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Methane seeps in the Condamine River

This fact sheet presents the current state of scientific knowledge on methane seeps in the Condamine River including natural and human causes, and the human and environmental health and safety impacts of methane escaping from underground. This fact sheet has been developed by CSIRO researchers with expertise in the hydrogeology, geology, ecology and biogeochemistry and from multiple sources to summarise what we currently know about these methane seeps.

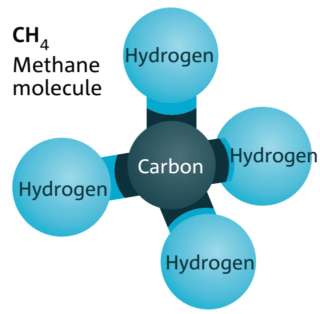
Key points

- Depressurisation of the Walloon Coal Measures during CSG production could generate horizontal migration of free methane gas. However, this flux of methane is likely to be small because of the shallow dip of the coal beds and the distance to gas production fields.
- Hydraulic fracturing is unlikely to be the cause of bubbling in the Condamine River because to date there has been no hydraulic fracturing by the CSG industry in these production fields.
- Variation in bubbling of the Condamine River may be caused by:
  - an increase in river water flow; moving sand and sediments that previously sat over the seeps and limited their seepage.
  - groundwater receding from the Condamine River alluvium since the 2011 floods has reduced pressure over the Walloon Coal Measures near Chinchilla, allowing trapped gas to expand and rise to the surface.
  - CSG industry activity in production fields 5 to 6 km away has reduced pressure in the coal seams leading to possible up-dip flow of gas into the network of fractures and thereby into the Condamine River.
- CSIRO research has found no evidence that these seeps have any adverse environmental impact on the plant or animal life of the river and its surroundings. To date, there is no public health or safety risk caused by the methane concentrations measured in the area of these or any other seeps in the Surat Basin that CSIRO has measured.

Capturing methane

Methane is a colourless, odourless, non-toxic gas. It is the main component of coal-seam gas (CSG), a gas taken from underground coal seams. The gas is lighter than air, so rises into the air when released. Methane originates naturally from biological sources (lakes, rivers, wetlands), agricultural sources (cultivation, ruminants), and geological sources (coal seams). Methane may also be released by humans when digging for coal from mines, producing Liquefied Natural Gas (LNG) from CSG and from city waste (land fill).

Methane is a potent greenhouse gas with a warming potential about 28 times that of CO_2 when considered over a 100 year lifetime in the atmosphere[1].



Sedimentary basins around the world that contain coal or organic matter naturally leak methane to the atmosphere. About a third of the 200 million tonnes of methane released to the atmosphere annually comes from these geological sources, which are derived from ancient organic matter deposited over millions of years and turned to coal under high temperature and pressure conditions underground. The fossil fuel industry including natural gas, coal and oil contribute between 15 and 22% of total global methane emissions[2].

Where leaking methane can be captured, it can be used as fuel to generate electricity. On combustion, methane produces carbon dioxide and water vapour, which trap heat in the atmosphere less than the original methane.

1 Kirschke et al (2013), Three decades of global methane sources and sinks, Nature Geoscience, doi:10.1038/ngeo1955
2 Schwietzke et al (2016), Upward revision of global fossil fuel methane emission based on isotope database, Nature 538, pp 88- 91 doi: 10.1038

Geology of the Condamine River region

The Surat Basin is situated in southern-central Queensland and is part of Australia's Great Artesian Basin. The Surat Basin contains the Walloon Coal Measures with large quantities of methane gas that are being extracted for LNG production. The Condamine River, near Chinchilla in southeast Queensland, is situated on the eastern edge of the Surat Basin.

The Surat Basin formed tens to hundreds of millions of years ago[3]. It consists of multiple aquifers (typically consisting of sandstones) and aquitards (typically dominated by claystones, siltstones and mudstones)[4]. The Walloon Coal Measures rise at an angle of about 1 degree to the surface from the west and meet the alluvial sediments deposited by the Condamine River (the 'Condamine River alluvium'). The layers of porous and non-porous rock above the Walloon Coal Measures intersect the surface and can be seen as outcropping rock formations along the river channel. The Condamine River has eroded the landscape over aeons, and the Surat Basin formations are intersected with numerous faults that have dissected and fractured these underground formations[5].

