Gas fuels proppant prospects

After a year of depressed oil and gas prices, North American gas exploration is tentatively fuelling a pick up in proppant demand. But how will US producers react to proposed legislation that seeks to further regulate drilling?

by Jessica Roberts, *Assistant Editor*

THE WORLD AVERAGE crude oil spot price peaked at $137/bbl in July 2008. Just a year earlier, the same spot price had hovered at around $70/bbl – almost 50% lower (*Figure 1*). This massive peak in prices sparked a flurry of oil exploration and drilling activity, the impact of which reverberated through the industrial minerals world (*IM July '08, p.23: Oil cloud yields mineral lining*).

Industrial minerals are the source of numerous oilfield materials, aiding activities such as drilling (barytes, bentonite, calcium carbonate, graphite, haematite, mica, soda ash, vermiculite), well hole cement (kaolin, zeolite), and oil extraction (proppants – silica sand, bauxite, kaolin).

Although advances in drilling fluid technology are leaning toward increased use of chemicals and additives, industrial minerals still play a pivotal role in the oil and gas industry – particularly those used in the manufacture of proppants (see *p.38: proppants at a glance*).

Propping agents, or proppants, are used to aid extraction of oil and gas from reservoir rocks. During a hydraulic fracturing treatment, engineered fluids (including water, chemicals and proppants) are injected down the well via powerful hydraulic pumps. As pressure builds up in the well, the surrounding reservoir cracks, and it is into these fractures that the proppants must migrate and prop open (*Figure 4*). Together, the fractures and proppants act as a horizon of high permeability; facilitating the movement of oil and gas from the reservoir rock into the wellbore.

Proppants at a glance

Proppants, or propping agents, are an important material used to aid the extraction of oil and gas from reservoir rocks. There are three main types of proppant: **ceramic** (comprising sintered bauxite, alumina, kaolin), **fracturing sand** (a type of silica sand with well constrained characteristics), and **resin-coated** proppants (ceramic and sand).

Ceramic proppants

Ceramic proppants can be subdivided into three groups: **lightweight**, **intermediate density**, and **high density**. As the density of a ceramic proppant increases, so does its alumina content and strength – but also cost.

Lightweight proppants are the most widely used of the ceramic family and are aimed at the largest well population. They have a similar bulk density and specific gravity to frac sand, but have a high conductivity and are chemically inert. Lightweight proppants tend to be used for oil extraction from fairly shallow wells, and can withstand pressures up to 7,000 psi.

With a higher alumina content, **intermediate density proppants** tend to have good crush resistance and are usually effective at pressures of up to 10,000 psi. They are usually selected for wells with a moderate depth, to aid extraction of oil and gas.

High density ceramic proppants are usually manufactured from sintered bauxite, which is derived from the abrasive grade of the mineral. Abrasive grade bauxite is otherwise predominantly used to produce abrasive- and refractory-grade brown fused alumina.

During manufacture the bauxite is milled, agglomerated into small spheres, and then sintered at temperatures of 2,000°C. The resulting product has a good roundness, sphericity and strength, and is particularly in demand for gas extraction from deep well settings (10-14,000 psi).

Table 1: ASTM sieve series

US Mesh	Sieve opening (inches)	Sieve opening (mm)
5	0.1570	4.0000
6	0.1320	3.3600
7	0.1110	2.8300
8	0.0937	2.3800
10	0.0787	2.0000
12	0.0661	1.6800
14	0.0555	1.4100
16	0.0469	1.1900
18	0.0394	1.0000
20	0.0331	0.8400
25	0.0280	0.7100
→ 30	0.0232	0.5890
35	0.0197	0.5000
40	0.0165	0.4200
45	0.0138	0.3510
→ 50	0.0117	0.2970
60	0.0098	0.2500
70	0.0083	0.2100
80	0.0070	0.1770
100	0.0059	0.1490
120	0.0049	0.1240
140	0.0041	0.1040
170	0.0035	0.0880
200	0.0029	0.0740

Per API specifications, 90% of proppant falls through the top screen and is caught on the bottom screen. Up to 1% is permitted to fall on the second screen below bottom. Arrows indicate material falling between the 30/50 mesh API specification.

Source: ASTM International

Fracturing sand

Fracturing (frac) sand is a form of silica sand with well constrained size, roundness and sphericity characteristics. It is traditionally divided into two types – **white sand**, and **brown sand**.

