Shale gas production

Shale gas: porosity, permeability and production

More than half of the Earth's sedimentary rock is made up of shale, a fine-grained rock formed over time from compressed deposits of mud, silt, clay and organic matter. The main characteristic of a shale is its low permeability (a measure of the ability of the rock to allow fluids and gases to pass through it). The geology, geochemistry and geomechanics can be highly variable for different shales and even within a shale.

When the organic matter in shales is heated during burial within the Earth, it is initially transformed into oil and then natural gas, known as shale gas. Shale gas is found at various depths but is typically located deeper than 1000 metres. Shale gas mainly consists of methane (although other gases may be present).

Over time, some of the gas may migrate into an overlying rock unit such as permeable sandstone. This is classified as a 'conventional reservoir' because the gas has moved and is trapped/concentrated in a reservior where it can be produced using traditional methods.

The generated gas however, may also remain trapped within micropores and fractures of the shale or adsorbed onto clay minerals and organic matter within the shale. Because of the low permeability of shales, shale gas reservoirs need to be fractured to allow the gas to flow into the well.

The presence of gas in shale formations has been known for almost 200 years, but the depth at which they occur and their low permeability meant that in the past shale gas has generally been difficult, and hence uneconomical, to extract compared to other natural gas resources. However, with the development of new technologies in recent years, particularly in horizontal drilling and hydraulic fracturing, operators have been able to achieve economic production; for example in the United States where approximately 20-25 per cent of the total gas consumed now comes from shale deposits.

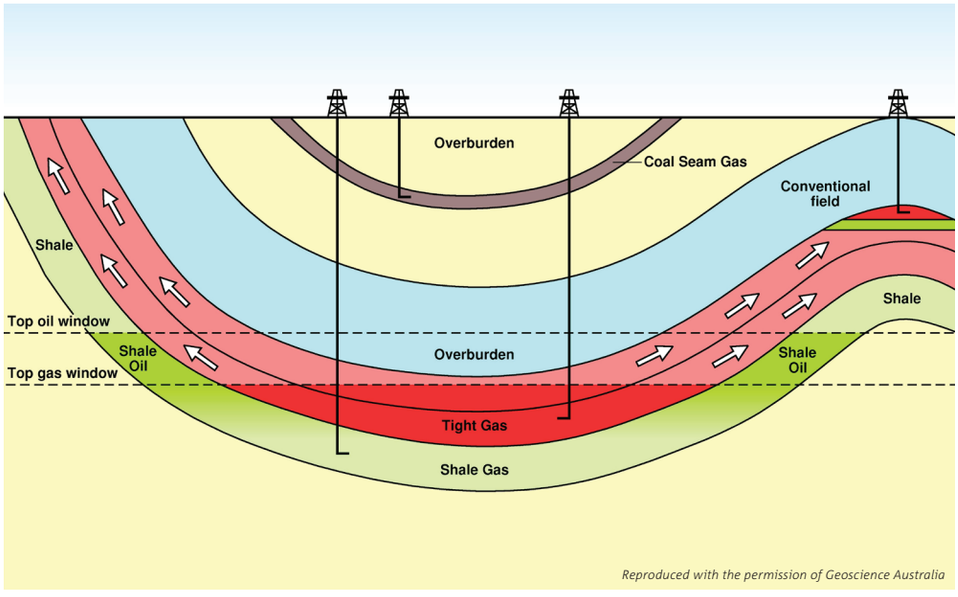
Exploration phase

The exploration phase of shale gas production involves drilling and fracturing vertical wells to verify the presence of gas, characterise it and determine whether it can be economically produced. The number of wells drilled in the exploration phase can range from two to 15 wells in a lease area. Up to 30 wells may be drilled to gain more data on the pressure and geology of the resource.

This data is used for modelling and forecasting the volume of the gas resource, production performance and development economics to determine the long-term viability of production. Shales with commercial reserves of gas are generally more than 100 metres thick and spread laterally over hundreds of square kilometres. Because of this feature, horizontal drilling is generally employed. Once a shale formation is located by vertical drilling, the direction of the drill bit is changed to run horizontally to maximise the wells exposure to the reservoir. In order to be produced, a potential gas bearing shale needs to contain some silt so that the rock is brittle enough to be hydraulically fractured.

Production phase

The number of wells drilled to produce a prospect depends on the lateral extent of the deposit and also on the reservoir pressure. Tight well spacing is sometimes required to lower the reservoir pressure enough to cause significant amounts of the adsorbed gas to be desorbed and released. Recovery of the gas from an individual well can range from 28-40 per cent of the total gas present (compared to conventional wells which drain gas over a larger area and recover up to 60-80 per cent). Historically the average well spacing for vertical wells is 400 metres while spacing between horizontal wells is a function of the shape of the induced fractures, but is often at least 800 metres. Operators aim to increase well spacing to reduce costs and environmental impacts.

