I would be interested to know what you would expect the water temperature to be in Lake Ellsworth. Would it be 0C or 4C as at the bottom of ponds here or some other temperature because of the pressure of all the ice above it?

The water temperature would be around -1.5 - -2C, as a consequence of the water pressure. It would not be so much like a surface pond, more like the deep ocean. In fact, when one gets deeper than lake Ellsworth, the situation is just like the abyssal ocean, where warmer water actually rises rather than sinks. In either case, the density differences caused by temperature would lead to mixing of the water, but the degree to which this happens is not known. Hence we do not know whether the lake will be thermally stratified or not.

The problem you had in the first 60m seemed to be the permeability of the less densely compressed snow. Would a well lined with compacted snow over this initial depth be of any use?

We have considered lining the hole, but the logistic cost of this and the complexity it adds was not considered advantageous. Drilling the top 60 m is done regularly, and our problems in doing this should have been less than we encountered. Certainly other drills have been able to penetrate this top surface more readily, so we don't actually think this is a major problem for us as we redevelop things.

Someone asked Martin at the December 18th Shell sponsored Lecture, about the expenditure to date (or the 2012/ 2013 season, I'm not sure what the exact time period was) on the Lake Ellsworth project. He replied £6 million, when I checked with a BBC News article, they mentioned a figure of £8 million. Could Martin clarify the difference? Does part of the £2 million difference include the capital value of equipment that is available for use in another season, or is the difference due to the accounting periods of the BBC and the questioner being different?

This is quite a difficult question in fact. The grant to us was ~ 6m, but under full economic costing rules, the BAS and NOC would put in additional funding of their own. This, added to a grant for the geophysics, which was separate, and logistics provided by BAS from their core programme, meant that a 8m total for the entire project would be reasonable full estimate.

I appreciate the need to ideally fully avoid (if not minimize) any pollution caused by all operations in the pristine environment of the Antarctic, especially drilling operations. Having a background in the oil and gas industry (I was trained as a geologist, but have worked mainly as a geophysicist), I was wondering why drilling using a "conventional" drill-bit and drill pipe had been rejected as a technique to drill through the +/- 3,500 metres of ice to the surface of Lake Ellsworth? Wouldn't it be possible to drill with hot water and a metal bit and drill pipe and have more control with drilling operations?

The problem here is that we'd need an antifreeze to drill conventionally. Taking that out of the hole would be non trivial, and there would always be trace left behind. This is a level of contamination that would not be acceptable to us. We remain convinced that hot water drilling is the way forward. If we used a conventional drill, it would take 3 seasons to get to the lake and with a far greater logistic cost.

If the near surface snow or firn is so porous and permeable, could it not presumably remain a zone of potential hot water losses, even though it would not take very long to drill through? From my experience, any zone where drilling fluid could "disappear" into the "formation" in this case very porous snow-ice, needs to be isolated from the well bore as it goes deeper, otherwise there is a

risk that the rate at which hot water can be created (from the melting of snow and ice at the surface) could be exceeded by the rate at which it disappears into the ice, especially cracks or fissures in the ice or other porous layers. There is already a logistical challenge in supplying hot water to an ever increasing volume of cylindrical hole, as the hole deepens, in the trouble-free situation, let alone a "leaky" hole, which is more likely to be the case?

This is correct, and is why we need a pump below the porous layer, which pumps after back to the surface before it becomes lost. This is a normal procedure for hot water drilling in fact, it just didn't work very well for us last year. If the pumping works, we'd keep the holes dry of water within the porous layer once they have been drilled. The major issue for us is keeping these holes vertical.

I was intrigued to see the image of lake Ellsworth as seen by ground penetrating radar, especially the evidence for the pre-ice "basement" and its general decrease in topography from the centre of the Antarctic continent going towards the coast. The evidence for a valley-shaped "V" was clear on a number of profiles. What I was not so sure about was the cause of what appeared to be a sub-horizontal event on one radar image. I couldn't see why the ice-water interface should be horizontal on a structural "dip" line across the lake. To me there were only two cases where a genuine horizontal interface could be created. One being the sediment-water boundary within the lake assuming very gentle (low energy) sediment settling out of suspension; the second would be a gas/fluid interface, with the ice acting as the top seal and the basement rock acting as the lateral seal. Do you have any gravity or seismic data to assess which of the two scenarios is more likely? From my experience in young Tertiary sediments in different parts of the world, I am aware that gas can really stick out very clearly as an amplitude anomaly in porous sediments, but I don't know whether radar has such power of discrimination. How likely is such a sub-horizontal event to be an artefact of the acquisition or processing of the data? If so how could it have been created?

I'm not absolutely clear about this question, but can say that we do have seismic data for the lake. The horizontal reflector is probably the ice water interface, but I can't be sure without known which bit is being referred to. The seismic data show a nice clean ice water interface, and the sediments beneath. The radar data do not show sub water reflections, however, due to the absorption of radio waves in the water.