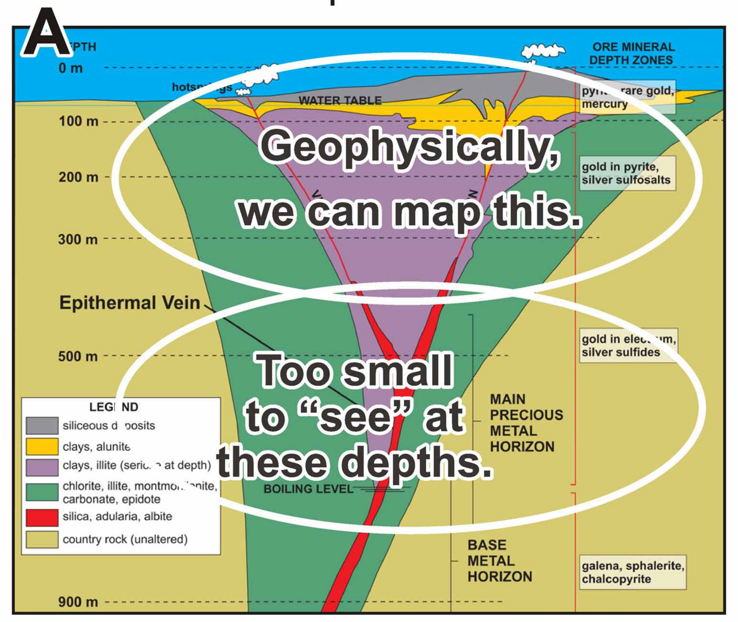
Very Large Scale 3D Resistivity mapping - VLS 3D

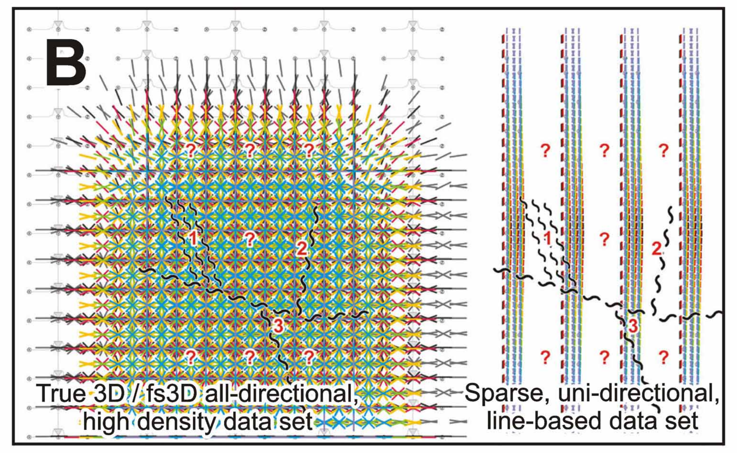
Very Large Scale 3D Resistivity imaging can be loosely defined as acquiring and investigating fs3D-quality field data that extend to 3 to 10 times the nominal depth of investigation (Ze) that is required for imaging a structurally conceived target feature. Being basically an extension of coverage to reveal the larger scale context, it also applies laterally. In both dimensions, there is the opportunity not only to better understand the nature and perhaps the genesis of the targeted body, but to discover additional potential resources of a completely different geophysical signature and/or scale. Even to be able to infer the probable location of a still-invisible ore structure on the basis of pattern components that are visible. This latter aspect is perhaps the most powerful tool of all.

The problem:

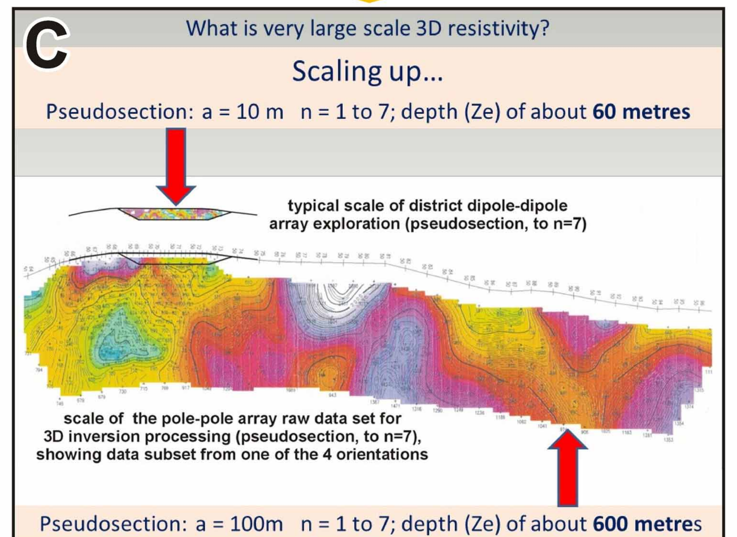


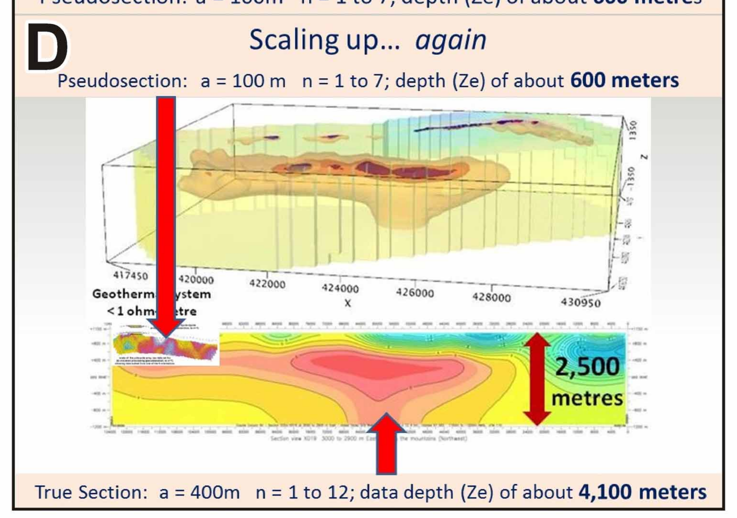
Can we use the *visible* upper levels 3D imaging patterns to recognize a model setting and then to infer the location of deeper, geophysically *invisible* structure targets?

