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Goehring & Rozencwajg  
Natural Resource Market Commentary

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# THE GAS CRISIS IS COMING TO AMERICA

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“A German retiree facing sky-high energy bills is turning to a wood burning stove. The owner of a dry cleaning business in Spain adjusted her employees’ work shift to cut electric bills, and a Mayor in France said he is ordering a hiring freeze because rising electrical bills threaten a financial ‘catastrophe.’ Europeans have long paid some of the world’s highest prices for energy, but no one can remember a winter like this one.” Bloomberg February 22, 2022

“The US has taken further steps to help send more LNG to Europe to replace Russian gas, but....it was not immediately clear where the additional 15 bcm of gas that the US has agreed to supply to Europe would come from.” Bloomberg March 27, 2022

GOEHRING &  
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Natural Resource Investors

A sudden and unexpected event is about to take place: the “global” natural gas crisis, now gripping huge swaths of the world, is about to engulf North America as well.

Asian and European natural gas prices stand at \$35 per mmbtu, versus \$8.20 per mmbtu here in the United States. Given the underlying fundamentals that have now developed in US gas markets, we believe prices are about to surge and converge with international prices within the next six months.

The natural gas market outside of North America has been in an extreme shortage since the end of last summer. Prices first broke \$35 per mmbtu last October, plateaued, and then surged again in December, surpassing \$50 per mmbtu – equivalent to \$300 per barrel oil. The problems started in Europe last spring. After a colder-than-normal end to winter across most of Europe and Russia, inventories reached dangerously low levels. By midsummer, European utilities and industrial consumers turned to global LNG markets seeking additional supplies after Russian pipeline imports failed to replenish stockpiles.

Conventional wisdom says that Russia withheld contracted gas throughout the summer; however, our analysis shows that Russia fulfilled all its volume requirements. What Russia did not do was ship additional gas over and above the contracted levels, preferring instead to refill first its own domestic inventories.

Strong Asian demand left little additional LNG for other buyers – a danger we warned about in our 4Q20 letter. European buyers panicked once they realized they would be unable to refill inventories ahead of the winter heating season. In response prices surged five-fold higher.

Although North American investors might not be aware, record gas prices have already impacted Europe's economy. Both fertilizer manufacturing and metal smelting facilities have been forced to close and governments have offered cash subsidies to help soften the blow. European coal demand has hit all-time highs, undoing a decade of CO2 reduction efforts in only a few months.

All this occurred before Russia invaded the Ukraine.

The upheaval impacting international gas markets has largely bypassed North America over the last 12 months. US natural gas briefly surpassed \$6 per mmbtu last September before falling back to \$4 by December. At the same time, European gas reached \$50 per mmbtu, twelve times higher than in the US. The natural gas crisis gripping huge swaths of the world has so far showed little inclination to move across either the Pacific or Atlantic ocean. "Gas crisis? What gas crisis?" might be something asked by North American investors today.

In this essay, we explain why North American investor apathy is foolish. Our models suggest the decades-long protection from international price swings, enjoyed by the North American gas market, is about to change. Slower-than-expected shale growth will push the US market into structural deficit for the first time in 15 years. Almost immediately following the shift, US prices will converge with global gas prices. Given today's \$35 per mmbtu international gas prices, prices could surge by almost four-fold.

The unique structure of the North American natural gas market has long protected it from foreign influences. Since its development, evolution, and massive expansion in the post WW2 period, the US market has been like an island. Gas was produced in the United States, and imported via pipeline from Canada or via LNG from any of its five import terminals. Once that gas arrived, however, it was trapped. Small amounts could

THE NATURAL GAS CRISIS GRIPPING HUGE SWATHS OF THE WORLD HAS SO FAR SHOWED LITTLE INCLINATION TO MOVE ACROSS EITHER THE PACIFIC OR ATLANTIC OCEAN. "GAS CRISIS? WHAT GAS CRISIS?" MIGHT BE SOMETHING ASKED BY NORTH AMERICAN INVESTORS TODAY.

be exported via pipeline to Mexico, but that was it -- no “Lower-48” facility existed to export LNG. Because of its island-like structure, international gas fundamentals only marginally impacted US prices, which often traded at a huge discount.

Prior to 2016, the US was only a tiny player in global LNG export markets -- a small amount was exported from the Kenai Peninsula in Alaska. In just six short years, the US has become the world’s largest LNG exporter. Six export facilities currently operate and a seventh, Calcasieu Pass, will add an additional 1.7 bcf/d of capacity, bringing total US LNG export capacity to 13 bcf/d, surpassing both Qatar and Australia, formerly the world’s two largest LNG exporters.

Even though it is now integrated into the global gas market via LNG, US prices remain disconnected from global prices. Why? Surging shale production has far exceeded LNG export demand. The US natural gas market has remained in structural surplus even with surging LNG exports. That is all about to change. Slowing shale production will cause the US to flip from structural surplus to structural deficit.

The impact of shale gas in the United States cannot be overstated. Prior to the unlocking of the Barnett Field in east Texas in the early 2000s, the US was running out of natural gas. In 2000, conventional production was 50 bcf/d. By 2005, this had fallen to 45 bcf/d and by 2010, conventional production was just 40 bcf/d. Even with the big shale ramp up from the Barnett, total US production fell from 52.6 bcf/d in 2000 to 49.5 bcf/d by 2005.

By the late 1990s, the US had become a significant LNG importer. In 2000, the US imported approximately 500 mmcf/d. By 2005, this had grown to almost 1.8 bcf/d and by 2007, LNG imports peaked at 2.1 bcf/d. The contrast between these two periods (2000 to 2007 and 2016 to 2021) are amazing. Between 2000 and 2007, natural gas production fell sharply and LNG imports into the US surged. Over the last seven years, production has exploded and the US has become the world’s largest LNG exporter. Talk about a difference!

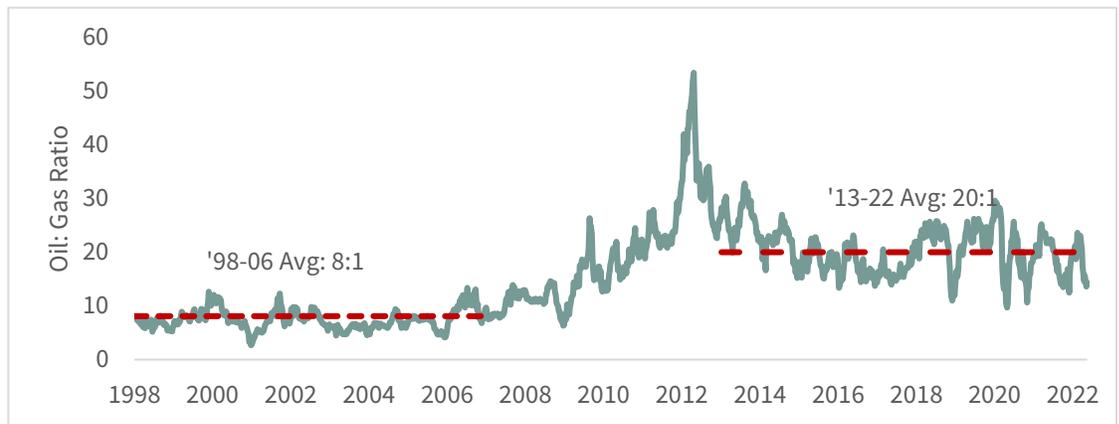
The Barnett started ramping up in 2002 and was soon followed by the Fayetteville in 2005. The Marcellus and Haynesville began their massive ramp ups in the late 2000s and were joined by associated gas from the Bakken, Eagle Ford, DJ, Permian, and Anadarko oil shales. Finally, the Utica began its production ramp up in the mid-2010s.

In 2000, US dry gas production was 52.6 bcf/d and the shales produced little. Today, production is 94 bcf/d with nearly 73 bcf/d, or 80%, coming from the shales.

Since 2016, US shale gas production has grown by an incredible 27 bcf/d, more than offsetting a 7 bcf/d decline in conventional supply. The 20 bcf/d net increase in supply far outstripped the 10 bcf/d of new LNG export demand. Reflecting the surplus over the last 10 years, US natural gas continues to trade at a material discount to crude oil. A barrel of oil has six times the energy content of an mmbtu of natural gas, so the “normal” ratio of oil to gas should be 6:1. Instead, the oil to gas ratio averaged 20:1 between 2016 and 2021, even as crude prices fell.

The following chart illustrates the impact of the shales. Between 1998 and 2006, before the shales were developed, the ratio of oil to gas averaged 8:1 – close to its energy equivalent value. The shales ramped up production in 2013 and ever since, the ratio has averaged

FIGURE 1 Oil:Gas Ratio



Source: Bloomberg.

20:1.

IN EUROPE AND ASIA, A NATURAL GAS MMBTU COSTS \$35. IN OTHER WORDS, US GAS IS PRICED AT AN ENERGY-EQUIVALENT DISCOUNT OF 56% TO WORLD OIL AND A 77% DISCOUNT TO WORLD GAS. IN OUR 35 YEARS INVESTING IN GLOBAL ENERGY MARKETS, WE HAVE NEVER SEEN SUCH A WIDE DISPARITY.

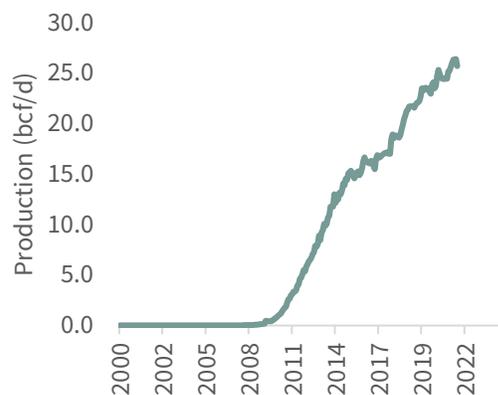
Now compare that to outside of North America, where natural gas trades at an oil-to-gas ratio of 3:1. An mmbtu in a barrel of oil today costs approximately \$18 outside of North America. That same mmbtu in US natural gas costs \$8.00. In Europe and Asia, a natural gas mmbtu costs \$35. In other words, US gas is priced at an energy-equivalent discount of 56% to world oil and a 77% discount to world gas.

In our 35 years investing in global energy markets, we have never seen such a wide disparity.

Almost everyone takes it for granted that US gas production will continue to grow strongly as we progress through this decade. With production having nearly doubled in the last 10 years, few analysts bother to even consider underlying shale gas supply issues. But something else has happened that receives no comment -- never before has production been concentrated in so few fields. Over half of production comes from just three fields. The Marcellus and Haynesville produced almost 40% of US gas while associated gas from the Permian oil shale takes this to 52%.

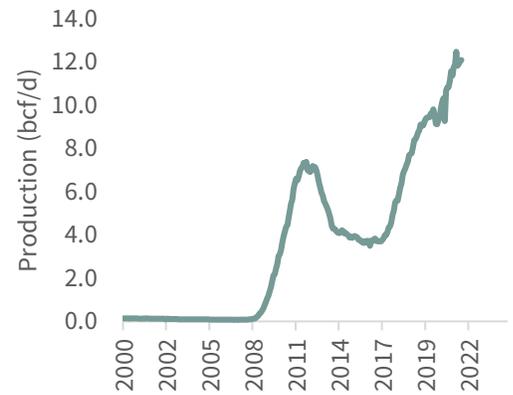
The production profiles of the Marcellus and Haynesville look like this:

FIGURE 2 Marcellus



Source: EIA.

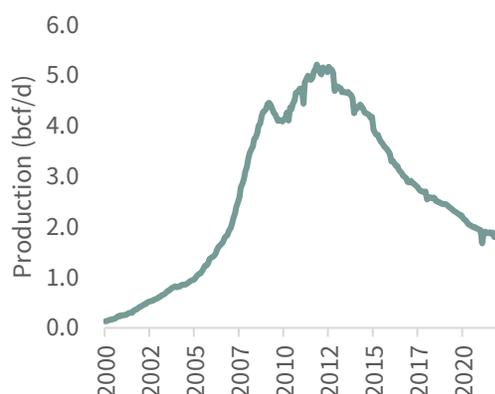
FIGURE 3 Haynesville



Source: EIA.

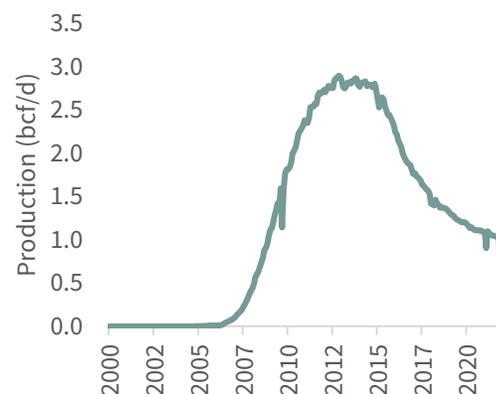
But how long until they begin to look like this?