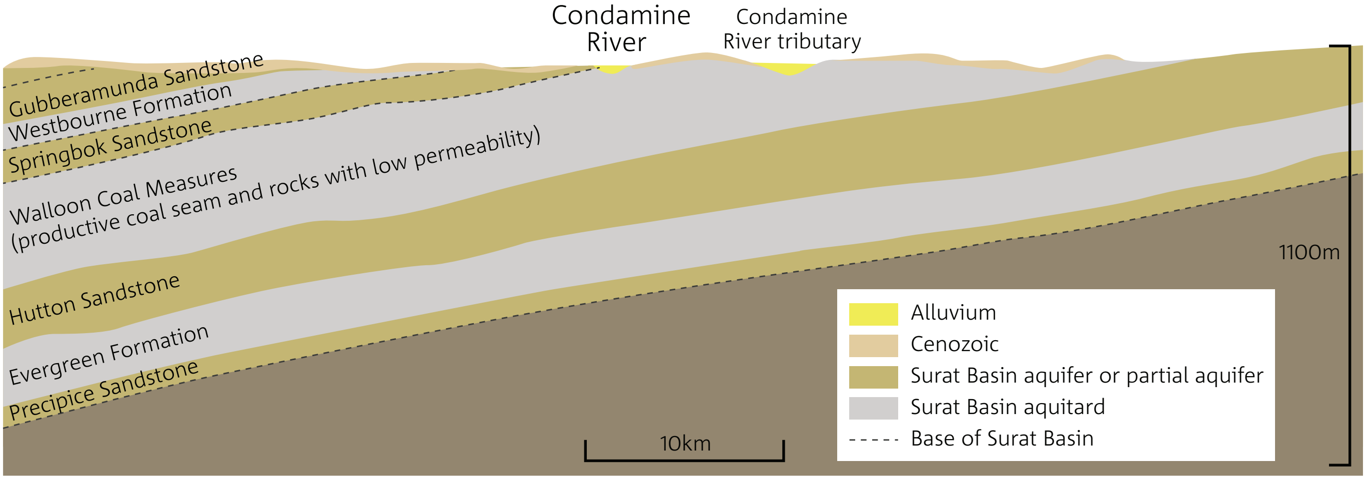
Geology of Walloon Coal Measures

Researchers have used seismic surveys, drill core data and other direct measurement techniques to create an image of the subsurface geometry and structure of the Walloon Coal Measures and other aquifers and aquitards beneath this region of the Condamine River.

This work has identified complex folding, faulting and deeply fractured rock layers beneath the surface[6]. These fractures can form natural links between coal seams and the surface via fissures and cracks that formed millions of years ago.

The Walloon Coal Measures in the vicinity of the Condamine River, near Chinchilla, Queensland, is a highly permeable underground environment which allows methane to flow easily[7]. In this part of the Condamine, the alluvium is very narrow and thin, and the Walloon Coal Measures are much shallower and closer to the base of the river than elsewhere within the catchment. The combination of fractured formations and permeability beneath the Condamine River allows migration of methane to the surface. The fractured geology also show structures underground at shallow depths where gas may accumulate in traps. These traps can collect methane under pressure (e.g. hydrostatic pressure from the alluvium above). As this pressure is eased the methane in these traps can expand and find its way to the surface. This could explain some of the variation in methane fluxes we see at some places in the Condamine River.

In the vicinity of the Condamine River where bubbling occurs, it is possible that depressurisation of the Walloon Coal Measures during CSG production could generate some horizontal migration of free methane gas. However, with the shallow strike of these formations and the 6 to 10 km distance to gas production fields, this flux of methane is likely to be small.



Conceptual geological cross section of the Surat Basin and Condamine River alluvium near Chinchilla

3 Jell, P.A. (2013), Geology of Queensland, Queensland Geological Survey, pp 928.

4 State of Queensland (2016) Underground Water Impact Report for the Surat Cumulative Management Area, The Office of Groundwater Impact Assessment, Department of Natural Resources and Mines.

5 Esterle, JS, Hamilton, SK, Ward, V, Tyson S, Sliwa, R, (2013), Scales of Geological Heterogeneity within the Walloon Subgroup and its Coal Measures. February 2013. Final report of Activity 1.3 of the Healthy Head Waters Coal Seam Gas Water Feasibility Study. Department of Natural Resources and Mines.

