RESUMED **[1. 30 pm]**

COMMISSIONER: The time is 1330 resume the session on geology and hydrogeology and I welcome Dr Steve Hill.

DR HILL: Thank you.

COMMISSIONER: Mr Jacobi.

MR JACOBI: Dr Stephen Hill is the chief government geologist and director of the Geological Survey of South Australia which is part of the Department of State Development. The geological survey collect information in South Australia, geology and resource potential for public use. In addition to that Dr Hill is also a member of the Geoscience Committee of UNCOVER and was in 2014 part of the objective of UNCOVER with wider published on that (indistinct) and will be talking to the commission.

COMMISSIONER: Dr Hill thanks. I might just start with a scene-setting question. Can you explain to us the role of government and the role of industry in this melding of information, where you see it working and perhaps where it can improve?

DR HILL: Yes, sure. I think this diagram up on the screen captures a lot of that and that was provided by one of our local South Australian industry leaders, Derek Carter and I think it's beautiful because it really captures where we are coming at and where industry is at. The name of the game is discovery. If you don't discover mineral resources, such as uranium resources then to have all of the other parts of that industry, you are really missing being able to build those other parts of industry. It is all about having discovery of the resources. So what we are trying to do in government is really help industry improve the quantity of exploration and the quality of exploration.

The reason that they need that help is that it is a tough job. It is high risk as far as success, it's expensive and it's a very competitive market out there for exploration. Every other part of the world is vying for that international mineral investment dollar and so we need to make South Australia as an attractive place for exploration as possible. Because without it, you are not going to have discovery and if you don't have discovery, then forget it. You don't have that industry, that minerals industry.

MR JACOBI: Dr Hill, has there been – is there a consensus as to what the major challenges are that face new mineral discoveries in South Australia?

DR HILL: Yes. We spent a lot of time talking to companies about exploring in South Australia, particularly international companies coming in to South Australia and the biggest fear that they have about South Australia is the cover and that is the sediments, the weathered material that sit above the target. So the geological target will sit at depth in the profile or in the crustal section and you have got to – to reach it, you have got to drill or image or sense through, in some cases, quite considerable depths of cover in South Australia. When you look at where there has been exploration success in the past, it has mostly been in areas where that cover has been either thin or non-existent.

There are some notable exceptions, things like Olympic Dam, incredible discovery when you think about they are sitting at 500 metres, 400 metres depth and they still discovered. But by and large it's the cover, it's because it conceals a lot of what lies beneath. It is also because it's expensive to drill through and look through and then when you've been through it and you get the one piece of information say, you then have to work out how to extend that information further through the cover. So it's not easy. If it was easy, people would be making discoveries all the time and they wouldn't need that sort of help.

MR JACOBI: I think perhaps by reference to the slide and we have now got up on the screen, are you able to give some broad description of the extent of basement cover as it affects South Australia?

DR HILL: Yes, sure. South Australia, we have done a lot of mapping of not only the rocks but we have mapped a lot of the cover in geological survey and a fairly conservative estimate is that 80 per cent for South Australia has cover that extends across it, thereby concealing the underlying rocks. So this cover is sediments, things like river sediment, sand dunes, old marine sediments from when inland sea came in to South Australia and those depths can be anything from – greater than a kilometre to tens of metres. And in fact in some cases, we can even see that only several metres of cover is enough to disguise an underlying mineral deposit.

COMMISSIONER: Are we unusual in terms of the amount of cover?

DR HILL: Yes. Australia as a continent is and South Australia is unusual within the context of Australia. So if there is one place where that cover challenge really manifests itself it is here in South Australia and that is made even all the more frustrating because what we do know about the underlying geology is that it is really prospective. So that is why that really comes to a head here in South Australia.

MR JACOBI: You identified industry as having identified that being a

particular issue, in terms of – is there a general consensus by other players, other than industry, that cover represents the barrier?

DR HILL: Yes. Industry researchers recognise that from government, we recognise it as well. So a lot of what we are trying to do in pre-competitive geoscience is really try to improve setting that context or that geological scene for the areas that are covered. So no, we have a pretty strong recognition of that and probably some of the best examples of that are the national UNCOVER initiative that was initiated by the Australia Academy of Science but since then has been really embraced by government geological surveys but also industry and then also researchers.

So we have things in government where we have set up the national mineral exploration strategy which is really the government, collective government geological survey response to that UNCOVER initiative. And that's basically saying that all of the states, territories and federal geological agencies, we recognise that challenge, we sign on to it and we are now developing programs that are aligned with that. And then just recently, through the Amira Organisation which is a way – which is an organisation that pools industry together, they have developed an UNCOVER road map and that is – what has happened there is that industry has sponsored that meeting, or those series of meetings and they have basically put on the table their opinions, their voice about what needs to be done in their minds to help address that cover challenge. So things are – I know there has been a lot of talk and a lot of setting things up but to get that industry engagement, government engagement and then we are trusting that the researchers will then follow that, I think is a big step forward.

MR JACOBI: I will come back to UNCOVER.

DR HILL: Yes.

MR JACOBI: I think perhaps towards the end of today. Just to pick up on something that you indicated before. You expressed a view about discoveries in circumstances where there was substantial cover and I think we have got a slide that shows that.

DR HILL: Yes.

MR JACOBI: Just wondering whether you can offer an interpretation of the graph that is showed there?

DR HILL: Yes. So this line here shows a range of commodities and in essence what it is showing - and what it is showing is that we're not too bad at finding things if they are at the surface or near the surface. So you can see the

– it is showing discoveries that are made over time, horizontally across the graph and then the – basically the depth of discovery, or the depth of the cover for the discovery on the vertical axis. So the deeper discoveries of course occur vertically lower down on the graph and the shallow discoveries at the top. And you can see that as time has progressed, particularly during the 1970's we became quite good at finding mineral deposits that are near the surface and that is because of the great technological advances that were made, particularly in geophysics and geochemistry.

