Australia's National Science Agency

GROUND AND SURFACE WATERS

GISERA | Gas Industry Social and Environmental Research Alliance

Cements, steels and microbial activities in Queensland's coal seam gas wells

CSIRO scientists have completed a first-of-a-kind project to improve community understanding of well integrity in Queensland's coal seam gas (CSG) wells, focussing on the materials used in cements and casings, as well as microbial processes associated with subsurface environments.

Key points

- The study found the consistency of well completion reports has improved since 2011 when a code of practice was introduced in Queensland.
- Steel grade K55 accounts for about 60% of casings reported. K55 is routinely used as it has the technical strength corresponding to depths, temperatures and pressures encountered in Queensland coal seams.
- Our understanding of subsurface microbiology is poor and contains many significant knowledge gaps.
- Microbial life in the subsurface forms biofilms that adhere to surfaces including well infrastructure. These biofilms can promote microbial activity that can impact corrosion and performance of materials used in CSG well infrastructure.
- The waters of the Surat and Bowen basins are extremely deficient in phosphorous, and oxidised forms of sulphur. Both deficiencies are likely limiting for microbial production of sulphides within these CSG formations.

Banner image: A coal seam gas well head in the Surat Basin, Queensland.

This project, conducted through CSIRO's Gas Industry Social and Environmental Research Alliance (GISERA), addressed community concerns about the integrity of Queensland's coal seam gas wells by providing information about the materials used in their construction.

Researchers undertook two distinct tasks. The first was to review and synthesise the information contained in Well Completion Reports (WCRs) about casing and cementing materials, and present this in a more accessible format.

The second was to review existing data on Australian subsurface microbiology, with a focus on those organisms known to have a capacity to negatively impact CSG well casings or cement.

The Bowen and Surat basins

Southern Queensland hosts the largest CSG producing fields in Australia with production commencing in the Bowen Basin in the 1990s and in the overlying Surat Basin in 2006. The key reservoirs are Permian coals of the Bowen Basin and Jurassic coals of the Surat Basin.

The number of CSG wells in Queensland is expected to reach 22,000 by 2050. Understanding any potential risks associated with gas development activities requires detailed knowledge of CSG well integrity.

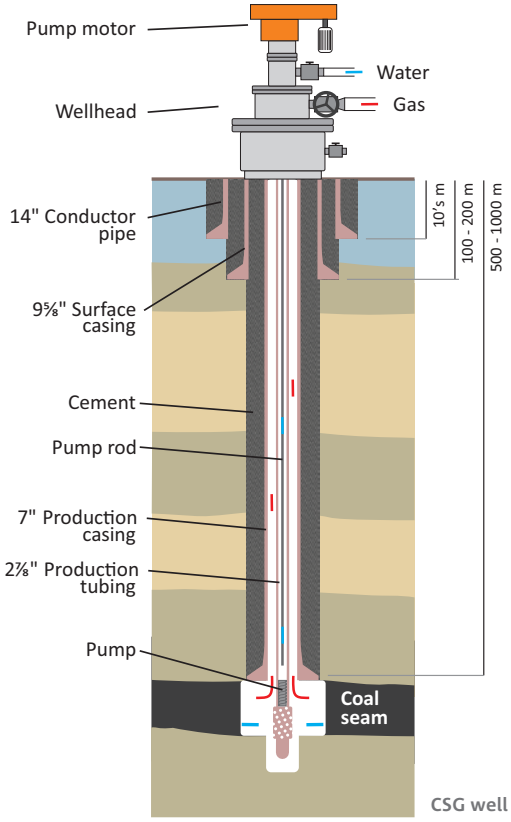
CSIRO | Australian Government Department of Industry, Science and Resources | NSW Government | Supported by Government of South Australia | Queensland Government | Northern Territory Government
origin | Australia Pacific LNG | QGC | Santos | tamboran Resources | Empire Energy

Steel, cement and CSG well infrastructure

CSG is extracted through wells drilled into coal seams. The wells are typically designed with multiple barriers to maintain well integrity, and to prevent the coal seam fluids from contaminating groundwater resources. They are mostly lined with steel casing, which is cemented in place to isolate aquifers overlying the target coal seams.

The environmental integrity of CSG wells is heavily reliant on the performance of casing and cementing materials used in completion and decommissioning.

Oil and gas operators have undertaken significant research and development to optimise cement slurry composition and cementing techniques to lower the risk of fluid escaping from the well. The use of steel, and type of steel used in the casing, are other key factors in the integrity of a well.



CSG well – not to scale.

Making information more accessible

WCRs prepared and submitted to the Queensland Government by the operating company provide detailed information on each CSG well drilled. These reports include information about the casing and cementing materials used in the construction of each well.

After a confidentiality period of three to five years, WCRs are available to read via the Open Data Portal of the Geological Survey of Queensland. However, WCRs incorporate considerable technical detail, and the information contained within them is not readily accessible or understood by community members who may have concerns about well integrity.

The objective of this CSIRO study was to synthesise the information from WCRs and present it in a more easy-to-read format that is accessible to the broader community. It should be noted that the study does not assess the suitability of the materials for well integrity.