6 Hamilton S.K., Esterle, J.S. & Sliwa, R. (2014) Stratigraphic and depositional framework of the Walloon Subgroup, eastern Surat Basin, Queensland, Australian Journal of Earth Sciences, 61:8, 1061-1080, DOI: 10.1080/08120099.2014.960000

7 S.K. Hamilton, J.S. Esterle, S.D. Golding (2012) Geological interpretation of gas content trends, Walloon Subgroup, eastern Surat Basin, Queensland, Australia, International Journal of Coal Geology 101, 21–35

Both CSIRO and the Gas Industry Social and Environmental Research Alliance (GISERA) are undertaking research to locate and measure these natural methane seeps, including the gas appearing as bubbling in the Condamine River. While the bubbling in the Condamine River is spectacular, it is only one location of many in this region where methane is being released at the surface. The other locations are cracks and fissures that are not visible and CSIRO researchers are using sensors to locate and measure the flow of methane at these locations[8,9]. CSIRO has also undertaken research on the potential impacts of the bubbling methane on the biogeochemistry and aquatic ecology of the Condamine River.

Natural and human causes of methane leakage

In addition to the natural underground formations and fissures which can form migration pathways for the methane to the surface, human activities such as drilling water bores, extracting gas, and exploring for gas and oil can allow methane to escape. Some of these activities (e.g. drilling of water bores or coal exploration holes) have created further pathways for gas to rise to the surface[10].

The presence of methane in water bores has been documented well before development of the region's CSG industry as far back as 1919[11]. Since the early 1900s, there has been natural gas in water bores in nearby Roma, which have led to well blowouts and occasionally caught fire. Methane in water bores in the Surat and Bowen basins has also been documented in drilling reports from the 1960s and 1970s.

CSIRO's isotopic analysis of methane gas collected from the main bubbling site in the Condamine River[12] shows that the origin of the methane is from bacterial metabolism of coal. Other research suggests that methane in groundwater of the Condamine River alluvium may originate from the Walloon Coal Measures or adjacent geological formations in the Surat Basin[13]. However, conflicting data also exists[14] suggesting virtually no migration of methane from the Walloon Coal Measures into the alluvium, at least at sites south-east of where bubbling occurs in the Condamine River. What is apparent, is that the methane seeps do not originate from biological sources in the river sediments.

The bubbling of methane from the Condamine River area has increased three-fold since ongoing measurement began in early 2015[15], but has declined again recently. There may be many reasons for this variation in methane flow to the surface through the Condamine River. CSIRO researchers provide three possibilities for this variation in methane flow:

1. that an increase in flow in river water has scoured the river bed moving sand and sediments that previously sat over the seeps and limited their flow
2. that groundwater receding from the Condamine River alluvium since the 2011 floods has reduced pressure over the Walloon Coal Measures near Chinchilla, allowing trapped gas to expand and rise to the surface
3. that CSG industry activity in production fields 5 to 6 km away has reduced pressure in the coal seams leading to possible up-dip flow of gas into the network of fractures and thereby into the Condamine River[16].

Scientists measuring methane gas using rising chambers from Condamine River (Source: Brad Sherman)

8 Day, S., Dell'Amico, M., Etheridge, D., Ong, C., Rodger, A., Sherman, B., Barrett, D.J. (2013) Characterisation of regional fluxes of methane in the Surat Basin, Queensland – Phase 1: A Review and Analysis of Literature on Methane Detection and Flux Determination. CSIRO, Australia

9 Day, S., Ong, C., Rodger, A., Etheridge, D., Hibberd, M., van Gorsel, E., Spencer, D., Krummel, P., Fry, R., Mark Dell'Amico, M., Sestak, S., Williams, D., Loh, Z., Barrett, D. (2015) Characterisation of regional fluxes of methane in the Surat Basin, Queensland: Phase 2: A pilot study of methodology to detect and quantify methane sources. CSIRO, Australia.