FIGURE 4 Barnett



Source: EIA.

FIGURE 5 Fayetteville



Source: EIA.

The answer will be critical in trying to ascertain the future of US gas prices. The US reached 13 bcf/d of functional LNG export capacity this year and is now fully integrated into the global market where prices are \$35 per mmbtu. The moment the US gas market swings from even marginal surplus to marginal deficit (i.e., when US demand plus LNG exports exceeds production and imported supply), something shocking will take place: almost immediately, US prices will converge with global prices.

Everything comes down to whether the US shales will continue to grow. Given the importance of the question -- and the fact that the Biden administration pledged another 5 bcf/d of LNG to Europe by 2030 -- you would think there would be endless analysis of the three shales upon which so much production depends. But if you thought that, you would be incorrect. As far as we can tell, while most analysts spend their time debating the international geopolitics of gas, they continue to take shale production completely for granted. We have not read any recent discussion of the geological or technical challenges facing the Marcellus, Haynesville, or Permian, or what their future production capabilities might be. These three fields represent over 50% of US production and their growth is critical.

We believe it's imperative to understand the future production profiles of these fields. Many analysts seem to believe shale growth is almost unlimited. Our analysis tells us something quite different. We believe all the fields -- especially the Marcellus and Haynesville -- will soon begin to exhibit the first signs of exhaustion, very similar to what happened with the Barnett and Fayetteville.

The Barnett and Fayetteville were the first gas shales to be developed and, despite being "unconventional," exhibited every classic sign of conventional field exhaustion. They ramped up, plateaued, peaked, and declined in an orderly fashion. Using this framework, we can attempt to understand what the future production profiles of the Marcellus and Haynesville might look like. When will they peak, plateau, and begin to decline?

The Barnett started producing in the early 2000s and peaked 12 years later at 5.2 bcf/d.

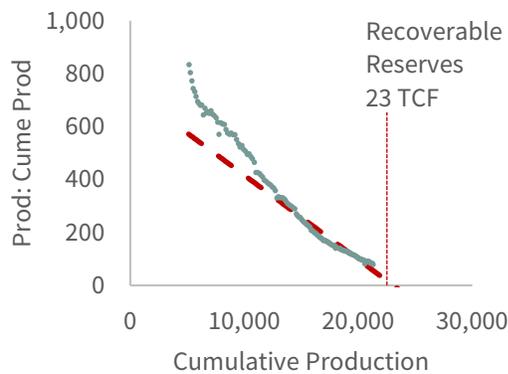
The field plateaued for two years and then started a sustained, steep decline. Today the Barnett produces 1.6 bcf/d, 70% below its peak. Drilling peaked in 2011 at over 80 rigs. Today, only three rigs operate in the Barnett.

The Fayetteville ramped up in 2007 and by 2012 production peaked at 3 bcf/d before also entering a steep decline. Fayetteville production has fallen 65% from its 2012 peak and today is just 1 bcf/d. Drilling peaked in 2011 at 35 rigs and since March 2020 not a single rig has operated in the Fayetteville.

Both fields exhibited well-defined “Hubbert Curve” profiles: production resembles a bell-shaped curve. (For those unfamiliar with King Hubbert’s work and what a “Hubbert Linearization” is, we have attached brief descriptions in the appendix.)

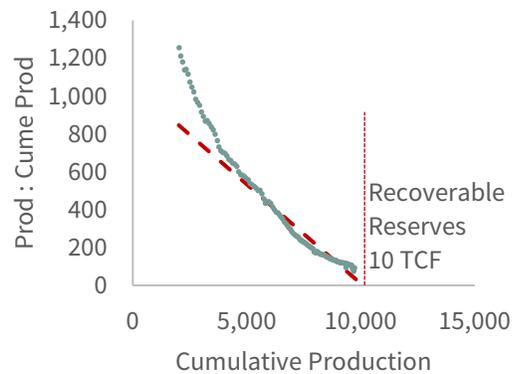
Hubbert believed that oil and gas reservoirs that were developed in an unconstrained manner would peak in production once half of their recoverable reserves were produced. By plotting a “Hubbert Linearization” of cumulative production to the ratio of production to cumulative production, we can indirectly estimate total recoverable reserves and by extension, peak production. The “Hubbert Linearization” for the Barnett and Fayetteville strongly suggest total recoverable reserves of 23 tcf and 10 tcf respectively.

FIGURE 6 Barnett Linearization



Source: EIA.

FIGURE 7 Fayetteville Linearization



Source: EIA.

If these estimates are correct, then half of the Barnett’s reserves were produced in 2013 while the Fayetteville produced half of its reserves in 2014. Looking at the production profile above, both fields began to decline just as half of their reserves had been produced. Given the limited drilling in both fields, it is safe to assume that the estimates of recoverable reserves from the Hubbert Linearization are now fairly accurate.

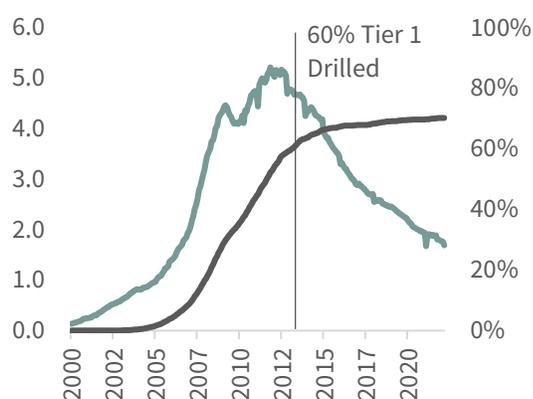
Several years ago, we developed an artificial intelligence neural network to study the shale basins. We have constantly refined this model and used it to estimate the total number of wells that will ultimately be drilled and to calculate our own expected recoverable reserve figure. In the Barnett, we identified 18,000 potential drilling locations of which 15,800 have already been drilled, leaving 2,200 remaining locations. Our neural network estimated the Barnett would ultimately recover 25 tcf from its 18,000 locations. Furthermore, production from the Barnett peaked once exactly half of the neural network’s expected recoverable reserves had been produced. Today, with production down 70%

we estimate that 21 of the 25 tcf of recoverable reserves have already been produced, leaving only 15% remaining. Our “bottoms up” analysis was within 10% of the Hubbert Linearization “top down” estimate.

In the Fayetteville, we identified 7,000 locations of which 5,600 have been drilled leaving 1,300 remaining wells. Our neural network estimates these 7,000 locations would produce 11 tcf of total recoverable gas, of which 9.7 tcf or 88% has already been produced. Again, our neural network was within 10% of the more indirect Hubbert Linearization methodology, and just like the Barnett, production peaked and plateaued within months of half the field’s reserves having been produced.

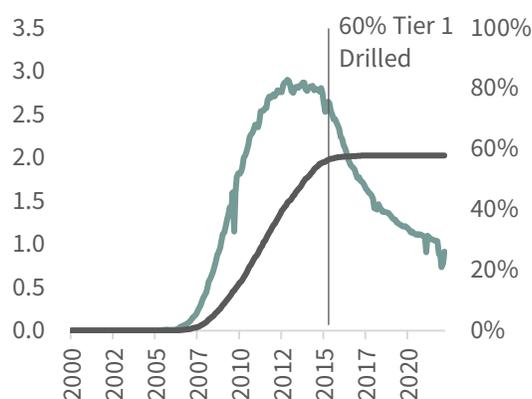
Next, we focused on only the best wells and we noticed another very interesting trend. We used our neural network to analyze every acre and to distinguish the best “Tier 1” areas from the lower-quality “Tier 2” locations. Both the Barnett and Fayetteville rolled over once 60% of their best wells were developed. It is interesting to note that drilling activity peaked in both fields approximately two years before production declines. Operators likely found it harder and harder to source top-quality Tier 1 locations and this showed up in drilling behavior well before it showed up in the production numbers.

FIGURE 8 Barnett Tier 1



Source: EIA, G&R Models.

FIGURE 9 Fayetteville Tier 1



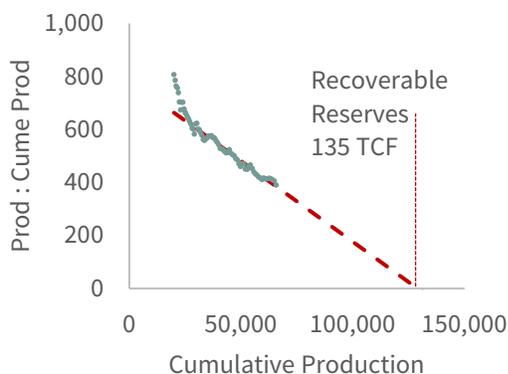
Source: EIA, G&R Models.

We applied this analysis to both the Marcellus and Haynesville to estimate where both fields stand regarding their production and when they might start to decline. According to the Hubbert Linearization, the Marcellus will eventually recover 130 tcf of natural gas, making it by far the largest shale basin. Our neural network identified 16,500 drilling locations of which 12,300 have been drilled, leaving 4,200 remaining. The neural network estimates these 16,500 locations will ultimately recover 135 tcf – within 5% of the Hubbert Linearization. Looking at the production profile, the Marcellus has clearly not plateaued; however, that day is likely closer than anyone expects. To date, the Marcellus has produced 65 tcf of our estimated 135 tcf of total recoverable reserves – or 48%. The Barnett and Fayetteville both plateaued once they hit 50% of total reserves, and according to our models, this would occur as we speak. Using the Hubbert Linearization, we can predict that Marcellus might peak as soon as June, at only 100 mmcf/d higher than today.

After plateauing, when could the Marcellus actually roll over? So far, it has completed 45% of its Tier 1 wells and, according to our models, has 1,500 remaining locations left

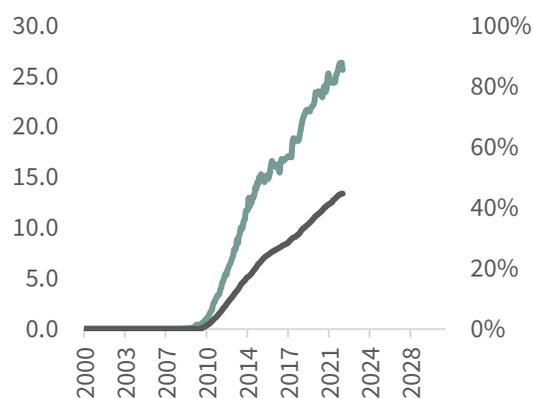
before it will have completed 60% of its best wells – the point at which both the Barnett and Fayetteville went from plateau to steep decline. Using what we learned from the Barnett and Fayetteville, the Marcellus will likely stop growing within the next 12 months and given today’s completion activity will likely begin its period of steep decline in 2025. Also of interest to note is that the Marcellus’s rig count peaked out in the summer of 2019 at 68 rigs—today the rig count sits at only 39 rigs. Is the declining rig count tipping us off that production declines are rapidly approaching, just like what happened in the Barnett and Fayetteville?

FIG 10 Marcellus Linearization



Source: EIA.

FIGURE 11 Marcellus Tier 1



Source: EIA, G&R Models.

The Haynesville is more complicated because its production ramped up and rolled over before surging again. A Hubbert Linearization is visually impossible given the “noise” over the past several years. However, our neural network is able to handle this production and drilling variability easily. We estimate there are 11,500 drilling locations of which 6,800 have been completed, leaving 4,600 remaining locations. Our neural network estimates total recoverable reserves at 73 tcf of which 30 tcf have been produced – or 41%. Based upon our models, the Haynesville will have produced 50% of its recoverable reserves by October 2023 at a rate only 500 mmcf/d higher than today. Nearly 47% of Tier 1 wells have been drilled in the Haynesville, suggesting a degree of high-grading is underway. At today’s rate of Tier 1 completion, we believe the Haynesville will reach 60% Tier 1 development by late 2024. In other words, the Haynesville will take somewhat longer to plateau but will then begin its steep decline more quickly thereafter – more like the Barnett than the Fayetteville.

Even if we are off by 20% in our recoverable reserve estimates (which we do not think we are), the Marcellus and Haynesville peak will only be pushed out by one year. Given the declines in the rest of the shale basins and in conventional production, this will still not be enough to avoid swinging the US natural gas market from structural surplus to structural deficit.

Most investors can only extrapolate a trend. In this case, the trend has been near endless growth from the shale gas basins. The idea that gas supply could falter and as a result that US gas prices could nearly instantly rise four-fold is completely off any investors’ radar. And yet, this is exactly what our models are telling us could happen within the next six

months.

