**Video Transcript**

**Goldfields Tender Briefing geodynamics and Implications for Gold Prospectivity**

*Cameron Cairns - Manager of Mineral Geoscience with the GSV*

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

So I’ve got the pleasure of introducing four very high quality presentations this morning.

I’ve been lucky enough to have a sneak peek at some of them, so I think you’re going to get a lot out of them, both around the tender area but just gold in general in Victoria.

So as I was saying to a couple of people this morning, there’s some incredible amount of exploration meetings going to the ground in Victoria at present, and a lot of exploration spend, so it’s very, very buoyant.

Small fact for those who may not know, so we’re in Treasury Theatre which is attached to the Treasury building just out the front there which was built 1858, or between 1858 and 1862, and that was built to house all the gold that came out of the gold rush in Victoria.

So there’s a number of vaults in the bottom, you’re free to walk in there and have a look at them, so if you get time maybe later today, but yeah, it’s quite interesting where we find ourselves right now in a new wave of gold exploration and discovery in Victoria.

All right, we’re going to move on to presentations.

As I said, fantastic presentations coming up, they draw on pre-competitive work and data and knowledge both from past and present, GSV workers and also applied research that’s been undertaken in Victoria over a significant period of time.

I’ll welcome to the stage Ross Cayley for our first presentation.

Ross is a Senior Geologist with the Geological Survey of Victoria, and Ross is going to be speaking on the geodynamics, so as I said, Victoria and South Eastern Australia, and the implications for regional gold prospectivity.

Thanks Ross.

[Slide: North-central Victorian goldfields: Tectonics, geodynamics and implications for regional gold prospectivity]

*Ross Cayley - Senior Geologist GSV*

Okay, so Cameron’s already introduced my talk.

I’ll apologise in advance I’ve got a cold, that’s how hard we’ve been working for you guys to try and understand Victorian gold, but we’ll crack on.

[Slide: Logos of different organisations that GSV had had collaborative dealings with]

This sort of work can’t happen by itself.

So the geological survey’s a very small team but we are very, very collaborative.

So over the last 30 years or so we’ve had long-standing collaborations with Geoscience Australia, other geological survey organisations, academia, various different funding bodies through C Linkages and by other means, collaborative research groups like the pmd\*crc and today we’re still working with all these groups just to try and understand Australia’s geology a bit better.

[Slide: The Tasmanides Orogenic System in Eastern Australia]

So what we’re talking about of course is the Bendigo Zone.

The rocks in the Bendigo Zone are a part of Tasman Fold Belt System and the Lachlan Fold Belt System, so these are rocks of oceanic origin that were sort of accreted onto the eastern edge of Australia starting about 500 million years ago in a series of orogenic cycles since then, going through to about 200 million years.

These rocks are really widely exposed but really the only world class in Tier-1 gold orogenic gold deposits are turning up in the Bendigo Zone, and that’s pretty interesting because of course that’s where the tender is.

So even though the rocks themselves don’t look that amazingly different from all the other rocks around eastern Australia, they are amazing in their orogenic gold endowment so there’s something interesting going on there, and that’s what I’m going to talk about today.

[Slide: Talk Outline]

So this is the talk outline, we’ll just step through it one step at a time.

What’s a world class of Tier-1 orogenic gold deposit look like when you drill into it?

[Slide: Significant Drill Intersections of 2017 - Common commodities]

It can look like that.

So this is one of the announcements from early intersections into the Swan Zone, 15m at 1500 grams a tonne for 340m, and then we’ve had lots more drill holes that look similar.

One of the world’s best intersections, I think it was the world’s best intersection for 2007.

[Slide: Kirkland Lake Gold Ltd]

This is a reminder of what made Victoria the city it is today, Melbourne the city it is today.

This is what was happening all over Victoria in the 1850s and 1860s as people stumbled onto these really rich orogenic gold deposits and just tore gold out of the ground and made an absolute fortune.

[Slide: Specimen from Swan Lode, Fosterville Vic]

This is the sort of stuff it looks like.

Now somewhere along the way people forgot about the possibility of success in these sorts of deposits, and so it’s great that something like Fosterville’s happened to remind everybody of really world class goldfields can look like here and how many there might be and how hidden they might be.

