Phosphate Rock

$Ca_5(PO_4)_3F$ (solid)

R Raw Material

Source of Raw Material: Naturally occurring ore

% of Total Domestic Consumption Attributed to Water Sector: Less than 1%

Product Family: Phosphate

Derivative Water Treatment Chemicals:
Phosphoric Acid
Fluorosilicic Acid

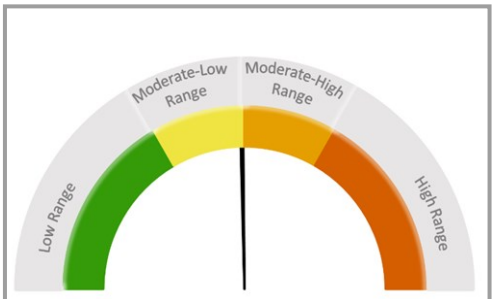
Understanding Chemical Supply Chains

CAS No.: 1306-05-4

Shelf Life: 60+ Months

RISK OF SUPPLY DISRUPTION (Assessed in 2022)

RISK RATING: Moderate-Low



RISK DRIVERS

Agricultural use of phosphate-based fertilizer, trade disputes, and reliance on a small number of countries for imports have led to limited supply and dramatically increased price of phosphate rock. Domestic production is largely intended for fertilizer.

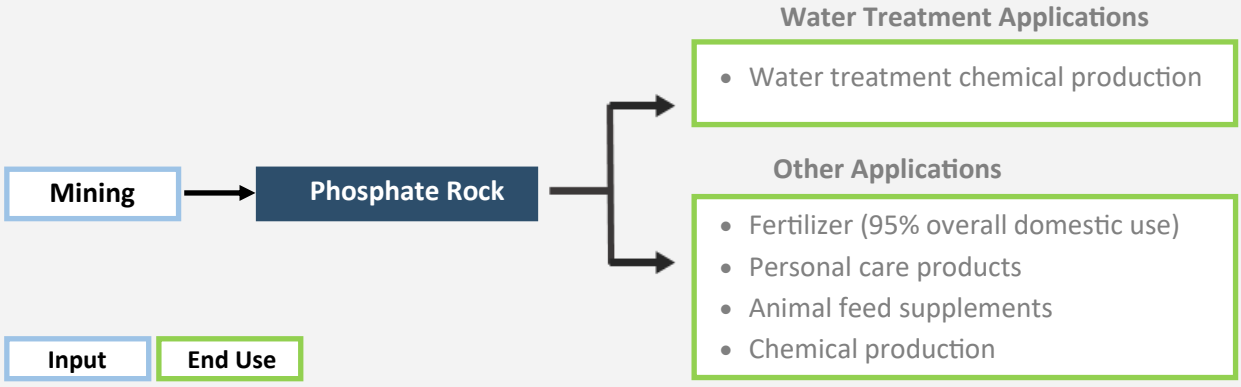
RISK PARAMETERS

Criticality: High. Essential for the production of chemicals necessary for corrosion control.

Likelihood: High. Previous disruptions in supply have impacted manufacturing of derivative water treatment chemicals.

Vulnerability: Low. The U.S. is a leading producer of phosphate rock, however the majority is used in fertilizer manufacturing, thus increasing reliance on imports for water treatment chemical manufacturing.

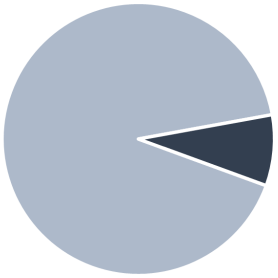
PRODUCTION PROCESS



DOMESTIC PRODUCTION AND CONSUMPTION, AND INTERNATIONAL TRADE

Domestic Production Locations (2019):
11, concentrated in Florida, North Carolina, Louisiana, and Wyoming.

International Trade (2019)
Primary Trading Partner (Imports): Peru
Primary Trading Partner (Exports): Canada



Domestic Consumption (2019): 25,500 Million kg

- Domestic Production (23,300 M kg)
- Imports for Consumption (2,100 M kg)
- Export of Domestic Production (0.152 M kg)

Product Description

Phosphate rock, most commonly found in the mineral fluorapatite ($Ca_5(PO_4)_3F$), is not used directly in water treatment. It is the most significant commercial source of phosphorous and is used in the production of phosphoric acid and fluorosilicic acid.