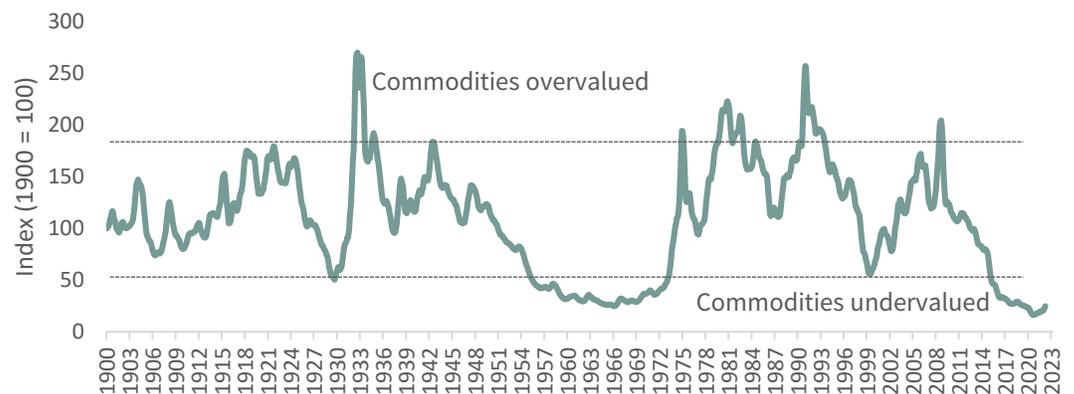
The world has enjoyed a decade of cheap, abundant energy and nowhere has that been truer than in US natural gas. We consume nearly as much energy via natural gas as we do via crude oil, although it is usually an afterthought. The rest of the world is in the midst of an acute gas shortage that has grabbed everyone's attention. We believe the same is about to happen in the US -- much faster than anyone realizes.

## The Commodity Bull Market Has Only Just Begun

One of the most frequent questions we get asked regarding this commodity bull market is: "Have I missed it? Is it too late to make an investment in natural resources?"

From our base of younger investors, we frequently get questions such as this: "I have been reading your material for the last two years and I started getting heavily involved in the commodity markets and I have made a lot of money. Is the top near? Should I sell out? Is this commodity bull market over?"

FIGURE 12 Commodities vs. Dow Jones Industrial Avg.



Source: Bloomberg, G&R Models.

Given the big moves in various commodity markets since the summer of 2020, it is logical to ask these questions. But our response to all these questions is going to be a real shocker. Not only is the commodity bull market not over, it has hardly begun. Look carefully at the chart below.

We first ran this chart on the front page of our 2Q2017 letter. This chart shows the returns of the Goldman Sachs commodity index versus the level of the US stock market, as measured by the Dow Jones Industrial Average. Although the Goldman Sachs commodity index was only constructed in 1971, we reconstructed it going all the way back to 1900. As you can see, commodities and financial equities have both traded in long cycles that are usually inversely related. Over the last 130 years, there have been four times when commodity markets became radically undervalued versus the stock market: 1929, the late 1960s, the late 1990s, and today. After each period of radical undervaluation, commod-

ities entered into large bull markets and then proceeded to become radically overvalued. If you had invested in commodities or commodity related equities in any of these three previous periods, the returns on both an absolute and related returns basis were huge -- even in the 1930s. Constructing a natural resources equity portfolio that consisted of 25% energy, 25% metals and mining, 25% precious metals, and 25% agriculture would have significantly beaten the stock market in each of these cycles.

For example, had you invested in such a natural resource portfolio in 1929, your return would have been 122% by 1940, which doesn't sound like much, but compared to the Depression ravaged stock market, the returns were almost spectacularly good. Between 1929 and 1940, the stock market fell 50%. Also, the 1930's was a period of chronic deflation and consumer prices fell over 20% between 1930 and 1940. In real terms, commodity prices (and related equities) offered real returns of almost 180% -- not bad in a period that included one of the greatest bear markets in history and a full-blown banking crisis that required the temporary suspension of the world financial system.

In 1970, a similarly constructed natural resource equities portfolio would have returned 400% by 1980, a return that handily beat the stock market which returned only 80% for the decade. Inflation was a huge problem in the 1970s and consumer prices advanced almost 130% for those 10 years. Natural resources not only provided excellent relative returns versus the stock market, but they provided investors with nominal returns far above the inflation rate as well.

And finally in 2000, a similarly constructed natural resources equity portfolio would have returned 360% between 1999 and 2010, significantly outperforming both the stock market, which returned nothing during that time period, and the inflation rate, which advanced 35% over those 10 years. Even though the 1999-2010 time period saw both the breaking of the "Dot-Com" stock market bubble, the Lehman Brothers financial collapse, and a global banking crisis, commodities again provided excellent returns relative to financial assets, as well as excellent returns relative to inflation.

These three periods couldn't have been more different: the 1930s were a period of deflation and global depression; the 1970s were a period of severe inflation and worries over currency debasement; and the 2000s were a little bit of everything including a stock market collapse, a global financial panic, and an oil price spike not seen since the 1970s. For those interested in the links joining these three periods together, please read "On the Verge of a Commodity Cycle" that appeared in our 3Q20 letter. That essay is a reprint of a presentation we made at the August 19, 2020 Finanz and Wirtschaft conference in Zurich, Switzerland. These three great commodity buying opportunities were all characterized not only by cheap commodity prices, but by the recurrence of four other events.

First, prior to each commodity buying opportunity was a decades-long commodity bear market that produced price declines so severe that capital spending in many extractive industries was impaired. Second, each period was characterized by excessive monetary creation. Third, all three periods saw intense financial speculation. And fourth, each period saw a major shift in global monetary regimes. All four conditions are once again present today and, in many instances, they are far greater in magnitude than in any of the previous three cycles.

It is no coincidence that commodity related investments have begun to radically outper-

IF THE STOCK MARKET STAYS AT PRESENT LEVELS, COMMODITY PRICES WOULD HAVE TO SURGE 600% TO BECOME OVERVALUED RELATIVE TO THE STOCK MARKET. IF THE STOCK MARKET FALLS 50%, COMMODITY PRICES WOULD STILL HAVE TO RISE 250% FOR OUR CHART TO ENTER "RADIALLY OVERVALUED" TERRITORY. THE BIGGEST RISK FOR INVESTORS IS SELLING TOO SOON.

form general equity markets. Since January 1, 2021, the natural resource equity portfolio construction above has returned 70%, far outstripping the S&P 500's 14% return over the same period. Commodity prices remain radically undervalued relative to financial assets and we have great confidence that we will swing from commodities being radically undervalued to commodities being radically overvalued relative to financial assets at some point in this decade. What will that radically overvalued level be? If the stock market stays at present levels, commodity prices would have to surge 600% to become overvalued relative to the stock market. If the stock market falls 50%, commodity prices would still have to rise 250% for our chart to enter "radially overvalued" territory.

The biggest risk for investors is selling too soon. From the bottom in 2020, the ratio of commodities to the Dow Jones Industrial Average has rallied by 40%. Using history, we can compare this move to past cycles. The ratio bottomed in December 1968 and by November 1970 had advanced by 40% -- commodities by 10% while the market fell by 16%. Many investors may have wanted to sell at that point; however the rally was just beginning. Over the next nine years, commodities rallied another 156% and commodity stocks rallied another 400%. Had you sold in 1970 after the index advanced 40%, you would have missed 90% of the rally. In 1999, the index bottomed in June and advanced 40% over the next 12 months -- commodities advanced by 33% and the market fell by 4%. At that point, oil was \$32 on its way to \$145, gold was \$289 on its way to over \$1,000. Over the next 10 years, commodities rallied 150% and resource stocks rallied by 325%. Again, if you had sold in 2000 once the ratio advanced 40%, you would have missed 95% of the rally.

As you can see, commodities still have to surge multiple times in price from here before they become overvalued. Given the huge amount of monetary creation that has taken place over the last 14 years and, given that inflation psychology is about to grip both consumers and investors alike, we have great confidence that we are about to transverse from one side of this chart to the other. The great commodity bull market has only started, and investors should use any resource market pullback as an opportunity to increase their exposure.

## Inflation and Magazine Covers Part III

On April 20th, 2019, Bloomberg/BusinessWeek magazine published an issue entitled "Is Inflation Dead?" with a dead dinosaur prominently displayed on the cover. The thrust of the cover story was that inflation had become extinct and investors should position themselves accordingly.

The cover story in our 1Q2019 letter was titled: "The Bell Has Been Run: The Contrarian Power of Magazine Covers." We discussed why the April 2019 article was the perfect "bookend" to the infamous BusinessWeek cover story, "The Death of Equities: How Inflation is Destroying the Stock Market," published back in August 1979. Just as the 1979 cover predicted that inflationary problems would never go away, the 2019 cover told investors that inflation would never return. The message in our cover story was simple: after declining for 40 years, inflation was about to return with a vengeance.

FIGURE 13 Magazine Covers



In our essay, we discussed the relevance of business magazine cover stories and the strong contrarian investment signal they often send. The 1979 BusinessWeek cover story was in a league of its own. If investors had done the opposite of what that cover story recommended, they would have become wealthy. Every investment projection made in that 1979 BusinessWeek issue proved to be incorrect. Instead of betting that inflation was about to worsen, investors should have bet that inflation was about to peak and then spend the next 40 years declining. Instead of buying inflationary hard assets, investors should have unloaded them as quickly as possible. Instead of selling stocks and bonds, investors should have taken the 1979 BusinessWeek cover story as a golden opportunity to literally “backup the truck” and buy as many financial assets as their margin accounts allowed.

We speculated in our essay that the 2019 Bloomberg/BusinessWeek cover story would be as important (and wrong) as the 1979 cover story and that investors should use its strong contrarian signal to significantly increase their exposure to hard, inflationary-sensitive assets -- an asset class that had become as unpopular as stocks and bonds were when the first BusinessWeek cover story was published over 40 years ago.

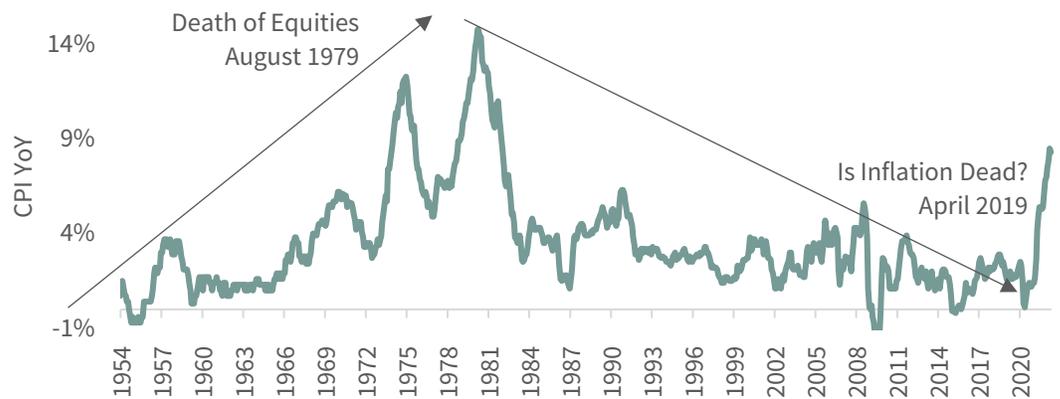
In our 1Q2020 letter, we reminded our readers about the magazine cover and how the massive explosion in government spending and the Federal Reserve’s balance sheet, all in response to the deepening COVID-19 crisis, practically guaranteed an upcoming inflationary surge.

One of the funny things about business magazine covers is that in the short term their predictions are often perceived as correct. Three years passed between the publication of the 1979 BusinessWeek cover story and the beginning of the great bull market in stocks. The Financial Times ran its very famous “The Death of Gold” cover story on November 1998 and again three years passed before the great gold bull market commenced. If the same time-lag materialized again, we predicted that three years might pass before accelerating inflation become a recognized problem. Global inflation began to unexpectedly accelerate last May and by March 2022 the US consumer price index hit 8.5% -- a rate not seen in 40 years -- exactly three years after the publication of the 2019 cover story. Everyone now understands the severity of our inflation problems. Even the US Federal Reserve, which spent all of last year predicting that inflationary pressures were

“transitory”, now admits the problem is real.

We believe today’s inflationary pressures are neither transitory nor moderate. We believe inflation will intensify as we progress through the decade. The 1979 BusinessWeek cover story declared that inflation and poor financial returns would extend far into the future. Why did they predict that? The reason is simple. As the chart shows below, inflation and interest rates had been rising for the previous 40 years. All the BusinessWeek editors did was express confidence in a trend that had been in place for two generations.

FIGURE 14 Extrapolating a Trend



Source: Bloomberg.