Also because at that time the governments of many surveys in Australia started to really get on board with the idea of flying airborne geophysical surveys across big parts of Australia. That was also matched by improved geological mapping. So that geological context took a big jump that was also matched with technology. Very good at the surface but we haven't been so good at making discoveries – essentially once you get below about 30 to 50 metres there, those discovery dots are a lot more sparse.

Notable exceptions, as I said, Olympic Dam at about 500 metres will be one of those dots in the mid seventies through there at about sort of late seventies might be shown on here, at about 400 metres. But they are an exception and there are fantastic stories about how in most cases companies have had to be very resilient and persevere and they have had strong backing financially and strong backing with their boards to keep drilling because those deep discoveries aren't made with drill hole number one, they are made with drill hole number 10 onwards.

So to have a drill – a very expensive hole drilled and not make a discovery from that first hole, you need to have pretty good support to go back and say, "We want to have another go," and they're some of the challenges. You think of the money that goes into drilling those holes, and also the odds of discovery - you know, they're the discoveries. It looks great, there's lots of dots, but I can tell you that for every discovery that's made there are thousands of metres that are drilled for those discoveries, thousands of holes that are just unsuccessful. The rewards are high, but the odds of success are low.

MR JACOBI: I'm just wondering about whether you're in a position to make any reasonable prediction with respect to what's likely to be contained within the basement undercover in South Australia.

DR HILL: Yes. That's a really good point, Chad. There is no reason why the rocks that are near the surface that have mineralisation are really any different to the rocks that are at depth. Okay. The reason that some rocks are at surface, some are at depth, is because of the geological history that's happened since those rocks formed. You know, you get uplift, mountain ranges and subsidence in basins and things like that. But what we can see, particularly

when we look at the geophysics, is that the geophysical patterns of the rocks at the surface continue at these depths into these areas.

So the prediction would be that the areas that are at depth should hold the same degree of mineralisation as the rocks that are at surface, and you think about that. There's 80% of South Australia is covered and so maybe a little less than that falls into that beyond 30 metres, but you're still looking at probably 7% of the State is effectively not well explored, and you think about what could be delivered then.

MR JACOBI: We understand from evidence that was given this morning that a judgment can be made based on the size of known discoveries as to the range of plausible other discoveries of similar deposits which might be located. I understand we've got a slide that addresses that issue as well specific to uranium. I was wondering if you could explain an interpretation of that graph.

DR HILL: Yes, that's right. I think Prof Giles this morning talked a bit about the Zipf curves, how you get these really quite gentle curves from the large deposits, then tailing off gradually into the small deposits. If you look at this slide here, you can see the towering giant that is Olympic Dam. Usually when we show Olympic Dam on these graphs we adjust the scale to make it so that it fits, but this is showing exactly how it is. And then after Olympic Dam we have an enormous jump down to the next size uranium resource in South Australia, and if you take that predictive curve, that Zipf curve, then what you can see is that in between Olympic Dam and Carrapateena here there is an enormous, effectively a discovery gap that we have there to fill.

I'm sure Prof Giles explained quite a lot about how in just about all of the major mineral provinces in the world that distribution of size is followed really well, and so in this one there is some incredible potential discoveries and you can be assured that those discoveries that will be there will be undercover. They're not sticking out of the ground because just about every rock that sticks out of the ground has been mapped and looked at.

MR JACOBI: I just want to see if we can get a bit more specific about what's not known and perhaps move away from that graph, we can leave it up, and turn to the extent to which the cover itself has been characterised.

DR HILL: Yes, that's right. So traditionally, with geologists and all explorers we become so fixated on the target that we forget about the journey, and the journey in this case, the metaphor is the cover. So we become so fixated on drilling through the cover, punching through the cover - you hear geologists talk about that sort of thing all the time - or using geophysics to see through the cover, make the cover invisible so that we can see what's underneath, but what we're also finding is that if we have enough understanding, then in some ways

we can use our enemy as our friend and use the cover as a tool to help us explore.

There's a real gap in developing our understanding of the geology of the cover and what its chemical properties are. We have some idea, particularly at the surface because we look at soils and things like that, but as you get into a greater depth there's still a lot that's unknown about the geochemistry of the cover, the physical properties, so the sort of properties that you'd see in the geophysics, and even just the simple depth of cover, that fundamental measurement, and the reason I really highlight the depth of cover is because it's the depth of cover that goes a long way to defining the economic search space, so that is the areas where it's more profitable or less risky to exploring and if you have a discovery it's actually going to be able to be extracted.

Okay. So we have areas where the cover might be a kilometre deep. We think, well, what's the point in looking there, because in some ways if you find something, what are you going to do with it? So understanding that depth of cover really helps you pinpoint areas that will still have cover but are still in the domain of worthwhile exploring and mineable once you make a discovery.

MR JACOBI: How much work is yet to be done in characterising the depth of cover? I notice that on the first chart we had some very broad indication of depth of cover.

DR HILL: We're getting there, Chad. It's a work in progress. We still have a lot to do, we really do, and, look, I can give you a specific example. At the moment we've got a government drilling program that we're doing in collaboration with industry. There's an area just out at Port Augusta where we're drilling at the moment and we're finding that the cover there is a lot deeper than we expected and that's having a big impact on - so I'm feeling it personally, you know, in my job - is that that's having a big impact on the amount of money that we're having to put into that drilling program, and you've got to make that decision about, "When do we stop?" When do you keep going?

Maybe the next metre will give you something that you're looking for, and these are emotional decisions but they're also financial decisions and they're all based on trying to have the best confidence you can in the geological knowledge, and we still have a long way to go there with understanding the characteristics and depth of the cover.

MR JACOBI: What are the steps that are necessary in order to develop some more detailed views so that you can make better estimates of costs?