Use in Water Treatment

None.

Use as a Precursor to Other Water Treatment Chemicals

Phosphate rock is used to manufacture phosphoric acid and fluorosilicic acid.

Other Applications

Phosphate rock has a wide range of applications. The leading use of phosphate rock is to produce phosphoric acid and other sources of phosphorous in fertilizer. It is also widely used in animal feed supplements, detergents, toothpastes, and beverages (USGS, 2020).

Primary Industrial Consumers

In 2017, approximately 95% of phosphate rock consumed in the U.S. was used in the production of phosphoric acid via the wet method, for intended use in fertilizer production (USGS, 2020).

Manufacturing, Transport, & Storage

Manufacturing Process

Phosphate rock deposits are naturally occurring calcium phosphate minerals found in large deposits in China, the Middle East, North Africa, and the U.S. Phosphate rock may be produced by conventional underground or surface mining (USGS, 2020).

The use of phosphate rock requires the removal of impurities, a process specific to the grade of the deposit. Mined phosphate rock is washed, crushed, screened, and floated before chemical processing can take place. Beneficiation steps may include separation of particles, crushing, and grinding to separate the phosphate from other material. Further processing includes multiple steps of flotation, and possible filtration. Phosphate may be dried and calcined or may be shipped as a slurry to accommodate initial processing steps by chemical manufacturers (DOE, 2013; FIPRI, 2021).

Phosphate mining and beneficiation is an energy-intensive process, and energy costs may play a considerable role in determining the price of purified phosphorous (DOE, 2013).

Product Transport

Phosphate rock can be transported to processing facilities from mines by rail, truck, boat, or as a slurry through pipeline. It is routinely transported by ship, rail, truck, and pipeline (USGS, 2020).

Storage and Shelf Life

Phosphate rock is stable and non-reactive over a wide range of temperatures. When stored properly, phosphate rock can have a shelf life in excess of 60 months (DOE, 2020; USGS, 2020).

Domestic Production & Consumption

Domestic Production

Production data was collected from U.S. Geological Survey (USGS), for the year 2019, while trade data was collected from the U.S. International Trade Commission (USITC) Dataweb, as shown in Table 1. Both production and trade data are specific to phosphate rock.

Table 1. Phosphate Rock Production and Trade Data Sources

Production and Trade Data			
Category	**Data Source**	**Identifier**	**Description**
Domestic Production	U.S. Geological Survey	CAS No.: 1306-05-4	Phosphate Rock
Imports and Exports	U.S. International Trade Commission	HS Code: 2510	Phosphate Rock

Total U.S. domestic production of phosphate rock was approximately 25,500 million kilograms (M kg) in 2019 (USGS, 2021). Domestic commercial production of phosphate rock takes place in five states within the U.S., with the majority (63%) of operations centered in Florida. All domestic mining operations operate integrated facilities which include fertilizer and phosphoric acid plants in addition to the mine and extraction facilities (FIPRI, 2021). As of 2017, there were five domestic producers, and production takes place at five mines in Florida, four mines in Idaho, one mine in North Carolina, and one mine in Utah. All phosphate rock mined from these facilities is utilized in captive production, and none is sold to the commercial market (USGS, 2017). The *Mosaic Company (Mosaic)* reported production of approximately 12.8 billion kg of phosphate rock in Florida for 2020, with a capacity of 17.2 billion kg. This represents a majority of domestic production capacity. Mosaic ships phosphate rock concentrate from Peru to their Louisiana processing facility for production of phosphoric acid and fertilizers (The Mosaic Company, 2021). The number of domestic manufacturing locations shown in Figure 1 represents operating facilities as of 2017 (USGS, 2020).

