COVERDALE 1.45 23/9
Protect the West Alliance

THE OBSERVER 21/9/15

Biggest earthquake in 50 years shakes south-west Victoria

LIAM O'CALLAGHAN

THE largest earthquake felt in the region for more than 50 years shook Portland at midday on Thursday with reports of tremors as far reaching as Melbourne.

The 4.8 magnitude earthquake occurred at 12.44pm with the epicentre located 181km south-east off the coast of Portland, within kilometres of the last earthquake in the area on June 30.

While Geosciences Australia (GA) received reports of shaking for up to 10 seconds in Portland, Warrnambool and as far as some Melbourne suburbs, but it was still wasn't considered a significant earthquake.

"It is still only a small to medium sized earthquake and we expect a few of those fairly regularly in this region, in 2005 there was a 4.5 magnitude earthquake in Bass Strait," said GA Duty Seismologist Dr Andrea Thom.

Still, the next largest earthquake in the region after Thursday's was a 5.3 magnitude earthquake that occurred only a few kilometres off Cape Otway.

In terms of the cause, it is comes down to pressure created from the movement of the Indo-Australian plate, the tectonic plate that Australia resides on.

"It comes from the plates being squeezed together, and our plate being squeezed by the Pacific and Eurasian plate. The bigger the movement the more pressure is created and the bigger the earthquake," Dr Thom said.

Earlier on Thursday morning on the other side of the Pacific, Chile experienced a 8.3 magnitude earthquake and although there is a chance they are connected it is difficult to say, according to Dr Thom.

She said while plate movement across the world can further destabilise other plates and the earthquake in Chile may have done so, 1:45 23/Sept COVERDALE Protect the West Alliance

Timeline 1949-2000

1949: An early, small-scale form of vertical fracturing is used to improve output from oil wells in Oklahoma and Texas. Oil and chemicals are pumped into existing wells, without horizontal drilling.

1953: Water is first used to stimulate oil wells. A typical operation uses 2,800 litres of fluid and 180 kilograms of sand.

1960s: The US government experiments with underground nuclear explosions to get hard-to-reach gas out of shale rock, without success.

1970s: The use of high-volume or 'massive' vertical fracturing becomes more common in US oil fields. Up to a million litres of fluid and half a million kilograms of sand are pumped down existing wells, improving output dramatically.

1980s: Horizontal oil drilling is pioneered along the Texan Gulf Coast.

1991: Horizontal fracking is carried out on shale for the first time.

1998: Mitchell Energy (now Devon Energy) develops a 'slickwater fracturing' technique that radically reduces the costs of horizontal hydraulic fracturing into shale.

Sources: Carl T Montgomery and Michael B Smith, 'Hydraulic fracturing: history of an enduring technology', *JPT*, December 2010; nin.tl/1hVNAil
CE Bell and others, 'Effective Diverting on Horizontal Wells in the Austin Chalk', SPE, 1993; nin.tl/19R83q0

2001-2012

2001: US Vice-President Dick Cheney (ex-CEO of oil services company Halliburton) leads an 'energy task force' that touts the benefits of fracking and downplays the risks.

2005: The US Congress votes to exempt fracking from the Clean Water Act and Safe Drinking Water Acts. Cheney's involvement causes the amendment to be dubbed the 'Halliburton loophole'.

2006: Fracking begins in British Columbia, Canada.

2006-08: US natural gas reserves expand by 35% as fracking spreads across the country. A single 'frack' now uses up to 19 million litres of water.

2007: Cluster drilling of multiple bores from a single pad begins.

2010: 60% of all new oil and gas wells worldwide now utilize fracking.

2012: The International Energy Agency calculates that fracking now produces around 14% of the global gas supply.

Alex Trembath, 'US Government Role in Shale Gas Fracking History', The Breakthrough, 2 March 2012; nin.tl/1hVO6xc
Andrew Nikiforuk, 'Shale Gas: Myth and Realities', *The Tyee*, 7 January 2013; nin.tl/19R8nVH

of trap types, including four-way dip, fault controlled and combinations of both. The major fault cuts along the Tartwaup Hinge Zone may form a barrier and trap for hydrocarbons migrating from the deeper basin. Intraformational rollover structures into these faults have a high prospectivity, with reservoir targets ranging from Sherbrook Group to Tertiary.