Very large scale true 3D imaging presents that possibility... but it is not easy: *not just any deep data will do.* The high cost of deep drilling demands equally high levels of confidence in the field data that are the basis for the targeting.



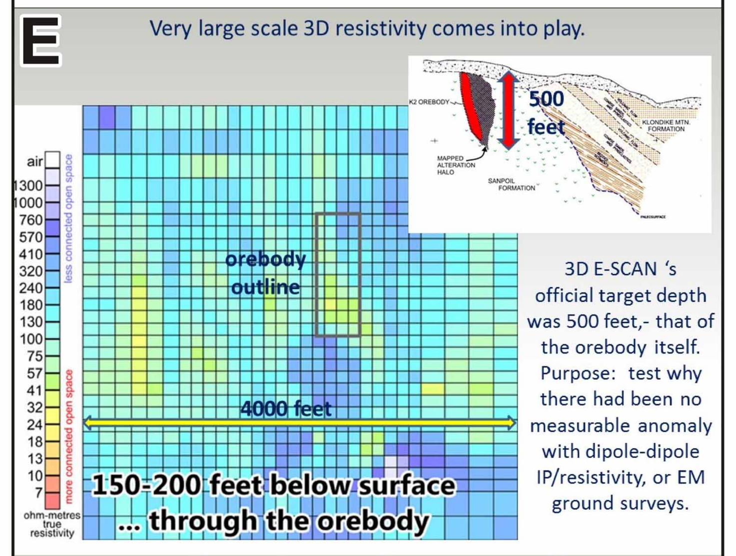
Some survey technologies may go "deep" enough (above right), but don't maintain the shallow true 3D (or fs3D) hard data objectivity and all-directional resolution at depth. Since increasingly subtle resolution may be needed to image deeper patterns, the same all-directional data intensity that is more easily achieved at shallow depths must be extended through the entire lateral ***and*** depth range that is to be investigated. 3D E-SCAN technology routinely achieves this data distribution, while avoiding the excessive operational costs that could discourage frequent use of the strategy.

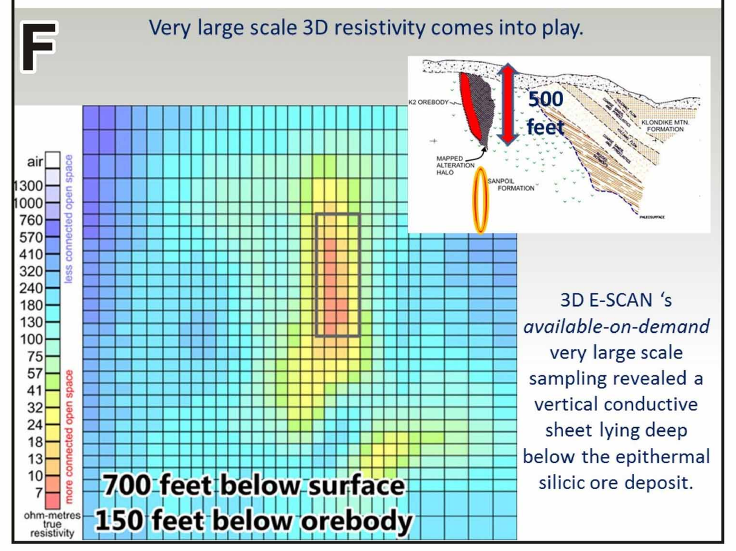




With this full range of fs3D resistivity data depths of investigation, the realization of the exploration insights of Very Large Scale 3D Resistivity becomes a matter of determining (1) when the extra field survey cost is warranted, and then (2) specifying the depth "overshoot" and/or lateral area extensions *relative to the initial target dimensions*, - 2X, 5X, 10X ?

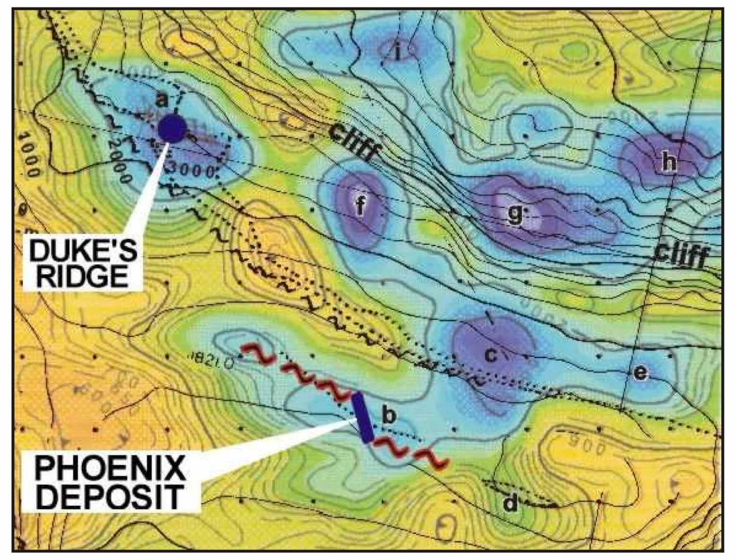
An incidental benefit of the routine inclusion of VLS 3D data in a fs3D mining survey: the K2 deposit.