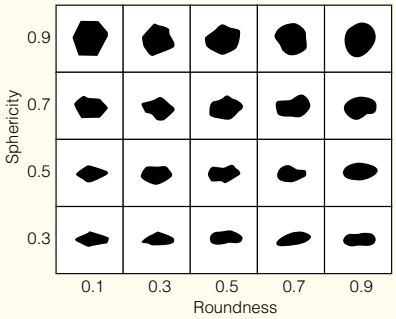
The standard for white sand is generally accepted to be the St Peter's sandstone, which is found throughout Ottawa in Illinois, USA, in large deposits. The St Peter's sandstone, which was used during early development of hydraulic fracturing testing, has continued to be mined for frac sand, as it comprises well rounded grains that meet crush resistance tests and American Petroleum Institute (API) standards (*IM January '07, p.59: The facts of frac*).

Meanwhile, brown sand has traditionally been sourced from the Hickory sandstone found near Brady in Texas, USA. Brown sand is polycrystalline (comprising multiple crystals bound together), and is weaker than the monocrystalline white sand.

Resin-coated sand

In the mid-1970s the oil and gas market saw the development of the first resin-coated sand proppants. Although resin does not increase the strength of the sand, its role is nonetheless vital. By applying resin, the sand pack can be consolidated and the risk of proppant flow-back is reduced. Further, when the sand grains fail and crush under pressure, the resin coating prevents individual fines from escaping. Resin-coating can also improve the distribution of stresses applied to the sand downhole.

API RP60 - proppant specifications



Source: Redrawn from *Stratigraphy* and *Sedimentation*, Krumbein and Sloss

Resin-coated ceramics

The development of lightweight and ultra lightweight ceramic proppants has seen more research into coating porous ceramic proppants. The ceramic proppant is underfired during manufacture, producing internal or external porosity which can be preserved by coating the proppant with resin. Although this produces a lightweight ceramic proppant, underfired products are weaker than traditional ceramic proppants. As with frac sand, applying resin to the proppant also reduces the risk of proppant flow-back.

API standards

The API has a number of specifications for proppants which the industry uses as a guideline for factors such as crush resistance, roundness and sphericity, and the amount of fines allowed above and below the specific mesh size. These factors all affect conductivity or the proppant pack.

Proppant size is measured using ASTM International's (formerly American Society for Testing and Materials) sieve series, which is based on the fourth root of two – whereby every fourth screen represents a doubling of particle diameter.

API requires that a minimum of 90% of the specific proppant size should fall between the designated sieve sizes. Not more than 0.1% of the total tested sample should be larger than the first sieve size, and not more than 1% should be smaller than the last sieve size (*Table 1*).

The use of proppants is especially crucial in the recovery of oil and gas from moderate to deep wells, as the proppants used must be able to withstand the high (10-14,000 psi) pressures encountered in these reservoirs.

Opening opportunities

Proppant usage began to decline at the end of 2008 – in tandem with falling oil prices and the economic recession – and has remained at lower levels throughout 2009, generally reflecting oil and gas drilling activity.

Perry Fischer, editor of *World Oil*, summed up the drilling market, commenting: "The global oil market will be off by around 5-7% this year in terms of drilling activity, but the US oil market will be worse – probably around 20% off."

"Gas is not yet a global market, but the North American gas market is way off – at about 50% in drilling terms – which is a situation that cannot last due to an across-the-board average 30% depletion rate," Fischer explained.

Fischer told **IM** that in terms of exploration – although most places in the world are very mature – very few locations have been exploited at depth.

"At greater drilling depths, say, 12,000 to 15,000 ft and deeper, everywhere is underexplored – even very old areas like Texas [USA]. Africa still has some shallow underexplored areas, and there have been some world class finds in Uganda, for example."

"In general though, it's the deepwater areas such as the Lower Tertiary in the US Gulf of Mexico, the per-salt depths in Brazil's Campos Basin, and the whole of West Africa's deepwater that will remain where most of the exploration dollars are spent," Fischer explained.

Ceramic proppants

Given the location of most of the exploration and drilling at present, it seems inevitable that this will be reflected in the demand for certain types of proppant (see *38: proppants at a glance*). This has already been witnessed over the past decade or so as production from hotter, deeper reservoirs has steadily increased demand for stronger, more crush resistant ceramic and bauxite proppants.

Robert Baylis, senior analyst at UK-based Roskill Information Services, told **IM**: "The complexity of wells is increasing , and the wells themselves are getting deeper and reaching higher temperatures."

This demand, said Baylis, has caused some sourcing problems for proppants producers: "There's an obvious shortage of adequate bauxite grades, with most of the Chinese material meeting refractory specifications. There is also a lack of abrasive grade material outside of China, and proppants producers are probably struggling to source material."