UPPER SHERBROOK GROUP AND TERTIARY

The structural regime for the potential Late Cretaceous targets is similar to that of the Waarre Sandstone. Flaxman Formation reservoirs are sealed by Belfast Mudstone or intra-Paaratte Formation shales, encountered in Breaksea Reef 1 (Figs 6.30, 6.31). Stratigraphic plays within the sand and shale succession of the Paaratte Formation are possible, but have only been tested by Argonaut 1. In this well, no shows were recorded in the Paaratte Formation, presumably due to lack of suitable intraformational seal at this locality, or perhaps it was sited too far downdip. The Tertiary Pember Mudstone provides a regional seal for upper Sherbrook Group and Pebble Point Formation targets. This scenario is likely to provide more trap integrity (in terms of breaching by syndepositional faulting). Vertical and lateral migration from adjacent intraformational sources is possible, although the volume of charge produced from these sources is likely to be low compared to that from the Eumeralla Formation, due to under-maturation of these shallow sediments.

Other potential Tertiary reservoir targets include the Dilwyn Formation overlain by Narrawaturk Marl. Structural entrapment for such targets is similar to that of the Late Cretaceous, in terms of down-to-basin extensional faults providing dip closure and compressional anticlines providing strike closure. However, the intensity of synthetic faulting is much reduced, the sediments rather draping the underlying Late Cretaceous units. At this level, fault leakage from lower sources and reservoirs is seen as the prime method for charging potential Tertiary reservoirs.

PRESERVATION RISKS

In addition to the usual risks of charge, trap timing, reservoir and seal capacity, which need to be defined to ascertain the likelihood of entrapment, it is very important in the Otway Basin to address preservation risk. This is especially so where Tertiary burial has failed to advance maturity of Early Cretaceous source rocks so that accumulation of hydrocarbons primarily relies on pre-Tertiary charge. The main preservation risks in the South Australian sector of the Otway Basin are fault-associated leakage and CO_2 displacement.

In situ degradation

Degradation caused by influx of meteoric water is not a significant risk for Cretaceous reservoirs, but this consideration is necessary for Tertiary targets. In Victoria, a significant oil column was discovered at Lindon 1 in the Tertiary but on test it failed to flow at economic rates due to its extreme viscosity. Mapping salinity from extensive water bore and petroleum tests together with log analysis should help define the risk of potential Tertiary oil accumulations being degraded in this way.

Fault leakage

The intensity of faulting in the Otway Basin provides a significant risk to trap integrity where such traps rely on fault closure. Tertiary to Recent compression has selectively reactivated earlier faults and may have had significant impact on their propensity for leakage (Jones et al., 2000; Boult et al., 2002). Early Cretaceous shales are more indurated / brittle than Late Cretaceous shales and more prone to rupture during fault reactivation.

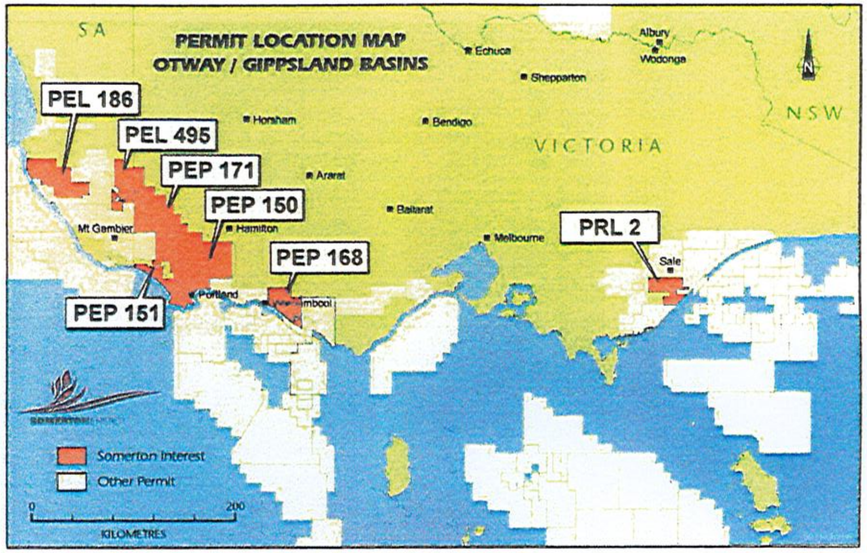
CD COCKSHELL - Geoscience Aust

COVERDALE
1:45 23 SEPT - Hamilton
Protect the West Alliance

SOMERTON ENERGY

Portfolio

- **Portfolio of high impact onshore projects in Otway/Gippsland**
  - » Western Otway shale gas & unconventional oil
  - » Eastern Otway gas (PEP 168)
  - » Gippsland tight gas (PRL 2)