Above, fs3D E-SCAN confirms that the silicic orebody is indistinguishable from the host volcanics signature. EM and resistivity methods failed for this reason. But VLS (deep) resistivity data obtained as a routine part of this fs3D E-SCAN survey have detected strongly conductive lower elements of the epithermal system, strong enough and within the depth range of an airborne VTEM survey. If this can be shown to be a consistent part of the area's typical epithermal deposit signature, fs3D E-SCAN survey may have mapped itself out of a job... *district-scale VTEM mapping could become the new cost-effective method here.* Note - the VLS data here are to-depth only,- no extra area was added laterally, and we see no evidence of any lateral connections extending *off-grid* at depth.

G Visualization benefits from lateral emphasis on the VLS data acquisition and interpretation.



In an area that saw a decade of high-cost and unsuccessful targeting of two metre wide quartz veins using very small scaled DC resistivity and EM surveys, a radical new geophysical approach was proposed: 100 metre wide spacing fs3D resistivity mapping. *VLS overview mapping.*

Opportunities for very large (or "overview scale") resistivity insights.

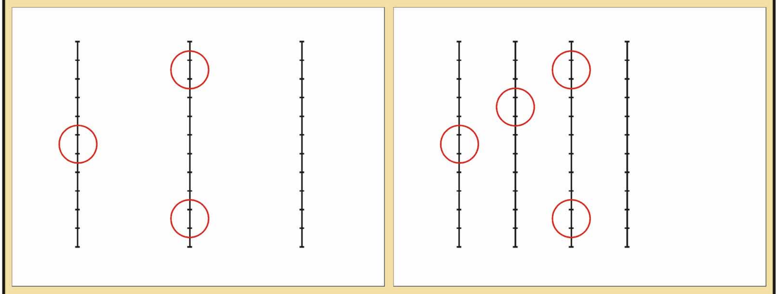
Before you can start:

1. Do you have the spatial data coverage within which to look for your very large scale patterns? *Deep enough? Wide enough?*
2. Do these data actually define and constrain pattern elements *at the level that you would like to employ them* for interpretation?
3. Do these data also define and constrain the *non-anomalous "background" areas* that lie between your selected pattern elements?

Or are you vulnerable to assigning exploration credibility to features that are the (predictable) artefacts, or the technically competent but ultimately misleading "good fit" computational result, of a too-sparse or non-uniformly distributed data set?

KNOW YOUR DATA... then you can get to work.

"Geological-looking" 3D imagery, without a verifiable hard data basis, isn't enough.



Above left, survey lines placed too far apart leave confusion when the explorationist is faced with deciding how to connect these anomalies... NE? SE? Adding just one line of data (right) makes it obvious - NE is the one.

When dealing with complex 3D data, this question arises within the inversion algorithm all the time, *millions of times*. Either you supply the hard data, or the 3D inversion algorithm will estimate for you, i.e. interpolate values between the available hard data. Sparse-data, highly interpolated 3D models may be difficult to distinguish from fs3D data-constrained 3D models. Your only assurance that the patterns you select for deep drilling are *verifiably data-based* is to supply a quality fs3D data set, up front.

A new characterization of 3D DC resistivity data is proposed. Use of two definitions recognizes that less dense and potentially more economical "True 3D" data sets can suffice for simple, large conductive targets, while the reliable mapping of resistive-end anomalies and subtle details requires a substantially denser version of True 3D,- called Full Spectrum 3D ("fs3D").

Not for down-hole, hole-to-hole, mise a la masse, or other below-surface (source or measurement) survey styles.

Definition: True 3D

"True 3D" is a term that is widely applied and seldom meaningfully defined. In this paper, "True 3D" means (for DC resistivity and IP): A True 3D field data set is
1. uniformly all-directional, and
2. uniformly distributed both laterally and to depth*.

* The density (of uniformly laterally-distributed data) is permitted to fall off logarithmically with increasing Ze or "n".

A True 3D inverted earth model is any model that has been data-constrained by a True 3D data set.

True 3D data occupy the central areas of any well-executed 3D distributed acquisition survey or 3D E-SCAN survey. Cross-line surveys are designed to produce **True 3D** data sets *for conductive targets*.

For Athabasca Basin purposes, low-density "True 3D" may be sufficient for targeting **large conductive zones**, for drill testing to confirm the presence of mineralization, alteration, or radioactivity levels of interest.

Definition: Full Spectrum 3D fs3D

"Full Spectrum 3D" or "fs3D" is a term that is proposed to distinguish those "True 3D" data which meet the extended criteria required for the equal and objective 3D resolution of features through the entire resistive-end of the conductive-resistive spectrum.

An fs3D field data set meets the definition of
1. True 3D, and has a ...
2. higher density of sampling*.

* sufficient to resolve 3D resistive features with sensitivity equal to that which is (more easily) attained for more conductive features.

