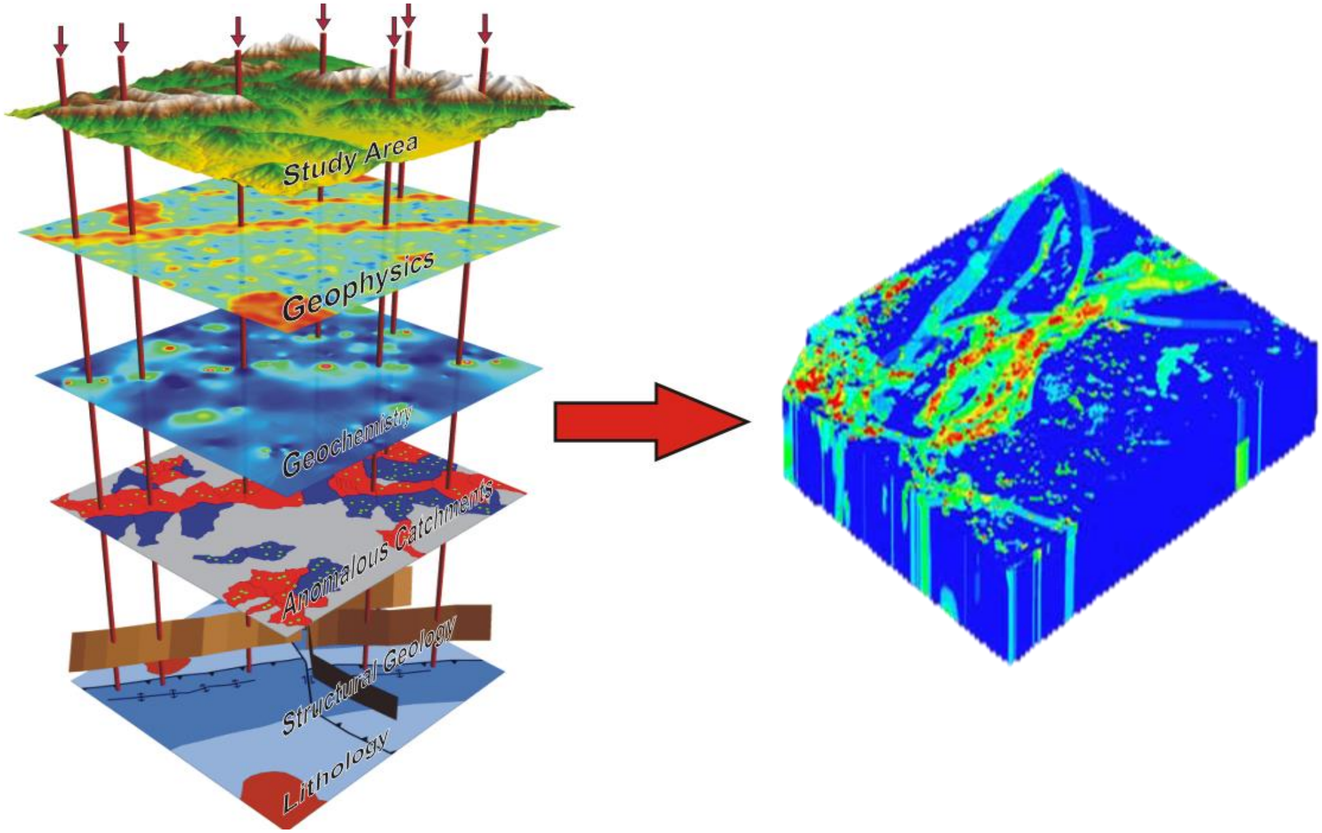

Taking SDM from the 2D to 3D world

Recent Developments and Issues

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Taking SDM from the 2D to 3D world

- **Industry View of SDM Based on Commercial Work Done by Kenex Over the Last Eleven Years: Thanks to All Kenex Geologists, Database Managers and Digi-Slaves.**

- **Focussing on Use of Spatial Data Modelling and Knowledge of Process to Allow Prediction in Exploration and Other Industries (Wind Energy: Marine) Globally.**

- **Aim of the Talk is Review SDM in 2D, Explore the 3D World and Discuss the Reality of Working in 3D Pros and Cons.**

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Understand and Improve Your Chances of Success?

