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Supply Chain Chaos: Securing Barite in the Aftermath of the Pandemic

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Abstract

Diminishing supply, increased environmental regulations, restrictive government policies, and challenging logistics disrupt the barite supply chain. The pandemic highlighted these critical shortages and increased the urgency to address them. As the weight material of choice for almost every drilling fluid application, any potential shortage remains at the forefront of supply chain concerns.

As a traditionally inexpensive weighting agent, under-investment in new mineral reserves reduces ore availability as legacy mines deplete. Additional reserves are found in remote locations or deeper underground where extraction is currently uneconomical. Other mines have closed as government regulations restrict access to viable of deposits – including export restrictions to insure domestic supply.

Freight represents approximately 30% of barite cost and is subject to the greatest volatility from fluctuating fuel prices and shifting supply chain demands. The pandemic aggravated many of these underlying issues. Bulk vessel prices spiked as availability dropped. Increased activity onshore and a drop in offshore activity required additional rail and truck transportation to deliver material to the rigsite.

Introduction

Almost 85% of barite is used in drilling fluids (Bleiwas and Miller, 2014). Other applications include paint pigments, noise dampening, pharmaceuticals, and radiation shielding. Alternative weight materials have been tested and applied in the field, but barite remains a preferred product because it features:

- High specific gravity to raise drilling fluid density. Pure barite has a specific gravity of 4.5. API grade barite has a specific gravity of 4.1 or 4.2 (American Petroleum Institute 2019).
- Low mohs hardness to limit abrasion of equipment
- Relatively inert to limit interaction with other drilling fluid chemicals
- Low solubility and nontoxic properties

The relatively low cost and widespread use of barite sustains the perception that barite is available in abundance; however, known supplies continue to dwindle without the replacement of depleted reserves. In effect, because barite is inexpensive, low profit margins at the mines discourage investment to explore for sources of new quality ore.

The United States is the largest importer and consumer of barite worldwide. (Newcaster 2022). Imports include mined ore and ground powder. Longer supply chains have many of their own issues as transportation options compete with other, higher-priced goods.

Barite Properties

Not all barite used in drilling fluids meets the standards set by the API, but it is a recognized standard used by the industry. Other specifications, such as limits on heavy metal content, are established by regulatory agencies or operators for specific drilling demands and working environments.

Scott and Robinson (2010) provide a detailed history of barite specifications, which is summarized in Table 1. The last significant change occurred in 2010 when the API approved a lower 4.1 specific gravity barite from the 4.2 specific gravity minimum.

Year	Ore Specification (Particle size specifications, if applicable, excluded)
1924	Dutch Boy Paint Pigment > 94% barite 4.2 – 4.3 specific gravity
1950	API RP29 Appendix A 1) 4.0 – 4.25 specific gravity: 5% cost of goods reduction for every 0.1 specific gravity below 4.25 2) 4.25 specific gravity free of abrasive material (sand) 3) > 4.25 specific gravity with a minimum 95% barite and < 0.1% calcium carbonate
1958	API RP 13A 4.20 specific gravity < 250 mg/kg water soluble earth metals, as calcium
2010	API RP 13A 4.20 specific gravity 4.10 specific gravity alternative < 250 mg/kg water soluble earth metals, as calcium

Table 1: A summary of historical barite specifications from Scott and Robinson (2010)

Prior to API approval, 4.1 specific gravity barite was extensively tested and trialed to demonstrate minimal impact on most operations (Fraser et al. 2009).

In land operations, it is not uncommon to use barite with a specific gravity as low as 3.9. Lower specific gravity barite ore will have a larger quantity of non-barite material, such as quartz. In some cases, lower quality ore can have an abundance of undesirable contaminants, such as pyrite, which can cause tool interference and erosion.

Weight Material Alternatives

Throughout the history of drilling fluids, barite alternatives have been evaluated to increase weight material supply, expand options, and lower prices. Unfortunately, an ideal replacement is yet to be found.

Today, barite alternatives are used for specific well challenges where the added material cost is justified by performance savings and reduced risk in the operation, but their availability and cost limits widespread adoption.

Materials with higher specific gravity require less solids per unit volume to achieve elevated density, improving flow properties. Fine-grinding limits abrasion, reduces sag tendency, and allows for lower rheology to suspend weight material to reduce equivalent circulating density (ECD).