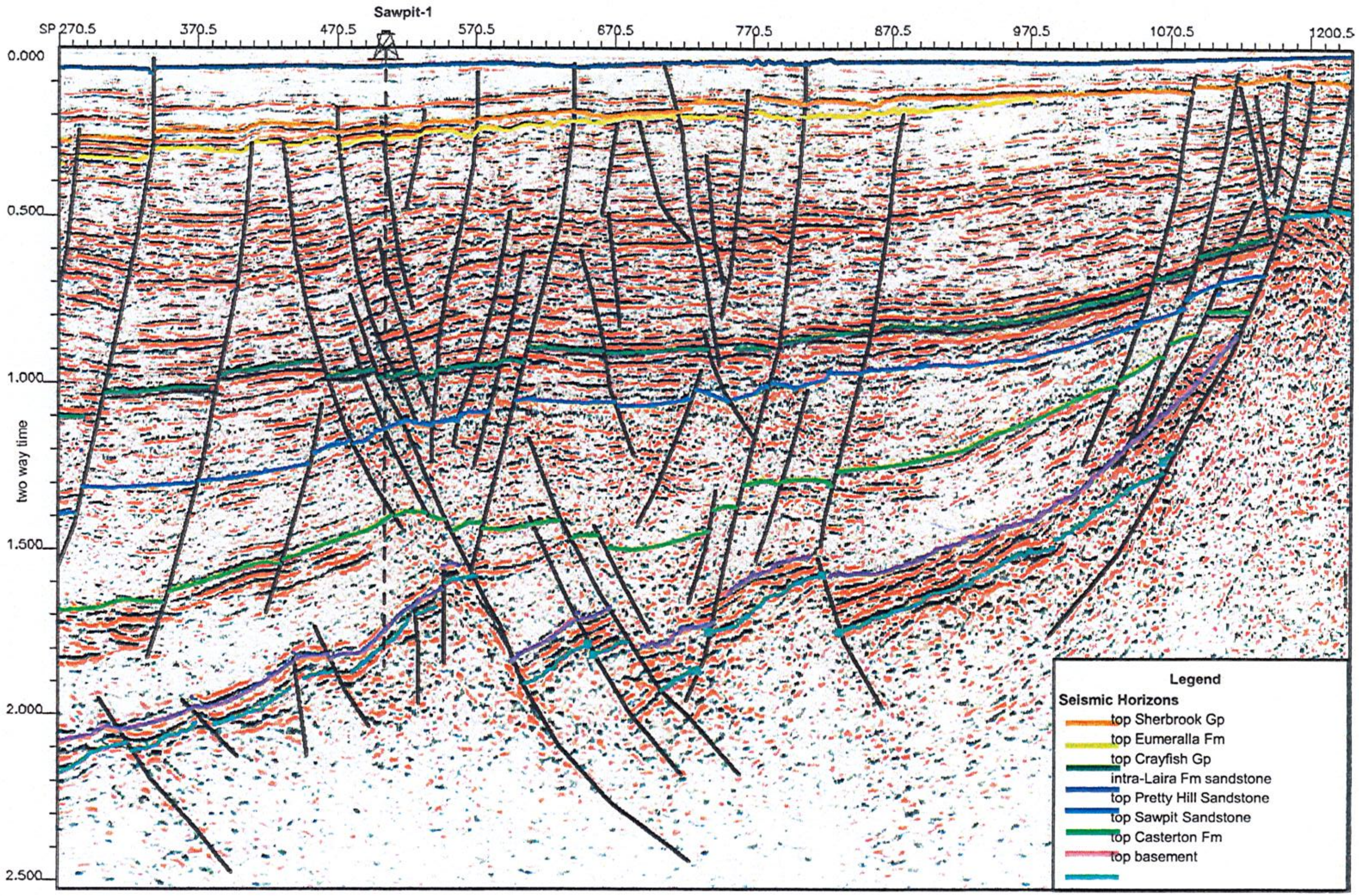


- **Otway Basin**
  - » 6 tenements
  - » 9,066 sq km (gross) / 2,768 sq km (net)
  - » Amongst largest Otway positions

