**Video Transcript**

**Goldfields Tender Briefing Getting the Most from the Data**

For those who don’t know me, my name is Cameron Cairns, I’m the Manger of Mineral Geoscience with the Geological Survey of Victoria.

Moving to the next talk now from the survey, so Phil Skladzien is one of our senior geophysicists and Phil’s going to be talking about regional potential field datasets in North Central Victoria and how to get the most from that data for your interrogation and interpretation.

Thanks Phil.

[Slide: Regional geophysical datasets in north-central Victoria: getting most value from the data. Phil Skladzien]

*Phil Skladzien - Senior Geophysicist*

Good morning everybody.

[Slide: Talk outline]

I’m just going briefly give you an overview of some the of the regional datasets, geophysical datasets that we have available, and some of the techniques that we’ve used to try and extract the most information out of that data and use that in our interpretations.

[Slide: North Central Victorian Goldfields Ground Release (NGVGGR)]

As you’ve seen today and probably know already, the tender blocks are situated in the northern Bendigo zone, the northern part of which is covered by Cenozoic sediments, the Murray Basin which you can see there in the yellow.

[Slide: Cenozoic cover]

And just looking at that in a bit more detail you can see this surface that we have produced as part of the Gold Undercover work.

Mark McLean created this from existing drilling depth to magnetic source modelling.

So the tender blocks straddle that margin of the basin and the thickness ranges from outcropping Ordovician rocks in the south up to about 200m thickness of the Murray Basin in the north there.

So you can see the reds are the thicker parts of the basin and then thinning out to the margin in the south.

We also have geological mapping that’s being carried out throughout the history of the survey.

There’s some great products, the 1:50 and 1:250k seamless geology, and of course that’s restricted in the north by the younger cover.

So gold occurrences historically have been mapped and utilised in the south where that basement is outcropping.

And we have these structures that are related to the gold occurrences, but again they terminate at the, or their exposure terminates at the margin basin.

So what kind of techniques can we use to look under that cover and follow these structures to the north?

Both Ross and Rob mentioned earlier, we have the seismic data, in 2006 we shot these slides, and they give us some information about what the geology is doing that cover in the section there, as well as providing geometries and information about the lithologies in 3D with depth.

[Slide: 2006 Central Victoria Deep Seismic Reflection Transect]

So just looking at those sections again, this is lines one and two, as we saw earlier we’re kind of concentrating on this region here, you can see the faults and the volcanics at depth, the source of the gold coming up into the positions of the occurrences and prospects.

[Slide: Cenozoic cover]

So how do we extend that information that we gleaned from the seismic and from the mapping up into the north, well we can use geophysics, potential field geophysics to do that.

And as you can see, when we strip away the Murray Basin cover those structures, which are highlighted by the anomalies in this case some filtered gravity, we can extend those to the north.

And we’ve used this data, or people have used this data to start exploring undercover, and a great example is the Four Eagles and the Tandarra prospects that we’ve sort of covered using some of the gravity.

[Slide: Talk outline - Regional airborne magnetics]

So briefly just going over what datasets are available, in Victoria we’re very lucky, we’ve got a great coverage of aeromagnetic data over the whole state, with line spacing ranging from 400m down to about 50m, and we’re able to compile all those individual surveys into a state-wide database and grid that at 50x50m grid cell size, and all of that data, the individual surveys as well as our regional grids and databases that are available either from GADDS or through the survey.

[Slide: Regional airborne magnetic surveys]

So just looking at our area in a bit more detail there, you can see the number of different surveys that have been flown in the area, highlighted by the different vintage there.

This map is available on GeoVic so Dave and Rob out the front there are demonstrating GeoVic, you can go on there and have a look at what surveys cover what areas and interrogate those surveys and then head over to GADDS to actually get the data.

And concurrently of course there’s radiometric data that is acquired at the same time with the magnetics, and we also have some airborne EM data that’s open file and available, and Mel will touch on that a bit later as well.

[Slide: Regional ground gravity - slide 1]

So gravity, similar story, we’ve got pretty good coverage over the state.

Nominal 1.5km station spacing, it’s sparser in the north-west and over the highlands in the east there, but generally pretty good coverage for a regional dataset.

Again, all of that data is available on GADDS, and the gridded products are available also, so a 300x300 cell size grid for the whole state.

