ore and beneficiated at the processing site;

- Transport will remain an issue well beyond the end of the current Five-Year Plan period. Two of the most important phosphate-rich provinces — Guizhou and Yunnan — are located on the interior plateau, almost 1,000km from the nearest port, posing difficulties for internal shipments. As rock supply tightens and seasonal stockpiles become smaller, questions are being asked as to whether plants distant from the mines will be supplied with acid-grade rock. Or even whether coastal plants might seek to import some or all of the rock requirements in order to produce acid-quality blend;

- Environmental levers are expected to play an important role in the last year (2015) of this Five-Year Plan period and the next period. The government has made it clear that companies not beneficiating rock or doing so wastefully or in an environmentally unfriendly fashion will be closed down. Already, phosphogypsum is on the radar as a source of concern — fines are regularly being imposed for leakages of effluent into the water table — and the actual Five-Year Plan decrees that the focus is now on finding uses for phosphogypsum rather than simply stacking. China's phosphate fertilizer industry association estimates that 70mn t of phosphogypsum is generated annually, of which 51mn t is discharged as waste, while only 19mn t is used as cement retarder, construction material, raw material for chemical products, soil conditioner or other purposes. We expect that the forthcoming Five-Year Plan may impose a mandatory requirement to process a proportion of gypsum, with a target of 40pc utilization of the phosphogypsum by 2020. In order to prepare the way, the national government has already imposed a tax on natural gypsum, in order to encourage the use of phosphogypsum. We expect there to be a significant attrition rate, as plants lose their licences to produce on the grounds of environmental performance or scale of production and are not in a position to transfer operations to a chemical park;

- The Chinese government has brought practically all phosphate product export activity under its control, using prohibitive export tariffs to ensure that seasonal domestic supply is always sufficient. This applies equally to the merchant phosphate rock business. Chinese rock exports hit 3.5mn t in 2000, since when they have declined. In 2013, exports were reported at 360,000t against a quota of 1.2mn t. It looks as although exports will gradually disappear, without a great deal of government pressure being exerted;

- The current and the next Five-Year Plan will focus on restructuring and optimisation, while maintaining self-sufficiency. The objectives of the current plan include a capacity total for phosphate fertilizers of 22mn t/yr P_2O_5 but an output of 16mn t/yr P_2O_5. This is in line with current capacity utilisation rates of about 70pc. While redundancy of capacity will be one solution to the problem, the impact of high magnesium rock on the efficiency of phosphoric acid units is a critical factor. The desirable way of dealing with this problem is beneficiation. Four years into the current Five-Year Plan period, we can begin to assess whether the government's intentions are being put into practice. The policies on phosphate rock and fertilizers are moving hand in hand. Throughout 2013 and 2014, the recurrent theme has been of local government "limitations" on the production of smaller operations. This is in line with the stated plan policy of closing smaller operations. The following measures are being implemented in the five main phosphate-producing provinces of Hubei, Hunan, Sichuan, Guizhou and Yunnan:

- Introduction of thresholds for entering the phosphate exploration industry;
- Introducing new regulations for granting phosphate mine operation licences;
- Control of total annual output of phosphate rock;
- Joint supervision of mines;
- Requirement for phosphate enterprises to report annually on social responsibility.

China's ministry of agriculture has recently revealed a campaign to achieve zero growth in the consumption of fertilizer and pesticide by 2020. The campaign aims to reduce fertilizer demand and raise usage efficiency, following concerns about inefficient use and potential ecological damage. The ministry's programme aims to modernise agricultural development and increase efficiencies, as well as placing higher emphasis on environmental protection. Strategies will include incentives to revamp older units and rationalise supply, which will certainly slow the rate of capacity additions.

2.8.2 Vietnam

Vietnamese reserves have been estimated at about 250mn t and resources at up to 1.5bn t. Phosphate rock production in Vietnam has expanded in recent years, in order to supply the ammonium phosphates complex at Dinh Vu, which was commissioned in 2009. The original mines in Lao Cai province, in northwest Vietnam, have a capacity of about 2.5mn t/yr and beneficiation capacity of 1mn t/yr and are operated by Vietnam apatite Ltd (Vinaapaco), a subsidiary of Vinachem. The untreated rock is used as feed for the country's three fused magnesium phosphate factories (1.4mn t/yr capacity) and two single superphosphate plants (300,000 t/yr capacity).

Production has been expanded by Vietnam Apatite — the leading producer of phosphate rock in Vietnam — which initiated work on a new mine in 2007. The North Nac Son project came on stream in 2012, with production of 2mn t/yr of ore. A beneficiation unit for 350,000 t/yr concentrate is included in the scope of the project. The existing and new beneficiation plants will be able to feed both the existing ammonium phosphates complex at Dinh Vu and the new DAP complex at Tang Loong in Lao Cai province due on stream in 2015-16. The beneficiation unit was due on stream in 2013 and the nameplate requirement for concentrate will then rise to 1.2mn t/yr.

Production of phosphate rock in Vietnam stood at 2.7mn t in 2013, the highest level recorded since 1988, and exports were only 114,000t. Export quotas are established annually by the government. With the commissioning of the Tang Loong unit in Lao Cai (330,000 t/yr DAP plant expected in 2015) and the ramp-up of the existing plant to fuller capacity utilisation, all the concentrate will be required for domestic processing. The government issued an export licence for 500,000t of concentrate for 2011 and halted exports in 2012, in order to ensure adequate feed for acid production, in the expectation that the new acid plant would come on stream. As it has been delayed, some rock exports were carried out last year, but it is not certain that there will be significant availability in the future. The industry has to contend with two problems outside the mining activity: the quality of the rock and the logistics of moving the rock from mine to the coast and the Dinh Vu diammonium phosphate complex (the new Tang Loong complex is adjacent to the mine) on an overtaxed rail system. The rock issue revolves around magnesium content, which is affecting both the output of the ammonium phosphates complex and the quality of the end-production (61pc total nutrient instead of 64pc). The following specifications are for the two grades of concentrate produced by Vietnam Apatite for use in diammonium phosphate and single superphosphate production, the surplus being sold on the export market. The company offers low-grade products with 23pc and 15pc P_2O_5, which presumably are used in fused magnesium phosphate production.

Table 33: Vietnam Higher- grade Rock Analysis

	Grade 1	Beneficiated Grade
P_2O_5	32pc	32pc
SiO_2	17pc	14.5pc
CaO	45pc	42pc
Fe_2O_3	3.4pc	3pc
Al_2O_3	6pc	3.5pc
MgO	3pc	1pc

2.8.3 Mongolia

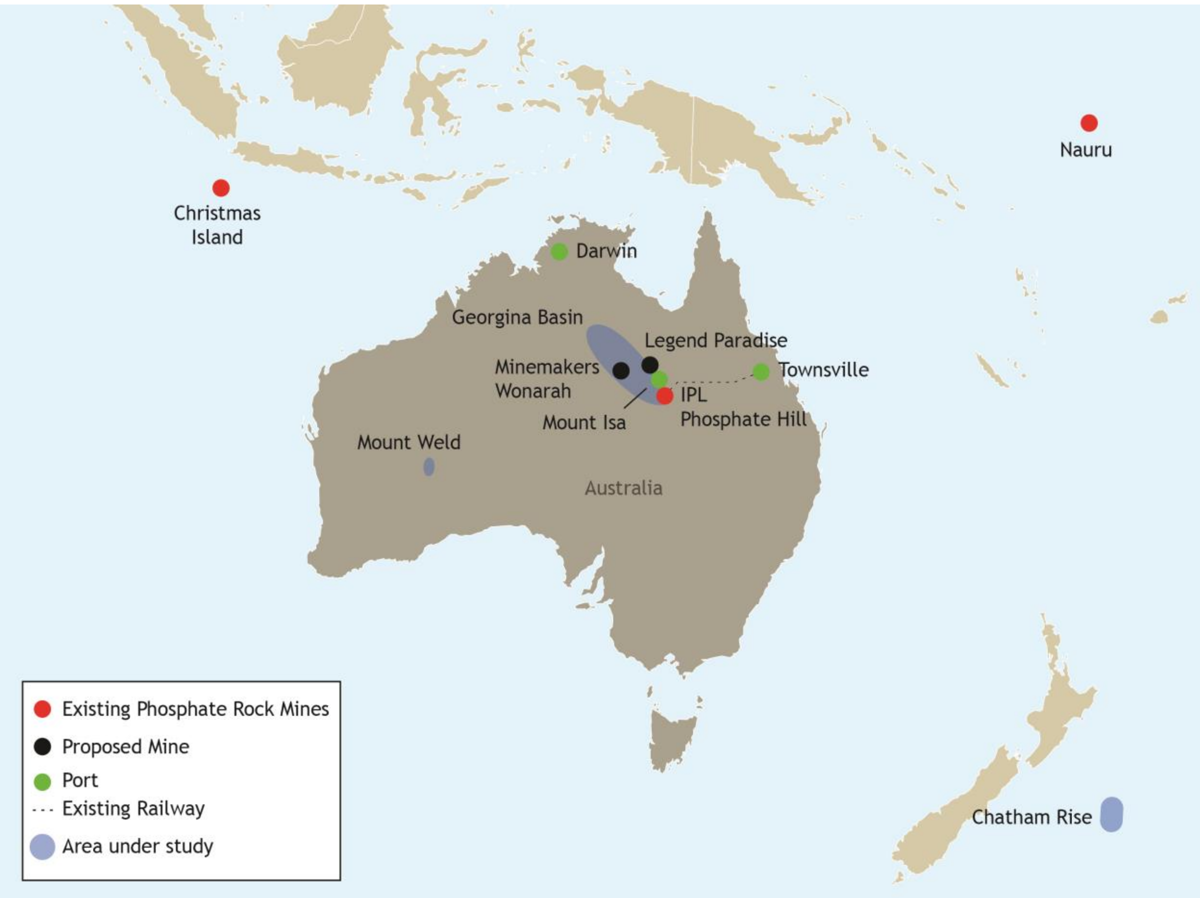
There are substantial resources of phosphate rock in Mongolia, particularly in the Khuvgul Basin where the volume of rock with above 20pc P_2O_5 totals more than 3bn t. In the western zone of the deposit, there is an estimated 300mn t of rock with 25-27pc P_2O_5. Chemical analysis of the ores suggests a relatively high magnesium content (4-12pc), although in beneficiation, testing at these levels were considerably lower.

A project is being developed in Mongolia, the Burenkhaan phosphate project, to exploit what is one of the largest undeveloped phosphate deposits in the world. The project is located in Khuvsgul province (Mongolia), just 20km north of provincial centre Murun. The project will consist of several open-pit mines and a beneficiation plant near Murun and a chemical plant in Erdenet (Orkhon Province). The plan is to transport phosphate concentrate from the beneficiation plant through a 420km slurry pipeline. Production is slated to be close to 2mn t/yr of diammonium phosphate, which indicates a concentrate output of 3mn-3.5mn t/yr. Exported product will presumably have to be transported to either Russian or Chinese ports.

Current indications show a resource of 218mn t of 18pc P_2O_5 ore. The project is still at the pre-feasibility stage, with Australian promoter Aspire Mining focusing on a number of coal prospects for the time being.

2.9 Oceania

Figure 14: Phosphate Rock in Oceania – Summary Map



2.9.1 Australia

Australia has extensive resources of phosphatic mineralisation. Currently, the only active mining operation belongs to Incitec pivot (IPL) at Phosphate Hill (Duchess) in Queensland, although exploitation of resources in the Northern Territory and Western Australia has recently been or is still being investigated. In the past, small-scale production occurred in a number of other states, such as South Australia, Victoria and New South Wales. But today the focus of attention is on Queensland, the Northern Territory and Western Australia where the bulk of phosphate resources, put at approximately 4bn t, are located.

IPL's Phosphate Hill is the only operational mine in Australia. It is part of the huge Georgina Basin deposit which stretches into the Northern Territory and is estimated to contain about 3.5bn t averaging 17pc P_2O_5. Production has reached up to 2.5mn t/yr in recent years, and all the material is converted into ammonium phosphates in situ at Mount Isa. IPL has considered expansion on various occasions in the past. While the deposit is not resource-constrained, there are logistical constraints that affect the movement both of raw materials and final product. The rock is very high in silica as quartz (24pc P_2O_5 and 40pc quartz) which effectively means that the rock can only be used for phosphoric acid manufacture. On the other hand, the run-of-mine ore can be upgraded by simple washing to the feed specification of the acid plant. It is not used by IPL in its single superphosphate production and is not suitable for merchant rock. There is currently a lot of uncertainty surrounding the outlook for the IPL downstream plant due to the future closure of the Glencore/Xstrata's copper smelter in 2016, and the potential escalation in ammonia costs following the increase of gas costs to plant.

Legend Paradise (Lady Annie), close to Phosphate Hill, has mutated over the past three to four years from a merchant phosphate rock project with a capacity of 3mn t/yr through a technical phosphate complex to an ammonium phosphates project that would see a requirement of rock concentrate (32.5pc P_2O_5) of 2mn t/yr. The rock at the South and North Paradise deposits is more variable and less concentrated than that being mined by IPL, and will need to be floated to make it suitable as an acid feed. As with IPL, the location (some 1,200km from the post of Townsville, and 135km northwest of Mount Isa) adds complexity to the project, as does the sourcing of sulphuric acid and gas for ammonia production. At the time of writing, the project had not received a mining licence, and is still waiting for the Environmental Impact Study (EIS) to be completed.

The Minemakers Wonarah project in the Northern Territory is located at the western extremity of the Georgina Basin deposit. The indicated and inferred resources, which are intended as feed for the acid plant, are 800mn t averaging 17-18pc P_2O_5. Like Legend, the Wonarah project has changed from a merchant rock venture which hoped to export 3mn t/yr of rock to a super-phosphoric acid or ammonium phosphate project using the Improved Hard Process (IHP) technology currently tested by JDC Phosphate (described earlier in the report). The use of the thermal process would obviate the need for expensive beneficiation of the run-of-mine rock. Like the Legend project, it is located inland (some 1,000km) and is 300km from the rail link to the Port of Darwin. The quantity of run-of-mine ore required for the super-phosphoric acid or ammonium phosphates option would be of the order or 6.5mn-7mn t/yr, giving a minimum mine life of 20 years. Targeted output would be 2.2mn t/yr diammonium phosphate or 1.5mn t/yr of super-phosphoric acid. According to Minemakers, the feasibility study is still underway and relies on progress to be made by JDC Phosphate on its pilot plant being built in Fort Meade, Florida (in which Minemakers has invested $1mn), meant to test the viability of the IHP technology. In June 2013, Minemakers indicated that *"JDCP has recently advised that while significant progress has been and is being made on the demonstration plant in Florida and its pre-startup activities, the process of validating IHP technology will be somewhat delayed because of construction related issues."* At the time of writing, the JDC pilot plant has not started yet, delaying further any progress on the Wonarah project.

In addition to these development projects, a number of companies have examined the prospects of a carbonatite deposit at Mount Weld in Western Australia that has estimated reserves of about 250mn t. There are no reports of current project activity. A number of other projects where phosphate is associated with other minerals have been or are being considered:

- Arafura Resources is looking at the production of phosphoric acid alongside its main interest, rare earths, in the Northern Territory;
- Aurox Resources is looking at exploiting the associated phosphate at its iron ore project in Northwest Australia;
- Uramet and Northern Uranium have been exploring sites across Queensland and the Northern Territory, although post-tsunami events in Japan have dampened interest in uranium recovery.

A great number of other exploration projects are under way. In the general area covered by the Georgina Basin, any exploration for other minerals such as uranium or rare earths, inevitably results in consideration of phosphate as a co-product. It should be said that all such embryonic projects struggle with the problem of logistics.

2.9.2 New Zealand

While there is no strong indication of significant phosphate mineralisation onshore New Zealand, there is active interest in marine deposits. Chatham Rock Phosphate is collaborating with dredging company Boskalis to develop a project in shallow offshore waters around Chatham Rise. Some 25mn t of reserves have been identified in 10pc of the company's licence area. The mineralisation takes the form of nodules in the top 1m of the seabed. The average P_2O_5 content of the nodules is 21.5pc, with low-impurity levels. The company is looking to increase merchant rock production over a five-year period, from 100,000-300,000t in year one to 1mn-1.5mn t in year five.

Chatham Rock Phosphate was granted a mining licence in December 2013, and submitted a marine environmental consent application in May 2014, with plans to start construction work in the second quarter of 2015. However, the application was declined in February 2015, and the company advised that it was planning to submit it again. As of December 2014 Chatham Rock Phosphate had managed to raise about $800,000 to fund the development of the project once environmental consent is granted.

2.9.3 Christmas Island

Phosphate has been mined on Christmas Island for over a century. As a result, reserves are declining. High analysis rock (so-called "A" and "B" grades) have been exploited to the point where they are no longer offered for sale as such. The residual "A" and "B" grade rock is mixed with a lower-grade aluminium phosphate to produce 600,000-700,000 t/yr of saleable rock. In 2013, production stood at 560,000t rock of which all tonnage was exported to Indonesia and Malaysia for direct application.

2.9.4 Nauru

The history of phosphate mining on Nauru is similar to that of Christmas Island. Once a producer of around 2mn t/yr of rock, output is falling every year and totalled 347,000t in 2013, all of which was exported to Australia and South Korea. The rock has a high P_2O_5 content (39pc P_2O_5) but also a very high cadmium content which restricts its marketability. Reserves are rapidly running down.

Section 2: Phosphate Rock Supply
Chapter 2: The Outlook for Supply

2.10 Outlook for Supply

The euphoria of 2007-08 resulted in a large number of planned capacity developments being justified at $400/t fob, although this is now being replaced by a sense of realism. Since then, the Arab Spring has led to disruption in important, established, producing countries which had expansion plans on the table, and this disruption has helped to keep prices attractive and project plans alive. The fall in prices closer to $100/t has created a large degree of inertia in both the government and private sectors in respect to investment in new or expanded rock production.

2.10.1 The Outlook to 2018

The vast majority of projects seeking to develop as yet unexploited reserves have not reached the financing stage. A great deal of work is being undertaken on scoping projects, testing ore, exploratory drilling programmes and planning a strategy to move the P_2O_5 values in the rock to market. While investment in downstream capacity (e.g. OCP/Ma'aden) will sustain rock expansions, the likelihood of non-integrated miners and junior miners increasing capacity and entering the market will depend on the competitive cost position and ease of access to potential buyers. While a valuable activity in respect of longer-term developments, it seems unlikely that a significant volume of new P_2O_5 will enter the market as rock before 2018.

In the period to 2018, we should realistically focus on expansions/declines at existing mining operations. Even here, it is probable that expansions not already approved and funded will not see commercial production in the medium term.

- The only major change of which we can be certain is the expansion of OCP's mining capacity in Morocco, principally at Khouribga. Financing is in place and work on the mining, beneficiation and logistical infrastructure is well advanced. The additional 26mn t of capacity will be brought on stream in increments throughout the medium term, as and when expansion in processing facilities at Jorf Lasfar and offshore joint ventures come on stream and merchant demand requires it. In the period to 2017 a tranche of up to 12.4mn t of rock will come on stream. In the same period, 4mn t of diammonium phosphate capacity will be commissioned, which will absorb half of the incremental rock availability.

- Exports of Bayovar rock have reached 3.5mn t/yr. As explained earlier in this report, it now seems far from certain that the company will go ahead with its expansion plan to reach 5mn t/yr. More likely is the commissioning of the neighboring FosPac project by 2018, with a total capacity of 2.5mn t/yr. This has the advantage of producing an acid-grade rock that is also suited for single superphosphate and direct application, as well as guaranteed offtake and powerful shareholders. It has relatively high cadmium and therefore will be mainly marketed in Asia.

- Acron's new mine at Oleniy Ruchey is building up to full utilisation. The second phase was planned for 2017, but seems unlikely to hit this target as the first phase has yet to achieve a full year's output of 1mn t/yr. Also, the production costs are believed to be higher than Apatit's in the first years of operation, mainly because of the company's inability to fully exploit the mine under the terms of the licence i.e. also extracting nepheline present in the deposit.

Section 2: Phosphate Rock Supply
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- New mines in China will open in the short term. But increasingly, new capacity will be replacing old and inefficient mines during the last year of the current Five-Year Plan and into the next Five-Year Plan period. We expect to see this incremental capacity partly cancelled out by closures of low-analysis fertilizer plants, non-basic acid units and units in environmentally-sensitive areas. We expect export availability of merchant rock to remain a minor feature of Chinese involvement on the world market.

- A decline in US production will occur over the long term. While the industry has developed plans to manage the decline, environmental lobbying threatens to disrupt the smooth transition to new mining areas, and the consolidation of the remaining operations. Problems similar to those encountered by Mosaic in respect of its important South Fort Meade extension could strike any producer at any time. The cost and inconvenience created by prolonged legal actions may well speed up the process of decline, although it is beyond our competence to forecast the precise impact of environmentally-inspired actions against the industry, either in respect of existing mining and processing operations or extensions to mining operations. In the short term, we expect US output to range from 26mn-28mn t/yr.

- The closure of the Canadian mine at Kapuskasing has removed 900,000 t/yr of production, which was and will continue to be replaced by Moroccan purchases. Agrium may consider replacing rock imports with rock from one of the projects in Ontario/Quebec described above at some point, although the building of a rock terminal at Vancouver argues against this. Without the participation of an offtaker, these apatite and chlor-apatite projects look difficult. In any event, none could realistically come on stream by 2018.

- The surge of production in Egypt which we saw in 2011-13 is likely to be a short-term event, as it replaced lost tonnage from Tunisia and Syria and was connected with the political and economic disruption the region is facing. The harvesting of outcrops of weathered phosphate or other shallow ore and its sale, often without any beneficiation or control over quality, indicates an absence of government control over the sector. The export of rock phosphate has often been regarded as a cash cow for those that have benefited from it, but does long-term damage to the resource. If all the high-grade rock is plundered, mining the remaining ore may not be economically viable. Outside Abu Tartour, proven reserves are rapidly dwindling. The bulk of the resource in Abu Tartour will be expensive to mine and need significant capital investment. Creaming off small occurrences of near-surface, weathered phosphate will not improve the economics of the rational exploitation of the reserve as a whole. At the time of writing, we understand there is a general concern among Egyptian phosphate exporters about an imminent regulation banning or hindering phosphate rock exports (via export taxes), with the aim of encouraging local valorisation of the raw material and exports of finished product.

- Eurochem's Kazakhstan mine in the Jambyl province started production in July 2014. The production capacity for phase 1 will be 650,000 t/yr and full commissioning is expected in 2016, mainly to feed Eurochem's downstream needs. The second phase involves a fertilizer complex, which will require an expansion of the mine to 1.5mn t/yr capacity. This phase of the project will take five years to complete and is not expected to materialise by 2018. As for the Sunkar project in the Chilisai deposit, the revised plan is looking at the production of 5mn t of 17pc P_2O_5 rock by 2018 for phase 1. However, the ore cannot easily be concentrated, and therefore is not suited to merchant sales for processing. It will mainly be consumed in a vertically integrated processing complex.

- We expect the new Ma'aden/Mosaic/Sabic mine and processing project to come on stream by 2018. The joint-venture mine will produce 5mn t/yr of rock to support fertilizer processing.

As a general rule, the majority of existing rock producers will adjust their output to the demands of their own in-house processing or that of joint-venture partners. For example, Jordanian rock output will increase to meet the requirements of its new joint-venture acid plant — as will Tunisian production once the country settles down. If we take the major increases in production capacity between 2011 and 2018 — which will probably be contributed by OCP, FosPac, Ma'aden and Eurochem — we reach a total of about 22mn t/yr. To this we add around 10mn t/yr in other adjustments, as we assume that Tunisia will return to historical production levels, while Jordan will increase rock output by at least 2.5mn t/yr to feed its new joint ventures. The sticking point is Chinese output, which will continue to grow until the end of the current Five-Year Plan (2015). The central government's policy of consolidating and rationalising production will not be achieved in the current plan period, although we may expect a slowdown in the rate of growth during the latter years. By 2018, we expect the policies to be taking effect, but the transition will last throughout the next Five-Year Plan period and into the following period (post 2020). By 2018, production should have stabilised at around 85mn t/yr (30pc P_2O_5). Again, we emphasise that the stress on the global P_2O_5 market will come from downstream processed fertilizers, rather than increasing rock shipments.