Although fracturing (frac) sand remains the most widely used proppant type – accounting for around 70% of the market, according to industry sources – its market share has fallen slightly in recent years (*Figure 2*). However, it is worth noting that during this time the price of oil, in particular, warranted the use of more expensive proppant types.

Murray Lines, director of minerals market consultancy Stratum Resources, told **IM**: "Frac sand – including resin-coated sand – will continue to grow steadily [once the market recovers], but ceramic proppants, including pisolitic bauxite-based grades, will grow even faster."

The development of "lightweight ceramic proppant with high crush strength" has had one of the biggest impacts on the proppants market in recent years, according to Daniyel Firestone of USA-based ALMA International Inc., which specialises in the manufacture and distribution of a wide range of industrial media.

"Depressed [oil and gas] prices make it impossible to use expensive ceramic proppants [at present]," Firestone told **IM**. "However, there are new, less expensive proppants being developed by more companies, which increases the options and also the competition." Firestone expects these factors to drive down proppant prices.

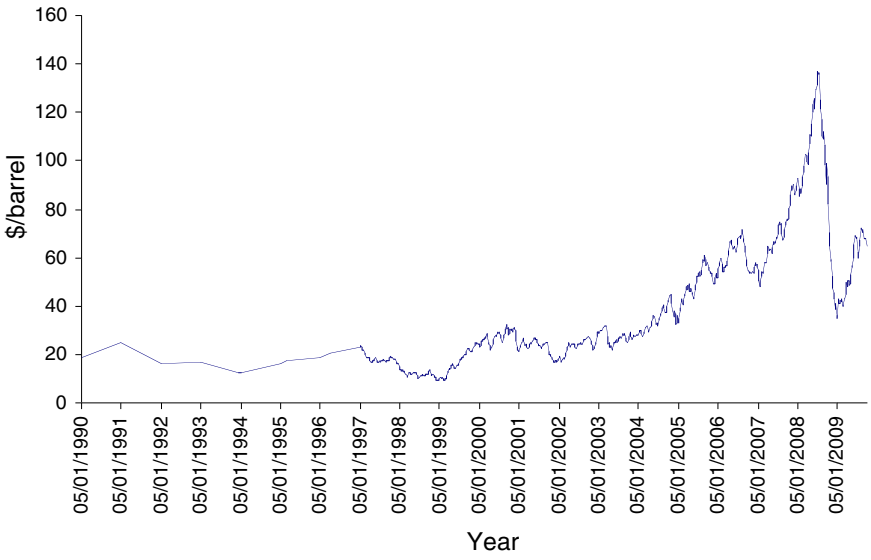
Yixing Orient Petroleum Proppant Co. Ltd echoed this opinion, telling **IM**: "There is still much room for the development of ceramic proppants, and we are confident about its future."

Although the company is positive that the market will see further development of ceramic proppant products in the future, it warned: "As we all know: no demand, no market."

"Because of the impact of the economic crisis, the development of the market has been hampered," Yixing Orient explained. "However, the situation is going to pick up in 2010. It's expected that demand will rise 20-30% on the basis of 2009 levels."

Yixing Orient, formed in 1986, operates two plants in Yixing City, located in Jiangsu province, eastern China, with a production capacity of 100,000 tpa (around 220m. lbs/year). The company is believed to be the largest producer of ceramic proppant in China, and claims it is third largest in the world, with a domestic market share of 95%

Figure 1: World average crude oil spot price, 1990-2009



Weekly all countries spot price (FOB, $/barrel) weighted by estimated export volume. Data includes period between 5 January 1990 to 2 October 2009.

Source: US Energy Information Administration

and 15% of the world's ceramic proppant production.

"Bauxite is the raw material of ceramic proppants and demand for it will be larger in the future than it is now," Yixing Orient told **IM**. "At the present time, more and more [proppants] factories are building, and the competition will be fierce."

Frac sand demand

Competition is also fierce in the frac sand supply chain, where it is becoming increasingly difficult to find silica sand deposits that meet the stringent specifications set by the American Petroleum Institute (API). The API's standards constrain the values for a number of proppant properties, including crush resistance, roundness, sphericity, and size.

Sands suitable for fracing must be sourced from high silica sandstones or unconsolidated deposits, well rounded, relatively clean of other minerals and impurities, fine, medium to coarse grain, and mineable (*IM January '07, p. 58: The facts of frac*).