DR HILL: Yes. So geophysics is used a lot for trying to image and

understand the cover over big areas, and so I'm sure Prof Heinson would've talked a lot about that this morning, and he's a fantastic expert there, so I won't try to reproduce some of his knowledge. And that's great. That's part of the story, but it's not the whole story, because what you're doing with geophysics is you're making interpretations of the depth of cover, and so what we're finding now is that you need to improve your confidence in those interpretations, and one of the important ways to do that, and I must say it's something I'm very passionate about doing, is more drilling in areas.

So we have big parts of South Australia that are effectively under drilled or under explored and there's a lot of opportunities there, but even getting back to how you can use that to help your geophysics is using the samples that you retrieve from drilling. You can look at what the physical properties of those samples are, what their density is, what their magnetic properties are, all of the radiometric properties, and then you can use that to recalibrate your geophysical models and get much better answers out of them.

MR JACOBI: I'll come back to the drilling as well. I just want to move on to deal with some of the more specific sort of things that I guess we understand that we have limited information about, and I'm wondering what the relevance of issues of underlying framework of the crust and the extent to which that's understood and might need to be developed.

DR HILL: Yes. So the way I like to think about it is that we've got these broad thematic gaps. So we've already mentioned that understanding the depth or characterising the cover is one of them. Then another one that's fundamental for this challenge is understanding the architecture of the lithosphere, and what I'm getting at there are deep crustal structures, the conductivity of the crust, and how the crust is really connected to processes that might be happening in the mantle, things like that. That all sounds sort of pretty out there, but what we're finding from looking at the distribution of mineral deposits, they're very closely associated with major crustal features, and that's why techniques such as magnetotellurics, deep seismic sections and so forth are a really important foundation.

The other thing that's great about them is if you think about a typical South Australian landscape, it might be a sort of fairly flat, featureless outback plain, as a geologist you think, where do I start, and understanding through some of the big, crustal architecture at least gives you a region to concentrate on, because otherwise you'd be looking at the whole lot and trying to work out – trying to find a needle in a haystack is easy compared to what this task is. This is a needle in the whole three-dimensional array of South Australia.

There's also just understanding the geological, geodynamic and metal, mineral forming evolution of South Australia. How did the geological history

incorporate the formation of things like Olympic Dam, sedimentary uranium deposits and things like that? They're very special geological entities. Olympic Dam is extremely special. Beverley uranium occurrence and Four Mile, all those things are extremely special. So what is the geological history and geological events that helped from those things? If we understand that we can also become a lot better in predicting where that same geological history extended or occurred elsewhere and start to think about looking in those areas as well. So we're trying, as geologists, to piece those things together.

I mentioned Olympic Dam as a really good example. It's amazing how that Olympic Dam mineralisation geological event seems to be connected to a whole of geological events that occurred at about 1.6 billion years ago. So the more we're looking the more we're finding that some of those events extended over big parts of South Australia towards the New South Wales but also westwards into the central part of the Gawler Craton. It starts to open up more.

COMMISSIONER: Doctor, can I just explore the idea of this data set. We've heard from previous speakers about pre-competitive geoscientific data and the fact that there are isolated events of magnetic, gravity, magnetotelluric, all of these activities being conducted but the information not being integrated together. Do you see that and how might that physically be done? Is that a role for government?

DR HILL: Yes, definitely. It's a big challenge. The geological survey, we're very proud of being, really, the custodian of the geological knowledge of South Australia. So we pull together a lot of those big regional surveys, existing geological samples and the knowledge. We have a big core library that holds all the drill coordinates being generated in South Australia. We host that. Then there's all the data that goes with it. What has happened is that in the past you get your funding to do your survey in one of those different attributes and you go, "Great. That's a piece of the jigsaw puzzle." Then your next round of funding you'll apply it somewhere else, but one of the big gaps is then having good, reliable data that actually overlaps so that we're getting the best information out of each of those different parts of the puzzle and not only looking at them individually together but then trying to model them in a way that brings them together.

So joint data inversions and modelling is the sort of thing that has enormous potential. One of the things that's going to be important there is to make sure that we've got the good data coverage. Then you bring that together – and it's still a challenge. If it was easy people would have already done it. Things like magnetotellurics is a very attractive new data sequence telling us a lot about crustal conductivity, but integrating that with other data sets like magnetics and gravity, even geochemistry, physics and chemistry, pulling those things together to get a better handle on targets but also seeing the things that are at

this stage cryptic. They're there but they're just not recognising because they're not quite standing out in any one set. So then you bring that together.

One of the things that will come from that will be enlarging the targets. If we think about the size of an ore body, it's very, very small in the context of all of South Australia, but by bringing those data sets together you start to see the footprint, a larger sort of trace.

COMMISSIONER: So you think that's a role for government?

DR HILL: Yes, it is.

COMMISSIONER: So how would you do it?

DR HILL: The reason it's a role for government – just leading to how – is because those data sets extend beyond the individual tenements of companies. So a company will have a very small part of that. Then researchers will be interested in trying to solve an academic problem, but actually making sure that it's pulled together with integrity for South Australia and used in a way across South Australia is exactly what we're about in government. How would you do it? Well, as I said, the first thing is – and fortunately we've got a good start there and that is we've got a good quality assurance of the data that we've got. It's accessible. All our data is openly accessible. So it's all there. Then what you're going to require will be engaging the right researchers with the right equipment. That sort of big data requires super computers, things like that, to start modelling it and pulling it together.

It's one thing to do that but then you've got to make that accessible. How does that then go out to Joe the miner or Joe the mineral explorer to help them in their areas? That's the other thing, I think, that's important for government, is to make sure that we have what we call geoscience delivery. So we have an Internet geo-server that pushes that out. Now, that's great but, as data becomes much more sophisticated, much larger, greater quantity, that's also going to have to keep evolving. It's a bit like painting the Sydney Harbour Bridge. It's just going to be one of those things that we're going to have to keep updating and keep maintaining.

MR JACOBI: You referred before and I asked this morning about whether there were gaps in the geophysical information that was available from well known techniques, gravity, magnetics and so on. Are you of the view that there needs to be, I guess, mopping up of the gaps in either the coverage itself or in the resolution of that coverage?