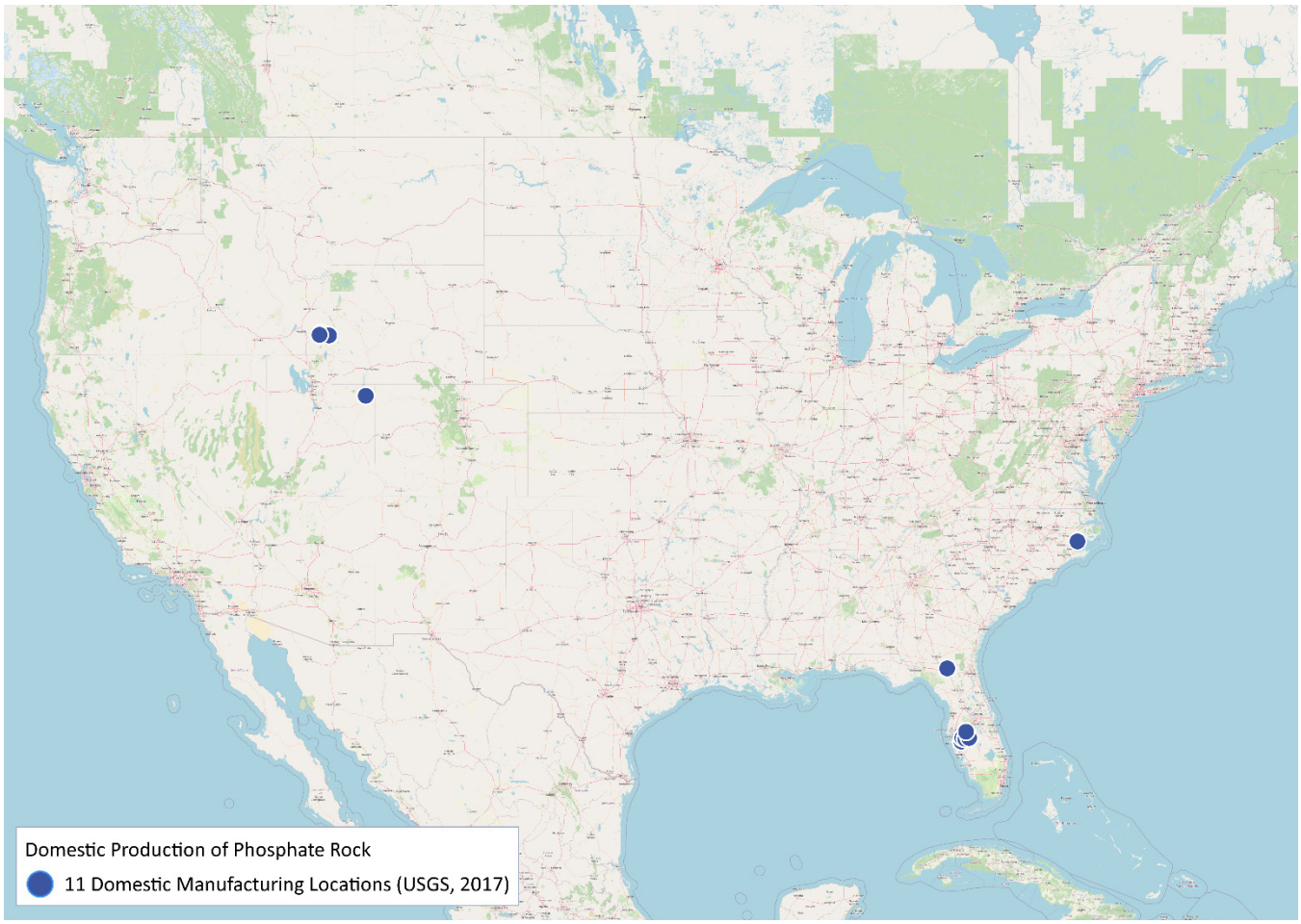


Figure 1. Domestic Production of Phosphate Rock

Domestic Consumption

U.S. consumption of phosphate rock in 2019 is estimated at 25,500 M kg. This estimate includes production of 23,300 M kg, import of 2,100 M kg, minus export of 0.152 M kg (USGS, 2021), as shown in Figure 2.

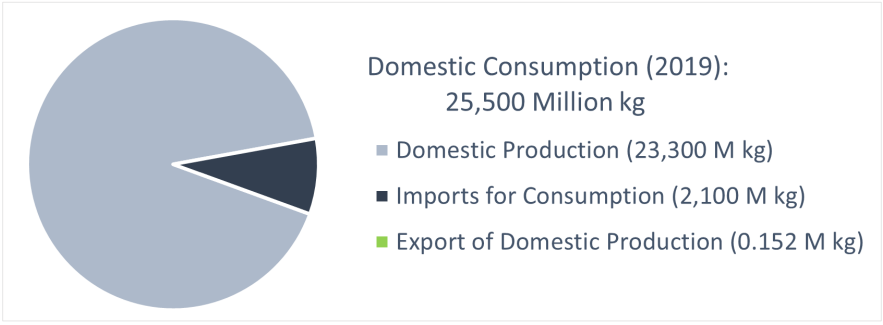


Figure 2. Domestic Production and Consumption of Phosphate Rock in 2019

Trade & Tariffs

Worldwide Trade

Worldwide import and export data for phosphate rock (ground) are reported through the World Bank's World