In contrast, we will see the loss of 2mn t/yr in the US with the closing down of the Hookers Prairie mine in the US in June 2014. Other countries such as Nauru, and those countries most affected by the political unrest in North Africa and the Middle East may see a decline in output from the record levels achieved at the time of the boom. We also assume that Egypt will revert to its average output levels as the current production rates are not sustainable. If we calculate a total output reduction in these countries of 6mn t/yr, the following short-term forecast for rock production emerges:

Table 34: Established Players Potential Rock Production to 2018				*mn t*
	2005	2013	2018	Change 2013-18
Total	**172**	**193**	**230.5**	**35**
Of which				
Russia	11.3	10.7	10.5	-0.2
Kazakhstan	1.5	1.8	2.45	0.65
USA	35.5	30.5	28.5	-2
Brazil	5.6	6.0	6.0	0
Peru	-	3.5	6.4	2.9
Egypt	2.6	5.3	3.3	-2
Morocco	27.6	25.5	37.9	12.4
South Africa	2.6	1.9	2.5	0.6
Tunisia	8.2	3.3	7.6	4.3
Israel	2.9	3.4	3.4	0
Jordan	6.4	5.4	8	2.6
Saudi Arabia	-	3	9.5	6.5
Syria	3.5	0.9	1.5	0.6
India	1.4	1.2	2.5	1.3
China	53	77	85	8
Vietnam	1	2.7	3.3	0.6
Australia	2.2	1.9	2.5	0.6
Others	6.7	9	7.2	-1.8
				Argus research

2.10.2 The Supply Outlook to 2029

Morocco

The OCP expansion at Khouribga/Jorf provides a secure supply of P_2O_5 well beyond when the next round of mine extensions are required by US producers around 2020. We assume that a significant US industry will remain in operation during the whole outlook period, although with some further attrition towards the run-up to 2029. The ability of OCP to ramp up rock and processed rock production at Jorf Lasfar at a cost well below that of any newcomer to the industry, and below the expansion costs of its existing competitors, will continue to act as a disincentive to many of the projects which briefly blossomed in 2008 and have since been placed on the back burner. By 2025, OCP will have increased its rock capacity to 57mn t/yr, with completion of its current expansion programme of 26mn t/yr.

Jordan

JPMC is expected to increase its rock production above 8mn t/yr from 2020 onwards to feed potential new Indian and Indonesian phosphoric acid joint ventures. The rock export capacity at Aqaba is so restricted that such rock expansion would not affect the merchant market, and any additional rock production would have to be upgraded into phosphoric acid in or outside Jordan. Indonesian and Indian joint ventures seem to make the most sense. We assume that JPMC will gradually build in an expansion in rock production post 2020.

China

More significant is the capacity consolidation and rationalisation of the Chinese phosphate industry. We expect new and stronger pressures to be exerted by the central government on the industry during the next Five-Year Plan (2016-20). The anticipated measures would primarily affect:

- Old low-grade single superphosphate, fused magnesium phosphate operations and yellow phosphorous plants, which use both rock and energy in significant amounts. The increased volume of pure, thermal acid being generated is leading to the development of surpluses in the technical phosphates sector. The pressure is growing to replace yellow phosphorus production by cleaning phosphoric acid wherever possible, and replace high-grade with low-grade rock in the thermal yellow phosphorus furnaces;

- Non-basic processing units distant from the mine site. Here too, a more stringent requirement to utilise phosphogypsum could result in closures depending on plant location — the current floor requirement in Hubei is 15pc utilisation. There is already a strong move by the phosphate-producing provinces to vertically integrate their operations;

- Small plants are already a target for closure and the threshold will rise — for example, in Hubei province it is currently 60,000 t/yr for phosphoric acid plants, 100,000 t/yr for single superphosphate and fused magnesium phosphate plants and 50,000 t/yr for compound fertilizers plants. More than 30 producers (operating about 45 separate units) have been investigated by the provincial phosphate industry association during the course of the current Five-Year Plan period. The downside is that the first reaction of the association is to regroup all but the oldest plants at one site, rather than close capacity permanently. Thus, closures are small-scale and far outweighed by expansions at the new chemical parks, to where some of the equipment is moved and revamped;

- Approval for new licences for the current plan period was halted in 2011 for ammonium phosphates, single superphosphate, fused magnesium phosphate and compounds. The continuing growth in production is an indication of:

    - The number of licences approved in the run-up to the Five-Year Plan;
    - The impact of expansion and “restructuring” whereby units are moved to more efficient sites and upgraded beyond the minimum capacity;
    - The policy of establishing new chemical farms.

New Resources

There are extensive resources of phosphatic mineralisation which have already been investigated. As we have illustrated, there are significant reserves in Iraq, Mongolia, Kazakhstan and Australia which have scarcely been touched. There are equally extensive reserves in many producing countries such as Jordan, Syria, China and Egypt, not to mention the large deposits at Meskala in Morocco. Even in the US, there are substantial resources of lower-grade rock which remain unexploited. But many of these reserves have remained untouched because they share a number of problems which combine to raise the entry bar to the industry:

- Mining in Iraq, Mongolia and Kazakhstan is likely feasible in terms of scale and extraction/beneficiation costs. The main problems which arise are in respect of rock quality, and the cost of moving product to market. In all cases, the make-up of the rock suggests that processing in situ is the logical way forward – as is generally the case today. To this must be added the long journey to export port, involving transit charges and third-country port charges in the case of Mongolia and Kazakhstan, which adds substantial and uncertain costs to export business;

- The quality of the rock is often such as to make the production of standard specification phosphate fertilizers difficult to achieve – hence the growing volume of mini-DAP produced in China. It also makes rock export unattractive, as impurities are penalised in terms of price. After years of work in developing export rock options, both Minemakers and Legend have settled for vertically integrated processing. This route also brings with it a range of problems, such as transporting or producing ammonia or sulphuric acid in a remote site. Most junior mining companies currently engaged in developing phosphate projects opt for merchant rock – at least for the first stage, and often introduce an initial phase during which the deposit is mined selectively to produce a higher-grade concentrate (27-30pc P_2O_5) without the need to invest in a flotation unit. The need for sophisticated beneficiation can add some $150mn-200mn in capital costs for a 2mn-3mn t/yr mine. Finance is the critical issue for these project development companies, first for the exploration programme and preliminary work on leases and licences, and then to create some cash flow which allows them to make further investments or achieve divestment. The cost of a phosphoric acid and ammonium phosphates complex likely adds some $750mn-1bn depending on the requirement for infrastructure and such sums are generally beyond the reach of the project developer. It is for these reasons that we have dubbed them embryonic projects;

- Finance and infrastructure costs also affect projects in established producing countries, where a new mining area has to be opened. In Tunisia, Algeria and Egypt new mining areas and/or rail links and new port facilities are required to support expansions. These countries' governments are unlikely to provide the financial support to infrastructural elements required by greenfield projects, but neither can private sector joint-venture partners justify such immense expenditure.

Probable Long-term Expansions

The anticipated expansion of OCP's Jorf Lasfar and the continued output growth in China have combined over the past five years to dampen enthusiasm for financing the new projects that were developed in response to the 2007-08 boom.

Existing players have proceeded with expansions wherever possible, and across all nutrients we have reached a point of comfortable, if not surplus, supply. During 2014, we saw a sustained weakening in prices across the board. For projects reaching the financing stage, this may have the effect of delaying start-ups to beyond 2018 in those cases where investment remains viable.

These developments underpin our decision to exclude new projects which have not yet achieved financing from the medium-term outlook. They are not likely to be in production by 2018 if the financial market experiences a brief period of nervousness.

With the pricing of domestic market product now out of the hands of the Russian competition authorities, the reinvestment required for Apatit to maintain its operation at 7mn-7.5mn t/yr is now under way. The commissioning of the new Acron mine in 2013, and the introduction of a second source of rock onto the market should introduce free market competition within Russia, where prices on the domestic market reflect export returns. If the regulatory problems surrounding nepheline are resolved, and when the first phase of mining and beneficiation achieve nameplate capacity, the second phase of the Acron project should move ahead. We expect it to be operating at full capacity of around 2mn t/yr before 2020.

The price boom of 2008 heightened interest in the phosphate sector, which in turn resulted in the scoping out of many new resources and initial work on project planning. It is apparent that the sector is not resource limited. It is also apparent that the majority of new projects will require a much higher price for rock than was historically the norm, if investment is to be forthcoming. At price levels below $150/t for 31-32pc P_2O_5 acid-grade rock, there will be no surge in investment. This is partly the result of global economic conditions and, temporarily, the "potash shock" in 2013. But it also reflects the far increased cost of exploiting remote deposits with lower grade ore. To this should be added the disincentive represented by the relative low costs of established producers and the cost advantages in respect to new production enjoyed by companies such as OCP, Ma'aden and the Chinese industry.

The rising cost of new production is likely to underpin the market price for phosphate rock and phosphate fertilizers in the long term. But higher price levels will also affect the structure of the industry:

- High-cost P_2O_5 is likely to encourage small-scale operations to open up. They will be designed primarily to serve domestic/regional markets — although earning hard currency returns on exports is often a pre-requisite for project financing. For example, some of the many smaller deposits in Africa may well be developed as an alternative to importing expensive, high-analysis fertilizers. The most likely final product would be single superphosphate and reactive rock (hyperphosphate), as the scale of operation and investment cost would argue against phosphoric acid-based complexes. The need in Africa for both calcium and sulphur could make single superphosphate a desirable product on the continent. Much of the agriculture in both Africa and Asia is small-scale, so lower analysis fertilizers will have a role to play. Although small-scale production will make a relatively insignificant contribution to overall supply, in a number of countries in Africa and Asia work on either reviving or founding industries is being actively pursued. In an environment of higher priced P_2O_5, the viability of small-scale production for local use improves;

- As costs for new supplies and therefore prices increase, attention will be given to the recovery of phosphate values from human and animal waste, and optimising the usage of phosphate fertilizers. Research into these issues has been stimulated by the peak phosphate debate. As increasing production costs are passed on in higher prices, eventually a commercial justification will be created for investment in the expensive procedures to recover P_2O_5. It is even possible that environmental fashions will encourage the development of P_2O_5 recovery, despite a lack of commercial justification;

- As the cost of fertilizers based on phosphoric acid rises, the pattern of rock demand is showing signs of change. Rock of acid-grade, comparable to OCP product, from new projects is not widespread. As we have seen above, many new projects are having to seek new options rather than depending on the shrinking market for merchant rock of traditional acid grade. The main alternatives are:
  - Very reactive rock for direct application;

- Reasonably reactive rock for direct application in tropical conditions (minimum 7pc citric soluble P_2O_5);
- Rock suitable for producing single superphosphate with 16pc P_2O_5;
- Rock suitable for producing single superphosphate with 18pc P_2O_5 and for use as secondary rock for triple superphosphate;
- Rock suitable for blending with other concentrates to produce a feed for acid production;
- Apatite for use in technical products and speciality fertilizers.

The most straightforward way of dealing with low-grade/quality rock is to opt for processing the rock captively. This option favours state-backed or supported projects, as venture projects cannot generally hope to raise the sums required to construct both mine and downstream facilities. Support can take the form of provision of low-cost raw materials — for example, the Kazakh Sunkar project has low-grade rock, but access to relatively low-cost gas and cheap sulphur plus government support for investment in raw materials processing.

The majority of early-stage projects being developed for merchant rock production will not see realisation before 2020. We will therefore focus on individual projects or project types which appear to have greater chances of success in the longer term:

- The projects based in Ontario and Quebec, Canada, will produce a very high quality apatite, but at high production and logistical costs. We have noted that Yara is investigating the feasibility of one such project as the preference is for high-quality apatite to feed nitrophosphate production in Europe. On the other hand, there is practically no general market for high-grade, high-purity apatite as supplied by Phosagro of Russia and Foskor of South Africa;

- Most of the projects being developed are not looking at producing acid-grade rock, although some of these projects will produce rocks which can be blended to produce an acid feed. Here, the main issue is cost. Some of the assumed netbacks produced as part of scoping studies seem more appropriate for an acid-grade rock, and neglect the fact that lower grades/qualities of rock suffer a significant price penalty. Others, like the Namibian project, are aiming specifically at the direct application and single superphosphate markets on the basis that the reactivity of the rock and its relatively low cost, in terms of both operation and capital, will result in a viable project.

Overall, there are a number of well-developed projects that could be brought on stream in the next two to three years based on demand. The political uncertainties in Egypt and Syria — two of the major sources of lower-grades and qualities of rock — may yet open up an opportunity for one or more of these projects, since a large proportion of rock from these countries ends up in single superphosphate, as direct application material or to blend into an acid feed. Overall, additional acid-grade rock production will derive from existing players, mainly Morocco, and possibly FosPac in Peru.

Section 3: The Phosphate Rock Market
Chapter 1: Market Drivers for Phosphates

The market for phosphate fertilizers is best regarded as a whole, since there is substantial flexibility in how producers take raw materials, in their choice of end-product and in the way in which consumers purchase P_2O_5. In respect of supply, phosphate fertilizers producers may take:

- Phosphate rock if they are producing phosphoric acid, nitrophosphate, fused magnesium phosphate, single superphosphate or fertilizers containing unacidulated phosphate (as an input in NPK compaction and granulation units);

- Phosphoric acid if they are producing ammonium phosphate-based fertilizers or technical products;

- Ammonium phosphate or superphosphates if they are compacting, blending or co-granulating compound fertilizers.

Some plants have the option to produce a combination of ammonium phosphates, triple superphosphates and NPKs. Wholesalers have the option to purchase NPKs or ammonium phosphates, which are then blended or sold as such. Farmers have the option to purchase fertilizers as straight (single nutrient) materials, which they may apply separately or mix to their specification prior to application. Alternatively, they may purchase ammonium phosphates and apply them directly or in combination with other products, or purchase ready-to-apply multinutrient fertilizers that have been chemically combined or blended. Phosphate rock is also purchased for direct application. This usage has grown in recent years, driven by the high price of final products, although it still only accounts for a small proportion of global P_2O_5 consumption.

The main demand drivers influencing the fertilizer sector can be summarised as:

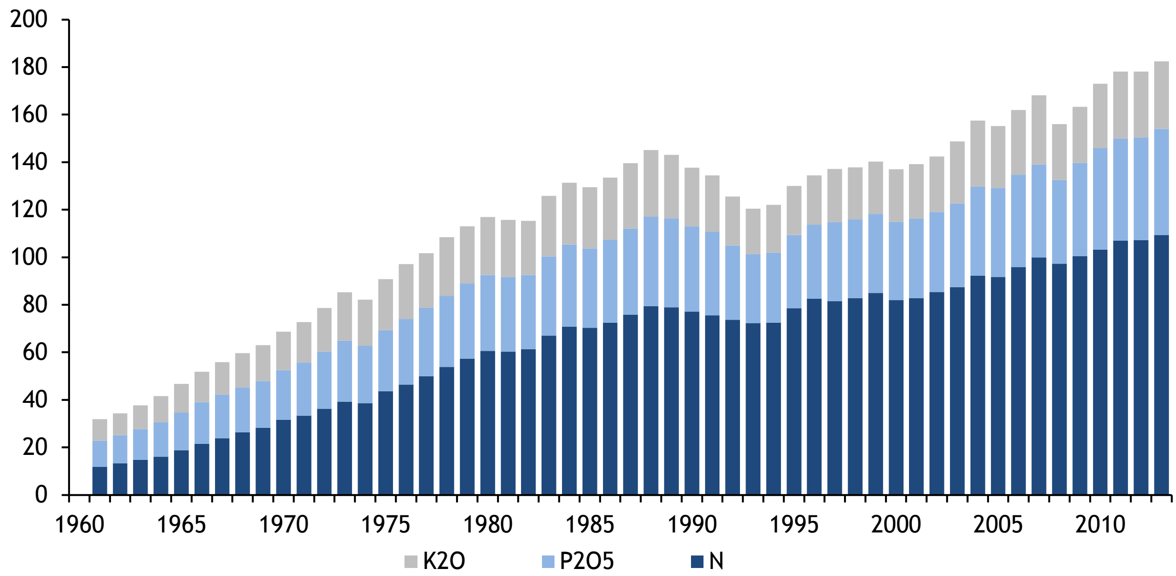
- Population growth;

- Changing dietary patterns;

- The bio-fuel sector.

The first and second drove growth in fertilizer usage from the 1960s to the late-1990s — with a major interlude following the collapse of the Soviet Union in 1989. And all three have combined to produce significant consumption growth since then.

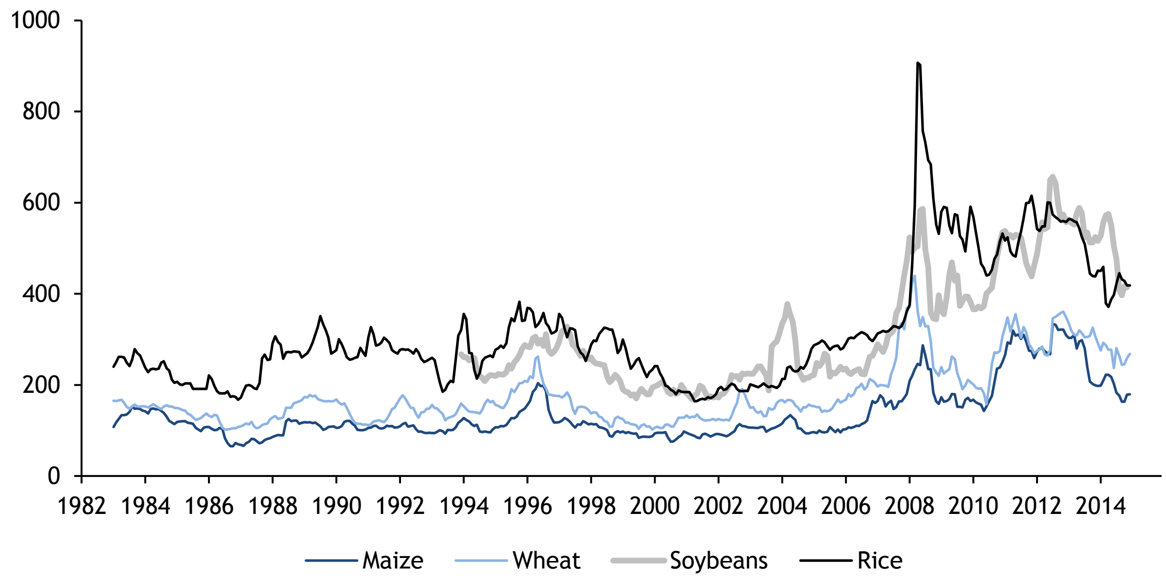
Figure 15: World Fertilizer Consumption 1961-2013 *mn t nutrient*



— IFA/Argus FMB; Argus FMB projection for 2013

Prices for the major crops have all fallen since 2013, although, in nominal terms, most remain above the levels achieved prior to the commodity market boom of 2007/2008.

Figure 16: Major Crop Export Prices *$/t*

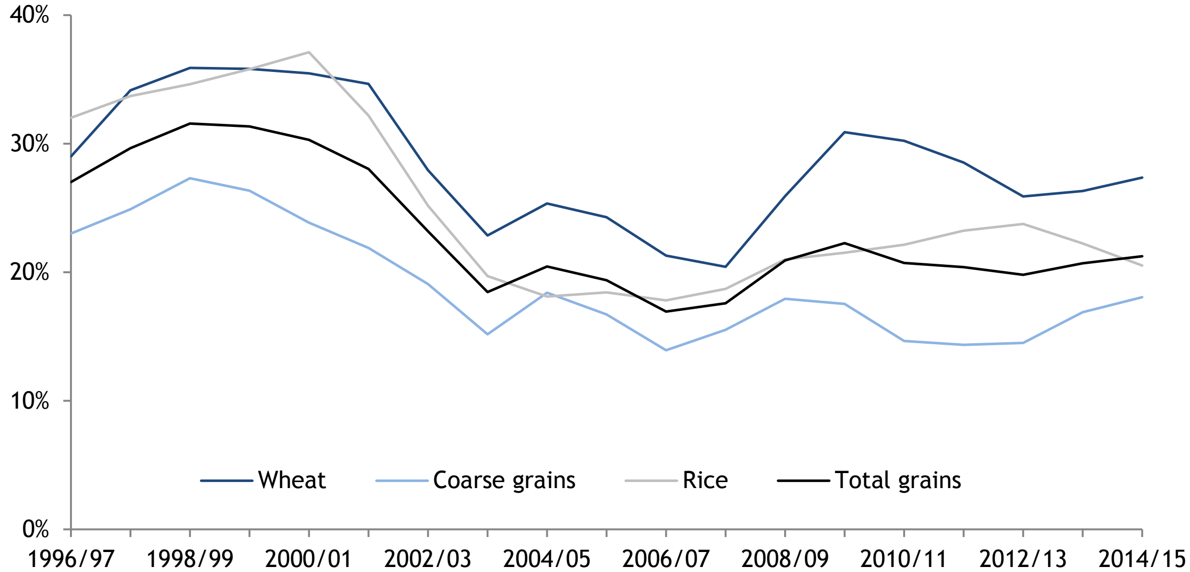


— FAO, World Bank

A series of good harvests in many key producing regions of the world in 2013 and 2014 have eased the stock situation for grains and contributed to the decline in grains prices. At the same time, the US has reached the limit of the usage of corn for ethanol production which had been supporting rising corn prices.

Despite a recent softening in the prices of major crops, there is unlikely to be further significant downward movement. There has been a structural break in agricultural commodity pricing and a return to the long-term decline in crop prices observed for two to three decades to the mid-2000s is looking unlikely. This is based on the assumption that the fundamentals of population and income growth are unlikely to change significantly. Growing urbanisation and inadequate water supplies represent significant constraints to expansion in agricultural production. Politically driven demand for biofuels is set to continue, even if the economic viability of these products is doubtful. And the success of the US shale oil and gas boom puts hydrocarbon alternatives into question. Added to this is an increasing desire around the world for food security, and continued concerns that we could potentially face a global food crisis, as stocks remain relatively low.

Figure 17: World Grains Stock-to-Use Ratios

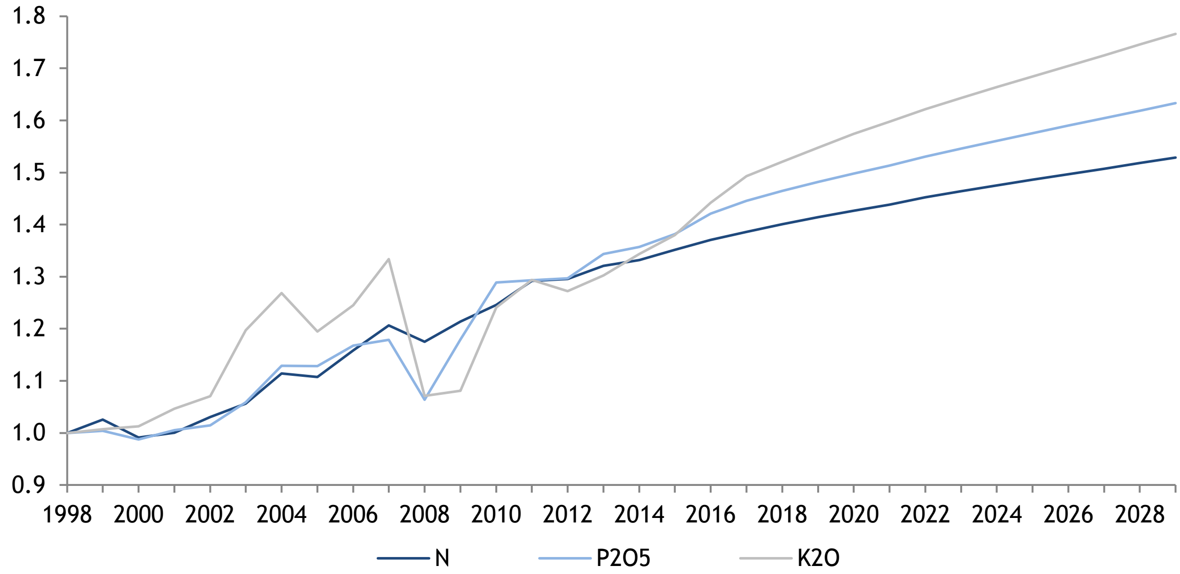


— USDA, December 2014

On the other hand, environmental pressures will see fertilizers used more efficiently, while technological developments will allow gains in food yields with a lower commensurate increase in fertilizer usage. Technological change slowed during the two to three decades before 2007, during a period of long-term food price decline. But a recent boom in prices, combined with changing perceptions of food security, has provided an incentive for new agricultural research. GM crops and other biotechnological advances, with their yield and input-saving advantages — such as introducing nitrogen-fixing DNA to crops that would not normally have this function — may be embraced worldwide. In the case of phosphates, scientists are working on the development of GM crops that use P more efficiently, but success has so far proved elusive as work on more than one gene is required. And political, environmental and economic hurdles also remain.