DR HILL: Yes, definitely there is, and in different ways. The real work horse of geophysical data in South Australia and in all of Australia is the airborne

survey, you know the airborne magnetics, radiometrics survey in particular, and usually supplemented with ground gravity measurements. Then there's these new techniques like magnetotellurics and even seismic coverage. The first objective has been to try to get South Australia covered with 400-metre line spacing. The reason for 400 metres is that we feel that gives a pretty good resolution. It's like having a reasonably tuned television set. It's not quite HD quality but it's reasonably tuned. Also, 400 metres, it's easy then for companies to build on that and do the infill because they would then do an infill at 200 metres, 100 metres and so on from there. So that's why we picked – that's why we haven't picked 500-metre spacing, because it starts to get awkward.

So we've still got fairly large areas of the state that haven't been covered at 400 metres. That's the sort of data that's used by Geoscience Australia federally to do the big mosaic of the country. One of our biggest gaps is in the far west of the state. The western Gawler Craton all the way across to the Western Australian border is an enormous gap. What we're finding is in Western Australia they've really moved forward in that equivalent space over the fence, so looking at what's underneath the Nullarbor, what's on the edges of the Yulgan which is Kalgoorlie and all those areas, and they're making mineral discoveries. They're finding copper, nickel mineralisation, gold mineralisation. But you've also got to remember it's a big basin system. So the potential for uranium in that basin is quite large as well.

They've been drilling over there as well. The government has been funding drilling and they're generally finding the cover is not more than about 400 metres thick. So although the Nullarbor might look like a flat, featureless plain and you think, well, where are the rocks underneath there, there's a lot of encouragement that the cover is not out of reach and that the rocks are still quite prospective in those areas. So that's one of the areas that we're very keen to try to address with airborne surveys and other geophysical programs and then eventually bringing in more geochemistry. Geophysics is great but geochemistry actually tells you the chemical fertility of some of those targets. At the end of the day we're going to be limiting what we can do until we drill and retrieve sample and actually get bits of those rocks and date them and geochemically characterise them and then use that to adjust the geophysical modelling.

Just as you mentioned, Kevin, about bringing all those different data sets together, nothing beats having a real piece of rock in your hand and then looking at how all those different data sets come together there.

MR JACOBI: Is the cost of drilling challenging? Are there - - -

DR HILL: Yes, there's a lot of sort of developments on the scene where you think cost of drilling might reduce and therefore increase your scope to be able

to do it. Drilling is not cheap, particularly in remote areas, particularly where drilling hasn't happened before and particularly in these cover areas. So yes, there is – that is a big part of the challenge. I am really happy to say that a group of companies and also particularly the South Australian government but the other geological surveys have also recognised the importance of trying to make break throughs ingenerating cheaper, faster drilling.

I would be very surprised if Prof Giles didn't mention that, the Deep Exploration Technologies Cooperative Research Centre. And I think it is really inspiring what they have done and what they are trying to do in making drilling cheaper and faster and then real time information out of the drill rigs. That is where we have been a major supporter of that because we believe that the place that that will make a big difference will be South Australia because if we can get things like coil tube drilling and real time lab read analysis coming back in to offices, that will change these big frontiers.

The western third of South Australia only has less than half a dozen drill holes that pierce to the basement. That is like an area that is bigger than most countries in Europe and we have only got four, six holes that go all the way through and in to the underlying rocks. You think if we had cheaper, faster drilling what it would do for those areas, not only in mineral exploration but understanding groundwater and just understanding the fundamental geology of the country. It is a big black hole there.

MR JACOBI: I think that picks up where I want to go next and that is in terms of the barriers facing greenfields as opposed to brownfields drilling and if (indistinct) pick this up.

DR HILL: Might be battling there. Yes.

MR JACOBI: And questioning the reason for the – what that graph appears to show which is a decline in overall greenfields drilling over the 12 years that it shows?

DR HILL: That is right. You can see that – just to help explain that because I realise the colours – don't think have really come through very well. So this is from – this is some data that was collected by the Association of Mining Exploration Companies. So they presented that earlier this year where you can see the line, the bottom line, the zig zagging line there that comes down to 22 per cent is showing the greenfields drilling and in the top line is showing brownfields drilling and I am assuming you guys are reasonably comfortable with the difference between - - -

MR JACOBI: Yes.

DR HILL: - - - greenfields frontier type drilling and brownfields new mine sort of stuff. What you are seeing there is it is amazing that back in 2003 there wasn't an enormous difference but over time, there really has been conservativeness to how investment in drilling has been spent. It is a little bit – with all due respect, it's a little bit like children going to the swimming pool and sort of staying in the shallow end of the pool. It's safe, it's fun, it's all – they know what's going to happen. But what we are seeing over time, and I think it's largely as finance for exploration has become a tougher commodity to obtain, but also ensuring that our knowledge, our background knowledge of greenfields areas is also keeping up with encouraging people to take the plunge in to the deep end of the pool.

Get in to those greenfields areas and because of what we were talking about earlier about the problems with cover and the potential discoveries in those areas, it's those areas, those greenfields areas that hold the key for making brand new high-grade discoveries too. But it is high investment risk and so that is, I think a large part why that has decreased over time. And I see that as a major – I think it's a major red rag for governments to say, hey look what can we do to address that because we have got big parts of South Australia that are greenfields, most of South Australia is greenfields rather than brownfields and what can we do to change that, so that at least in South Australia the greenfields side of that equation is increasing.

The other thing to remember there is that most – the way the minerals industry is structured at the moment is that most of the exploration that's happening in greenfields areas is being done by the junior companies, the smaller companies. Why? Well, they are more agile, they are able to take those riskier propositions of moving in to these areas and hope to find something that will be a company maker in there. And generally, a lot of the larger companies are sticking closer to their known resources and trying to expand that and that is partly because they have got the infrastructure around those resources, that they can build on. So it is logical.