During the period of peak oil prices in mid-2008, frac sand supply was in considerable demand. In North America, where numerous silica sand deposits exist, demand for oil and gas sparked a flurry of capacity increases, from major producers such as U.S. Silica Co. (USS) and Unimin Corp.

U.S. Silica

One of the world's leading frac sand producers is USS, headquartered in Berkeley Springs, West Virginia. USS has an overall frac sand capacity of 1.5m. tpa and produces a number of grades at plants across the USA, including Columbia, South Carolina (grades 12/20-20/40 mesh); Dubberly, Louisiana (40/70); Jackson, Tennessee (40/70), Mill Creek, Oklahoma (100 mesh); Ottawa, Illinois (20/40-40/70); and Pacific, Missouri (40/70-100 mesh hybrid). Additionally, USS is evaluating process changes at its Pacific plant to make a spec 40/70; the evaluation will be completed in early 2010, the company told **IM**.

USS owns >130m. tonnes of the high quality St Peter's sandstone reserves in Ottawa, and in June this year the company announced plans to expand its frac sand capacity at the Ottawa facility by 500,000 tpa, through the construction of a new processing facility (*IM 25 June 2009: U.S. Silica ups frac sand capacity*).

John Ulizio, chief executive officer of USS, explained: "Ottawa frac sands are the premier frac sands, and we wanted to meet the frac sand market demand for premium northern white API specifications 20/40 through 40/70 frac sand."

The most widely used frac sand grade is 20/40 mesh, comprising silica sand grains 0.84-0.42 mm in size. Although the market for proppants has been deflated somewhat throughout 2009, Ulizio explained that the expansion would give USS "the ability to add more capacity when market conditions warrant it, and the ability to make an API spec premium 40/70 frac sand at Ottawa".

Unimin

Another of the USA's biggest frac sand producers is Sibelco subsidiary Unimin Corp., which produces frac sand at its operations in Guion, Arkansas. In April this year Unimin announced that it would increase production at the site by 700% – a move that would see capacity grow by an additional 250,000 tonnes.

Unimin said the expansion was in response to market demand for more 40/70 frac sand, a type commonly used in the shale reservoirs of the Fayetteville, Haynesville and Barnett basins, where gas is extracted.

Unimin was aiming to complete the expansion by the end of 2009, but the latest estimate from the company puts the project completion at end-Q1 2010.

New frac sand projects

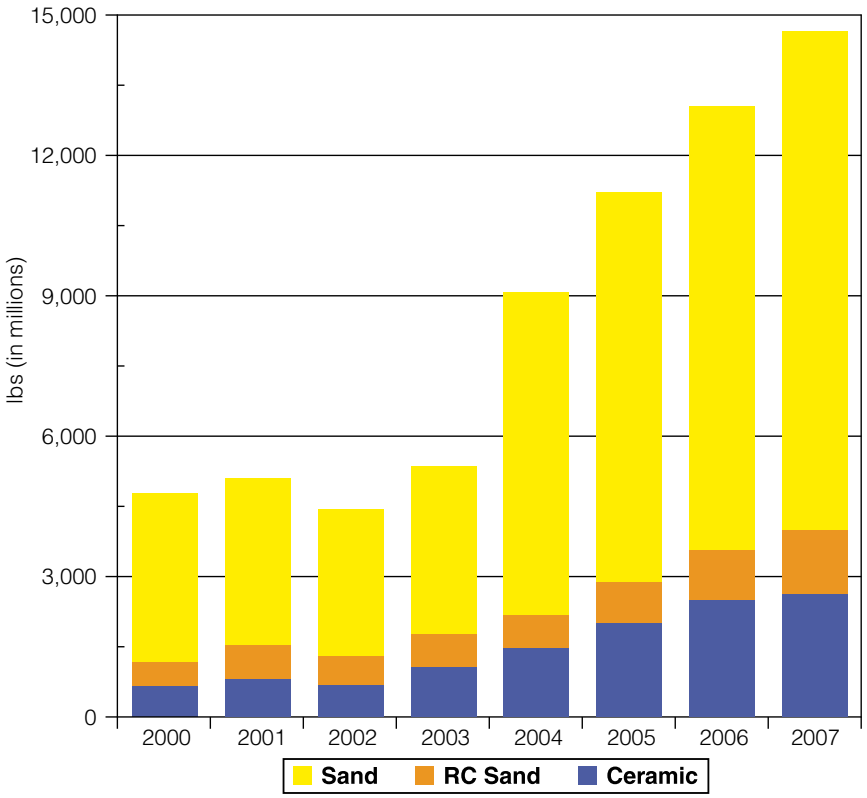
The flurry of frac sand activity over the past two or so years has not been restricted to existing operations. Indeed, several exploration companies looking to develop North American frac sand have attracted a lot of attention – perhaps the most viable of these being Stikine Gold Corp. and Victory Nickel Inc.