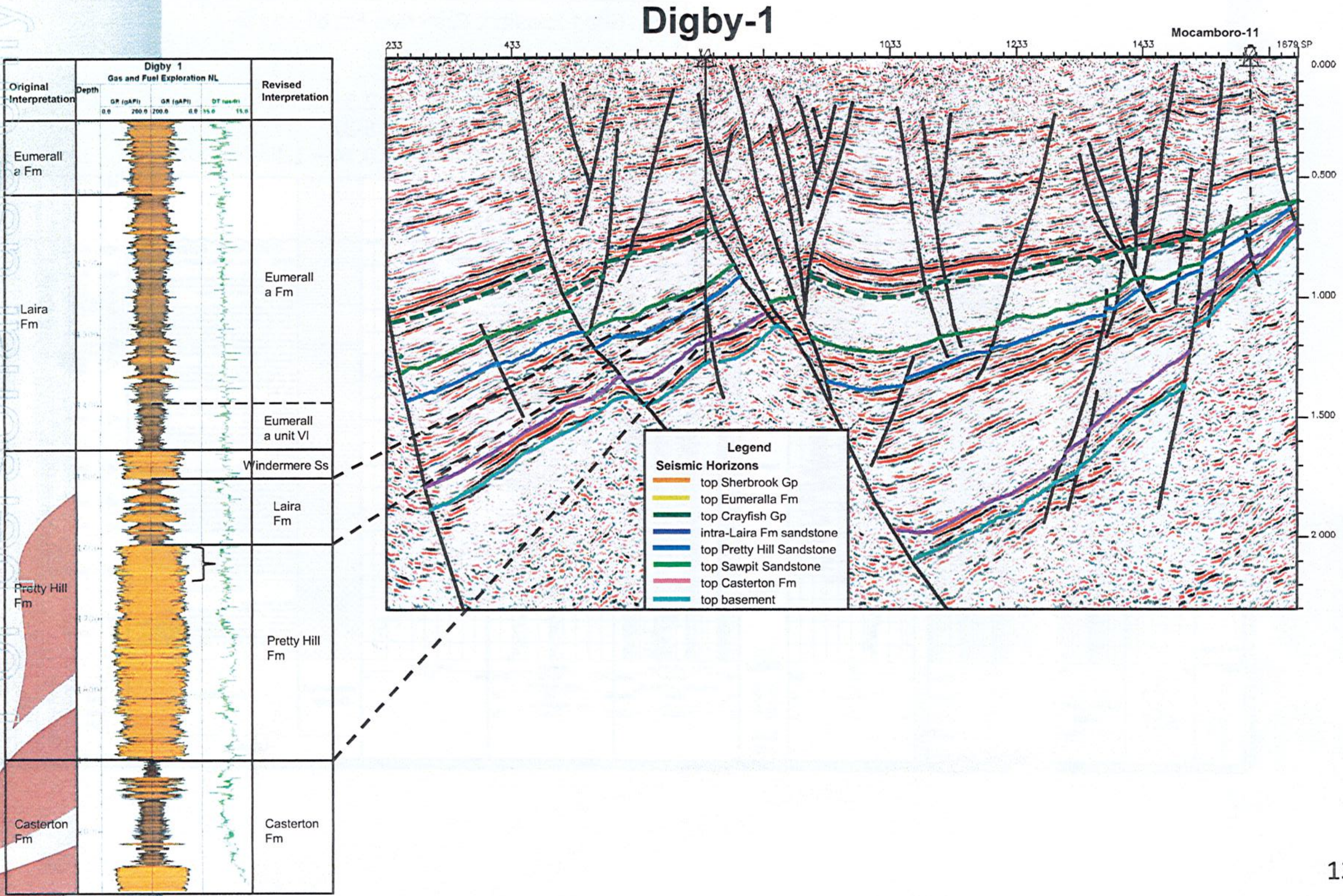
- **Gippsland Basin**
  - » Wombat Tight Gas project

Tenement	SNE Equity	SNE Net Potential
PEL 186	100%	10's of MMboe gas/oil
PEL 495	15%	5 MMboe oil/gas
PEP 150	20%	3 MMbbl oil
PEP 151	75%	3 MMbbl oil
PEP 168	50%	1 MMboe gas
PEP 171	25%	10's of MMboe gas/oil
Wombat	up to 16.7%	10's of MMboe gas