THE DEFLATIONARY TREND OF THE LAST 40 YEARS IS NOW OVER. A NEW INFLATIONARY TREND IS IN PLACE AND WILL LAST LONGER AND CARRY ON FARTHER THAN ANYONE EXPECTS. HUGE CHANGES IN INVESTMENT FLOWS ARE ABOUT TO TAKE PLACE WITH LARGE IMPLICATIONS.

Not only did the 1979 cover story tip investors off that a huge trend reversal was fast approaching, but also that a powerful new trend, lasting far longer than anyone thought, was about to start. The decline of inflation, the fall of interest rates, and the surge in the prices of financial assets have been happening for 40 years. And just the like in August 1979, the April 2019 Bloomberg/BusinessWeek cover story sent investors an incredibly strong contrarian signal that not only was a huge trend reversal about to take place, but that inflation was about to return as a serious problem that could last for decades.

The deflationary trend of the last 40 years is now over. A new inflationary trend is in place and will last longer and carry on farther than anyone expects. Huge changes in investment flows are about to take place with large implications. Although inflation-sensitive assets have already begun to radically outperform bonds and the general stock market, investors’ interests in these assets remains subdued. Pundits, market analysts, and investors remain in a state of confusion and hope that the trends of the previous cycle will return. Very few market commentators or investors have taken serious steps to protect themselves from the massive trend change that has now taken place.

Given the significant amount of money printed and the huge amount of debt now accumulated throughout the world, we believe the trend change in inflation as telegraphed by the 2019 BusinessWeek cover story will last decades. We also believe the recent outperformance of inflation-sensitive assets will last for years as well. There is still plenty of opportunity to not only protect yourself from the ravages of inflation, but to profit by it as well.

## Natural Resource Market Commentary

Following the February 24th Russian invasion of Ukraine, commodity prices staged their strongest advance in over 30 years. Throughout 2021, commodity prices had moved up as strong demand was met with a limited supply response, but investors paid little attention. Invasion related supply disruptions and resulting price jolts forced investors, for the first time, to confront and recognize these severe underlying tightening forces.

The advance was broad-based across most commodity and natural resource equity markets. The Goldman Sachs commodity index, which is heavily weighted toward energy, advanced an extremely strong 29%. The Rodger's International Commodity Index, which has much higher exposure to agriculture and metals, rose 27%. The S&P North American Natural Resource stock index, which is very heavily weighted towards large capitalization energy names, rose 29%, and the S&P Global Natural Resource Index, which has much higher metal and agricultural equity exposure, rose 16%. In comparison, the general stock market, as measured by the S&P 500 stock index fell 4.6% for the quarter.

The global energy crisis continued to gather strength during the quarter as prices continued their advance from last year. Oil prices surged 38%, reaching a peak of almost \$125 per barrel just after the Russian invasion. After pulling back at the end of 2021, natural gas prices both here in the US and abroad resumed leadership positions. Led by colder than normal weather forecasts, US gas prices surged over 50%. European natural gas prices, driven by fears of interruptions in Russian supply, surged by well over 200% during the quarter, hitting almost \$70 per mmbtu (or \$400 per barrel in oil terms) before pulling back in the second half of March. By the end of the quarter, both European and Asian prices pulled back to \$40 and \$35 per mmbtu respectively, or \$240 and \$200 per barrel of oil equivalent.

Driven by the continued strength in global natural gas prices, international coal prices surged. Australian and South African seaborne thermal coal prices spiked to almost \$450 per tonne during the quarter, vastly exceeding their old record-breaking cycle highs of \$150 per tonne set back during the last coal bull market, which ended in 2011.

We continue to believe this energy crisis has many years left to run, and profits remain immense for investors establishing positions today. The US natural gas market will be the next energy market to fall into full-blown crisis. We remain wildly bullish on North American natural gas and we continue to recommend large exposure to natural gas focused E&P companies. Even after their big runs in 2021 and into the first quarter of 2022, natural gas related equities are priced extremely cheap. In no way do these stocks incorporate \$4.00 per mmbtu gas, let alone today's \$8 price. As the natural gas bull market unfolds, these stocks still offer tremendous upside profit potential.

Global oil inventories continue their highly unusual counter-cyclical draw, and demand, even with the Russian invasion of the Ukraine and the Chinese COVID lockdown, remains incredibly strong. In the January "Oil Market Report," the IEA revised up its 2021 demand estimate by almost 1 mm b/d, their largest single demand revision ever. Missing barrels still exist in the latest IEA supply-demand numbers, suggesting the IEA's demand figures will be revised higher again.

The United States has resorted to releasing a massive 180 mm barrels of oil from its

strategic petroleum reserves (drawing it down another 30%) and this will be joined by another 60 additional barrels by other OECD countries over the next six months. Although the news of these releases has caused oil to pull back by \$10 per barrel over the last several weeks, we believe the release does little to change the underlying supply trends now embedded in global oil markets.

Grain prices surged in Q1 on threats of supply disruptions from both Ukraine and Russia. Although Ukraine and Russia combined produce only 15% of world wheat and 5% of world corn, their presence in global export markets is much higher. Russia and Ukraine make up 30% of global wheat exports and 15% of global corn exports.

Wheat prices surged the most during the quarter, rising by over 30% and setting a new all-time high. Corn advanced 26%, narrowly missing an all-time high while soybeans rose 22%. As our readers know, we have warned repeatedly that a substantial global agricultural crisis loomed in the not too distant future. It has emerged with a vengeance. Extremely strong global grain demand has collided with a myriad of supply problems. In the Agricultural section of this letter we discuss the supply problems, and focus on the rapidly intensifying global fertilizer crisis and the impact on 2022-2023 crop yields.

Precious metals continue to lag overall natural resource markets. Gold advanced 6%, silver advanced 12%, and platinum advanced 3%. Gold stocks rose 20%, but silver stocks actually fell 1% during the quarter. Palladium was the strongest performer, advancing 20% -- not surprising given Russia produces almost 40% of world supply. We turned neutral on the precious metals complex back in the summer of 2020 after silver's furious catch up rally and since then we have been sitting on the sidelines with minimal exposure. The Precious Metals section of the letter discusses the various underlying trends that signal to us why the next great precious metals bull market is rapidly approaching.

Base metals were also strong during the quarter. Nickel led the base metal complex with a 58% gain. Supply disruptions in Russia, combined with projected strong battery demand, pushed prices higher. Potential Russian aluminum supply disruptions pushed prices up almost 25% during the quarter. Russia produces 6% of primary aluminum supply. Zinc prices rose 18% while copper lagged the base metal complex, rising only 7%. Copper continues to be our favorite metal. Copper mine problems, a subject that we discussed at length in previous letters, have become a critical issue. Chile, by far the world's largest producer with over 25% of world mine supply, saw a large unanticipated drop in the first quarter. According to the World Bureau of Metal Statistics (WBMS), Chile's copper production fell over 7% in the first two months of 2022 versus 2021. Water problems, labor shortages, social unrest, and ongoing falling ore grades, all contributed to the shortfall. Chile's mine supply could contract by almost 300 tonnes this year, falling back to levels not seen since 2012.

On a global basis, copper mine supply will barely grow in 2022, despite an impressive number of new projects scheduled to come on line this year. Kamoā Kakula Phase 2 and Quebrada Blanca Phase 2 will each add 100,000 tonnes of new production. Anglo American's large Quellaveco mine in Peru will commence operation and could ultimately produce 150,000 tonnes of mine supply. Finally, the expansion of the huge Spence mine in Chile could add 75,000 tonnes. However, all this new mine supply will be offset by depletion issues now firmly embedded in legacy global copper mine supply. On balance

WHILE RUSSIA'S INVASION HAS MADE THE ENERGY SHORTAGE MUCH WORSE IN THE SHORT TERM, THE UNDERLYING PROBLEMS HAVE BEEN BUILDING FOR MANY YEARS AND CANNOT BE EASILY REMEDIED.

we believe 2022 will show little in the way of net mine supply growth.

Copper demand remains very strong. For the first two months of 2022 -- the latest data we have available -- copper demand grew by 5% year-over-year. China, the world's largest copper consumer, grew 6% year-over-year while India (which we believe is now following China's footsteps regarding copper consumption) registered an 8% jump. Russia saw a huge increase in copper consumption in the first two months of 2022, almost doubling year-over-year according to WBMS data.

Copper inventories have rebounded slightly but remain near their 2021 historic lows. In our last letter we wrote that combined copper inventories on the Shanghai, London Metal Exchange (LME), and COMEX, when adjusted for days of consumption, had fallen to levels not seen since 2005, just before copper staged its huge three-fold increase in price. Since then, combined copper inventories on these three exchanges rose by approximately 100,000 tonnes to 280,000 tonnes, but remain extremely low compared with historical levels. In 2005, exchange inventories covered only two days of global demand. By the end of 2021, this had reached three days -- nearly as low as in 2005. Currently, inventories cover four days of demand -- still extremely low. To put these numbers in perspective, in 2018 exchange inventories covered daily consumption by 15 days. We remain extremely bullish towards copper and believe prices are heading much higher. Investors should maintain significant exposure to copper related equities.

Uranium prices rose by nearly 30% over the quarter and are now at the highest levels in eight years. Please read our Uranium section where we explain the potential implications of Russia's invasion of Ukraine on uranium markets.

## Out of Spare Capacity

Between 2010 and 2020 the world grew accustomed to cheap, abundant conventional energy. Global energy markets were so well supplied for so long that neither investors nor consumers gave energy markets much thought. We were one of the few warning that an impending energy shortage and crisis would emerge in the next several years. The calm of the past decade has been turned upside down seemingly overnight. Conventional wisdom holds that today's energy shortage is the result of Russia's invasion of Ukraine; however, we strongly believe this is incorrect. While Russia's invasion has made the energy shortage much worse in the short term, the underlying problems have been building for many years and cannot be easily remedied.

Our biggest short term problem is that we are now running out of spare oil pumping capacity. In every prior energy shortage, including the dual oil crises of the 1970s and the rally of 2008, OPEC maintained ample spare capacity that could quickly be brought online. In past letters, we explained why the second half of 2022 would mark the first time in history that global demand bumped up against total pumping capacity.

As we begin to run out of spare capacity, we are only starting to see what that world looks like and, unfortunately, investors still do not appreciate the huge impact this will have. Energy related equities have now significantly outperformed the general stock market

over the last two years and yet, investor interest remains extremely low. As far as we can tell, few investors have repositioned their portfolios at all.

Internally, we have discussed what we should expect to see as the world runs out of spare pumping capacity. Although extremely challenging and uncertain, we find it valuable to lay out a roadmap with mile makers that we should expect to pass if our premise is correct. We agreed that if we are in fact running out of spare capacity, we should see a series of large releases from strategic petroleum reserves. On March 31st 2022, President Biden announced he would release a record 1 m b/d for six months from the SPR. Other countries followed suit and agreed to release another 1 m b/d for at least two months.

Historically, SPR releases have been unsuccessful in reducing oil prices and instead are an indication that the physical crude market is exceptionally tight. The larger the release, the tighter the market. The recent announcement from the US and the rest of the International Energy Agency (IEA) member countries is by far the largest coordinated SPR release in history and we believe confirms our thesis that the oil market has fundamentally changed. On the surface, the releases were blamed on the war in Ukraine; however, we believe the true reason is something much more fundamental: if we are running out of spare capacity at some point, oil must be released from the SPRs.

There is no doubt the conflict in Ukraine is making energy matters worse; however, it's not the complete story. The war in Ukraine is only eight weeks old while the crude market has been in sustained (albeit not widely appreciated) deficit for nearly two years. If we want to ultimately fix today's energy crisis, we must acknowledge its underlying causes. The record deficit we are now experiencing is the result of a decade of chronic underinvestment combined with relentlessly strong demand. Unfortunately, reversing these factors will take years—an easy and quick fix to the energy crisis is nearly impossible.