In terms of the relative performance of the three nutrients, phosphate fertilizer consumption showed fairly robust growth in the 15-year period of 1998-2007. This is particularly the case from the early-2000s onwards — roughly matching nitrogen demand growth, although lagging the expansion in potash usage. But many countries and regions registered a downturn in phosphate and potash usage following the financial and economic crisis in 2008-09. Nutrients tend to remain in the soil, while nitrogen and sulphur are much more mobile, and farmers tend to reduce or omit applications of P_2O_5 and K_2O in periods of economic pressure. For the most part, phosphates have recovered from the global market crisis, and looking at overall growth in the three nutrients in the 15-year period to 2012-13 there has been a rough convergence with nitrogen and potash. By contrast, we expect to see a divergence in growth paths over the next 15-years to 2029, with potash the strongest performer, followed by phosphates and nitrogen.

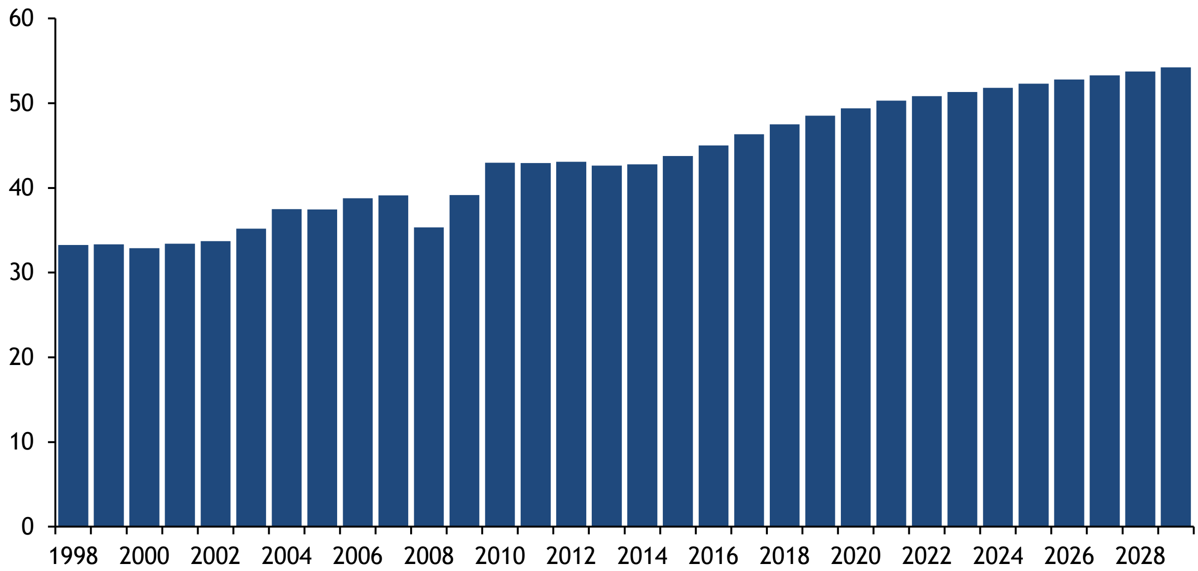
Figure 18: Index of World Fertilizer Consumption 1998-2029 (1998=1)



— Historical figures IFA/Argus FMB; Argus FMB projection for 2013-2029 plus selected IFA country projections to 2017

Total phosphate fertilizer consumption is projected to rise from 42.8mn t P_2O_5 in 2014 to 54.2mn t P_2O_5 in 2029. This 11.4mn t P_2O_5 increase is 2mn t higher than the 9.4mn t increment seen in the previous 15 years. The forecast growth is equivalent to 40mn-42mn t of rock.

Figure 19: World Phosphate Fertilizer Consumption 1998-2029 *mn t P_2O_5*



— IFA, Argus FMB

The following table examines the changing usage of phosphates by region over the last 15 years, and the expected changes in the next 15 years.

Table 35: Phosphate Fertilizer demand by region 1999-2029 *mn t P_2O_5*

	1999a	2014f	2029f	± 2014-1999	± 2014-2029
World Total	**33.3**	**42.8**	**54.2**	**9.4**	**11.5**
West Europe	4	2.7	2.9	-1.4	0.3
East Europe/Central Asia	1.2	2.0	3.2	0.8	1.2
Africa	1	1.3	2.8	0.3	1.5
North America	4.6	4.3	4.9	-0.3	0.6
Latin America	3.3	6.4	8.8	3.1	2.4
Middle East	0.8	0.5	0.8	-0.3	0.4
South Asia	5.7	7.4	11.4	1.7	4.1
South East Asia	1.6	2.1	2.8	0.5	0.8
East Asia	9.7	15.0	15.0	5.3	0.0
Oceania	1.5	1.2	1.4	-0.3	0.2

— IFA /Argus FMB historical; Argus FMB forecast

We add the following comments on historical demand and the current forecast:

- Developed markets have seen a small decline in phosphates consumption for food crops, reflecting agricultural competitiveness and past over-application. In particular, there was substantial overuse of P_2O_5 in Europe over many years and significant soil reserves were accumulated. They are only slowly being eroded, but simultaneously, agriculture is under pressure from environmental lobbies. A ban on the burning of crop residues has meant that a significant part of the phosphate applied is re-cycled by ploughing in. Fears of nutrient run-off are already an important factor in determining application levels in Europe and increasingly in North America. These factors underpin the stagnation in these markets, even in 2000-07 when agricultural commodity markets boomed.

On the plus side, the political pressure to increase biofuels production has seen some additional use, with the removal of set-aside in the case of the EU. Much of the land which was set aside is not of premium agricultural quality and needs significant levels of nutrient inputs to ensure satisfactory yields. Nevertheless, the outlook for these countries is unexciting. From the viewpoint of trade, the expectation of weak consumption growth should be seen against a background of plant closures within the EU. It is likely that the last big ammonium phosphate unit in northern Europe (Police, Poland, 900,000 t/yr plus NPK/DAP) will have to close for environmental reasons in the medium term as its ability to stack more gypsum is limited. The plant could extend its existing stacks by producing more NPK, or alternatively move to phosphoric acid as the phosphate input, and avoid further production of phosphogypsum entirely.

A similar fate awaits a number of plants in eastern Europe, as the conditions for EU membership become binding. On the other hand, the cadmium debate in Europe could work to the advantage of products based on Russian phosphate rock and also Finnish and Norwegian NPKs;

- In the developing world, nitrogen is always the first nutrient to be applied in large volumes, as it shows the most immediate results. P_2O_5 tends to be the next nutrient to become the focus of attention as improved yields from the use of nitrogen begin to flatten out. Overall, where an acceptable N:P ratio has been achieved for the cropping pattern and soil conditions — notably in many of the most important growth markets including Brazil, India and China — P_2O_5 consumption is expected to grow in line with nitrogen and agricultural production. China's move away from its 95pc self-sufficiency policy is likely to result in the country importing more agricultural products, particularly from South America and Africa, reducing the pace of Chinese fertilizer consumption growth compared with the recent past.

Table 36: NPK Ratios, 2012

		N	P	K
World Average		1	0.38	0.26
Ranking	**Country**			
4	Brazil	1	1.26	1.41
10	Vietnam	1	0.52	0.34
2	India	1	0.40	0.12
7	Canada	1	0.33	0.14
1	China	1	0.35	0.17
3	United States	1	0.34	0.37
8	France	1	0.23	0.24
6	Pakistan	1	0.26	0.01
5	Indonesia	1	0.22	0.47

— IFA

The aim to achieve balanced fertilisation has shifted the focus to potash, and is likely to progress to sulphur and other secondary nutrients and trace elements in the future;

- In eastern Europe and central Asia there are signs of growth. Countries such as Russia, Ukraine, Belarus and Poland have great scope for enhancing the productivity of their agricultural sectors. And in the case of Russia, Ukraine and some other CIS countries such as Turkmenistan and Uzbekistan, there is significant potential to expand the crop planted area. Russia and Ukraine have recently seen a rise in demand for all fertilizer nutrients as their agricultural sectors are gradually being reformed and local producers begin to focus more attention on developing their domestic market. But the political and economic situation in Ukraine is likely to lead to a reversal of the recent phosphate demand growth, at least in the short-term. Overall growth in phosphates usage in the eastern Europe and central Asian (EECA) region is projected at 1.2mn t P_2O_5 over the next 15 years. It is likely that a greater proportion of output will remain in the domestic market or within the region, and expansions to capacity will be required if export levels are to be maintained. Such expansions take time to plan and implement and will depend on guaranteed access to phosphate rock, such as Acron's development of its Oleniy Ruchey mine, which was commissioned in 2013. Without guaranteed access to rock, some plants in the region, for example in Ukraine, could come under pressure, despite a buoyant market. As Russia converts more of its rock to processed phosphates, it is not hard to imagine non-integrated competitors being starved of raw materials, as experienced by Uralchem at its Voskresensk plant in 2014. All future expansion of Russian phosphate rock production is likely to be processed in situ rather than exported. The premium high-grade of the rock that is exported will probably make it unattractive for basic phosphoric acid-based fertilizer producers;

- Over the past 15-years, Africa has failed to register any significant rise in phosphate fertilizer consumption. But there is growing interest in the region, driven by the development of the agribusiness sector in countries such as Ethiopia and Sudan. And also by non-governmental organisations (NGOs) interested in developing infrastructure to promote the supply of raw materials to the sector (e.g. the International Finance Corporation, World Bank and Bill Gates Foundation).

  Africa represents a major growth opportunity and one of the last frontiers for significant growth in phosphate fertilizer consumption. Most of this potential is based in east and west Africa, and we assume that it will be increasingly harnessed over the next 15 years. But this is dependent on a stable political environment. South Africa is already a mature market for nitrogen (170-180,000 t/yr P_2O_5) with little potential for further growth. Egypt is the largest north African consumer, but there is still scope for increasing the area under irrigation, and we expect to see a greater emphasis on both phosphate and potash fertilizers.

  In the case of east and west Africa, many countries have land available for bringing under permanent cultivation and existing agricultural land where yields can be much improved — including through multi-cropping. The fertilizer markets of both east and west Africa are seeing strong growth, albeit from a low base. The systemic problems hindering regional agricultural development — a lack of available foreign currency for purchasing fertilizers, poor infrastructure and limited or no access to credit for farmers — are showing signs of easing. And many governments are developing fertilizer subsidy programmes aimed at the small-holder sector. At the same time, the region's plantation sector has been boosted by (sometimes politically sensitive) investment by foreign agribusiness companies.

The recent fertilizer growth seen in countries such as Ghana (mostly NPKs so far), Tanzania, Ethiopia and Kenya is a reflection of solid economic advances, and is unlikely to be derailed by anything other than political factors.

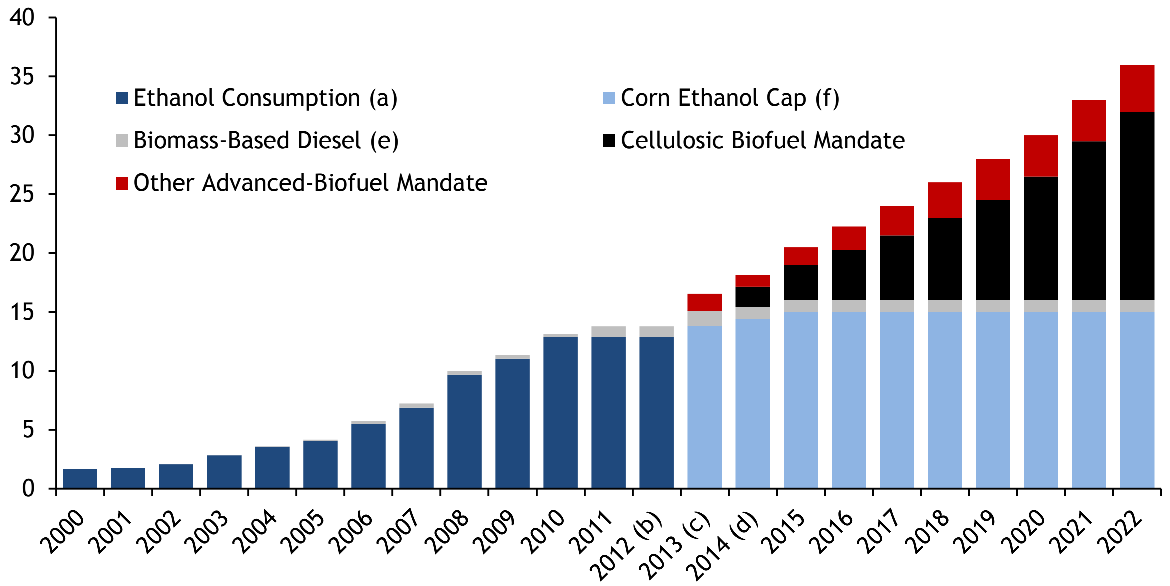
In Nigeria, developing the agricultural sector has returned to the top of the agenda, after several decades of neglect and in the face of rising grain imports. Increasing fertilizer use is a key component of the Nigerian government's strategy to improve food security for its large and rapidly growing population by harnessing the country's rich agricultural resources. With the recent sharp decline in oil prices hitting Nigeria's foreign exchange earnings, the need for improvements in agriculture has increased further, but the means to achieve them through subsidies will be considerably diminished.

Growth in imports into east and west Africa may result in existing ports evolving into key hubs for fertilizer trade on the continent, with the development of transportation and distribution corridors inland. In east Africa, the hubs with the greatest potential are Djibouti, Beira (Mozambique), Mombasa (Kenya) and Dar-es-Salaam (Tanzania). Dictated by geography, the situation for west Africa is more fragmented with a number of smaller ports handling fertilizers. Tema (Ghana), Dakar (Senegal), Abidjan (Ivory Coast) and Lagos (Nigeria) currently handle in excess of 100,000 t/yr of fertilizers.

In the short and medium term, countries in Sub-Saharan Africa that do experience demand growth are likely to focus first on nitrogen, although we are seeing greater volumes of ammonium phosphates going into east Africa and more NPK sales to west Africa over the last two to three years. Ethiopia is a good example, as it has traditionally consumed urea but has recently switched to importing NPS. Overall, we assume a 1.5mn t P_2O_5 increase in phosphates consumption in Africa during the next 15 years;

- Phosphate demand in North America has been in the 4.6mn-4.7mn t/yr P_2O_5 range in recent years, and we expect usage to show modest growth in the next 15 years (+600,000t P_2O_5). US phosphate fertilizer consumption decreased in 2014, on the back of lower crop prices. In the short-term, lower grain prices and in particular lower corn prices relative to soybeans, are encouraging a switch towards more areas planted with more phosphate-intensive soybeans. This reverses the trend seen in the last seven years when more land was planted with corn to supply the mandated requirement of ethanol for biofuels in the US. The country has now reached a peak in terms of this usage, and may even see a decline.

Figure 20: Past Renewable Fuels & Future Requirements of the Renewable Fuel Standard *bn USG*



— US Congressional Budget Office June 2014

(a) Primarily corn ethanol, but includes small quantities of sugarcane ethanol and other types of advanced biofuels either produced domestically or imported
(b) Renewable Fuels in 2012 roughly unchanged on 2011 levels, but fuel blenders and importers achieved compliance with RFS by submitting 'renewable identification numbers' (RINs) accumulated from exceeding obligations in previous years.
(c) For 2013, the EPA retroactively reduced the cellulosic biofuel requirement for that year to 6mn gallons and raised the mandate for biomass-based diesel to 1.28bn gallons. Actual figures yet to be available.
(d) Volumes required under EISA.
(e) Minimum requirement for biomass-based diesel of 1bn USG under EISA. EPA will set the actual requirement through future rulemaking.
(f) The cap on corn ethanol represents the maximum amount of such ethanol that can be used to meet the total requirement for renewable fuels under EISA.

- Under the Energy Independence Security Act (EISA), the 2007 Renewable Fuel Standard (RFS) set the mandatory volume of corn-based ethanol that refiners and other obligated parties had to blend with US gasoline at 13.8bn USG in 2013 rising to 14.4bn USG in 2014, and to a maximum level of 15bn USG in 2015. At the same time the non-corn/advanced biofuels requirement was due to rise from 2.75bn USG in 2013 to 3.75 in 2014 and 5.5bn USG in 2015, thereafter accounting for all of the 16.5bn growth in the total renewable fuels requirement to 36bn USG by 2022. The non-corn/advanced fuels include Brazilian sugar-based ethanol, soy-based biodiesel and fuels manufactured from solid biomass in technologically advanced plants, but most of the growth would come from cellulosic ethanol;

- However, as the Congressional Budget Office (CBO) report of June 2014 notes, the requirements of the EISA will be very hard to meet because of two main obstacles: the amount of ethanol that older vehicles can 'tolerate' and the potential future supply of cellulosic biofuels;

  - In the case of vehicle tolerance, currently most gasoline sold in the US is a blend of 10pc ethanol (E10) — the maximum concentration feasible to avoid corrosion damage to engines and fuel delivery systems in older vehicles, and the level most manufacturers are willing to warranty. The EISA requirement of growing usage of biofuels combined with a decline in gasoline usage which is projected to continue suggests the average concentration would have to rise well above the so-called 10pc 'blend-wall', potentially increasing to 25pc by 2022. More ethanol could be accommodated in the fuel supply if flex-fuel vehicles (up to E85) bought larger volumes of such fuel. However, less than 2pc of filling stations in the US currently sell high-ethanol blends with little incentive to expand further under the current RPS, since the cost of encouraging additional sales of high-ethanol fuels falls on producers and consumers of gasoline and diesel;

  - In response, the EPA released a draft biofuels mandate in October 2013 for 2014 with the conventional corn-based ethanol requirement falling to 13bn USG down on the original mandate for 2014 as well as for 2013. At the same time, the total advanced biofuels requirement for 2014 was reduced from 3.75 to 2.2bn USG under the draft, with the proposed requirement for cellulosic biofuels slashed from 1.75bn USG to 17mn USG, partially offset by an expansion in biomass-based diesel from 1bn USG to 1.28bn USG. However, reducing standards helps compliance in the short-run but reduces incentives for companies to invest in production capacity for cellulosic and other advanced biofuels and to expand availability of high-ethanol blends, making future targets yet more difficult to meet. Not surprisingly, the EPA's draft mandate for 2014 led to an outcry from biofuels groups and the EPA has been unable to issue a final mandate during the year, announcing in November 2014 that it would now be issued in 2015. In turn, refiners and other blenders have further protested against the on-going uncertainty and some have called for the entire RPS to be scrapped;

  - It is hard to second guess what shape future biofuels mandates will take, especially as the country continues to benefit from the rapid growth in oil and gas production from the shale revolution, even if this growth is tempered in the wake of the recent decline in international oil prices. But we would expect that some policies to encourage filling stations to sell high-ethanol blends on the one-hand and buyers with flex-fuel vehicles to buy these blends on the other hand, will see the 15bn bioethanol cap reached as older vehicles are replaced with new vehicles;

  - Overall, the policy seems likely to lead to some switch away from corn acreage to soybeans in the US midcontinent to supply new soydiesel facilities. This will have a negative impact on nitrogen but a roughly neutral effect on phosphate usage;

  - In the longer-term we expect that both the US and Canada will play a growing role in supplying the fast-growing populations of Asia with grains and meat, as food prices resume an upward trend. This will be the primary driver of phosphate usage in the region;

- Latin America will remain a focal point for demand growth in the foreseeable future. There is significant scope for expanding the agricultural land area and intensifying farming, particularly in Argentina and Brazil. Both of these countries are expected to increase their role in supplying the international market with food and oil crops in the coming 15 years. Given the importance of soybeans, a crop that saw tremendous growth in the first half of the 2000s, Brazil has a higher ratio of phosphate and potash to nitrogen, beyond that of a country with a less dominant single-crop sector. In particular, the Cerrado region is one which will see an increase in cultivation — especially for soybean production. As previously mentioned, the supply of bioethanol from sugarcane to the US market, being classified as an 'advanced biofuel', could provide a further significant impetus for an expansion in production of this crop in Brazil or other Latin American countries. We are projecting total Latin American growth of around 2.4mn t P_2O_5 in 2014-29, which equates to a requirement of more than 8mn t of additional phosphate rock;

- Excluding China, Asia will remain the powerhouse of fertilizer demand growth. Population growth alone dictates this, and demand for food production will be coupled with growth in industrial demand for biofuels. India is expected to see the biggest absolute increase in phosphate fertilizer demand in the region during the next 15 years (+3.4mn t P_2O_5), assuming a reform of the fertilizer sector that will encourage a more balanced use of fertilizers through the deregulation of urea, which will ultimately increase the use of phosphates and potash. Pakistan, Bangladesh and Indonesia will also drive demand upwards as P_2O_5 consumption still lags behind nitrogen consumption in these countries and a period of "catch-up" is required if balanced fertilization is to be achieved (recent figures suggest Bangladesh is on such a new trajectory). We are projecting total Asian growth of around 4.9mn t P_2O_5 in 2014-29, which equates to a requirement of over 17mn t of additional phosphate rock.

Section 3: The Phosphate Rock Market
Chapter 2: The Merchant Market

2.1 Recent Trends

In terms of volumes and market, merchant rock trade has declined significantly over the last 30 years. In 1984, rock trade peaked at around 48mn t but collapsed with the fall of the Soviet Union and has not since recovered. The figures below provide an insight into the recent trends for phosphate rock trade:

Table 37: Phosphate Rock Exports By Major Country *mn t rock*

	2000	2007	2010	2011	2012	2013
Total	**30.18**	**31.31**	**29.98**	**31.15**	**30.17**	**26.00**
Of which:						
Russia	4.09	2.72	2.15	1.39	1.60	2.19
USA	0.18	0.00	0.00	0.00	0.00	0.00
Peru	-	-	0.62	2.58	3.22	3.59
Algeria	0.88	1.69	1.62	1.28	1.20	1.07
Egypt	0.32	1.50	2.45	3.04	4.07	2.42
Morocco	10.49	14.12	10.22	9.66	9.59	8.60
Togo	1.22	0.74	0.85	0.89	1.03	1.14
Tunisia	1.07	1.20	0.70	0.15	0.08	0.03
South Africa	0.76	0.12	0.18	0.19	0.42	0.19
Israel	1.12	0.44	0.87	0.90	0.90	0.95
Jordan	3.13	3.60	4.30	5.40	4.34	3.24
Syria	1.56	2.99	3.14	2.74	1.25	0.78
China	3.45	0.98	0.88	0.66	0.49	0.36
Others	1.91	1.21	2.00	2.26	1.89	1.44

— IFA

- The majority of established, vertically-integrated producers are seeing a gradual reduction in the export availability of merchant rock. Key countries (Israel, the US, South Africa, Russia, Tunisia, Vietnam, China) have gradually expanded their downstream operations to use available rock from existing mines, and here, new mines will be constructed only in association with additional processing capacity;

- For a number of producers, the decline is simply a result of the depletion of reserves at existing mining operations. This is true for exporters such as Nauru, Christmas Island, and the US;

- The main exception to this trend is Peru where the new Bayovar export operation is now adding 3.6mn t of rock suited for phosphoric acid production when blended with other rock, but which is also highly reactive and suitable for direct application. Algeria has also increased rock exports in recent years. The rock is of low grade and quality and is finding markets on the strength of its relatively low cost, mainly in Europe;

- Phosphate rock exports stood at 26mn t in 2013, down by 4.2mn t compared with 2012 levels. This decline was primarily caused by a fall in north Africa and Middle East exports — Egypt (-1.6mn t), Jordan (-1.1mn t), Morocco (-1mn t) and Syria (-0.5mn t);

- The rise in Egyptian exports witnessed in 2011 and 2012, as companies took advantage of the decline in Syrian exports, was short lived and started to reverse in 2013. On the other hand, the decline in Jordanian rock exports observed in 2013 reversed in 2014, as indicated by the latest company data disclosed to the Amman Stock Exchange, which showed an increase in rock exports of 1.4mn t to a total of 4.6mn t in 2014. In 2011, Jordanian exports had reached a peak of 5.4mn t to take advantage of the loss of Syrian tonnage;

- The concentration of export volumes is increasing. Although the industry was never as concentrated as the potash sector, OCP and JPMC now account for 46pc of total rock exports and a higher proportion of good quality acid-grade material. Gradually, OCP has emerged as the key swing producer in the acid-grade rock business:

Table 38: OCP as Swing Exporter *mn t*

	Export Tonnage	Market Share (pc)
1996	10.14	33pc
2000	10.49	35pc
2005	13.39	43pc
2006	13.51	46pc
2007	14.12	45pc
2008	11.82	39pc
2009	5.83	30pc
2010	10.22	34pc
2011	9.67	31pc
2012	9.59	32pc
2013	8.60	33pc

— IFA

- Statistics in recent years suggest that OCP is not only adjusting export availability in line with demand requirements but also in line with development of new or expanded availability, particularly from Egypt, Syria and Peru. OCP has also demonstrated that it can bring up to 14mn t/yr of material to market — as and when conditions require — even before its major +20mn t/yr rock expansion is completed.

