Geosteering of horizontal wells: current UK practice in unconventional exploration

by

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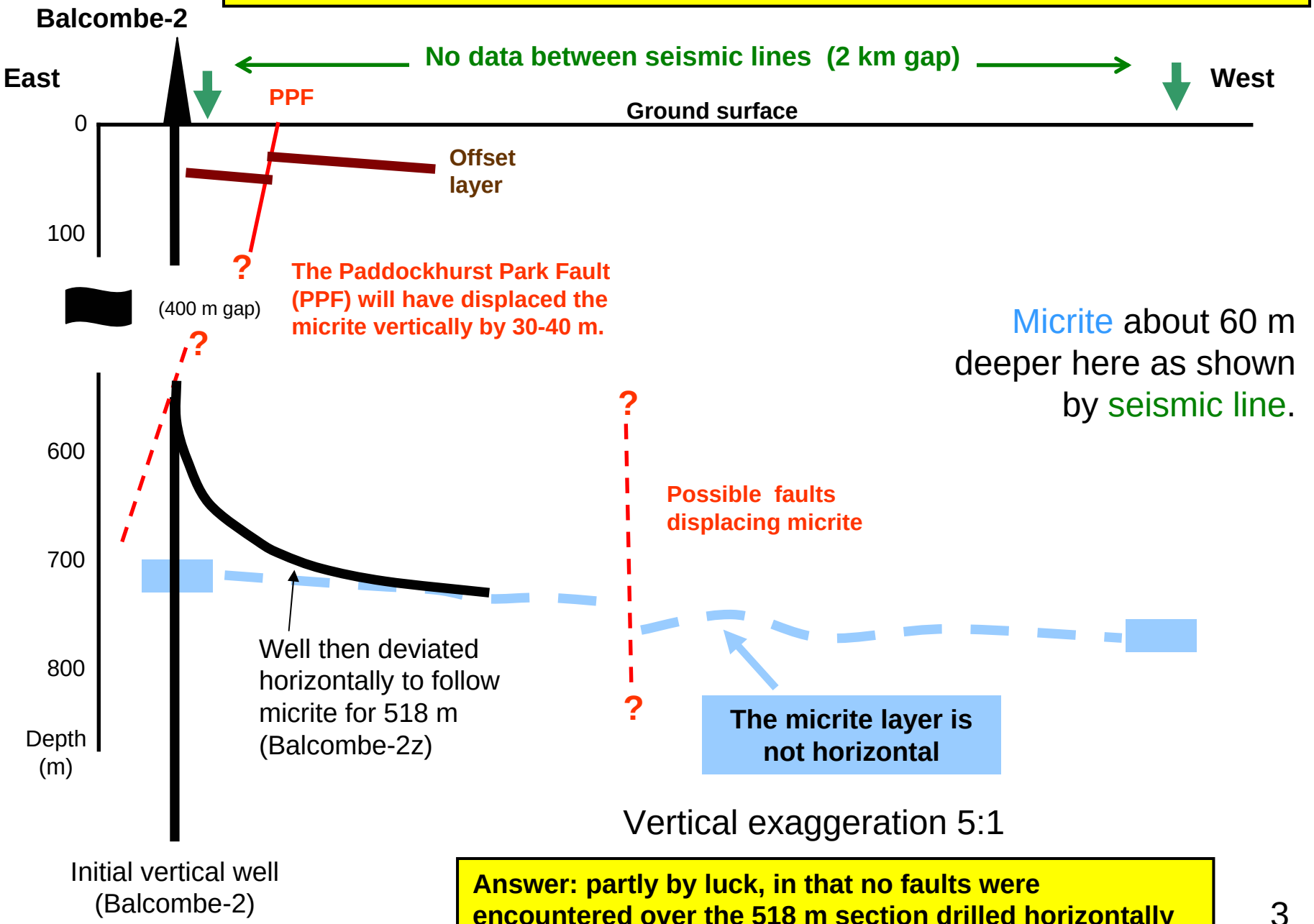
Comments on the horizontal drilling of Balcombe-2z in 2013

Cuadrilla refers in its press release to ‘geo-steering’ technology. No details have been released, but it would appear to have been the type of gamma-ray tracker that I learned more about during the Airth coal bed methane (CBM) inquiry of March 2014, held in Falkirk.

This geosteering device is relatively crude; it works by warning the driller in near-real time, while the drill bit is driving horizontally through a limestone (or coal) layer, if the bit is approaching the top or the base of the layer. It is not in any sense following a pre-prepared image or plan of the rock formations.