FIGURE 15 OECD Petroleum Inventory vs. 10-Year Average



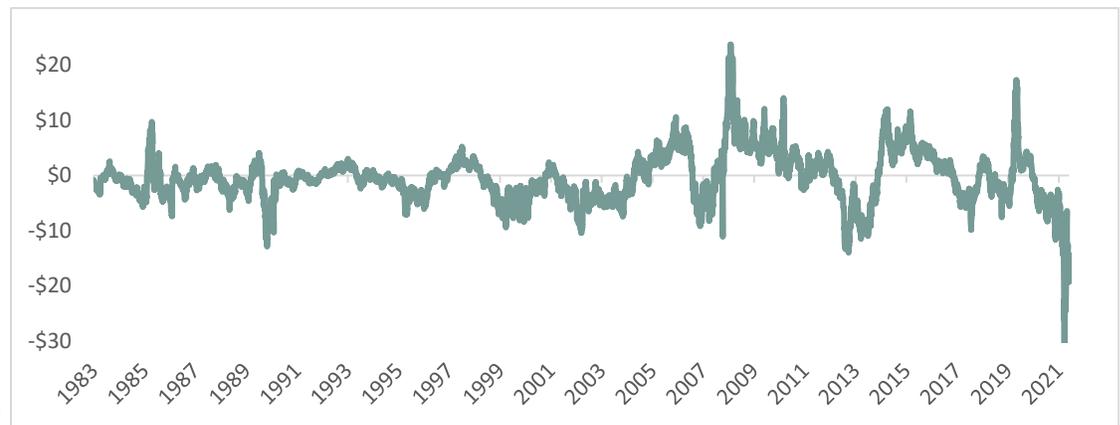
Source: IEA, Bloomberg.

OECD inventories (a good proxy for global inventories) peaked at the height of COVID-19 related restrictions in July 2020 at 4.8 bn bbl – 380 mm bbl above the 10-year seasonal average. Just as global inventories peaked -- along with bearish investor sentiment -- we wrote that we were on the verge of an energy crisis. Demand was likely to rebound much faster than supply, pushing oil markets into severe deficit and resulting in strong inventory drawdowns. Since then, inventories collapsed by 1.2 m b/d, the fastest sustained rate in history. In their latest release, the IEA estimates that OECD inventories ended

February at less than 4.1 bn bbl, the lowest absolute level since 2007 and the lowest level relative to 10-year seasonal averages since our dataset begins in 1980. This all took place before Russia invaded Ukraine on February 24th.

More recent data from the Energy Information Agency (EIA) shows US inventories drew counter seasonally again in March and April and that in recent weeks these draws accelerated from 1 m b/d to 1.8 m b/d. Given that the US makes up nearly 50% of total OECD inventories, we expect upcoming data releases will confirm global deficits are quickly getting much worse.

FIGURE 16 12 Month WTI Backwardation



Source: Bloomberg.

YEARS OF UNDERINVESTMENT IN UPSTREAM OIL AND GAS PROJECTS HAS PRODUCED THE PRESENT DEFICIT. TRYING TO REVERSE THIS SHORTFALL WILL TAKE YEARS OF UPSTREAM CAPITAL SPENDING AT RATES DOUBLE AND TRIPLE OF WHAT WE ARE SPENDING TODAY. UNTIL WE REVERSE THIS SHORTFALL IN UPSTREAM CAPITAL SPENDING, WE WILL NOT FIX THE UNDERLYING PROBLEM.

The term structure of WTI and Brent are both signaling extreme physical market tightness. Under normal circumstances a commodity contract for delivery in the future will trade at a premium to the prompt month contract, reflecting the costs of capital and storage. In periods of acute shortage, physical traders are willing to pay a premium for prompt delivery, pulling the near-term contract above the later-month contract – a situation known as backwardation. Currently, physical markets are so tight that traders are willing to pay a record \$17 premium (or nearly 15%) for oil delivered promptly compared to a year from now. We have never seen this level of anxiety or market tightness.

Years of underinvestment in upstream oil and gas projects has produced the present deficit. Trying to reverse this shortfall will take years of upstream capital spending at rates double and triple of what we are spending today. Until we reverse this shortfall in upstream capital spending, we will not fix the underlying problem.

The oil industry is inherently cyclical: high prices lead to strong profitability which attracts investment and ultimately leads to surplus production. Prices then fall, hurting profitability and pushing capital out of the industry. Ultimately shortages arise once depletion takes hold. At the end of the last energy bull market in 2010, inventors worried that “peak supply” would lead to persistent shortages. Crude averaged almost \$100 per barrel between 2010 and 2014 and capital poured into an E&P industry that was busy developing the nascent US shale oil fields. Between 2010 and 2019 production grew from nothing to over 9 mm b/d. If the shales were a country, they would have gone from no production to being the world’s third largest producer in just 10 years, behind only Saudi Arabia and Russia. The shales produced more oil than all of Europe, Central and

South America combined. It is not an exaggeration to say the shales were the most important oil development since the Saudi super major fields, led by Ghawar, in the early 1950s.

Oil began to collapse at the end of 2014 and capital began flowing out of the sector. Oil and gas capital spending fell by over 60% between 2010 and 2020. Investment in the US shales fell by over 70%. Over that entire period, the cumulative reduction in capital spending compared to trend was more than \$1 tr.

Over the same period, ESG concerns came to grip the global investor community. We believe much of the capital needed to build renewable projects was diverted away from upstream oil and gas investment. Unfortunately, wind and solar are intermittent sources of power that suffer from very poor energy efficiency. Lithium-ion batteries, necessary for both buffering intermittent renewables and powering electric vehicles, are also extremely energy intensive to mine and manufacture. Our research tells us that neither wind, solar nor electric vehicles, because of their poor energy efficiency, will live up to their promise of replacing oil and gas. Please see our 4Q2021 letter where we discuss the limitations of wind and solar. We now know the incredible growth of shale oil (and shale gas), and the resultant downward pressure it put on oil and gas prices, fooled investors into thinking they could divert huge amounts of capital into unproductive renewable projects without any consequences. What are those consequences and how painful are they going to be? We are only now beginning to find out.

In a normal cycle, falling inventory levels, rising prices, and improved profitability would have attracted capital back into the industry by now. Instead, ESG commitments made over the past several years are keeping capital from reentering the oil and gas industry, making the production problems much worse. Oil prices are at 15-year highs and natural gas in Europe and Asia are setting new records and yet E&P capital spending is still down 50% from the peak with shale spending down 60%. Despite record free cash flow, companies prefer to return capital through dividends and share buybacks rather than drill new wells. Several E&P executives were brought before Congress last fall and criticized for not doing more to curtail their fossil fuel production. These same companies were called to Washington again in April and asked why they were not producing more. Unfortunately, the impact of many years of anti-fossil fuel rhetoric cannot be undone overnight.

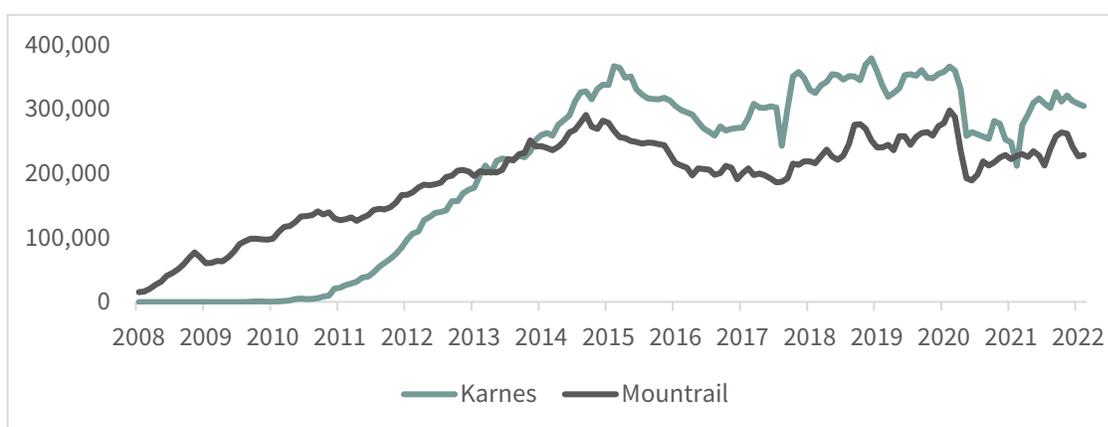
Another major issue facing the energy industry is that, although the shale resource is extremely large, it is ultimately finite just like any other conventional field. Like a conventional resource, a shale basin ramps up early in its life then plateaus and ultimately declines. We were among the first to intensely study the concept of shale depletion as early as 2019 and we concluded their best days were likely past. This was an incredibly important conclusion given the US shale basins represented nearly 90% of all non-OPEC+ growth between 2010 and 2019. In our 4Q2019 letter, we laid out our research and predicted that shale growth would begin to falter, causing the global crude market to slip into deficit. So far this is exactly what has happened.

We built an artificial neural network to understand the factors driving shale productivity growth. Immediately, we realized the industry was preferentially drilling its best wells – a process known as high-grading. Instead of improving their drilling techniques (a common industry story at the time) and turning Tier 2 areas into Tier 1 wells, the E&P

industry was drilling out the cores of the shale basins at ever-faster rates. We argued that as companies drilled out their Tier 1 inventory, well productivity would soon begin falling, making it far more difficult for the shale basins to grow.

To understand the importance of drilling productivity, we put forth these real-life examples. Consider the best county in each of the Big 3 shale basins: Karnes County in the Eagle Ford, Mountrail County in the Bakken, and Midland County in the Permian. Each of these counties are prime Tier 1 acreage with wells that enjoy production rates nearly twice the average Tier 2 well. Karnes County is 750 square miles. Assuming 6,000 foot laterals and 800 foot lateral spacing, there are at most 3,800 drilling locations representing 23 mm lateral feet of wellbore. To date, we estimate 18 mm of the 23 mm lateral feet have been drilled – or nearly 85%. Out of 3,800 top tier Karnes drilling locations, only 400 remain undrilled today.

FIGURE 19 Karnes and Mountrail County Production



Source: ShaleProfile.

DESPITE BEING BOTH THE YOUNGEST FIELD AND HAVING THE MOST DRILLING LOCATIONS, EVEN THE PERMIAN IS NOT IMMUNE FROM THE EARLY STAGES OF RESOURCE DEPLETION.

Mountrail County, home to the best wells in the Bakken, is larger at 1,900 square miles. Assuming 9,000 foot laterals and 1,300 feet between wells, there is room for at most 3,200 wells in the county totaling 27 mm lateral feet of well bore. So far 19 mm lateral feet have been drilled or 70% of the total. Of 3,200 locations only 700 remain today.

Production from both counties peaked all the way back in 2015, and despite big increases in oil prices between 2016 and 2018, and again today, neither Karnes nor Mountrail counties have been able to grow production.

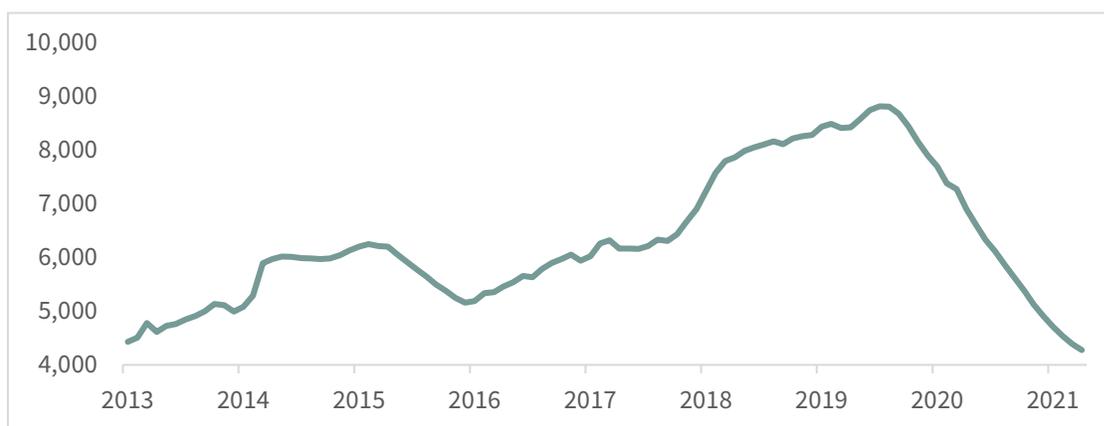
Both counties saw production ramp, plateau, ultimately make a second peak, and then roll over. Today both counties remain 50,000 b/d below their pre-Covid level. As these basins run out of undrilled locations, operators have been forced to look to lower quality parts of the basin, hurting productivity. In the Bakken, per well productivity peaked in December 2019 and has since fallen by 6%. In the Eagle Ford, productivity has held in better but only because total completions remain down by over 40% compared with 2019. Eagle Ford companies have been able to keep their well productivity high by reducing completion activity by nearly half and focusing only on their remaining high-grade inventory. Clearly this trend cannot last. If companies lack high-quality Tier 1 drilling locations, production will continue to disappoint.

Despite being both the youngest field and having the most drilling locations, even the Permian is not immune from the early stages of resource depletion. Midland County is 900 square miles of the best acreage in the entire Permian basin. Assuming 10,000 foot laterals, 1,300 feet between wells, and three productive zones of stacked Wolfcamp pay (very generous), we believe there are at most 3,900 drilling locations in Midland county representing 39 mm lateral feet of wellbore. Thus far, 24 mm feet have been drilled implying Midland County is over 60% developed. Although Midland production is still growing, our models believe this will likely soon begin to plateau as well.