The Practical Implication Of High Discovery Risk For Strategic Planning & Exploration Budgeting Is A Large Difference Between The Average Cost Of Exploration Success And The Level Of Funding Required To Ensure Success (e.g. - “World Class” Deposits)

Discoveries Are Typically Made By The 5th-7th Person/Company Covering The Ground

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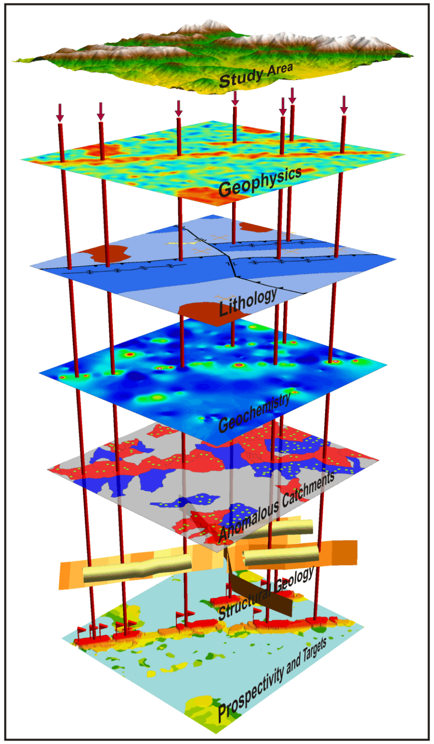
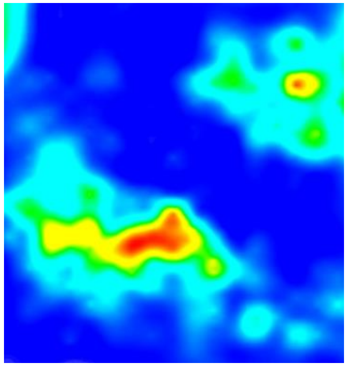
2D Approach: Kenex Work Flow

- Use All Digital Data Available
- Predictive Maps from Geological, Geochemical and Geophysical Data Based on Mineral System Model
- Use Known Deposits to Test Spatial Correlation of Maps or Develop Expert Weights Based on Known Systems.
- Combine Maps Using Weights from Spatial Correlation or Experts
- Use Software Toolbox to Create and Manage Predictive Maps, Run Spatial Analysis and Develop Prospectivity Models





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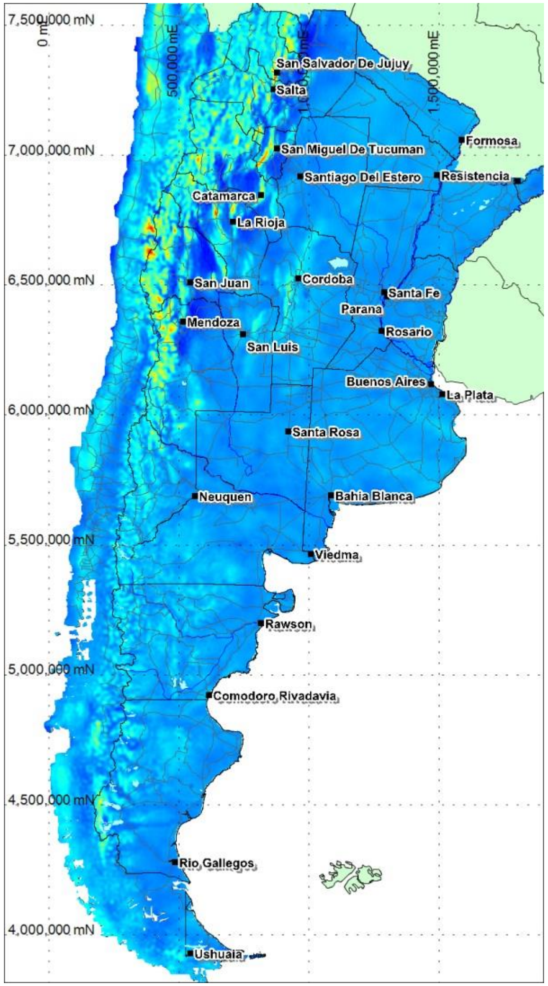
Understanding Mineral Systems Critical

- **Mineral Systems Approach Allows Probabilistic Assessment.**
- **Requires Critical Parameters of Ore Formation to be Identified Related to :**
  - **Controls on generation and preservation of Ore**
  - **Processes that Cause Metals to be Mobilised from Source, Transport and Deposition into Traps.**
- **This Approach Allows for Multiple Ore Deposit Styles to be Realised in Single Mineral System.**
- **Need to Map Evidence for These Processes.**

