20211025 – Presentation Jim Granath - Houston Geological Society – Unofficial transcript

Mon, 10/26 10:20PM • 1:35:42

SUMMARY KEYWORDS
basin, belt, kuru, precambrian, fold, drilled, basins, namibia, section, carbonates, rocks, basement, developed, shows, faults, rift, questions, wells, geologic, africa

SPEAKERS
Moderator, Jim Granath

[intro by Moderator]

Moderator 02:14
Without further ado, Dr. Jim Granath.

Jim Granath 02:20
Thanks, Mark.

Moderator 02:21
Superb. So how you doing this evening?

Jim Granath 02:24
I'm doing okay. I'm going to fire up the presentation. We'll see if we get organized. Can everybody see that? Or have you given me, have you given me control of the slides or not?

Moderator 02:41
You should be able to you should be good to go.

Jim Granath 02:44
Can you see it?

Moderator 02:46
Not yet? No, sir.

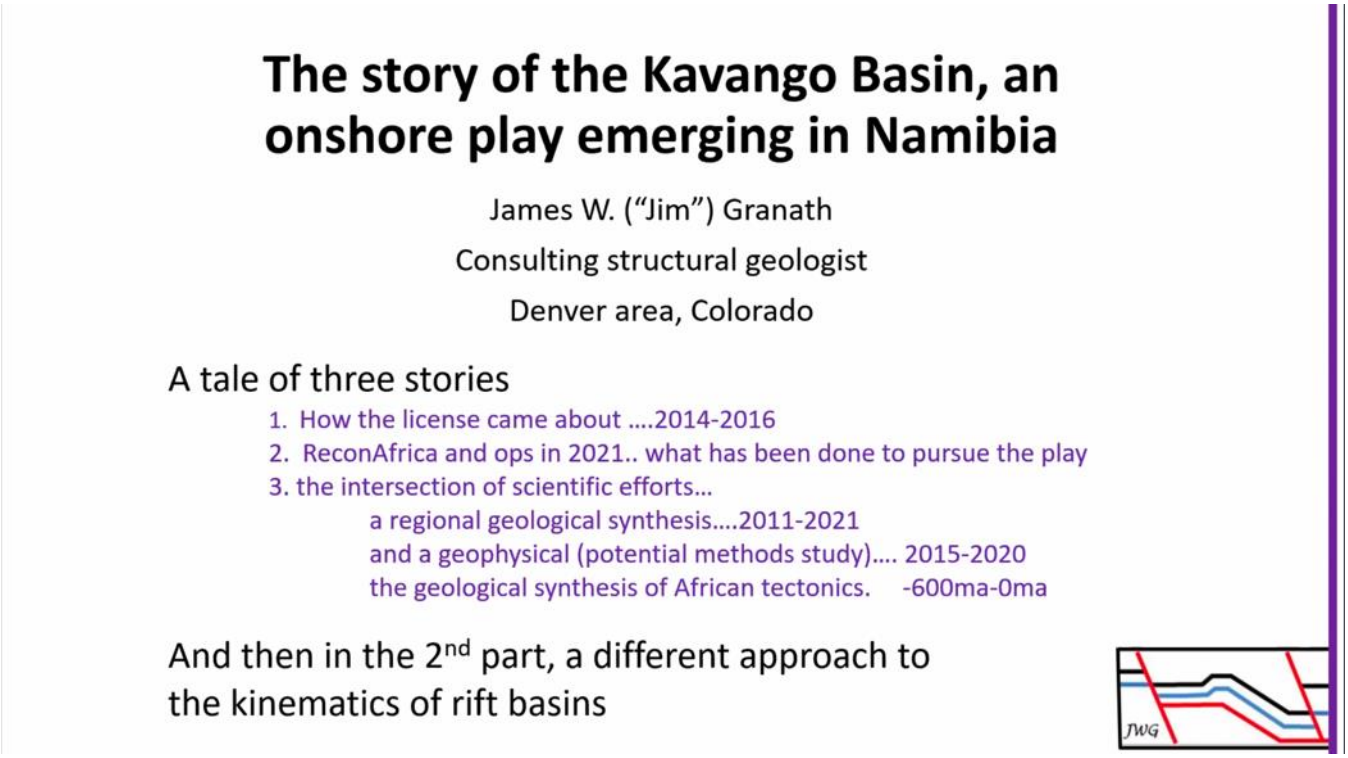
Jim Granath 02:48

All right, then you need to give me the control.

Moderator 02:55
I have given you control.

Jim Granath 02:57
All right. We'll take it. All right, you should see the title slide now. Everyone is that true? We good Mark?

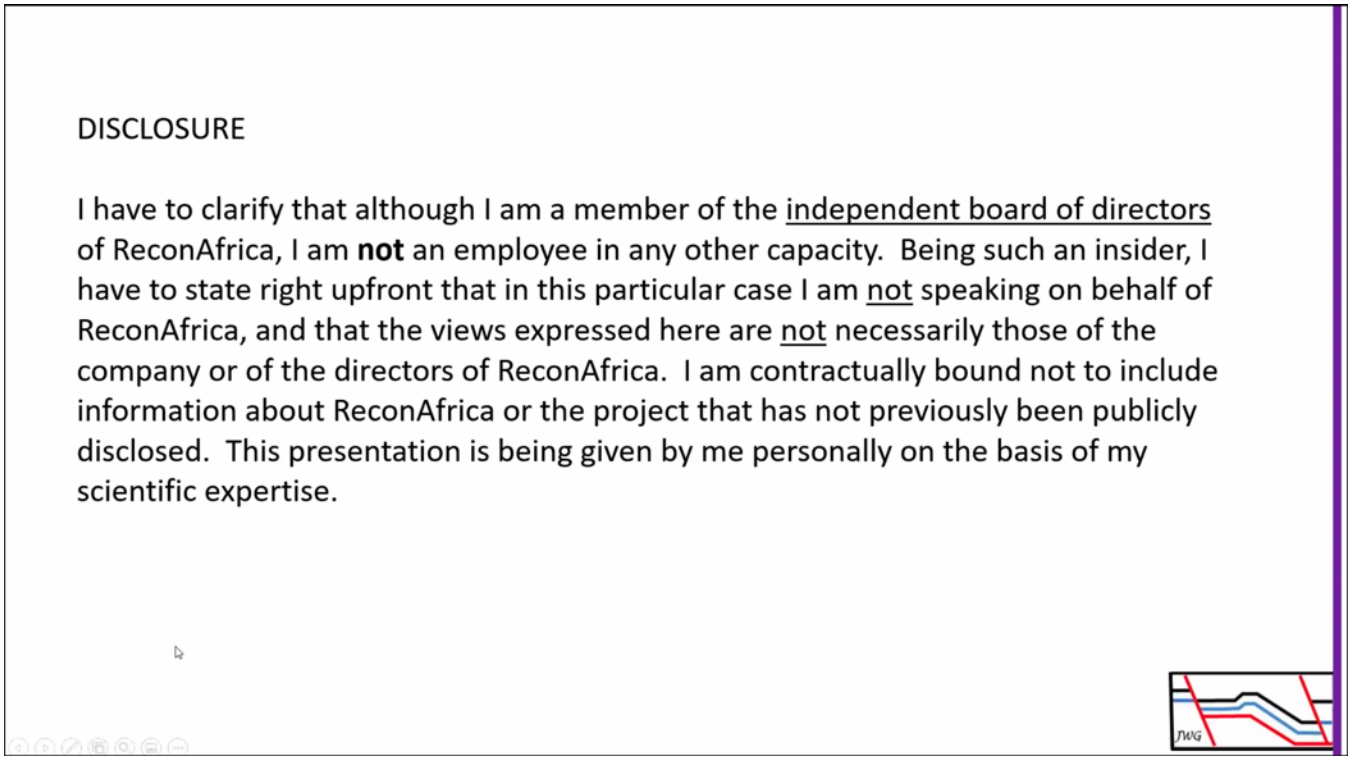
Moderator 03:13
Excellent. Yes, we are.



Jim Granath 03:15
Okay. Let me say I'm pleased to be with you tonight. For this marathon kind of session, two hours is slated for all this. This talk, it'll be in two parts. It'll be first of all, really the story of the Kavango Basin, which is an onshore play that's been emerging in Namibia for the last five, six, or maybe even seven years. It's unusual in the sense that it's really out of place in today's time and space. It's more like a basin that would have popped out in 1950 when the [inaudible] boys found it. But since there's no outcrop no wells, no seismic data, it took some interesting interpretation to elucidate it, separate it from the Owambo Basin.

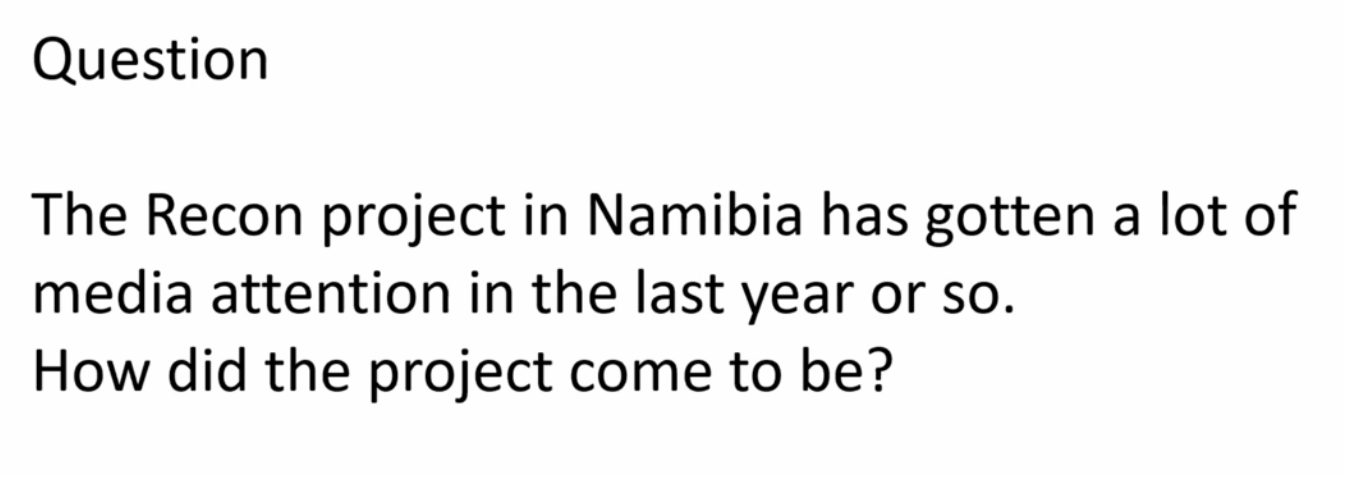
Jim Granath 04:07
And so tonight, I want to tell really three stories, first of all, how the license came about in 2014-15 or so. The operations that have taken place with ReconAfrica in the last year, year and a half. What's been done to pursue the play, and particularly we're talking about this tonight, because there's been a

lot of media interest in this, it created quite a sensation on a number of fronts. And then I'd like to develop the idea of why the play even exists: the regional geologic synthesis that led to it early on, geophysical potential methods studies that contributed to that and dovetailed with it. Finally put it in the context of geologic synthesis of African tectonics from about 600 million years ago to today. It's an unusual situation in that regard too because it involves the basement of the African continent. And we should be able to field some questions if anybody has them. Please write them into the chat box. And we'll pick them up as we go, we'll stop in places to, to pick them up and take care of them. I won't be able to watch my screen and talk and keep track of that. So Mark will be monitoring that. It would be useful if you hit the Raise Your Hand button somewhere, so you can alert us that you've got something in there now. Then we'll have an intermission. And then we'll come back for a heavy structural geology session, which is some thinking about the development of risk basins that's developed. As over the last few years. Almost all of this material has in one form or another been shown at various meetings. But I'd like to thank the HGS for giving us this opportunity to synthesize it all in one place during a time period, a time slot where we can actually develop the ideas rather than just gloss over them. I would also like everybody to realize that with the interest that this project generated, which was quite surprising to me, we probably have not only the HGS professionals on the line for which this talk is is aimed. But we probably also have members of the investor community, maybe even some regulators, maybe even some lawyers who are looking in for various reasons. And so with that, I have to say, Oh, come this, there we go.

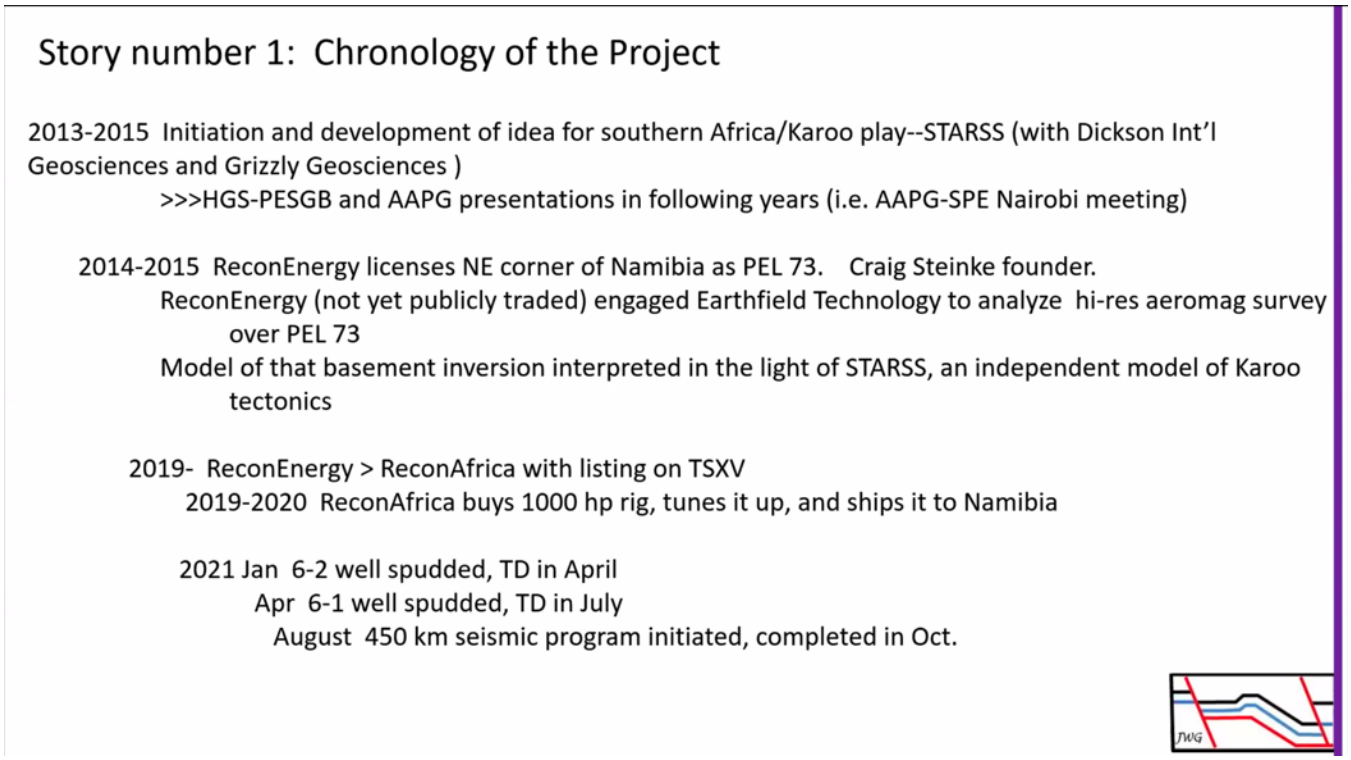


Jim Granath 07:02
I have to put some sideboards on our discussion tonight. And disclose to everybody that although, and it's public knowledge that I'm an independent board of directors member of the ReconAfrica company, I am not an employee in any other capacity. What this means is that I'm bound by the contracts that

ReconAfrica has with the country of Namibia. And also that I'm not necessarily privy to everything that's been taking place with regard to the data that's coming out of the project. So tonight, I'm speaking on behalf of myself, and not particularly ReconAfrica, because I'm putting the play that originated before ReconAfrica in the context of the modern, or the current controversy about it. Particularly people in the North American business, and some investors, and maybe lawyers and regulators might not realize that in the international oil and gas industry, almost exclusively of the United States countries own their own resources and they own their own data. So an operator is basically just operating as, as a contractor on behalf of the country involved. And so a lot of the information that they have not released by Namcor, or the Mines and Ministry of Namibia is out of bounds. So we have to stick to almost exclusively public information.



Jim Granath 08:48
So as we go along, I'm going to sort of prompt myself and you with some questions. So the Recon project in Namibia has gotten a lot of media attention in the last year or so. Let's start out with a little bit of an explanation of where it all came from.



Jim Granath 09:07
So this is Story number one, the chronology of the project. Back in the early 2010s, probably about 2010, 2011, 2012. Bill Dickson of Dickson international Geosciences and, and Mark Odegaard, who's Grizzly Geosciences in Montana and I, started out on a project that we called TFA. Tectonic Fabric of Africa, you'll see a lot of products of that project. It's a multiclient available project that's been going on for a number of years. And the ideas for Southern Africa and particularly the Karoo play in general that we call STARSS, I'll get to that in a little while, came out of that. There were a number of HGS-PESGB Africa conference presentations and AAPG-SPE presentations over the years and in various meetings. But they're also overall nice little 20 minute slots. I think I got a keynote in Nairobi once that was 30 minutes. So they don't get a chance to develop things very well. And they particularly for such a diverse audience. Well, in about 2014, or 2015, some of us in Denver were contacted by Mr. Craig Steinke, the founder of Recon Energy at that time, looking for plays around the world. And we steered him to Southern Africa and a couple of other plays. At that time, Recon Energy was not publicly traded. And it engaged in the PEL 73 project, or license that you're going to see in a minute. And engaged Earthfield technology to to reanalyze, some high resolution aeromag, that was flown over PEL 73. I was not involved at that stage. So I was not involved in the licensing or, or actually in Recon Energy prior to that I was simply in my humble little consulting role. So out of the convergence of the STARSS idea with the basement inversion, we ended up with a play model for the Northeastern corner of Namibia that ended up being different from the conventional understanding of the region. And for a number of years, Craig stuck with that trying to promote it trying to get private money to get things going at the time that these different lines of reasoning sort of converged. I had recommended that since there was no subsurface information whatsoever that we just drill a Strat test, or two - and that's that's eventually what eventuated - there was precedent for that stratigraphic test number one in Namibia is a few 100

kilometers to the to the west of the block. Well, around 2019, Recon Energy merged with a company called Lund on the Toronto Stock Exchange on the Venture Exchange and became Recon Africa. I don't know how that marriage came about. But as a result of it, I ended up on the board because things started to move. Right after that, having a bit of a budget, they found that there were no rigs in southern Africa that were suitable to drill hydrocarbon type wells. So in fact, Recon Africa bought 1000 horsepower rig in Houston, tuned it up and shipped it to Namibia. So it's now actually also its own drilling contractor, drilling company, which again is a throwback, we're talking going back. When was the last time anybody had a an operator as their own rig company?