MR JACOBI: Does that not though present a structural problem in terms of the ability of smaller companies to sustain long term drilling programs with low risk of success.

DR HILL: Yes, it does. And that is why we are seeing in these downturn times that it's the junior companies that are going to – that are really doing it tough. I think the average life span – and perhaps don't quote me on these figures but the average life span of a junior company is 10 years or so. It is not your sort of big long-term big company kind of thing and it's because they are in that game. I think the other thing, just if I can point out one other thing about it too, is we talk a lot about the decreased efficiency of mining and extraction and a lot of people put a lot of effort, quite rightly, in to improving

our processing and other parts of the system.

One of the things that this really demonstrates though is that if we are to increase or maintain, or increase the efficiency of our mines, one of the biggest limitations on that is grade. If we are mining a higher grade then the mine is more efficient because we are getting more of the commodity for our efforts. It is the new discoveries in greenfields areas that essentially maintain grade because they are usually a big discovery of high grade in that commodity. Whereas the tendency, not a hard-wired rule, but the tendency will be brownfields areas that you are trying to incrementally increase your mine life and that because you have got the infrastructure there, you will be perhaps taking on projects that are a little more marginal and therefore it doesn't always go with your efficiency.

So that is the other incentive here. It is not just let's get people out in to new areas; it actually makes some economic sense. So if that part of the discovery pipeline falls down, we are going to have some problems because eventually you either run out of resource or it just doesn't become efficient to keep mining it.

MR JACOBI: You expressed before a view that it would be desirable that there be more of a state-wide program of drilling. Could you explain first, I think, the rationale for that and whether there have been any examples where that has been done elsewhere?

DR HILL: Yes, sure. So this graph (indistinct) I think the next one – well, actually just to build on the – this does lead in to that as well. I think this graph is really informative. It shows discoveries in the bars and then it shows metres drilled in those lines and you can see there is a pretty good match, particularly in recent times between the metres that are drilled and the discoveries that are made. So this is why drilling – I really believe drilling is a big part of the whole equation. If we go to the next slide, I think this slide is really an interpolation of existing drill holes in mostly the Gawler Craton of central south but – central South Australia, trying to show directly from the holes what the depth of the cover is, it looks pretty good. It's all kind of nice pretty colours spread across the whole of that area but if you go to the next slide, it actually shows what that data is based on and what you can see is that there is a lot more black than colour in there. Even where that colour is, even that is extrapolated a bit.

But it is showing major holes in where we just don't have drilling data telling us what the underlying rocks are. And most people are very surprised to see that there. Most people assume, but I thought you had a pretty good idea of what rocks extend under all of South Australia. This shows that we don't. This shows that, particularly in the west there, there is something like, as I

mentioned earlier, about half a dozen holes that we are basing interpretation in that area on. And as I said, in Western Australia they are making mineral discoveries in the equivalent geology, on the other side of the fence. And that eastern part of that Gawler Craton there, there is still big black holes there.

Well, that is some of the most prospective ground in the world. That is where Olympic Dam is in part of that cluster, that little island in the middle of the black on the eastern edge there. But as you move away from Olympic Dam, albeit in to areas where there is quite a lot of cover, you can still see it's under explored and, as I said, some of the most prospective areas in the world. So we have big areas of the State where we don't have drill holes for hundreds of kilometres or tens of kilometres even when we move into the prospective areas. So big gaps actually equals big opportunities, because these areas are still prospective.

MR JACOBI: Coming back to where we started, is there any model that's been applied elsewhere in the world in terms of having a focused or strategic drilling program?

DR HILL: Yes. You know, I have a definite bias, Chad, into being very proud about what we're doing in South Australia. I will start off with a South Australian example, but I promise I'll pitch it out wider than just our beloved State, and that is to say that South Australia has been a leader in the world on doing collaborative drilling with industry, and that has been a game changer and that's been through the PACE initiative, which is the Program for Accelerated Exploration, and what we've been doing there is making financial contributions to companies to drill holes throughout the State and in return for that, we're receiving the drill core samples and the data that comes out of those holes.

So they're the sort of things that we're holding in our drill core library, and what that's doing is it's making that information publicly available and it's information that would otherwise, at least initially, be held confidential by the company. So we're in a very unique situation. I've just come back from a couple of weeks in Chile. They can't believe that we do that. In Chile they will have a company drill a hole. They'll keep everything confidential and maybe even just chuck it back down the hole if they don't want the samples any more. Then the next company that comes along effectively redrills that hole, and so they're just cycling over the same lot of investment into this one area.

In South Australia we've got a great system of collaborative drilling, but also the repository for those drill holes, so we're moving forward all the time. Yes, that's been great. We also have been doing what we call mineral systems drilling, which is a regional-type program of trying to map out areas. So if I

move now away from South Australia, what's now happened is that other parts of the world, and Australia, have said, "Those guys in South Australia got it right. We want to do the same thing," and so we're now finding that just about every State and Territory in Australia has the same model of collaborative drilling, and they freely acknowledge that, "We're copying the South Australians there," and we're now also finding that's happening around the world.

So that's why, you know, we see that as - what is it? - copying is a great form of flattery, and I think the State over the last 10 years has invested about $55 million into this collaborative drilling and that has leveraged something like $700 million of drilling all up. So we're getting a great return that's leading to mineral discoveries. Carrapateena was discovered through this program. It was also really important around the development of Four Mile and Prominent Hill. It didn't directly lead to their discoveries, but it was part of their development in finding water and understanding the geology around those areas.

So, yes, I think we've got a really successful model. Because it is a competitive world out there and the other States and countries around the world are also doing it, it's now because the benchmark and we want to keep rising above that benchmark, because to do that is how you attract the attention and interest from around the world for the work, and that's why recently we've been developing a thing called Mineral Systems Drilling Program, which is saying, "Look, instead of a single hole that we're go to co-invest with a company in, we're actually going to do an array of holes," because from doing an array of holes you're able to vector and search within that space under the cover.