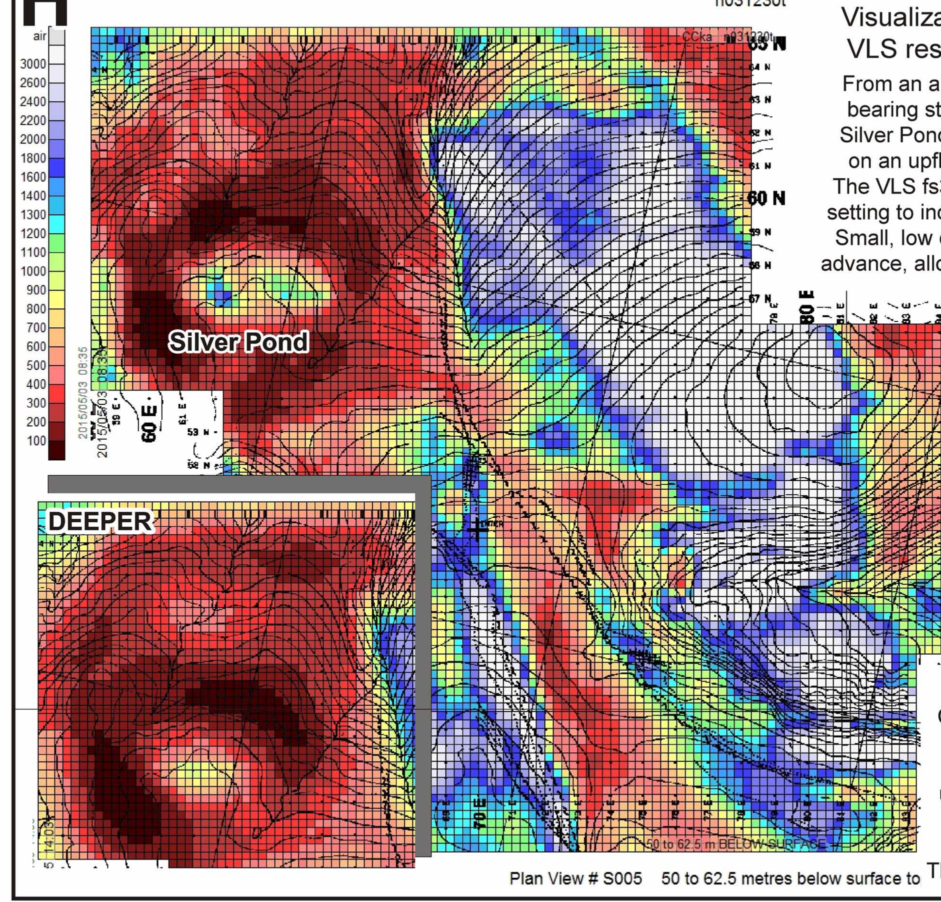
A full spectrum fs3D inverted earth model is any model that has been data-constrained by an fs3D data set.

fs3D data sets are found within the central areas of any 3D distributed acquisition (data-logger) survey or 3D E-SCAN survey, provided that the increased sampling density is uniformly distributed.

For Athabasca Basin purposes, low-density "True 3D" may be sufficient for targeting **large conductive zones**, for drill testing to confirm the presence of mineralization, alteration, or radioactivity levels of interest.

Focussed surveys weren't working, so why not look for a larger alteration imprint made by the epithermal system itself? Above left is the Phoenix deposit, a 2 metre wide shear zone some 60 metres long, and grading up to 76 ounces/ton Au, discovered by drilling *across* the VLS resistivity mapped silicification envelope: the light blue 100 metre wide zone.

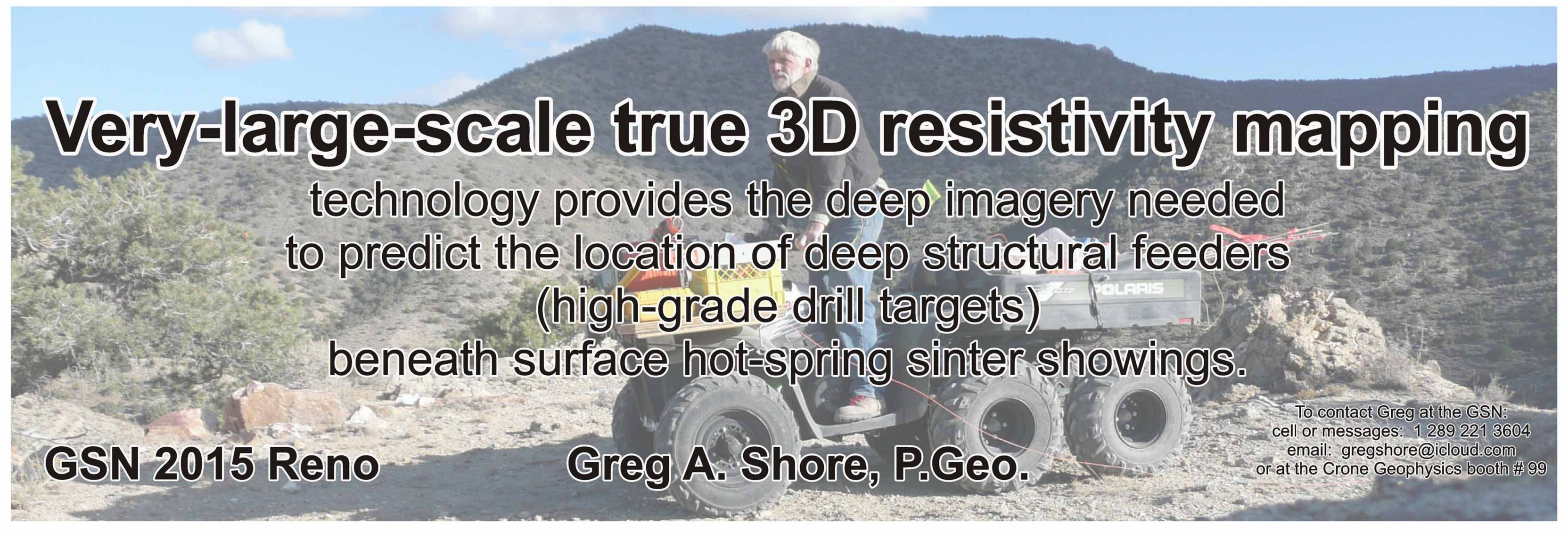
H



Visualization benefits from lateral emphasis on the VLS resistivity data acquisition and interpretation.