Jim Granath 13:02
So early in 2021, in January, the first well was spudded. It was called 6-2 on the basis of a notional location that we had way back when in about 2016 and it TD-ed in April with some announcements, I'll show you the basis of that, that caused the beginning of the stir. That was TD-ed and then another well 16 kilometers away I believe 6-1 was started immediately afterward and TD-ed in July with an announcement of similar results. And since since July, or since August or so 450 kilometers of a seismic program has been completed. In fact, it was just announced the other day that that was completed. And that was innovative in itself too, it was a throwback, it was an impelled weight drop system paired with modern electronics of course to to be able to get good data.

Moderator 14:02
Oh, I've got a couple questions. But yeah, let's so this is from Jack. Does seismic show the lower Karoo was present and has more section of Karoo then was seen in 6-2? And then also does seismic indicate that the Karoo was buried deep enough to become an oil window, source rock.

Jim Granath 14:30
Well, the second one I can answer we don't know yet. The data's in processing. And so we don't have any definitive answers right now about that. What depth the oil window would be we really don't know. What was the first question mark?

Moderator 14:46
The first question was 'does seismic show that a lower Karoo was present and has more section of Kuru than was seen in 6-2?'.

Jim Granath 14:56
Well, the paleontology in the well indicates that it was lower Karoo and I think that that information's been released. I'm going to show you some data from the well, from 6-2, 6-1 hasn't been released yet. But there really weren't any surprises or anything in it, so. We'll get to that. Any anything else?

Moderator 15:19
Yeah. Then on seismic, can you see the the Mulden black shell marker through the sub basin?

Jim Granath 15:27
Not at the present, the processing is underway, and we don't quite know what's what yet. That needs to be processed and tied to the well and then interpreted.

Moderator 15:38
Okay, and then I guess I can do this as well as the Mulden was not seen in 6-2 this section? No, we won't do that.

Jim Granath 15:49
I'm going to comment about what we've seen in 6-2, there's been a lot of confusion about that. The section in 6-2 below the unconformity, in other words, the carbonates was very highly folded and standing up on end. So we don't, we don't know how much section is actually involved. It may be a very narrow part of the stratigraphic section that had drilled down more or less parallel to the bedding. And, and so we don't know where in the pre-rift it sits. It may be Otavi, it may be Mulden. I think we're going to clarify what Otavi and Mulden mean, as we go along tonight. Okay, so put that question off for a moment. I see a question on there about the geochemical analysis. I can't answer that. I'm not privy to that. I know we were unsuccessful in separating any biomarkers.

Moderator 16:53
What about frequencies of seismic sources?

Jim Granath 16:57
frequencies of seismic sources? What do you mean?

Moderator 17:01
Can you expound on your question? Please? Victor?

Jim Granath 17:11
The frequency content of the signal? I don't I don't off-hand know the answer to that.

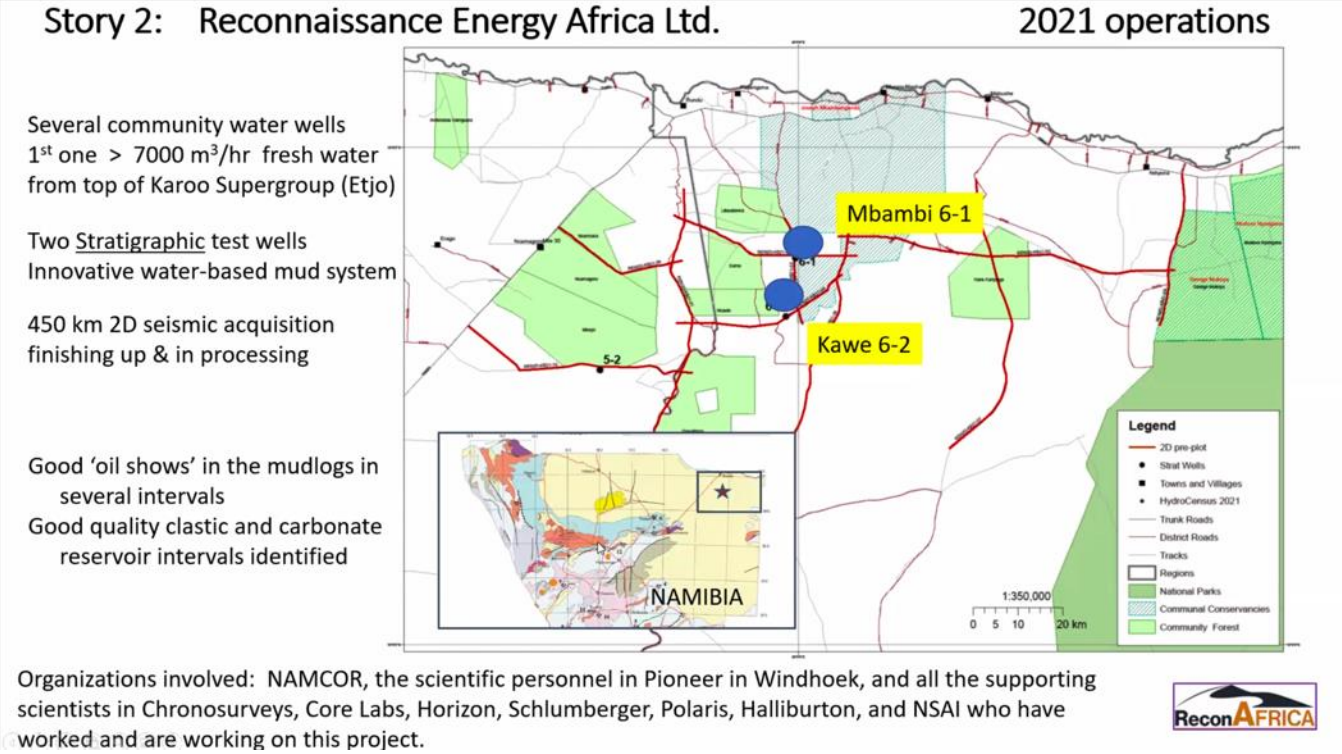
Moderator 17:19
Yes, please. Okay, superb.

Jim Granath 17:21
Yeah, I don't know what the frequency content of the source was. That would be a question for the acquisition crew. Anyway, so let's go out I think we'll get to a lot of these things as we as we go.

Question

What operationally got it to this particular moment in time?

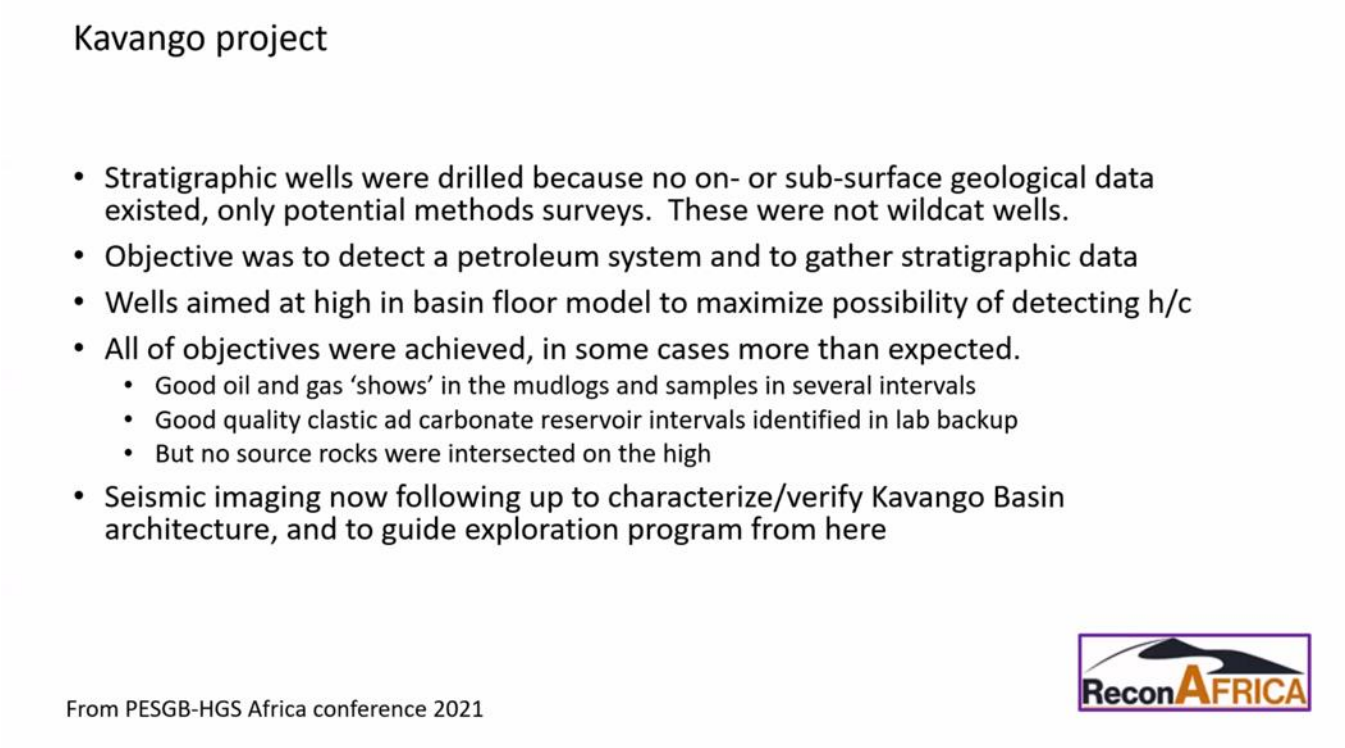
Jim Granath 17:36
So the question is what what operationally got the project to the, to this particular moment in time.



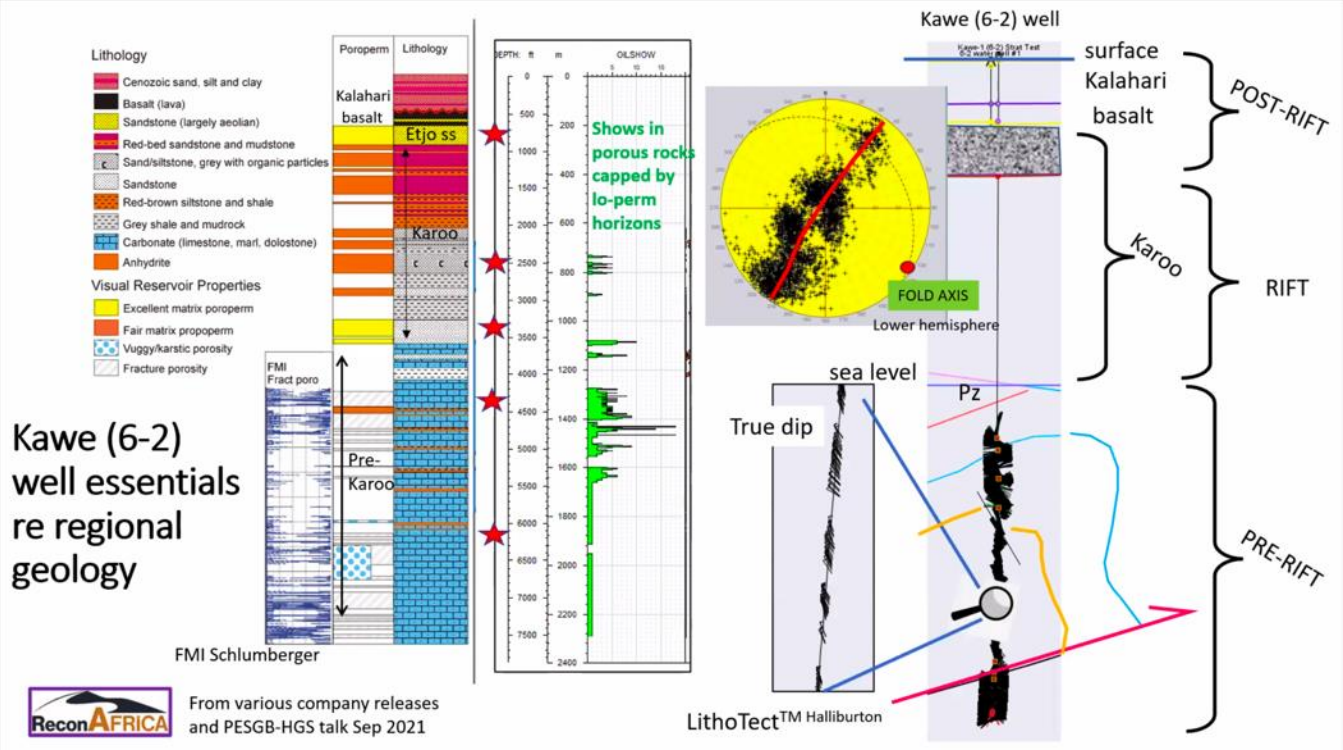
Jim Granath 17:45
Okay, so here, here's a map of the the basin or a map of the permit PEL 73. Most of it anyway, in the inset map here we've got the geologic map of Northern Namibia, with the location where the permit is and the star is where the two wells are located. The two wells are the blue dots on the bigger map and the 450 kilometers that has been acquired are in the red lines and they've just just recently finished over here in the east. So during 2021 Recon drilled, it says several here but by the last count a couple of days ago, there were 14 water wells that were drilled for the communities in the region. Only two of them were really used for any operations, as the type of wells we drilled didn't need a lot of water. It

was remarkable that the first well, and all the other ones are similar to it, produce 7000 cubic meters per hour of freshwater. In fact, we have pictures of our own management drinking directly out of the well. The water came out of the top of the Karoo supergroup, the Etjo, at a couple of 100 meters. So the two stratigraphic tests wells were drilled and there's been a lot of flap about that, it used a biodegradable water-based mud system. And the pits were lined with spray-on type liners, they weren't just plastic liners they were a little like Flex Seal if you watch TV or a little like the lining that's being added to farmers' and ranchers' water distribution systems here in the West to minimize loss. And then there were 450 kilometers of 2d seismic, finished up recently and it's now in processing. Again, it was an impelled weight drop. And it got well variable but I think the minimum fold we got was 200 and the offset was was quite a few kilometers since we were trying to get some steep dips, but we'll see how that goes. The results were good oil shows in the mud logs at several intervals. In parts of the carbonates there was oil on the shaker. Subsequent work by some of the supporting lab organizations have shown that then with the plugs was that the reservoir intervals had good porosity and good permeability, and I'll show you some of the summary stuff from one of the wells in a minute. Here's a list of the organizations involved NamCor of course is the licensing organization for the block. They're also partners, they signed on as partners. The scientific personnel of a consulting group in Pioneer, called Pioneer in windhoek. And then scientists in Cronosurveys, Core Labs, Horizon, Schlumberger, Polaris, Halliburton and Netherland Sewell have all contributed to various aspects of the, of the project.

Jim Granath 20:59
Now, right away on this geologic map, you can see something that's very strange, and it's been bothering me for years. The blue on that map is a band of Otavi carbonates that are at the surface by reason of being in a fold belt. And it's a fold belt, just like the Appalachians or thrust belt in Wyoming, or Algeria, or Zagros, or whatever. And they front, the crystal and rocks which are in gray and the pinks and oranges, which is the core of a mountain belt that's about 500 million years old, then it goes over to just stops here. It stops as it goes underneath cover, which is this pale yellow, and pale yellow is the Kalahari sands, the famous Kalahari sands. This is Etosha National Park right up here, the famous Kalahari sands that cover a good portion of Central Africa. They of course, are Neogene, and current. So to have this full belt, just go and stop, like that implies that it's disappearing under cover, and then it continues. So part of the reason the play came about was the observation that this has to figure somewhere in the the geology of Northern Namibia, that has not been elucidated previously.



Jim Granath 22:21
Alright, so the project was stratigraphic wells, the objective was not to test a prospect. The objective was to sample the stratigraphy since it was nowhere else available. And to see if there were any petroleum system indications. And so the wells were aimed at a high in the basin for model that I'll show you in a little while, with the logic that if you drill near the high, you've got a chance of maybe picking up some shows coming or some hydrocarbons passing by. And all of those objectives were achieved, in some cases, more than expected, the good oil and gas shows in the mud logs and on samples were more than you would normally call shows. And then the good quality source rock in both the carbonates and the overlying Karoo was encouraging. I got to admit that this, these oil and gas shows are migrated hydrocarbons, they are not hydrocarbons in place. And we didn't find any source rocks in the sense of being able to sample the stratigraphic column and say, Aha, here's our kerogen. So that's still to be to be determined. Right now, the seismic imaging was decided to replace the third well, because of the success in these things. And so now we're, we're after some idea of the, of the details of the Kavango Basin architecture, and to guide the exploration program from here on out. What's next, and those decisions are, are in management.



Jim Granath 23:58

Okay, so the 6-2 well, that was the first well that was drilled after it started to be drilled and picked up the name Kawe. And here are the essentials of the geology. In the column of lithology, here drawn by Ansgar Wanke for us, it shows the Kalahari sequence of sands and mudstones overlying a basalt which is probably the Cretaceous basalt or equivalent to the Eton Deka if you're at all interested in Namibia geology and then that lies over on top of the Etjo sandstone. This is the sandstone that produced the water in the wells. And it's the top of what's normally considered to be the Karoo section. Below that is a sequence of upper Karoo, which is red bed, going into stuff in the lower part of the section, which is more gray and colored gray as well. And it's a mixture of different kinds of lithology. Some of them are terrestrial, many of them are terrestrial, and some of the lower ones down at the bottom of the section ordinarily would be Periglacial but we didn't get any Periglacial stuff in this particular well. Then there's an unconformity in several intermixed lithologies of sandstones and limestones and a shale. And then going through another unconformity, we're uncertain of the age of this upper part of the carbonate section, that's probably Paleozoic lying on top of the line below the Karoo. Karoo, of course, is Triassic to Jurassic, actually Permian to Jurassic. That's probably Paleozoic, indications from [inaudible], or that it's probably [inaudible] of some description. And then below that, we go into the folded up carbonates and anhydrites. And some of the problems with doing the, the Petrophysics was, first the recognition that there were anhydrites in here rather than other lithologies. And unlike the bedded nature that is shown in here, it's actually standing up on end, I'll show you the structure in a minute. In the second column from Dan Jarvie's shop is the shows in the porous rocks kept by low perm horizons, all of the levels in green, where the spread of the different shows and you can they extend quite a few distance and down well into the well near the TD. So if we look at the structure of the well, here's a, a slice that I've taken out of my LithoTect project, which is a structural modeling program that some of the audience may be aware of. We have the upper part of the section, the Kalahari and the basalt, we go into the

Etjo, that's just indicated by that, then we go across this boundary and into the mixed clastics of the Karoo, down through the Karoo, on through the unconformity, perhaps some Paleozoic carbonates and other lithologies. And then we get into the lower part of the well where the carbonates were and they're they're significantly dolomitized. And they're mixed limestone lithologies. They look like shallow water carbonates, we'll talk about where they're from stratigraphically in a little while. But plotted on here are these black columns, are just the density of bedding plane determinations from the FMI that was run and the FMI was only run from - because of hole conditions - only run from about the unconformity down from about here. I've sort of blown up one of those to show you the individual readings on the FMI and how steep they are. So what this is saying, and if you plot that up on a stereonet, here's the stereonet of that data. If you've had any basic structural geology, you might remember that a great circle of poles of bedding tells you the shape of the fold and the fold axis. So this is telling us that we have a fold with some very steep limbs going through a sinusoidal spread of of orientations with a shallow plunging fold axis to the Southeast. And then if you start to play with the axial planes indicated by the change in the dip orientations, you can tell that we're on a steep limb, which comes up and flattens over near the top of that. So here's kind of a cartoonish suggestion of the geometry of the of the structure. That fold of course is older, much older than the unconformity above it so we're looking at something that's older than Paleozoic. In terms of the regional model, the post-rift would be the Etjo and everything else which is lying up in here and doesn't show much thickness around the region whatsoever. Above the Karoo Rift, which does show us some stratigraphic thickness changes as we go around the area. And then below that what we would call the pre rift. So we've got some pre-rift and post rift to work with in terms of our our thinking about the models. Alright, I think that's it. The carbonates were highly fractured. Here's some more of the FMI from Schlumberger with the fractures separated out from the from the dips.