Integrated Trade Solutions (WITS) software, as a category specific to ground phosphate rock. In 2021, the U.S. ranked 12th worldwide in total exports and 22nd in total imports of ground phosphate rock. In 2021, the Russian Federation ranked first worldwide in total exports and India ranked first worldwide in total imports (WITS, 2022), as shown in Table 2.

Table 2. WITS Worldwide Export and Import of Ground Phosphate Rock in 2021

2021 Worldwide Trade Phosphate Rock, Ground (HS Code 2510.20)			
Top 5 Worldwide Exporters		Top 5 Worldwide Importers	
Russian Federation	2,067 M kg	India	4,556 M kg
Egypt	747 M kg	Turkey	990 M kg
Senegal	403 M kg	Russian Federation	640 M kg
Uzbekistan	40 M kg	Lebanon	531 M kg
Austria	26 M kg	Bulgaria	508 M kg

Domestic Imports and Exports

Domestic import and export data are reported by USITC in categories specific to phosphate rock. Figure 3 summarizes imports for consumption[1] and domestic exports[2] of phosphate rock between 2015 and 2020. During this period, the overall quantity of imports varied, with the greatest volume of imports occurring in 2018. The volume of exports, considerably smaller than the volume of imports, remained relatively steady. Over this five-year period, Canada was the primary recipient of domestic exports while Peru was the primary source of imports with a much smaller quantity consistently originating from Morocco throughout this period (USITC, 2021).

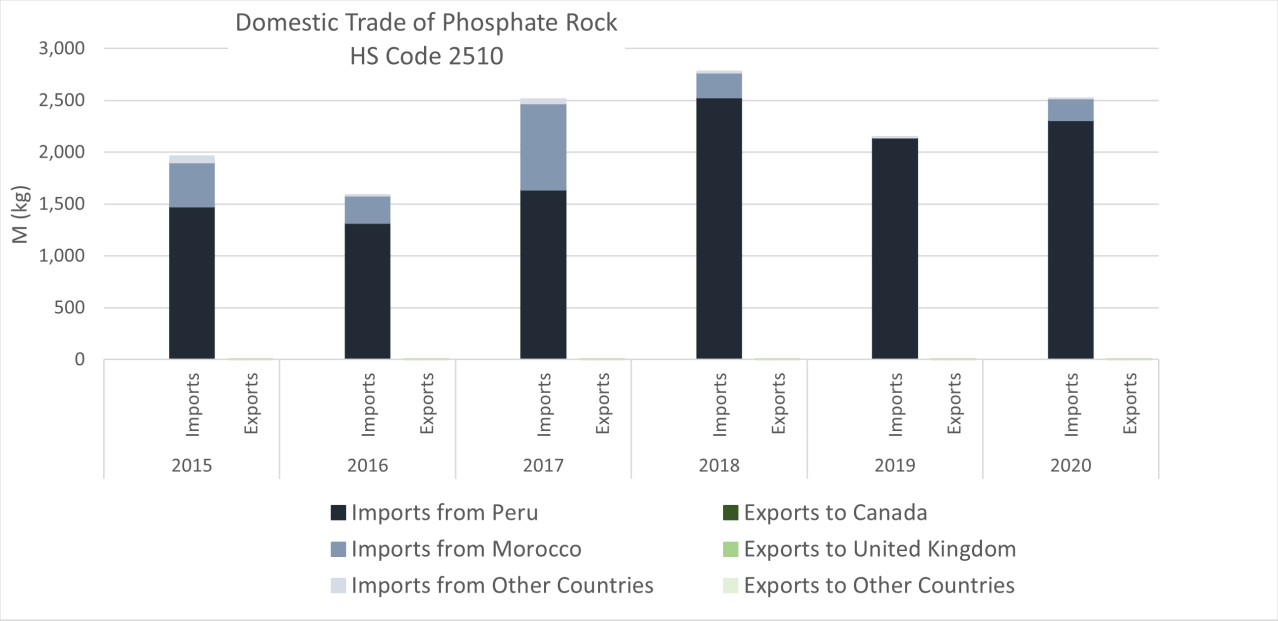


Figure 3. USITC Domestic Import and Export of Phosphate Rock between 2015 and 2020

[1] Imports for consumption are a subset of general imports, representing the total amount cleared through customs and entering consumption channels, not anticipated to be reshipped to foreign points, but may include some reexports.
[2] Domestic exports are a subset of total exports, representing export of domestic merchandise which are produced or manufactured in the U.S. and commodities of foreign origin which have been changed in the U.S.