It's a bit like if you blindfold yourself and reach into a bucket and pull out something. It's like a lucky-dip one hole. It's not quite a lucky dip, but it's like taking one hit and hoping that you score a goal, compared with saying, "Well, no. This is about holes number 2, 3, 4, 5 and onwards," and then putting them together coherently to produce a map of what the geology or the mineral system is like undercover. And that's what we're doing at the moment out near Port Augusta. We've got some drilling that we're doing in collaboration with Kingston Resources, Minotaur Exploration and also the Deep Exploration Technologies Cooperative Research Centre, and we've had $2 million of government investment. We've now levered that into a $7 million program and we are answering questions about the geology in those areas where we're drilling holes. There was no hole for 30 kilometres or more in, you know, Olympic Dam type geological settings, really prospective areas.

MR JACOBI: With that sort of industry support model, who determines the location where the hole goes? Does the government get a say in where the hole goes?

DR HILL: It does. Yes. We have a very tried and true formula of governance and putting out calls for expressions of interest and applications, and then we have a panel that we set up that has not only people from government, but also people who may have previously been in industry or industry-type representatives who don't have, you know, a cross-purpose in their role in that panel, as well as researchers from academia, and we assess those applications to assign out collaboration funds from that. So, yes, it's a pretty big process that goes on. And then from those applications, that basically says that the companies are proposing to partner with us on, and so that's how that moves forward.

MR JACOBI: Moving away from drilling, the Commission understands that there's been some movement in terms of geochemistry in other jurisdictions. I'm just interested to understand what the position is in South Australia.

DR HILL: Yes, that's right. So we've talked a lot about drilling. We've talked a lot about geophysics and, as I said, geophysics has been great because you can fly aeroplanes and you can cover broad areas very cheaply and efficiently, and it has changed geology and exploration in South Australia, and probably one of the areas that we're behind on, I have to confess is, geochemistry. We have some success in using geochemistry in drill holes to better model footprints of iron oxide-copper-gold mineralisation and so forth, but if we look to States like Western Australia that are doing large regional soil and geochemistry programs, so very systematic geochemical sampling across big areas, we haven't really moved into that in South Australia.

It gets back to Kevin's earlier question about integrating data. Integrating geochemistry and geophysics have got a geophysical platform, but then to bring regional geochemistry over the top of that, as I said, that tells you the chemical (indistinct) I think we've got a long way to go there, Chad, and as I said, I see that as an opportunity. I would love to think that in five years' time, you know, if you were to ask me that question again, I'd be able to tell you with great pride about what we're doing in South Australia. So that's something I would love to see us develop.

MR JACOBI: In terms of the impact, you mentioned that after a time, information is provided. Following core sampling being done by companies, it's then shared with government.

DR HILL: Yes.

MR JACOBI: How complete is the government's access to the information is gathered from those private investments? Could there be improvements there?

DR HILL: So that's all part of the legislation, both in terms of the company taking up a tenement and exploring, and certainly when we do collaborative programs it's very clear in the agreement that that's all part of the legislation there. I feel we have pretty good access in those areas and pretty good capture of that data. You've got to remember that we're looking at a geoscience community where, you know, people will have their professional interests, but still, you know, at the end of the day, people change companies, people, you know, go and have a drink at the nearest watering hole, and you kind of have an idea of what's been collected and what people are doing and where things are at, and from that, we feel that we've got a pretty good collection of things.

MR JACOBI: I understand that companies that explore are licensed to target a particular resource and, as a consequence, will then test for that particular mineral. Is there an opportunity there in terms of having access to the other information that a core sample might provide that's not tested for?

DR HILL: Yes, that's right, and I think what you're asking there, Chad, is because we also take the core sample and put it in our core library, that core sample is available for future testing. Part of the conditions of access to that core sample is that the information that's obtained becomes publicly available as well. We have a pretty good community in Australia. It's not perfect but it's pretty good in understanding the public good and the benefit of being to build on what previous people have collected in samples of data.

MR JACOBI: Trying to deal with and come back to dealing with UNCOVER, which I think we dealt with at the start, I understand that since the UNCOVER report was released in 2012 there was a next steps report released in late 2014. I'm just to understand the progress that has been made in South Australia in terms of fulfilling the priorities of that particular program.

DR HILL: It's ambitious. It's a real change of focus in many ways. The challenge there is to really get people to break out of their silos with their company or with their individual – so in industry, getting people to break out of the silos of their company in research and academia, getting people to break out of the silos of their narrow expertise and try to put all those things together.

So, as a result, I think when you look through at the record of what UNCOVER has been doing, there has been a lot of talk, there has been a lot of meetings, a lot of symposiums, a lot of position statements. I know some people have sometimes been a bit frustrated, "I wish we could be doing it and moving forward on this." What we've got to do is get it right and get particularly the industry engagement. If the industry don't own it and aren't part of it, it's not going to change exploration, because otherwise if the industry aren't part of it then they've got the researchers and government telling them what they think they should be doing. No-one likes to be told by know-it-alls what they should

be doing.

So what has happened in that UNCOVER space since those meetings that you talked about, Chad, is that, as I said, the state governments have developed their national mineral exploration strategy and we're all – we meet very regularly with my counterparts in other states and territories and we're now talking more and more, not about just what we're doing but what we're going that's better positioning us in the UNCOVER space. So now when we talk about geophysical surveys we talk about how that fits into the main themes of UNCOVER and how that will make a difference.

One of the reasons for that is that we see that has industry endorsement because what industry has also done is they've developed that AMIRA Roadmap, which is where AMIRA got sponsorship from industry participants to meet in rooms a bit bigger than this but similar and a lot of hard work on whiteboards and Post-it notes where industry were hand on heart saying, "This is what we need in these areas to make a difference." I think that's pretty encouraging to get that sort of open, frank communication about what industry feel they need. They also have to confess to what they don't know and also what they're challenged by and what some of their failings are and all of those sorts of things. So to get that information out of industry and then have it, I think, quite beautifully put together into the AMIRA Roadmap report – it was Robbie Rowe that worked on it and did a fantastic job – for us to then be able to pick that up and say the government is looking to do these things and this is endorsed by industry there.