Stikine Gold

Canadian exploration company Stikine is developing a large quartzite deposit – the Nonda frac sand project – located in British Columbia, south-west Canada.

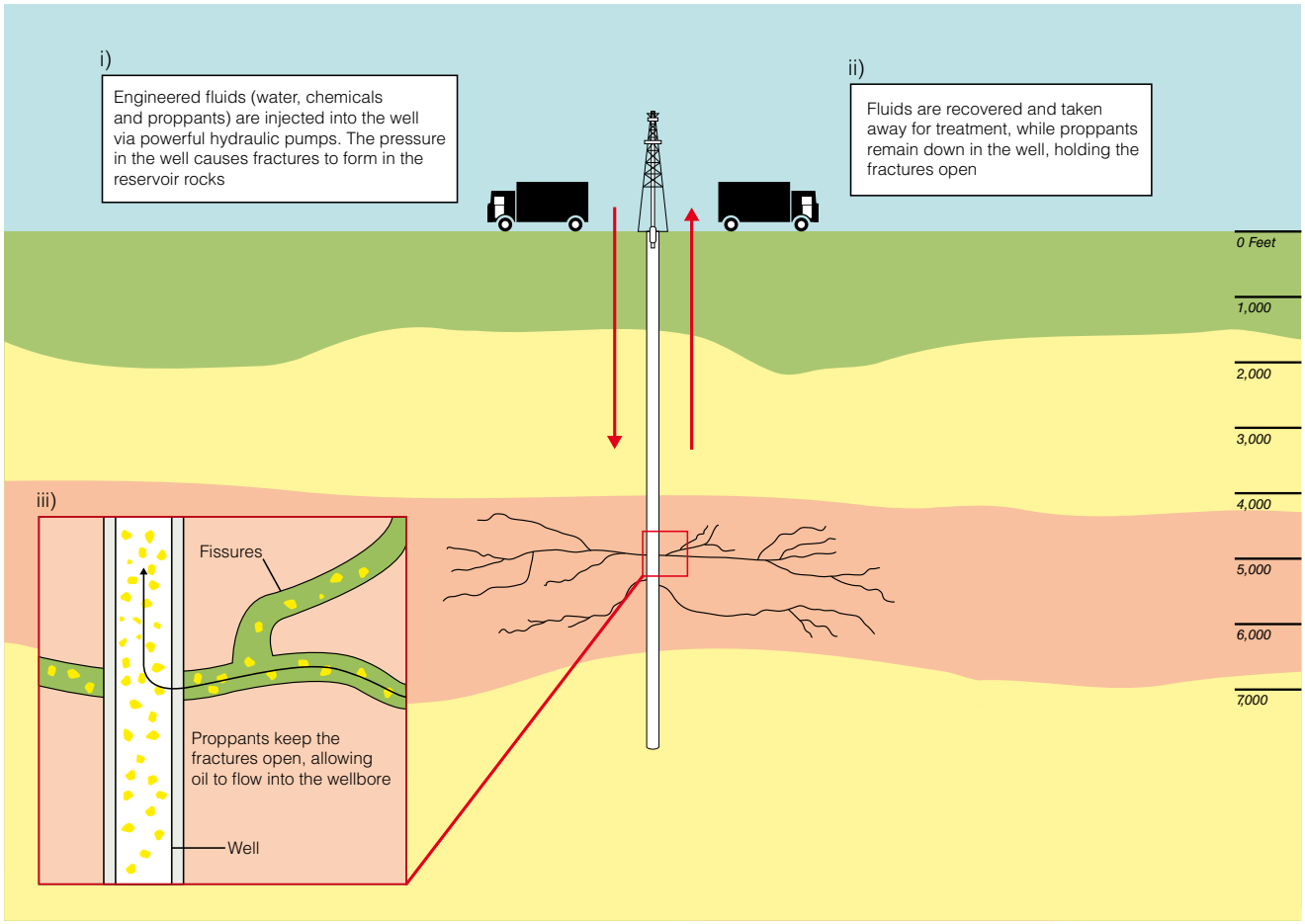
In mid-October 2009 the company received the first results from its initial drill programme at the site, which involved nine

Figure 2: Global proppant production, 2000-2007



Around 14,500m. lbs of proppants were produced in 2007, compared to approximately 5,000 lbs in 2000. In this period, market share shifted in favour of ceramics over frac sand by around 5%.
Source: Adapted from CARBO Ceramics

Figure 4: Hydraulic fracturing steps



Visiting geologist reviewing quartzite in drill core at Stikine's Nonda Project, October 2009.
Courtesy Stikine Gold Corp

drill holes along 2.2km of the >11km strike length deposit. All holes were collared in and ended in quartzite, with hole depths ranging 70-168 metres.