[Slide: Talk Outline]

So in order to give it some global context, how good it was and how good it can be, there’s a few statistics and fun facts.

[Slide: Satellite view of Victoria]

So this is the bit of Australia we’re going to be talking about mostly for the rest of the talk, it’s Victoria.

[Slide: Victorian Seamless Geology map]

That’s the geology, orogenic gold is sort of confined to the bluey-purpley rocks or the yellowy-greeny rocks are sort of cover on top.

So total all-time gold mined globally is almost 200,000 tonnes.

Victoria’s recorded gold production is about 2,600 tonnes minimum, but probably over 3,000 because so much of the early gold wasn’t recorded.

That’s about 1.5% of all the world’s gold but from a tiny surface area.

The productive goldfields are just 0.03 times of the global land area.

So what that means is Victoria’s goldfield geology is orders of magnitude 100 times richer than the global continental average, something really unusual is going on here, especially when you consider that the rocks themselves don’t look that amazingly unusual.

[Slide: Old photograph of miners - fun facts]

That’s why old-timbers were able to find this stuff.

The fun facts, the only goldfield that have actually produced gold are ones where they’re exposed serendipitously to the surface today, and they were discovered by people who basically couldn’t read, and if they could read they certainly didn’t know much about geology, but they were good a panning for gold.

Our modern understandings have taken some of those deposits and extended to depth for real value, and there’s a few great modern examples of exactly how that can happen.

But in terms of finding a completely brand new blind new gold deposit, that hasn’t happened in Victoria, but we know they can be there.

[Slide: Photograph of Fosterville mine]

And Fosterville gives you an idea of what they can look like.

Of course the old-timer’s stuff is still there today and you can still see some of that stuff just in a time capsule in parts of Victoria, especially parts that you have to walk to get to.

Another fun fact, we just haven’t really applied the full predictive power of modern geoscience to Victorian goldfields yet globally.

There’s abundant opportunities to find blind ones including in exposed brownfields, and Fosterville level strikes that potential.

But yet to find gold estimates for Victoria are really focused on under younger cover estimation, so looking at a surface area of the area under metavolcanics or underneath the Murray Basin.

They haven’t really consider the idea that the brownfields can contain blind world class deposits.

Undoubtedly it can and we just have to get smarter at trying to work out how we’re going to find those things, and you can sort of see what they might look like.

You know Fosterville’s virtually blind, the historic production was very low but now it’s world class.

[Slide: Talk Outline - Victorian Seamless Geology]

Okay, so zooming into Bendigo, really we’re going to be talking about this little bit of central Victoria for a fair bit now looking at the geology of Bendigo.

[Slide: Map showing position of all the major goldfields in the Bendigo Zone]

So here’s a geology map sort of simplified, showing the position of all the major goldfields.

And they’re colour coded by what we think their age is, and that really relates to the age of the regional deformation and the gold seems to be coming in quite late in the regional deformation.

So green orogenic gold deposits either formed during the Benambran orogeny, sort of 440-430 million years ago, quite late in the following process.

The Melbourne Zone’s got a younger structural history and so it’s gold deposits seem to be younger.

And there’s a zone of overlap between the two, and you can sort of see that Fosterville there is FOS in the centre of the map there, kind of shows that overlap, where you’re getting some of the younger style deposits in the older Bendigo Zone terrain.

That effect might be more widespread.

This paper is from 2011.

Our understanding it’s grown heaps since then.

But in terms of thinking about a structural system with congruent gold mineralisation of fold, you can see that they’re domain or separated by this large crustal scale of faults, so it’s the Moyston fault in the west in red, and the Heathcote fault in central Victoria, separating up these areas of different geological history and different gold mineralisation age.

[Slide: Lachlan Supergroup]

If we have a look at the dominant rock type in the Bendigo Zone and the Stawell Zone, in here essentially they’re turbidites, dominated by deep marine siliciclastic sediments that have been folded.

And what’s interesting about these rocks, is that when you look at the rocks themselves away from a goldfield they’re not inherently rich in gold.

So there are black shale horizons in there which are pyritic, and that’s potentially source of gold and undoubtedly a little bit of gold comes out of there.