Permian Tier 1 exhaustion might be happening already. Between late 2019 and March 2022, Permian per well productivity has fallen by a very large 14% even though completions remain down 7%. The only source of non-OPEC+ growth over the past decade is now suffering resource exhaustion, just like any other conventional resource. We predicted this trend in late 2019 and if our models continue to be correct, then production will soon begin to disappoint materially.

In aggregate, productivity in the Big 3 shale basins is down 6% compared with 2019 and production remains 550,000 b/d below the peak. In other smaller shale basins, the declines have been more dramatic with production now 450,000 b/d below the peak (on a smaller base). Moreover, we estimate that nearly 1 mm b/d of incremental production came from the completion of drilled but uncompleted wells (DUCs). These wells were drilled in the lead-up to COVID-19 but ultimately not completed when oil prices collapsed. In 2021, energy companies completed 50% more wells than they drilled as they drew down their DUC inventory, leading to a one-time boost in production. Today, there are fewer than 4,300 DUCs – the lowest level since our dataset began in 2013. Clearly the industry needs some DUC inventory to properly function, and we believe we have now reached that level. The past four months saw sequential shale growth in excess of 100,000 b/d but, if our models are correct regarding DUC liquidation, this will slow dramatically as we progress into the summer.

FIGURE 21 Drilled but Uncompleted Wells



Source: EIA.

Conventional US production continues to fall precipitously, having declined by 16% since its peak while Gulf of Mexico production is off 20%. Higher oil prices have not

helped either source of supply: conventional US production is off 7% year-to-date while the Gulf of Mexico is down 6%.

Non-OPEC+ production outside of the US was supposed to have been a bright spot in 2022 (something we never agreed with) but is now severely disappointing as well. In the first four months of the year, the IEA has revised 4Q21 and 1Q22 estimates lower by a material 300,000 b/d. In a pattern that has repeated itself many times, the IEA revised down the actual data while revising higher the second half estimates, leaving the full-year figures unchanged. The IEA now expects non-OPEC+ production outside of the US to reverse course and grow by a staggering 1.2 m b/d over the next two quarters – something we believe to be impossible. To put this in proper context, production from this group is now down 500,000 b/d over the past six months versus original estimates calling for growth of 500,000 b/d.

At the same time as production is disappointing, demand is running far ahead of expectations. In our past letters, we explained how the IEA has embedded a chronic demand underestimation into its forecasts, largely driven by flaws in its emerging market methodology.

In 10 of the last 12 years, the IEA has ultimately been forced to revise its demand estimates higher by 1 m b/d on average and this problem is getting worse. In their February 2022 report, the IEA undertook the largest series of demand revisions in their history. Going back to 2018, the IEA revised global demand higher by nearly 1 mm b/d each year on average with nearly all the revisions focused on the emerging markets. This was followed up with a smaller set of upward demand revisions in March of nearly 200,000 b/d on average going back to 2019.

Even after these historic revisions, we believe the IEA is still underestimating demand. In the first quarter of 2022, the IEA claims that global supply averaged 98.7 m b/d while demand averaged 98.5 m b/d, suggesting inventories should have built by 200,000 b/d. Instead, preliminary data points to inventory draws between 500,000 and 600,000 b/d. In other words, the “missing barrels” are back: that is oil that was produced but neither consumed nor added to inventory. Our readers know that the “missing barrels” are usually under-reported non-OECD demand and we believe this time will be no different. In the first quarter, we estimate that even after the historic revisions, the IEA continues to underestimate demand by as much as 800,000 b/d. If this demand continues – and we have every reason to believe it will – the crude market is even tighter than most people currently realize.

One question we are often asked is whether high prices will curtail demand and potentially push the world into recession. The topic of demand destruction is extremely interesting and in a future letter we will likely dedicate a whole essay to the subject. Using the relationship of oil expenditures to GDP helps us put the current situation in proper context. The last two major oil tops occurred in 1980 when oil rallied from \$3 to \$36 per barrel and in 2008 when oil rallied from \$11 to \$145 per barrel. In 1980, the US consumed 17 m b/d which amounted to \$225 bn per year on GDP of \$2.9 trillion. In other words, nearly 8% of US GDP was spent on oil. On a global basis, oil demand averaged 61 m b/d, amounting to \$800 bn on GDP of \$11 trillion, or 7.2%. In 2007, the US consumed 19 m b/d, amounting to \$1 tr on GDP of \$14.5 tr, or 6.9%. Globally,

we consumed 86 m b/d, amounting to \$4.5 tr or 7.8% of \$58 tr in global GDP.

At present, the US consumes 20 m b/d, amounting to \$730 bn at \$100 per barrel crude. With GDP running at \$21 tr, oil expenditures amount to 3.5% -- less than half the prior two peaks. Globally, demand ran at 97.5 m b/d last year (although we believe this is higher), amounting to \$3.4 tr or only 4% of global GDP – again only slightly more than half the prior two peaks. Oil prices likely contributed to slowing economic growth in 1980 and 2008, however we are not yet at the same levels of expenditures. Were oil to reach \$170 per barrel, expenditures as a percentage of GDP would reach 6-7%, more consistent with previous market tops. We actually believe, for a variety of reasons, that a figure closer to \$150 per barrel would put undue pressure on the economy, and in our upcoming letter we will discuss our rationale.

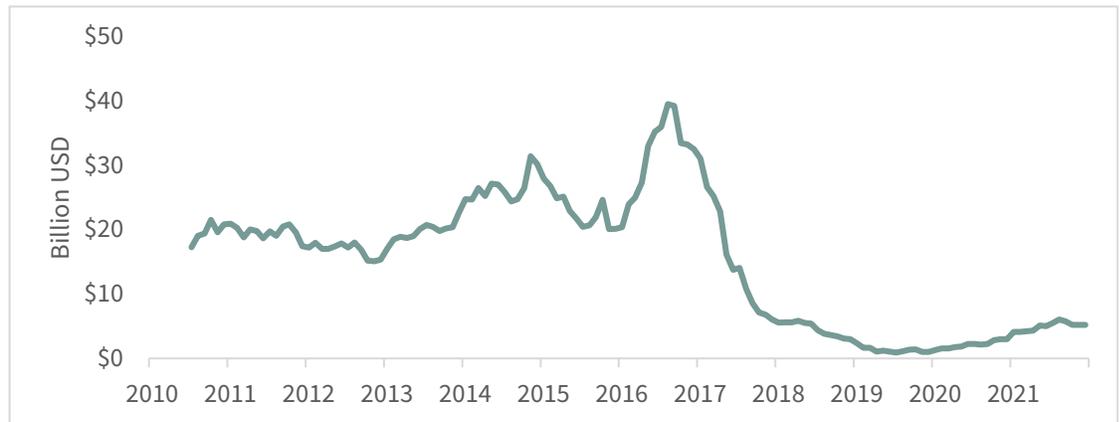
With demand running higher than expectations and non-OPEC+ supply disappointing, all eyes are on OPEC+. President Biden asked the cartel to produce more oil in November 2021 and again in February 2022 and both requests were ignored. Most analysts we speak with believe that OPEC+ (led by Saudi Arabia) chose not to increase production; however we believe they tried but were ultimately unable to. In our past letters we have detailed extensively why we believe OPEC+ spare capacity is much lower than anyone realizes. As of March 2022, nearly every OPEC+ country was producing below their allotted quota – something we never recall seeing. The core OPEC-10 countries produced nearly 1 m b/d less than allowed, effectively leaving \$3 bn in revenue on the table in March alone while the remaining member countries missed their quota by 700,000 b/d. There is no logical explanation for why this should happen consistently, as it has, other than the member countries have been unable to increase production. The argument that OPEC+ is somehow aiding Russia by keeping prices high also seems unlikely. Saudi Arabia serves as the de facto leader of OPEC+ and is very skeptical of Russia. As recently as March 2020, Russia and Saudi Arabia were engaged in an outright price war within OPEC+ that was partially responsible for taking prices negative. Furthermore, Russia's support of Iran in various proxy fights is fundamentally opposed to Saudi Arabia's interests. Instead of cooperating to the detriment of NATO and the West, we believe OPEC+ in general (and Saudi Arabia in particular) found they were unable to boost production in March – another sign we are now running out of global spare pumping capacity.

The current energy crisis will not be solved until capital comes back into the industry in significant quantities. Normally high commodity prices and improved profitability help attract capital, but ESG pressures are keeping that from happening. E&P capital budgets are indeed up 25% compared with the 2021 lows, however they remain 60% below trendline. Moreover, we are hearing that most of the increase is not the result of increased activity but rather represents cost inflation as bottlenecks have now developed in key equipment, steel, and labor. Energy related IPOs and secondary offerings totaled a mere \$1.8 bn over the past six months, 80% below the \$10 bn average between 2010 and 2017 and 90% below the \$22 bn peak in 2016.

Capital remains unavailable even though oil and gas prices are high and even energy hostile politicians are now calling for more upstream investment. Investor interest in the energy sectors also continues to be extremely low. Between January 2021 and today, the

XOP (the largest ETF of E&P stocks) has advanced by 120% and yet, over that period, the shares outstanding have actually decreased--investors have actually redeemed shares on balance.

FIGURE 22 E&P IPO and Secondary Fundraising (12 month MVA)



Source: Bloomberg.

We are now beginning to understand what a world looks like as it runs out of spare oil pumping capacity. Even with the huge releases of oil from Strategic Petroleum Reserve, oil prices have hardly pulled back. Global inventories, now at record lows, continue to draw counter-seasonally and are reaching dangerously low levels. Even with all the dislocations caused by the Ukrainian conflict and COVID problems in China, global oil demand in Q4 will approach global pumping capability according to our modelling. Strong demand, declining production, record low inventories, and now no spare pumping capacity—all these factors will push oil prices higher in the second half of 2022. Even in the face of all these factors, investor interest in energy markets remains incredibly subdued. The advances we have seen to date have basically been short covering and active managers buying on the margin. Once investors and institutions realize the energy market has fundamentally changed and the decade of cheap, abundant energy is over, the amount of capital that rushes into this sector could be huge. The global energy crisis has just started, and it will take many years to fix. For those that make investments today, the rewards could be immense.

GLOBAL AGRICULTURAL MARKETS ARE BEING BUFFETED BY SEVERAL ALMOST UNPRECEDENTED FORCES. SURGING NATURAL GAS AND COAL PRICES LAST FALL SEVERELY DISRUPTED NITROGEN AND PHOSPHATE FERTILIZER PRODUCTION, PRIMARILY IN EUROPE AND CHINA.

## Catastrophic Agriculture Markets

“World Bank warns of ‘human catastrophe’ food crisis.” BBC News, April 20, 2022

“Farmers are seeing prices for fertilizers skyrocket. Some may choose to rotate crops or use less nutrients, which could reduce crop yields” CNBC April 6, 2022

“Fears of a fertilizer shortage are slowing soybean expansion in Brazil, the world’s top exporter, nearly to a halt. Bloomberg March 29th, 2022

“The global shortage of fertilizer is a huge problem. We are facing a problem of catastrophic proportions here.” Tony Will, CEO of CF Industries, one of the world’s largest nitrogen

fertilizer producers. April 6, 2022 CNBC.

Global agricultural markets are being buffeted by several almost unprecedented forces. Surging natural gas and coal prices last fall severely disrupted nitrogen and phosphate fertilizer production, primarily in Europe and China. Reflecting cut-backs in domestic production, China and Russia banned the export of urea (the solid form on nitrogen fertilizer) and phosphate last fall, which in turn created fertilizer shortages in both Australia and South Korea.

Next came Russia's invasion of Ukraine. Russia and Ukraine combined represent almost 30% of the world's exported wheat. Ukraine exports 30 mm tonnes of corn or 10% of global exports. Almost all of Ukraine's corn and wheat is exported via the Black Sea which is now entirely controlled by the Russian Navy. As of today, Russia continues to block any grain export trying to leave Ukraine's Black Sea Ports.

Russia's actions have enormous impacts on global fertilizer markets as well. Russia and Belarus (a Russian ally) supply almost 40% of the world's potash. All of Belarus's potash supply (representing 20% of world supply) is shipped by rail through Lithuania and current European sanctions block this supply from leaving the country.

Over the previous 20 years, huge attention has been paid to improved crop genetics and the positive impacts on grain yields. US corn and soybean yields over the last 20 years have grown by 35%. While increases in global grain harvests have been positively impacted by improved genetics and excellent global growing conditions, investors have underappreciated the impact of big increases in fertilizer application that have occurred over the last decade on growing the size of the global grain harvest.