Other weight material selection factors include iron content, which can cause magnetic interference, acid solubility for drill-in fluid treatments, and pneumatic transfer ability for safer handling. Table 2 provides a select list of drilling fluid weight material options. Materials such as calcium carbonate, ilmenite, manganese tetroxide, and hematite have common use cases. Strontium carbonate, iron carbonate, and celestite are mentioned in technical literature and patents, but lack widespread use.

Material	Specific Gravity	Comments
Calcium Carbonate ($CaCO_3$)	2.7 – 2.8	Highly acid soluble for drill-in fluids, low hardness
Strontium Carbonate ($SrCO_3$)	3.5	No domestic production. Few documented cases.
Iron Carbonate ($FeCO_3$)	3.7	Magnetic interference, acid soluble but iron risks causing formation damage
Celestite ($SrSO_4$)	3.95	No domestic production. Few documented cases.
Barite ($BaSO_4$)	3.9 – 4.2	Micronized options, including those at higher specific gravity
Ilmenite ($FeTiO_3$)	4.6	Micronized option to limit abrasion. Limited acid solubility.
Manganese Tetroxide (Mn_3O_4)	4.8	Used in critical offshore wells and cement slurries. Limited acid solubility.
Hematite (Fe_2O_3)	5.0	Magnetic interference, abrasive, Some acid solubility but iron risks causing formation damage

Table 2: Weight material options for drilling fluids

Sources of Ore

Barite ore is found across the globe and is primarily extracted by large, open-pit mines. It is also accessed underground via mine shafts, usually as a byproduct of mining other, more valuable minerals (Highley 2006).

Existing Sources

Domestic barite production peaked in 1981 (Bleiwas and Miller 2015). Since then, foreign sources displaced most domestic production, with China providing 80% of supply by the mid-2000s (Bruton, Bacho, and Newcaster 2006). As domestic production waned, mines were idled or closed. The acceptance of a 4.1 specific gravity barite extended reserves to several mines with depleted 4.2 specific gravity material. There are a handful of mines remaining in Nevada, but no other domestic mines remain operational.

In the past decade, a shift in international sourcing occurred as China retained more barite for domestic use and closed mines that failed to meet environmental standards. India, Morocco, and Mexico are key sources with a combined 80% of imports. Figure 1 provides a breakdown of barite imports in 2021 (Newcaster 2022).

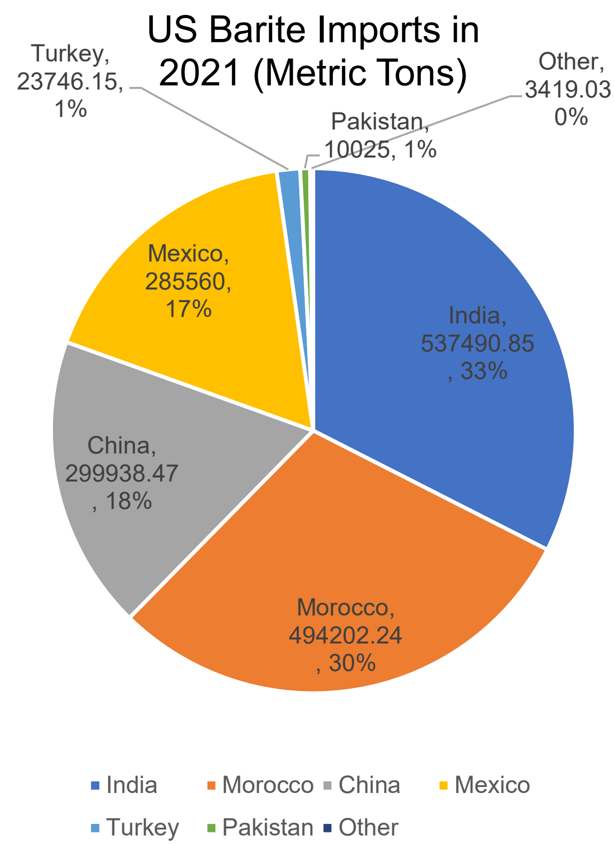

Figure 1: Barite Import Tonnage by Country in 2021

Exploration Limitations

Additional barite ore is available for extraction, but there is a cost to identifying locations for new mines. It is estimated that it costs between $1 million and $1.5 million to evaluate the feasibility of an area for barite mining. This includes studies to evaluate the size, quality, and scope of the reserves – but is no guarantee the investment will justify a new mine.