From an analysis focussed on near-surface, metres-wide gold-bearing structures emerges the image of a comparative giant, Silver Pond. This 1000 metre wide alteration system is centred on an upflow conduit mineralized with silver and base metals. The VLS fs3D data set allows a deeper look at this, clarifying the setting to include a weaker twin system imaged to the north (inset). Small, low cost adjustments to the fs3D survey layout pattern, in advance, allow routine shallow mapping to include a VLS overview.

This is the Toodoggone district of north central British Columbia. The property is known as the Lawyers, after the operating gold mine located at "L" above. The 3D E-SCAN discovered Phoenix Deposit was mined out using a decline and simple caving, producing gold ores that often had to be hand sorted or diluted extensively to avoid gumming up the mill,- with gold. The Silver Pond Ag/Cu prospect has not been developed.

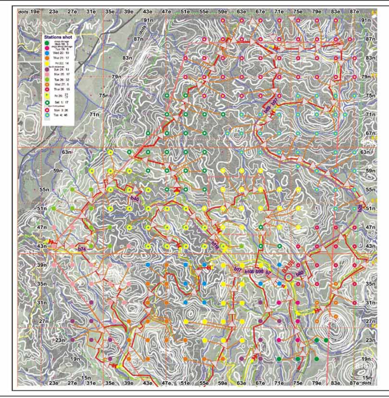


Central Volcanic Region, North Island, New Zealand

In regionally pervasive layered volcanics, 7 to 10 kilometre diameter fossil *(and active)* geothermal systems are known to host gold-bearing silicic zones that outcrop occasionally, in this case about 2 Km apart. Wide area 3D resistivity mapping that was intended to image just the first 600 metres below surface was allowed to continue sampling to the much greater depths that were available within the pre-installed, property-wide 3D E-SCAN measurement system.

The resulting ***very large scale 3D resistivity*** imaging provides some valuable perspective on the deep plumbing configuration that is seen to connect the two distant (and initially presumed to be separate) outcropping silicified areas.

This revelation of a common deep fluid source now offers a new deep drilling target, with the possibility of intersecting bonanza-grade gold in the deep feeders.

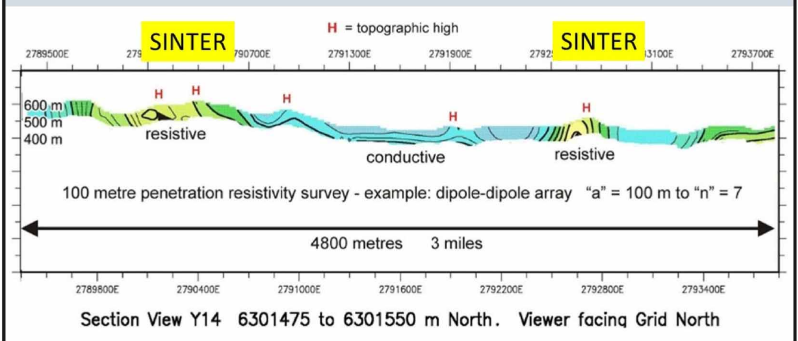


The opportunity for the addition of **Very Large Scale 3D** resistivity mapping to an otherwise moderate (e.g. 600 m Ze) depth of investigation 3D survey arises whenever conditions either allow or require the installation of the 3D field measurement system, in advance, across a broad survey area.

Here, terrain conditions *required* it. In other settings, including more amenable flat lands, explorationists may simply request that the "**VLS 3D**" extra data be acquired.

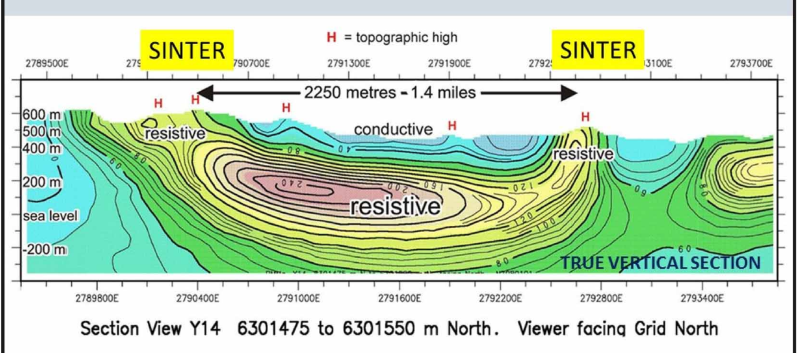
The added cost can be comparatively very low, since few changes are required to the planned progressive survey setup, and very little extra manpower or physical activity is involved. The data sampling just runs longer and wider (*wider = deeper data*), across the existing setup.

A Conventional resistivity traversing detects resistive zones that are associated with silicic erosional remnants... sinters.



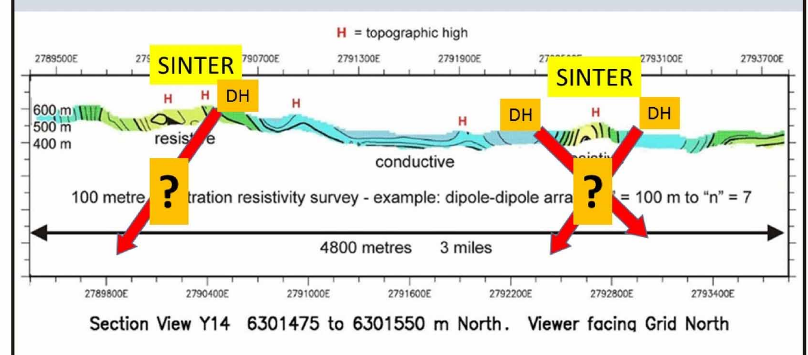
Typically, both hot spring sites will be peppered with drill holes in search of the potentially-high-grade feeder systems beneath each one.