Between 2000 and 2020, global coarse grain production surged by 42%. Over the same time, fertilizer application also grew by 40%. On a shorter term basis, the same relationship holds. Global grain production grew 18% between 2010 and 2020, while fertilizer application increased 17%.

Fertilizer prices have surged over the last two years. Ammonia prices (nitrogen fertilizer in gaseous form) have gone from under \$200 per tonne at the end of 2020 to \$1450 today. Phosphate fertilizer prices have risen from \$350 per tonne to over \$1000, and potash price has grown from below \$200 per tonne at the end of 2020 to almost \$900 today. In Brazil, where soils are extremely potash deficient, and imported Russian and Belarus supply dominates, potash is priced at \$1250 per tonne.

Given the high prices of grain today, farmers in industrialized countries can pay this high price and still earn a margin on their plantings. However, the problem for many farmers is not the price, but the availability. Nitrogen production, driven by production cuts in Europe, is down 5%. Russia is also a large nitrogen fertilizer exporter -- 7 mm tonnes or 30% of the total export market -- and it is unclear how much will be blocked by Western sanctions.

Crop yields are extremely difficult to model given the non-linearity and correlation between variables, including fertilizer application. We tried applying machine learning last year to predict US crop yield with only mediocre results. Despite the difficulty in modeling the exact impacts, it is clear that fertilizer application is critically important. Most investors are underestimating the impact nitrogen availability will have on yields.

We trained a machine learning algorithm to attribute changes in crop yields over the last sixty years to various inputs such as fertilizer application, weather, genetics, and other trends. The results were unequivocal: using a technique known as support vector machines, and “Shaply values,” we estimate that as much as 40% of coarse grain yield increase since 1961 can be attributed to increased nitrogen application. We believe that a 5% reduction in nitrogen application could result in an immediate 1 to 2% reduction in global grain supply. Given the existing tightness, such a drop will have an outsized impact on supply-demand balances going into the 2022-2023 planting season. For example, the International Rice Research Institute predicts rice yields could drop as much as 10% this season, causing a loss of 36 million tonnes or 7% drop of world rice supply. The lost rice production would be enough to feed 500 mm people.

As opposed to farmers in industrialized countries, emerging market farmers do not have the available cash to purchase fertilizers that now cost 100% more than last year. Also, outright shortages are reducing fertilizer applications in areas such as West Africa, while in countries such as Peru, Costa Rica, the Philippines, and Brazil, potash shortages are forcing farmers to slow the expansion of soybean plantings.

Since 2000, Brazilian farmers have increased dedicated soybean acreage by approximately 4% per year. Brazilian farmers this year will increase soybean planting by only 0.5% -- the smallest growth rate since 2006. Stories abound of Brazilian soybean farmers cutting back on sky-high potash for the upcoming planting season as well.

A 20% cut in potash application could decrease the size of the upcoming Brazilian soybean crop by 14%, according to industry consultant MB Agro. In 2000, Brazil produced 30 mm tonnes of soybeans. By 2010 this had grown to 57 mm tonnes and today it is estimated that Brazil's 2022 soybean crop (just now being harvested) will be 125 mm tonnes – or 40% of world supply.

Brazil's ability to grow soybean production -- a function of both increasing acreage and huge amounts of potash application -- has been a huge input to world grain growth. That source of growth has now come to a short term end.

The 2022 northern hemisphere planting season is only just beginning and, at this point, it is difficult to make an accurate prediction regarding yield and crop size. However, we should point out that weather conditions have already proved challenging. Drought conditions emerged in Brazil at the end of 2021 and continued into 2022, severely impacting the 2022 soybean harvest. The USDA originally estimated Brazil's 2022 harvest would reach a record 144 mm tonnes, but estimates have been reduced to only 125 mm tonnes -- a drop of 13% in only a few months.

China enters the 2022 planting season with very difficult growing conditions, especially for the winter wheat harvest, now underway in the southern provinces. At the end of March, China's agricultural minister made the following comments according to Bloomberg: “China faces big difficulties in food production because of unusual floods last autumn. Many farming experts and technicians told us that crop conditions this year could be the worst in history.”

Record breaking rains in Henan province last fall damaged 2.1 mm acres of winter wheat and delayed the planting of an additional 18 mm acres -- about 35% of China's total crop.

A scorching spring heat wave is also threatening India's winter wheat crop. The crop could be negatively impacted by 10 to 15% as excessive heat has damaged the plant in its seed formation phase. India is the world's second largest wheat producer and has become a significant exporter over the last decade. Original estimates had India exporting 15 mm tonnes of wheat in 2022 -- or about 7% of global exports. Depending on how much damage has been done, India might export little wheat at all this year, further tightening the global wheat market.

North American weather conditions will also have to be watched closely. The western half of the United States and almost all of western Canada are under severe drought conditions. Two very late snowstorms hit the upper Midwest and the southern Canadian plains posing problems as well. Southern Manitoba and western Ontario remain covered in deep snow which could delay the 2022 planting season and impact overall grain yields.

How these weather events will ultimately affect the planting and harvest will have to be carefully monitored, especially given all the other global agricultural problems existing today.

As if the world's agricultural markets don't have enough stress placed on them, two additional items will have to be watched.

The first is the emergence of food protectionism, something we haven't seen since the 1970s. As fears of scarcity and resulting high prices increase, we should expect countries to severely restrict agricultural exports to lessen the threat of shortages. The potential disruption and closing of agricultural trade will drive prices up even further, create shortages, and ultimately lead to empty store shelves in countries dependent on imports.

On April 28th, Indonesia announced that it banned the export of palm oil, one of the world's most popular cooking oils. The ban follows the sharp rise in global cooking oil prices due in large part to the disruptions caused by Russia's invasion of Ukraine. Ukraine produces almost 50% of the world's sunflowers and shortages of sunflower oil have driven up the prices of all other cooking oils, including palm oil.

This export ban is already causing huge problems for other emerging markets. India imports 45% of its palm oil from Indonesia, and the ban has already produced a shortage of cooking oil across the country.

The second is the Biden administration's announcement allowing the year-round selling of gasoline with 15% ethanol content. Although it is unclear how much the new E-15 mandate will stimulate corn demand, adding any additional demand pressure to corn is the last thing grain markets need right now. Almost 35% of the US's 15 bn bushel corn crop goes into the making of ethanol, almost all of which is then blended into gasoline.

Making matters worse, we believe weather patterns are becoming more challenging for crop yields. Although highly controversial, we believe we have entered into a long term cooling trend that will be driven by declining sun-spot activity —a subject we have discussed in past letters, and will again address in our next letter. Cooling trends often produce adverse crop growing conditions which could severely hinder global grain harvest. Although we have had plenty of isolated adverse weather over the last three years (primarily dry conditions here in the US and Canada and a full blown drought in Brazil and India), overall global growing conditions were actually quite favorable. However, we still believe

much more adverse weather conditions may still be in our future.

We continue to recommend investors have significant exposure to agricultural related equities, including the fertilizer stocks. Although these stocks have had large upward moves over the last 12 months, they remain extremely cheap based upon their earning power.

## Russia and the Uranium Fuel Cycle

Uranium prices surged during Q1. Spot uranium advanced 26% from \$42 to \$53 per pound while the quoted term price rose 19% from \$42 to \$50 per pound. Anecdotally we heard of several unreported transactions as high as \$60 per pound. The term price is now the highest since 2014 and the spot price is the highest since 2013. In February, Cameco announced that it would seek to restart its MacArthur River mine in the Athabasca basin of Saskatchewan. Before deciding to suspend operations at the mine due to low prices in 2018, MacArthur River produced 19 mm pounds of U3O8 on a 100% basis (Cameco owns 70% in a joint venture with Orano). We hoped that Cameco would hold off on restarting MacArthur River until it was able to secure long-term production contracts that would effectively tie up MacArthur River's incremental production and this is exactly what happened. We believe this removes a key overhang from the uranium spot market.

WHILE RUSSIA'S IMPACTS ON URANIUM MINING MIGHT BE INDIRECT, IT IS CRITICAL IN THE CONVERSION AND ENRICHMENT SEGMENTS OF THE FUEL CYCLE. RUSSIA CONVERTS 35% OF WORLD URANIUM PRODUCTION FROM U3O8 CONCENTRATE TO UF6 GAS AND ANY DISRUPTION WOULD BE IMPOSSIBLE TO OVERCOME.

Russia's invasion of Ukraine has serious implications for the global uranium and nuclear fuel cycle markets as well. Uranium and nuclear power can be more complex than other commodities, so we would like to provide some background. First, uranium is mined, either from dedicated uranium hard rock mines (i.e., Cigar Lake and MacArthur River in Canada), from in-situ leach operations (i.e., Kazatomprom's operations), or as a by-product in a larger mine (i.e., Olympic Dam in Australia). Uranium is concentrated and shipped to a conversion facility in the form of U3O8 – a yellow powder. Before uranium can be fabricated into fuel rods, it must first be turned into a gas – uranium hexafluoride or UF6 – at a conversion facility. The uranium gas is next sent to an enrichment facility. All uranium is made up of two distinct isotopes, U-258 and U-235. The former makes up 99.3% of all uranium, and the latter is only 0.7% by mass. In order to sustain a chain reaction in a nuclear reactor, the fuel rods must contain between 3-5% U-235. Centrifuges are able to carefully separate the two isotopes and effectively “enrich” the uranium hexafluoride from 0.7% to 3-5% U-235. The low enriched uranium (LEU) is then fabricated into fuel rods and shipped to nuclear power plants.

Russia is a key direct and indirect player at several points along the fuel supply chain and the impacts could be material. First, Kazatomprom is the world's largest uranium producer from its in-situ leach mines in Kazakhstan. Although not involved with the conflict in Ukraine, Russia's presence looms large. Earlier this year, civil unrest broke out in Kazakhstan and Russia sent troops into the country to quell the uprising. Given how critical Kazakhstan is to upstream global uranium production, the proximity with Russia is likely putting pressure on some US utilities to enter into long-term contracts with other producers and diversify the upstream source of their fuel.

While Russia's impacts on uranium mining might be indirect, it is critical in the conversion and enrichment segments of the fuel cycle. Russia converts 35% of world uranium production from U<sub>3</sub>O<sub>8</sub> concentrate to UF<sub>6</sub> gas and any disruption would be impossible to overcome. This has led some officials to consider fast-tracking the reopening of US conversion capacity. The US presently maintains no conversion capability of its own. Similarly, Russia is crucial in the global enrichment business, controlling nearly 50% of the world's capacity. It remains unclear how the industry would manage if Russian conversion and enrichment capacity was made unavailable. This will likely all lead to increased pressure to acquire and potentially stockpile material. Unfortunately, given the deficit in mined uranium over the past several years, it is not clear this will be possible.

On the demand side, there have been several bullish developments. As we discussed in our last letter, the European Union officially added nuclear power in its "taxonomy" of green technologies. The designation now allows institutions to invest in uranium and nuclear power without running afoul of any ESG commitments. The implications are huge. Immediately following the announcement, France declared they were embarking on an ambitious nuclear reactor new build program and extending the life of several existing reactors. The UK has committed to a nuclear new build program as well. No analyst had any European new build reactor demand as recently as a year ago and so these announcements serve to further tighten the market going forward.

Since China, India, Saudi Arabia, Canada, and now Europe have all embraced nuclear power, we've been arguing the US should follow suit. No matter how unfortunate, the US seemed to be going in the wrong direction. But an extremely interesting and positive development has just taken place, suggesting a turn in fortune for the US nuclear power industry might be at hand. Having firmly committed to closing the large Diablo Canyon reactor in California, on April 29th, Governor Newsome abruptly changed course and suggested he would seek to keep Diablo Canyon open with \$6 bn in potential federal funding for several capital projects at the reactor. We cannot overstate what a change this represents. Diablo Canyon was the most politically charged and significant energy decision since cancelling of the Keystone XL pipeline. As recently as eight weeks ago, it seemed impossible that Governor Newsome could walk back his commitment to shut down the facility. We are hopeful this is a signal that US can now be added to the list of countries that are once again embracing nuclear power. As we have discussed in our past letters, nuclear power is the key to our energy future. For every unit of energy expended in mining, converting, enriching, and reacting uranium, 100 units of electricity are generated. This EROEI is at least three times better than oil and gas and 20-30 times better than renewables. Furthermore, nuclear power emits no carbon.

Even before all this renewed interest in nuclear power, the uranium market was in severe long-term structural deficit—a deficit that could only be solved by much higher uranium prices. When we made our uranium investments in 2018, we did not count on any nuclear renaissance from the OECD world. Given all the renewed interest in building new plants and extending the life of present generating facilities, the long term structural deficit in uranium is set to become even larger. Uranium prices are poised to move dramatically higher as we progress through the 2020s.