So that is definitely filtering into exactly what we're now doing in the PACE Initiative and also in the geological survey. In fact, a lot of our programs in geological survey have also been updated to fit much more closely into those things because we think that translates really well when we're talking to industry and talking to other states. So instead of having very traditional mapping themes and very geophysical themes and so forth, a lot of our themes in the survey now are very much geared up towards those UNCOVER themes.

MR JACOBI: I'm interested to understand what in practical terms might be thought to now need more work. That is, what are the identified practical things that need to be done in order to achieve the sort of collaboration that is spoken about and I guess so that private objectives align with whatever the public needs are?

DR HILL: Speaking really – this is pretty straight off the top of my head here, Chad. I think one of the big things that we need runs on the board of trust. I think we need to have areas or regions that we can put forward and say, "This region personifies the challenge of the cover." So one example of that might be the far west of South Australia. We say, look, this is a big geological frontier. The reason it's frontier and the reason the companies are very

tentative about going near it is because there's a lot of cover. So if we can identify those areas and then use them as the focus for collaboration, then as we start to make achievements there we're going to start to build trust and get runs of the board.

So that's why a lot of what we're trying to do in South Australia with the far west is – we've just completed a large seismic line across that area. We're currently collecting magnetotellurics data. We've done plant biogeochemistry. So if you can implant leaves and analysing them to tell us about what the roots are intersecting. We're flying the state's largest airborne survey in that area. It's that concentrated effort of all of those different data sets, data compilations or data acquisition into that one area that fits that UNCOVER dream. It's no longer just the one-trick pony tried in a little isolated spot. It's bringing those things together It's when we've got that that the vision that Kevin spoke about, modelling these data sets together, will make a big difference.

I think the far west is great model. The big thing missing there will be actually we can model it and model it and model it with geophysics but we've got to get some holes in there and get some samples out and actually see – I think it might be the next slide. Just go back, back another one, that one there. That's showing a lot of the west of South Australia and you can see some of the things that we're doing in that area. In the south-west corner there's a big blue blob called Coonpana. That's one of the largest magnetic anomalies on the Australian crust and we don't think there's a drill hole that goes into it. Companies have tried to put a hole into it. We don't think they quite reached it.

So we think that is one of the great geological promises in that area. As I said, similar structures to that over the fence in Western Australia are turning up nickel-copper deposits and other types of mineralisation and we don't have a hole in it. So we can pull this sort of data together and that's great because that will give us good direction and good targeting. Then I think if the government – I'd like to think that we can lead the way in finding new a mineral province in that area with some drill holes and other things like that.

MR JACOBI: If success is dictated by a successful case study, if I can express it that way, is there a long-term strategy to deliver that success?

DR HILL: If you think about South Australia's geology and mineral exploration success, what we offer in South Australia through our geology is really a prospectus of investment opportunities and exploration opportunities. In that prospectus we have a range of regions and projects that are at different degrees of development. I've been highlighting there one in the west. That's a real greenfield. This is an opportunity to be a first mover into an area like that. Then as you move further east into areas around Olympic Dam, the eastern Gawler but even further towards the so-called Curnamona province which

Broken Hill in New South Wales is part of that province – the Curnamona province, I think, is amazing because we know that it's prospective for sedimentary uranium. It has got Beverley, Four Mile, Honeymoon, all of these things.

The other thing about that area is it's also prospective for iron oxide copper gold mineralisation, things like Olympic Dam. Sometimes you look at the way that we've been exploring in those areas and you think it's funny that parts of the Curnamona have been very top-down driven, very focused on sedimentary uranium. Not a lot of the drill holes have gone all the way down to where there might be an iron oxide, copper, gold deposit underneath that. So that's a great example, I think, of an area that we know a little bit about but it has actually got another step again that it can take.

Similarly, around Olympic Dam I think we have a lot of potential for sediment hosted mineralisation uranium, but also copper, copper being held in some of those sediments. But we're so focused on looking for iron oxide copper gold there, that we sometimes forget about the material that we're drilling through and what that might host.

So those two are examples that I think are intermediate, they're areas where we know that they're prospective, we know a bit about the geology, but there's just other ways of looking at it that will offer new opportunities. It's only through gathering more of that information and looking at the existing drill holes in whole new ways, that we're going to make those inroads.

Yes, I think we have a whole range. We have things that are, you know, things that are nearly pre-prepared, things that are somewhere in between, then things that are a complete green field. I think that's exciting, because I think that tailor makes opportunities for a whole range of people that might be looking to explore, and it certainly keeps us very excited.

We're going to change the geological map in the next few years, and there will be discoveries that come out of that, and that's what motivates me, to see that happen at the time.

MR JACOBI: I just want to turn to exploration expenditure, I think. I want to flick through a couple of slides.

DR HILL: Will I come in?

MR JACOBI: Yes. I think this particular column chart, I think closed down at the end of 2013, I'm just interested in your interpretation of the more recent years, in terms of expenditure in the state, and the story that sits behind them.

DR HILL: Yes. And that does cut out there, partly because collecting some of that data in a definitive way actually takes – there is a lag to it, and the Bureau of Statistics and so forth do give pretty good updates, which are indicative, so some of this is a little bit behind for that reason.

Firstly, the forward trend beyond 2013 is not especially pretty, the graph continues to go down, and you know, people are wondering what that might mean, as far as, "Is that the bottom, and are things about to pick up, or will things be flat at that level, or will things continue to go down?"