Scott Broughton, president and chief executive officer of Stikine, said of the drill results: "We wanted to prove to the market that we had a massive quartzite resource. We tested over 2km strike of the deposit and found that the material was very consistent."

Broughton told **IM** that the next step for the company would be to conduct large scale bench tests on the Nonda material, for which Stikine collected around 2 tonnes of material, in order to determine yield.

Stikine also plans to submit the quartzite to a number of certification labs and potential customers . "We hope to get the results back from that in 2-4 weeks," Broughton said.

The potential of the Nonda frac sand project is good, as there are a number of gas companies in the British Columbia area – focused particularly in the Horn River Basin – that will require higher volumes of proppant as they progress to full production.

"Our agenda is to begin production by the time the Horn River Basin gets into its stride – in 2-3 years' time," Broughton explained. "There are eight or nine companies in Horn River and we want to supply all their needs. At the moment that's only about 300-400,000 tpa of frac sand, but in the next couple of years that could grow to 2-4m. tpa."

Although originally a metals-focused company, Stikine was inspired to develop a new Canada-based frac sand supply after learning how much the British Columbia gas companies were paying for the proppant. Certainly, the Nonda project is a positive development for these companies, many of which have been transporting frac sand in from the USA.

"We could make the Horn River Basin gas more competitive," Boughton said. "In turn, that would help to secure a clean energy source for North America and reduce its reliance on imported energy."

Victory Nickel

Another frac sand developer to have gained attention in recent months is Canadian exploration company Victory Nickel Inc.,

currently developing the Minago nickel deposit - which also has a significant frac sand resource - in Manitoba, central Canada.

The Minago frac sand resource, a 10 metre thick sandstone layer, was discovered by Victory after it was found to be overlying a nickel deposit that the company is developing.

Paul Jones, vice president of exploration for Victory, told **IM**: "In Manitoba you're exposing the frac sand layer to get to the nickel deposit. The sand perhaps wouldn't be feasible as a standalone project as you also have around 70-80 metres of limestone to get through first."

In September, the company revised its frac sand estimate at the Minago site, raising the amount of marketable frac sand from 4m. tonnes to 12.6m. tonnes. In its revision, Victory noted: "It's important to remember that the sandstone layer is not confined to the Minago pit area, and that this resource estimate doesn't consider the potentially significant additional tonnage of frac sand that exists outside the open pit limits and which could conceivably be mined using conventional underground mining methods."

Victory believes demand for high quality frac sand should continue to expand, driven by the development of unconventional oil and gas resource plays – such as the shale-gas developments in the Montney and Horn River regions of north-east British Columbia.

"In Canada there's a lot of exploration for gas right now, and it looks like demand for frac sand from those companies alone could require around 2m. tpa of proppants during the next few years," Jones told **IM**.

Proppants' prospects

In North America the proppants market is generally tied to natural gas production. While prices for US gas have been staggeringly low recently (around $3-4), they are now beginning to rise – something both proppants producers and gas companies will be relieved about.

Proppant prices and usage

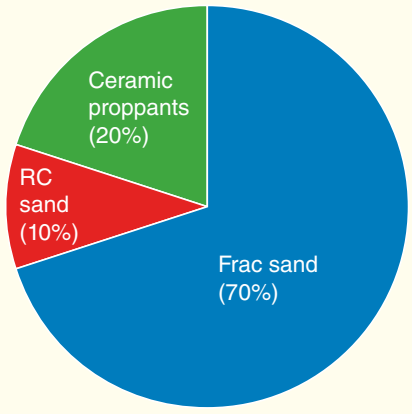
Recent prices for bauxite proppants have been estimated at $0.45-0.50/lb, while ceramic proppants levels are thought to range $0.40-0.45/lb, and frac sand around $0.08-0.10/lb.

One industry source said: "Some companies are reporting prices as low as $0.20/lb for lightweight proppants."

Another ceramic proppant producer, meanwhile, estimated prices for medium density high strength ceramic proppant to be close to $460/tonne ($0.21/lb).

Ceramic proppants are estimated to hold around 20% of the overall proppant market at present, while frac sand accounts for 70% and resin-coated sand accounts for around 10%. Of the three types, frac sand is the cheapest.