## Time to Buy Gold is Getting Closer

We turned neutral on gold and silver in the summer of 2020. Over the last 50 years, silver has shown strong tendencies to lag an advancing gold market and then stage furious catch-up rallies. After silver catches up with the gold price, either a lengthy correction phase ensues or an outright bear market unfolds. Furious silver catch-up rallies experienced at the end of 1973 into the first quarter of 1974, produced a two-year corrective phase in which both gold and silver prices pulled back 45%. The huge catch-up rally silver experienced at the end of 1979 produced the great precious metals bear market that lasted 20 years. Finally the massive silver catch-up rally at the end of 2010 when silver advanced 175% in just six months produced the four-year bear market that saw gold and silver prices pull back 45% and 70%, respectively. After lagging the advancing gold price for two years, silver surged in March of 2020 by over 150% in just 5 months -- a catch up rally similar in magnitude to what happened back in 1974, 1979, and 2010. Since then gold prices have entered a lengthy period of consolidation. After peaking in August 2020, gold and silver prices still sit 10% and 20%, respectively, below their highs.

Avoiding precious metals has been the correct thing to do over the last 18 months on both an absolute and relative basis. For example, since the summer of 2020, gold mining stocks (as measured by the GDX ETF) fell 15%, whereas oil stocks, as measured by the XOP ETF, rallied by 150%, and copper stocks, as measured by the COPX ETF, advanced over 75%.

The gold bull market started in December of 2015 when gold bottomed at \$1,050 per ounce, and we strongly believe it will peak out around \$15,000 per ounce by decade's end -- a price target we will address in our next letter. We have great confidence the corrective phase will be resolved to the upside.

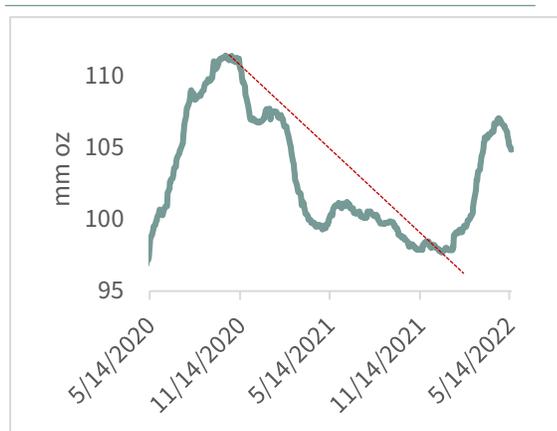
The most important question for investors is when this corrective phase will end.

Although we can't say for sure, we are confident that we are getting closer to a resolution to the upside and that investors should begin to increase their precious metals exposure now. Here at Goehring & Rozencwajg Associates we have begun to increase our weightings in precious metals related equities in the funds we manage.

In trying to time the arrival of the upcoming bull market, we are monitoring the following trends.

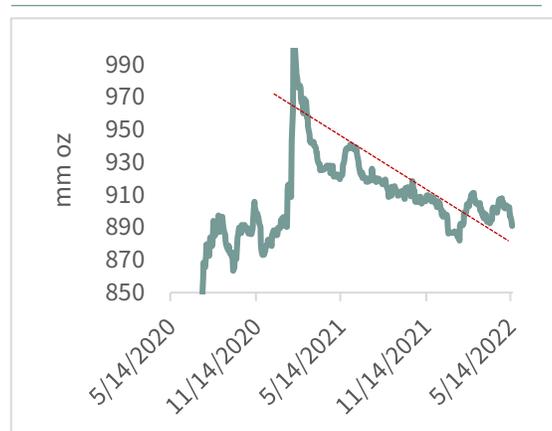
First, as mentioned in our last letter, western investors have begun a new phase of precious metals accumulation. Since gold prices peaked in the summer of 2020, the 16 physical gold ETFs we track have consistently shed gold, but, as you can see in the chart below, the downtrend line in gold selling by these ETFs has been broken. Since the beginning of 2022, these 16 ETFs have accumulated 300 tonnes of gold, only 100 tonnes below their October peak. The 10 physical silver ETFs we track are also exhibiting similar behavior. The physical silver holdings in these ETFs peaked in February 2021, just after the Reddit crowd tried to corner the silver market and since then these ETFs have liquidated 3,000 tonnes of silver. Starting at January's end, these ETFs stopped their shedding and began accumulating. As the chart shows, the silver shedding downtrend line looks to have broken.

FIG 23 ETF Gold Holdings



Source: Bloomberg.

FIGURE 24 ETF Silver Holdings



Source: Bloomberg.

We believe this precious metals bull market has been and will continue to be driven by western investors, very much as it was in the 1970s. Back then, the western investor, driven by inflation and currency debasement, drove the 25-fold advance in the gold price. We believe those same inflationary and currency debasement forces will drive the western investor to become the most important participant in this precious metals bull market. A lengthy period of physical accumulation by western investors will be a necessary driving force in the gold market's next bull market leg. Recent accumulation behaviors in both the gold and silver physical ETFs strongly suggest this investment interest has picked up.

Second: the decline in the gold-oil ratio also strongly suggests the gold bull market's next leg is getting closer. When gold gets expensive relative to oil (an ounce of gold buys 30 barrels or more of oil) then oil related investments have historically strongly outperformed gold investments. Conversely, when gold gets cheap relative to oil (an ounce of gold buys only 15 barrels or less of oil) then gold related investments have strongly outperformed oil related investments. The last time the gold-oil ratio hit 15 was back in September 2018 when gold traded down to \$1,175 per ounce and oil prices hit \$80. For the next two years, gold and gold equities radically outperformed oil and oil related investments. After bottoming in September 2018, gold rose 75% and gold stocks rose 125%. Over the same two year period, oil fell over 60% (actually going negative in April 2020) and oil related equities fell over 60%.

In the summer of 2020, the gold-oil ratio peaked at over 50 (gold radically overvalued relative to oil). Since then oil and oil related investments have outperformed gold and gold equities. Oil and oil related stocks, as measured by the XOP ETF, are up 150% and 175%, respectively, whereas the gold and the average gold stock is down 5% and 15%, respectively.

With oil prices rising and gold prices falling, the gold-oil ratio has now contracted significantly, and on March 8th, with oil spiking to \$130 per barrel and gold trading down to \$1,980 per ounce, the gold-oil ratio touched 15 intraday, the same level we saw back in September 2018.

Third: we are carefully monitoring central bank gold activity. Central banks finally stopped selling gold back in 2008 and have since become aggressive buyers. However, as you would have expected given all the COVID economic dislocations, 2020 saw a big

pullback in central bank buying. Central banks bought only 270 tonnes of gold for all of 2020, down from the 600 and 650 tonnes they bought in 2018 and 2019, respectively. In 2021, they bought 460 tonnes, up 70% from 2020 depressed levels. If central bank buying had remained weak in 2021, this would have suggested that the gold corrective phase could last longer and pull back farther than we originally thought. Their resurgent interest in gold last year removed that fear.

So far we don't have enough data to confirm whether central bank's gold buying interest will stay strong in 2022. The World Gold Council announced that central bank purchases were down 30% from the Q1 2021. It's too early in the year to extrapolate the first quarter trend, but we will continue to monitor central bank activity. If central bank gold purchasing continues to weaken, then this would suggest that the gold market's corrective phase could stretch out further.

Fourth: In last quarter's letter, we mentioned we are monitoring the position of precious metals traders on the COMEX exchange. Back in September of 2018, commercial traders (the smart money) had gone net long in both gold and silver future markets and speculators (the dumb money) had positioned themselves net short in both markets for the first time in almost 20 years. Although not always perfect, the positioning of the smart money being long and the dumb money being short often indicates that a tradable market bottom has been put in place. As of today, we are getting no such buy signals from the futures trader. Commercials remain stubbornly net short and speculators remain net long in both gold and silver markets.

Fifth, we remain concerned that rising interest rates will have an effect on the gold price. In the 1970s bull market, rising interest rates in response to the Arab-oil embargo broke the back of the gold market's first upward advance. From 1971 to 1974, gold prices surged four-fold, however, aggressive Fed tightening forced gold to undergo a huge correction. From its peak in Q1 1974, gold eventually fell 45%. The Fed is again talking about aggressively raising rates, possibly by 50 basis points this month and an additional 75 basis points in both June and July. How this will impact the gold price is unclear, but it is one of the major reasons why we don't have a full position in precious metals presently.

Summing all this up: we are now getting continued positive data that western investment demand is strongly returning to both gold and silver markets. Gold has now become cheap relative to oil. Central bank buying, may have turned slightly negative on a short term basis, but we only have one quarter of data and we will have to monitor their activity closely as we progress through the next several months. And finally, the positioning of traders is giving us little insight into whether the low we saw in gold prices this quarter was the definite low for this cycle. A pull back in gold prices related to the expected Fed tightening might produce much more bullish sentiments from gold futures traders. However, as of today, this data point is neutral, as opposed to the last bottom in gold back in September 2018 when it was strongly positive. Given the return of the western investor, the cheapness of gold relative to oil, the surge in inflation, and Russia's invasion of Ukraine, we believe the next leg of the gold bull market may have already started and we have begun to increase our exposure in the accounts we manage. The only thing that continues to nag us is how gold prices might react to the Fed's tightening of monetary conditions.

## Appendix

Back in the late 1960's, my father, a chemical engineer who started his career working in the refineries of Chevron and Exxon during World War 2, used to lecture my brother and me on how oil was formed, produced and ultimately refined into product. In those "dinner table talks" going back well over 50 years ago, I vividly remember my father mentioning that oil was a finite resource, and that it was only a matter of time before all the great oil reservoirs were discovered and that eventually the world's oil supply of oil would decline. Oil being a finite resource is something I remember him bringing up multiple times.

My father never mentioned where he was getting all this information from back then; however, over time, I came to the conclusion that my father must have been a keen follower of King Hubbert, the famous Shell Oil geologist.

King Hubbert was a well-known controversial geologist who worked for most of his career at Shell Oil. Hubbert's theories centered on the belief that the future production profile of a hydrocarbon basin could be fairly accurately predicted, given several assumptions. In its most simple form, Hubbert believed that following the discovery of a new oil or gas field, its production would follow the shape of a bell-curve.

Production would ramp up before ultimately reaching a "peak," which would occur when one half of the field's recoverable reserves had been produced. Following this peak, production from the field would begin to decline in a manner that mirrored the ramp-up phase, thereby creating a bell-shaped curve. Therefore, the most important data-point in determining a field's peak level of production, according to Hubbert's theories, is to accurately estimate the field's total recoverable reserves. Hubbert became famous in 1956 when, as the key-note speaker at the annual meeting of the American Petroleum Institute, he predicted that US oil production would "peak" between 1965 and 1970. He later refined his prediction, stating that US oil production would reach its peak in 1970.

While his original prediction was met with wide-spread skepticism, he was largely vindicated when US oil production did in fact peak in 1970 at approximately 12 million barrels per day, just as he had predicted nearly 14 years earlier. Both Hubbert and his theories regarding the estimation of oilfield production peaks, remain surrounded in controversy and skepticism even to this day. For example, many prominent followers of Hubbert's theories have been calling for a peak in global oil production for the last twenty-five years, only to be discredited as global oil production has continued to grow.

As non-academic followers of King Hubbert, we believe that that the largest drawback to his theories has been the relentless advancement of technology that has pushed recovery factors (and by extension total recoverable reserves) constantly higher across most oil fields. Also, technological advancements have opened up new fields that no one ever expected thirty years ago. For example, no one thought that we would be drilling in 10,000 feet of water to reach oil reservoirs that are another 15,000 feet below the seabed floor, and yet, this is exactly what the oil industry has achieved in the Brazilian "pre-salt" oil fields. Similarly, twenty-five years ago no one expected that we would produce both oil and gas from rock that had virtually no permeability, and yet this is what we are doing

in today's shale basins.

Hubbert's theories are currently undergoing yet another round of intense criticism, however we ultimately believe there are real benefits to studying his work, even today. Many elements of his theories do manage to keep showing up again and again over time. In particular, "Hubbert-style" production profiles show up in enough places to make his theories a necessary tool in understanding the supply dynamics of many global oil basins -- including shale.

The introductory natural gas essay in this letter references "Hubbert Linearizations" multiple times. A Hubbert Linearization is simply a plot of cumulative production vs. the ratio of current production to cumulative production. Hubbert noticed that after an initial "noisy" period, this trend settled into a very predictable straight line which could then be used to estimate a field's recoverable reserves. Recoverable reserves are calculated by extrapolating this straight line to see where it crosses the x-axis.