Globally, demand for merchant rock remained fairly static at about 30mn t/yr up until 2012, before declining to 26mn t in 2013. There are three main elements of the change in global demand patterns — geographical change, industry structural change and quality changes. In this section we will focus specifically on geographical and structural changes and thereafter devote a separate chapter to grade and quality issues.

In the following table, we compare export deliveries for the peak year of 1984 and 2013 (most recent available statistics):

Table 39: Changes in Geographical Demand Patterns				*mn t*
	1988	**2012**	**2013**	**Change 1988-2013**
World*	**46.43**	**30.16**	**25.96**	**-20.47**
West Europe	25.69	6.89	5.88	-19.81
Central & East Europe*	2.60	2.37	1.64	-0.96
North America	2.84	3.55	3.53	+0.69
Latin America	2.04	3.04	2.94	+0.9
Africa	0.003	0.01	0.04	+0.04
Middle East	0.12	0.48	0.42	+0.03
South & East Asia	9.2	11.90	10.47	+1.27
Oceania	2.66	1.01	0.96	-1.7
Various	1.27	0.91	0.07	-1.2
** Central Europe plus FSU*				

— IFA, Argus regional classification as detailed in the appendices

The following points arise from this table:

- The story of the last 25 years has been about the decline of the western European phosphate industry. With the closure of Fertiberia's Huelva (Spain) phosphoric acid plant in 2011, the region's current requirement is below 6mn t/yr, compared with over 25mn t/yr in 1988. In particular, the 1mn t decline observed in western European rock imports between 2012 and 2013 resulted from a fall in imports from Belgium (-300,000 t), Poland (-350,000 t), Netherlands (-340,000 t). But Lithuanian imports were up by 300,000t;

- Changes in central European and FSU rock demand have not had a significant global impact. Much of the traded rock was within the Soviet bloc and was consumed domestically. From a global phosphate rock perspective, the only significant change has been a reduction in the availability of high-grade rock for export as Apatit adjusts its output to both mining and commercial circumstances. The reduction of Russian rock imports by 300,000t between 2012 and 2013 coincides with the commissioning of Acron's Oleniy Ruchey mine in 2013. However, the changes in Russia have impacted more significantly on the ammonium phosphates market;

- There are significant changes within North America. In 1988, the US industry shipped 2.1mn t/yr of rock to Canada and imported just 700,000t. Since then, the US has emerged as a significant importer of rock with 3.2mn t imported in 2013, while Agrium's Redwater operation imported 300,000t from OCP as part of the 1mn t/yr contract running until 2020;

- In Latin America, Brazilian phosphate rock demand has increased from 130,000t in 1988 to 1.6mn t in 2013, despite an increase in domestic output. Mexican imports have fallen from 1.7mn t in 1988 to 800,000 t in 2013 as the Fertinal mine has increased its output and production efficiency;

- The African market has remained static over 25 years. In 2010 and 2011, the only significant trade in rock was Togolese exports to Foskor (South Africa), where it was used as a supplement to the apatite produced at Phalaborwa. But this trade route was non-existent in 2012 and 2013, following the poor operation of the Richards Bay acid complex, which is undergoing operational issues. However, this has resulted in a corresponding increase in South African rock exports;

- Turkish imports have remained steady over the last 25 years at 600,000-900,000 t/yr. Imports of Syrian rock to supply Lebanon Chemical are traditionally steady at about 700,000 t/yr but have been affected by the political unrest. The Iranian Razi Chemical phosphoric acid plant continues to work below capacity with imports in 2013 at just 30,000t;

- Asia has shown the most significant growth in rock imports over the past 25 years, most notably India whose imports have grown from less than 2.5mn t in 1988 to 6.7mn t in 2013. Growth in imports is expected to continue over the medium term, stimulated in particular by the growing single superphosphate industry. Indonesian demand also continues to grow — from 1mn t in 1988 to 1.8mn t in 2012 and 1.5mn t in 2013. A substantial share of imports is directed to the direct application and NPK granulation sectors. In contrast, Japanese demand has declined by 1.5mn t and South Korean imports by 1mn t;

- The development of mining and processing at Phosphate Hill has led to a fall in imports of rock into Australia. The phosphate rock mined by IPL is not suited to the manufacture of single superphosphate which is favoured domestically, so Australia still imports +300,000-500,000 t/yr of merchant rock. New Zealand imports ±700,000t of rock for both single superphosphate manufacture and direct application.

The following, table summarises the development of imports over recent years:

Table 40: Phosphate Rock Imports							'000t rock
	2007	2008	2009	2010	2011	2012	2013
World Total	**31,318**	**30,580**	**19,576**	**29,984**	**31,146**	**30,159**	**25,995**
West Europe	**9,844**	**8,804**	**4,544**	**8,193**	**7,654**	**6,890**	**5,884**
Spain	1,846	1,390	428	1,010	288	233	242
Poland	1,693	1,347	558	1,324	1,385	1,272	915
Belgium	1,392	1,326	597	1,339	1,540	1,254	974
Lithuania	1,218	1,246	1,169	1,364	1,287	1,013	1,342
Others	3,695	3,495	1,792	3,157	3,154	3,119	2,412
EECA	**2,136**	**2,633**	**1,459**	**2,113**	**2,324**	**2,369**	**1,676**
Turkey	647	682	712	781	833	637	600
Belarus	355	450	401	553	515	493	469
Others	1,134	1,501	347	778	977	1,239	607
Africa	**127**	**208**	**54**	**132**	**104**	**9**	**41**
North America	**2,797**	**2,755**	**2,091**	**2,885**	**3,273**	**3,553**	**3,532**
USA	2,670	2,755	2,091	2,817	3,273	3,493	3,214
Canada	127	-	-	68	-	61	318
Central America	**908**	**1,021**	**104**	**981**	**872**	**852**	**800**
Mexico	899	1,021	91	981	865	836	800
Others	9	-	13	-	7	16	-
South America	**2,641**	**1,816**	**1,369**	**2,077**	**2,078**	**2,188**	**2,145**
Brazil	1,996	1,288	936	1,416	1,460	1,448	1,608
Others	645	528	433	661	619	741	537
Middle East	**984**	**727**	**728**	**1,012**	**876**	**477**	**419**
Lebanon	762	630	660	878	781	447	387
Iran	170	-	17	112	85	30	31
Others	52	97	52	22	10	-	1
South Asia	**5,730**	**5,703**	**5,619**	**6,799**	**7,946**	**7,731**	**7,092**
India	5,244	5,261	5,327	6,388	7,522	7,312	6,685
Others	486	442	292	412	423	420	407
South East Asia	**2,471**	**2,735**	**2,110**	**2,811**	**3,095**	**3,094**	**2,445**
Indonesia	1,402	1,559	1,352	1,636	1,621	1,767	1,480
Malaysia	794	769	376	723	985	837	575
Philippines	210	343	285	441	481	464	387
Others	65	65	96	11	8	25	4
East Asia	**2,090**	**2,448**	**1,028**	**1,526**	**1,481**	**1,073**	**931**
South Korea	1,238	1,447	413	910	749	567	430
Japan	671	823	390	327	548	308	376
Others	181	179	225	290	184	197	125
Oceania	**1,476**	**1,689**	**442**	**1,252**	**1,018**	**1,009**	**962**
Australia	581	818	121	505	347	389	354
New Zealand	895	871	321	747	671	619	608
Unspecified	**115**	**43**	30	204	424	915	68

— IFA, Argus regional classification as detailed in the appendices

Section 3: The Phosphate Rock Market
Chapter 2: The Merchant Market

The following analysis will highlight a number of major structural changes and market drivers that have affected the phosphate sector over the past 25 years. The pace of change has accelerated over the last 10-15 years.

2.1.1 Vertical integration

The development of vertically integrated industries commenced on a large scale in the US following the Second World War. This approach was adopted gradually in the newer producing states, such as Morocco, Tunisia and Jordan. Overall, vertical integration has displaced non-integrated plants, and no new plants based on merchant rock have been built in the last ten years.

The extent of the change is illustrated by the share of production which is exported as rock as opposed to being processed domestically:

Table 41: Global Rock Production versus Exports *mn t*

	1990	2000	2005	2010	2011	2012	2013
Production	156.0	131.7	172.8	183.8	193.7	196.7	193.3
Exports	37.0	30.2	31.3	30.0	31.15	30.17	26.0
Export Share	24pc	22pc	18pc	16pc	16pc	15pc	13pc

— IFA

The advantages of vertical integration are clear cut and can be summarised as follows:

- The added value of processing remains with the mining company;
- Phosphoric acid plants can be designed to accommodate lower-grade rock with a variety of impurities. Expenditure on beneficiating rock to merchant quality (where this is possible) and drying costs are saved;
- Phosphogypsum can often be more easily disposed of at the mine site. For example, older European operations were once separate from residential areas, but were gradually engulfed by urban sprawl. Phosphogypsum disposal problems were the primary cause for the demise of the European and Japanese phosphoric acid sector;
- P_2O_5 can be transported in more concentrated forms from vertically integrated plants, especially as the P_2O_5-content of the rock being mined falls.

We do note that in a few instances, rock being processed in the domestic market is not vertically integrated in the full sense of the word. For example, in Russia, the old Soviet phosphate industry, which was state-owned and centrally controlled, was fragmented after the collapse of the Soviet Union. Apatit, the mining subsidiary of Phosagro, has since supplied Acron, Rossosh and Uralchem — which to varying degrees compete with Phosagro's own downstream production. Acron has now become self-sufficient since opening its own mine at Oleniy Ruchey in 2013.

We also note some examples of "arm's length vertical integration". By this we mean offshore subsidiary or joint-venture companies being supplied with rock by one of the partners. The rock production and processing are in the same hands, but the processing takes place in the end-market rather than close to the rock mine. Examples of this are OCP's Paradeep plant in India and the PT Petro Jordan Abadi joint venture between PT Petrokimia Gresik and JPMC located in Gresik, Java. This sort of arrangement has some distinct advantages:

- It mitigates the build-up of processing capacity at a single location, which may become congested;
- It extends the logistical reach of the phosphate company in respect to supplies of raw materials — sulphur and ammonia. For example, Paradeep and Gresik can be more easily supplied by Arab Gulf ammonia and sulphur;
- It embeds the finished product manufacturing units in the target market, and allows a range of locally-suited fertilizers to be developed in appropriate volumes.

A number of companies in rock-importing countries are looking to achieve this form of vertical integration. The FosPac project in Peru involves Indian processed phosphate producer Zuari, which will have an allocation of 1.25mn t/yr of phosphate rock from the mine, as does Mosaic from its shareholding in the existing Bayovar mine (35pc stake). Although the purchase price for the rock is related to market pricing, the consumer has a guaranteed source of supply and a share of any dividends paid plus its share in a company of growing value.

2.1.2 Economic Shifts

Over the last 30 years the phosphate sector has been affected by major economic shifts. The most important of these has been a decline in the competitiveness of the European, and to a lesser extent the Japanese, fertilizer industry. This decline has a number of aspects:

- The old economic model was based on importing cheap raw materials for processing into finished products for home consumption and export. While the key components of fertilizer manufacture — nitrogen feedstock and phosphate rock — remained cheap, the industry was able to survive as a significant player. But since the Opec crisis, the cost of nitrogen feedstock, whether naphtha, fuel-oil or natural gas, has been rising. The European and Japanese nitrogen industries have been in decline since that time, with the exception of a small surge in investment in northern Europe occasioned by the discovery of North Sea gas. As nitrogen plants closed, so did associated NPK units;
- Many of the phosphate/NPK units in Europe were established before the Second World War. The plants were old and the production facilities small-scale, making them unsuited to re-engineering as modern production centres. As the pace of advances in technology increased, the operation of these old plants became uncompetitive. The establishment of the European Community and the Single Market further undermined their competitiveness, and a vast rationalisation programme was required;
- The national industries served national markets and encouraged an over-application of fertilizer, particularly phosphate and potash. In 1979-80 P_2O_5 consumption in western Europe peaked at 6.45mn t. More recently, it has been steady at about 3mn t/yr P_2O_5. A lack of competitiveness and investment in its traditional markets has deprived Europe of a large part of its export share.

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There are clear-cut reasons why a plant based on imported raw materials is likely to be less cost-effective than a vertically integrated operation. This was even more the case following:

- The demise of small-scale metal smelting operations that supplied sulphuric acid as a disposal product to small-scale phosphate plants;
- The end of the oversupply, which characterised the rock market until the early years of this century. Even in the first years of this century, Moroccan acid-grade rock was selling in the $40-45/t range. This gave rock purchasers a sufficiently low cost-base to serve a domestic market, if not direct supplies to export markets.

A surge in demand growth for P_2O_5 commencing in about 2003-04 saw the beginnings of an alignment of the price of a unit of P_2O_5 in merchant rock and processed phosphates. This finally gave the vertically integrated industries, which had come to dominate the sector, the ability to maintain prices for merchant rock at a level which made it virtually impossible for rock purchasers to compete against the processed phosphate products.

This shift in relative power is best illustrated by the impact of the recent market cycle, which saw high deliveries in 2007 and 2010 and a market collapse in 2009. It was the merchant market which bore the full brunt of sharply reduced demand for P_2O_5 in 2009 – although there was significant stock-building by the vertically integrated companies and also at consumer level:

Table 42: The Vulnerability of Non-Basic P_2O_5 Processors *mn t*

	Home Deliveries	Export Deliveries
2013	163.3	26.0
2012	163.8	30.2
2011	163.3	31.2
2010	143.6	30.0
2009	138.5	19.6
2008	138.9	30.6
2007	147.7	31.3
2006	137.9	29.7
2005	138.7	30.8

– IFA

2.1.3 Environmental issues

We have touched on the environmental issues that affect the mining and processing of phosphates in many countries. In respect to merchant rock, phosphogypsum disposal has been one of the main contributory factors in the closure of phosphoric acid plants in the developed world, especially in Europe (eg. Fertiberia in Spain, Prayon in Belgium and Agrifos in the US). Discharge into rivers and the sea are generally no longer permitted, and there is a limit to the volume that can be stacked in industrial sites that have been affected by urban encroachment or other industrial development adjacent to a phosphoric acid plant.

These constraints are of little concern in some of the major Asian markets. In India, phosphogypsum is used in building materials in place of natural gypsum. The quality of such building products is not generally acceptable in European or US markets. In Indonesia, the phosphogypsum is treated and used as the raw material in the production of cement, as there is only a limited supply of naturally occurring calcium carbonate available for this purpose.

We emphasise the role of phosphogypsum disposal, simply because it has become a major factor in the decline of many established industries based on merchant rock, and also explains the growth of imports into countries which:

- have sufficient space to stack;
- are not affected by environmental objections to stacking;
- are located close to strong ocean currents which allow for disposal into the sea;
- are not as yet affected by regulations limiting either stacking or other means of disposal;
- can use phosphogypsum as a raw material for building materials or a soil amendment agent, for example, Egypt.

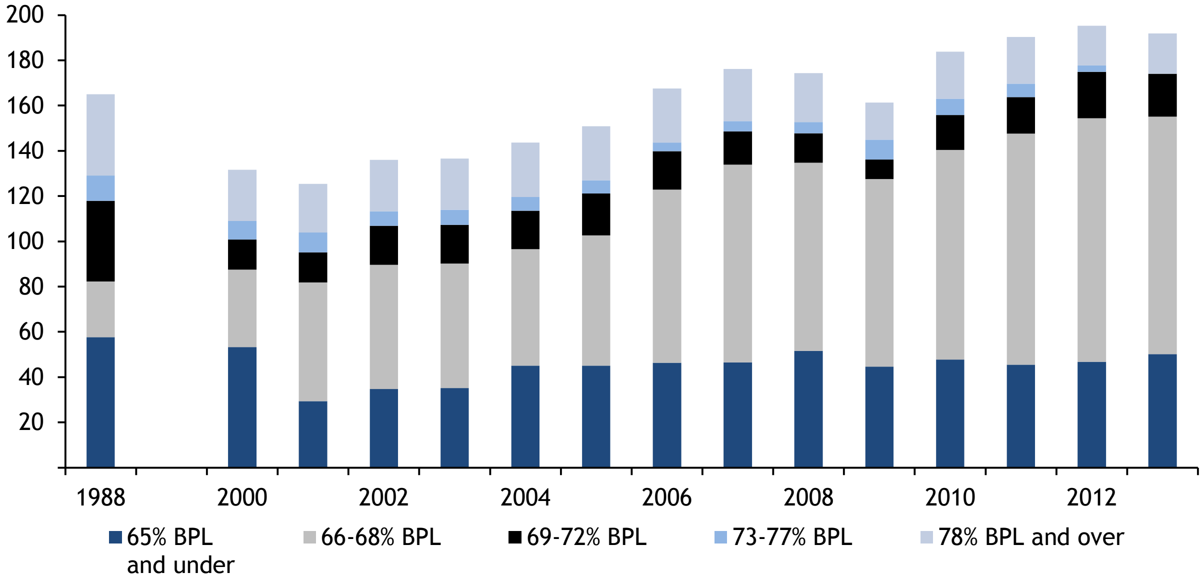
These considerations will continue to influence the possibility of taking P_2O_5 in the form of rock, aside from economic and other considerations.

2.2 Rock Grade

"Phosphate rock" is an umbrella term covering a wide range of P_2O_5-containing ores and concentrate. Generally, the term "grade" is used to describe the P_2O_5 content of the rock. The average grade of the rock produced for sale or processing worldwide has been declining gradually over many years: 31.1pc P_2O_5 in 1980, 31pc P_2O_5 in 1991 and about 30.7pc in the last three years. The amended IFA assumptions in respect to Chinese rock grade have, until the recent revision, had the effect of understating the average decline in grade which we believe to be closer to 30% P_2O_5.

The figure below highlights the development of phosphate rock production by grade in 1988 and annually from 2000 to 2013:

Figure 21: World Phosphate Rock Production by Grade, 1988-2013 *'000t*



– IFA

The following table describes the changes in grades produced, processed in situ and exported in the period 1998-2013:

Table 43: Changing Rock Grades, 1998-2012						*mn t*
	All Grades	65pc BPL	66pc-68pc	69pc-72pc	73pc-77pc	78pc BPL
1998						
Production	144.5	65.3	28.9	17.1	9.9	23.3
Home Deliveries	107.4	44.8	39.6	6.9	2.3	11.8
Export Deliveries	33.7	3.8	7.0	8.9	3.4	10.6
2008						
Production	174.3	51.6	83.2	13.0	4.9	21.6
Home Deliveries	138.5	42.1	73.2	4.4	3.6	15.2
Export Deliveries	30.5	4.4	11.6	7.1	0.8	6.6
2012						
Production	196.7	46.7	108.9	20.5	2.9	17.7
Home Deliveries	163.8	40.1	97.9	12.5	1.4	11.9
Export Deliveries	30.2	5.7	13.3	5.3	0.3	5.5
2013						
Production	193.3	50.2	104.9	19.0	1.4	17.7
Home Deliveries	163.3	42.2	95.9	13.1	0.6	11.5
Export Deliveries	26.0	5.4	9.0	4.9	0.7	6.0
						— IFA

In respect to trade, there has been a dramatic shift to lower grades of rock. The following table reclassifies the IFA categories by combining the two low grades, the "acid-grade" rock, traditionally the 69-72pc and the high-grade rock (the two higher categories).

Table 44: Changing Merchant Rock Grades, 1988-2013						*mn t*
	<69pc BPL		69pc-72pc BPL		73pc-78pcBPL	
	Export Tonnage	pc Share of Exports	Export Tonnage	pc Share of Exports	Export Tonnage	pc Share of Exports
1988	7.7	16pc	19.8	42pc	19.5	42pc
2008	16.0	52pc	7.1	24pc	7.0	24pc
2011	18.8	60pc	5.9	19pc	6.5	21pc
2012	19.0	63pc	5.3	18pc	5.8	19pc
2013	14.4	55pc	4.9	19pc	6.7	26pc
						— IFA

In 1988, the majority of rock exports were grades above 69pc BPL. Of the 16pc (7.7mn t) made up of lower grade rock, a large part was for direct application and use in metallurgical processes. By 2013, low-grade rocks made up 55pc of total export deliveries.

2.2.1 Low Grades of Rock

The following table shows the trends in the supply of merchant rock with a grade below 69pc BPL:

Table 45:Export Trends in Lower Grades of Rock (<69pc BPL) *mn t*

	1988	2008	2012	2013	Change 1988-2013
Total	**7.72**	**16**	**18.87**	**14.33**	**6.61**
Algeria	0.5	1.66	1.2	1.07	0.57
Egypt	0.27	1.62	4.07	2.42	**2.15**
Peru	-	-	3.22	3.54	3.54
Jordan	0.12	1.7	2.72	2.03	**1.91**
Kazakhstan*	-	0.4	0.51	0.25	0.25
Morocco	0.69	4.9	4.67	3.12	**2.43**
Syria	1.86	2.47	1.24	0.78	-1.08
Tunisia	1.16	0.89	0.09	0.03	**-1.13**
USA	3.12	-	-	-	-3.12
China	-	2	0.49	0.36	**0.36**
Vietnam	-	0.43	-	0.11	0.11
Christmas Island	-	-	0.75	0.56	**0.56**

**Sales in 2008 were substantially larger but were within the FSU and counted as home deliveries*

– IFA

Exports of lower grade rock have almost doubled over the last 25 years. This in turn has led to adjustments to plants and practices by wet-process phosphoric acid producers. They are willing to tolerate the loss of throughput, which is the result of taking a lower grade of rock, as long as there is equivalent price compensation. The same applies to vertically integrated producers, which today will take lower P_2O_5 rock with a greater humidity in order to save beneficiation and drying cost. In Morocco, we note that the new slurry pipeline will deliver rock slurry that will not require the addition of water at Jorf, although it needs to be thickened before introduction to the reactors.

The change of attitude forced on the industry (initially in Florida) by declining rock grades has permitted previously small-scale and new producers to enter the merchant market or grow their market share. This applies to Syria and Egypt in particular. On the other hand, the change in market acceptance of lower grade material has led both Morocco and Jordan to increase their sales of lower grade rock. Over the past two years, the reduced availability of Syrian rock has been compensated by sharp increases in export deliveries from Jordan and Egypt. But most of the 4mn t decline in global phosphate rock exports (all grades) between 2012 and 2013, has been observed in the low-grade segment (below 69pc BPL) and resulted from a fall in exports of low grade rock from Egypt (-1.65mn t), Jordan (-0.7mn t), Morocco (-1.5mn t) and Syria (-0.5mn t).