Figure 3: Market share by proppant type, 2007



Approximately 14,500m. lbs of proppants were produced in 2007, divided between frac sand (~70%), ceramic proppants (~20%) and resin-coated sand (~10%).

Source: Industry sources

Leading proppants producers

Ceramic proppants: The world's leading ceramic proppants producer is USA-based CARBO Ceramics, which operates six plants – one in China, one in Russia, and four in the USA. CARBO produces a range of ceramic products, including ultralight, lightweight, intermediate density and high density proppants.

CARBO's biggest competitor is **Saint-Gobain Proppants** (SGP), a subsidiary of the French glass producer Saint-Gobain. In 1989 Saint-Gobain acquired proppants producer Norton Co., and in 2004 Norton's name was changed to SGP. The company produces a number of ceramic and sintered bauxite proppant types.

Another leading bauxite proppant company is Brazilian bauxite producer **Mineração Curimbaba Ltda**, whose exclusive distributor in Canada, Mexico and the USA is **Sintex Minerals & Service Inc.** Curimbaba owns more than 250 bauxite mines which together represent reserves of around 300m. tonnes.

In Russia, a major ceramic proppants producer is **JSC Borovichi Refractories Plant**, which has been manufacturing proppants under the trade name BorProp since 1998.

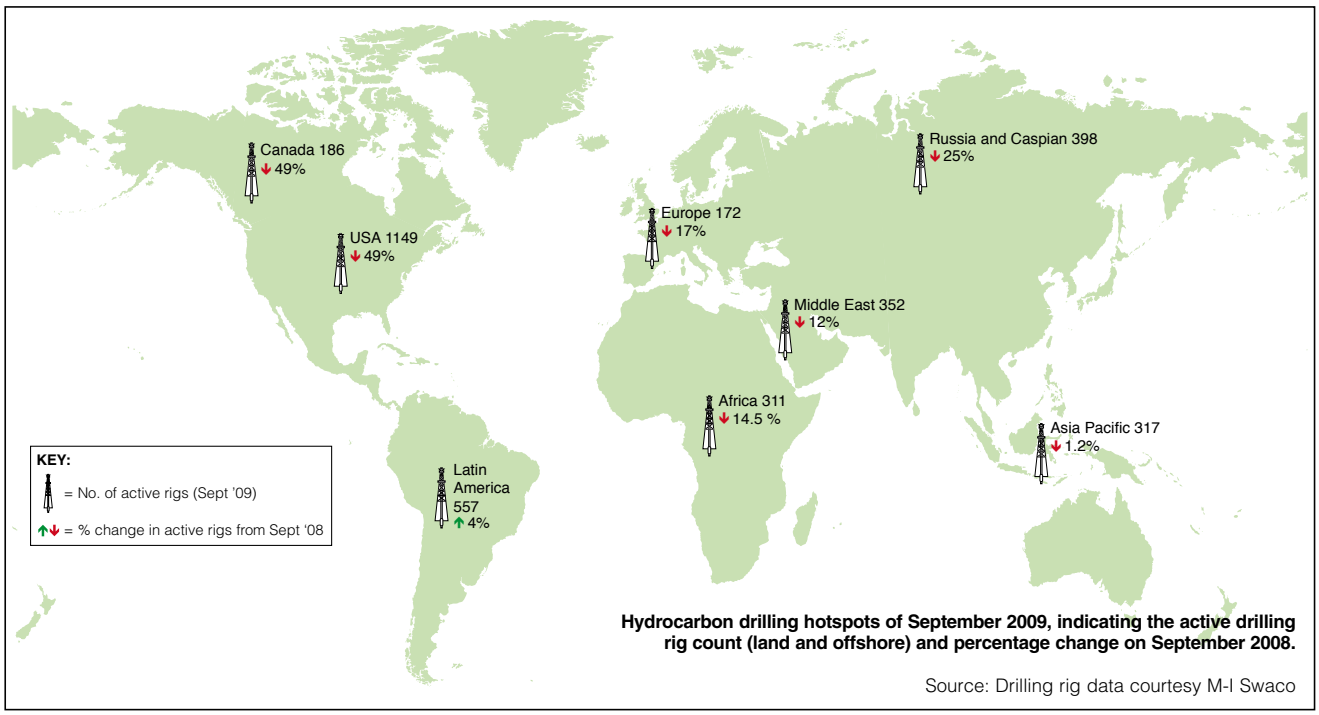
The market for ceramic proppants has grown steadily in Asia over the past few years, and **Yixing Orient Petroleum Proppant Co. Ltd** is believed to be the biggest producer in China, with a capacity of 100,000 tpa. Also in China, an emerging bauxite proppants producer is **China Gengsheng Minerals Inc.**, which has won a number of high profile contracts this year with companies such as China National Petroleum Corp., and PetroChina Co. Ltd.