It may take multiple studies to identify one economically viable site. New sources of ore are likely deeper and in more remote areas, requiring greater costs to extract. In most cases, the best opportunities consist of expanding or re-activating existing mines or identifying reserves adjacent to these areas. In some cases, legacy costs and time to reclaim depleted mining areas limit expansion until producers address their current sites.

In 2006, Bruton, Bacho, and Newcaster estimated Nevada mines would exhaust economical 4.20 ore reserves within 5 years. They forecasted acceptance of 4.10 specific gravity barite would extend reserves by 11 years with an investment of $7.5 million. A 20-year extension of 4.20 specific gravity would cost $100 million – in 2006 dollars.

While there is significant interest in domestic production of critical minerals such as lithium, barite is a material primarily used for hydrocarbon extraction and faces political headwinds for permitting and community acceptance. Some financial institutions refuse to provide loans to projects involved with the oil and gas industry, limiting access to capital for any expansion.

In 2020, President Donald Trump, signed Executive Order 13953 ordering an investigation into foreign dependence on 35 critical minerals, including barite, and directed resources towards greater domestic production. While the executive order cites barite specifically for energy security, there are no specific steps towards domestic production for oilfield barite.

The Inflation Reduction Act includes incentives to invest and develop critical minerals (barite is on the list), but much of the language excludes barite as it would apply to oilfield applications due to purity requirements to qualify for incentives (DGS Law 2022).

Political Instability

There are many countries with known deposits of quality barite. In many cases, unstable political environments prevent reliable barite exports.

Peru is a mineral-rich country, known for its large copper reserves. Among copper deposits lie significant barite reserves. Recent unrest has claimed tens of lives. Protests have forced the closure of mines, impacting the supply of Peru's mineral wealth (Swaminathan and Villegas 2023). Other countries struggle with unclear regulatory frameworks, limiting outside investment, particularly for low-cost barite ore (The World Bank 2022).

Freight

Freight represents about 30% of the price of barite. From crude ore at the mine to ground powder at the rig-site, barite travels by a combination of truck, rail, and ocean freightliner.

All modes of transportation were impacted by the pandemic, and many have yet to fully recover. Regardless of the transportation vessel, fuel is a critical cost factor and fluctuations in the price of oil impact freight costs in kind. Figure 2 illustrates a typical process from the barite ore mine to finished product at the rig-site. Each load requires multiple modes of transportation, consuming fuel subject to fluctuation.

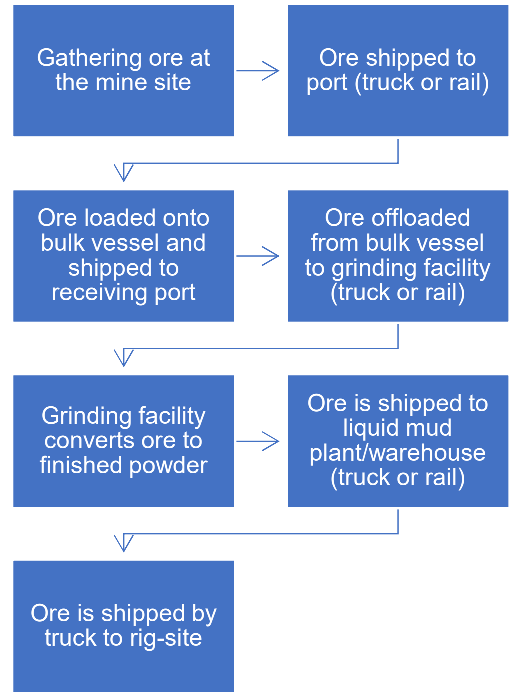

Figure 2: Typical path of imported barite ore to finished powder at the rig-site

Bulk freight by ship or rail improves the cost per ton of barite, but larger loads require higher carrying costs. In the 1980s, ocean vessels carried 35,000 tons of ore. Today, 60,000-ton loads require the capacity to hold larger inventory over time, limiting new entrants into the market. Similarly, rail is more fuel efficient per ton, but material remains in rail cars for days or weeks before sale.