The two complete newcomers to the merchant market, China and Vietnam, are both in the process of building up processing industries and their rock exports are declining. In 2000, China was exporting almost 3.5mn t of rock, which fell to less than 500,000-1mn t in 2012 and 2013. Higher grade rock is being reserved for domestic processing. Vietnamese exports ceased after a second acid plant was commissioned and exportation banned in 2012, but limited exports resumed in 2013.

In low-grade rock, OCP has proven to be just as much the swing producer as in other grades. OCP's export of the two lower grade category rock shipments during the recent boom-bust cycle is as follows:

Table 46: OCP Export Shipments of Lower Grade Rock 2008-13 *mn t*

	2008	2009	2010	2011	2012	2013
World Lower Grade Rock	**16.03**	**10.69**	**16.68**	**18.88**	**19**	**14.33**
Of which						
Below 65pc BPL	4.41	2.86	5.71	5.46	5.7	5.38
66-68pc BPL	11.62	7.83	10.97	13.31	13.27	8.95
OCP Lower Grade Rock (<69pc BPL)	**4.9**	**2.67**	**3.79**	**4.25**	**4.67**	**3.12**
Of which						
66-68pc BPL	4.9	2.67	3.79	4.25	4.67	1.69

— IFA

In 2009, OCP absorbed about half of the reduction in sales of lower grades of rock. As OCP did not export rock of the lowest grade category (<65pc BPL), it accounted for about 60pc of the reduction in deliveries of 66-68pc BPL rock. We note that OCP started exporting rock with a grade below 65pc BPL in 2013 (1.4mn t), at the expense of 66-68pc BPL rock exports which declined by almost 3mn t between 2012 and 2013.

In terms of demand for the lower grades of rock, the trends are illustrated in the following table. Please note that insignificant deliveries have been excluded

Table 47: Main Importers of Lower Grade Rocks *mn t*

	1988		2012		2013	
	≤65pc BPL	66pc-68pc BPL	≤65pc BPL	66pc-68pc BPL	≤65pc BPL	66pc-68pc BPL
Total Deliveries	**2.62**	**5.12**	**5.71**	**13.31**	**5.38**	**8.95**
W. Europe	0.6	1.89	0.63	0.86	0.5	0.11
Cen. & E. Europe	0.99	1.05	1.61	0.99	1.28	0.43
N. America	0.55	0.45	-	3.12	0.61	1.9
L. America	-	0.6	0.25	1.43	0.15	1.34
West Asia	0.16	0.33	0.48	0.46	0.57	0.28
South Asia	0.01	-	1.17	4.01	1.13	3.54
East Asia	0.22	0.63	1.17	1.55	0.9	1.14
Oceania	-	0.16	0.03	0.27	0.16	0.18

— IFA, using IFA regional classification

Europe traditionally dominated the market for the lowest grades of rock. In western Europe this was driven by the non-acid and non-nitrophosphate producers of PK and NPK products. Unacidulated, reactive phosphate rock (hyperphosphate) always played a role in the acid soils of north and northwest Europe, where there were numerous small plants producing compacted PKs or granulated PKs and NPKs using some rock or partially acidulated phosphate rock, or a mixture of acidulated and non-acidulated rock. In central Europe, some suppliers were favoured by a number of states for political reasons, for example, Algeria and Syria. The development of Comecon saw central Europe largely as a producer and user of low-grade phosphate fertilizers such as single superphosphate, and there was no extensive investment in phosphoric acid production. Today, it is central Europe that dominates imports of low-grade rock, with Poland and Bulgaria appearing as the primary importers.

In recent years, there has been a large increase in usage of low-grade rock in south Asia, given its suitability for plantation crops and its low cost per unit P_2O_5. In South America, there is significant growth in the sale of reactive Gafsa rock in Brazil and Uruguay (marketed as Gafsa Hyper), where there is a government requirement for a minimum calcium content of 34pc and 6pc citrate solubility in the P_2O_5 applied. The product is used for organic beef pasture in Uruguay and organic sugar cane, and has been successfully trialled on soybean/corn/millet rotation and coffee/sugarcane rotation:

Table 48: Estimated Market Growth for Reactive Rock in Brazil and Uruguay *'000t*

	2006	2011
Total Demand	**480**	**860**
Of which:		
Imports	357	621

'Direct Application Of Phosphate Rock The Brasilian And The South American Experience', Heinz Huyer, InterTrade Group, FMB Latin American Conference & Exhibition, Buenos Aires, February 2012

Rock from Bayovar is also entering a market traditionally served by Tunisian rock, as the reduction in exports of Gafsa rock is enabling other supply sources to enter the market. Any new source will benefit from astute marketing in regions where the "organic" label is established — currently Europe and South America. On the other hand, there is a growing body of evidence that is leading research work to suggest that applying phosphate alongside organic material has a beneficial impact on the uptake of P_2O_5. The phosphate, which attaches itself to organic matter, appears to be much more available than water-soluble phosphate locked up with iron and aluminium.

Sharper demand growth is seen for 66-68pc BPL rock, particularly in Asia and the US. This has much to do with the increasing scarcity of the higher grades of rock. The US industry has long been using rock of lower grade in its own plants, as higher grade reserves were exhausted. Mosaic have purchased rock of about 30pc P_2O_5 from OCP and Bayovar and blended the two imported rocks with its own rock to produce an acid feed. In Asia, 66-68pc BPL is fast becoming the main rock purchased for processing into phosphoric acid. It has overtaken the traditional 69-72pc range as the most traded rock grade.

2.2.2 69pc-72pc BPL Rock

The 69-72pc BPL rock was once the most commonly traded grade. It was the grade required to produce single superphosphate with a minimum 18pc available P_2O_5 content, and became the standard feed for a large part of the phosphoric acid industry.

Table 49: Supply Trends in 69pc-72pc BPL Rock				*mn t*
	1988	2012	2013	Change 1988-2013
Total	**19.82**	**5.31**	**4.94**	**-14.88**
Jordan	2.4	1.27	0.87	-1.53
Israel	1.84	0.89	0.95	-0.89
Morocco	10.98	3.01	2.99	-7.99
Senegal	-	0.15	0.14	+0.14
USA	4.58	-	-	-4.58
				— IFA

Exports of 69-72pc BPL rock are now falling rapidly. Technical innovations over the past 30 years and the cost of beneficiating rock up to 32pc P_2O_5 have contributed to greater flexibility for importers. The practice of blending rocks to produce an acid feed of suitable grade and quality is now commonplace. This sector of the merchant market is dominated by OCP and JPMC. Israel also exports to traditional customers, mainly in Europe and Asia.

About 30pc of the exports of this grade are shipped to southeast and east Asia and another 40pc to west European and Latin American markets. It is suited both to acid production and, in countries such as Argentina, to the manufacture of standard grade single superphosphate (18pc P_2O_5).

Table 50: Main Importers of 69pc-72pc BPL Rock				*mn t*
	1988	2012	2013	Change 1988-2013
Total	**19.82**	**5.31**	**4.94**	**-14.88**
West Europe	9.1	1.44	1.03	-8.07
Cen. & E. Europe	3.66	0.49	0.26	-3.4
N. America	0.62	0.06	0.16	-0.46
L. America	1.33	0.87	0.96	-0.37
West Asia	0.58	0.15	0.14	-0.44
South Asia	1.3	1.27	1.38	0.08
SE & East Asia	2.96	1.01	1	-1.96
Oceania	0.27	0.02	0	-0.27

— IFA, using IFA regional classification

2.2.3 Higher-Grades of Phosphate Rock

The IFA has two categories of higher grade rock, 73-77pc BPL and 78pc BPL and over. There is relatively little of the 73-77pc BPL sold these days and that tends to be in the 73-74pc BPL range:

Table 51: Supply Trends in High-Grade Rock				*mn t*
	1988	2012	2013	Change 1988-2013
Total	**18.88**	**5.88**	**6.73**	**-12.15**
Of which				
73pc-77pc BPL	**6.68**	**0.35**	**0.74**	**-5.94**
Algeria	0.37	-	-	-0.37
Jordan	3.09	0.35	0.35	-2.74
Israel	0.41	-	-	-0.41
Morocco	1.11	-	0.39	-0.72
Senegal	0.07	-	-	-0.07
Sweden	0.06	-	-	-0.06
USA	1.56	-	-	-1.56
78pc BPL and above	**12.2**	**5.53**	**5.99**	**-6.21**
Russia	3.21	1.6	2.19	-1.02
Sweden	0.07	-	-	-0.07
Morocco	1.48	1.91	2.1	0.62
Senegal	1.77	-	-	-1.77
Togo	2.87	1.03	1.14	-1.73
South Africa	1.27	0.41	0.19	-1.08
Nauru	1.54	0.52	0.35	-1.19
				— IFA

The main markets for the limited volume of 73-77pc BPL traded are in south and southeast Asia, principally India but also Turkey in the past. The market is generally supplied by Jordan or OCP, and the product is generally around 74pc BPL (less than 34pc P_2O_5). It is mostly used in blending with lower-grade rock to produce a regular acid feed, but can readily be replaced by other blends or grades of rock.

The market for high-grade rock of 78pc BPL and above is dominated by two end-uses: nitrophosphate fertilizers and a variety of technical phosphate products. In the 1980s, western and central Europe took over half of global shipments. The following table shows the distribution of imports of the highest grades of rock:

Table 52: Main Importers of High-Grade Rock (≥78pc BPL)				mn t
	1988	2012	2013	Change 1988-2013
Total	**12.2**	**5.53**	**5.99**	**-6.21**
West Europe	2.97	0.84	0.97	-2
Cen. & E. Europe	3.31	1.76	1.98	-1.33
N. America	1.23	0.37	0.85	-0.38
L. America	0.05	0.48	0.48	0.43
Africa	-	0.05	0.01	0.01
West Asia	-	0.03	0.03	0.03
South Asia	0.45	1	0.8	0.35
East Asia	0.97	0.37	0.25	-0.72
Oceania	1.98	0.67	0.6	-1.38
Various	1.27	-	0.01	-1.26

— IFA, using IFA regional classification

Once again, it is the industrialised countries of Europe, North America and east Asia that have experienced decline. Australasia continues to import some high-grade rock, principally for use in 20pc P_2O_5 single superphosphate manufacture. In the case of Canada, Togo rock was the main feed for the Redwater phosphoric acid plant in 1988, but since 2013 it has been replaced by imports from OCP.

2.2.4 The Current Market

The market returned to a degree of stability in 2011 and 2012, following the problems created by the global economic slump of 2009. OCP has once again adjusted production to meet rising demand. The following table shows export deliveries by grade in 2013 and highlights those major exporters shipping +1mn t of rock of all grades:

Table 53: Export Deliveries by Grade - 2013						mn t
	All Grades Total	65pc BPL And below	66pc-68pc BPL	69pc-72pc BPL	73pc-77pc BPL	78pc BPL And above
Total Exports	**26**	**5.38**	**8.95**	**4.94**	**0.74**	**5.99**
Of which						
Russia	2.19	-	-	-	-	2.19
Egypt	2.42	2.17	0.25	-	-	-
Peru	3.54	-	3.54	-	-	-
Morocco	8.6	1.43	1.69	2.99	0.39	2.1
Algeria	1.07	0.73	0.34			
Jordan	3.24	-	2.03	0.87	0.35	-
Syria	0.78	0.64	0.14	-	-	-
Subtotal	**21.84**	**4.97**	**7.99**	**3.86**	**0.74**	**4.29**
pc of Total	**84pc**	**92pc**	**85pc**	**78pc**	**100pc**	**72pc**
Others	**4.16**	**0.41**	**0.96**	**1.08**	**-**	**2.29**
pc of Total	**16pc**	**8pc**	**15pc**	**22pc**	**0pc**	**28pc**

— IFA

The recovery of the market after the 2009 slump simply emphasises the trends which we have identified in the above analysis:

- The market is becoming more concentrated in the hands of seven major players, which together account for 84pc of all export deliveries;
- The lowest grade material (≤65pc BPL) is supplied mainly by Syria, Egypt and Algeria (730,000t). We note that OCP was also competing in this market over 2013, with 1.4mn t of below 65pc BPL rock exported;
- The 66-68pc BPL grade is the point at which those with lower grade ore and OCP and JPMC do compete. In 2013, the two major producers accounted for less than 50pc of deliveries in this category, while Peru alone accounted for 40pc of it. This grade of rock is now the main product in the market for wet-process acid-grade use;
- In the higher grade 69-72pc BPL category, Jordan and Morocco account for 78pc of deliveries. Availability elsewhere continues to decline;
- The 73-77pc BPL grade is gradually disappearing. It accounts for just 2.8pc of global rock exports, down from 3.5pc in 2010. The sole suppliers in 2013 were JPMC and OCP;
- The high-grade category (≥78pc BPL) is dominated by OCP and Apatit (Phosagro, Russia), which account for about three-quarters of trade material. The remaining exporters — Togo, Nauru and South Africa — are in decline as exporters. Although technical problems caused by lack of regular maintenance at Foskor's Richards Bay ammonium phosphate complex may free up rock for export until repairs and upgrades are complete. We saw less South African rock in the European market in 2013 in comparison with 2012. Phosagro's investment in a new shaft and underground mine (largely replacement capacity) and the opening of a new mine by Acron should result in a Russian export capability of 2mn t/yr, assuming that today's levels of domestic deliveries to competitors remain stable.

We conclude this section by presenting a trade matrix for 2013, which describes in greater detail the points arising from the above analysis:

Table 54: Phosphate Rock Trade Matrix, 2013 *'000t product*

Importer	Russia	Algeria	Egypt	Morocco	Togo	Tunisia	Finland	Israel	Jordan	Syria	Peru	Vietnam	China	Christmas Island	Nauru	Other	Total
World Total	**2,186**	**1,070**	**2,415**	**8,602**	**1,143**	**31**	**-**	**946**	**3,241**	**779**	**3,539**	**114**	**358**	**557**	**347**	**666**	**25,993**
West Europe	**1,771**	**646**	**263**	**1,817**	**292**	**9**	**-**	**359**	**149**	**427**	**-**	**-**	**-**	**-**	**-**	**184**	**5,917**
Belgium	485	30	-	437	-	-	-	-	-	-	-	-	-	-	-	21	974
Lithuania	788	-	-	367	187	-	-	-	-	-	-	-	-	-	-	-	1,342
Netherlands	-	-	-	-	-	-	-	202	-	-	-	-	-	-	-	27	229
Norway	407	-	-	273	-	-	-	-	-	-	-	-	-	-	-	-	680
Poland	-	393	162	143	23	-	-	56	-	89	-	-	-	-	-	50	915
Spain	-	12	8	149	-	-	-	27	-	-	-	-	-	-	-	46	242
Other	91	210	93	448	82	9	-	75	149	338	-	-	-	-	-	41	1,536
EECA	**415**	**271**	**21**	**547**	**-**	**11**	**-**	**-**	**-**	**124**	**-**	**-**	**-**	**-**	**-**	**254**	**1,643**
Belarus	415	17	-	-	-	-	-	-	-	37	-	-	-	-	-	0	469
Turkey	-	72	5	485	-	11	-	-	-	18	-	-	-	-	-	8	600
Ukraine	-	158	16	46	-	-	-	-	-	68	-	-	-	-	-	-	288
Other	-	25	-	16	-	-		-	-	-	-	-	-	-	-	246	286
Africa	**-**	**-**	**1**	**7**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**32**	**39**
North America	**-**	**-**	**0**	**2,546**	**-**	**-**	**-**	**-**	**-**	**-**	**986**	**-**	**-**	**-**	**-**	**-**	**3,532**
Canada	-	-	-	318	-	-	-	-	-	-	-	-	-	-	-	-	318
United States	-	-	0	2,228	-	-	-	-	-	-	986	-	-	-	-	-	3,214
Latin America	**-**	**118**	**30**	**1,326**	**51**	**-**		**44**	**-**	**-**	**1,318**	**-**	**-**	**-**	**-**	**58**	**2,944**
Mexico	-	-	-	533	-	-	-	-	-	-	267	-	-	-	-	-	800
Brazil	-	105	30	484	-	-	-	44	-	-	888	-	-	-	-	58	1,608
Other	-	13	-	310	51	-	-	-	-	-	163	-	-	-	-	-	537
Middle East	**-**	**-**	**1**	**173**	**-**	**-**	**-**	**-**	**-**	**214**	**-**	**-**	**-**	**-**	**31**	**0**	**419**
Lebanon	-	-	-	173	-	-	-	-	-	214	-	-	-	-	-	-	387
Other	-	-	1	-	-	-		-	-	-	-	-	-	-	31	-	33
South Asia	**-**	**35**	**1,297**	**1,276**	**671**	**-**	**-**	**318**	**2,507**	**-**	**914**	**-**	**-**	**-**	**22**	**52**	**7,092**
Bangladesh	-	-	-	82	-	-	-	-	33	-	-	-	-	-	-	-	115
India	-	35	1,297	907	671	-	-	318	2,474	-	914	-	-	-	22	48	6,685
Pakistan	-	-	1	287	-	-	-	-	-	-	-	-	-	-	-	5	292
SE Asia	**-**	**-**	**719**	**479**	**-**	**-**	**-**	**127**	**387**	**-**	**199**	**-**	**1**	**529**	**-**	**5**	**2,445**
Indonesia	-	-	454	242	-	-	-	-	387	-	162	-	-	235	-	-	1,480
Malaysia	-	-	239	-	-	-	-	-	-	-	37	-	-	294	-	5	575
Philippines	-	-	22	237	-	-	-	127	-	-	-	-	1	-	-	-	387
Other	-	-	4	-	-	-		-	-	-	-	-	-	-	-	-	4
East Asia	**-**	**-**	**-**	**50**	**81**	**-**	**-**	**98**	**177**	**-**	**-**	**23**	**329**	**-**	**137**	**37**	**931**
Japan	-	-	-	49	-	-	-	3	93	-	-	23	161	-	13	34	376
Korea South	-	-	-	-	81	-	-	58	-	-	-	-	168	-	124	-	430

Table 54: Phosphate Rock Trade Matrix, 2013 *'000t product*

Importer	Russia	Algeria	Egypt	Morocco	Togo	Tunisia	Finland	Israel	Jordan	Syria	Peru	Vietnam	China	Christmas Island	Nauru	Other	Total
Other	-	-	-	1	-	-	-	38	84	-	-	-	-	-	-	3	125
Oceania	**-**	**-**	**41**	**382**	**48**	**10**	**-**	**-**	**21**	**-**	**123**	**92**	**28**	**28**	**157**	**32**	**962**
Australia	-	-	23	66	-	-	-	-	21	-	115	-	0	28	102	-	354
New Zealand	-	-	18	317	48	10	-	-	-	-	8	92	28	-	56	32	608
Unspecified	**-**	**-**	**43**	**-**	**-**	**-**	**-**	**-**	**-**	**14**	**0**	**-**	**-**	**-**	**-**	**12**	**68**

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Again the matrix confirms the analysis of recent trends:

- The majority of Apatit's high-grade exports are destined for Europe. In western Europe the main customers are nitrophosphate plants in Norway (Yara) and Belgium (Prayon and Eurochem's Antwerp plant) plus industrial users. Eurochem's share (36pc of Russian rock exports) mostly goes to its Lithuanian plant Lifosa, while the Gomel plant in Belarus took up to 19pc of Russian exports in 2013 for the production of phosphoric acid-based ammonium phosphates;

- In terms of low-grade rock, the other significant supplier of rock to Europe is Algeria, which mainly supplies material for compaction and co-granulation;

- In respect to the two main acid-grade rocks 66-68pc BPL and 69-72pc BPL, the major exporter, Morocco, demonstrates its swing status by exporting to all regions. Its main export market in 2013 was North America, following the signing of a contract with Agrium for the supply of 1mn t/yr of rock. OCP's second largest market has been western and central Europe, but its share of the Belgium market has reduced, following an increase in Russian product. OCP's third-largest market is India, where a large part of shipments go to the Paradeep phosphate complex. The only area in which OCP does not have a major presence is southeast and east Asia, as the logistics are less favourable. Southeast Asia takes large quantities of low-grade Egyptian rock for direct application, as this is more suitable for its large plantation sector.

Section 3: The Phosphate Rock Market
Chapter 2: The Merchant Market

2.3 Rock Quality

The P_2O_5 content of rock is clearly of importance to the merchant rock market. Shipping of 29pc P_2O_5 content rather than 32pc P_2O_5 content rock adds approximately 10pc to all the handling and shipping costs per tonne of nutrient. It is also significant for processing, as it reduces the output of acid or nitrophosphate solution from a plant because most handling systems, crushers, reactors and filters will generally have been designed to take a 32pc P_2O_5 rock feed. For those with gypsum disposal problems, the generation of phosphogypsum will be increased per tonne of rock used. Gypsum production is related directly to the $CaO:P_2O_5$, ratio, which will tend to be higher in lower grade rock because of the presence of other calcium salts, such as calcium carbonate. The volume of gypsum waste is also increased if the rock contains high percentages of insoluble silica. The following examples serve as illustrations:

- A high-grade igneous rock with a CaO: P_2O_5 ratio of 1.34:1 will generate 4-4.4t of gypsum per tonne P_2O_5;
- A low-grade sedimentary rock with 31pc P_2O_5 and a CaO: P_2O_5 ratio of 1.55:1 will generate 5-5.5t of gypsum per tonne of P_2O_5;
- In the case of the IPL plant in Australia, where the rock is 40pc silica, the generation of gypsum is also 5t per tonne P_2O_5.

These factors will be calculated into the price of the rock being shipped, as is discussed later in the report.

The P_2O_5 content of rock is not the only critical factor in establishing its desirability and value. The variety in the chemical make-up of mineral ore bodies containing phosphate brings with it a whole range of other minerals, metals and chemical compounds, which impact on the properties of the various “phosphate rocks” that are produced from the ore. Some of the unwelcome constituents — regarded by the industry as impurities — can be removed from the ore by beneficiation techniques. But in some cases beneficiation designed to increase the P_2O_5 content of rock may not increase the concentration, but increase the ratio of the impurity to phosphate. An even greater problem is the risk of reducing P_2O_5 recovery. For example, at Araxa in Brazil the concentration of rock reduces the content of magnesium, iron and aluminium, which is present mainly in the form of phosphates — with the result that the overall recovery of P_2O_5 may be reduced from a maximum of 62pc to lower than 50pc.

On the other side of the coin, some phosphate-containing minerals are found in combinations with other minerals which have commercial value. The most common co-product is the iron compound magnetite, which is usable as an iron ore. As previously discussed, in the case of Russia, nepheline is produced as a co-product from the Apatit mines. In South Africa, phosphatic ore bodies are exploited principally for their copper and/or zirconium content and phosphate rock is a by-product. Currently, phosphate rock is being considered as a co-product in projects for rare earths, niobium and uranium production. For example, ore body at Araxa contains both phosphate and niobium, as do a number of apatite projects in Canada.

In the following sections we will examine two major aspects of rock quality:

- Reactivity of rock, both as a direct application fertilizer and in respect of its suitability for processing;

- The impact of unwelcome components, which will be referred to as “impurities”, on the processing of rock into phosphoric acid and subsequently into fertilizer products.

2.3.1 The Reactivity of Phosphate Rock

As prices for acidulated P_2O_5 have risen from the depressed market of 1975-2004, farmers have started to look for cheaper sources of phosphate fertilizer. Demand for rock used in this way has shown significant growth. “Reactive phosphate rock” is the term normally used for phosphate rocks which are effective in their own right when applied directly to the soil without any prior chemical processing. But they are only effective under certain soil and climatic conditions:

- Soil pH of less than 6.5;
- Annual rainfall minimum of 600mm to 800mm;
- Soil temperature minimum of 10°C.

There are three main sources of phosphate rock which have long been recognised as being highly reactive — Bayovar (Vale), Gafsa (GCT) and North Carolina (PCS - Aurora). The reactivity is based on the isomorphic substitution of the (PO4)3-ions in the apatite crystal lattice by (CO_3)2-ions. To maintain ionic neutrality there is also a substitution of Ca_2+ by Na+. These changes cause measurable distortions in the crystal structure. The agronomic efficiency is correlated to the degree of the distortion. In short, the distortion in the crystal structure weakens the chemical bonds which otherwise prevent the P_2O_5 from being released to the soil in a form that plants can absorb.