Tariffs

Imports of phosphate rock are primarily supplied from Peru. There is no general duty for import of phosphate rock, however there is an additional 25% duty on imports from China (USITC, 2022), as summarized in Table 3.

Table 3. 2022 Domestic Tariff Schedule for Phosphate Rock

HS Code	General Duty	Additional Duty – China (Section 301 Tariff List)	Special Duty
2510	None	25%	None

Market History & Risk Evaluation

History of Shortages

Phosphate rock is a raw material necessary for production of phosphate-based corrosion control chemicals and water fluoridation chemicals. While the U.S. is a leading worldwide producer of phosphate rock and phosphoric acid, approximately 95% of domestically produced phosphate rock / phosphoric acid is used in captive manufacturing to produce fertilizer (USGS, 2020). Domestic production of phosphate-based chemicals other than fertilizer may rely on import of phosphate rock from a small number of countries including Peru, Morocco, China, and Russia. Domestic manufacturers and suppliers of phosphate-based water treatment chemicals oftentimes rely on the international market for supply of inputs and raw materials (ICL, 2021). Price and access on the international market, like the domestic market, is driven by agricultural demand and increasingly by demand for lithium iron phosphate battery materials (Murtaugh, 2021; Spears et al., 2022). The international market for phosphate rock and phosphoric acid may also be impacted by trade barriers, international events such as armed conflict, and natural disasters.

Challenges in obtaining phosphate rock, phosphoric acid, or downstream precursor chemicals such as monosodium phosphate on the international market. This has led to repeated shortages of phosphate-based water treatment chemicals. Most recently, the disruptions in international trade caused by the COVID-19 pandemic have severely challenged these manufacturers.

Risk Evaluation

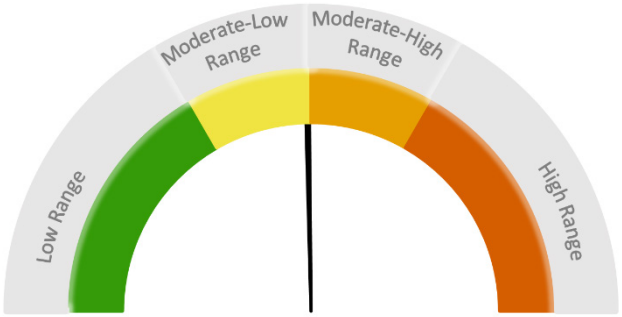
The complete risk assessment methodology is described in *Understanding Water Treatment Chemical Supply Chains and the Risk of Disruptions* (EPA, 2022). The risk rating is calculated as the product of the following three risk parameters:

Risk = Criticality x Likelihood x Vulnerability	
Criticality	Measure of the importance of a chemical to the water sector
Likelihood	Measure of the probability that the chemical will experience a supply disruption in the future, which is estimated based on past occurrence of supply disruptions
Vulnerability	Measure of the market dynamics that make a chemical market more or less resilient to supply disruptions

The individual parameter rating is based on evaluation of one or more attributes of the chemical or its supply chain. The ratings and drivers for these three risk parameters are shown below in Table 4.

Table 4. Supply Chain Risk Evaluation for Phosphate Rock

Risk Parameter Ratings and Drivers		
Criticality: High	**Likelihood: High**	**Vulnerability: Low**
Phosphate rock is essential to production of all phosphate-based water treatment chemicals including chemicals necessary for corrosion control.	There have been historic widespread supply disruptions due to decreased production in countries that are significant suppliers to the international market. Supply disruptions have impacted availability of derivative products and inputs for water treatment chemicals.	Though the U.S. produces a large quantity of phosphate rock, the vast majority produced is intended for use in fertilizer manufacturing, which increases reliance on imports for manufacture of water treatment chemicals.
Risk Rating: Moderate-Low		



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