[Slide: Regional ground gravity - slide 2]

And again looking at our area of interest in a bit more detail, you can see all the stations there.

So in the north we’ve got pretty good coverage ranging from sort 100m to 200m spaced along some of the lines, but nominally 500m spacing along lines from the Bendigo-Mitiamo Survey that was acquired in 2007.

And then in the south it’s a bit sparser where there’s actually the Ordovician outcrops, so that survey was concentrated up in the north where there was cover.

[Slide: Regional ground gravity - slide 3]

And just to give you a bit of a feel for the increase in detail and resolution that we can get, on the left there you can see the 1.5k station spacing data prior to the Bendigo-Mitiamo Survey.

On the right is after we acquired that survey using the 500m station spacing.

Just recently we’ve released the 100 and 200m sections that are open file now, so again Mel will touch on that about how you can go about accessing those.

They’re not actually available on GADDS because Geo are updating that system and currently we can’t put more data into it so you will have to get that from us, but like I said Mel will touch on that.

If you’re interested in any other information about that survey there’s two Gold Undercover Reports as well that were produced for that.

And just zooming in on a little area here to show that resolution increase in a bit more detail, we can see on the left the 1.5k spacing station grid and the 500 on the right, so things like that Palaeo channel stand out in a lot more detail in the high resolution data.

[Slide: Talk outline - Filtering of potential field data - gravity]

So filtering and image enhancement, what can we do with these datasets to actually get more out of them and be able to interpret some structures and features that we can’t from the standard simple data?

So we can apply mathematical filters both to the magnetics and gravity data, and both to gridded datasets for a qualitative interpretation, so drawing lines on maps and tracing out faults and offsets, and we can do that with line data as a more quantitative approach.

So you can see here a number of different examples of some filters for the gravity.

Starting with the top left there is the standard complete Bouguer, and then various filters applied.

And you can see some of these north-south structures really standing out in the different datasets.

We can apply low pass and band pass filters to look at the response coming from the deeper sources, things like the tilt-filter in the bottom left there that give us high frequency information about the shallower sources and the features associated with structures, associated with that response.

But most of the filters that we found useful are listed there, the vertical derivatives, wavelength filters, tilt filter, analytic signal and continuation filters.

[Slide: Filtering of potential field data - magnetics]

And similarly with the magnetics, we can apply various filters to try and enhance that signal as well.

The problem with the magnetics in this part of the world is that the response from the Palaeozoic metasediments is generally non-existent or very weak, so we don’t really get to see those structures that stand out in the gravity.

However, we found that it’s still quite useful because we can use the magnetics to interpret and to model some of the other features that do show up in the dataset, so for example the volcanics there, the Mt William-Heathcote fault zone with the Heathcote Volcanics really stands out and you can trace that out really nicely in the magnetics.

There’s paleo-channels there as well, all those sort of dendritic features that you can see, as well as newer volcanic flows, so down the Campaspe, sort of down the middle of the area there you can see that volcanic flow.

[Slide: Image enhancement - slide 1]

And we can do things like combining some of these filters to again try and correlate different datasets and extract some more information out of them.

So here we’re looking at a high pass gravity filter on the left, reds are high obviously, blues are low.

The Heathcote Volcanics stand out as you’d expect.

And similarly with the magnetics, this is a reduced pole intensity surface and we can combine those and drape the gravity over the magnetics to give us a bit more information about sort of how those two signals correlate with each other.

[Slide: Image enhancement - slide 2]

And another example here is using magnetics, so the tilt-angle on the left and a band pass filter on the right, so we’re trying to combine the information that is in the field from the shallower high frequency stuff on the left there, giving us detailed information about shallow sources and sort of edges and boundaries of those, as well as trying to extract some information from the deeper, larger anomalies with the band pass filter.

And if we combine those as well we get a fairly decent image of the magnetics, and I think that’s kind of the best that I’ve been able to extract out of the data for this area because it’s just so non-magnetic, the Ordovician metasediments.

But we can see some features here, that large sort of deep body in the centre there as well as really good definition of the Heathcote Volcanics and the stack, antiformal stack there.

[Slide: Image enhancement and display]

That’s our area over the top.