Jim Granath 29:57
Are there questions at this time?

Moderator 29:58
Yes, we do. from, from Kinly three questions, I'll go through them all at once. And then one by one 1) expectation for the third well, where do you expect the third well to be? Will the third well be in between 6-1 and 6-2? 2) Given more data do you still think this field is comparable to the Zagros belt that you mentioned in the July interview? Or do you still think they have similar reservoir properties? And then 3) will you go back to the first two wells to do a flow test?

Jim Granath 30:39
I'm, I'm not in a position right now, since I'm not in management to, to discuss anything about plans for the company. All of those things are possible. And I don't think any of the decisions I've been have been made. Of course, the seismic data is going to be processed in about a month that's going to go into a pretty crash interpretation program all aimed at where does the program go from here, and those decisions will be made by management down the road. The remark about the Zagros, let me clarify. There are similarities between the Otavi fold belt down here, and the Zagros fold belt, but remember, they are gigantically different in age. And one point I'm going to make is that they are gigantically different in the level of exposure. The Zagros fold belt is young, it's active right now. And it's basically literally covered by its own Foreland basin. We'll get into this base and stuff later on. So I don't want to

push anything other than the idea that the Otavi fold belt was a long linear arrangement of folds in front of an Orogenics Belt. And it's carbonates, and the carbonates are great reservoirs. That was the only point because people panicked and said, Oh my God, there's nothing in the wells that can produce. Now the world's full of carbonates that produce they're tricky, but they can produce. Does that kind of cover for now?

Moderator 32:25
We have another question. Are you seeing any structural deposition or relationship in the overlying [inaudible] cover with deeper structural highs seen in the ..

Jim Granath 32:36
That's the objective of the seismic data. We'll have to wait and see what the architecture of the whole system is. At that scale, remember, a well is a what, three or four inch diameter straw stuck into the ground, it's hard to to elucidate anything about straddled geometries from that. The Karoo is particularly hard because it's dominantly terrestrial sediments, it's not, mostly not Marine. And so, you know, just from that point of view, and from the point of view of riff basins all over the world, lakes are going to be in the Grabens. And that's where the source rocks are going to be. So you know, you really don't look on the tops of the horse. You don't look, you don't look on the rift shoulders in Kenya to see the lakes. Okay.

Moderator 33:29
And then I'll do a couple more, it seems like we're gonna have a lot, so. Is anything known about the anomalous formation pressures from 6-2 from the drilling data? And that's from Stephen Campbell, and then Jim Taka, if you can, say, are the oil shows shown in matrix or in fractures, or both? So question, one from Steve Campbell, is anything known about anomalous formation pressures from say...

Jim Granath 33:52
I haven't heard anything about extraordinary pressures at all.

Moderator 33:56
Okay.

Jim Granath 33:56
And as far as the the.. I forgot to mention it, but here are the five horizons that turned out to have decent reservoir characteristics. The, as far as I know, well, the the data is actually in the public domain, you can go back to my talk at PESGB and see the chart that Netherlands Sewell put up or you can go to Scott Evans talk about a month ago or so in London. And I mean, this is in this category on the basis of the fact that it's such a good flower of water, it doesn't have any shows but it's a fantastic poro perm rock type. When we got deeper, there were poro perm quality at several horizons some of which didn't have a lot of shows and some of which some of which did. And when you got deep in the well, down in the carbonates, the fracture porosity was substantial. So I think that the permeability measurements from the lab would be enhanced by that second mode of, of permeability.

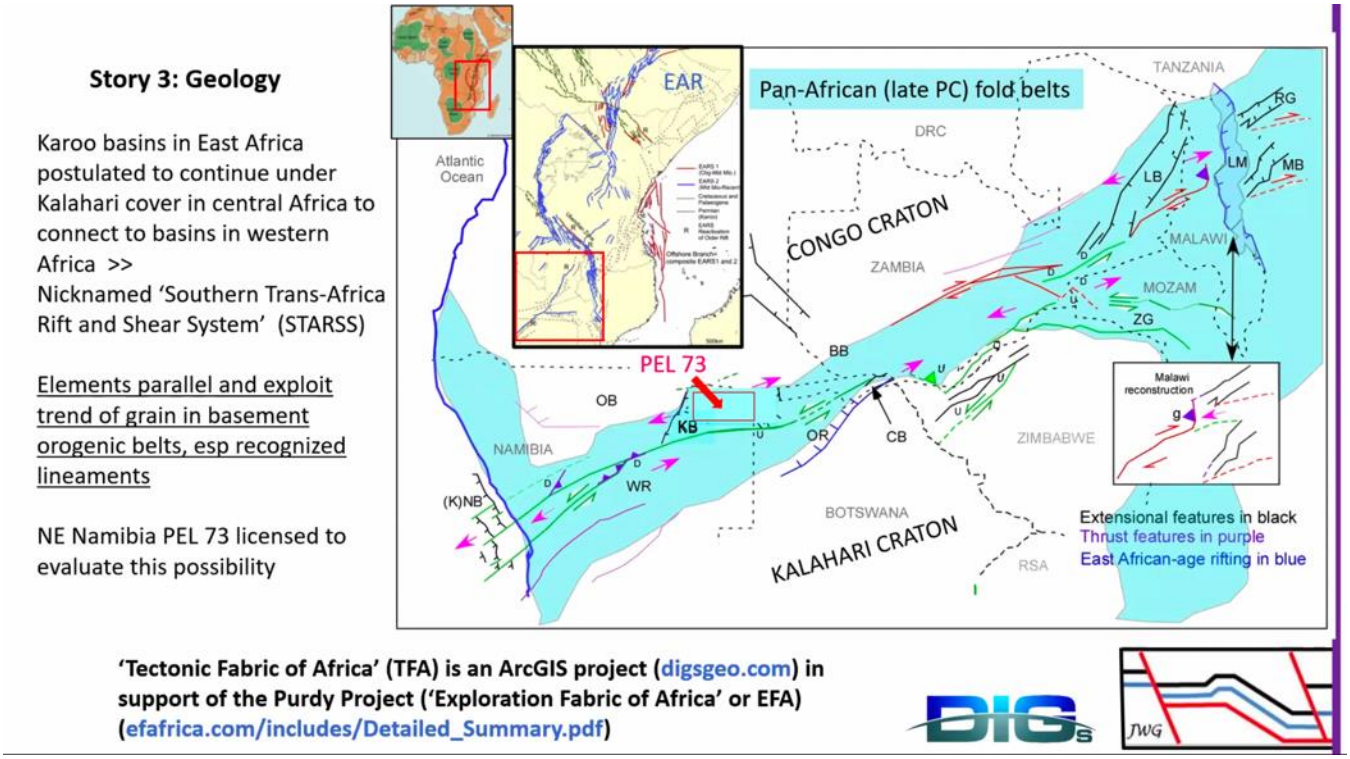
Moderator 35:14

And then if you can say, Are there any oil shows shown in the matrix of fractures or both?

Jim Granath 35:21
I presume they're both. I mean, it was it was recoverable oil. So it would move. Whether it's going to flow at producible economic rates is another question. But, so I presume that it would have occupied any pore or fracture that was open to its neighbor.

Moderator 35:46
Okay, let's get the show on the road.

Jim Granath 35:48
Alright, so where did the ideas come from?

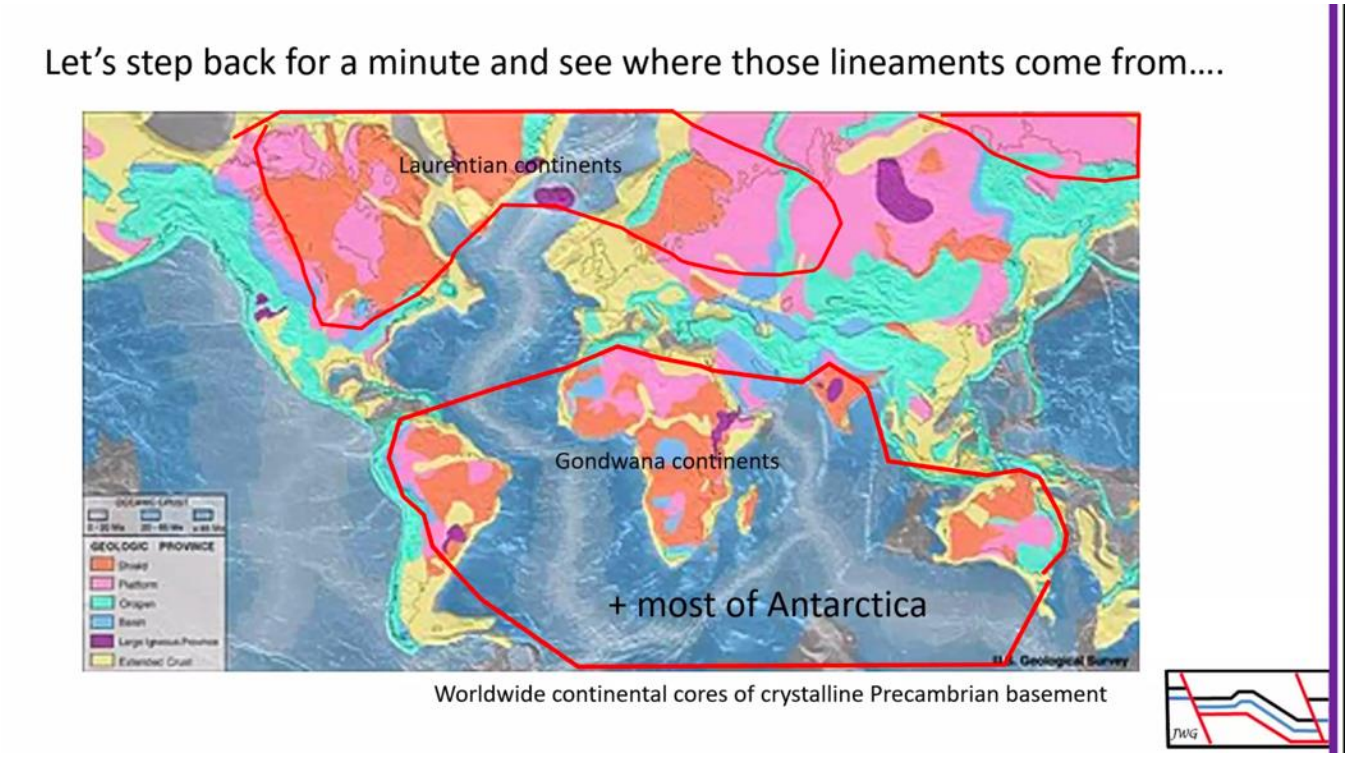


Jim Granath 35:54
Let's step back to the idea of the geology. So here's this is from the tectonic fabric of Africa, the ArcGIS project that I mentioned earlier with Bill Dickson and, and Mark Odegaard. Some people may recognize them as the authors of Marimba, the South Atlantic project, they've been compiling synoptic datasets and doing fantastic melding of gravity and mag data from, and doing derivative products, from all over the Southern hemisphere on both sides of the Atlantic. Some of that comes well into the African continent. And then a number of years ago, Bill and I embarked on doing this tectonic fabric of Africa as a support to the Purdy Project. Some people may recognize that as an old data set available from AAPG that had Purdy put together. The tectonic part and the structure part was pretty non existent. So we took it upon ourselves to fix that deficiency. And Bill and I have been working for years, you might

recognize that some of our work, you can see online it [inaudible] from SEA-Tiger, which is a similar compilation for Southeast Asia, which is still in process. So anyway, the idea is to compile the structural elements at a more granular level than you normally have with a with a published tectonic map and do it in an Arc environment. So you can mix and match different kinds of data and points, lines and shape files to build the sort of map that you would like to do. So here's a map that's out of the project. And it shows the Karoo elements from Lake Malawi all the way to the African coast. And it's it's basically just a screenshot right out of the GIS project. All the ones in the east, the Luangwa Basin, the Ruhuhu Basin, Zambezi Basin and a number of others are exposed. And they're exposed within an area of Precambrian outcrop that I show here in blue that's related to the very latest Precambrian fold belts that sort of lace all the way around Africa. So these have been mapped, there are some seismic data from some of them. What we do is pull together existing maps or even get on our synoptic datasets and do some original interpretation to fill in the holes. Now, it's been an idea for a long time, at least since since Michael Daly and Derek Fairhead, what 30 years ago, that these extensional basins are connected together by reactivated shear zones in the basement. It's the idea that if you reactivate old features in the basement, they can contribute to the existing structure. The story for Africa for a long time. What's important to realize is that a lot of the so called rift basins are parallel to or semi parallel to, or at a low angle to the shear zones which have not really undergone a lot of uplift except in certain locations. So the overall general direction of extension is shown in the pink arrows here for all of these structures. And they are connected together by like I said these older shear zones, which act like transfer faults between the rift segments. And they are strike slip faults. So, and in the East here you can see that this older Karoo trend, which continues up into Tanzania and actually jumps over to Madagascar - we didn't go that far for the purposes of this -, are cross-cut by the current East African rift system which is Neogene in age, and is shown in blue here, for example, the elements that contribute to the opening of Lake Malawi are shown. And the opening of Lake Malawi is messed with the orientation of some of the older Karoo features, so I did a restoration in here to put those elements back in place.

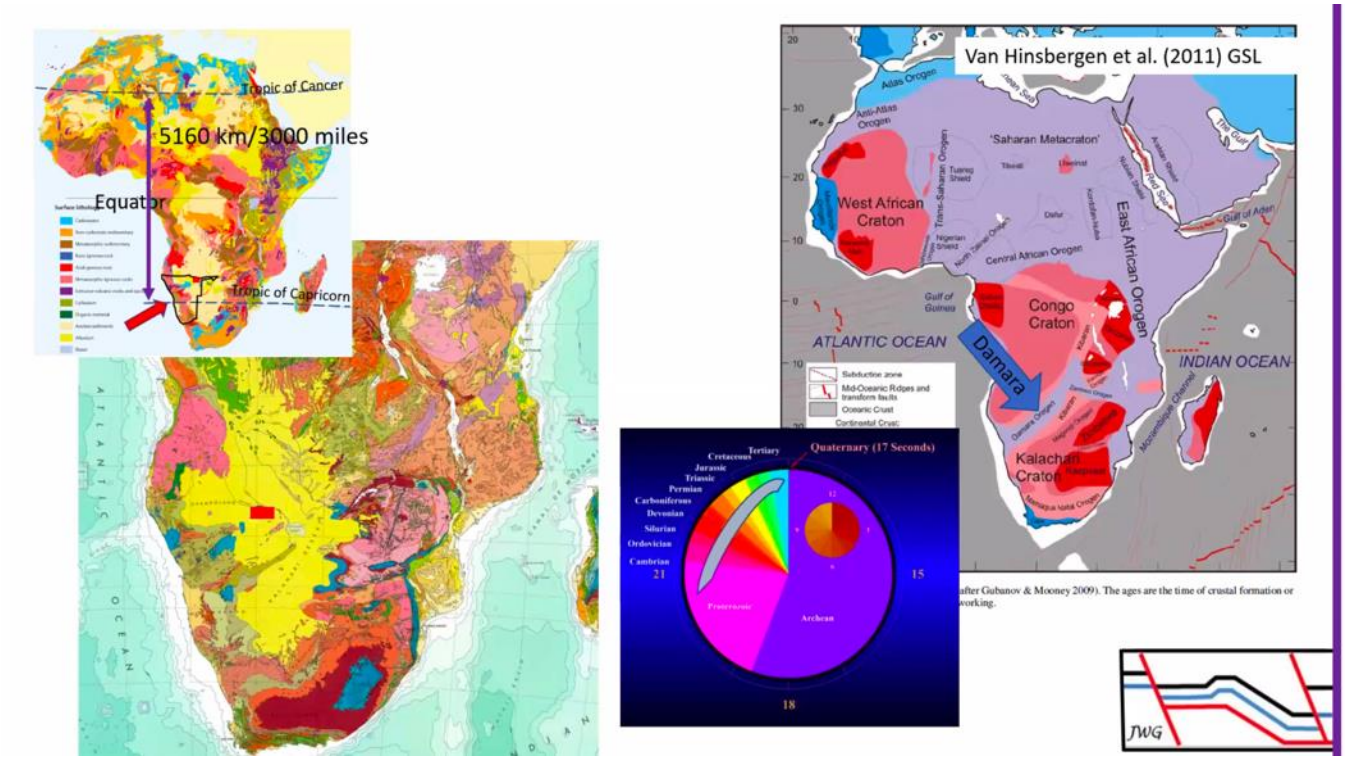
Jim Granath 40:26
Now, I mentioned that the shear zones are activated and strike slip faults. So they have all the characteristics and all the structural style relationships of strike slip fault. So they have releasing bends and restraining bends and things like that. And there are some strange uplifts here in there, for example, right along the shore of Lake Malawi, that looked like they might be on restraining bins for these sorts of situations, which is what I've done here with this restoration. That particular location where I marked the G is an area where Charnockites have been exposed.Charnockites are normally interpreted as pieces of the lower crust. So if they're, if they're uplifted in this extensional system along the strike slip elements, then we're cutting below, down to around below 20 kilometers depth in the crust on some of these thrust falls. Alright, if you go over to Namibia, then in Namibia, the Waterberg basin, sits right in here and it's an area of exposed Karoo. Then there are a bunch of scattered elements of Karoo in between these, these lineaments that I've mentioned before, they look like they're pretty banged up. They look like they're related to fault surfaces that cut them. So they look like they're in the foot walls of some thrust faults. So this looks like a much deeper look into the whole system. And we'll discuss that in a little while later. In between, of course, we got our areas that are covered. We'll get into that in a minute. And then offshore, I think I've mentioned that a Karoo basin has been identified a number of years ago. So the key point here is that these lineaments that have been recognized in Africa for a long time, trend from the southwest go undercover and they come out on the

east. And they're related to all the Karoo features that we've seen. That's the key, the key observation. So the whole point of PEL 73 was to approach this trend, which we call STARSS, Southern Trans Africa Rift and Shear System as a covered potential element along this particular trend with all sorts of basins and different orientations in geometries. It's important to realize they all occur within the Pan African fold belt, which cuts across Africa at this particular level. Because that's where the lineaments are set up. They're set up as zonal boundaries between elements of the fold and thrust belt. Okay, questions so far?