To be available for absorption by crop plants, any phosphate applied to the soil must dissolve at least partially in the soil solution. The chemical make-up of the soil solution and the phosphate-dissolving characteristics vary according to local pedology and climate. In the agriculturally advanced regions of the northern temperate zone, soils are predominantly calcareous and the soil solution is neutral or slightly alkaline — although in the past it was affected by acidic rainfall, which resulted in a requirement for liming. For maximum effect, the phosphate content of any fertilizer applied should ideally be water soluble. But even when there is a water insoluble component, it may be at least partially plant available because of humic acids and other constituents of the soil solution. This is emulated in laboratory tests using a solution of ammonium citrate that is buffered to be neutral or slightly alkaline as the case may be. Properly speaking, the citrate-soluble portion of a fertilizer’s phosphate content is the proportion of the total (expressed as a percentage) that does not dissolve in water but does dissolve in ammonium citrate, but often the water soluble component is included to give an overall indication of the plant-available phosphate.

In most tropical and sub-tropical regions, the soils are much more acidic and the ammonium citrate buffer solution is inappropriate. The best reagent for measuring the available phosphate content of reactive phosphate rocks is 2pc formic acid, although citric acid can also be used. Because there is essentially no water soluble phosphate in phosphate rock, the formic (or citric) acid soluble portion represents the total plant-available phosphate content. Although this may be quite a small proportion of the total phosphate content, in many cases there would be little or no benefit from having a water soluble content as high concentrations of phosphate in the soil solution react with the iron and aluminium compounds in the soil to form very insoluble phosphates and are thus rendered unavailable to the crop.

In general, reactive rocks are applied to tree and bush crops — oil palm, rubber or tea — as a background application of phosphate which may be topped up with water soluble phosphate during critical periods of the fruiting cycle. It is not particularly well-suited to crops with short growing periods, such as vegetables or rice. In all cases reactive rock works only in acid soils.

The Bayovar operation sells a significant proportion of its rock specifically for direct application as the concentrate is not always suitable for use as a sole-acid feed. When used for acid production, it has to be blended with other rocks. The availability of the most reactive material, Gafsa, theoretically amounts to 1.5mn t/yr. In practice, growing requirements for downstream acid production and disruption to production are limiting the volume sold as direct application material much less than that amount — about 30,000t in 2013. PCS does not market North Carolina phosphate rock as a direct application product, requiring all output for internal processing into merchant grade acid, ammonium phosphates and animal feed.

A second group of phosphate rocks, with high solubility in citric and formic acids is also sold for direct application:

- Arad, Israel
- Daoui, Morocco
- Djebel Onk, Algeria

With the limitation in the availability of reactive rocks from Gafsa and Bayovar, they are being exported in increasing quantities.

Recently, OCP launched a range of highly reactive rock products (the Terractive range), based on ore mined in Benguerir. The straight rock product has an average of 22pc P_2O_5, 43pc CaO and 5pc S.

There is a third category of rock which is finding increasing use in the unprocessed form. These are rocks with a minimum 27pc P_2O_5 content and a minimum 7pc citric acid soluble P_2O_5 content. Such rocks do not display particular reactivity but, in quality and price, they appear to be suited to the fast-growing plantation sectors in southeast Asia.

Traditionally, Egyptian Red Sea ground phosphate rock was exported as direct application material. Recently, other Egyptian rock, for example from Abu Tartour, has been exported, along with low-grade rock from a variety of other sources such as China and Vietnam. These latter two countries have also developed a granular phosphate rock for use in blends. Since its high-grade rock exports were terminated, Christmas Island has also developed a blend suitable for direct application in the southeast Asian market. Some low-grade rock is also available locally in Indonesia and elsewhere in southeast Asia, where guano and guano-based rocks are available — but in very small volumes. In Indonesia, some rock is ground and mixed with a small quantity of sulphuric acid to produce a form of partially acidulated phosphate rock (PAPR), which can be granulated for use in blending. Small volumes are used in single superphosphate manufacture. A higher grade (and effective) PAPR was developed by B Quinn in New Zealand, and uses a reactive rock and 50pc of the phosphoric acid used in the production of TSP, currently produced by Ballance Fertilizers.

A number of rock sources in Africa are being exploited on a small scale for local use — for example, the Mingingu phosphate from Tanzania. This is one of several reactive rocks in Sub-Saharan Africa, which often occur in a single seam in ore bodies, where the other seams are less reactive. There is also a small-scale operation in Malawi. Most phosphate rocks also contain calcium, which is a limiting factor in African agriculture and has a value as a secondary nutrient that may or may not be recognised in pricing. In global terms, this type of locally used phosphate rock is not significant. But in Africa, it represents a promising innovation in countries that do not have access to high-grade imported fertilizers.

Igneous versus Sedimentary Rock

The reactivity of phosphate rock is also an important factor in its performance in processing, sedimentary rock being more reactive than igneous material, which is metamorphic in origin. The key difference between sedimentary and igneous phosphate involves a simple physical characteristic — surface area. Sedimentary rock is a loose consolidation of discrete, mostly fine-grained particles, which largely separate from each other during grinding and processing, presenting a very large overall surface area upon which reaction can take place. Igneous rocks, as their name suggests, were formed under conditions which led to fusion and vitrification. Even after milling, the particles are not friable and the specific surface area is nothing like as high as that of a sedimentary rock milled to a comparable degree. Rock reactivity is measured using surface areas and density, for example:

- Gafsa rock has a surface area value of 19.4 m^2/g and an apparent density of 2.76 g/ml;
- Apatite has a surface area value of 0.6 m^2/g and an apparent density of 3.19 g/ml.

The practical effects of surface area on reactivity are as follows:

- For superphosphates manufacture, igneous phosphates have to be ground more finely than sedimentary rock: 85pc passing 44 microns, as against 85pc passing 75 microns for sedimentary rock;
- In phosphoric acid manufacture, igneous rocks need a lower free sulphate level (approximately 2.0pc) in the reactor. Sedimentary rocks need a free sulphate level of about 3.3pc.

All igneous phosphate ores are more complex to beneficiate, with several stages of milling followed by several stages of froth or column flotation. It is possible to take a run-of-mine feed with 4.2pc P_2O_5 and produce a concentrate of 36pc P_2O_5 with an 84pc P_2O_5 recovery. Normal sedimentary ores are crushed, screened, and washed and attrition scrubbed to remove the clays. They may pass through hydrocyclones and/or a spiral conveyor before filtration.

In consequence, there is a significant difference in the investment levels required to exploit these two types of ore bodies. The investment cost for beneficiating igneous rock is double that of beneficiating sedimentary rock. But, as rock grades fall, sedimentary ore producers are increasingly being forced to use flotation to make even 27-28pc P_2O_5 concentrate. The exception is those ore bodies where the impurity is quartz and the phosphate rock is destined for use in phosphoric acid production, as the silica collects on the phosphoric acid plant filter and is removed in the phosphogypsum.

2.3.2 Impurities Affecting Rock Quality

We list below some of the factors which influence the suitability of a rock for phosphoric acid manufacture. Some of these also apply to downstream products based on phosphoric acid.

Carbonates: Carbonates are present in phosphate rock mainly as calcium carbonate and, to a lesser extent, as magnesium carbonate. The main impact of carbonates in the production of phosphoric acid is to increase the consumption of sulphuric acid and, in the presence of organic material, to create a stable foam in the reactor. Expensive anti-foaming agents are necessary to counteract the foaming problem and the net result is to increase losses of P_2O_5. Such problems are encountered when processing rock from North Carolina, Tunisia, Mexico and Bayovar.

The relative content of carbonates is generally expressed as a ratio between CaO and P_2O_5. The following table shows the impact of high CaO:P_2O_5 rates on sulphuric acid consumption

Table 55: Carbonate Content and Sulphuric Acid Use

	CaO: P_2O_5	H_2SO_4 Use per tonne P_2O_5
Kola (Russia)	1.29	2.5
Central Florida	1.50	2.9
OCP (Morocco)	1.60	3.1
Gafsa (Tunisia)	1.66	3.4

Magnesium: While low concentrations of magnesium (less than 0.5pc) reduce corrosion by chemically binding fluorides, a higher level (0.8pc or more) increases acid viscosity and reduces filtration rates. Magnesium presents itself in two distinct forms — the acid soluble carbonate, normally derived from dolomitic limestone, which is responsible for most of the negative effects; and silicates, which are much less soluble and consequently have less impact on processing. As the rock reserves in central Florida become depleted and mining moves further south, high magnesium levels have become an issue for the Florida industry. This problem also affects Jacupiranga and Tapira rocks in Brazil, many Chinese rocks and Foskor (South African) phosphate rock. As the above analysis shows, much of the phosphate rock being considered for exploitation in Saudi Arabia, Kazakhstan, China and Vietnam contains relatively high levels of magnesium. Removal of magnesium is difficult — various types of selective scrubbing are used and, more recently, selective flotation.

A high level of magnesium in phosphate rock can make it difficult to achieve an ammonium phosphate product with sufficient nitrogen content (DAP: 18pc N; MAP: 11pc N). There have been a number of instances, for example, in eastern Europe, and currently in Vietnam and China, where producers simply produced an “off-spec” ammonium phosphate such as 16-48-0 or 10-44-0. Many purchasing countries have official specifications within their fertilizer and tendering regulations, with the result that irregular formulations are not permissible. But we expect such rigidity to disappear as more “mini-DAP and mini-MAP” enter the market at prices appropriate to their nutrient content.

Aluminium: Aluminium has similar effects to those of magnesium in terms of phosphoric acid manufacture. At levels above 1.5pc it increases the viscosity of the acid and reduces the water solubility of P_2O_5.

Sodium and Potash: Both create increased scaling due to the formation of fluosilicates and increase post-precipitation solids (solids which form during the storage of the product acid).

Iron Compounds: At high levels, (1.5pc or more), iron oxide reduces water soluble P_2O_5 in the product acid and, in the presence of potash, greatly increases post-precipitation solids. For example, high levels of pyrites in New Valley phosphate rock in Egypt affect both water-solubility and colour, producing a black acid.

Fluorine and Chlorine: Both increase corrosion rates. Chlorides are the greater problem since they are not neutralised by complexing, while fluorides are complexed by both aluminium and magnesium.

- Rock with less than 200ppm Cl is classified as low-chloride, for example in Florida, North Carolina, Araxa, Jacupiranga and Siilinjarvi.
- Rock with 200-500ppm Cl is classified as medium-chloride, for example in Morocco and Jordan.
- Rock with around 600-1,000ppm Cl is regarded as borderline to high-chloride, for example in Tunisia, South Africa, Togo and some Syrian grades.
- Rock with 1,000-2,000ppm Cl is classified as very high. Examples are Israel, Syria and the chlor-apatites being mined or considered for mining at Eppawala, Sri Lanka and Evate Mozambique. Much of the Bayovar output is also in this category.

The processing of the high and very high-chloride rocks into phosphoric acid requires the use of expensive materials in vessels and piping to avoid excessive corrosion. This may be in the form of special grades of stainless steel, plastic or even glass. As such, this type of rock is generally not traded as acid feed material — although in some instances it is blended with low-chloride rock to reduce costs.

Sulphides: Free sulphides are normally found only in rock which has been beneficiated by calcining (heating to high temperatures), which is an expensive beneficiation route given current energy costs. Free sulphides greatly increase corrosion as well as releasing hydrogen sulphide, which is a poisonous gas. These problems have been encountered in phosphate rock in both the Western US and the Carolina deposits. They are controlled either by increasing the level of aeration and using a foam-breaking agitator in the reactor (this method was used at by Simplot at its Pocatello site) or by adding an oxidising agent such as potassium permanganate or hydrogen peroxide.

Strontium: Strontium presents a problem only when it is in soluble form, in which case it dramatically and adversely affects the performance of evaporators by forming a scale of strontium sulphate. It also adversely affects the working of the hemihydrate-dihydrate phosphoric acid process by impairing the formation of proper crystals of dihydrate gypsum. In several igneous phosphate rocks, strontium is present with barium sulphate to the extent of 3-5pc, which slightly increases the volume of phosphogypsum produced. Brazilian phosphate rock from Catalao contains 2.7pc strontium and barium sulphates.

Silica: There are two types of silica:

- Reactive silicates of iron, aluminium and magnesium which, in low concentrations, help to chemically bind fluorides, although they cause scaling in the presence of sodium and potash. In the manufacture of single and triple superphosphate, a high reactive silica content increases the release of fluoride gases. For wet-process phosphoric acid production, a maximum of 3pc of reactive silica is used, although it depends on the levels of aluminium and magnesium present;

- Inert silica (quartz) in any concentration accelerates abrasion in agitators and pumps. At high levels, inert silica (quartz) significantly increases the amount of gypsum produced and makes it unsuitable for certain uses such as plaster board. There are examples of high-silica rock being used for acid manufacture, although beneficiation is expensive and results in significant losses of P_2O_5. The phosphate rock in Australia has a P_2O_5 content of 22-23pc and a SiO_2 content of more than 30pc (equal to 40pc quartz content). Recieto rock in Venezuela contains 29pc P_2O_5 and 24pc SiO_2. Once again it is noted that the higher-grade Indian rock in Rajasthan has not been used in phosphoric acid production to date, mainly because of the hard silica matrix.

Organic carbon: Traces of organic carbon can cause foaming and produce foul odours during acidulation. All traces of carbon need to be removed from the phosphoric acid if it is to be purified for technical and clear liquid fertilizer use.

We have listed the main impurities, which can adversely affect the processing of rock to provide plant-available P_2O_5. To this we add a number of impurities which affect either the saleability of the fertilizers produced or the manufacture of specific products:

Cadmium: Over the past two decades, cadmium has emerged on the agenda as a potential health issue. In Europe, in particular, there is a continuing debate as to the safe limit for cadmium in fertilizers. The concern over relatively low levels of cadmium will continue to affect phosphate rock and acid for processing into fertilizers and finished phosphate fertilizers. When processing cadmium containing-rock, the proportion which passes into the acid and to finished fertilizers depends on the process used. In the dihydrate wet-acid process 75-90pc of the cadmium passes into the acid, while in the hemihydrate process this amounts to about 50pc. The only proven way to remove cadmium from rock is calcination, which is expensive and also produces a highly toxic waste with a high level of cadmium.

The rocks with the lowest cadmium levels are of igneous origin, which generally have less than 10ppm cadmium. Medium cadmium content is considered to be 10-35ppm. This includes many of the most commonly traded rocks, for example, OCP Khouribga, Ben Guerir, and Jordanian grades. Rocks at the upper end of the medium limit are generally not sold in Europe. High cadmium-content is considered to be above 35ppm, for example, Senegal (70ppm), Nauru (up to 100ppm) or Togo (60ppm). As the earlier analysis shows, not all deposits in one country will have the same cadmium content — it depends on the type of mineralisation. For example, there are some lower cadmium rock deposits in Senegal.

Water solubility: Many countries stipulate levels of acceptable water solubility of the phosphate content of fertilizers. As we have noted above, some impurities such as iron compounds can reduce the water solubility of the processed phosphate product. The value of high water solubility of P_2O_5 is sometimes disputed by agronomists as an absolute requirement in all circumstances. Umbrella regulations that sometimes apply may require a water solubility level (plus 90pc), which may not be strictly necessary in some acidic soils and on some crops (for example, shrub and tree crops). Whatever the agronomic arguments in specific conditions and specific crops, there is a general preference for a high degree of water solubility for fertilizers used on annual crops with relatively short growth periods.

Producing DAP: With the exception of PCS in North Carolina, none of the other key US producers can make 18-46-0 without the addition of a secondary nitrogen source, normally urea. This is because the increasing levels of impurities in the phosphate rock are transferred into the phosphoric acid. The iron, aluminum, magnesium and all the other transition elements are present in the phosphoric acid, essentially as water insoluble phosphates. One way of evaluating the rocks and acid is to calculate the "MER" Ratio.

This is calculated as follows:

$\%(Fe_2O_3 + Al_2O_3 + MgO) \div \% P_2O_5$

It is generally considered that, if this ratio is greater than 0.08:1.0, it is difficult to produce 18–46–0. This ratio is a simplification as it does not include all the other transition metal impurities. These impurities generate a condition where there are different types of water soluble phosphates present in the acid:

- H_3PO_4, which can be ammoniated to Molar Ratio (MR), $N:P_2O_5$ = 1.80:1 without excessive ammonia losses in the granulator
- $Ca(H_2PO_4)_2$, which can only be ammoniated to MR 0.5:1
- $Mg(HPO_4)_2$, which can also only be ammoniated to MR, 0.5:1
- $FeHPO_4$, $AlHPO_4$ can also only be ammoniated to M.R. 0.5: 1

Phosphates with P_2O_5 insoluble in water but soluble in citrate (NAC) can only be ammoniated to an MR of 0.5: 1.

Table 56: Characteristics of Various Phosphate Rock

	Central Florida	Togo	OCP/Israel
MER ratio	0.11	0.07	0.03
Acid Analysis (P_2O_5)	54pc	54pc	54pc
SCAN	52.5pc	53.2pc	53.7pc
Water solubility (P_2O_5)	51pc	52.7pc	53.2pc
Mole ratio for DAP	1.95	1.77	1.72

The higher the molar ratio used, the greater the "slip" of the ammonia to the granulator scrubber. For example, a pipe reactor which was installed on the diammonium phosphate plant in a Florida plant had to be removed, as the ammonia losses from the granulator were so high that the scrubber solidified six times in the first nine months of operation. This in part accounts for the introduction in the US of products such as 10-50-0, and a growing production of monoammonium phosphate.

There are problems with the addition of urea, mainly which point to add it:

- In the acid – which causes foaming and makes pumping difficult;
- In the granulator – which results in poor distribution because of the small quantity required and can lead to a very large recycle;

- As a liquid sprayed onto the granules in the cooler — which increases moisture pick-up in the product and can cause caking.

Rocks containing the impurities which make diammonium phosphate production difficult are found in North America, Togo, South Africa, Egypt, China, Saudi Arabia, Vietnam, Australia and Kazakhstan, Uzbekistan

2.3.3 Main implications on the merchant market

We conclude this section by briefly describing the practical implications arising from the characteristics of the main traded rocks:

- OCP rock generally has no significant processing limitations in wet-process phosphoric acid or nitrophosphate production, although some odour problems were recently reported with the 66-68pc rock during acidulation. OCP rock is more corrosive than the Florida rock and care needs to be taken in those old units which were designed to process the latter. Currently, OCP offers seven grades/qualities of rock, ranging from 64.5-66pc BPL from Khouribga to 78.12-80.20pc BPL produced at the smaller Boucraa mine. Boucraa rock is a preferred feed in the production of superphosphoric acid and purified phosphoric acid. It is also used in Australia and New Zealand in the production of 20pc P_2O_5 single superphosphate. Its downside is its cadmium content of around 35ppm. The cadmium content of Khouribga rock is generally around 20ppm and for this reason lower-cadmium Ben Guerir rock (71-72pc BPL) is shipped to the European market;

- Jordanian rock is mainly sold to Asia, where it is used in phosphoric acid manufacture, often as a mixture of 73-74pc BPL and 66-67pc BPL. Initially, JPMC sold the pure high-grade rock which produced an acid that was too pure, making downstream solid products difficult to granulate. There are no major problems with this rock except for the medium levels of chlorides (350-500ppm) and the generation of odour in the acidulation step in phosphoric acid manufacture;

- Syria produces a number of grades of rock, the most concentrated of which is 68pc BPL. The main problem with the rock is high chlorides content (product specifications suggest 1,500-2,000ppm for their standard material). When used in phosphoric acid manufacture, Syrian rock is generally blended with other rocks to reduce chloride levels. It also has a medium magnesium content (0.4-0.7pc MgO), which makes dilution desirable. It has a low cadmium content of about 5-7pc ppm;

- Tunisian rock is now rarely traded as a feed for phosphoric acid manufacture because of a number of impurities:

    - Medium to high chloride levels (600-800ppm);
    - High organics and carbonates, causing stable foam formation and a need for additives to improve filtration;
    - Problems of odour release during acidulation;
    - The rock is very reactive and not well suited to blending with other rocks as an acid feed;
    - Medium cadmium-content (30 -35 ppm).

- Russian rock has the highest P_2O_5 content of any traded material, with a minimum 39pc P_2O_5 (85pc BPL). It is shipped to Belarus and Lithuania for phosphoric acid manufacture, Norway (Yara) for nitrophosphate production, and Belgium (Prayon) for purified acid production. The rock has a low CaO: P_2O_5 ratio and very low heavy metals. The only downside is that its low reactivity means it is not suited to blending with sedimentary rocks;

- Egyptian and Algerian rock generally have a low BPL (<69pc) and a high Bond Index (representing the hardness of the rock and the kWh/t required to grind it). Algerian rock has a medium cadmium content (25 30ppm). These rocks are generally blended with higher grade rock for use in phosphoric acid production. The exception is the more reactive Djebel Onk rock. Attempts to use Egyptian rock by itself in Indian plants were quickly discontinued;

- Israeli rock is sold to a handful of established markets. The majority of the material is used in blended feeds for phosphoric acid and single superphosphate production. Additionally Arad rock is being marketed for direct application:

    - The majority of west European product is shipped to ICL's own operations in the Netherlands and Germany. The Police plant in Poland also takes a small tonnage. The Amfert tonnage is generally mixed with Algerian material for single superphosphate production as Israeli rock alone produces soft granules;
    - Exports to India are blended with other low-grade rocks to produce single superphosphate with a 16pc P_2O_5-content.

    Israeli rock demonstrates a number of problems:

    - It has medium to high levels of chlorides; (1,000 -1,200 ppm);
    - Granular products have low hardness due to the very low magnesium and aluminium-content. In ICL's Dutch subsidiary it is blended with Jordanian rock to improve granule hardness;
    - It has a very high CaO and CO_2 content which results in high sulphuric acid consumption during acidulation and excessive heat release during the production of phosphoric acid.

- Togo rock has a high P_2O_5 content (35.5pc) but also high cadmium (60ppm) and high aluminium. It is mixed with Phalaborwa igneous rock. The high aluminium level improves filtration at the Richards Bay acid plants. It also compensates for the high magnesium level in the phosphoric acid which was making the production of diammonium phosphate difficult using only Phalaborwa rock. Exports to India and Brazil are possible as a result of the liberal cadmium limits applied in these countries;

- Bayovar is a 64-65pc BPL material and exhibits similar problems to Tunisian rock — a high chloride content (but without the odour problems) and unsuitability for mixing with some rocks because of its high reactivity. US imports are understood to be mixed with a minimum of 10pc Florida rock, or more often 30:70 to provide a suitable feed for the phosphoric acid units there. Relatively high organics content results in the production of a stable foam;

- Nauru rock has a high P_2O_5 (37pc) and cadmium (70-100ppm) content. It is blended with other rocks in New Zealand and Australia in the manufacture of 20pc P_2O_5 single superphosphate. In Asia, it is blended with other rocks as an acid feed. The rock has a significant proportion of larger grains (+20pc) which makes feeding the crushing mills difficult as ring roller mills and ball mills are normally fed through rotary valves which have very small clearances;

- Originally, there were three grades of Christmas Island rock. The highest, “A” grade, was a conventional calcium phosphate but has depleted. Grades “B” and “C”, are aluminium phosphates and are unsuitable for acidulation. If they are calcined and finely ground they can be used for direct application, but their efficiencies are less than the highly reactive rocks;

- Chinese and Vietnamese rock exports are of various qualities and generally have high magnesium content, but their availability is declining. Vietnam stopped exporting in 2012 when the government imposed an export ban. It was lifted in 2013 but could be re-imposed. Both are very variable, as a result of lack of process control during the beneficiation processes, as well as a lack of interest on the part of the seller to invest in quality control.

Section 3: The Phosphate Rock Market
Chapter 3: Outlook for Merchant Rock

What has emerged from the analysis of grade and quality is that the generic term "phosphate rock" is fairly misleading. The market for rock is fragmented into specialist sectors:

Single superphosphate
Secondary rock for triple superphosphate
Phosphoric acid
Nitrophosphates
Ammonium phosphates
Direct application (tropical tree crops)
Reactive rock
Metallurgical end-uses
Purified phosphoric acid
STPP and other phosphate chemicals
Super-phosphoric acid

Each of these sectors has special requirements in respect to rock grade and quality. On the supply side, quality and grade issues are gradually rising up the agenda, as many high-quality rock resources are depleted. The requirement to develop new deposits to meet long-term demand raises the question as to what will be the quality of new supplies. Overall, some rocks are not suited to merchant sale and will suffer significant price penalties if they are exported as such.