[Slide: Talk outline - Qualitative interpretations]

So regional interpretations is our datasets again, this is 15k high pass of the gravity, and you can see once we put on the faults how they really map, this dataset really maps out those faults.

So west dipping faults, bringing up the western side of the fault, and we can map those structures into the north there.

Again, the resolution isn’t perfect but for this sort of scale it’s quite good, so we’ve utilised this to help inform our modelling and our interpretations.

And that’s just the faults overlayed on the magnetics.

There is some correlation you can pick up but generally it’s not really the dataset that we’ve used to interpret in this part of the world.

[Slide: Airborne Gravity Gradiometry (AGG) - slide 1]

So that’s fine with the regional data, the 1.5k and 500m stuff, but we can actually get a bit more information.

So here’s a high pass filter with the faults on it, you can see it’s much better than the Bouguer, which is that one the standard gravity.

[Slide: Airborne Gravity Gradiometry (AGG) - slide 2]

But there have been airborne gravity gradiometry surveys flown over the area, so Four Eagles flew one up in the left there, the top left, and Fosterville have recently acquired one over some of their holdings and this dataset is now, what you see there is available, it’s open file now, so that can inform our interpretations as well.

And you can see the difference here, this is a high pass filter, so trying to get a similar response from the regional compared to the airborne gravity, and that level of detail is just an order of magnitude better in the new data.

Of course ground gravity would give you similar results but this is much quicker and you don’t have to actually get down on the ground to acquire this data.

And I’ll just mention that the Falcon Surveys, they capture the shorter wavelength anomalies, so we’re not actually capturing the longer wavelengths in that dataset, and it’s not a conformed product which is where those longer wavelengths are incorporated into the Falcon or the airborne data.

But for this sort of work that we’re doing and trying to map faults and stuff, it’s a great dataset.

So I’ll just quickly show you a couple of comparison examples of Bouguer gravity and the GD, the vertical component of the Falcon data, you can see there’s a lot more detail in the airborne data, so again a high pass filter just to try and compare those two datasets, we can see if we put on the faults that we’ve mapped they’re really joining up nicely in the high detailed data.

[Slide: Airborne Gravity Gradiometry (AGG) - slide 3]

And similarly with the Four Eagles band pass comparable to the GD, the faults and a vertical derivative, so theoretically these two datasets should be directly comparable.

And you can see the amount of detail that’s in the Falcon data compared to the regional.

And one other sort of technique that Mark McLean has applied in the last couple of weeks to some of the airborne data that we have is the shape index, and you can see that in the middle image there.

[Slide: Airborne Gravity Gradiometry (AGG) - Shape Index]

It’s really picking out some of the structures way better than I think than the other datasets you see there, so the GD and the gravity gradient on the right, it’s really giving us a better definition of that fault for example than the two arrows that are pointing at there.

So that’s the sort of stuff we can do with these datasets.

[Slide: Quantitative interpretations - slide 1]

Doing a quantitative interpretation requires some information about what we’re looking at and what we’re going to do to interpret and inform our models interpretations.

And one of the issues we have in this part of the world is that we don’t really understand why there’s a contrast across some of these faults in the Northern Bendigo.

So here for example we’ve got the Redesdale Fault and the Drummartin Fault, and you can see that gravity contrast in the signal across the fault.

So is it to do with metamorphic grade?

And studies have shown, based on the seismic, based on some mapping and tectonic work, that some of these faults should have a large enough throw that there would be a change in the metamorphic grade across the faults, and perhaps that’s what we’re picking up.

[Slide: Quantitative interpretations - slide 2]

Another option could be that it’s something to do with the fold intensity and development and amplitudes, and maybe that’s causing that difference in the density of the rocks and again showing up in the gravity.

So in order to try and work some of that out we really need to find a way to correlate the geophysics and the geology better.

[Slide: Correlating geophysical response to geology …]

And one way that we can do that, well to help inform that, is to use Petrophysics.

So we have some petrophysical data available for this area, again another Gold Undercover Report.

[Slide: Petrophysical data - Bendigo]

Highlighting here, this is the Bendigo zone out of that report, so we have some density data available but it’s quite sparse.

[Slide: Petrophysical data - Geotek Multi-Sensor Core Logger (MSCL)

There’s also some data from the Multi-Sensor Core Logger that’s held at Melbourne Uni, and that’s from by AGOS through AuScope.