Jim Granath 43:19

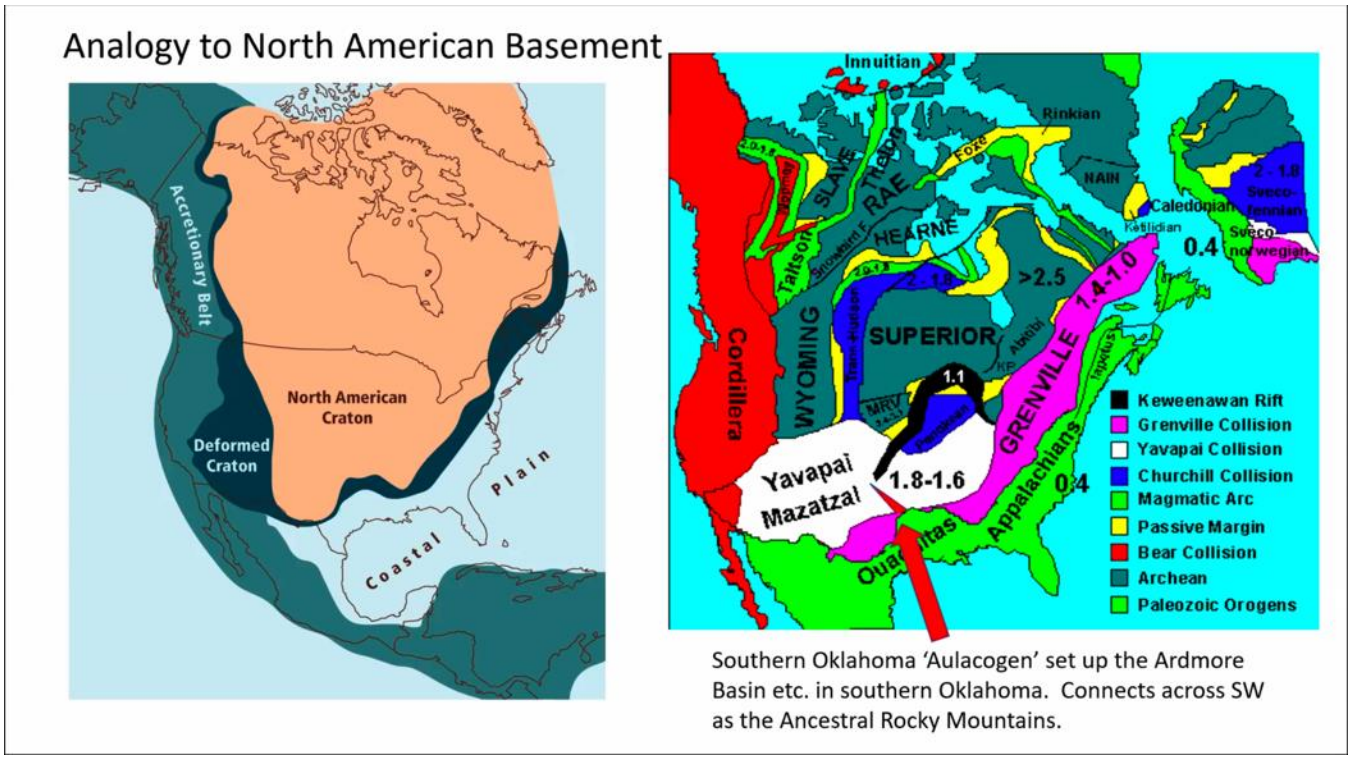
Alright, so for the non geoscience people, let's step back for a minute and see what this Precambrian really comes from. So in the Southern hemisphere, on this particular map, which is basically the age of all the deformation in geologic time, we've got areas in the pink and the red, which are old Precambrian Cratons. And they tend to be the cores of the of the current continents. And so in the Southern Hemisphere, we have India, Australia, Africa, South America, and then Antarctica, which would fit into the bottom here, all were together, at about the time of the Karoo deposition, 250 million years ago, forming the assembly of continents called Gondwana. And that the breakup of this, since, starting in Jurassic or Cretaceous time, has dispersed them to their present positions. So the continents have grown. There's a similar situation in the North with the Canadian Shield, most of Greenland, the Baltic shield, and bits and pieces underneath Siberia and other parts in Asia here form a similar set of continental fragments that were assembled at that time. They broke up a little bit later than the Southern ones. But again, they were the cores of the continents now, they were a continent into themselves, at one particular time.



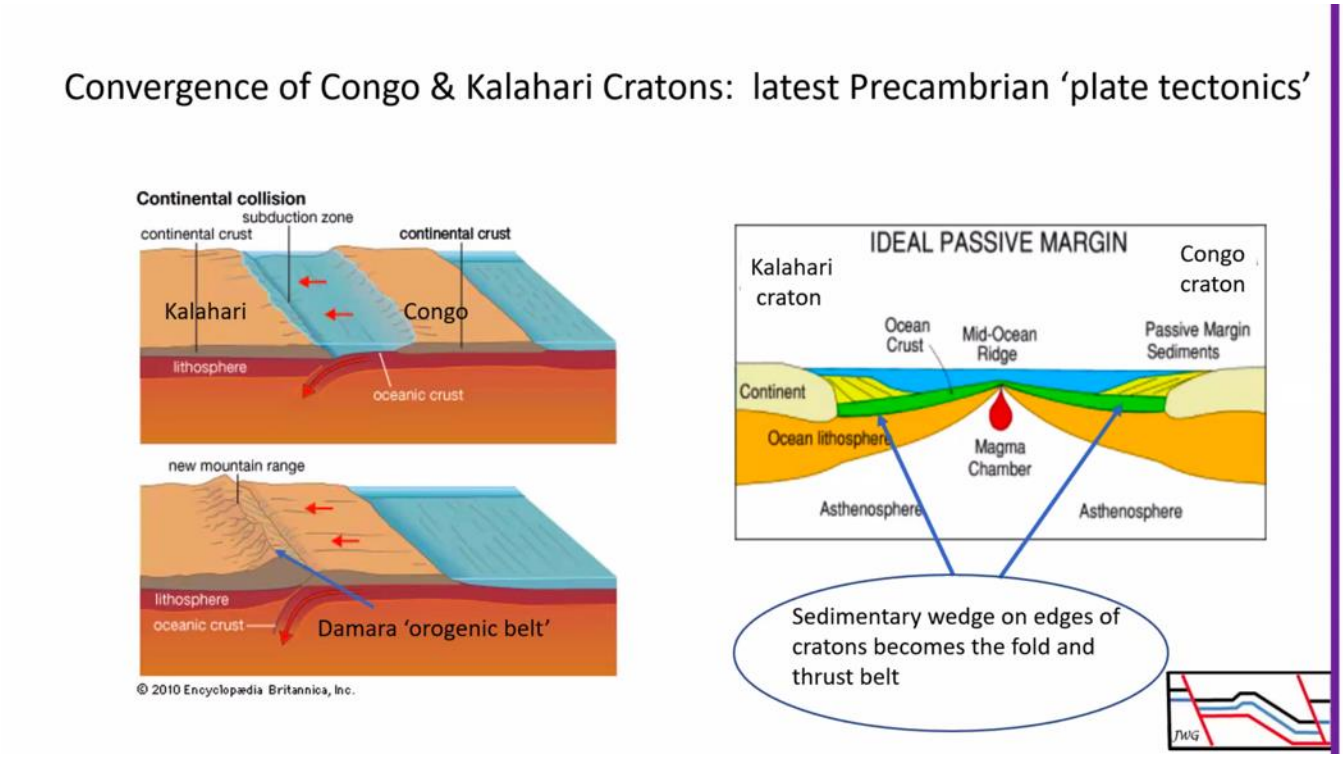
Jim Granath 44:51

If we step back and look at the African ones, we have a map here that shows some of those Cratons in the areas where they're mostly exposed. There's another one here I would, I would argue that there's a third one here called the Nubian Craton, that's exposed in different places, but it has a thin cover on it, like a lot of North America over the Precambrian. But you can see in here that even though they are cratonic masses in themselves, they themselves are composed of other elements of different ages. So over geologic time, starting at about here at 15 minutes in the geologic history, the continents have been accreting together with various bits and pieces to form the cratons, which get ever bigger as they go. Until you get to the latest Precambrian, what's called the Eocambrian or the or the latest Proterozoic. That's when this last suturing took place in Africa with these fold belts like the Damara, the blue one that I just showed you in the previous slide, and a lot of the other Pan African fold belts, that was the last stage of assembly of these older continents. Now, if we look at the geologic situation, you can see that most of them are covered by yellow. They're basically covered by younger sediments. And so much of it is really not accessible to geologic mapping and would only be accessible to techniques like seismic and gravity and mag and drilling. That's the case of most of the southern part, southern continent here, the Kalahari, in fact, it's called the Kalahari basin or the Kalahari Desert, or the Kalahari this, or Kalahari that. But it's enormous. Here's the size of Namibia. And you can see that the whole that whole basin Kalahari basin going from Kalahari upon covering the Congo Craton is what, what's that distance? It's getting close to 2500 kilometers. So, between the Tropic of Capricorn and the Tropic of Cancer, Africa is about 3000 miles tall, that's 500 miles longer than the distance from New York City to Los Angeles. So that's the area that's covered and is essentially particularly unknown on both sides. So in the geologic history, all of these cratons are assembled by about the end of the Precambrian. And then during the Phanerozoic, or the Cambrian, in later times, we have the geologic events that affect the cratons. And essentially, that's the period of geologic time that we see all of our familiar mountain

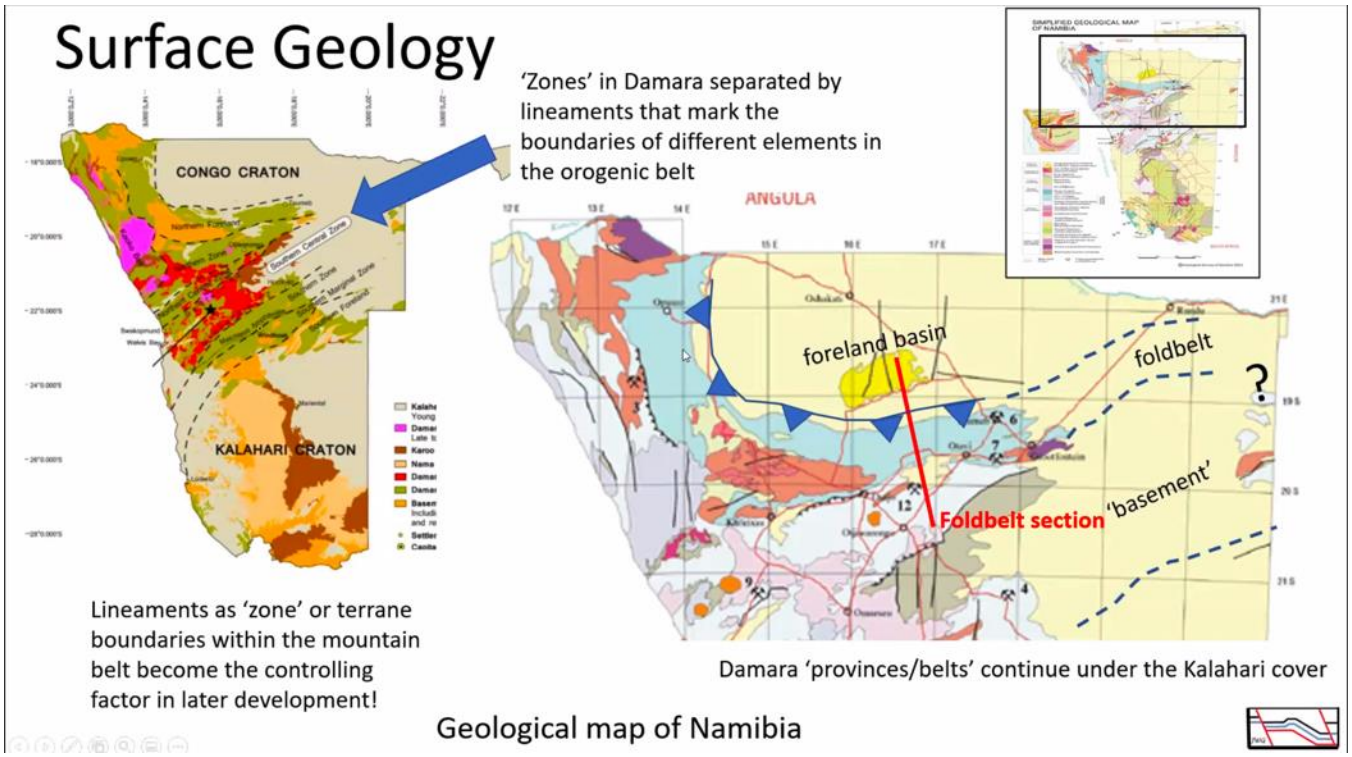
belts we see all are familiar basins. And what, don't quote me, but 99% of the, of the petroleum plays in the world fit into that part of the geologic column.



Jim Granath 47:55
Okay, so for you, North Americans, North America isn't much different. Here's a map showing the various terrains in the Precambrian of North America. On the West, of course, we have the Cordillera, which is younger added to the continent. In the East we have the Appalachians but otherwise everything's about 1 billion years old or older in different terrains. And there are pieces of those that are reactivated in very similar ways. Here's where the southern Oklahoma Aulacogen, which was a Cambrian extensional belt occurs, and it's reactivated during the Permo Triassic, or let's say [inaudible] and Permian to form the Southern Oklahoma belt and that connects into the Rocky Mountain area as the Ancestral Rocky Mountains. So it's a familiar story to all the continents, but a lot of the industry has just forgotten about it. And never used it for years and years in the construction of any plays.



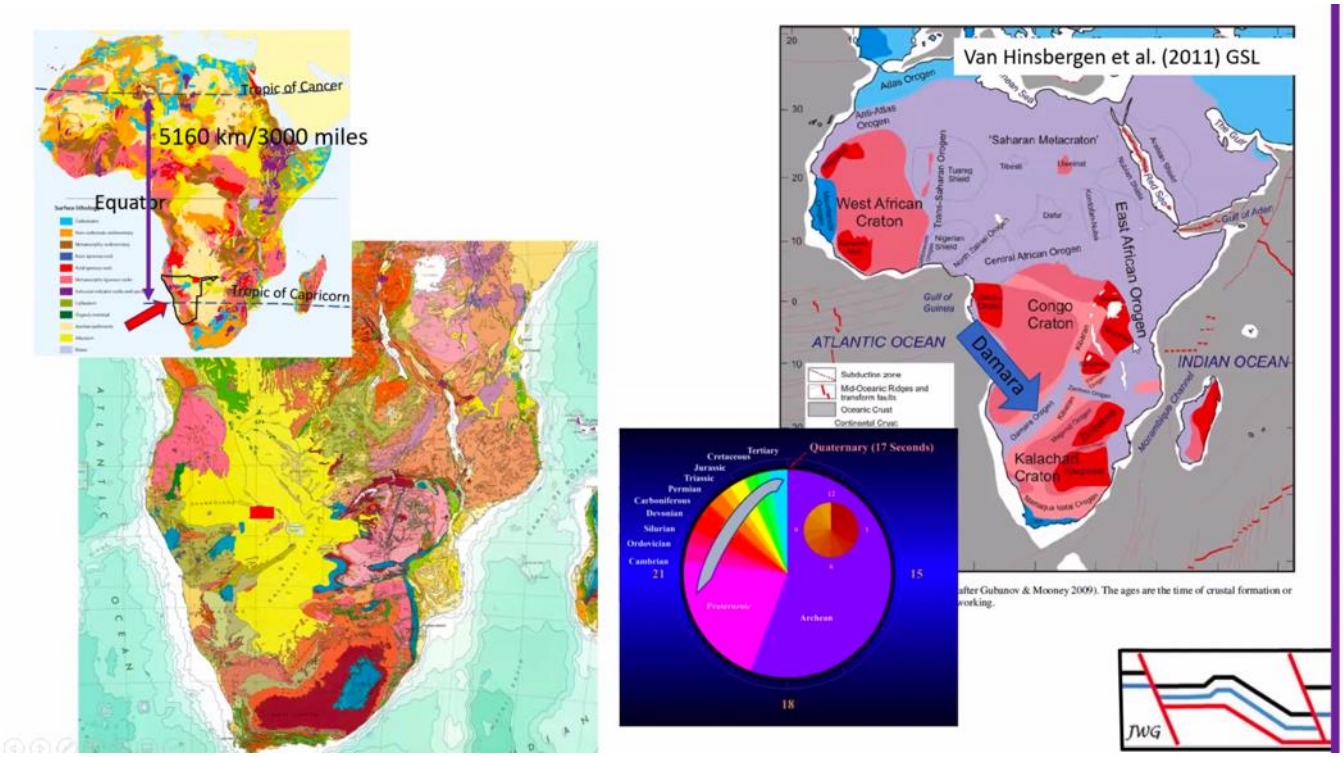
Jim Granath 49:00
So let's build the elements that we see in the well. Let's do it by simple kind of plate tectonic processes, and I'm stepping back and pulling stuff all the way out of Encyclopedia Britannica. So back in pre, Damara time, when Kalahari and Congo were separate continental masses, they were sitting across some kind of an ocean basin in between and they collected sedimentary prisms on both sides, on the edges of both sides of those cratons. With time they drifted together, and eventually, at Damara time, about 600 million years ago, those two cratons collided to form a larger craton. You can think of it as the growth process of the continental crust. And that orogenic belt was composed of things that we see in orogenic belts today. Developed a new mountain range, probably look like the Alps or something like that, maybe not as tall as Himalaya, but certainly something like the Alps. And it developed all of the structural features that are associated with that, you'll have the core of the mountain belt, where there's metamorphism, and intrusion of rocks.



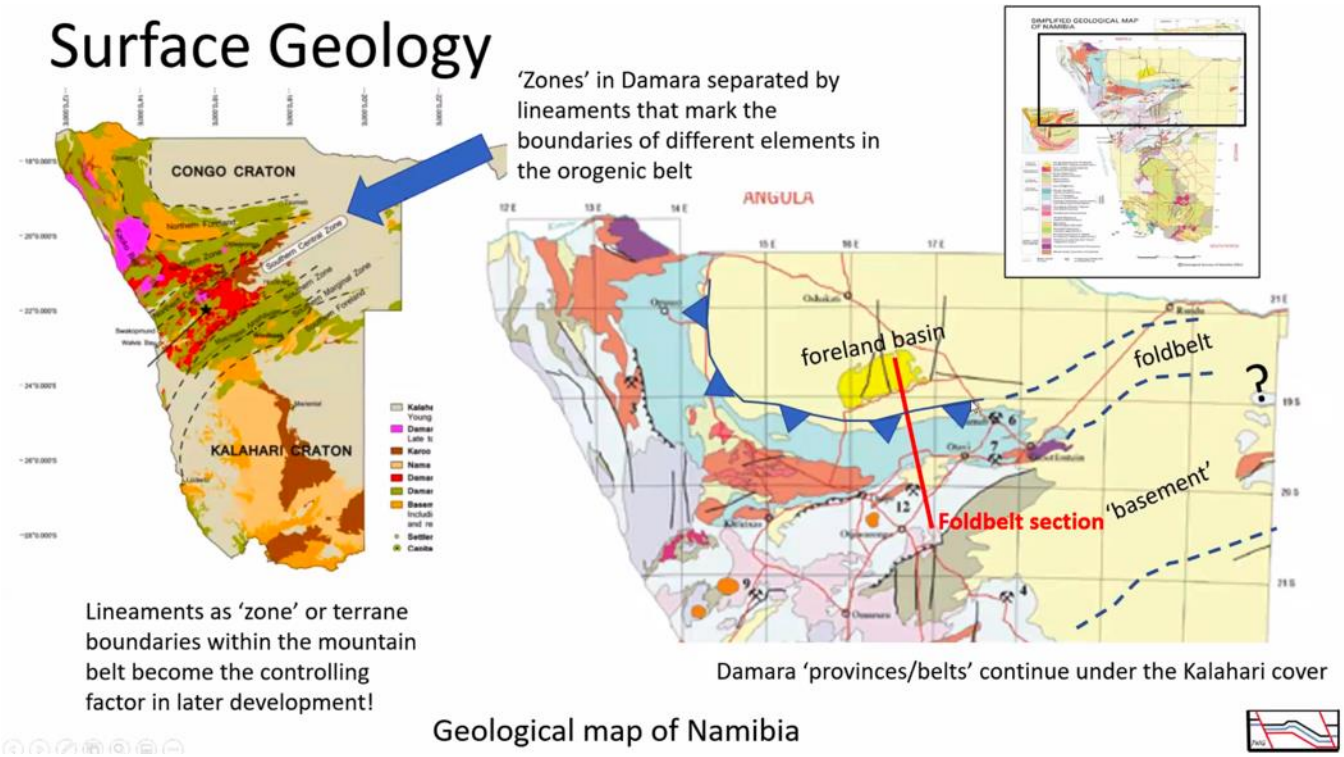
Jim Granath 50:17
Then to the sides, you'll see the development of the fold and thrust belt out in front. This is like the Bavarian Alps or the Zagros, or any other fold and thrust belt developed in the rocks that

Jim Granath 50:36
come from the edges of the original plates.