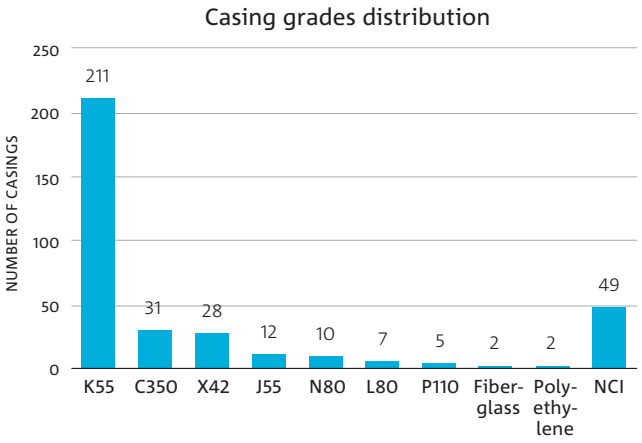
Cements and steels: project approach and outcomes

Researchers reviewed WCRs for 131 randomly selected wells that were drilled between 2002 and 2023.

For the 116 wells that were drilled prior to 2019, the WCRs were open-file and were downloaded from the Geological Survey of Queensland's Open Data Portal. For the 15 wells that were drilled after 2019, the WCRs were obtained from the operating companies.

WCRs document specific information related to drilling and construction of the well, as well as geological data and other observations related to CSG, and any aquifers intersected in the well.

Individual operating companies use different reporting formats and layouts, which can lead to inconsistencies in the level of detail about, for example, the casings and cements included in the reports, nomenclature for cement types, additives, and units of measurements. This sometimes made the task of extracting comparable data a challenge for the research team. However, the study also notes that the consistency of reports has improved over time, especially since 2011 when a code of practice with prescriptive requirements for reporting was introduced in Queensland.

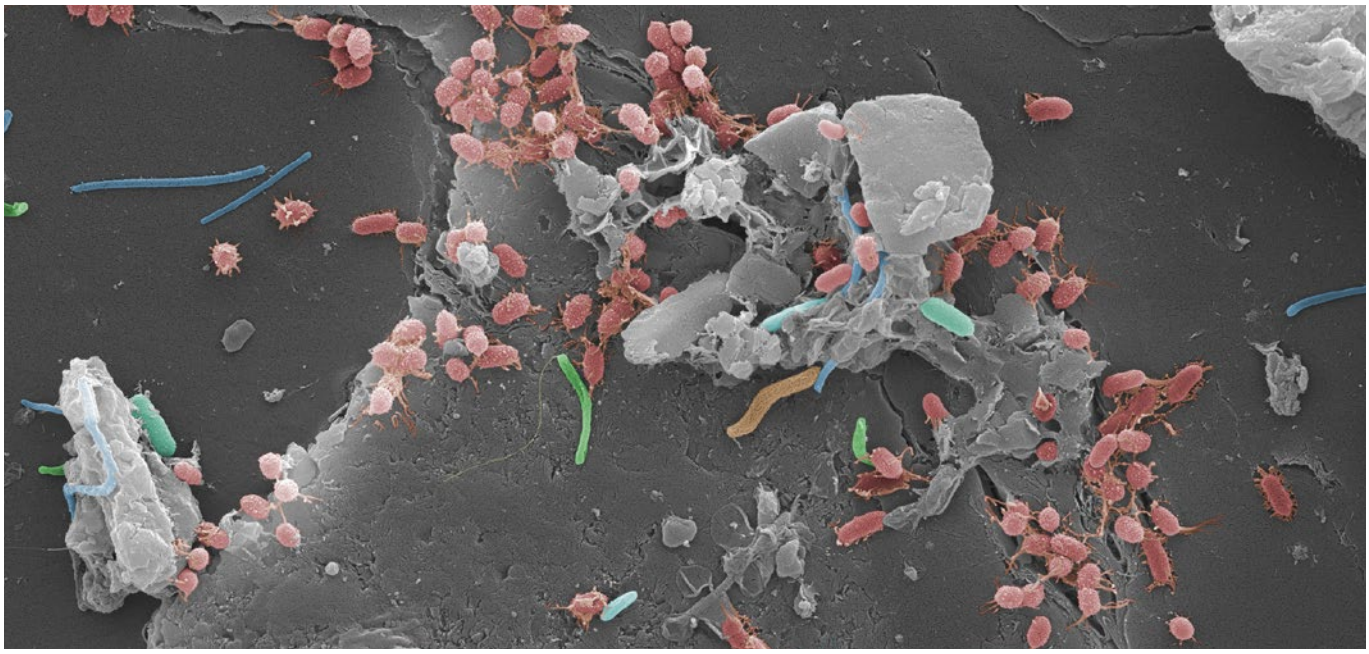


An example of the way this report presents clear and accessible information about well construction materials; this chart shows the variety of casing materials used, with the majority of wells using grade K55 steel. Other grades of steel or casing materials are selected to suit specific subsurface conditions. More detail about casing materials referred to here can be found on page 14 of the final report Cement and steel used in coal seam gas (CSG) well construction in Queensland.