So you get diamond core, run it through the machine and it gives you a list of properties there, magnetic susceptibility, bulk density, resistivity and a couple of others.

So that’s what the data looks like here on the right, measuring multivariate properties sort of at a resolution of 2 centimetres up to about 10, so a lot of data that comes out of that.

And we’ve put three of the Lockington holds through the machine and have that data available as well.

[Slide: Increasing geological information]

So using that sort of capture of the petrophysics gives us more information about the distribution of the property and we can then correlate it between different properties.

So the graph under space and distribution there showing magnetic susceptibility and resistivity, we can start mapping different units and perhaps alterations and just getting more information out of those datasets.

[Slide: Quantitative interpretation]

And then we can use that information to put into our modelling.

So here is a serial section out of the 3D Victoria work that we did back in 2011 and a few years before that.

So in the Bendigo zone we created a whole bunch of serial cross-sections and they were modelled using gravity and magnetics as you can see there in the profile data.

We ran some worms as well to give us ideas of dips and created cross-sections which then provided a framework to build our 3D models.

[Slide: Quantitative interpretation - 3D Model]

And that’s what the Bendigo 3D model looks like, so down in the corner there in the left you can see a cross-section of the whole state-wide model, a slice through that.

And these are some other pictures of the Bendigo zone models, so it’s 1:50,000 scale model, but it gives us a great idea about those crustal features that Ross was talking about and how that gold is being tapped from the deeper crust.

[Slide: Magnetic inversion modelling]

More recently I’ve done a little bit of other modelling as well, mainly around the Heathcote Volcanics and the antiformal stacks, so these are a bunch of magnetic inversions.

And you can see the profiles there, so what these were showing is that the west dip of the volcanics and the faults is actually overturned around the antiformal stack and just north of it.

These are the blocks that were modelled.

[Slide Magnetic inversion]

And I’ll just run a quick little video to give you a bit of a 3D view of that.

So here’s our magnetics on top with the seismic section and you can see that those dips of the bodies line up really well with we’ve interpreted in the seismic and what we see in the seismic.

And as you get further to the north it appears that these blocks are actually becoming overturned.

So that north-south compression that Ross was talking about, if we apply that to this it appears that west dipping belt is actually where it’s being buckled, it’s being overturned as well.

So we have the megakink in the south and the antiformal stack is expressions of that compression.

And in this sort of region here you can see that those bodies are being overturned, the antiformal stack, both limbs of it appear to be dipping to the south, and so we can infer perhaps a, well there’d have to be a fault there to take up that displacement within the turbidites.

We’ve seen it at the Tooborac Megakink, and presumably there should be one associated with the antiformal stack as well.

And surprisingly enough, or not, it actually correlates quite well to the location of Fosterville and the Lockington prospects as well.

You can see that’s overturned cartography there, the gravity on top and our 3D model faults that were produced as part of 3D Victoria.

And you can see that we’ve actually – we didn’t have this information at the time, we didn’t do this modelling, but if you look at this sort of area here, you can see that we probably need to revisit that and update that model as well based on some of this new information.

[Slide: Are regional transpressional NW-trending structures a secondary control on mineralisation?]

So we’ve got these structures that we can see inferred from the modelling and actually mapped in the south there, and perhaps they are associated with mineralisation, secondary structures that control where that mineralisation along the north-south compressional faults is being concentrated.

And perhaps there’s a whole bunch of other ones that we seem to be able to get a feel for out of the data, so hopefully some new high resolution data we’ll be able to shed more information and more light about trying to map some of these things and seeing how they relate to mineralisation.

[Slide: Summary]

So in summary gravity is a great dataset, the regional interpretations would not be possible without it basically, but there’s room for higher resolution ground grab or airborne gravity which will just provide a way better targeting tool.

The magnetic data is limited in its use, but again, as I’ve shown with the Heathcote fault we can use that then to – the results out of that modelling can inform some of the other interpretations as well.

And we need to better understand what is causing some of these responses in the turbidites data that we see.

And 3D modelling and geophysical modelling and petrophysics can all play a part in trying to help us do that.

And these north-south structures are they related to the mineralisation and controlling whether mineralisation is occurring.

So thank you.

[Slide: Geological Survey of Victoria]