B Very large scale 3D resistivity comes into play. 100 m Ze limitations give way to 1,500 m Ze imaging

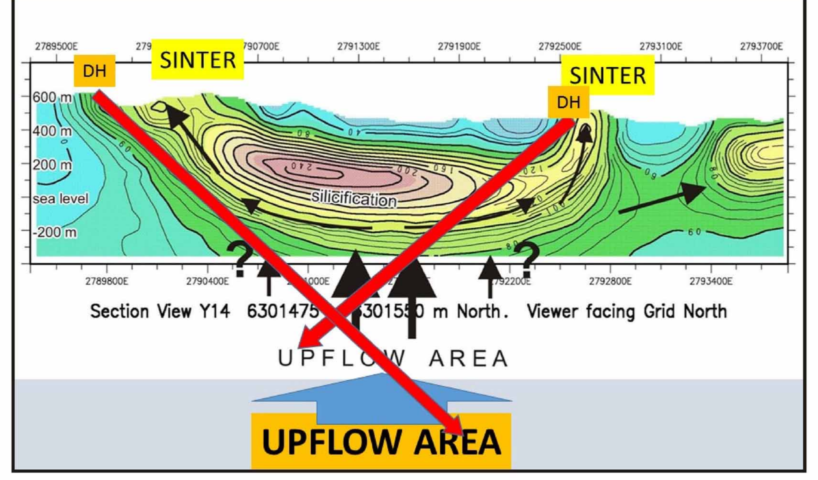


Now we see the 3D resistivity imprint of the single hydrothermal upwelling system (epithermal system) that feeds both surface vents.

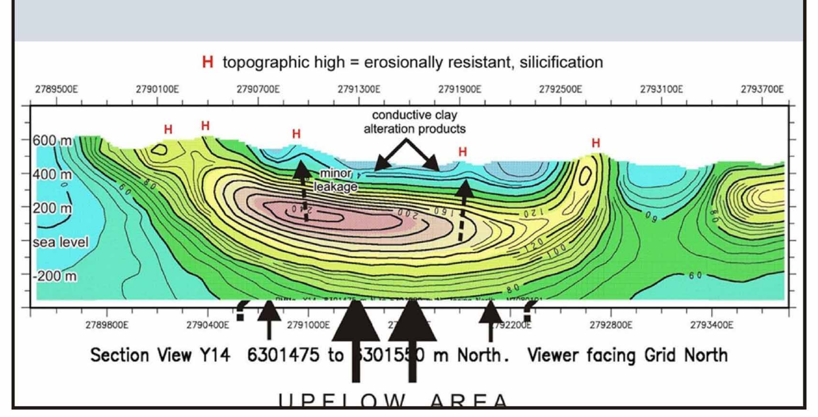
C Where conventional exploration has drilling concentrated in the two proposed feeder areas beneath the surficial sinters....



D ... the real target for deep feeders lies deep below the single-source feeder system.



E Very large scale 3D resistivity comes into play. With Full Spectrum 3D resolution, subtle patterns that are usually buried in noise or as inversion interpolation pseudo-artefacts become *data-secured*, verifiable exploration detailing of the epithermal system's alteration imprint.



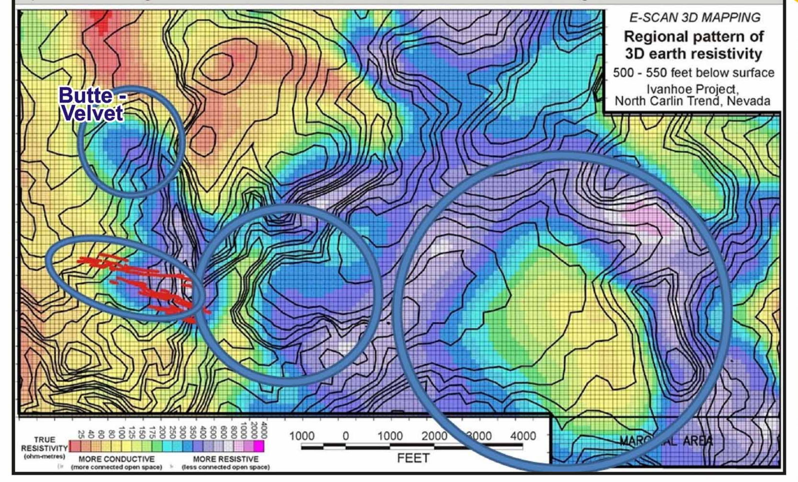
Greg is at the controls of the 3D E-SCAN system (and the lights and sirens) in the New-Zealand-style 3D survey van (a former Tokyo 4x4 ambulance).

The Hollister's Gwenivere-Clementine vein system, Nevada

Toward the north end of the Carlin Trend, the Hollister property has seen decades of exploration effort leading toward the present status of over a million ounces of gold in a basement-hosted feeder vein system. The presence of disseminated gold and alteration in the area's volcanic cover has been known for a long time; the USX open pit remains as visual evidence of the early focus on the lower-grade, shallow resources. Arrowhead-quality silica sinters are exposed at surface in the area, and these attracted attention in early days as (presumed) stand-alone systems, which were drilled vertically to locate feeders. Eventually, angled drilling expanded the testing to deeper possibilities, not restricted to directly below the surficial hot spring sinter manifestations. High-grade intercepts resulted. These images show how that success could have been predicted, and may yet prove useful in predicting elsewhere on the property, - using *very large scale 3D resistivity mapping.*