But looking at the whole state and whole of eastern Australia, the relative stratigraphic abundance of black shale is anti-correlated with the goldfields.

So for example, eastern Victoria has so much black shale it’s called a group, the Bendoc Group, but there isn’t nearly as much proven gold endowment in eastern Victoria, so there’s something else going on.

Looking at turbidites, this is some of work Frank Bierlein did where he categorised different potential rock types and their capacity to deliver gold when you heat them up and metamorphise them.

Turbidites aren’t the worst rock, granite’s the worst rock, but it’s almost the worst rock.

So if you have to think of a scale of 1:100 in terms of its capacity to deliver gold it’s pretty much one, it’s not that great in terms of its capacity to deliver gold, there’s something else going on.

[Slide: Map showing position of all the major goldfields in the Bendigo Zone]

So the turbidites aren’t the only rock type in the Stawell and Bendigo Zones, there’s also rocks that sit stratigraphically underneath turbidites.

And what are they?

Well they’re deep marine rocks so you’d expect there’d be oceanic rocks underneath, and in deed we do see this oceanic rocks coming up in the major faults where they’ve been uplifted towards the surface, so Dja Dja Wurrung super group.

[Slide: Major faults expose Early Cambrian MORB, BABB and boninite, deep marine setting]

And what do they look like?

Well they’re sort of igneous, mafic igneous rocks, basalts and sills and related gabbros and dykes.

And if they were on the sea floor you’d get these pillow structures which form in modern rocks in subaqueous environments, that’s from Heathcote on the left there.

This one’s underground at Stawell and [0:09:42] pillow basalts there as well.

The ones at Stawell have been squashed a bit, they’ve been deformed, so they’re a bit more deformed.

The context of these rocks as a deep marine, middle of the paleo Pacific Ocean setting, is confirmed by things like this pelagic siliceous shale called the Goldie Chert which is also Cambrian.

So these rocks are formed in the open ancient paleo Pacific Ocean, the deep marine environment, miles from the continent.

They weren’t getting any continental detritus, they were just forming these silica oozes and stuff for millions of years and now they’ve got turbidites on top.

[Slide: Graphs showing possible source of gold]

Now what’s interesting about those rocks is they are a possible source of gold in and of themselves, so there’s been a bunch of work done on this that showed that to be the case, especially interflow sediments where you’re getting volcanic massive sulphites associated with volcanic eruptions.

So when you think about the range of gold, sort of capacity to deliver gold, they’re more like 10:100.

So they’re sort of 10:100 times better than the sediment that’s sitting on top of it.

[Slide: Talk Outline]

So that’s the Bendigo Zone, the basics, looking at the basic geology.

But those rocks have become deformed in that part of Australia, in order to understand that we have to understand the regional tectonics.

[Slide: Mineral Exploration Fairways]

So we’ve got this map of the mineral exploration fairways for Victoria, and we’ve attributed the whole different bits of the geology and different potential economic type deposits that might be in those rocks, or they seem predisposed to.

And the reason we have created this map because we’ve had a think about the geodynamics and tectonics that have made geology the way it is in Victoria.

[Slide: Benambran deformation - Late Ordovician]

So here’s a stripped back map showing the basic structural elements of the geology.

So without going into too much detail, the arrows refer to the direction the faults were verging, or the opposite way that they were dipping, and the age is the colour code.

So because of the changes in the direction of those arrows, back in the 1990s, so academics Dave Gray and Dave Foster, came up with a really good model and said well we think it’s all subduction related, as all these subductions are causing the deformation, and the different geologies are caused by the different dips of the subduction zones.

It’s a pretty good model but it does imply that the whole of eastern Australia is just ocean crust that’s been attached onto the eastern edge of Australia, and some of these rocks, especially the Bendigo Zone, don’t look like they were formed in a classic subduction accretion environment.

They don’t have the right textures and deformation history, so there is some ambiguity there.

So we’ve always been interested in testing this model, so one of the things we’re interested in is the area of young deformation in central Victoria.

In their model, in the subduction model it’s young because it was the last bit to be drawn into the conveyor belt of the subduction zone, but we thought maybe there’s something else going on.

The history there is very different, so we looked at the geophysics.