We believe that the total volume of phosphate rock sales for acid manufacture will not increase significantly over the long term, as the growth in phosphoric acid production is almost entirely driven by vertically integrated complexes. As discussed previously, recent trends show a static picture at best in respect of demand for phosphoric acid production. Growth in merchant rock will be centred on imports supporting single superphosphate manufacture, co-granulation and direct application.

The changes we might expect to see in the medium and longer term are summarised below:

Western Europe: A further decline in rock imports for phosphoric acid production seems inevitable. Since 2010, we have seen the closure of the Fertiberia acid plants in Huelva and the substitution of imported rock by merchant ammonium phosphates. This has reduced rock import requirements by about 750,000 t/yr. There are a handful of plants still operating in Europe, but all will face a combination of economic and environmental difficulties through the medium and long terms, and few seem likely to survive to 2029. The major exception is the Finnish plant which is supplied by captive rock and the Lithuanian unit of Eurochem (Lifosa), which will be entirely or almost entirely supplied by Russian rock from the company's Kovdor mine in the short term. The investment in a mine in Kazakhstan will provide a supply of rock for use in the Belorechensk fertilizer complex on the Black Sea.

In respect to non-acid end uses, we have the following expectations:

- The remaining nitrophosphate units in Europe are expected to continue production in the long-term. For Yara, this will involve obtaining a secure supply of high quality rock from either investment in mining or a long-term contract with a suitable and reliable partner. Alternatively, Yara may use the existing option to top up lower-grade rock with imported phosphoric acid. Rock availability should grow from Russia as and when the Acron mine achieves the 300,000t rock sales availability it is targeting, which may ease Yara's supply position. Eurochem's nitrophosphate plant in Antwerp will be supplied by Phosagro rock, as Eurochem has a close working relationship with that company. The smaller ODDA unit in Linz has proved more flexible in respect of rock grades and qualities than the Yara units which also applies to the Antwerp unit;

- The development of small-scale co-granulation and compaction units in Europe, to take advantage of the reduction in the number of industrial chemical compounding plants, has increased in recent years. The organic movement, which has seen a proliferation of organic and organo-mineral fertilizers entering the market, has in part driven this growth. Given the limited availability of high-reactive, the effectiveness of fertilizers based on unacidulated P_2O_5 is not always certain. On the other hand the price differential between a low-grade rock and acid-grade rock is such that the users of unacidulated rock gain a competitive edge over those purchasing for and producing fertilizers containing acidulated phosphate. We cannot be certain whether the organic movement will continue to grow, but suspect that this sector of the European market will grow rather than decline.

Eastern Europe: There are currently few imports of rock outside tied and semi-tied shipments to clients and subsidiaries from the Soviet era. The future of the Gomel plant is uncertain given the fragile political relationship between Russia and Belarus, which was affected by developments in the potash sector. The Gomel plant has to be heavily subsidized by the Belarus government and is increasingly producing single superphosphate for the domestic market.

North America: The region will remain a significant player in the merchant rock market. On the one hand, Agrium will be importing 1mn t/yr of Moroccan rock until 2020 (imports started in 2013). Given the age of the Redwater plant and the ever-changing structure of the market, Agrium has decided not to pursue involvement in any of the proposed Ontario projects which might have replaced Kapuskasing. Imports have also become a part of the US phosphate industry. The closure of the Agriphos Pasadena plant in 2011 took out about 1mn t/yr of import demand. In 2014, Mississippi Phosphates closed its Pascagoula plant amid rising costs, removing a further 800,000 to 1mn t/yr of rock import demand going forward. PCS imports smaller volumes of rock for its Geismar unit, primarily for non-fertilizer end-products. The acquisition of a stake in Bayovar is a part of Mosaic's long-term plan for rock sourcing, so we expect imports from Peru to be a permanent feature of the US scene. Over the medium term, we expect imports into North America to fluctuate at around 3mn t/yr, given that any reduction following the closure of the Pascagoula plant will be compensated on a regional basis by the imports linked to the Agrium contract for 1mn t/yr. The critical factor will be the availability of captive rock supply. The South Fort Meade experience has shown that non-mining disruption to supply has become a serious problem for the US rock industry. Future permitting applications are likely to be bedevilled by complaints from environmental lobbies and may encourage Mosaic/CF to maintain a higher level of imports of blending rock to extend reserve life.

In the longer term, it is likely that mine run-downs and closures will result in a decrease in processing activity or a change to lower P_2O_5 products such as MicroEssentials. We expect a gradual and planned contraction of rock production and a consolidation of processing, excluding any external factors. Phosphate rock imports will be used as top-up material, as and when required in order to optimise processing economics. Equally, economics dictate that imports will never replace captive production to a substantial extent. In respect to merchant rock demand, we are looking at marginal rather than core tonnage.

Latin America: Rock imports have remained stable in recent years. Brazil, Mexico and Argentina dominate the regional import market. We do not expect to see strong growth in the region in respect to rock deliveries. New processing capacity in Brazil will be linked to domestic rock developments rather than dependant on imported product.

- We have seen growth in imports of reactive rock into Brazil in recent years, and this product has established a niche in the market. The organic fertilizer market will continue to grow in many countries in Latin America, partly for political and emotional reasons, but also because it supplies low-to-medium grade fertilizers to farmers at prices below those of high-analysis, standard products.

- A significant volume of 69-72pc BPL rock is being imported into the region. It is especially important for those producing single superphosphate, as it the minimum grade which guarantees a final product with 18pc available P_2O_5.

- In Brazil, some blending of local and imported rock occurs in preparing suitable feeds for acid and single superphosphate production, as using 100pc local apatite creates some problems.

- Rock imports into Mexico are mainly for the Innophos operation producing purified acid, in addition to some triple superphosphate, east coast single superphosphate producers and direct application material. The Rofomex mine on the west coast has made Lazero Cardenas self-sufficient.

Africa: Apart from Togolese shipments to Foskor, there are limited imports into Africa. Foskor has in the past used 5-10pc Togo rock to improve filtration, dilute chloride content and enable acid production at nominal capacity. With the Richard's Bay plant having technical problems there were no imports recorded in 2012 and 2013, and this trend continued in 2014. The only growth to be expected is of reactive rock and rock suited to plantations, particularly oil-palm, as these sectors grow. There are practically no facilities operating which could process imported rock into final products.

West Asia: Imports are concentrated in Turkey (±600,000 t/yr) and Lebanon (±800,000 t/yr of Syrian rock historically, down to 400,000t in 21013). Both these markets are being affected by the loss of Syrian rock, which means either a reduction in output or substitution with more expensive rock. We foresee no investment in new acid plants based on imported rock in this region, and therefore, static demand. There has been consideration by some Middle Eastern nitrogen producers of establishing a joint venture to process rock into ammonium phosphates in the Gulf for shipment to Asia, but this has so far come to nothing. The phosphogypsum problem is a major barrier to any such project.

South Asia: Countries, notably India, have seen growth in rock imports in recent years. Indian imports peaked at 7.5mn t in 2011 before falling to 6.7mn t in 2013. Imports consist mainly of 66-68pc BPL and 69-72pc BPL for use in phosphoric acid manufacture. Lower grade rock, often blended with 66-68pc BPL material is being imported to make use of existing and new single superphosphate capacity. The economics of such imports is enhanced by the fact that 16pc is the standard grade for single superphosphate in India, which widens the range of suitable (and lower cost) rock sources.

There are no new non-basic acid complexes under construction in south Asia, although there is a constant flow of Indian company announcements suggesting that they are planning such an investment. We would not expect new investment unless a company succeeds in developing a new offshore rock deposit, which might supply rock at a break-even cost or on advantageous terms. Such moves as the Zuari offtake agreement in Peru offer security of supply rather than a great discount on the market value of rock. Therefore, the economics of production and justifying a massive investment (which would depend on imported ammonia) would not be easy. We do expect to see expansions at existing sites, but primarily in sites taking merchant acid as its raw material. Overall, we expect growth in rock imports driven mainly by single superphosphate.

Southeast Asia: Import levels have also been flat over the previous five years. However, a 200,000 t/yr phosphoric acid plant was brought on stream in the second half of 2014 in Gresik, Java, as a 50:50 joint venture between PT Petrokimia Gresik and JPMC. The PT Petro Jordan Abadi joint venture has a contract in place with JPMC to supply rock for the next 20 years, adding up to 800,000 t/yr of rock imports to the current level of Indonesian purchases from 2015 onwards. This is the first of three similar joint venture plants between the state owned PT Pupuk Indonesia Holding Company and JPMC. All three of the plants are based on Jordanian rock and the acid will be used as a feedstock for three new 1mn t/yr NPK plants. The construction of the second 200,000 t/yr phosphoric acid plant, Pupuk Kaltim, was scheduled to start in the third quarter of 2014 for completion in 2016. The third 200,000 t/yr acid plant will be located in South Sumatra and is a joint venture between JPMC and PT Pupuk Sriwijaya (Pusri). Those two plants could bring an additional 1.6mn t/yr to Indonesian rock imports, if and when they are completed. Additionally, the rapid development of the oil palm sector in the region is expected to boost P_2O_5 consumption in the form of low-grade rock for direct application or adding to NPK products.

East Asia: Demand has continued to decline steadily over the past five years and South Korea is the only main regional importer (430,000t in 2013). Philphos imports around 400,000-500,000 t/yr of lower grade rocks from a variety of sources depending on availability and cost. We expect a slow erosion of demand throughout both the medium and long term.

Oceania: Australia and New Zealand continue to import rock, mainly for the production of high-grade single superphosphate (960,000t in 2013). The rock is generally blended with cheaper lower-grade rock. In New Zealand, demand for products based on reactive rock will grow and could serve as a substitute for any lost production of single superphosphate. We expect no net growth in import demand.

The main points which emerge from this analysis are as follows:

- We expect no major trend change in the rock market in the foreseeable future which can be summarised as follows: static to declining sales of rock of 69pc BPL and above; increasing sales of rock below this grade for blending to create an acid feed, for single superphosphate production and for application as such;
- The main driver for the trade of merchant rock will continue to be phosphoric acid production. Many of the existing non-captive acid plants are over 30 years old and face threats to their long-term survival, economic, environmental and socio-political. We expect to see further closures in the medium and long term;
- There have been no new non-basic plants constructed this century. The most recent such plants were in Thailand (National Fertilizer), India (Oswal Industries) and Philippines (Philphos). All of these ventures ended in financial failure. The Oswal plant was taken over by IFFCO in 2005, and is still undergoing a thorough rebuilding programme while the National Fertilizer plant has closed. Philphos continues production at a reduced capacity utilisation rate, although it is now in private hands;
- We see no evidence to suggest that there will be a return to constructing phosphoric acid or nitrophosphate complexes of large scale based on imported rock. The only exceptions will be

complexes built as joint ventures between a mining company and a processing company, a form of arm's length vertical integration. The most recent of these was the PT Petro Jordan Abadi joint venture acid plant in Indonesia which will take about 800,000 t/yr of rock. A further example is the Zuari-Mitsubishi FosPac consortium;

- We expect growth in the export of rock for use in single superphosphate. This trade will continue in Latin America and Oceania and is developing in India in order to take advantage of rock not suited to acid manufacture and available at discounted prices. Some of this rock may be used in partial acidulation processes, which allows a granular form of phosphate rock to be produced for the blending market. This market has so far been dependent on rock from China and Vietnam, availability of which will not grow. More generally speaking, increased production of single superphosphate will develop in order to exploit local rock which, given the small scale of reserves and/or impurities, would be unsuited to feed a large-scale phosphoric acid complex. Where 16pc P_2O_5 is an acceptable grade, imports of low-grade or low-quality rocks will be feasible. This in part revolves around the value attributed to the sulphate-content of the low-grade single superphosphate and its use as a carrier for other secondary and trace elements. Where local apatite is used for single superphosphate production, imports of reactive rock such as that from Peru may be taken in order to improve the product and especially its water solubility;

- The market for low-grade rock for direct application on tropical tree crops will advance, driven by demand for palm oil. A combination of a minimum level of citric solubility will be required (6-7pc P_2O_5), a minimum total P_2O_5 content (26-27pc) and in some cases a minimum calcium content. Specifications will vary between location and crop type, and will be influenced by the unit P_2O_5 cost of suitable phosphate rocks;

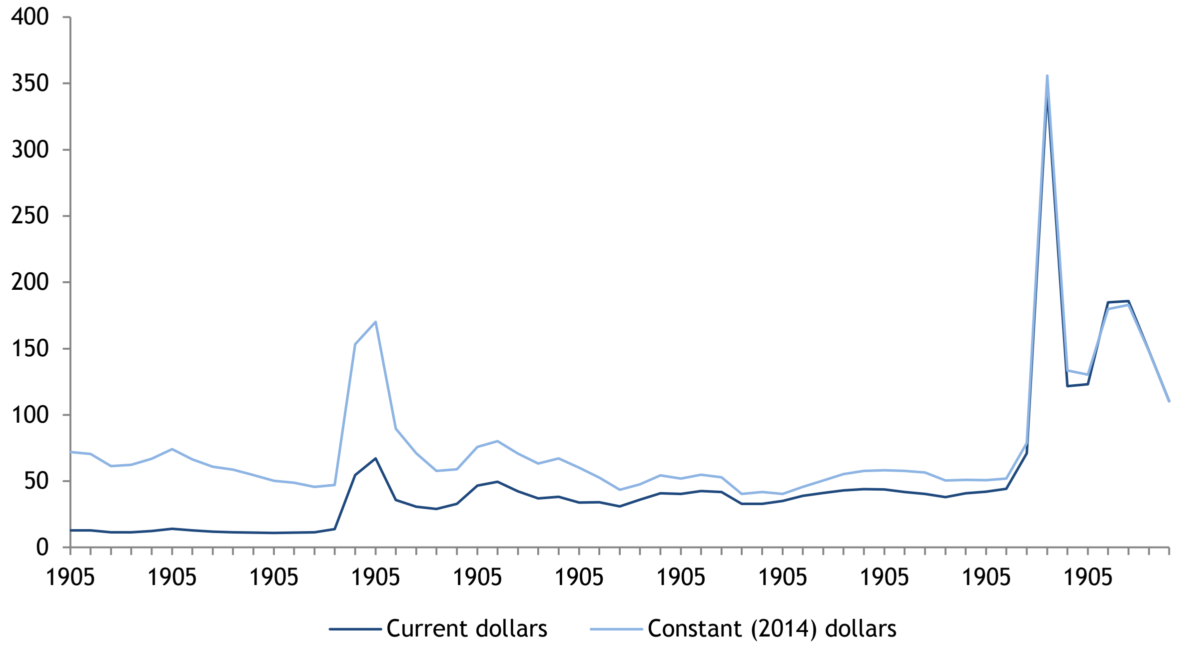
- The market for reactive rock is likely to grow if sufficient supply is available. Tunisian availability has declined and will not recover to traditional levels, owing to requirements of captive acid production and recent disruptions. Bayovar rock is available and ICL is marketing Arad rock as a direct application material. OCP has developed multi-nutrient fertilizer grades incorporating reactive rock from Ben Guerir as a part of its African marketing strategy. The extent of growth will be determined on the one hand by supply and on the other by the spread and success of the organic movement. Some small-scale, cross-border trade in direct application phosphate rocks may well develop in Africa, but volumes will be minimal;

- There remains a small market for high-grades of rock and especially those without impurities. This category today is restricted essentially to supplies from Russia, OCP Boucraa and South Africa. Demand for these products will depend on the performance of the sectors which show preference for or require them:

    - Nitrophosphate production, especially using the Yara process;
    - Production of 20pc P_2O_5 single superphosphate in Australia and New Zealand;
    - Production of super-phosphoric acid (often for use in clear fertilizer solutions);
    - For use in purified acid (the many technical products made from purified acid range from washing detergents to food and pharmaceutical products). The purity requirements vary accordingly. Given the limited export availability of the very highest grade apatite (Russia and South Africa) and the premium which limited supply often creates, we expect continued development of (expensive) solvent extraction processes to remove impurities from wet-process

acid made from rock containing unwanted impurities. These processes can selectively remove those elements in the acid which are detrimental to the process and product for which it is destined.

Figure 22: Phosphate Rock 70pc BPL (fas) Casablanca $/t

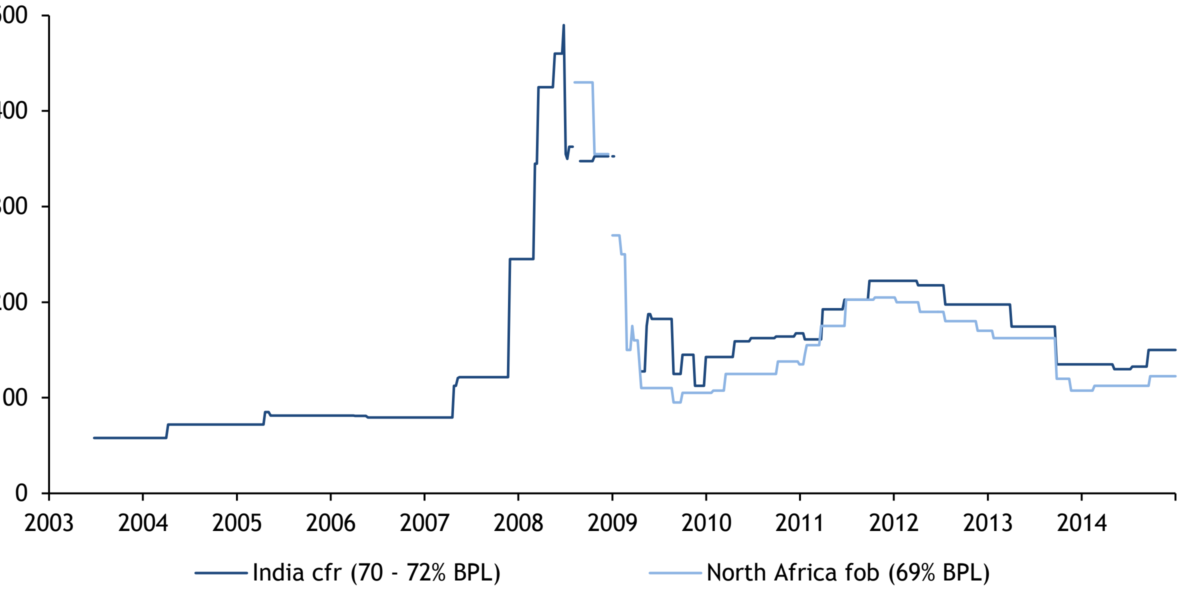


— World Bank Pink Sheet
2014 - January-October Average

For many years, phosphate rock prices languished in the $40s/t fob Tunisia/Morocco, falling into the $30s/t in the early-1990s as the Soviet Union market collapsed and generated oversupply on the export market. This situation has changed dramatically. In 2008, amid the boom across fertilizers and commodity markets, phosphate rock prices cfr India peaked at almost $500/t, with the free alongside (fas) Casablanca price recorded by the World Bank at an average of just over $350/t for the 2008 calendar year and fob North African (69pc) prices reported by *Argus* FMB reaching $400-460/t in August 2008.

Section 3: The Phosphate Rock Market
Chapter 4: Phosphate Rock Price Outlook to 2029

Figure 23: Phosphate Rock Prices *$/t*



— Argus FMB

Note: Since end-March 2010 Argus FMB reports fob North Africa 68-70pc BPL, previous North Africa prices refer to 68-72pc BPL.

With export markets slashed in 2009 — and OCP alone reducing exports by 6mn t compared with 2008 — prices first fell dramatically, and then ratcheted down, during the course of the year as attempts were made to recover sales volumes. By mid-December 2009 cfr India (70-72pc) prices had fallen to $110-115/t cfr and fob North Africa (68-72pc) to $80-90/t fob representing what appears to be the absolute market low of the (abnormal) downturn. Indian cfr (70-72pc) prices staged a recovery, reaching $250-225/t cfr by Q4 2011-Q1 2012 and fob North Africa rock (69pc) also rising to $200-210/t fob at that time. Since then, weak demand fundamentals for ammonium phosphates have led to a decline in rock prices, with a prolonged downward correction in reported prices between Q3 2013 and Q3 2014 to $130-140/t cfr India and $100-120/t fob North Africa (69pc), before starting to pick up again in Q4 2014. Nevertheless, these prices remain well above historical pre-2007 levels, albeit with some support provided by the temporary loss of exports out of Tunisia and Syria.

It will be clear from the market analysis in this report, that the basis for pricing phosphate rock is rapidly moving away from an alignment with the production costs of the more competitive producers. The emphasis is shifting towards comparability with the market price for processed phosphates. This process started in earnest in 2003-04 and hit a temporary obstacle with the major slump in demand in 2009. OCP's reaction in the heat of the crisis was to reduce production to maintain prices as close to the $100/t mark as possible. The company has likewise temporarily accepted lower prices on its rock given the overall weakness in the phosphates market, and perhaps even to discourage the progress of competing projects.

As the market for acid-grade rock shrinks, so the management of that market will be orchestrated by OCP. OCP will not wish to maintain export tonnage in a declining market at the expense of price. Its preference will be to invest in processing in order to replace the tonnage from closed plants with acid or finished product. In some instances it may be willing to put rock or acid into joint ventures at a price related to that achieved by the processed end product. In the case of Fertiberia, where the end product is NPK, with which OCP does not compete, a contract for the supply of merchant phosphoric acid replaced rock imports in 2011, although the ammonium phosphates plant was permanently closed in December 2013. OCP has also contracted to supply 1mn t/yr of rock to Agrium's Redwater plant in Canada, following the closure of the Kapuskasing mine. In 2010, OCP sold its first cargoes of diammonium phosphate to the US and has increased exports to the region since then. While OCP may be willing to top up rock supply for acid production in the US, we expect its long-term strategy to be expanding its own exports to replace tonnage lost as the US industry declines to the point at which non-basic acid production becomes its only option.

The balancing act required of OCP as swing export producer will consist of:

- Achieving the best parity it can between the unit P_2O_5 price of rock on the one hand and processed phosphate on the other hand;
- Keeping the rock price attractive enough to keep its main customers in business;
- Maintaining prices at a level which discourages merchant rock projects and makes them uninteresting to lenders.

After the current market softness unwinds, the immediate objective of OCP will be to establish a floor price as close as possible to $150/t — although accepting a lower absolute floor of $125/t when its market control margin is assumed to come under more significant pressure in 2016-18 — but probably not greatly in excess of $200/t for short periods, a level which could conceivably revive interest in new projects for merchant rock. Over the medium term, we would expect the market for merchant acid-grade rock to be even more dominated by India, which accounts for the frenetic search by Indian companies (supported by the government) for participation in a rock project which would give them some room for manoeuvre in its dealings with OCP and JPMC.

The markets for rock for direct application, single superphosphate manufacture and high-quality technical products will not be directly affected by the developments described above. We expect the single superphosphate and direct application sectors to show slow growth as consumers seek lower cost P_2O_5 and opt to use lower grade rock unsuited to acid manufacture, while the market for high-grade technical quality apatite is in decline.