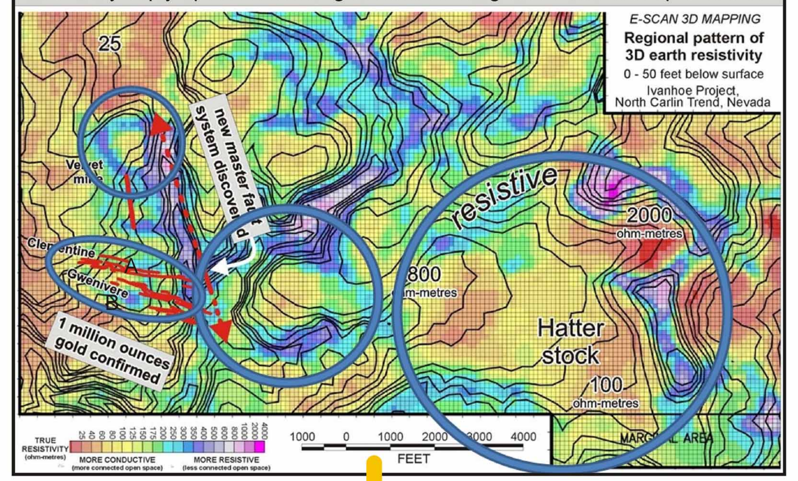
A The Hollister's Clementine and Gwenivere vein system: >1 million ounces Au

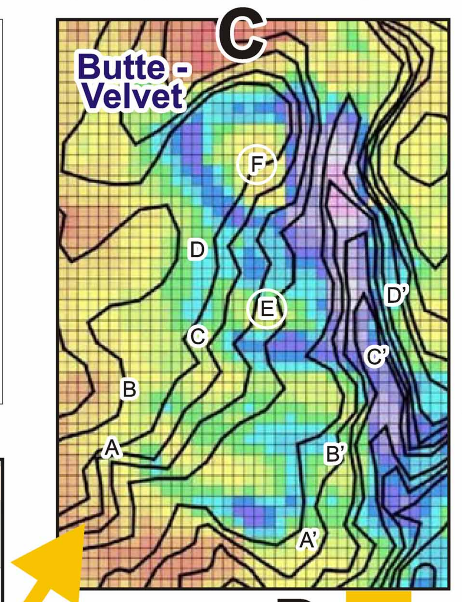
500 feet below surface, a complex pattern of resistive signatures offers many potential targets for encounters with silicification or other tight rock formations.



B The Hollister's Clementine and Gwenivere vein system: >1 million ounces Au

Back at surface, corresponding patterns linear, linear-parallel, and circular high resistivity imply upflow channelling of silica-bearing fluids from a deeper source





This blow-up of the shallowest 50 feet of the Velvet/Butte - Clementine area (north to south) reveals narrow linear and circular traces of elevated resistivity, indicating... what?

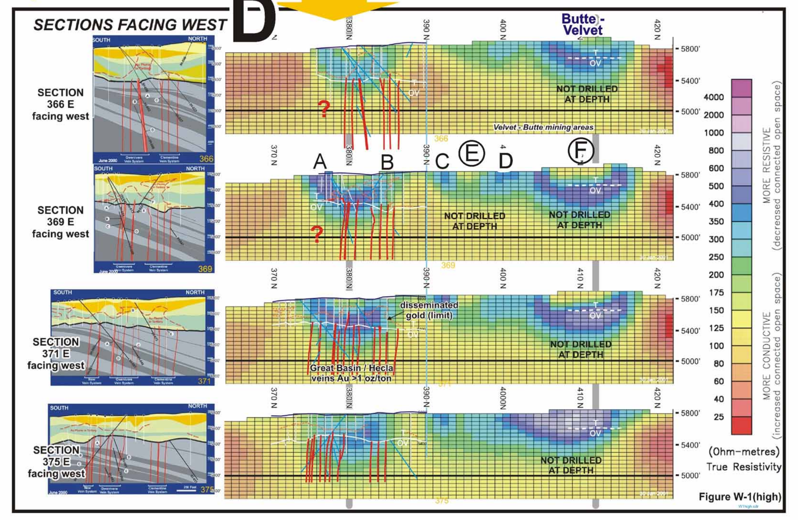
We now know that resistive features in a pervasive volcanic host like this demand attention. They could be linked at depth; could be the surface indicators of complex deeper plumbing systems that could mark previously unrealized, higher grade gold drill targets.

We label four E-W linears and two circular patterns, A through F. The circular features E and F seem obvious, but what about linears A, B, C and possibly D? Are they linked?

Why wouldn't we just drill each feature and nail down the enclosed leaky structure, just like in the Toodoggone example?

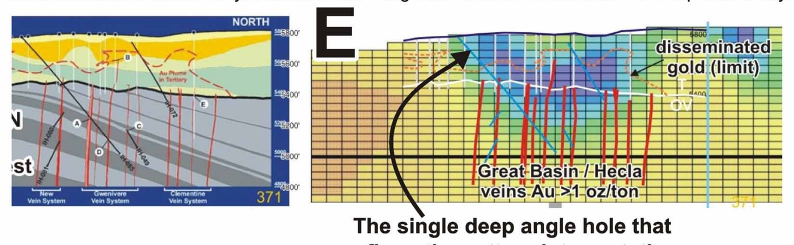
Absent any better imaging, we would do just that, - drill each individually. However, we already know from image A (left) that there are broader resistive zones underlying these groups of narrow rings and linears, - perhaps signalling more complex, possibly linked patterns with different exploration implications.

If you have the ability to get inside these patterns, roam about in fs3D, do it... See what the hard-data-supported patterns may suggest as new exploration model options.