The warning sign is an increased gamma-ray count due to the proximity of the shales above or below the drilled layer. The bit can then be steered back towards the middle of the layer. The position of the drill bit can be tracked to high precision using gyro-compass orientation and accelerometers for dead-reckoning, or else by using surface sensors to listen to the grinding noise; this information can be used to calculate the location of the sound. Here is a description of the method as used by Dart Energy at Airth.

How did Cuadrilla keep the horizontal drilling within the micrite?



Answer: partly by luck, in that no faults were encountered over the 518 m section drilled horizontally

So Cuadrilla was steering ‘blind’, except that the drill-bit could sense the roof and floor of the limestone layer and keep to the middle of the layer.

What happens if a fault is encountered?

Andy Sloan, an independent drilling management engineer and company director, gave evidence to the public inquiry held at Falkirk in March 2014. He was appearing on behalf of Dart Energy, the appellant. He described in his Precognition the geosteering method used by Dart. This would be a system similar to that used by Cuadrilla at Balcombe.

Under cross-examination, Mr Sloan explained that, if a fault is encountered, so that the coal horizon being drilled is no longer present, the procedure is to continue drilling for a maximum of one twelve-hour shift, in the hope that the same coal (or a different one) will be picked up. If, after 12 hours, a coal layer has not been (re)encountered, the well is abandoned.

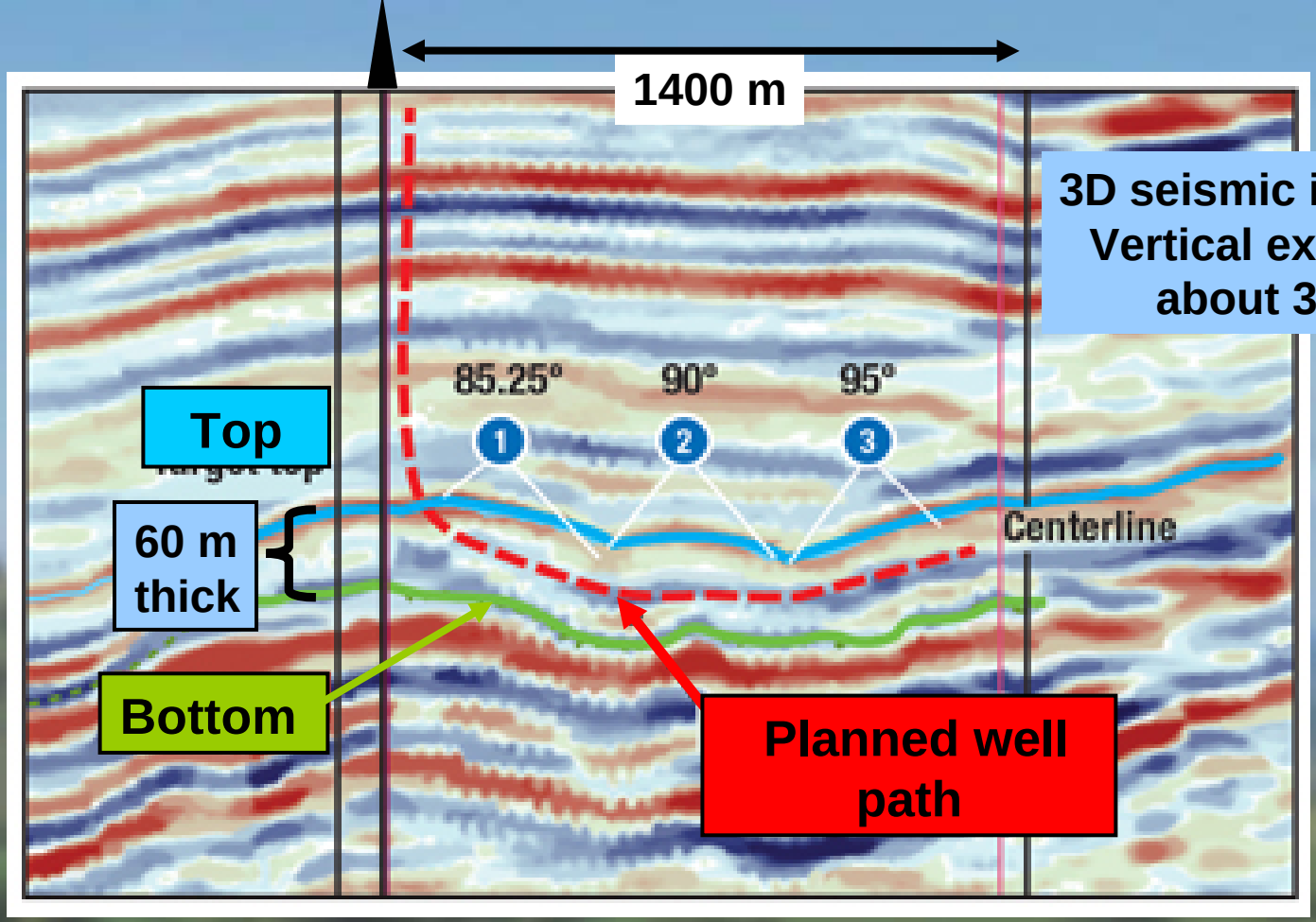
In conclusion, the geosteering method employed by Cuadrilla at Balcombe relied entirely on the assumption that there would be no faults in the target micrite (limestone layer). As we have already seen, The Paddockhurst Park Fault was almost certainly intersected by the vertical portion of the well.