The table below provides our base forecast for phosphoric acid and phosphate rock prices to 2029 following the below methodology:

- A "value" approach is largely adopted, the starting point being the fob Morocco diammonium phosphate benchmark;
- The base diammonium phosphate price forecast builds in a long-term structural adjustment, driven by a long-term upward shift in the price of ammonia and sulphur and, more significantly, by the evolution of a "market control margin", given the influence that OCP can now wield on the global phosphates market;

- From the fob Moroccan diammonium phosphate benchmark, a cfr contract price is derived for the key phosphate import market, India. Because India offers a significant base load for the major diammonium phosphate exporters, the long-term assumption is for this cfr price to incorporate a 5pc discount relative to the spot fob Moroccan price, while assuming a long term freight differential of $40 to 53/t of DAP;

- Our benchmark urea price forecast (fob Yuzhny) is used to generate a cfr India value for the nitrogen component of diammonium phosphate. The value for the phosphates component is expressed as the cfr India phosphoric acid equivalent being derived from the residual after subtracting the nitrogen value from the diammonium phosphate price. This methodology appears to roughly underpin contract pricing for phosphoric acid in India;

- As discussed above, OCP will be looking to price rock at a level which discourages the development of major new phosphate rock export capacities. After the expected overall price weakness of diammonium phosphate prices in the period to 2018, by which time OCP will have completed the first major tranche of capacity under the Jorf Lasfar Hub programme and the Ma'aden/Mosaic/Sabic joint venture will have started, we expect that the absolute floor for fob Moroccan rock prices will be $150/t with prices generally held not too far above $180/t in the medium term. As such, a "discount" is assumed for rock vis-a-vis phosphoric acid, after allowing for process losses (incorporated by taking 3.5t of phosphate rock per tonne P_2O_5 of phosphoric acid). The rock discount implied figure was $82/t in 2011, $50/t in 2012 and a narrower $30/t in 2013 as renegotiated contract prices lagged the sharp decline in spot prices. In 2014, this implied rock discount widened again to $63/t as cfr India rock prices plummeted to an average $138/t. We stress that this "discount" expresses the outcome of our pricing model. We do not suggest that it describes the method whereby OCP prices phosphate rock. We expect the rock discount to decrease to $40/t in 2016-18 and to gradually erode over time to just below $30/t by 2029, as non-basic ammonium phosphates capacity is closed removing the incentive to develop rock export projects to supply the rump of demand left in India;

- Our short-term view of the market is for an increase in Jordanian exports to Indonesia and Moroccan shipments to Canada, coupled with minimal imports from the Philippines and lower US imports following the closure of MissPhos in 2014. The increase of $40/t P_2O_5 on the phosphoric acid contract price between OCP and its Indian partners for the first half of 2015 (which settled at $805/t P_2O_5 vs. $765/t in the second half of 2014) could translate into a $10-12/t price increase on a rock basis;

- Our long-term view of phosphate rock taking a 70-72pc BPL benchmark for both India cfr and Morocco fob is for prices to generally range between $140/t and $180/t fob in current/nominal dollars on an annualised basis to 2020, albeit lower around 2018 at $120-125/t representing the market trough. We are forecasting acid prices to trade in the $720-850/t range to 2020. Our trend forecast is for phosphoric acid prices to reach just over $900/t cfr India by 2029, and in the case of phosphate rock, to rise to $230-236/t cfr India and $177-184/t fob Morocco.

Table 57: Phosphoric Acid and Phosphate Rock Price Forecast to 2029 *Current $/t*

	DAP		Urea		Nitrogen Value of DAP	Phos. Acid#	Rock Discount	Phosphate Rock (70-72pc BPL)	
	fob Morocco	cfr India contract	fob Yuzhny	cfr India	cfr India	cfr India		cfr India	fob Morocco
2004a	233		177	222	87	383	40	68-70	
2005a	260		218	263	103	425	41	79-81	
2006a	266		224	269	105	454	48	80-82	
2007a	431		305	350	137	532	36	114-117	
2008a*	984		497	542	212	1682	117	357-367	
2009a*	343		250	295	115	590	14	152-156	
2010 a	503		288	333	130	748	55	156-160	
2011 a	656		425	470	184	983	82	195-201	
2012 a	567	597	410	455	178	924	50	210-216	188-193
2013 a	475	491	341	386	151	716	31	171-176	151-155
2014 a	504	460	319	364	142	712	63	138-142	114-117
2015	505	521	259	304	119	805	45	184-189	142-147
2016	472	491	240	286	112	824	40	194-200	152-157
2017	461	481	240	287	112	802	40	188-193	145-150
2018	452	473	320	367	144	716	40	163-168	120-124
2019	485	505	260	308	121	836	38	199-205	155-161
2020	506	526	320	369	144	829	37	198-204	153-159
2021	526	546	335	385	151	860	36	208-214	162-168
2022	532	552	358	408	160	853	35	207-213	161-167
2023	538	559	364	416	163	861	34	210-216	163-169
2024	544	565	371	424	166	868	33	214-220	165-171
2025	550	572	378	431	169	876	32	217-223	168-174
2026	556	578	384	439	172	884	31	220-226	170-176
2027	562	585	391	447	175	892	30	223-230	172-179
2028	568	592	398	454	178	900	29	227-233	175-181
2029	574	599	405	462	181	908	28	230-236	177-184

a-actual

** Estimated prices or partial year averages used where no reported prices: DAP fob Morocco Q4 2008 and January 2009 where based on estimates; fob Morocco benchmark for 2009 based on reported 68-72pc BPL figures for April-December. Argus FMB historical cfr India 70-72pc BPL prices generally reflect 70pc BPL (32pc P_2O_5) rock, which is provided in the low-end price. High-end prices reflect the pro-rated upper value for 72pc BPL rock.*

 # Includes 30 days credit.

— Historical benchmark prices, FMB

Appendices

Table 58: Phosphate Rock Exports by Country, 1990-2013												*'000t product*
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
Countries	**36,995**	**30,345**	**30,181**	**30,826**	**29,657**	**31,304**	**30,588**	**19,576**	**29,984**	**31,148**	**30,169**	**25,995**
West Europe	**33**	**-**	**-**	**-**	**-**	**-**	**-**	**10**	**62**	**117**	**44**	**-**
Finland	21	-	-	-	-	-	-	10	62	117	44	-
Sweden	12	-	-	-	-	-	-	-	-	-	-	-
Switzerland	-	-	-	-	-	-	-	-	-	-	-	-
United Kingdom	-	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-	-
EE/CA	**2,608**	**1,730**	**4,499**	**3,205**	**2,683**	**2,833**	**2,771**	**2,477**	**2,418**	**1,817**	**2,107**	**2,432**
Kazakhstan	-	-	408	105	64	115	399	162	267	423	505	246
Russian Federation	2,608	1,730	4,091	3,100	2,619	2,718	2,372	2,315	2,150	1,394	1,602	2,186
Tajikistan	-	-	-	-	-	-	-	-	-	-	-	-
Turkey	-	-	-	-	-	-	-	-	-	-	-	-
Africa	**18,292**	**16,385**	**15,086**	**17,742**	**18,613**	**19,393**	**16,810**	**9,748**	**16,078**	**15,299**	**16,556**	**13,670**
Algeria	734	671	879	841	1,516	1,686	1,664	927	1,616	1,276	1,197	1,070
Egypt	297	48	316	1,578	1,488	1,498	1,618	1,741	2,453	3,043	4,073	2,417
Morocco	11,672	9,420	10,488	13,388	13,506	14,122	11,825	5,825	10,222	9,662	9,593	8,602
Senegal	1,356	859	356	-	-	18	50	35	58	81	156	209
South Africa	1,217	1,408	756	120	163	124	80	50	177	195	415	187
Tanzania	-	-	-	-	-	-	-	-	-	-	-	-
Togo	2,422	2,652	1,220	1,048	1,173	743	687	680	854	892	1,033	1,143
Tunisia	593	1,327	1,071	767	768	1,202	887	489	699	149	85	31
North America	**6,882**	**3,090**	**179**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Table 58: Phosphate Rock Exports by Country, 1990-2013												’000t product
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
United States	6,882	3,090	179	-	-	-	-	-	-	-	-	-
Central America	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	-
South America	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**618**	**2,577**	**3,218**	**3,539**
Peru	-	-	-	-	-	-	-	-	618	2,577	3,218	3,539
Middle East	**8,213**	**7,289**	**5,846**	**7,067**	**6,691**	**7,036**	**7,168**	**6,031**	**8,309**	**9,050**	**6,467**	**4,978**
Israel	1,994	1,964	1,125	474	559	439	719	716	873	902	885	946
Jordan	4,875	3,879	3,126	4,006	3,254	3,604	3,976	3,248	4,297	5,403	4,336	3,241
Syria	1,394	1,447	1,595	2,586	2,878	2,993	2,473	2,068	3,139	2,743	1,245	779
Iran	-	-	-	-	-	-	-	-	-	2	11	12
South East Asia	**40**	**388**	**590**	**680**	**719**	**852**	**1,341**	**781**	**1,209**	**1,192**	**754**	**671**
Christmas Island	34	388	590	680	657	704	750	463	610	635	754	**556**
Vietnam	6.4	-	-	-	62	149	591	318	600	557	-	114
East Asia	**-**	**958**	**3,446**	**2,114**	**952**	**976**	**2,001**	**382**	**883**	**660**	**489**	**358**
China	-	958	3,446	2,114	952	976	2,001	382	883	660	489	358
Oceania	**926**	**505**	**536**	**18**	**-**	**214**	**498**	**147**	**407**	**437**	**523**	**347**
Nauru	926	496	528	18	-	214	498	147	407	437	523	347

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Table 59: Phosphate Rock Imports by Country,1990-2013												*'000t product*
	1990	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
	37,370	**30,364**	**30,180**	**30,826**	**29,656**	**31,304**	**30,588**	**19,576**	**29,983**	**31,145**	**30,158**	**25,994**
West Europe	**18,131**	**12,114**	**10,826**	**10,048**	**9,274**	**9,845**	**8,806**	**4,543**	**8,225**	**7,654**	**6,889**	**5,917**
Austria	574	162	199	182	185	97	159	145	275	303	225	129
Belgium	1,859	1,530	1,570	1,586	1,328	1,392	1,326	597	1,339	1,540	1,254	974
Bulgaria	335	272	342	560	577	510	336	319	379	573	483	368
Czech Republic	-	-	35	35	21	27	26	-	14	-	-	-
Cyprus	-	-	-	-	-	-	-	-	-	-	-	-
Denmark	145	139	74	-	-	-	-	-	-	-	-	-
Estonia	-	-	-	-	-	-	-	12	-	-	-	110
Finland	112	91	104	54	54	50	23	-	6	-	-	28
Former Czechoslovakia[3]	253	40	-	-	-	-	-	-	-	-	-	-
France	3,104	1,590	1,219	399	357	416	289	142	347	216	291	209
Germany	958	249	80	154	95	137	100	-	16	24	-	18
Greece	607	478	395	375	225	227	217	206	253	199	129	105
Hungary	289	50	27	-	-	-	-	-	-	-	-	0
Iceland	-	-	-	-	-	-	-	-	-	-	-	-
Ireland	5	10	3	-	1	2	-	-	1	-	2	-
Italy	848	264	208	196	214	242	188	67	183	185	214	151
Latvia	-	-	-	-	-	-	-	-	19	-	-	-
Lithuania	-	-	820	1,186	1,161	1,218	1,246	1,169	1,364	1,287	1,013	1,342
Malta	-	-	-	-	-	-	-	-	-	-	-	-

[3]Czech Republic and Slovakia

Table 59: Phosphate Rock Imports by Country,1990-2013												’000t product
	1990	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Netherlands	2,004	1,876	1,118	709	824	789	916	307	649	680	572	229
Norway	692	632	627	709	653	654	661	418	674	632	675	680
Portugal	178	157	131	134	89	109	84	44	88	70	105	66
Poland	1,411	1,849	1,507	1,608	1,644	1,693	1,347	558	1,324	1,385	1,271	915
Romania	1,577	861	470	414	298	396	421	102	232	265	359	318
Serbia and Montenegro	-	-	-	-	-	-	-	-	32	-	-	33
Slovakia	-	-	-	-	-	-	1	-	-	-	-	-
Slovenia	-	-	-	-	-	-	6	2	-	2	-	-
Spain	1,962	1,759	1,812	1,737	1,538	1,846	1,390	428	1,009	288	280	242
Sweden	696	76	61	-	-	-	-	-	-	-	-	-
Switzerland	1	-	-	-	-	-	-	-	-	-	-	-
United Kingdom	521	31	28	12	10	22	20	2	11	4	17	2
Other	-	-	-	-	-	20	49	25	8	-	-	-
EE/CA	**1,868**	**908**	**1,833**	**1,763**	**1,933**	**2,117**	**2,633**	**1,459**	**2,080**	**2,324**	**2,367**	**1,643**
Albania	114	6	-	-	-	-	-	-	-	-	-	-
Armenia	-	-	-	-	-	-	-	-	-	-	-	-
Azerbaijan	-	-	-	-	-	-	-	-	-	-	-	-
Belarus	-	-	248	362	392	355	450	401	553	515	493	469
Bosnia-Herzegovina	-	-	-	-	-	-	-	-	-	-	-	-
Croatia	-	-	238	276	332	319	321	119	51	62	46	41
Former Yugoslavia	1,003	356	-	-	-	-	-	-	-	-	-	-
Georgia	-	-	-	-	-	-	-	-	-	-	-	-

Table 59: Phosphate Rock Imports by Country, 1990-2013 *'000t product*

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
Kazakhstan	-	-	-	-	-	-	-	-	-	-	-	-
Kyrgyzstan	-	-	-	-	-	-	-	-	-	-	-	-
Macedonia	-	-	8	-	-	-	-	-	-	-	-	-
Moldova	-	-	-	-	-	-	-	-	-	-	-	-
Russian Federation	29	4	60	105	62	35	166	60	143	298	499	192
Tajikistan	-	-	-	-	-	-	-	-	-	-	115	-
Turkey	722	543	691	541	659	647	682	712	781	833	637	600
Turkmenistan	-	-	10	17	-	80	127	-	85	100	-	53
Ukraine	-	-	239	452	486	681	823	168	428	491	578	288
Uzbekistan	-	-	338	-	2	-	65	-	40	26	-	-
Yugoslavia	-	-	-	-	-	-	-	-	-	-	-	-
Eastern Europe and Central Asia	-	-	-	-	-	-	-	-	-	-	-	-
EE and CA Unspecified incl. FSU	-	-	-	12	-	-	-	-	-	-	-	-
Africa	**5**	**704**	**287**	**26**	**161**	**131**	**214**	**54**	**132**	**104**	**9**	**41**
Algeria	-	-	-	-	-	-	-	-	-	-	-	-
Angola	-	-	-	-	-	-	-	-	-	-	-	-
Benin	-	-	-	-	-	-	-	-	-	-	-	-
Burkina Faso	-	-	-	-	1	1	-	-	-	-	-	-
Cameroon	-	-	-	-	-	-	-	-	-	0	-	-
Congo	-	-	-	-	-	-	-	-	-	-	-	-
Cote d'Ivoire	-	1	-	-	-	4	7	7	0	4	3	6
Djibouti	-	-	-	-	-	-	-	-	-	-	-	-

Table 59: Phosphate Rock Imports by Country,1990-2013												'000t product
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
Egypt	-	-	-	-	-	-	-	-	-	-	-	18
Eritrea	-	-	-	-	-	-	-	-	-	-	-	-
Ethiopia	-	-	-	-	-	-	-	-	-	-	-	-
Gambia	-	-	-	-	-	-	-	-	-	-	-	-
Ghana	-	0	-	1	1	1	0	2	2	3	1	2
Guinea	-	-	-	-	-	-	-	-	-	-	-	-
Kenya	-	-	-	-	-	-	-	1	2	3	0	-
Liberia	0	-	-	-	-	-	0	-	-	-	-	1
Libya	-	-	-	-	-	-	-	-	-	-	-	-
Madagascar	-	-	-	-	-	-	-	-	-	-	-	-
Malawi	-	-	-	-	-	-	-	-	-	-	-	-
Mali	-	-	-	-	-	-	-	-	4	-	-	-
Mauritania	-	-	-	-	-	-	-	-	-	-	-	-
Mauritius	3	-	2	-	-	0	1	-	-	-	-	-
Morocco	-	-	-	-	-	-	-	-	-	-	-	-
Mozambique	-	-	-	-	-	-	-	-	-	-	-	-
Namibia	-	-	-	-	-	-	-	-	-	-	-	-
Niger	-	-	-	-	-	-	-	-	-	-	-	-
Nigeria	-	2	-	-	-	-	-	-	-	-	-	0
Reunion	-	-	-	-	-	-	-	-	-	-	-	-
Senegal	-	-	-	-	-	-	-	-	-	-	-	-
South Africa	-	701	285	25	159	124	207	45	124	94	5	12

Table 59: Phosphate Rock Imports by Country,1990-2013												*'000t product*
	1990	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Sudan	-	-	-	-	-	-	-	-	-	-	-	-
Tanzania	-	-	-	-	-	-	-	-	-	-	-	-
Togo	-	-	-	-	-	-	-	-	-	-	-	-
Tunisia	-	-	-	-	-	-	-	-	-	-	-	-
Uganda	-	-	-	-	-	-	-	-	-	-	-	-
Zaire	1	-	-	-	-	-	-	-	-	-	-	-
Zambia	-	-	-	-	-	-	-	-	-	-	-	-
Zimbabwe	-	-	-	-	-	-	-	-	-	-	-	-
Others Africa	-	-	-	-	-	-	-	-	-	-	0	-
North America	**1,681**	**3,025**	**2,183**	**2,625**	**2,421**	**2,797**	**2,754**	**2,091**	**2,885**	**3,272**	**3,553**	**3,532**
Canada	1,273	1,215	231	-	-	128	-	-	68	-	61	318
United States	408	1,810	1,951	2,625	2,421	2,670	2,754	2,091	2,817	3,272	3,493	3,214
Other	-	-	-	-	-	-	-	-	-	-	-	-
Central America	**1,946**	**1,465**	**1,498**	**950**	**922**	**908**	**1,021**	**104**	**981**	**872**	**852**	**800**
Belize	-	-	-	-	-	-	-	-	-	-	-	-
Costa Rica	2	4	-	-	-	-	-	-	-	-	-	-
Cuba	8	-	-	-	-	-	-	-	-	-	-	-
Dominican Republic	-	-	-	-	-	-	-	-	-	-	-	-
El Salvador	-	18	-	-	-	9	-	13	-	7	16	-
Guadeloupe	-	-	-	-	-	-	-	-	-	-	-	-
Guatemala	5	-	-	-	-	-	-	-	-	-	-	-
Haiti	-	-	-	-	-	-	-	-	-	-	-	-

Table 59: Phosphate Rock Imports by Country,1990-2013												'000t product
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
Honduras	-	-	-	-	-	-	-	-	-	-	-	-
Jamaica	-	-	-	-	-	-	-	-	-	-	-	-
Martinique	-	-	-	-	-	-	-	-	-	-	-	-
Mexico	1,929	1,442	1,498	950	922	899	1,021	91	981	865	836	800
Nicaragua	-	-	-	-	-	-	-	-	-	-	-	-
Panama	1	2	-	-	-	-	-	-	-	-	-	-
Puerto Rico	-	-	-	-	-	-	-	-	-	-	-	-
Trinidad & Tobago	-	-	-	-	-	-	-	-	-	-	-	-
Others Central America	-	-	-	-	-	-	-	-	-	-	-	-
South America	**401**	**735**	**1,254**	**1,668**	**1,866**	**2,641**	**1,816**	**1,369**	**2,077**	**2,078**	**2,188**	**2,145**
Argentina	-	4	-	1	57	203	139	91	274	215	279	154
Brazil	207	549	941	1,251	1,352	1,996	1,288	936	1,416	1,460	1,448	1,608
Chile	26	5	4	-	-	-	-	-	10	22	6	12
Colombia	45	57	69	89	90	94	63	58	97	94	69	68
Ecuador	-	-	-	-	-	-	-	-	2	3	3	2
Guyana	-	-	-	-	-	-	-	-	-	-	-	-
Paraguay	-	-	-	-	-	-	-	-	-	-	-	-
Peru	-	-	84	109	134	118	148	111	152	90	132	117
Surinam	-	-	-	-	-	-	-	-	-	-	-	-
Uruguay	49	29	46	84	95	103	81	54	41	99	142	110
Venezuela	74	91	110	134	138	127	97	119	85	94	111	74
Others South America	-	-	-	-	-	-	-	-	-	-	-	-

Table 59: Phosphate Rock Imports by Country,1990-2013												*'000t product*
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
Middle East	**441**	**728**	**1,016**	**1,249**	**1,101**	**984**	**727**	**728**	**1,012**	**876**	**479**	**418**
Bahrain	-	-	-	-	-	-	-	-	-	-	-	-
Iran	290	367	425	363	276	170	-	17	112	85	30	31
Iraq	-	-	-	-	-	-	-	-	-	-	-	-
Israel	-	-	52	87	69	52	97	52	16	8	-	-
Jordan	-	-	-	-	-	-	-	-	-	-	-	-
Kuwait	-	-	-	-	-	-	-	-	-	-	-	-
Lebanon	135	361	540	799	755	762	630	660	878	781	447	387
Oman	-	-	-	-	-	-	-	-	-	-	-	-
Qatar	-	-	-	-	-	-	-	-	-	-	-	-
Saudi Arabia	17	-	-	-	-	-	-	-	-	-	-	-
Syria	-	-	-	-	-	-	-	-	-	-	-	-
UAE	-	-	-	-	-	-	-	-	-	-	-	0
Yemen	-	-	-	-	-	0	-	-	-	-	-	-
Others WANEA	-	-	-	-	-	-	-	-	-	-	-	-
Others Near East	-	-	-	-	1	-	-	-	5	2	2	-
South Asia	**3,700**	**3,023**	**4,777**	**5,429**	**5,761**	**5,730**	**5,703**	**5,619**	**6,799**	**7,946**	**7,731**	**7,092**
Afghanistan	-	-	-	-	-	-	-	-	-	-	-	0
Bangladesh	147	140	186	232	159	62	115	31	74	128	53	115
India	3,236	2,604	4,315	4,816	5,322	5,244	5,261	5,327	6,387	7,522	7,312	6,685
Nepal	-	-	-	-	-	-	-	-	-	-	-	-
Pakistan	292	279	274	379	280	424	327	261	338	295	366	292
Sri Lanka	25	-	3	2	0	-	-	-	-	-	-	-

Table 59: Phosphate Rock Imports by Country,1990-2013												*'000t product*
	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
Others	-	-	-	-	-	-	-	-	-	-	-	-
South East Asia	**2,581**	**2,485**	**2,389**	**2,999**	**2,757**	**2,471**	**2,746**	**2,164**	**2,957**	**3,125**	**3,094**	**2,445**
Burma	-	-	-	-	-	-	-	-	-	-	-	-
Christmas Island	-	-	-	-	-	-	-	-	-	-	-	-
Indonesia	1,329	1,189	967	1,559	1,486	1,402	1,559	1,352	1,636	1,621	1,767	1,480
Malaysia	404	495	636	662	674	794	768	376	723	985	837	575
Myanmar	-	-	-	0	-	-	-	-	-	-	-	-
Philippines	843	767	482	447	560	210	343	285	441	481	464	387
Singapore	-	-	-	-	-	-	41	73	-	-	-	-
Thailand	6	29	284	234	21	13	10	23	11	-	20	-
Vietnam	-	5	18	73	16	18	14	-	-	8	5	4
Others	-	-	2	24	-	34	11	54	146	30	-	-
East Asia	**3,680**	**3,364**	**2,351**	**2,362**	**2,186**	**2,089**	**2,437**	**973**	**1,380**	**1,451**	**1,073**	**931**
China	275	-	-	-	89	55	-	-	-	23	3	-
Hong Kong	-	6	-	-	-	-	-	-	-	-	-	-
Japan	1,270	1,281	814	777	746	671	823	390	327	548	308	376
Korea DPR	81	1	-	-	-	-	-	-	-	-	-	-
Korea Republic	1,637	1,687	1,360	1,428	1,221	1,238	1,447	413	910	749	567	430
Mongolia	-	-	-	-	-	-	-	-	-	-	-	-
Taiwan, China	417	388	177	157	131	126	167	171	144	132	195	125
Others East Asia	-	-	-	-	-	-	-	-	-	-	-	-
Oceania	**1,427**	**1,659**	**1,749**	**1,695**	**1,254**	**1,476**	**1,689**	**442**	**1,252**	**1,018**	**1,009**	**962**

Table 59: Phosphate Rock Imports by Country,1990-2013												*'000t product*
	1990	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Australia	824	939	812	843	487	581	818	121	505	347	389	354
Nauru	-	-	-	-	-	-	-	-	-	-	619	-
New Zealand	603	720	937	852	768	895	871	321	747	671	-	608
Papua New Guinea	-	-	-	-	-	-	-	-	-	-	-	-
Others Oceania	-	-	0	-	-	-	-	-	-	-	-	-
Unspecified	**1,509**	**155**	**19**	**14**	**20**	**115**	**43**	**30**	**204**	**424**	**914**	**68**

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