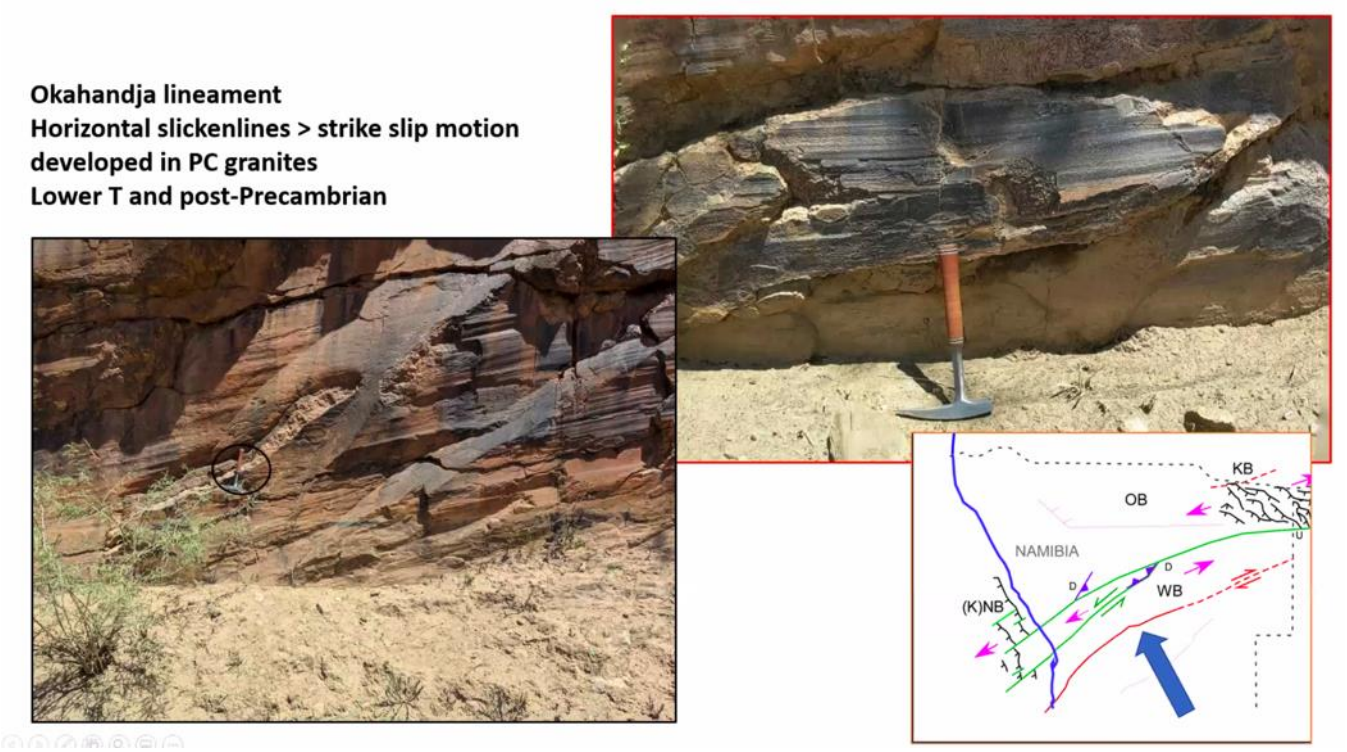
Jim Granath 50:43
So that forms a belt in front of all the cores of the mountain belts. And there's another one on the south side here, we just haven't gotten a big enough picture, you can see it's right in here. It's not as well exposed, but it's there. So there's this kind of a symmetrical bivergent or, or sort of mountain belt. And if we go down to there and dissect the different pieces within the mountain belt, that's where these lineaments come in. And they've actually caught names. They separate different zones within the orogenic belt, and they've picked up names, the Omaruru lineament, the Autseib Lineament, and the Okahandja lineament. And they're very prominent in the Namibian literature. Well, they got to go somewhere, this fold belt, go back,



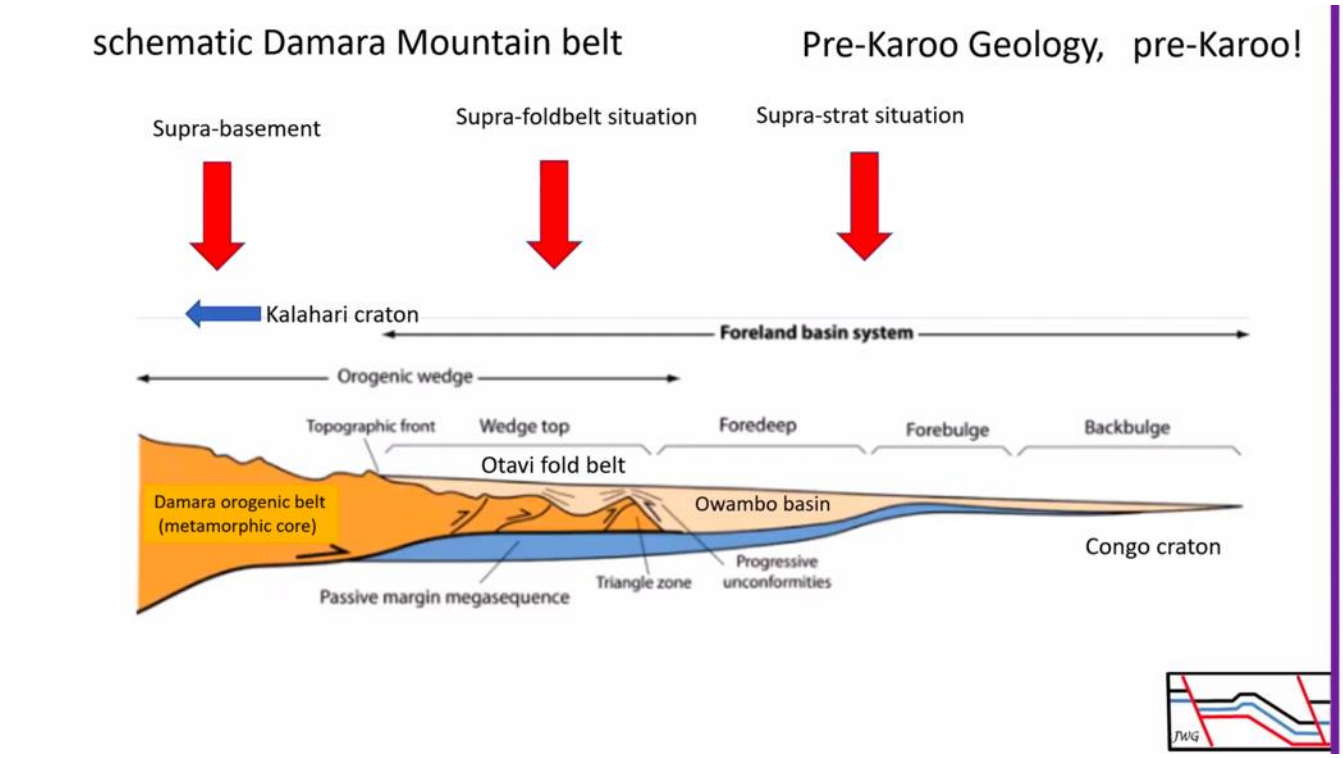
Jim Granath 51:40
That fold belt has to go somewhere to the east and northeast and connect with things that are exposed where the other basins are over here.



Jim Granath 51:50
So somehow, they project underneath this cover. And if we take those boundaries, the frontal part of the fold belt, we can come up into the PEL 73 area, to pick the frontal part of the crystalline basement that comes up like that. And there's actually a piece of it exposed in the Southeastern part of the block. And you could do the same thing on the South side. But the exact position of these is a little bit sketchy. It's got to be there somewhere. But it's a little bit sketchy. But notice what it does, it separates out. Let's call the Owambo proper, from this area in the east, which until the last few years, everybody just sort of thought was the extension of the Owambo Basin. It's something different because it's got this different structure. That foreland basin is there. And it's in its position because of its relationship to the fold belt. So it's not going to be the same kind of relationship as we go over here. It's going to be deflected north, into into into Angola, and then eventually into Zambia. And we're going to see the whole spectrum of the zones of the fold belt underneath the Kalahari cover in the Northeastern part of the country.

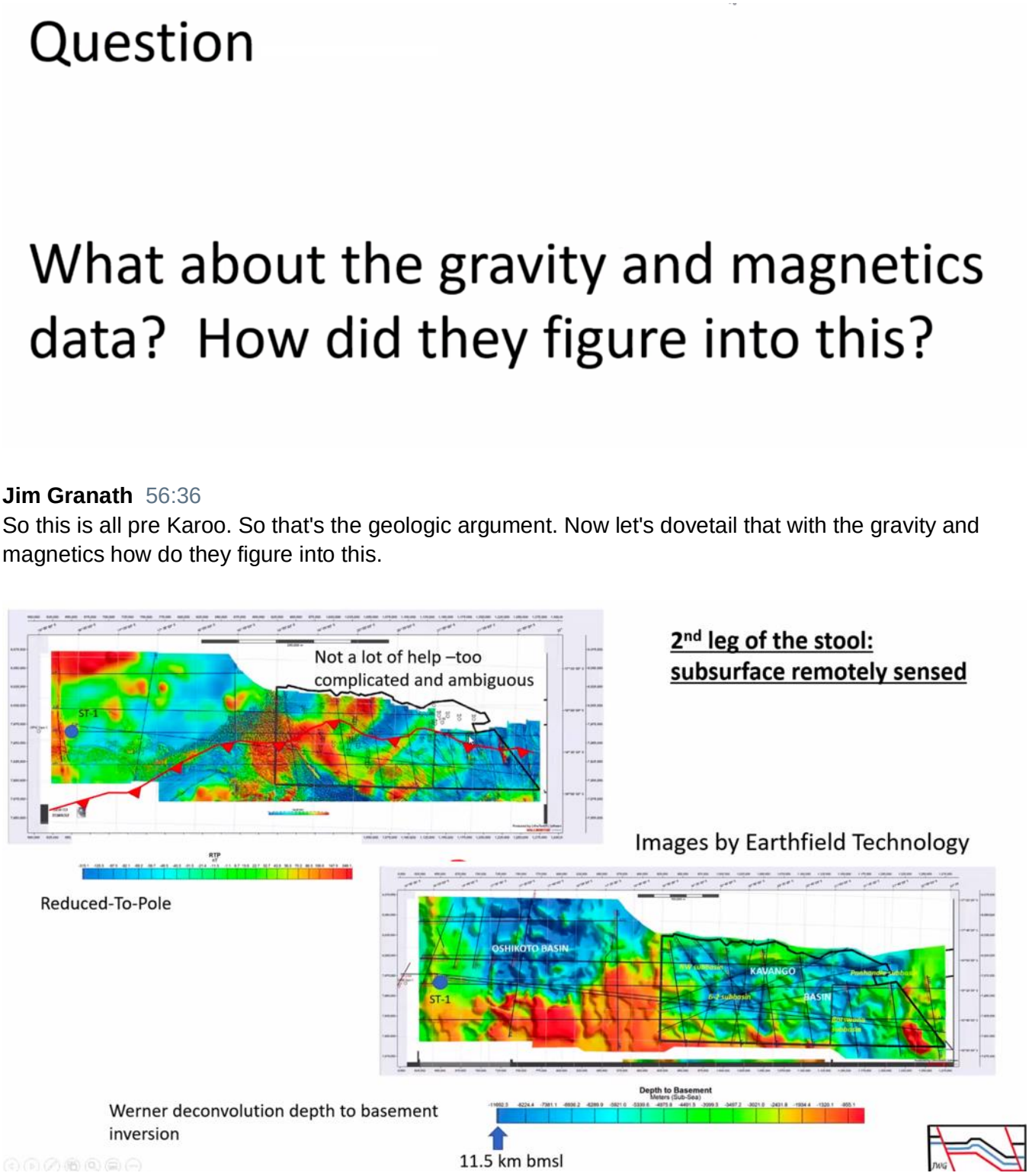


Jim Granath 53:10
So this is what it looks like along the lineaments. You can see these slickenlines. These are scrapemarks if you like as the rocks have gone past each other in a horizontal way. So these are great evidence of strike slip motion. And they're very young, can't date them. But they're certainly not Precambrian because they are superposed on the Precambrian structures themselves, so there's something younger. They're the most spectacular slickenlines I've ever seen. So I took these photos when we were in the field. It's from the Okahandjo lineament down here, which is one of the most famous ones and it goes right up the guts of the crystalline rocks in the orogenic belt.



Jim Granath 53:57

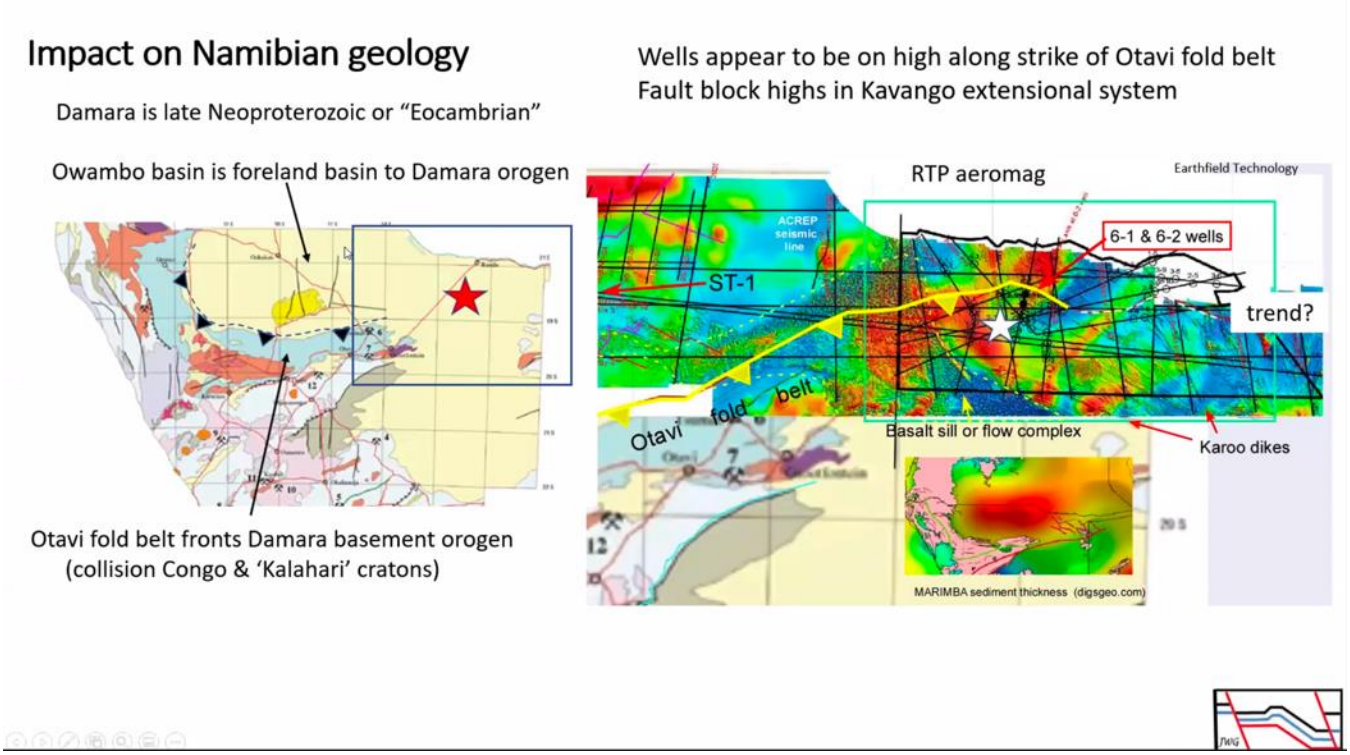
Okay, so let's dissect the Damara mountain belt for a minute and see what we've got. projecting into the block. So in, in modern, and I say modern, I mean post Cambrian during the Phanerozoic in the last 500 million years of Earth's history, collision belts have a repeatable, systematic anatomy. They're composed of the core of the mountain belt, which is uplifted above a metamorphic core, which has igneous intrusions and all that sort of stuff. The amount of uplift depends on the convergence, and it also depends on climactic things like erosion rates and everything. So you've got everything from Himalaya-Tibet kind of relationships to the Alps, which are which are not as high and eroded a little more. Out in front of that it's bulldozing the sedimentary rocks that were there before the belt, before the collision happened. And so that's what forms the sedimentary fold belt, or fold belt of sedimentary rocks out in front of the Orogenic belt. This is in Namibia., this is the Otavi fold belt, that blue band on the geologic map. And they can catch pockets of sedimentation on top of them called [inaudible] basins. And that's because there's some relief and enclosed areas, it can get some of the detritus that comes off the, the Orogenic belt. And then because this is slapped on to the craton to the South here, it sort of depresses and flexes the craton, in this case, the Congo Craton, and it creates a wavelength of the top of the basement below the fold belt that's characteristic of the strength of the crust. So it's going to be pretty broad because the Congo Craton is old and very stiff. And so that's where the Owambo Basin proper comes from. It's called the Foredeep or the Foreland basin. And it's catching sediment while the fold belt is actually developing, and while the full belt is sneaking to the North in this particular case, and it actually gobbles up some of its own foreland basin into these folded structures. And this is why I say that, if you're going to drill into the fold belt, you're going to get Mulden. And you're going to get Otavi, and you're going to get everything else that was there all interdigitated. And it's almost sort of irrelevant from the point of view of interpreting the well at one particular scale, exactly what you get in the well.