[Slide: TMI DATA IN Bass Strait pointed us towards …]

And what we found is that old continental crust of western Tasmania comes under the centre of Victoria and is sitting underneath central Victoria.

You can see it in this magnetic data coming under Bass Strait.

So obviously magnetics isn’t enough, you have to test these ideas.

So we went to outcrops where we could see these magnetic Tasmanian rocks at the surface and we traced them into Victoria.

[Slide: Waratah Bay, Victoria: part of Western Tasmania]

So here’s an outcrop, underneath the hammer we’ve got these deformed rocks, so they’re magnetic volcanic rocks that have been trashed up, they’ve got strong folds in them and stuff.

But then there’s an unconformity on top of that, there’s quartz, cobbles and pebbles and lithic fragments, so it was in a continental setting because that’s where quartz, cobbles and things come from, they’re coming out of rivers and whatnot.

[Slide: Graph showing different periods of orogenies]

When did that happen?

Well we’ve got fossils, that tells us it happened in the Cambrian, in this period here.

This is a time space plot for the whole of eastern Australia from west to east and from south to north.

Now what’s important about that unconformity underneath central Victoria in the Melbourne Zone, is it doesn’t exist in the Bendigo Zone.

So in the Bendigo Zone the rocks right next door didn’t see this deformation, weren’t in a continental setting or a deep marine setting, completely different.

And you also see this all through the rest of eastern Australia, so something really interesting is happening under central Victoria that relates to Tasmania, and it’s completely different from all the surrounding rocks.

[Slide: Offsets between near-surface over-thrust Selwyn Block margin positions compared to influence on magmatism of depth gives crustal scale geometry]

We can map this using geophysics.

These the surface outcrops of the faults overthrust the margins of what we think is this western Tasmanian block.

Now what’s really interesting about that is you can trace the effects of this margin where it goes at depth by looking at the influence it’s had on melting of granite.

So western Tasmanian crust is old and dry it doesn’t melt easily, so consequently when these rocks have been melted for granites the underlying basin hasn’t, and we can see a clear boundary between the areas which have melted to form the magnetic granite and the areas which haven’t.

It’s really, really clear.

This is telling us what the Selwyn block’s doing at depth, it’s dipping outwards from the surface positions of these faults.

And so this is a first clue as to the extent of this system at depth.

We can also do the same for the fault that separates the Lachlan from the Delamerian further west, and we can also see a bit of an effect there.

So there are things going on in the deep crust you can even see in the magnetic data.

[Slide: One hypothesis: Corridors of gold prospectivity]

And this led to a model where people were thinking so there’s corridors or orogenic gold, they’re related to these underlying ramps of the Selwyn block.

So there’s a really interesting ideas.

You can see that that eastern one includes Ballarat, Castlemaine, Bendigo, Fosterville, it includes all the big ones.

Worth testing so we shot some deep seismic over it to see if the first appearance we had off the Selwyn Block was actually correct.

[Slide: Regional deep seismic reflection transects - Selwyn Block test

So here’s our seismic data.

There it is all laid out west to east.

That’s it interpreted.

So one of the hypothesis was is it all oceanic and part of a subduction system in which case it should all look the same, or are there micro [0:14:44] in it in which case it should look different.

So this is the Bendigo Zone all stacked up reflective crust, extends to the surface at Heathcote as those Cambrian volcanics, and this is the stuff under the Melbourne Zone, it looks completely different.

So this tells us that we’ve got some different crust under the centre of Victoria, probably is western Tasmania sitting down there.

We can have a look at this stuff where it sticks out of the ground, including inland in Victoria.

[Slide: Seismic graph of Selwyn Block]

So this is a seismic line in northern Victoria and we can see there’s a whole stack of crust under there which has got a completely different history to the Melbourne Zone and the Tabberabbera Zone, and the upper reflective package that is exposed just south of this line as the Jamieson Volcanics which is Hill 800 which [0:15:22] Resources if finding a Mount Reidsdale deposit in right now, Tasmanian style mineralisation in central Victoria.

[Slide: Western Lachlan Orogen - ca. 455 to 420 Ma]

So in terms of thinking about how these systems work, we are starting to favour these complex systems.