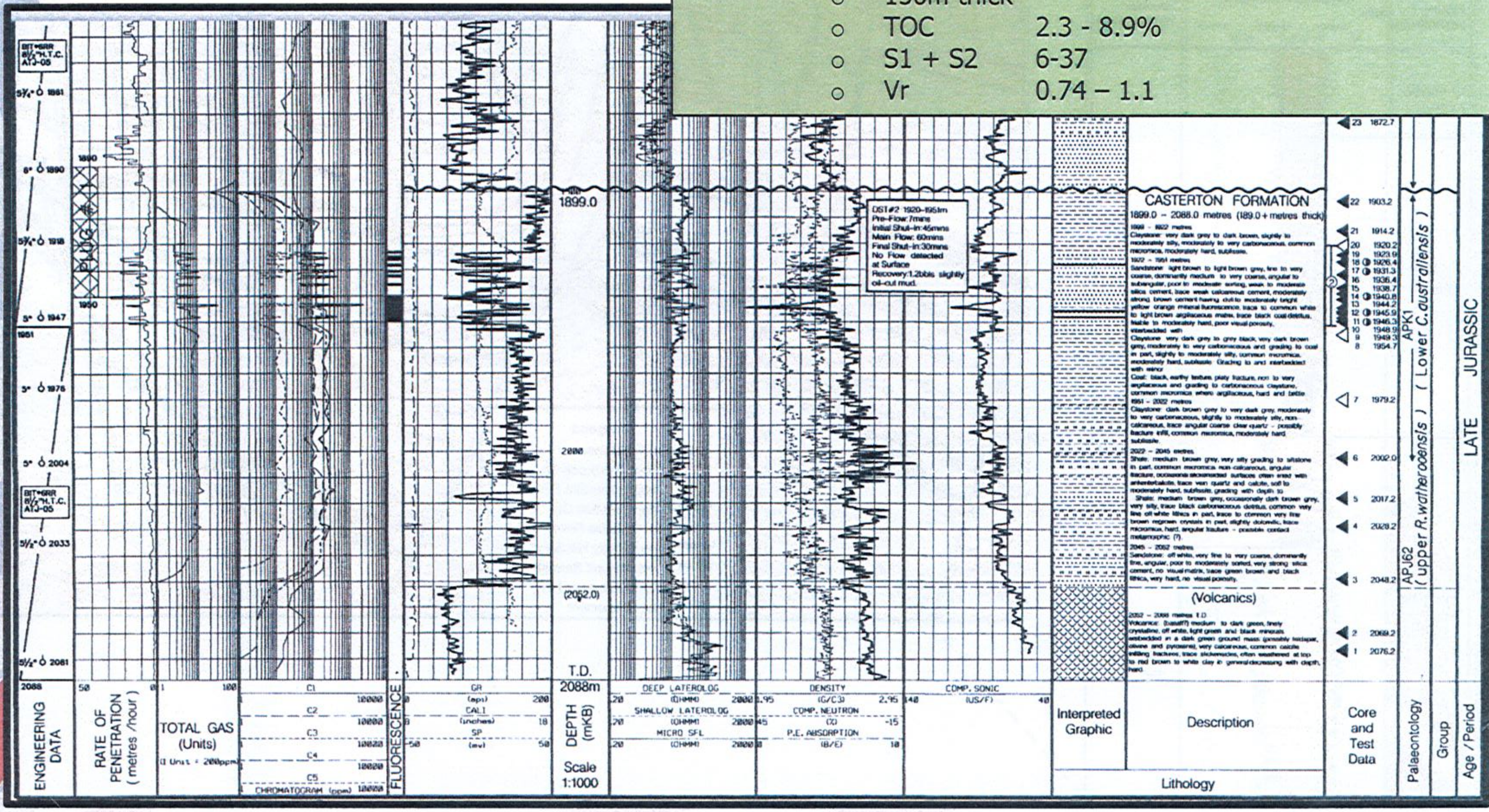
Penola Trough – PEL 495/PEP 171



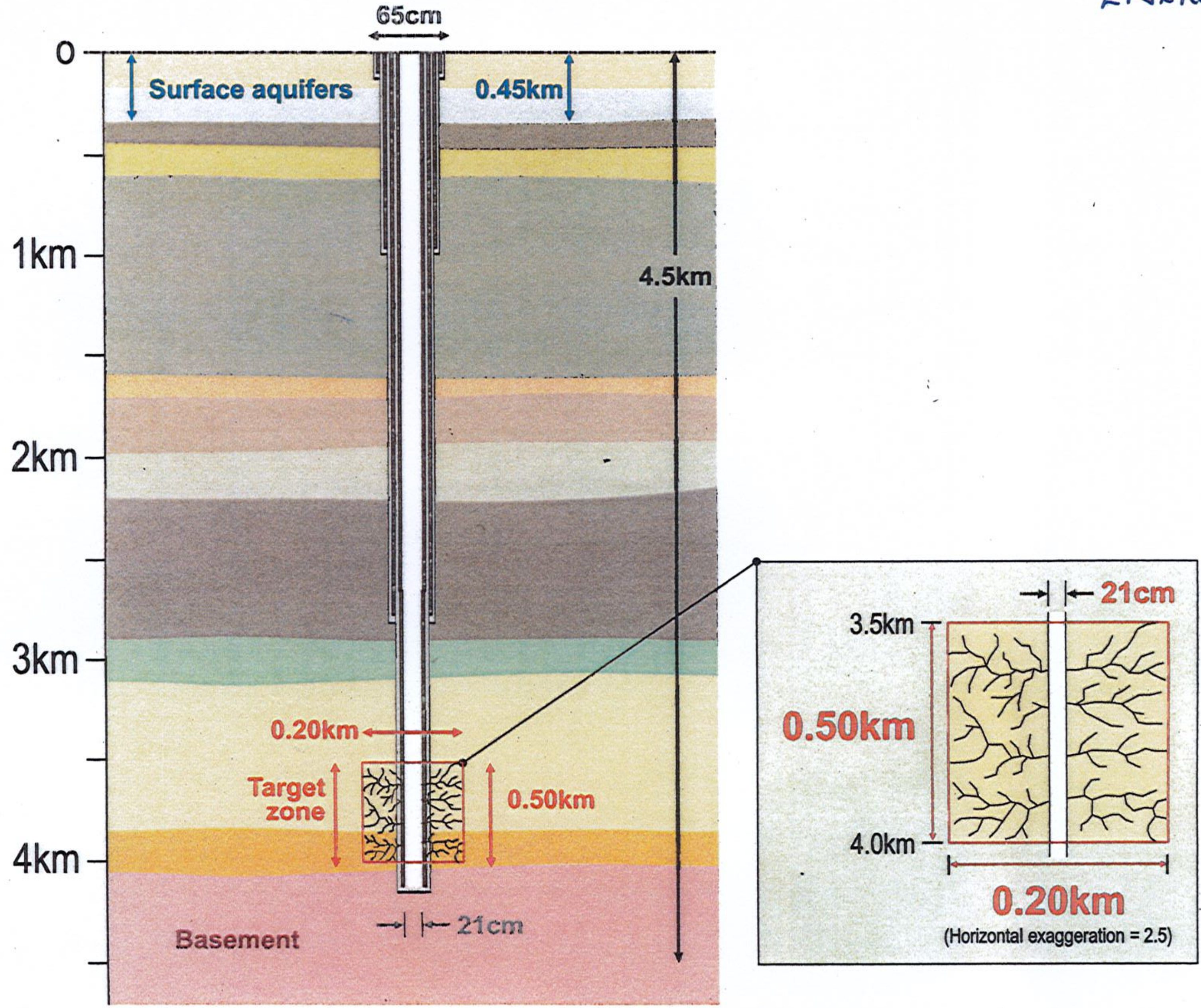
Ardonachie Trough (PEP 150/151)



- Good-Excellent Casterton Fm oil source
  - 150m thick
  - TOC 2.3 - 8.9%
  - S1 + S2 6-37
  - Vr 0.74 – 1.1