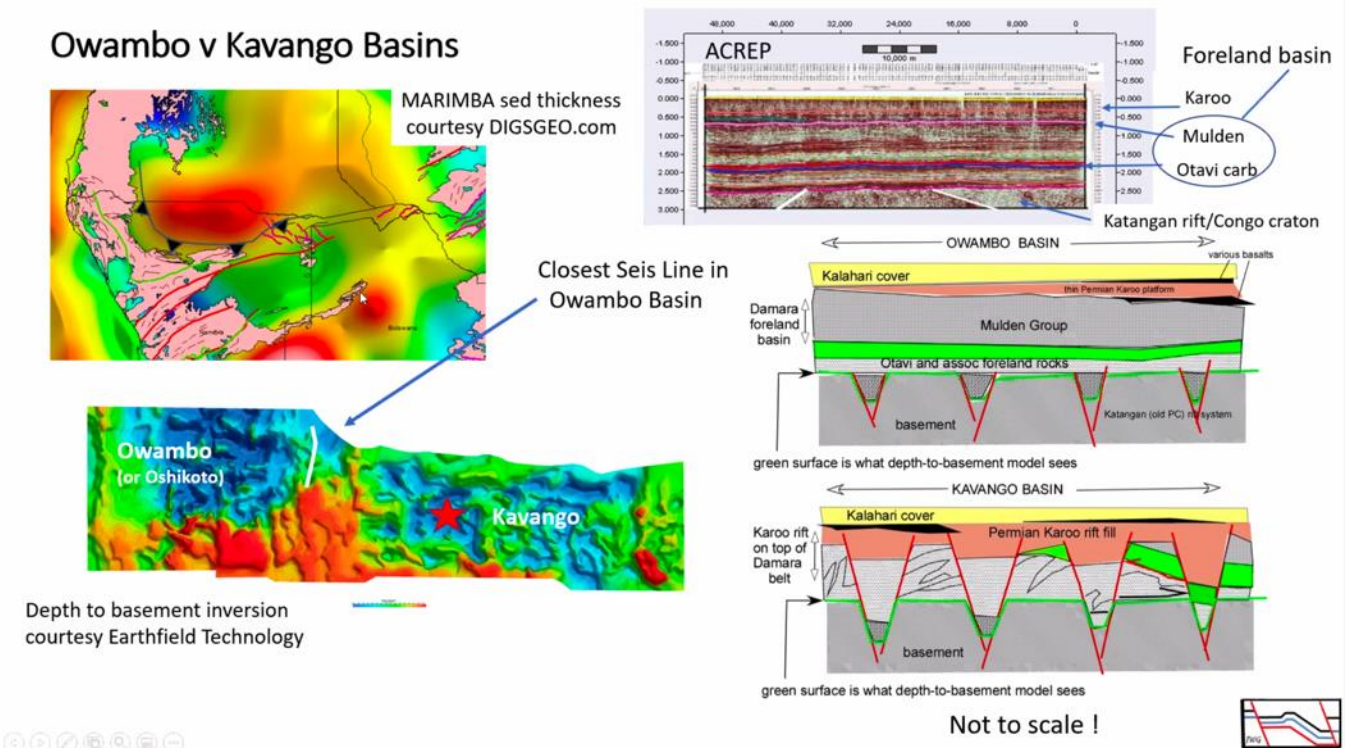
Jim Granath 56:36
So this is all pre Karoo. So that's the geologic argument. Now let's dovetail that with the gravity and magnetics how do they figure into this.

Jim Granath 56:46
Here's the frontal up here in the upper left is a magnetic map. This is the high resolution aeromagnetic data sort of produced as a Reduced-To-Pole demonstration or display. Down here is Earthfield

technologies depth-to-the-basement. This is the depth to the primary magnetic signal generator. So it's interpreted as crystalline basements in places but it can also be influenced by piles of volcanics and any other rocks that have magnetics, minerals in them. Crystalline rock, igneous Rock, metamorphic rock, volcanic rock tend to be the big ones, it's going to be subdued by the magnetic susceptibility of sedimentary rocks is subdued. So Bill Cathey who generated this would tell you that this is telling you the depth to the primary magnetic signatore, plus or minus 10%. So in the bottoms of these basins, the blue, we're talking about stuff that's 10 to 12 kilometers below sea level. In the red, we're talking about stuff that's at sea level or one kilometer below it. Right. So the suggestion is that this red is something different from the blue areas. Alright, for a moment, let's go back to the Reduced-To-Pole. What do you see in it? What can you interpret geologically? Well, up in the West here, the Northwest, and this is where that old stratigraphic test was, you can see rather mundane magnetic signature. This is in the classic Owambo Basin. And this persists as you go farther to the east all the way to the other side of the basin. When you come West, and you get close to the Kavango states, East and West Kavango districts, the world changes quite dramatically. You see this black stippled body which seems to overlay everything else and obscure things. You see a lot of amorphous red and blue blobs. You see lineaments on here of various orientations. There's two prominent ones one like this, and one like this, but it's hard to put a put a handle on everything in terms of what they are. Well, we know that this black stippled area is a basalt area, a flood basalt near the surface, not as thick as but it would be similar to the Columbia River basalts for anybody in North America. And we know that the lineaments on here are mostly dikes swarms, we're way at the Northeast end of the Karoo age and younger dike swarm. So these are basaltic dikes that are cutting the section and they give us a nice discreet magnetic signature. Remember that things that are very finely defined are shallow. So these dikes which are very narrowly defined and clear near the surface. In fact, some of them outcrop and get over in Botswana, you can find them outcropping. And there are kimberlites involved. And you can see the stippling on the black here is very fine texture. That's because it basalts not too deep. It's underneath the Kalahari sands, but it's not too deep. Other than that, there are these red and green and blue areas that are all very fuzzy. They're giving us some kind of a signature from depth that we really can't pick up on visually as a human being. So Earthfield technology and other people sort of filter out, separate out all the wavelengths of all these different anomalies. And that's how they get to the Werner deconvolution, sort of story that gives you an approximation of the depth of the basement. Okay, so right across here, East to West things change. That's where the Owambo Basin, the foreland basin to the to the Precambrian fold belt occurs and the fold belt starts to come up like this and cross [inaudible] but we can't tell exactly where. This is telling us the two areas are different. And it's up to us to do this geology to do the difference.

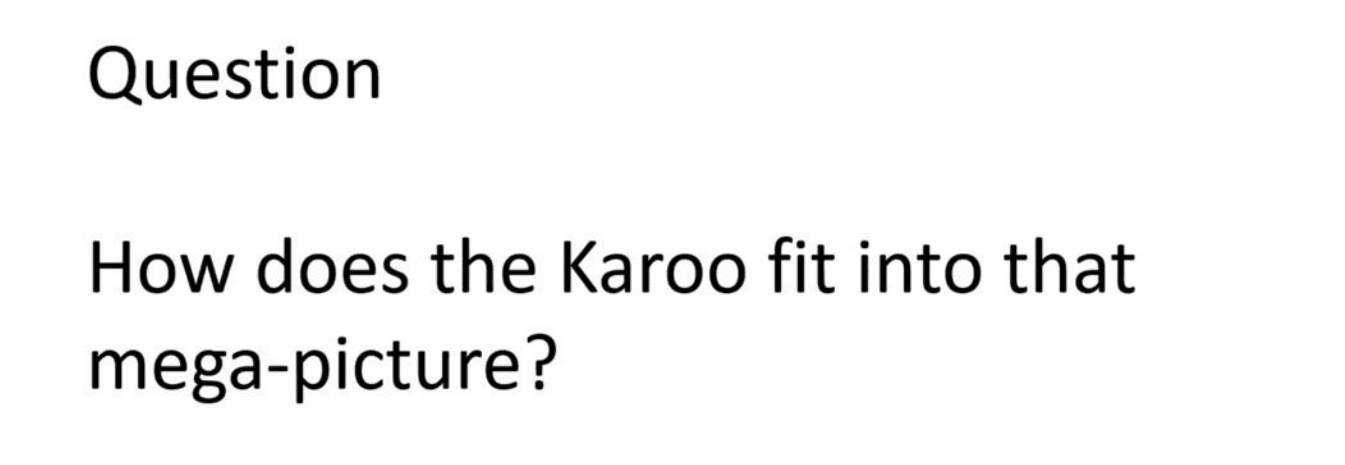


Jim Granath 1:01:41
Okay, another argument. Here's that same map shows us the Otavi fold belt that shows us the Owambo basin in front, that big change in magnetic character comes through here. So we can extend the frontal fold belt something like this, we don't know, exactly where. It's going to be the tip of the wedge that was pushed to the North. If we look at it, we're going to look at in a minute, a gravity inversion from the Marimba project, the two areas are different again, as well. So the star is where the wells were drilled. And you can see that, you know, it's not to take too much to imagine that you're right on the trend of the Otavi fold belt. And so, we have to expect that somewhere in the subsurface. So this summarizes where we are in terms of understanding the difference between the two basins.



Jim Granath 1:02:36
Now, on this map, the pink is the exposure at the surface of Precambrian rocks. Here it's covered by Kalahari everywhere that it's in the colors. This is a thickness of the sedimentary section estimated from gravity in the digsgeo, Grizzly geo marimba project. And it shows you a very distinct thick stratigraphic section in the Owambo basin, the changes very dramatically, where the aeromag changes as we go from East to West. Now, at depth carbonates are denser than a lot of siliciclastic rock. So I'm interpreting this to suggest that, that since this is not a very discriminating picture, this is telling us again, that Kavango at depth is something different from Owambo. What does it look like? Well, the only, the closest piece of information that subsurface in nature is, is an old line here from ACREP. That's right at this location. And I have this because they use it on their promotional brochure for trying to develop an exploration play. And in what you see down here in the bottom is the cotangent rift. This is the old passive margin Congo craton section, the normal faults that were related to the creation of that Congo passive margin. And then above it, there's probably some sediment that covers that and then we go up into the Foreland basin. Otavi carbonates in here, and then the Mulden group, various kinds of Mulden lithologies. And you get up to the top here, there's a thin Karoo that's only a couple 100 meters thick and then you get discontinuous basalt in the Kalahari. The point is there's nothing on this seismic line that would show anything like the pre-rift section in the six two well. So we're interpreting this as being the far Eastern end of the fold belt, which is a basin in itself and younger basins, including a piece of a platform Karoo sitting on top of that. So in a cartoon, this would be what we regard the Owambo basin has Kalahari cover, a thin Karoo platform section, perhaps with some basalts, the Muulden group containing the Foreland basin section, the Otavi carbonates, which are probably deposited pre-fold belt. I think they're part of the passive margin section on the craton, and other rocks associated with that part of the section, lying on an unconformity down below that's faulted. It's normal faulted because that's the, basically the passive margin geometry for the Congo craton. So when you

come along, and you image, the crystalline rocks, in the Owambo, to the west, this is what you're seeing. This is what's being imaged the top of the basement as you come across, and it jumps up and down with regard to the cotangent structures. And that's the texture over here in the Owambo, or we call it the Oshikoto, because the Owambo is divided into different basins. Right now, by the time you get over to Kavango, we've got to think a little bit differently. We have a well now that samples this kind of a situation. The Kalahari, basalt, 800 meters of Karoo, maybe a little bit of some non Foreland basin section sitting on top of that, and then we go across the unconformity in the exposed folds. So we're in this kind of an environment. Again, the depth to basement inversion is showing us this surface, which isn't a hell of a lot different from over in Owambo. Except that occasionally it's probably telling us something about the Karoo rifts surface. And that's what some of the texture, we interpret the texture of differences in here is related to that. So the implication is that we get off the high, we're going to get more Karoo, we're going to get a different section, we're going to get different kinds of depositional environments. And who knows what will come out of that. But normally, exploration programs don't drill, the lows, they drill the highs, so we just haven't encountered the source rocks yet.



Jim Granath 1:07:19
Okay, any questions at this time? I want to talk a little bit more about the Karoo.

Moderator 1:07:25
I have a couple of questions. And the comment that you have a voice that is perfect for radio or television.

Jim Granath 1:07:39
I've heard that before Thank you very much. But when I hear my own recordings, I'm getting rather embarrassed.

Moderator 1:07:46
No, no worries, Shumate. That's the humility in you. Okay, so I'm Jim Taka: thinking of the pre Karoo carbonates with a reverse sense folding and faulting. He thinks you said that there were [inaudible] that would put these carbonates between two glaciations, is trying to think how this fits into the paleogeography. You might have answered this earlier. He did mention Thank you.

Jim Granath 1:08:14
Yeah, I think I know, Jim. Hi, Jim. I think you're thinking of the Eocambrian glaciation and then the the Karoo glaciation. And there's, you know, there's 200 million years in between those. We don't have, I have not seen much indication in this part of the world of the Cambrian one. So remember that those carbonates, if they are [inaudible] the passive margin for the Congo Craton, they're probably drifting South out of low latitudes toward the, toward the colder areas. And by the time they collide, they've been around for quite some time. So we have a Precambrian carbonate platform, which in itself is an interesting thing. And drifting down and being involved in the foreland fold and thrust belt and then sitting around being eroded away during that erosion. Elsewhere in the region there's some some kind of a cold climate thing. So it seems like the whole system drifted from Equatorial or at least lower latitudes down toward the pole. And then after the collision during the Paleozoic got a Karoo aged Permian glaciation and then drifted back north. So I don't I don't see a conflict or a contradiction in that.

Moderator 1:09:50
Thank you and then from Kin Li. What caused the difference between the two basins Owambo versus Kavango Basin

Jim Granath 1:10:01
The key thing is that's position relative to the, to the deformable reactivateable zones in the basement. Those zones are only in the Damara fold belt. So where that fold belt tracks, where that Orogenic belt tracks, the Karoo basins track and Kavango we're postulating is just one of those. Now there's Karoo all over the place, you know, some outside that there's Karoo, up in the North, even in Angola, but it's not basinal. The Kavango is a fault controlled depositional basin, just like Waterberg to the South and some of the other ones to the East. That's that's the difference.

Moderator 1:10:53
Okay, thank you. And is it possible? And thank you for the questions, folks. This is keeping things really interesting

Jim Granath 1:11:00
and sorry to go over time, but as long as there's interest, we'll keep going.

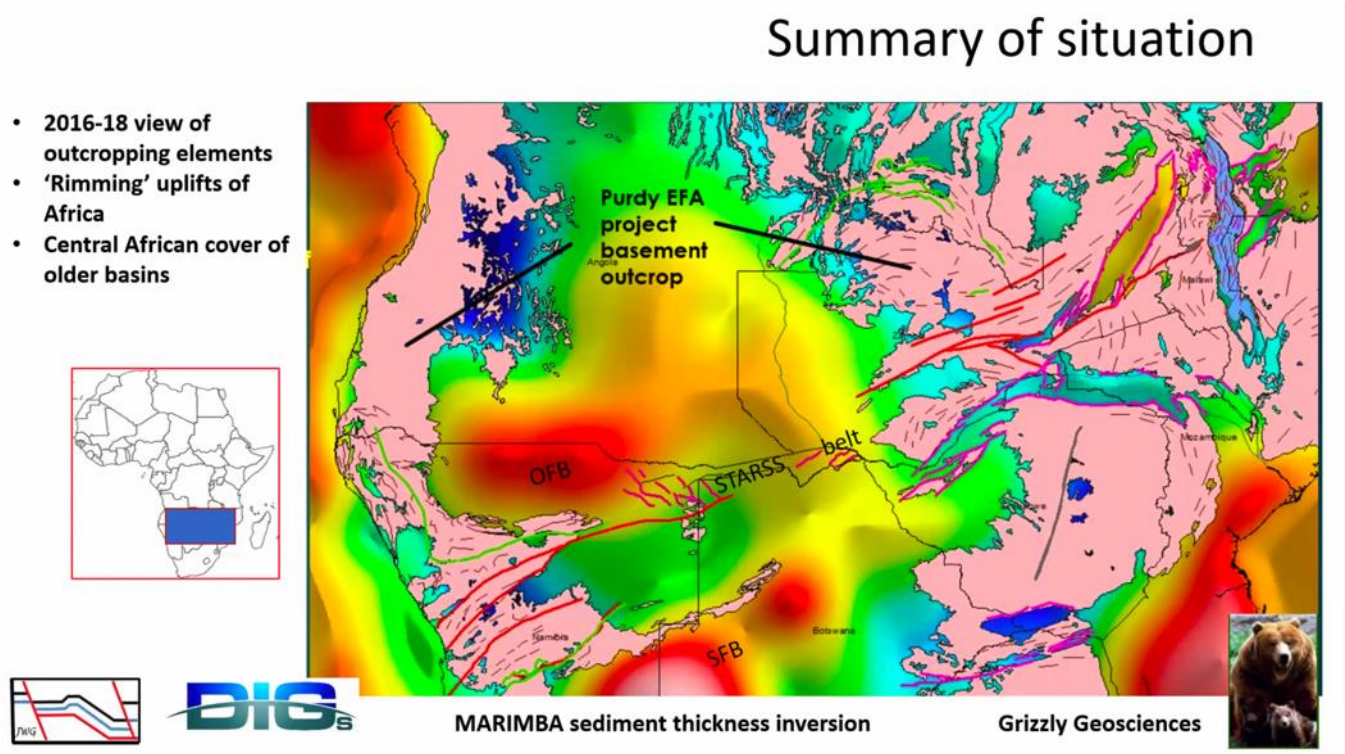
Moderator 1:11:04
That part exactly, we'd have rather questions than none. So, Jack: is it possible that Karoo sauce rocks could be deep enough in the Grabens to generate hydro carbons?

Jim Granath 1:11:17
Oh, absolutely. I think that's probably what I mean. That's what the original play concept was that the rift basins would accumulate, like other rift basins around the world, they would accumulate their own source rocks, and by fact of the extensional heating, they generate their own hydrocarbons and, and they tend to bury themselves because they are holes. So they're anywhere you have a rift base, and you've got the potential for a really nice little self contained petroleum system. That's the root of the idea.