One of the things that really informs us in that discussion and those thoughts is, when you look at these things, you can see that there's a wave. If you take that back, way back through time, you can see there's peaks and troughs in the minerals industry. And that's actually one of the things that makes it a real challenge to invest in, and a real challenge to kind of, have patience with it, because you know, it has good times where things seem easy, and then bad times where things seem really tough.

What this graph really brings out, that I love, is that firstly, the importance of discoveries for sustaining, you know, a sustainable series of discoveries that helps sustain exploration, and by sustaining exploration, they then help to sustain more discoveries.

But the other thing is, if you look at 2004, you can see that's when the PACE program was initiated. What happened then was, that times weren't particularly great in the early 2000s, yet that was the time that the government got on board with trying to make a difference to how things happen. The interesting thing about that is, it's not too different. The situation in 2004, 2003 is not terribly different to how things are now.

I think we can learn a lot from that past example, and that is about things like counter-cyclic investment. It's when things are tough that the rest of the world might be saying, "Well, we'd better retreat into ourselves." But, if in contrast we say, "Well, this is the time to start building those foundations and get behind the industry," then you can see that what happened after 2004 was that we didn't just have a boom in the world, but South Australia actually out-paced that. You can see that blue line is South Australia's percentage share of expenditure, and that similarly skyrockets into 2007, 2008 and so forth.

And that, I think, is largely because, not just because times were good, but it was actually amplifying that way, because of the foundations that were set prior to that. And also, because we then had discoveries coming online, you can see that Jacinth-Ambrosia was closely associated with PACE, Carrapateena was directly a PACE discovery. Four Mile, there was a lot of drilling connected to PACE that contributed to it as well.

So you know, it's those things that change the game. You know, it's that sort of raft that gives me a lot of heart about what we can do, not only in government, but also in a mineral exploration community, to make a difference. Things will get better, let's be ready for it.

MR JACOBI: Just studying the decline that merged there. As I understand it, it trends off in the same way in the 14, 15 years.

DR HILL: Yes.

MR JACOBI: And kicking back to the chart which showed the level of green field investment, and it declining as well. I'm just interested if I understand your perspective about how that sits with the idea of industry collaboration with Uncover, in a sense that that was a program that announced in 2012, a collaborative program of green fields drilling.

Both charts appear to show, in fact, declines in investment in drilling over that period of time.

DR HILL: That's right. And that's one of the sad outcomes, is that in those tough times, there is a tendency to want to retreat and pull in, particularly in the higher risk side of things. So it's usually exploration in those green fields areas that suffers. So we've seen, I think, a few graphs that if we start putting together, we start to get a very interesting story about where things are at, and where things can go.

The other thing to point out there is, that a lot of those discoveries such as Jacinth-Ambrosia, you know, Four Mile, Carrapateena, were certainly away from existing head frames. You know, they were effectively green fields discoveries that were made at that time.

Then it's that knock on that you get, then people start looking for another one of them, in those sort of areas. That helps them raise investment funds, which then cycles on through. It gets back to that first slide that I showed, from Derek Carter, that had that whole cycle of how the industry works. This is really showing that same. If you superimpose that cycle onto this linear graph, then you can see how things are working, and that's why that trend of green fields drilling decline is a concern.

MR JACOBI: Yes. Am I right in thinking that we've really not seen the benefits of Uncover yet?

DR HILL: No, that's exactly right, yes. That's right.

MR JACOBI: We've also asked, and I'll get to slide 16 for you to give us the budget figures for PACE. I'm just wondering about whether you can offer some basic interpretation of the expenditure in South Australia, and I think we've got a chart to look at the other jurisdiction.

DR HILL: So we'll just look at this one first. Yes, this is just them you know, the sort of, publicly available budget figures on PACE. As I said, we're very proud that we're getting a lot of leverage out of those figures. You can see that there's, just down on the left, you can see that there's been a lot of different re-births of PACE over the years, you know, with slight changes in the names and so forth.

The duration of that funding has varied. It's really been that PACE 2020 ongoing funding has been a really important pillar for us, partly because it's enabled us to plan our program ahead, but it's also really important for industry to know that next year or the year after, there will be a government collaborative program available. Because, some of the shorter programs have been great to be able to get big, high impact surveys done and things like that, but we always have a bit of a rush with companies hearing the announcement and then trying to get their application in.

The thing that's really helped us maintain momentum has been that ongoing PACE 2020, because we know that we've got it into future years. We do find that we get calls from companies, usually at least a year to two years in advance of them putting in applications, because they need to know that they can go to their shareholders, their boards, raise money on the prospect of taking up a tenement in South Australia, and the government will be there. The government will be in there with them.

MR JACOBI: So if we can plot the last table, just the jurisdiction?

DR HILL: Yes, so this last one really shows our challenge, and that is keeping our PACE funding, and particularly for initiative funding, making sure that we really keep that up to date and competitive against the other states. I think I mentioned earlier that one of our great successes has been that we set up PACE and then the other states were very quick to identify, "Hey, those South Australians, they're bucking the trends here, and doing really well. We want a piece of that action."

What's happened immediately before that period of figures is, those other states have really ramped up in their funding. In fact, you can even see here, you know, Northern Territory has ramped up. Just in that period there, they've gone from funding that's been pretty much comparable to ours, to now moving onwards with that.

There has been some big movements in also Victoria have got a lot more serious about trying to fund these sorts of things and they have had some pretty innovative programs in the west of their state which has involved drilling for what they think is a big volcanic arc system that hosts copper mineralisation.

MR JACOBI: Am I right to assume that there is no amount budgeted for South Australia at the current year and none for the (indistinct) year?

DR HILL: So we have a core ongoing budget but what this graph is showing is the extra initiative funding which is the money that we use for big new ventures and at the current situation, we are – most of our activity is really happening from forward spend from last financial year. So we have a challenge there to maintain our deliveries and presence with the government and make sure that we keep competitive in that space. And we are certainly having to discussions with the government about doing that.

COMMISSIONER: Dr Hill, thank you very much. We will adjourn until 15.00.

ADJOURNED **[2.41 pm]**