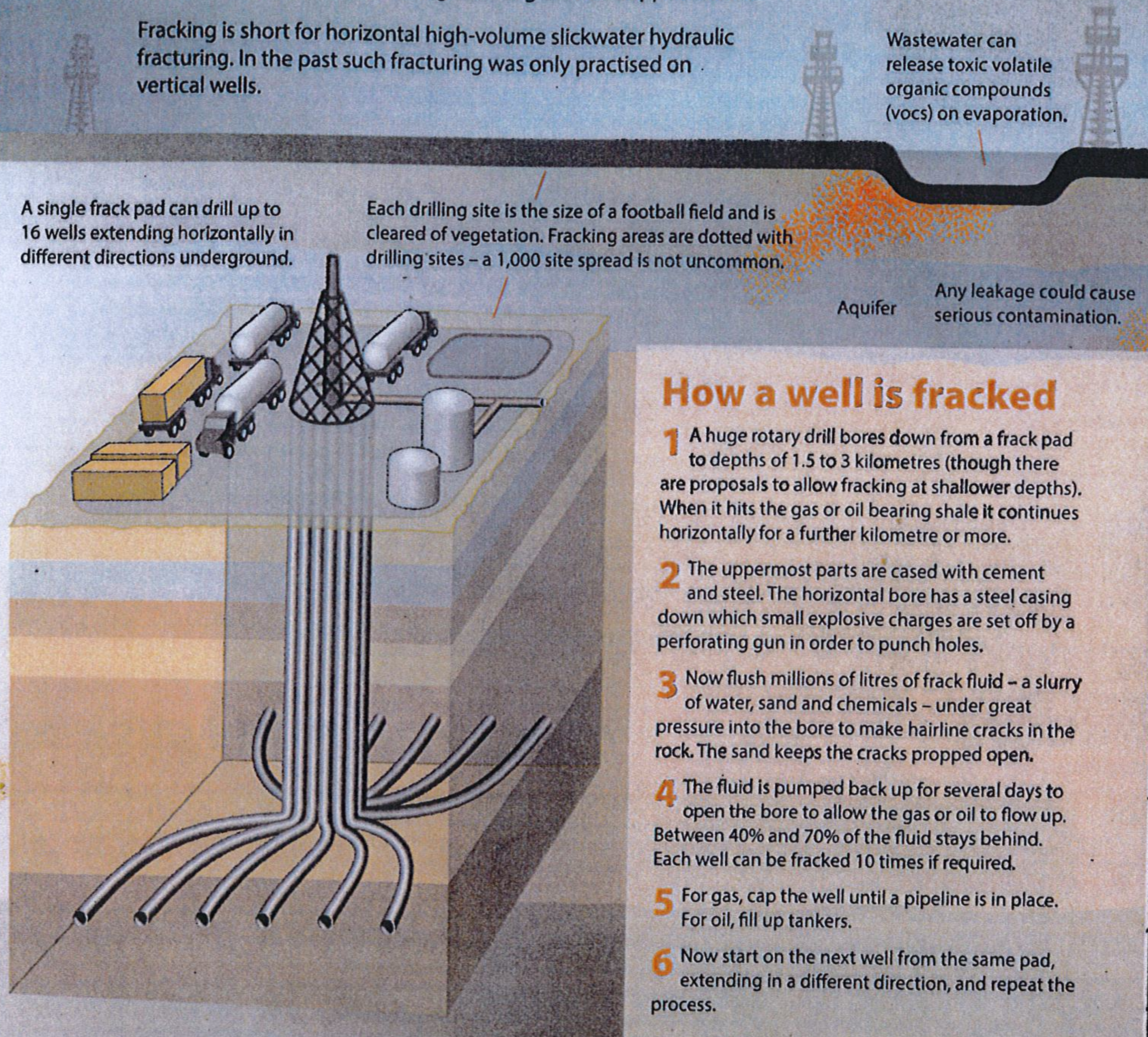
Fracture Stimulation Schematic (FROM BEACH ENERGY)



What The Frack...?

Fracking is a process of drilling sideways deep underground, then injecting fluid at high pressure to fracture shale (a kind of sedimentary rock) or coal formations releasing natural gas or oil trapped within.

Fracking is short for horizontal high-volume slickwater hydraulic fracturing. In the past such fracturing was only practised on vertical wells.



How a well is fracked

1 A huge rotary drill bores down from a frack pad to depths of 1.5 to 3 kilometres (though there are proposals to allow fracking at shallower depths). When it hits the gas or oil bearing shale it continues horizontally for a further kilometre or more.

2 The uppermost parts are cased with cement and steel. The horizontal bore has a steel casing down which small explosive charges are set off by a perforating gun in order to punch holes.

3 Now flush millions of litres of frack fluid – a slurry of water, sand and chemicals – under great pressure into the bore to make hairline cracks in the rock. The sand keeps the cracks propped open.