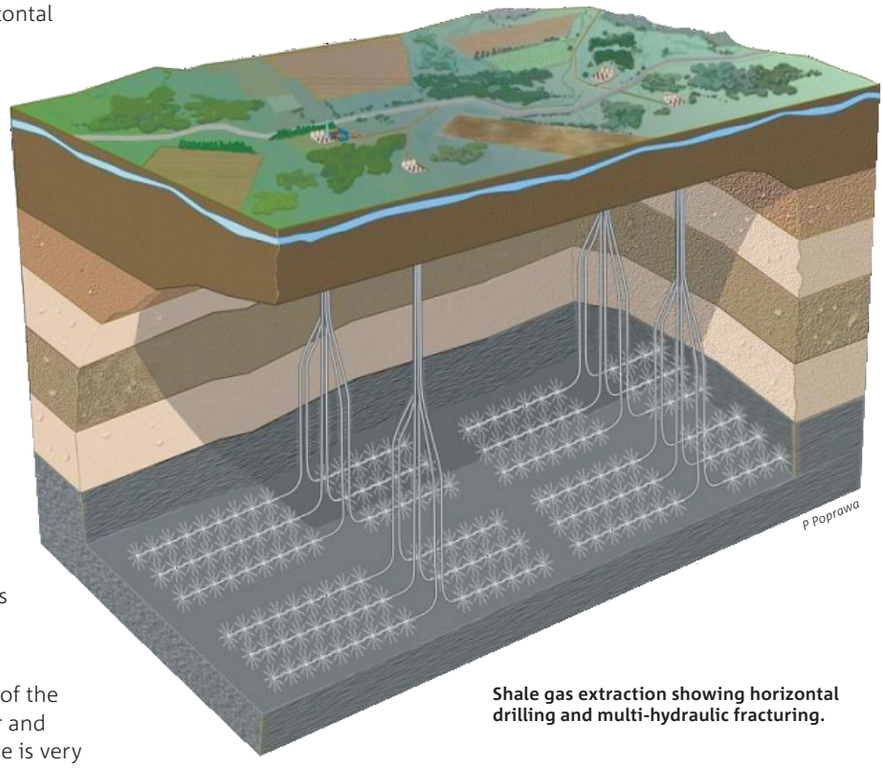


This diagram shows a conventional hydrocarbon accumulation on the right, and the spectrum of unconventional hydrocarbon accumulation types in the centre. The arrows show gas migration over geological time.

Multi-lateral drilling (drilling two or more horizontal wells that extend in different directions from the same vertical well bore) is also used to maximise access to shale gas reservoirs.

Because of the low permeability, several hydraulic fracturing treatments are generally applied over time.

Hydraulic fracturing for shale gas is mostly done in horizontal wells using 'slick water' and sand. Slick water is water mixed with a low concentration of guar (a vegetable gum made from guar beans) which reduces the fluid friction during pumping. The slick water and sand are pumped down the well at sufficient pressure to fracture the shale. The sand holds the fractures open so that the gas can be produced. After the fracturing is complete, part (approximately one third) of the fluid injected flows back to the well. These types of treatments are often done in CSG wells using similar fluids.



Shale gas extraction showing horizontal drilling and multi-hydraulic fracturing.

Many fracture stages are employed per well, typically 10-20, spaced out in a horizontal part of the well typically 1-2 km long. The amount of water and sand proppant needed for each fracturing stage is very large (1 million litres or one mega litre per fracture), so this is a potential limitation (ie 20 mega litres per well). Water availability and long distance transport of materials in Australia is a very different logistical and economic prospect than in North America. Flow-back water then has to be dealt with and best practice usually involves transporting it to a treatment site, which needs a large economy of scale to be viable.

Once extraction from a well is no longer economic, sections of the well are filled with cement. This is to prevent gas from flowing up to the surface or into any zones containing water/aquifers. The well is then capped below ground level and buried.

Commercial production considerations

There are a number of factors to be taken into consideration for commercial production of shale gas in the Australian context. Some of these factors include:

- Whether there is a large enough supply to merit the substantial investment in research, technology development, infrastructure and extraction costs.
- Demand needs to be high considering the low gas prices in Australia. However, the local gas prices relative to other energy sources may change, particularly while conventional oil and gas production continues to decline around the globe. This will dictate whether returns from exploiting shale gas will justify the large capital investment required.
- The price of gas markets overseas will determine the price in Australia. Currently the local price is low but export prices are high. Any change in this will affect the prospectivity of the resource in Australia.
- Australia has limited pipelines, natural gas liquefaction plants and other infrastructure to support the production, processing and transportation of most of its remote shale gas resources. This will require significant capital investment.
- A well developed, stable and comprehensive regulatory regime is needed to support large scale shale production capacity and at the same time address environmental management, water management, land access and other issues such as air quality, noise impacts, impacts on local communities and waste disposal. Health, safety and environmental concerns associated with shale gas production is currently under study.

These key variables, along with the research and development challenges faced in producing shale gas safely and economically, need to be addressed before the shale gas industry can become a reality in Australia.

REFERENCES

P Poprawa, 'Shale Gas Extraction' Polish Geological Institute

CONTACT US
t 1300 363 400
+61 3 9545 2176
e enquiries@csiro.au
w www.csiro.au

YOUR CSIRO

Australia is founding its future on science and innovation. Its national science agency, CSIRO, is a powerhouse of ideas, technologies and skills for building prosperity, growth, health and sustainability. It serves governments, industries, business and communities across the nation.

For further information please contact:

Amir Aryana
Group Leader
Onshore Gas Program
t +61 2 9490 8109
e amir.aryana@csiro.au