Bulk Vessels

Barite ore is transported in bulk vessels that also carry other products including coal, iron ore, and grain. Shipping routes are aligned to minimize empty vessel movements and extra fuel costs. For example, China is a major importer of soybeans from the United States. Once a bulk load of American soybeans arrives in China, the backhaul to the United States is relatively in expensive. This is an ideal scenario to transport barite at lower cost.

Bulk vessel transport cycles have been disrupted repeatedly – prior to, and after, the pandemic. In 2018, the trade dispute between the United States and China resulted in a 25% tariff on soybeans from the United States, sending bulk vessels to South America for lower-cost soybeans (Cowley 2020, S&P Global 2019). This eliminated the traditionally low-cost backhaul option for barite ore from China. The longer routes also increased shipping times, reducing the number of available vessels to transport barite ore.

In Figure 3, an example shows barite leaving Shanghai and arriving to the Gulf Coast. From there, it can return with grain to Shanghai (blue line) or, with tariffs on American goods, pick up grain in Santos, Brazil before returning to China (red line). Due to limited commodity trade with Brazil, the ship may leave the United States empty, increasing costs, shipping times, and fuel expenditures.

Figure 3: Example barite delivery route from China (black dashed line) and grain returns from the United States (blue line) versus

At the start of the pandemic, a dispute between China and Australia left as many as 70 ships stranded in Chinese ports waiting to offload (Zhuang 2020). With these bulk vessels unavailable for service, the global market constricted, increasing rates.

In addition to temporary disruptions, dry bulk vessel supply is expected to remain limited. The current fleet continues to age with few orders for replacement vessels. In 2020, a global regulation established by the International Maritime Organization (IMO 2020) went into effect, limiting marine fuel sulfur content to 0.5% from 3.5% (International Maritime Organization 2019). To meet these requirements, vessels were required to use alternate fuels or install scrubbers. For older vessels at the end of their service life, this was not economical, taking them out of service – and likely to a scrap yard prematurely.

In 2023, the IMO is targeting the carbon intensity and overall efficiency of vessels. As part of a greater effort to reduce carbon emissions by 40% in 2030 from 2008 levels, IMO 2023 requires monitoring and efficiency standards. For current vessels, a key compliance method is slow-steaming, or sailing at slower, more fuel-efficient rates. A 10% reduction in speed increases fuel efficiency by 30%, requiring no additional capital to improve an ageing vessel. This in effect extends days at sea, constricting available vessels (Hellenic Shipping News 2022, Muenster 2022). Uncertainty about future regulations to meet stated goals further limits the appetite for investment.

An anticipated recession has short-term expectations for dry bulk vessel rates to remain low in the short term (Lee 2022). Long term, many shipping analysts see elevated dry bulk shipping rates into the future as fewer vessels are available due to under-investment and compliance requirements (Catlin 2021, Lee 2022, Lindstrom 2021, Roussanoglou 2022).

Rail

Rail provides a safer, lower-cost transportation option to trucking, yet the producer price index for rail freight remains near historical highs as shown in Figure 4 (St. Louis Federal Reserve 2023). Rail delays and service issues remain a major issue reaching national attention. While the risk of a high-profile strike was averted, many of the underlying issues with domestic rail remain. This includes a shortage of personnel and issues locating railcars. High levels of attrition and loss of experience personnel continue to plague railroads (Stephens 2022, Zimmerman 2021). In some cases, shippers switch to truck freight to avoid these issues, increasing demand for more-expensive truck freight that is still required for final delivery of barite (Semuels 2022).