We do not know why the horizontal well stopped at 518 m (1700 ft). For all we know, Cuadrilla may have encountered a fault. The well logs (the records of the drilling) need to be released for independent assessment.

True measurement while drilling (MWD)

"There is no point steering a wellbore if you don't know where to go."

More sophisticated methods than geosteering, which is clearly designed to work only in the simplest of geological structure, require a pre-existing image or model of the geology. Typically this would come from a 3D seismic survey. The progress of the drill-bit can then be tracked on the image and geosteered in real time. *Crain's Petrophysical Handbook* website gives a useful description. But note the caveat therein:*"There is no point steering a wellbore if you don't know where to go."*



This is an example from the Woodford Shale, USA, of guiding the horizontal drilling, the real-time position of which is overlain on a vertical slice of a 3D seismic image, the 'backdrop'. This is simple geology, unlike the UK, in which the dip (slope) of the target layer is within 5° of the horizontal, as measured by the three average figures shown in the centre of the image (90 ° = horizontal). Other examples can be found in the paper by Mottahedeh (2005).

Comments by Dr James Verdon

In his Frack-Land blog entry dated 3 September 2013 Dr James Verdon criticises my apparent lack of knowledge of a simple geosteering technique, in the context of my critique of Cuadrilla's drilling proposals at Balcombe dated August 2013. It is correct that I did not at that time know about the gamma-ray geosteering technique, which, now that I know and understand it, is rather crude. I did, however, understand that the more complete Measurement While Drilling (MWD) process requires, *inter alia*, a 3D picture of the geology. Dart Energy's practice at Airth, as admitted at the public planning inquiry, confirms my view (slide 4 above) that gamma-ray geosteering on its own will fail sooner or later in faulted geology.

However, my criticism of Cuadrilla in 2013 was and remains substantially correct, in that Cuadrilla, using only gamma-ray geosteering without a 'backdrop' image on which to plot the real-time data (e.g. slide 6 above), was effectively drilling blind. The technique could only retain the drill-bit within the micrite limestone as long as the layer is unfaulted. Dr Verdon has never responded to this criticism. It appears that he does not appreciate the difference between:

- Knowing where you are in three dimensions, with knowledge that you are within the desired rock layer, and

- Knowing where you are in three dimensions, and plotting it as you go on a backdrop of the 3D geology, usually derived from a 3D seismic data volume.

Only in the latter case is it possible to anticipate the approach to a fault zone, and then steer the drill-bit in the appropriate direction to pick up the desired layer on the other side.

Dr Verdon defends other aspects of Cuadrilla's operations at Balcombe which I found to be unacceptable. I deal with these elsewhere.

Conclusion

In the relatively complex geology of UK shale basins the full methodology of measurement while drilling must be applied. A pre-requisite for this is a high-quality 3D seismic survey. The practice employed by Cuadrilla for Balcombe-2z is unacceptable.

Documents and data sources

Cuadrilla announces completion of Balcombe drilling
http://www.cuadrillaresources.com/news/cuadrilla-news/article/cuadrilla-announces-completion-of-balcombe-drilling/

Crain's Petrophysical Handbook: measurements while drilling (MWD) and geosteering. http://www.spec2000.net/08-mwd.htm.

Mottahedeh, R. 2005. Horizontal Well Geo-Navigation: Planning, Monitoring and Geosteering Petroleum Society's 6th Canadian International Petroleum Conference (56th Annual Technical Meeting), Calgary, Alberta, Canada, June 7 – 9, 2005 (pdf)

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