10 Walker, G.R., Mallants, D., Methodologies for investigating gas in water bores and links to coal seam gas development (2014). CSIRO. Australia

11 Gray, A.R.G. (1967) Natural Gas Occurrence in the Brigalow Area, March 1967. Queensland Government Mining Journal. 68, 394 - 396

12 Sherman B.S. and Ford, P.W. (2014) Condamine River Coal Seam Gas Emissions: Final Report. CSIRO, Water for a Healthy Country Flagship, Australia

13 Iverach, C.P., Dioni I. Cendón, Stuart I. Hankin, David Lowry, Rebecca E. Fisher, James L. France, Euan G. Nisbet, Andy Baker & Bryce F. J. Kelly (2015) Assessing Connectivity Between an Overlying Aquifer and a Coal Seam Gas Resource Using Methane Isotopes, Dissolved Organic Carbon and Tritium. Scientific Reports. DOI: 10.1038/srep15996

14 Owen, D.D.R., Shouakar-Stash, O., Morgenstern, U. & Aravena, R. (2016) Thermodynamic and hydrochemical controls on CH_4 in a coal seam gas and overlying alluvial aquifer: new insights into CH_4 origins. DOI: 10.1038/srep32407

15 CSIRO flux measurements https://www.aplng.com.au/topics/coal-seam-gas/condamine-river-seeps.html

16 Norwest report, Executive Summary, p.17-18

It is well known that water and gas extraction activities reduces pressure in underground coal seams and aquifers, thereby releasing methane. Experiments undertaken by the CSG industry that involve shutting down gas wells in these production fields have shown pressure changes due to gas industry activity in the vicinity of the Condamine River, but only a few per cent of the current methane flows in the Condamine River can be explained by these activities. Furthermore, the very low angle of dip (about 1 degree) of the Walloon Coal Measures would preclude large-scale transport of gaseous methane underground. Hydraulic fracturing is not the cause of this increase in bubbling in the Condamine River because there has been no hydraulic fracturing by the CSG industry in these production fields.

Impact on health and environment

CSIRO has found no evidence that the seepage of methane from the Condamine River area has any adverse environmental impact on the plant or animal life of the river and its surroundings[17]. While higher concentrations of methane are present in the river up to 8 km downstream of the river seeps, temperature, electrical conductivity and turbidity are not affected. Nitrogen, ammonium, phosphorus and organic carbon concentrations in the vicinity of the seeps are not different to other parts of the river and are typical of Australian inland rivers. Phytoplankton, zooplankton and macroinvertebrates are unaffected by the presence of the seeps; although, bacterial and fungal populations were higher which is to be expected given that methane is the food source of methanogenic bacteria.

There is no public health or safety risk caused by the methane concentrations measured in the area of these or any other seeps in the Surat Basin CSIRO has measured[18,19]. Analysis shows the gas is very pure, composed almost entirely of non-toxic methane, with traces of carbon dioxide and nitrogen. There is no evidence of volatile organic compounds or dangerous hydrocarbons in the seeping gas. Metals, such as silver, cadmium, chromium, mercury, lead, aluminium, iron and manganese, were either at the threshold of detection or within the range expected for inland Australian rivers.

Methane is only dangerous if concentrated in enclosed spaces to levels where it is explosive, and there are safety risks if it is deliberately lit. In the Condamine River the seeps can only be lit when the river is not flowing and where flames are supported by additional combustible material.

Ongoing monitoring

CSIRO has been undertaking research on gas seeps in the region for more than three years. Scientists have used remote sensing, isotopic analyses, field surveys, computer modelling and other techniques to map methane sources and understand the processes that lead to methane emissions.

CSIRO will continue to independently measure and monitor methane from geological sources and from other origins including old coal exploration wells from the 1960s, fugitive emissions from the gas industry, and methane emissions from cattle and agriculture. In addition, the Queensland Government is monitoring water quality and gas levels to identify any environmental harm or safety concerns, and reviewing relevant research to ensure a high level of scientific rigour and independent research is maintained.

17 Rees GN, Nielsen DL, Cook RA, Petrie R, Watson GO, Davey C, Oliver R, Lorenz Z (2016) Condamine River: Ecological study. Report to Origin Energy.

18 State of Queensland, Department of Natural Resources and Mines (2012) Summary Technical Report - Part 1 Condamine River Gas Seep Investigation.

19 State of Queensland, Queensland Health (2013) Coal seam gas in the Tara region: Summary risk assessment of health complaints and environmental monitoring data.

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