This section view sequence resolves the relationships between the separate shallow linear and circular features. Linears A and B share a common, deeper elongate-west (probably faults/veins) source of fluids, quite separate from C and D, where the circular mode indicates a single pipe-like fluid source at E and F.

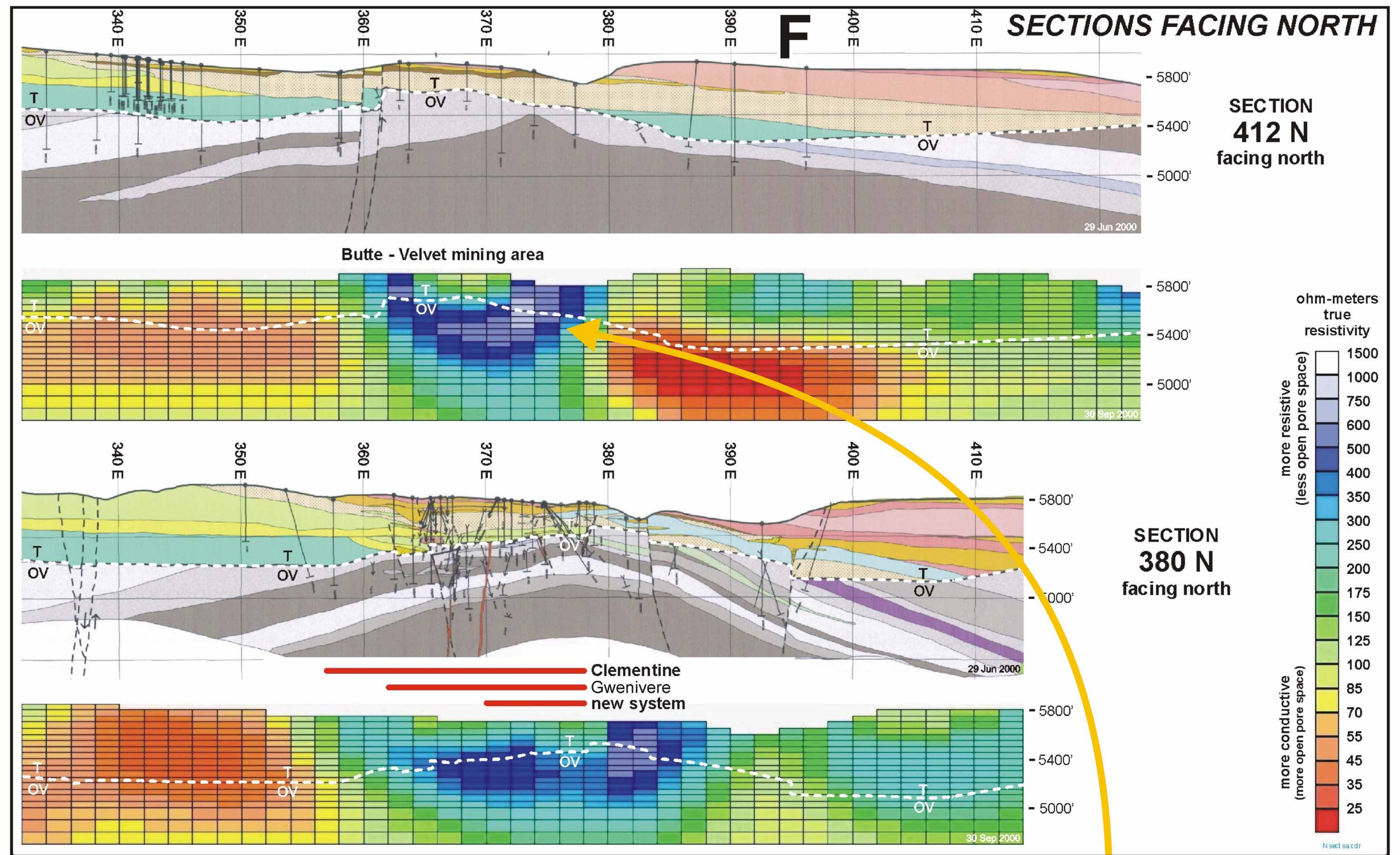
The high grade vein resource remains effectively invisible to the resistivity survey,- too insignificant a volume to be recognizable even with fs3D data quality. We the presence of structure based on the process that is interpreted to have taken place in the well-mapped shallower pattern... an explanation which demands a source of hydrothermal fluid rising from somewhere below the "U" shaped anomaly.



The single deep angle hole that confirms the pattern interpretation.

Fig F (BELOW) The E-W section through the Butte-Velvet area circular pattern, reinforces the notion of a central pipe-like feeder system, capped, and leaking upward on all edges. Possibly at a major fault intersection. The limited lateral extent for the pipe-like feeder would require smart drilling. A considerable amount of gold could be concentrated within such a structure.

Below that, a section along the E-W strike through the Clementine-Gwenivere cap-and-leakage pattern shows probable minor leakage off the ends of the elongate cap. This adds some detail to the hydraulic picture of fluids rising, self-capping, diverting laterally, and finally venting at surface.



The Hollister area fs3D resistivity coverage illustrates the advantages of mapping both extra-deep and extra-wide, in imaging the context and geo-electric setting of a specific exploration area of interest. Large scale fs3D delivers a plausible hydrothermal process explanation that links the surficial clues.

The patterns suggest that an important target for drilling is deep below any observed pattern of resistive materials that may graphically suggest a flow-constraining cap over deeper fluid conduits, *whether we can actually see or image those conduits or not.* The historic drilling sequence at Hollister confirms this strategy for the local setting and conditions. An effective property-wide mapping tool appears to have been demonstrated.

How would you drill the circular, bowl-shaped Butte-Velvet anomaly?