It wasn’t just subduction zones, there was micro continents in there as well

[Slide: Graphs of the Heathcote Fault]

Another thing about seismic it gives you a great idea of where things are going at a depth and starts to allow you to test ideas.

So this the Heathcote Fault over central Victoria.

There’s Cambrian oceanic volcanics thrust to the surface on the fault.

Where do they go?

[Slide: Detail of the Heathcote Fault Zone]

Well the seismic shows they go right down there.

It’s a really coherent fault site, so when we map it it looks coherent for 140 kilometres of length.

And now the seismic shows it just heads on down, it stay coherent right down into the lower crust.

[Slide: Graph of the Heathcote Fault]

In fact you can trace it from the surface where we can map it to the [0:16:06] which is as deep as you can use seismic to image.

That’s 40 kilometres deep.

So this is the scale of these systems, it is fully crustal scale.

So we can take our surface understanding and extend it down to look at rocks that have the same character and density, so you can model these rocks using gravity this is work Phil [0:16:23] did, where he took the densities, we’ve measured from the volcanics and sediments and compared them, and validated our seismic interpretation.

Now what’s significant about this is that these are the rocks that we think could be a potential gold source.

And this new work shows that gold fluids out of these rocks doesn’t have to be efficient.

It could be 0.01% efficient, it will still explain the world class endowment, because we’ve got literally thousands of cubic kilometres of these rocks stuffed down there at the depth where they’ve metamorphosed and [0:16:50] fluids.

That’s Bendigo, that’s Fosterville, we’ll talk about that in a minute.

[Slide: Seismic graphs by Cayley, Gray et al]

With geological understanding, for example that’s our shape from the seismic, this is the estimations that Dave Gray and co-workers did using fossils in the turbidites to constrain how shortened they’ve been, and then undoing that deformation, now we understand the whole system’s thick-skinned, we can apply this template to the whole crust and wind it back through time to see what it looked like and actually unfold it right back to an ocean basin.

Now that’s in cross-section.

[Slide: Cayley graph of Bendigo Zone]

What’s that look like in plan?

Well it’s really about taking the Bendigo Zone and just unfolding it, and when you do that it moves a lot of Victoria a long way away.

This was an ocean basin prior to the orogenic gold belts deforming, and it was some sort of ocean basin with micro-continent stuck in it.

Where did it go?

Interesting question.

[Slide: Talk Outline]

But now we’re getting down to the bit you’ve probably come here for.

[Slide: East-west cross-section through the Fosterville goldfield]

We want to understand these things.

This is a cross-section on the Swan Zone and the Fosterville deposit.

Now I’m not putting it up there because I want to sing the praises of Fosterville, although it is an interesting deposit.

I’m putting it up there because most of orogenic gold field deposits in Victoria look like this one.

They have these bedded faults that dilate where they cut across bedding of opposite dip to varying degrees.

And if you could find a really bit shoot then you can get a really big deposit, provided there was hydrothermal fluid there that were gold-bearing at the time.

So what’s interesting is that the shoots are obviously later than the faults, the folds, they cut across and deflect the faults and folds with reverse senses of displacement.

And most of the dilation zones they put up was towards the sky and that implies that these things are falling in response to compressive stress.

All the work has indicated that since the nineteenth century.

The shoots are often oblique to regional fold trends and that implies that they’re forming in a slightly different stress field to the folds that preceded them and we’ll get to that in a minute.

[Slide: Graphs of Willman et all and Cayley at al]

Going back to our cartoon, what does this mean, compressive stress?

Well basically it means these rocks have been squashed while they were exsolving gold.

So at the left there is a schematic cartoon of some of the seismic.

And basically what we think was happening is as you shorten and thicken rocks you bury them more deeply, and that causes them to heat up.

So for example, for the volcanics, once you heat them beyond 300 degrees, 350 degrees, they go through a greenschist-amphibolite transition and lose a lot of their metamorphic water as fluid and that fluid has to go up and just starts to exsolve fluid as you heat these rocks up, and the gold can come out in those fluids with sulphur.

That’s what we think’s happened in Victoria.

And what’s happened to that fluid?