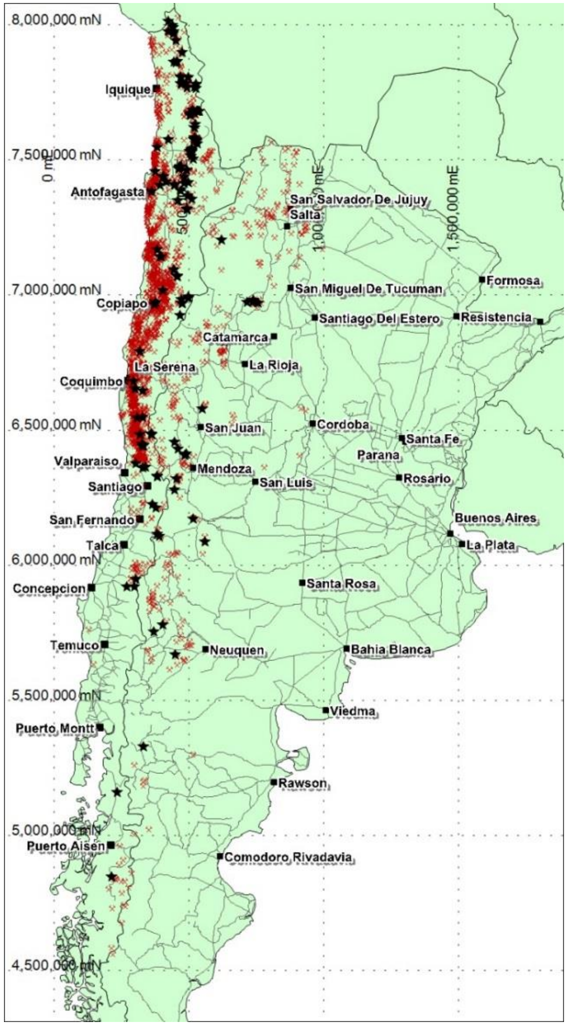
Databases That Cover Study Area

- **Integrated and Assessed in Argentina and Chile.**
- **6,347 mineral occurrences.**
- **7,717 rock data.**
- **128,902 SS data.**
- **21,016 soil data.**
- **790 drill holes.**
- **3,525,700 km^2 geology, gravity and DTM.**
- **Added New Attributes and Age Data to Geology and Faults.**



Training Databases Available

- **Mineral system defines study area and consequently training data to be used and distribution.**
- **Apples and Oranges**
- **Based on size and production**
- **Subset of total database allows testing of predictive efficiency.**
- **Check government databases as they contain errors, including misclassified occurrences.**



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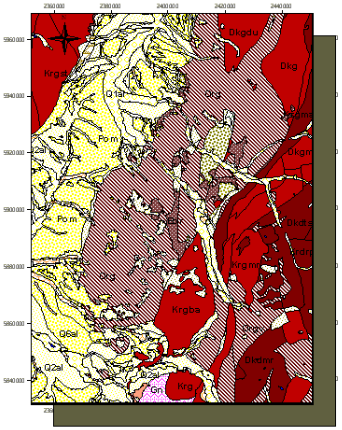
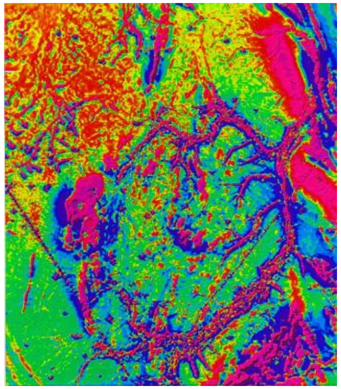
Tools to Develop Predictive Maps Available in GIS

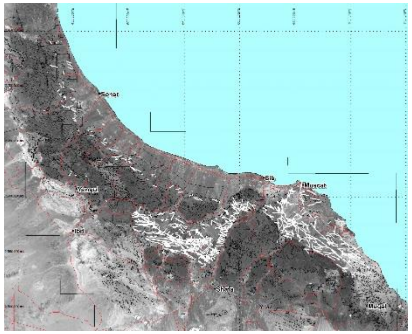
- **Data That Map Key Processes in Mineral System**

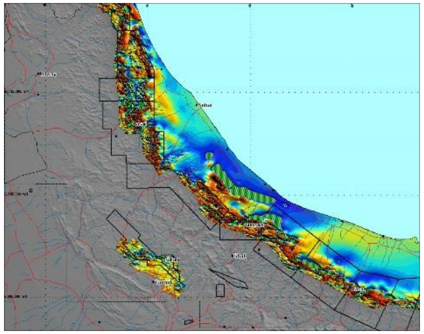




- **Lithology**
- **Geochemistry.**
- **Structure.**
- **Geophysics.**
- **Mineral Occurrences.**

- **Map Variables Stored as Points, Lines and Polygons into Grids.**
- **GIS Mapping Skills.**