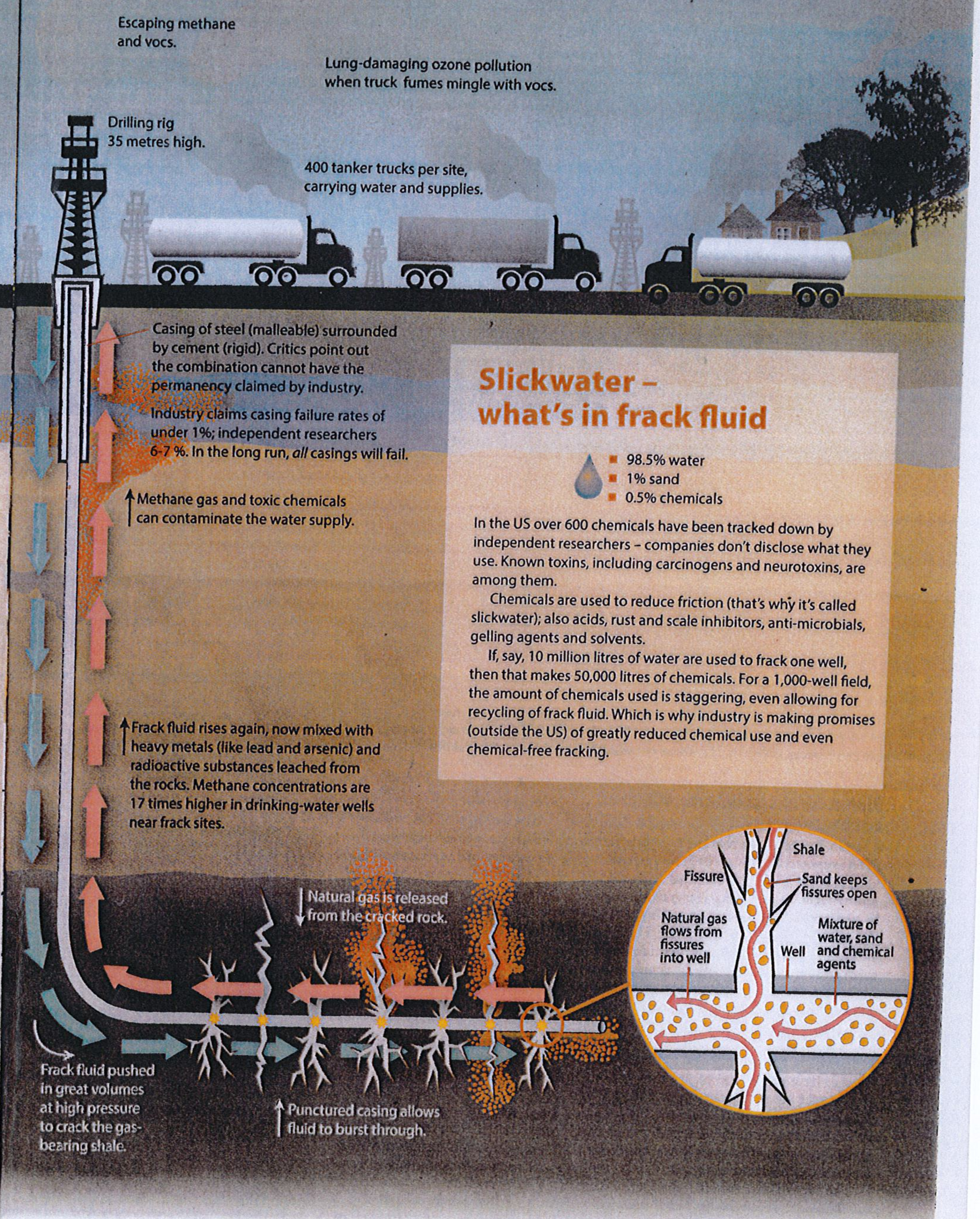
4 The fluid is pumped back up for several days to open the bore to allow the gas or oil to flow up. Between 40% and 70% of the fluid stays behind. Each well can be fracked 10 times if required.

5 For gas, cap the well until a pipeline is in place. For oil, fill up tankers.

6 Now start on the next well from the same pad, extending in a different direction, and repeat the process.

- Non-productive wells are closed off by inserting cement plugs.
- Disposal of recovered frack fluid is a headache. Best practice is to reuse it. But often it is off-loaded on ill-equipped municipal treatment plants or even surreptitiously dumped.
- Frack fluid remaining in wells is freshwater contaminated with chemicals and effectively removed from the water cycle – millions of litres per well.

Shale gas – natural gas trapped within shale formations.
Tight gas – retrieved from rocks of extremely low permeability, sandstone and limestone.
Coal seam gas (CSG) or coal bed methane (CBM) – natural gas extracted from coal beds.
Tight oil – oil from shale formations. Not usually called shale oil in order to avoid confusion with 'oil shale' (or kerogen, a substance requiring heating to be turned into fuel).



Slickwater – what's in frack fluid

- 98.5% water
- 1% sand
- 0.5% chemicals

In the US over 600 chemicals have been tracked down by independent researchers – companies don't disclose what they use. Known toxins, including carcinogens and neurotoxins, are among them.

Chemicals are used to reduce friction (that's why it's called slickwater); also acids, rust and scale inhibitors, anti-microbials, gelling agents and solvents.

If, say, 10 million litres of water are used to frack one well, then that makes 50,000 litres of chemicals. For a 1,000-well field, the amount of chemicals used is staggering, even allowing for recycling of frack fluid. Which is why industry is making promises (outside the US) of greatly reduced chemical use and even chemical-free fracking.