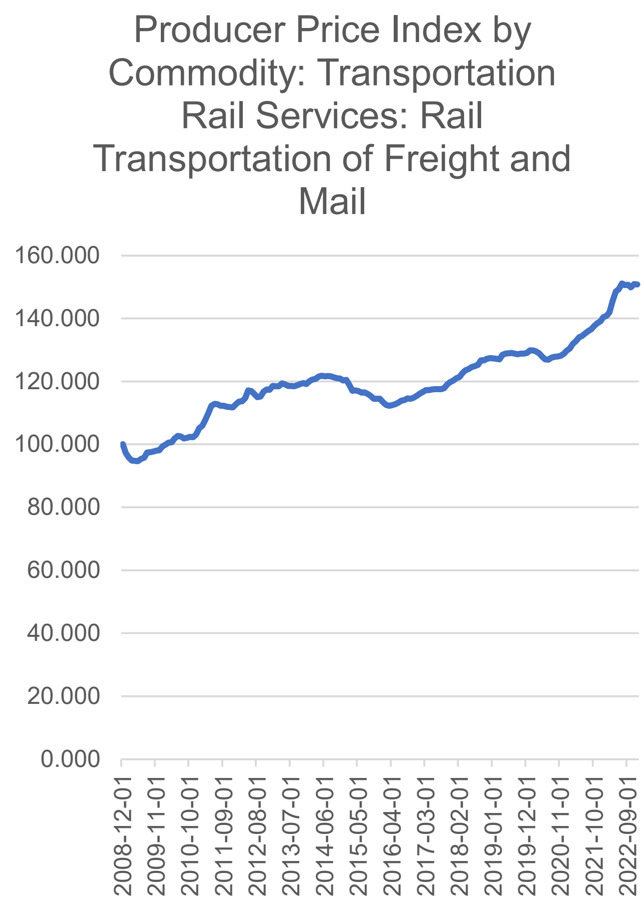

Figure 4: St. Louis Federal Reserve Product Price Index for Transportation Rail Services: Rail Transportation of Freight and Mail

Trucking

Trucking rates are beginning to stabilize, but they remain at record highs according to the St. Louis Federal Reserve (2023), illustrated in (Figure 5). Barite movement requires trucking across multiple phases of its journey to the rig-site.

Qualified drivers remain in short supply and trucking rates remain elevated. In many key mines, such as those in India and Mexico, ore is transported in trucks to the quayside or to the grinding plant. After processing at the grinding plant, trucks (and sometimes rail) transport bulk or bags of barite powder to field warehouse before it is trucked to the rig-site.

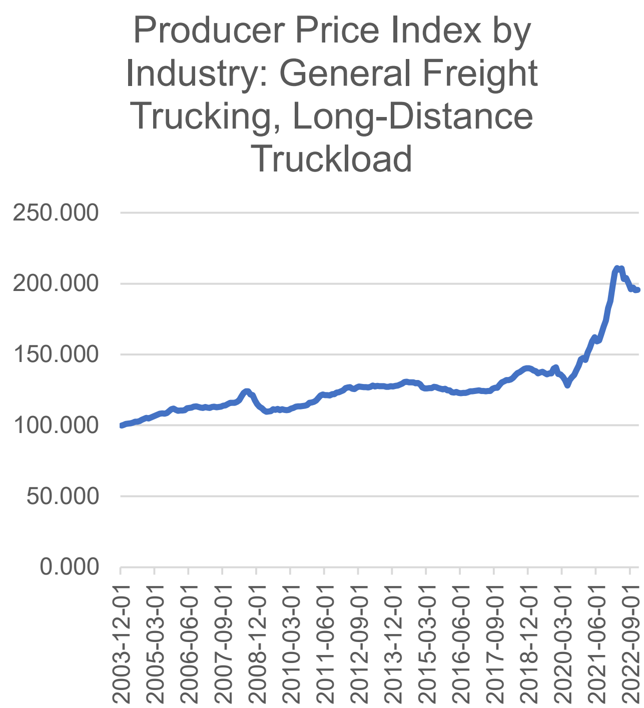

Figure 5: St. Louis Federal Reserve Product Price Index for General Freight Trucking, Long-Distance Truckload

Trucking rates are also subject to the price of diesel. Diesel price volatility in 2022 created serious issues for spot-rate trucking. As diesel spiked, the previously agreed spot-rate did not reflect the current price for fuel. In addition, 60-day payment terms for services created a cash-squeeze for smaller trucking companies and owner-operators waiting on payment as fuel prices increased (Solomon 2022).

Conclusions

The supply chain for cost-efficient barite sources remains at risk due to:

- Underinvestment in new source mines
- Regulatory and political uncertainty
- Transportation and logistics concerns

As existing resources deplete pricing pressure and supply inconsistency adds greater risk to the economics of drilling future wells.

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