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Spatial Analysis Techniques

Element	Area km2	Points	C	Stud(C)
Magnetic Mid Range	9176.99	68	0.1712	0.5467
Radiometrics U Mid Range	6513.48	59	0.6895	2.7134
Rock Anomalies Buffered To 400m	77.51	3	2.0223	3.4358
Rhyolite	**268.02**	**6**	**1.5016**	**3.5372**
Radiometrics Total Mid Range	4592.08	51	0.9184	3.9485
Radiometrics K Mid Range	**1903.98**	**30**	**1.0653**	**4.6124**
Radiometrics Th Mid Range	5395.06	63	1.3718	5.0193
N Faults Buffered To 1700m	2431.5	32	1.2456	5.4576
Anakie Contact Buffer	2537.82	36	1.3992	6.2256
N Faults Buffered To 1800m	2668.12	38	1.4393	6.4282
E-NE Fault Intersections	757.59	20	1.8427	7.1362
NE Faults Buffered To 1100m	815.22	21	1.831	7.205
Andesite	**49.5**	**6**	**3.2063**	**7.5494**
All Fault Intersections	2119.88	39	1.7625	7.8794
NE-NW Fault Intersections	318.26	15	2.3727	8.2815
Tuff	**2105.81**	**41**	**1.8703**	**8.3612**
All Faults Buffered To 2900m	479.09	21	2.386	9.3883
E-NW Fault Intersections	**2272.83**	**51**	**2.2956**	**9.8699**
NW Faults Buffered To 1400m	**2035.16**	**50**	**2.3707**	**10.265**
Stream Anomalies Buffered To 800m	**2267.27**	**57**	**2.6415**	**10.6929**
Cycle 1	**1304.93**	**46**	**2.6609**	**11.7643**
Sinters Buffered To 2700m	**330.14**	**38**	**3.7022**	**16.5307**

Bonham-Carter, 1994

Binary Maps

Stud(C) > 1.5 Indicates +ve Correlation

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Spatial Data Modelling Techniques Researched and Available to Industry

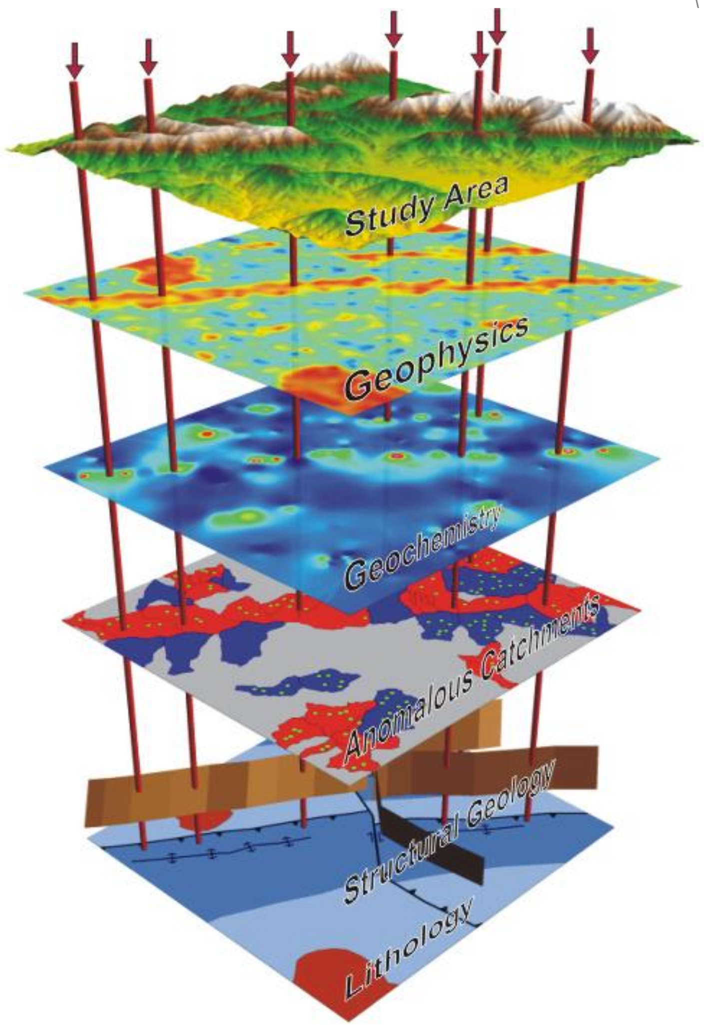
Maps From Points and Lines, Interpolation,