Moderator 1:11:55
Great, excellent. Um, and then Chris da Costa, probably an innocent question: 30 days ago, you said the 6-2 and 6-1 showed "my earliest structural models grossly exaggerated, the Karoo fill in the Kavango basin"

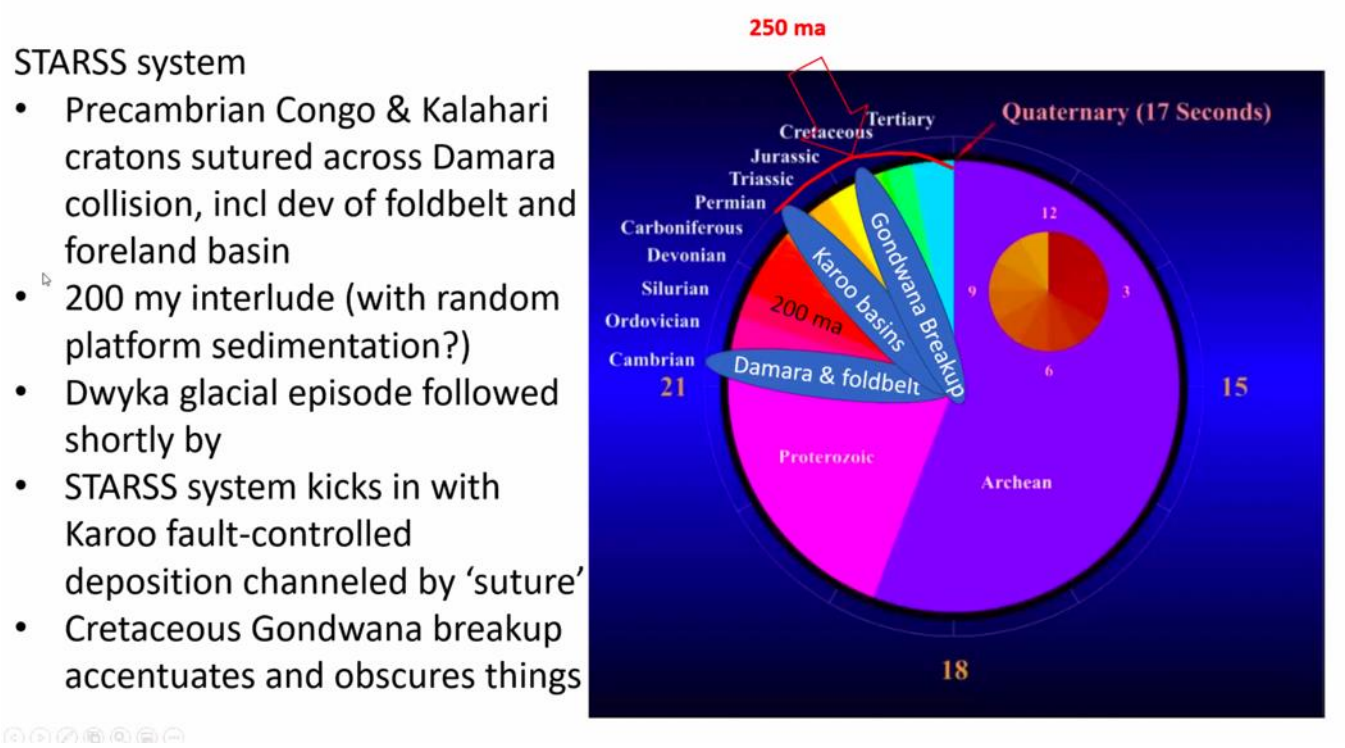
Jim Granath 1:12:22
What Chris's is referring to is some of the early models that I did before there even was a Recon Energy interest. We drew some Lithotect based models on virtually no information with regard to stratigraphy. So all I was really saying there is that if you go back and look at that one that's in search and discovery, you'll see that it's got way more Karoo than the 6-2 well showed us we had. I'm going to show a similar model at the end of this segment of the talk that kind of has a more realistic indication. We don't know how thick the Karoo is in the Grabens. Nobody's looked into the Grabens. Nobody's drilled into the Grabens. Nobody's even done Magneto torquers in the Grabens. They tend to be very difficult to image and get at because they're not big enough for really coarse potential methods dissection. Again, back to it, the seismic data is going to tell us that. Okay,

Moderator 1:13:39
I say thank you. And please keep your questions coming. We appreciate them. Thank you very much.



Jim Granath 1:13:49
Okay, to summarize where we've gotten to, this is an image out of the TFA. It's got every country in coastline boundaries. It's got the Purdy project outcrop of basement in the solid pink in the translucent colors. Red, yellow, green and blue. It's got the sediment thickness model from Marimba. And it's got

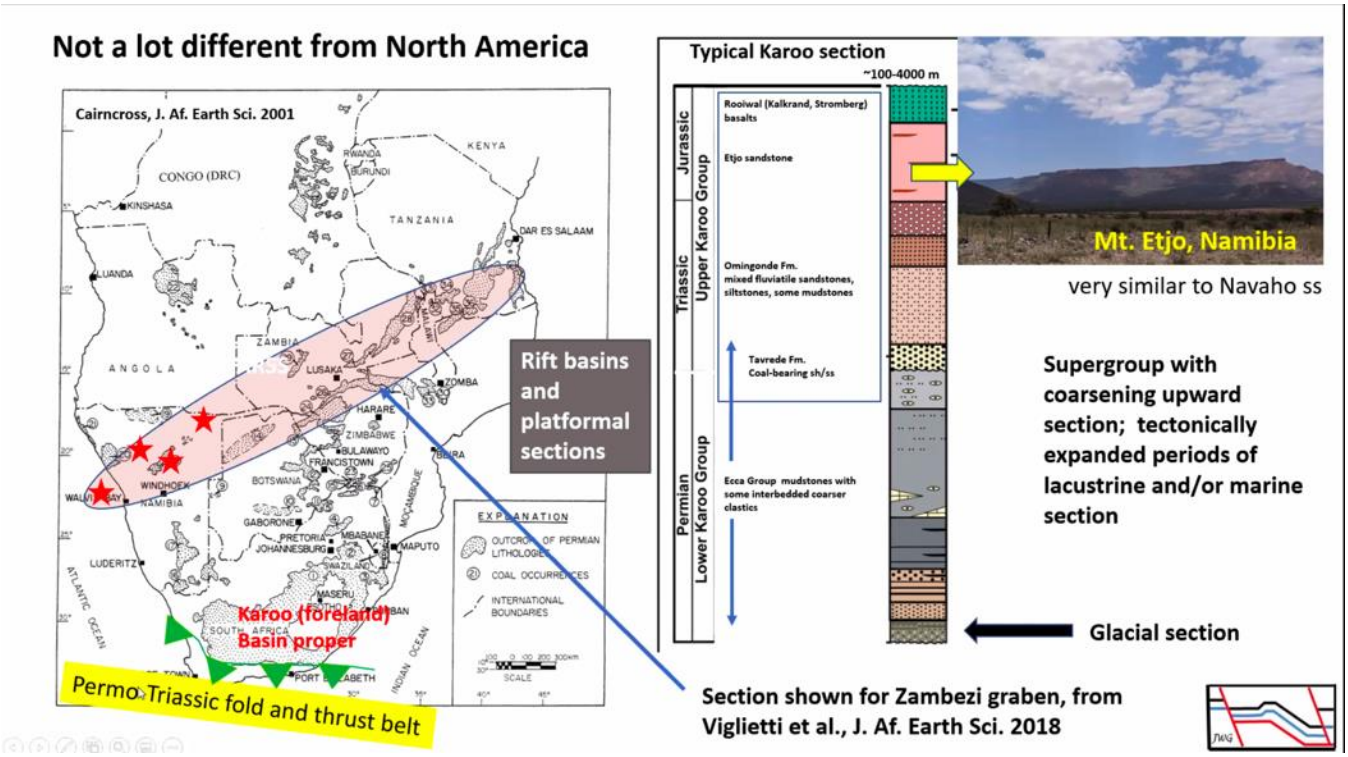
the structural elements out of STARSS plotted on here and you can see the Luangwa basin here that's really shows up nicely it's big enough to actually see. Then you can see some of the other basins, then tails off into, but it gets more complicated as you go up into Tanzania. But basically, these things all connect together, it shows where the shear zones are and the shear zones have names, the Mwembeshi, got to get used to these African names and a couple of others, go undercover. Big sediment thicknesses here and there, which look about the same, the same magnitude as some of the extensional basins and it comes out the other side as the lineaments going across the, the Damara section. Now, notice where the Precambrian is exposed. They rim the continent in the West side of Africa, their uplifts related to the breakup, the Atlantic breakup, and other things happening in the tertiary. In the East. They're related to the Kenya dome and other domes that were uplifted during the development and the initiation and development of the East African Rift system. So it's left this bowl in the middle. That covers the older basins. So we got the Owambo Foreland basin. We've got the Kavango basin extensional basin sitting up on top of here along with the rest of the belt. We've got other features that are hinted at. Down on the South side we've got the Southern foreland belt, the other side of the crystalline rocks, they're exposed right along in here in some degree. And they have their own Foreland basin which has been developed down here. This is the Nama and other basins which looked like they are Karoo, or look like they are routed by similar Precambrian Foreland basins. Okay.



Jim Granath 1:16:22

So, the STARS system, the whole sort of the history is a is a is a catalogue of features in the Phanerozoic or since the Cambrian, we got the development of the fold belt itself which is key in the whole thing and the lineaments parallel in the zones in the basement. Then we have a 200 million year gap and they're reactivated by the Karoo basins. And that's probably been driven by some of the

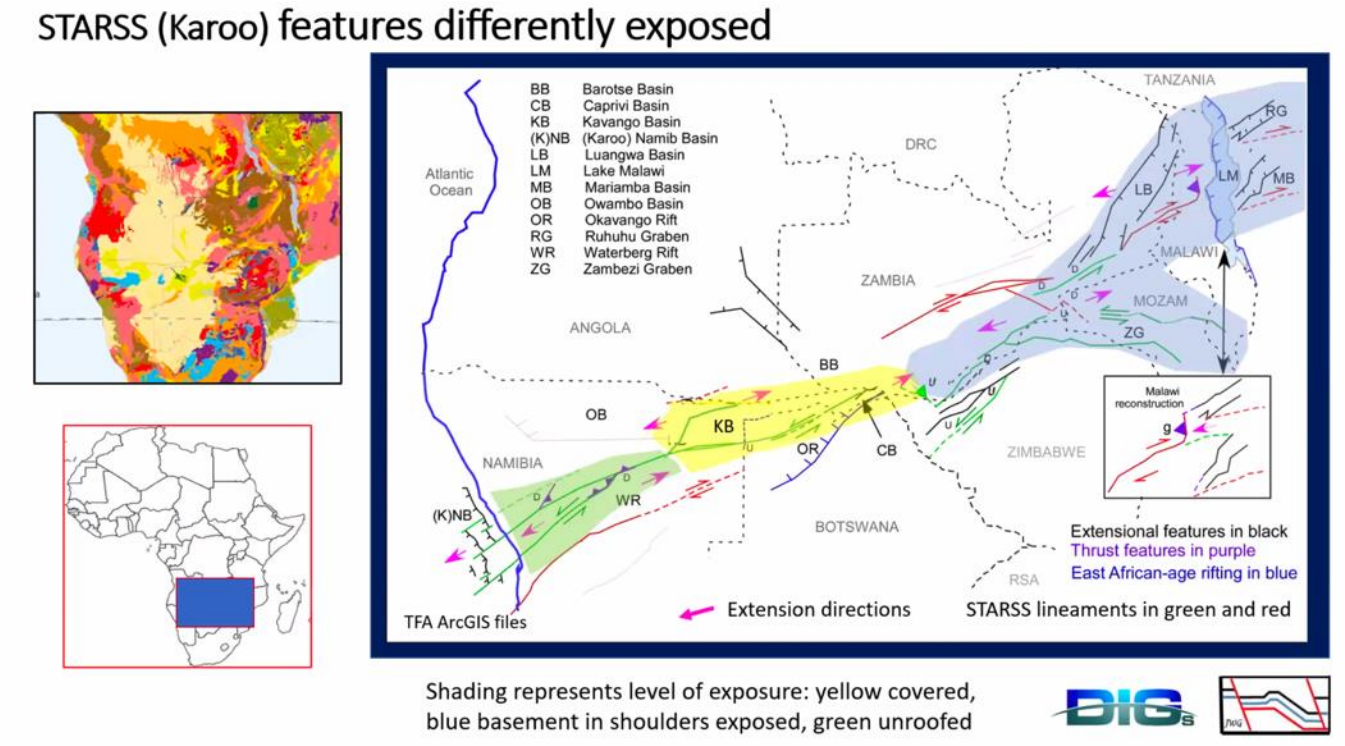
Gondwana assembly things this will show in a slide. And then that's another 250 million years to get to today. But along the way, those things were deformed by Uplift to the Gondwana breakup things on the west side, and then over on the east side. Even younger stuff that I haven't put on here, younger stuff from the East African Rift system. So you can see that all fits in about 25% of geologic time. So the STARSS system is kicked in, and is channeled, if you like by features that parallel the suture, and then the whole thing is, is obfuscated by younger tectonic elements.



Jim Granath 1:17:36

So here's a map of all the Karoo exposures in Southern Africa, all these stippled areas from Cairncross and company. They were doing a paper that was evaluating the coal bed methane potential in the Karoo. Here's a number of important outcrops or important locations in Namibia. The karoo. Here's the Waterberg basin. In between the Waterberg and the coast there are a number of pieces of Karoo that are too small to show on here. But they show structural relationships just like the Waterberg and then there's the offshore one that's that's preserved in seismic information. Elsewhere, most of these are platformal pieces of Karoo, sitting, just exposed and are surrounded by younger rocks or sitting as patches on top of the basement until you get down to the Karoo basin proper in South Africa, where it itself is the Foreland basin to the Permo Triassic Cape fold belt, which is part of the assembly of Gondwana. So you can almost see a parallel to North America here you've got something that's about the same age as the Appalachians, pounding on the bottom side of Africa. And way inside the continent, you've got different kinds of activity taking place that are extensional basins, and perhaps some uplifts that are related to it. A lot like the reactivation of the southern Oklahoma Aulacogen or the Ancestral Rocky Mountains. So here's the section we expect. And this is based on one of the Zambezi Graben things, but it's typical of the Karoo. At the bottom is the glacial section, which is latest, latest carboniferous or earliest Permian. And then you get in cold weather kind of depth deposits with high

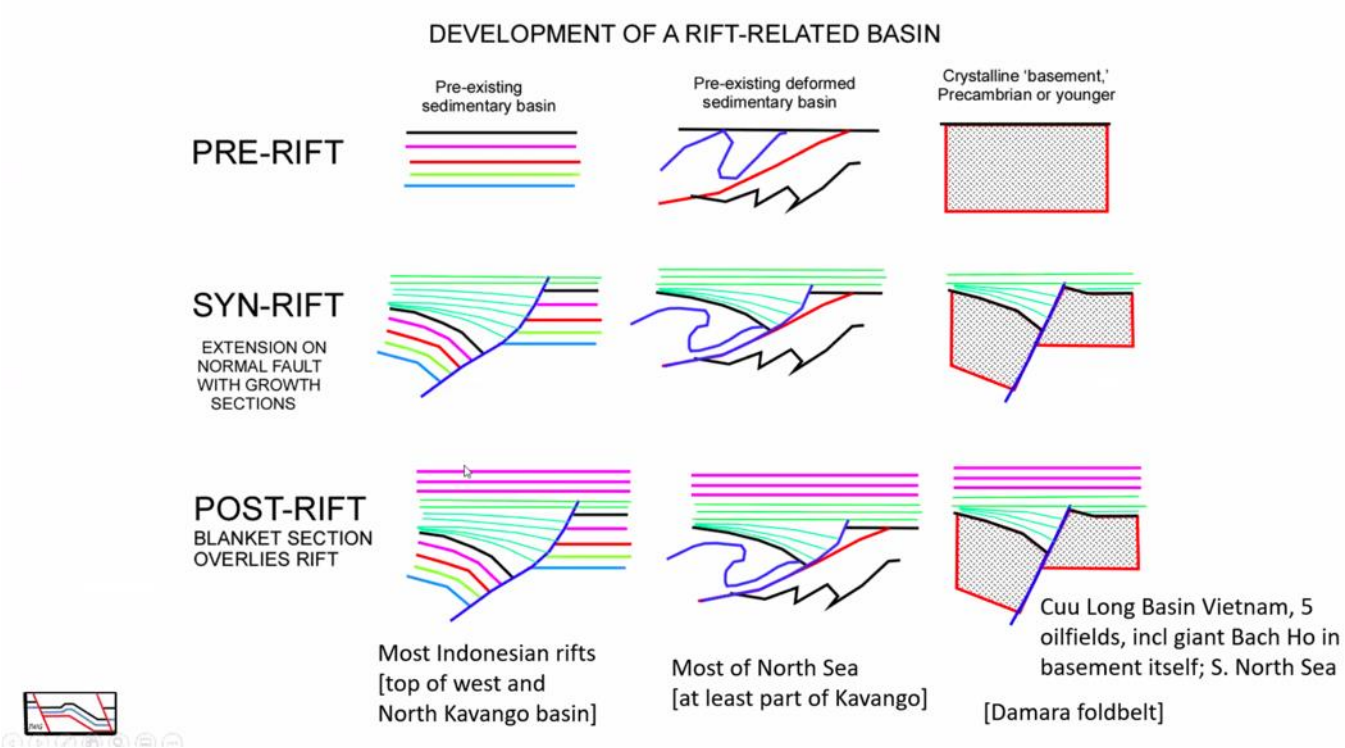
latitude, Flora things and then you get into some gray section. And all the while this is drifting farther and farther north into more equitable climates. Until you get up into the the Triassic here in the Namibian area where we see the Tavrede formation and, and this thing called the Omingonde formation, which is basically the terrestrial and perhaps Lake deposits that are prior to the Etjo, and then what caps it is the Aeolian dune system of the Etjo sandstones, which are shown here at Mount Etjo. It's the highest point in Namibia. It's about a couple of 1000 meters high. It's in a national park. And if you were to go up and look at that, you would swear you were looking at the Navajo sandstone of the southwestern United States, it's it's stained red, it's got the Aeolian you know, the dune cross bedding, the whole bit. And in this section, in the, in the lower part of the Etjo, there are lower Jurassic dinosaurs, both bone fossils and tracks. And then in the Omingonde here in the upper part of the Karoo. There are l ots of the Dicynodont fossil locations, very classic ones, there's an extensive literature of it. That basically dates a lot of the particularly the upper part of the Karoo. You know, those are the mammal like reptiles early in the, in the dinosaur sequence. And then when you get down in the lower part of the Permian, you'd have to depend on mostly on paleonology. And so we went over to go working on that, not necessarily in the wells, but we worked paleonology over in the ST Well, and then down in the in the Waterberg. And I'll show you that in a minute.