Well basically (a) we know what the fluids look like because the research has been done on the Victorian orogenic gold deposits, fluid salinities are low so they look like metamorphic fluids not magnetic fluids, and the trapping pressures are quite low and the fluids are quite hot, so they’re fitting all these categories.

So what happens with the fluids is they’re trying to escape out of these rocks that have been buried more deeply, and the utilising faults that are active at the time the rocks have been buried there, the reverse faults, the thing is that what the seismic shows and what the mapping confirms is that these reverse faults where they’re open at depth because they’ve been squashed, steepens the surface where they’re being pushed up, so consequently the steep sections are the faults that you can map at surface are not good fluid conduits naturally because they’re basically being held shut by the very compressive forces that are causing the crust to thicken.

So in the case of all these fluids that have to go somewhere, what happens is they leak up subsidiary structures in the hanging wall above an inflection point.

So in the case of the Bendigo Zone, what that means is that fluid travelling up load structures were leaking up through distributor structures to a site where you can find an orogenic gold deposit.

And it does mean there can be a bit of a disconnect between the structures that are important for fluid transport at depth and the surface positions of the deposits that result from them.

So for example the Fosterville Fault that hosts the area around the Fosterville mine probably isn’t a fault that fluids came up from.

It’s probably some fault at depth underneath the deposit which can’t even see.

It probably doesn’t matter as long as you have the understanding and we can build a model of it which we’ve tried to do.

[Slide: Seismic model of the Melbourne Zone]

Here’s our model.

Here we are in Melbourne.

So this is western Victoria with the seismic lines, so obviously we’ve done a lot of mapping, but a lot of geophysics tests that was deep seismic transic, we’ve gone and built a framework model.

There’s our two corridors sitting on the model showing where the previous ideas of rich gold for the Selwyn Block and Moysten Fault might exist.

We can draw a cross-section through this model and have a look at its geometry.

That’s the section there, see it’s quite divergent.

I’ll put the two corridor sections up on top there.

The idea that we’ve been working on is that the green stones were a source of the gold, they’re most deeply buried in the centre, the fault network is divergent, so consequently fluids are migrating both west and east up towards the surface where you’re seeing the rich deposits of gold.

It doesn’t mean there’s no gold in the centre part either, it just means that we’d have to use a number of different pathways to get there, and I don’t know if that’s a problem or not.

It might not be actually, and we’ll get to that towards the end of the talk.

[Slide: Full crustal section, Stawell and Bendigo Zones]

So we’ve got these full crustal scale of control on the geometry of these faults.

So they’ve got low angle segments at depth, high angle segments at surface and inflection points.

And we can map these now because we’ve got this 3D model.

We can estimate what they look like and where they go, and we’ve done this.

[Slide: Inflection-point mapping, using the 3D model]

There’s some mesh networks for some of the faults we’ve modelled.

There’s the surface mapped positions of the faults confirmed by fossil offsets and stratigraphic offsets.

These are the inflection point positions of the model based on all the data that’s available to us, but of course par for the seismic lines it is an estimation, but there is some other data that helps us constrain it.

And what we’ve done is take those inflection points at depth in the crust and project them to surface positions.

And once we’ve done that we can start doing some statistics to have a look at how things might compare.

[Slide: Rawling et al graph showing 1500m buffer]

So for example, if you put a 1500m butter around the surface fault position, so that’s yellow around red, we get less than half the known gold deposits, so only a really small amount of the large ones.

Now if we do the same with the buffers projected to surface it’s a much better result.

And so this tells us inflection points win as a first pass predictor of gold position.

So it’s something happening in the lower crust that’s more important than the surface expression of the big obvious faults that you see when you’re mapping.

This is a really big breakthrough.

[Slide: Numerical modelling of crustal-scale deformation]

We can model these things.

So now we’ve got these shapes we can build computer models of the same shapes and see what happens when you squash them, try to replicate these things.

And this work’s being done by Morris Leader and various other people at Peter Shaw’s, various other people.

[Slide: generic fault graph]

I’m going to show you a quick rundown of what we can do with these systems.

You can take a system like this, you can put some folds in it to replicate how folds might behave.

The scale doesn’t matter because these sorts of systems are scale invariant, it’s just the geometry that’s really important.