Frac sand: One of the world's leading frac sand companies is USA-based **U.S. Silica Co.**, owned by private equity group Golden Gate Capital. The company has a frac sand capacity of 1.5m. tpa, which is shared between six plants throughout the USA. The company's principle site is in Ottawa, Illinois.

US company **Superior Silica Sands LLC** produces 20/40, 40/70 and 100 mesh fractions of Ottawa-type frac sand. This year, Superior entered into a partnership with fellow US company **flexFrac Proppant Frac Sand Suppliers**, a frac sand producer with operations in Wisconsin and Texas.

Fairmount Minerals' subsidiary **Santrol** also produces Ottawa-type sand, and resin-coated products. Fairmount's frac and gravel pack sand processing capacity is over 400,000 tpa, and the company claims to have enough mine reserves to supply Ottawa sand for the next 80 years.

Figure 5: Drilling market (land and offshore), September 2009



Hydrocarbon drilling hotspots of September 2009, indicating the active drilling rig count (land and offshore) and percentage change on September 2008.

Source: Drilling rig data courtesy M-I Swaco

"Companies can't really tolerate gas below $6, especially in the shale plays, so many of those with significant shale gas exposure are trying to stay alive through cash flow, but even that won't allow them to survive long at current prices," Fischer of *World Oil* explained. "I think we'll see gas rise above $6, probably within the next 6 months. Either that or there will be a wave of consolidation."

As with most industrial projects, the development of the North American shale plays will depend on profitability returning to the gas market; at present, it seems the expense of shale gas development is simply not sustainable in the face of low industrial demand.

But, at some point, gas prices will rise, and with it so will proppant demand. However, industry sources predict that the development of shale plays will see a return to gel fracing over water fracing: "In shales fracing is needed of course, but the problem with these wells is the gas production depletion rate – which is atrocious," one source said.

Another energy source that proppants producers may have been eyeing up is coal bed methane (CBM), a source of gas which is extracted from coal deposits. According to industry sources, CBM is more stable than shale gas plays; but its one major wildcard is de-watering.

CBM wells need to be dewatered, though not necessarily fraced. The cost of pumping, treating and disposing of the water is the biggest unknown, particularly regarding how long the dewatering process has to continue. This contrasts with shale gas where the water issues lie on both sides of the development process – finding the 2-8m. gallons of water needed for each frac job, plus disposing of the produced water.

These water issues come at a time when the effects of hydraulic fracturing on ground water are being closely scrutinised, particularly in the USA.

The FRAC Act problem

In the USA, a potential roadblock to the recovery of the oil and gas markets is a piece of legislation that seeks to further regulate hydraulic fracturing in the country. The Fracking Responsibility and Awareness of Chemicals Act (*FRAC Act*) is a proposed amendment to the *Safe Drinking Water Act* that, if successful, would place further restrictions on fracing and force oil and gas companies to disclose the chemicals used during drilling.

"Our legislation says everyone deserves to have safe drinking water by ensuring that hydraulic fracturing is subject to the protections afforded by the Safe Drinking Water Act. The bill also lifts the veil of secrecy currently shrouding this industry practice," commented US congressman Maurice Hinchey.

But in a recent press release, the American Petroleum Institute dismissed these concerns, stating: "Hydraulic fracturing is a safe, proven, 50-year-old technology… More than one million wells have been completed using this technology. Unnecessary additional regulation of this practice would only hurt the nation's energy security and threaten our economy."

Although proppants themselves are not classed as chemicals, and would not be regulated under the *FRAC Act*, any legislation limiting the oil and gas drilling market – particularly in an important oil and gas producing country such as the USA – would have repercussions for the material and its producers. As it stands, the real questions regarding the proposed *FRAC Act* is not whether fracing will be regulated (as it already is), but rather *who* will regulate fracing and *how*?

"At the moment hydraulic fracturing is a motley quilt of state regulation. If HF came under federal regulation, that wouldn't necessarily be a bad thing, it's just an unknown; and business generally would rather work with the known status quo than deal with unknown future regulation," said Fischer of *World Oil*.

In a time of the utmost uncertainty in economic and market terms, an additional "unknown" is the last thing the industry wants.