The final report of this project provides clear and accessible written descriptions of the materials used to case and cement CSG wells in the Surat and Bowen basins. These have been written in such a way as to be accessible to any interested members of the community, rather than solely to expert audiences.

For example, steel grade K55 accounts for about 60% of the total casings reported in the WCRs reviewed. K55 is routinely used by the CSG industry as it has the necessary technical strength corresponding to depths, temperatures and pressures encountered in Queensland.

Additionally, the report provides observations to further improve the accessibility of WCRs – in particular the use of well schematics (simple diagrams showing the position of different types of casing and cement used in the construction of a well).



False-colour scanning electron micrograph of subsurface microbial communities.

Potential microbial interactions with steels and cements

Microbes are tiny organisms too small to be seen by the naked eye. They include things like bacteria, fungi, and some types of algae.

Microbes are widespread in subsurface environments around the world and occur at depths hundreds to thousands of metres below ground, only limited where temperatures exceed about 120°C. Many inhabit fracture or pore networks within rocks that are filled with water.

Our understanding of subsurface microbiology and ecology is poor and contains many significant knowledge gaps. The most well studied subsurface microbial communities are related to hydrocarbon reservoirs, but these environments are often quite different to other subsurface environments.

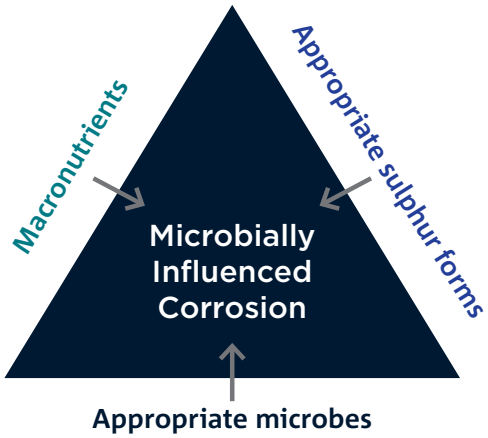
Microbially influenced corrosion

We do know that microbes that are capable of producing acidic products or directly interacting with various metals occur in the subsurface and may influence corrosion of pipes or other infrastructure.

Microbial acid production can take many forms, including production of sulphides, organic acids, protons or inorganic acids. Direct interactions can also occur i.e. some microbes can remove electrons directly from metals.

One of the main modes of microbial life in the subsurface is the formation of biofilms that adhere to surfaces including rocks and well infrastructure. These biofilms create microenvironments that promote microbial activity that can positively or negatively impact corrosion and performance of materials used in CSG well infrastructure.

However, all of these processes are highly dependent on geochemical conditions. For instance, microbial production of sulphide cannot occur in the absence of organic sulphur compounds, like sulphate, sulphite, thiosulphate or elemental sulphur. Furthermore, microbial activity requires the presence of essential macronutrients such as nitrogen, phosphorus and accessible organic carbon.



In the same way the fire cannot occur without heat, fuel, and an oxidising agent, microbially influenced corrosion (MIC) cannot occur unless all three factors – macronutrients, microbes capable of reducing organic sulphur compounds, and suitable sulphur sources – are present in the subsurface. The subsurface waters of the Surat and Bowen basins are extremely deficient in phosphorous, and mostly deficient in oxidised forms of sulphur. Both deficiencies are likely to be a limiting factor for microbial production of sulphides.

Assessing the current state of knowledge

In response to community concerns about well integrity in CSG wells, researchers undertook a desktop study to gather data on the type of microbes that occur in subsurface environments of south east Queensland and explore the capability of those microbes to interact with metal casings or cements used in CSG well construction.

- This study revealed significant knowledge gaps: there is very limited available data on the microbiology of aquifers, especially non-CSG aquifers.
- no information is available for domestic or agricultural aquifers, and
- no data was found on microbes that create biofilms which adhere to surfaces (pipes or other infrastructure).

A CSG well head in the Surat Basin, Queensland.

Microbial interactions: project outcomes

All the available data about subsurface microbial communities in the region is associated with water from coal resources in the Surat or Bowen basins.

Analysis of this data indicated that approximately one fifth of the identified species of microbes likely have the potential to produce sulphide when in the presence of suitable sulphur sources.

However, the waters of the Surat and Bowen basins are extremely deficient in phosphorous, and mostly deficient in oxidised forms of sulphur. Both deficiencies are likely to be a limiting factor for microbial production of sulphides within these coal formations.

As a result of the information gaps identified in this initial report, further work has now begun to improve our understanding of the potential for microbially influenced corrosion in onshore gas wells.

In a new research project, CSIRO scientists will collect and analyse water and biofilm samples from aquifers and infrastructure in south central Queensland. DNA sequencing analyses will be used to determine and compare microbial community profiles, and analyses on a suite of water chemistry values that underpin specific microbial activities will also be carried out.

The results of this study will provide valuable insights into the potential for microbially influenced corrosion of gas wells.

More information

Read more about this project

Find out about new microbial research underway in the Surat Basin

Learn about other GISERA research in Queensland

Explore GISERA's research into ground and surface waters across Australia

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