And then we can take these shapes and we can squash them and see what happens.

And what happens is you get dilation of fluid flow in areas where faults change, dip, steep and shallow and do all sorts of different things.

The middle one’s a particularly interesting one, you can see the high fluid flows near the inflection point, and then it tapers off towards the surface because the rocks of the fault’s being pushed shut.

[Slide: Stress field graphs and models]

You can do it with a variety of geometries, a lot of different stress fields.

Why would you do that?

Well because we think it’s got a complex history.

Now we know that Tasmania is connected to Victoria and it’s moved, we can actually start doing modelling about what happens when you move things.

[Slide: Gale simulations of basin closure]

So we can build on Tasmania to the right there and Gondwana to the left and the ocean basin in between and just squash it and see what happens.

[Slide: Various examples of what happens when squashed]

You can do it in computer space.

And when you do that you end up with lots of the same sorts of structures that we’ve seen and mapped in outcrop but at a crustal scale these things are able to be replicated.

[Slide: Talk Outline]

Surely this is going to help us.

Now the last bit of the talk is scaling up, the big picture.

[Slide: Satellite view of Australia - map of Victoria]

The picture you need geophysics for this.

We now have the geophysics.

This is the tilt filter of aeromagnetic data and you can use it to strip off all the younger cover and see where the bedrock that we’ve mapped in Victoria goes in NSW and up into Queensland.

And it allows us to produce bedrock geology maps as a simplified and categorised and what it would look like if there was no younger rocks.

So when you do that you can see where things like the Selwyn Block and Tasmania under western Victoria go, and this is important because it’s a micro-continent stuck in a bunch of oceanic rocks.

What happens when you have a micro-continent stuck in a bunch of oceanic rocks?

[Slide: Geodynamics of congested subduction zones]

We can model that these days, and we did this work in 2014, looking at what happens when you suck a micro-continent into a subduction zone.

So that’s the cartoon and we can run it through time, 50 million years, you’ve got a linear system, a micro-continent gets sucked into it.

It can’t subduct because it’s a continent that’s buoyant, but the bit of the subduction zone that isn’t congested by it continues to subduct and then it wraps around.

I don’t know what happened, and it ends up looking crazy but it takes millions of years to do it.

What does that mean for Australia?

Well what it means is there’s a whole stack of things that you can’t assume about the current shape of eastern Australia, including implications for the gold.

So it means for example, you can have collision directly along strikes and extension at the same time.

You can have giant scale strikes with faults at [0:25:54] scale.

You can have rifting and basins opening up, obviously if you have extension of [0:25:59] basins, and previously straight things can end up really highly curved over tens of millions of years.

[Slide: Cayley & Musgrave in pre graph]

And it can all happen under a common stress field, and we see all these things.

We have these giant strikes with faults, we have sedimentary basins and we have all these crazy high curves.

Now we’ve got a template and geological control and we’ve got a whole stack of geodynamic models that gives us evidence of the processes, the timing of when these things happen.

We can apply these to the present shape of Victoria and eastern Australia and see what it looked like, so that’s what we’ve done.

We’ve taken the current geometry, run it backwards through time using geological constraints, and a common stress field to see how it’s evolved through geological time.

This is through about 30 million years of evolution.

[Slide: Various slides showing the past and present Bendigo Zone]

This is what we think it looked like at the time the goldfields formed.

Now what you can see here is that the Bendigo Zone down in Victoria, is nowhere near the subduction zone, it is trapped between Tasmania and Gondwana.

The subduction materials happening further north.

[Slide: The Lachlan Orocline]

When we draw a cross-section across it, because it’s folded we’re swapping the geometry of everything, so this is a viable alternative for the previous models, it just does it a different way.

This is the scale of it, so we’re working in Victoria but we’re working a truly Australia scale.

This is why people are interested in it, it means that some of the orogenic gold in Victoria was formed in Benambran times, like in the Bendigo Zone and the Stawell Zone, is potentially folded around these things because it proceeded them.

Some of it also though, and including at Fosterville formed during it, and that’s the key part of the story.

So basically part of the takeaway message is Bendigo Zone can be in the Tabberabbera Zone, but there are complications.