Jim Granath 1:21:43

Okay, so STARSS features differently exposed, Eastern ones here, exposed down to basement with the rift keels preserved in, in between in the middle of the continent, everything's covered, then you go off to the west, it's popped up by the very dramatic uplift to the of the margin of the continents. All the indications from the normal faults are that extensions are more or less parallel to the belt. So what's happened is this, these basins have accommodated differential motion between I think what is going on in Kalahari and what's going on in Congo, during the Permo Triassic. In the second hour, we're going to

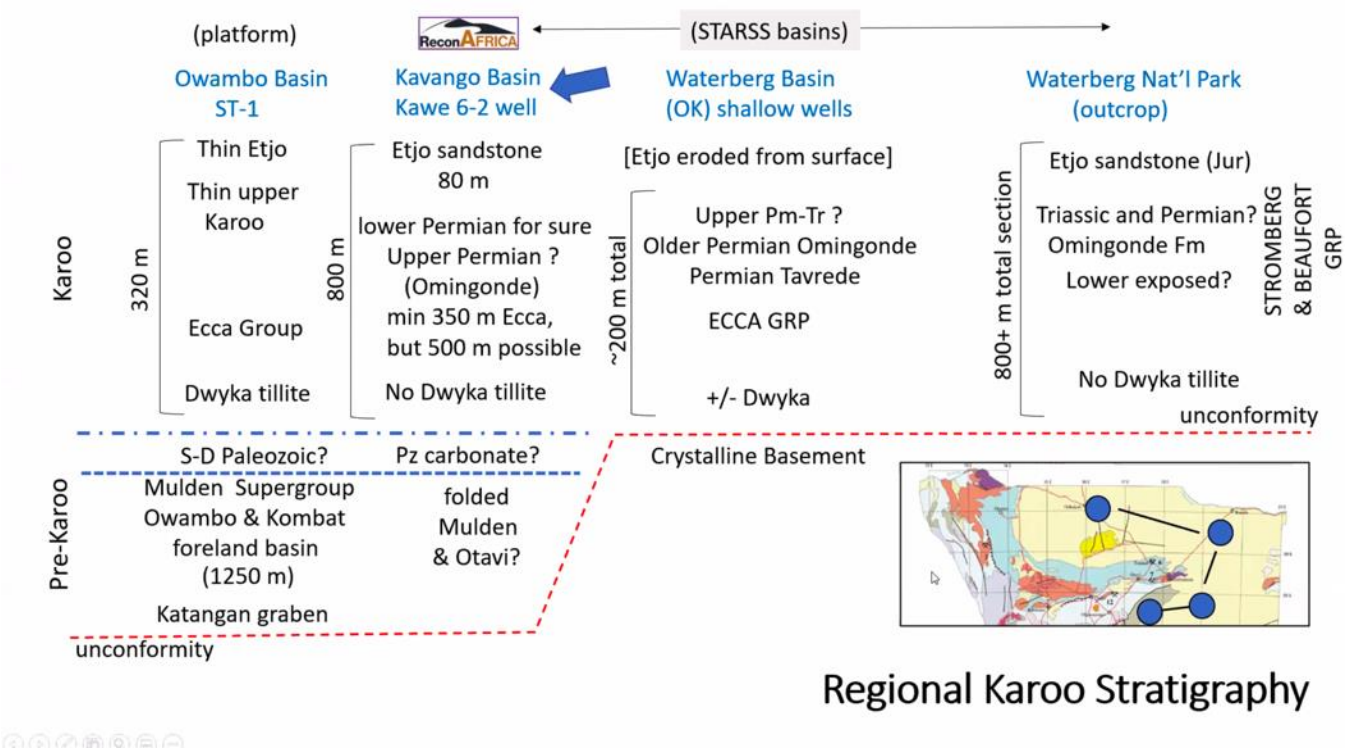
talk a lot about extension and displacement vectors. So it's a little bit different from your normal kind of extensional system. The Luangwa basin is what you would normally think and it looks like it, with all the all the transfers and relays and types of things that are typical of rift basins, but that's because of its orientation up here and the orientation of the of the basement. Otherwise, the transfer faults are segmenting the extensional pieces up into into short segments like it's shown off here and in the offshore.



Jim Granath 1:23:08

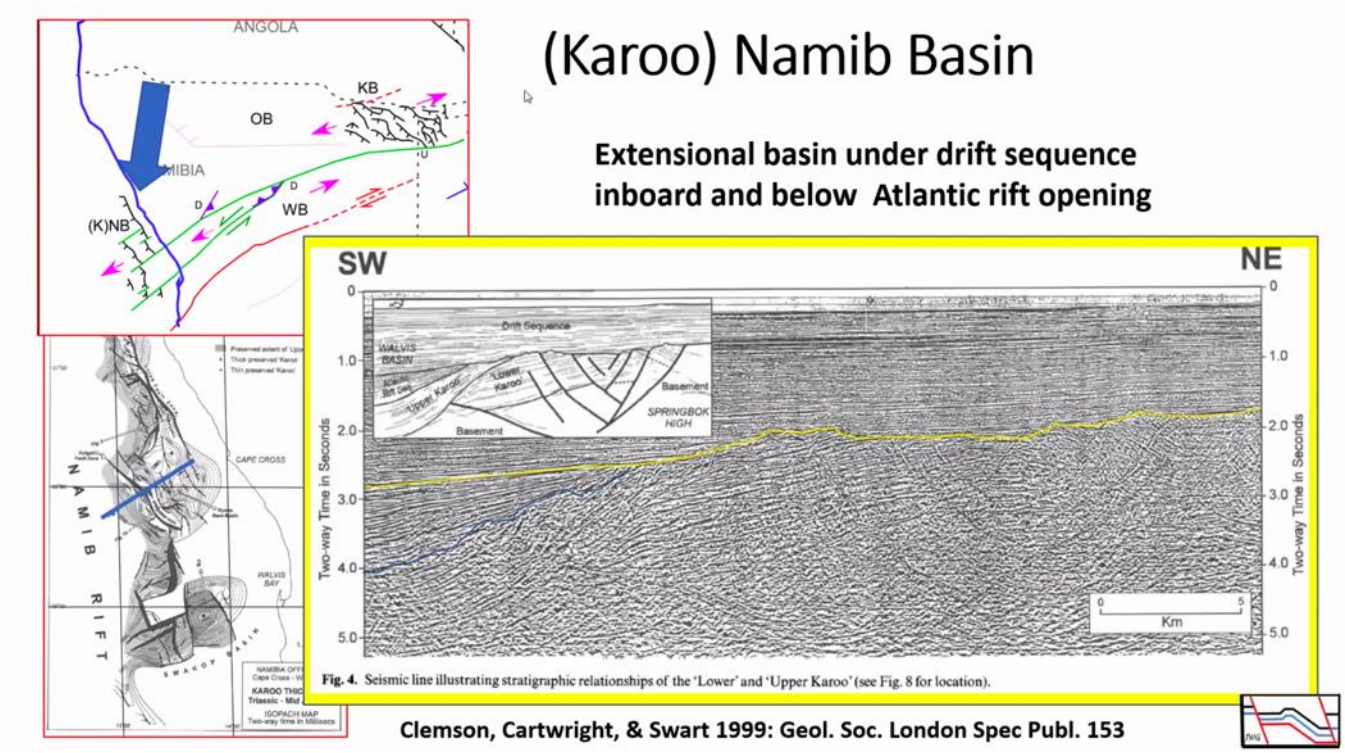
Alright, development of a rift related basins. This kind of gets to the definition of a basin. In geologic terms, most structural geologist, I think, think of basins as prisms of rock. They're not necessarily the shape that they're filling, not bowls, they're not necessarily wedges are in the basin is the sedimentary rock. And so if there are rocks that are genetically unrelated to each other, they can be stacked in the same place. And they would be considered separate basins from that point of view from untangling the geologic history. But they might pick up the same name. And that's what's happening here, we borrowed the name Kavango from the the local geography, and previously it had been used only for the basin on the describes the Kalahari groundwater system. But we picked it up to, because it was more or less the same area, we picked up the term to describe the stuff underneath. So in terms of the life cycle of a rift, rifts have to be developed on top of something else. So they may be developed on some other sedimentary basin, maybe a nice stacked sequence of rocks. They can be developed on a basin that's been deformed like a fold belt, in this case, or they could be developed on Crystalline rock. A Precambrian or younger, they can be developed on intrusive belts, for example. If you had a rift developed in the Sierra Nevada it would be developed right on top of Cretaceous rock, which by the way, is what's going on in Vietnam and we'll get to that in a minute. So you start to develop the rift you develop a Syn-rift sequence in the Grabens with extended thicknesses and on the highs. In all of these

cases, I've just drawn them as slightly, you know, various variations on the Listrik shape here. But you can you can recognize this because of the expanded section you can see these in seismic data, when they're apparent. In fact, we'll see it in a minute in the offshore. Okay, so then the rift quits and, less it's eroded, uplifted or somehow lost, it gets covered with a post rift here in the pink and the post rift is going to be nice parallel bedding relatively uniform thickness, all very monotonically changing with time. And there are examples of all of these in the world in terms of petroleum systems. I mentioned the crystalline basement one here, the Cuu Long basin in offshore Vietnam, there are five oil fields where the production is out of the basement rock, basement rock is Cretaceous granites, but it has tertiary sediments developed in the rift basin and then tertiary sediments lying on top of that. One of those is the giant Bach Ho field, White Tiger. And it produces out of hydrothermally altered and weathered basement for its porosity and permeability. A good part of the Northern of the North Sea is the same thing. In the South, a lot of it's developed on the crystalline core of the Paleozoic fold belts of Central Europe. It doesn't really matter. And a lot of the Indonesian basins are developed on pre existing sedimentary basins like this geometry. And I think that we may run into that sort of thing in the Northern Kavango basin. In terms of the fold belt, this looks like it's what we drilled into, a situation sort of like this. Where we have drilled the high block we went through the post rift. Remember from our diagram of 6-2, through the rift sequence, the Karoo and then into, through an unconformity, and then into the pre-Rift, which here happens to be an old fold belt. Most of the North Sea is this kind of a situation, it's developed on the northern part of the North seas on the Caledonian fold belt. And so the Kavango go could be in the block, in the PEL 73, we could have elements of all of these, I think this is a situation we've got at 6-2, if you go North, we may get into the Foreland basin where it skirts the edge of the fold belt. Or if you go South, we may get into the core of the of the crystalline rocks.

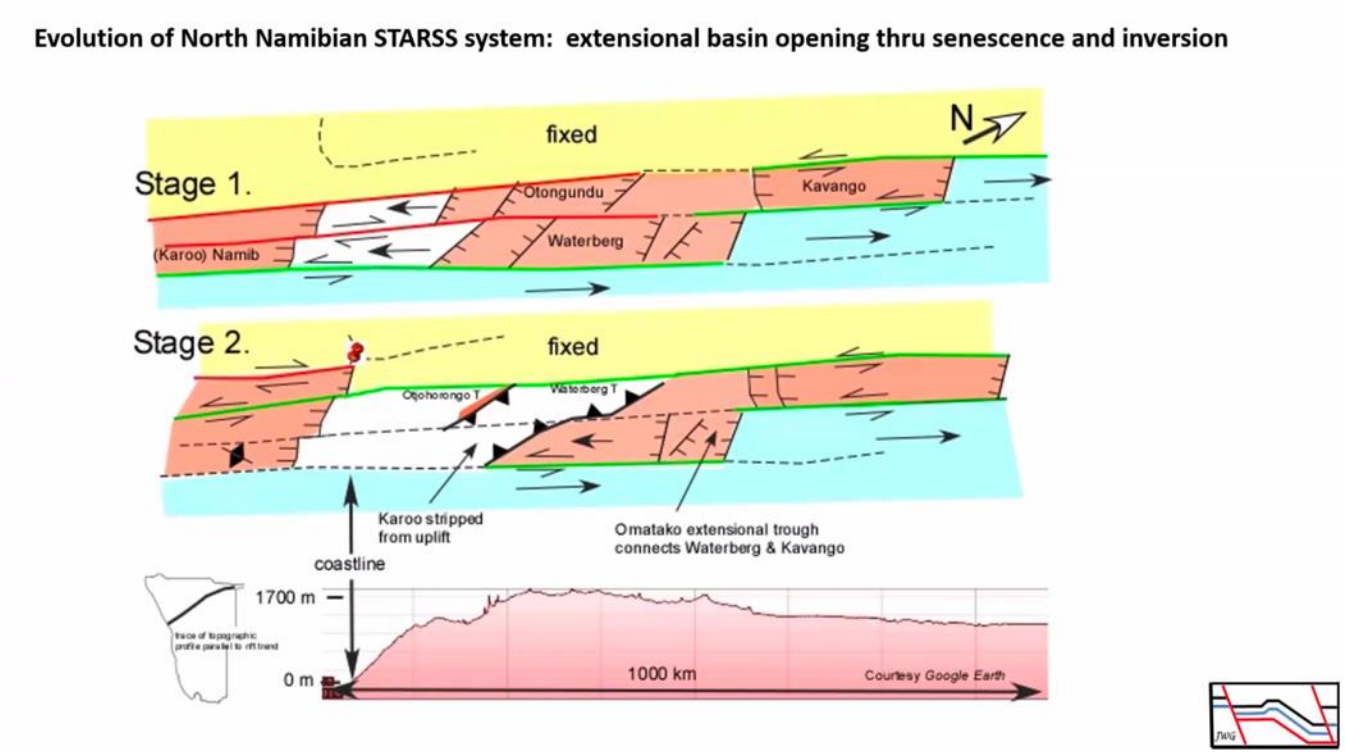


Jim Granath 1:27:48

So again, now this is data that's been released from Recon, so to speak. At least this column, here was the Owambo Basin where the ST-1 well was drilled, and then about 300 meters of various aged Karoo including some Dwyka tillites, some drop stone type sediments at the bottom, and a very, very thin Ecca, just a few meters. If you can, and that's over here. If you jump across, down to the Waterberg, there's a place where the Waterberg is exposed. I showed you that that photograph from Mount from Etjo. That's the type locality for the sandstone. In that particular locality, we've only got the upper part of the what we can tell of the of the of the Karoo, we don't see the Dwyka tillite, we don't get that deep. We see this Omingonde formation, we see that vertebrate fauna the dates it quite well. And basically, one of the attractions in the Mount Etjo area is the dinosaur tracks, which have been dated as Theropods of early Jurassic age. So we've got that section and it's about, it alone without even knowing the bottom of the section, it's over 800 meters thick. In between, we jumped to the middle of the Waterberg where there are two other wells, they're only 200 metres deep. They were drilled for coal exploration. And they got deep into the section they got down to the bottom of the Ecca group. A couple of them tagged Dwyka and a couple of them actually got in tagged the crystalline basement. So it looks like there we're seeing the lower part of the of the Karoo, but we don't quite know how these two connect together. There's no subsurface or seismic data to do that. It'd be nice to do some paleonology to find out if there's any overlap in these sections. And get some of that, perhaps, in mind later on for a research project outside Reconnaissance Africa. In the wells, we got about 800 meters, didn't happen to have Dwyka locally, but that's no particular problem. We drilled into these mysterious carbonates above the folded carbonates which are probably the folded part of the Foreland basin that's at the tip of the fold belt. So here we've got, we've got a good healthy section of 800 meters which sort of smacks that it's fault controlled, It fits with the original Kavango interpretation.

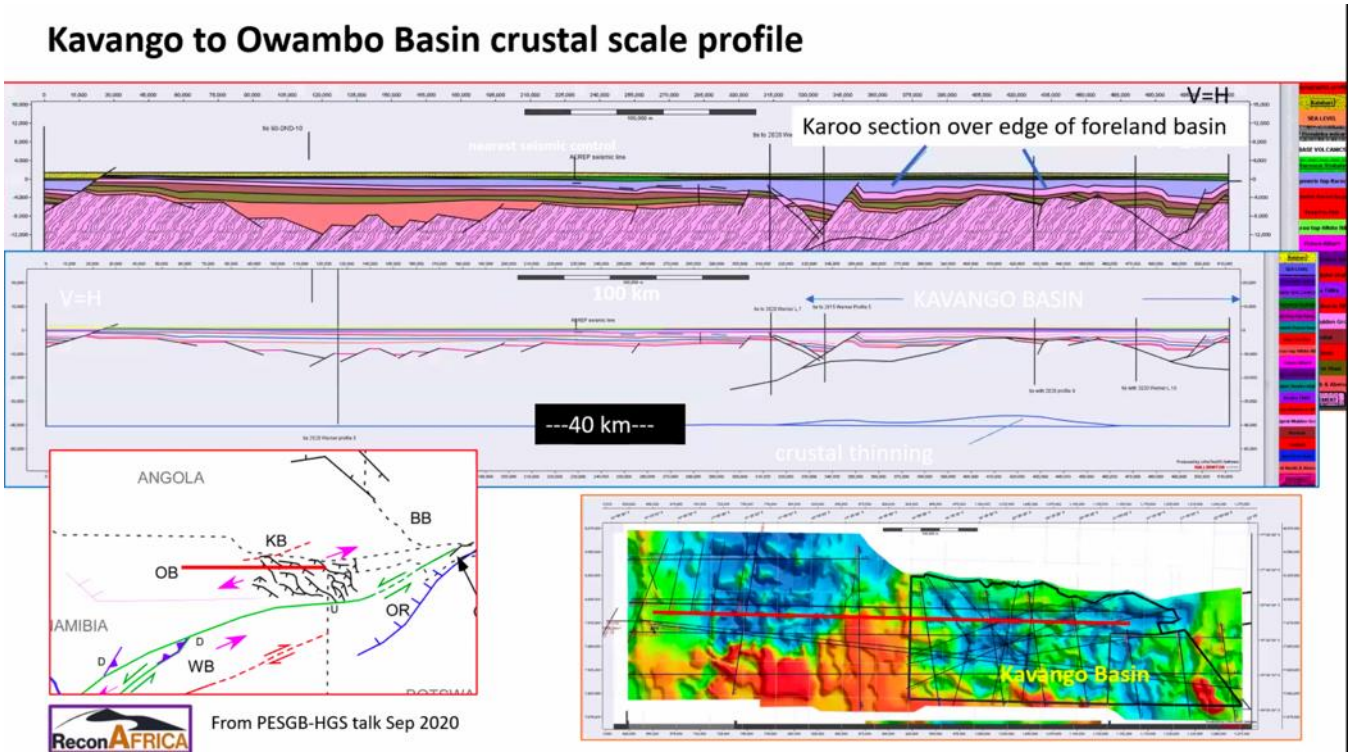


Jim Granath 1:30:28
So now if we actually get some real live seismic data from the offshore here, what Clemson and company called the Namib rift, I call it the Karoo Namib basin just to separate it from the [inaudible], which is farther to the north and younger. So we got the breakup unconformity down here, three seconds offshore comes up to about two seconds near shore. And beneath that you can see there's some very clear, fault controlled basins with some unconformities developed inside of it and they analyze this whole thing basically, but a really good argument to connect it onshore to pre Atlantic opening Karoo section. So that's our, and you can see if you map the elements in there the principal elements, you can see that they're very short rift segments separated by transfer faults, some of which line up directly with the lineaments onshore in the in the basement.



Jim Granath 1:31:38
So we could make a story in Namibia about the number of these basins being developed the one we just looked at offshore, the Waterberg and half the Waterberg is cut off by an inversion structure. The name OtonGundu is not not my name, but it's been applied to a number of discontinuous outcrops sitting on top of the of the basement rocks. And then we're postulating out here to the northeast is the Kavango. And then as that develops these open up and as they develop and [inaudible], and in the second hour I'm going to give you that argument, the Waterberg thrust was formed, some of the basement blocks were uplifted as the whole [inaudible] were uplifted in relative relationship to their rift basin. As the passive margin was uplifted and even as the extension developed, that's partly the second hour. So now we see the topography reflecting that from the coast you go up to about 1700 meters in elevation near the Waterberg rift, and then it, or the Waterberg thrust, and then it drops down dramatically down to about 1000 meters over here in Kavango, where we've got a big thick section, or we have a nice blanket of Kalahari developed on top. Some estimates using after data, and other things

which which are in the public literature, suggest as much as three kilometers of rock are moved or removed here. So you can pop this down, you can make considerable Karoo sections out of that situation.



Jim Granath 1:33:25
So this is how we see the situation now, this is a model that I built from the late development of the depth-to-basement models. And it shows a section that goes all the way from the Owambo base and across our transition into Kavango. Some sort of postulation of some fault systems in here, showing extension more or less in the Northeast southwest direction, parallel to the lineaments. here's the, here's the line diagram. Here's the colored diagram. And what it shows over in Owambo is our passive margin section for the Karoo. For the Congo craton, the older Precambrian, and then its Foreland basin section developed on top going up into something like Karoo in the blue. As we come to the West, that gets faulted, cut up, and we've got variable thickness of Karoo in the in the rift basins. And so what we happen to drill at 6-2 was something like this. So I don't know if this is dimensionalized correctly, but it's certainly possible. I don't know if it's dimensionalized correctly, of course, because it was done about a year and a half before the wells were drilled. But that's how we see the situation now. So with that, I'll close it there. Let's take some questions and take a break on the intermission.