Complications, well when the process was half forming you can see what’s happening here is that the subduction zone is trying to subduct the northern Melbourne Zone.

And basically we can see these effects.

We’ve shot seismic over it, that’s this line here.

What we see here is the Tabberabbera Zone thrusting over the crest of the Selwyn Block, and [0:27:49] space through the Selwyn Block and up into the Melbourne Zone and we’ve mapped these faults in the Melbourne Zone, gold fluids could follow these faults just saying.

[Slide: Selwyn Block diagrams]

Basically this region has been squashed north-south at this time.

This is in Silurian they’ve been there for about 20 million years ago.

Some of you may have heard that age before.

What was happening in that system, well apart from anything else we were end loading the Bendigo Zone and starting to buckle it.

So making a cartoon out of it, the system’s wrapping around, starting to end load the Melbourne Zone and Selwyn Block and deforming that, but it’s also deforming the Heathcote fault zone that was there before, formed in the Benambran and it’s buckling it.

There’s an antiformal stack at Rochester, there’s a megakink, there’s flow faults coming off the megakink, there’s potentially a late gold, Fosterville sits on one of those lines.

This is the sort of process.

As the system kept evolving basically it’s trying subduct the eastern margins of the Selwyn Block now, and so it starts shortening the Melbourne Zone and the Selwyn Block is under thrust in the Bendigo Zone and reactivating all these faults.

And in the middle there’s a zone of fold interference, and that has been mapped before.

This is an area that’s covered by [0:28:58] area, the Rochester antiform, some of these flow faults coming off the megakink.

Other geologists here today will be talking about these in more detail.

[Slide: Melbourne Zone diagrams and photographs]

This is what fault interference looks like in the Melbourne Zone.

Early east-west folds over [0:29:10] and north-south folds, but these effects are much more widespread.

They head over into other areas.

[Slide: New Jubilee Mine]

This is the last bit of the talk now.

Looking how it was for any of these effects?

Well I’ve gone about as far away from Fosterville and the northern Bendigo Zone and the tender release as possible just to demonstrate how widespread these effects are.

I could have gone to Stawell, it’s quite well documented there, so these effects extend in to the Stawell Zone, instead of going to a little known deposit, south-west of Ballarat called the Jubilee Reef.

Here’s a cross-section across the Jubilee Reef east-west, so you can see, just like at Fosterville, this just sort of folded, nothing really special there.

But what’s interesting about that is that that cross-cut there is actually a drive.

So what they’ve been doing there is driving along the reef, and why is that?

Well it’s because the reef – so these faults are formed by squashing, but the reef is actually falling parallel to that compression direction, it’s actually striking east-west and cutting across all the folds at right angles.

[Slide: Jubilee C.M.C - Baragwanath 1913]

That was the location of that previous section.

So the reefs are actually at right angles to the folding, what does that tell us?

It tells us that there was late north-south compression causing dilation and quartz mineralisation and east-west trending structures at quite a big scale.

You can see the scale of that plan there.

And this was not an insubstantial shoot, about a few hundred thousand ounces came out of it at least.

What’s interesting is when you look at the vein, it’s all crenulated.

It’s got all these kinks and folds in it.

And what does that tell us?

Well it tells us that after the north-south shortening, there was another event of east-west shortening superimposed over the top and it’s buckled that vein.

Now you may have heard this structural history from somewhere similar like, say for example the Melbourne Zone or the Eastern Bendigo Zone, and this shows that it’s happening all across western Victoria.

[Slide: Talk Outline]

It’s a really widespread system.

[Slide: conclusions]

So in terms of conclusions it’s a world class ground and much bigger than just the tender area.

Some of the Greenfields look like awesome analogues for specific Fosterville structural scenario, I think probably a better candidate on structural grounds but I guess time will tell.

The Brownfields are massively underexplored, particularly when you consider how much better understanding is now.

We’ve got this whole suite of new technology that we can bring to bear.

Structural history is complex but it is possible to sort it out, and it is possible to recognise it, and you can even recognise it in legacy data, and that was the point of my last few slides there.

I think the important thing is just to identify zones of dilation at critical times when there was supply of the most gold rich hydrothermal fluids.

There’s lots of modest deposits around, and Fosterville was one.