GIS Map Queries and Map Addition, Fuzzy Logic,

Neural Networks,

Weights of Evidence

Predictive Modelling Replicating Known Systems



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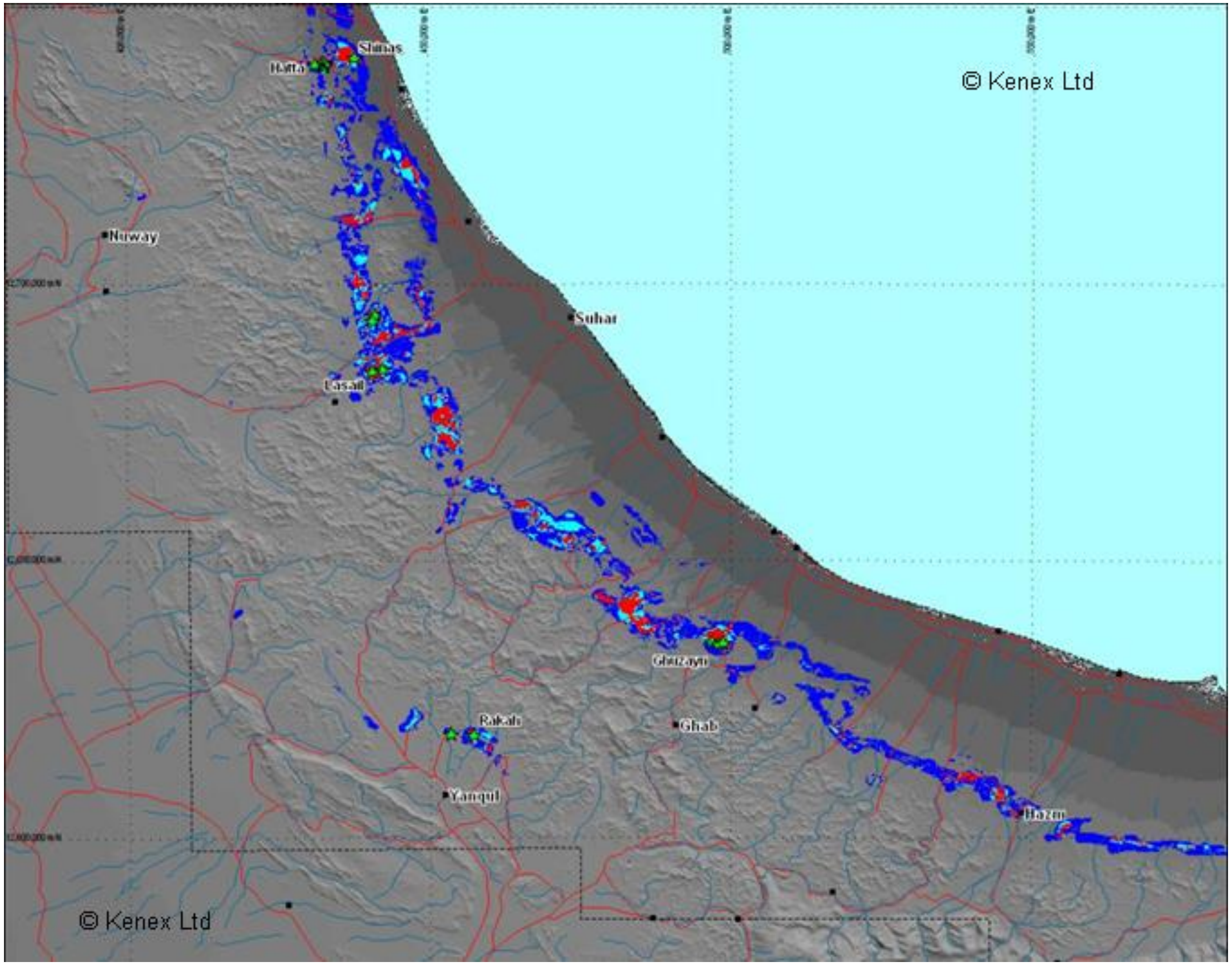
Prospectivity Maps Analysis for Targeting



Name	Area	Tenement	PPb
Shinas	9.33	Block1	1.000
Hatta	4.57	Block1	1.000
Aarja	5.60	Block3	1.000
Lasail	17.48	Block4	1.000
Ghuzayn 3	21.11	Ghuzayn	1.000
Rakah	2.98	Block10	1.000
Hyal-as-Safil	0.30	Block10	0.550
Ghuzayn 2	21.11	Ghuzayn	1.000
Mahab	**1.34**	**Block1**	**0.995**
Zuha	**17.32**	**Block4**	**1.000**
Hara Kilab	**4.22**	**Block5**	**1.000**
Mahab 3	**1.06**	**Block5**	**0.998**

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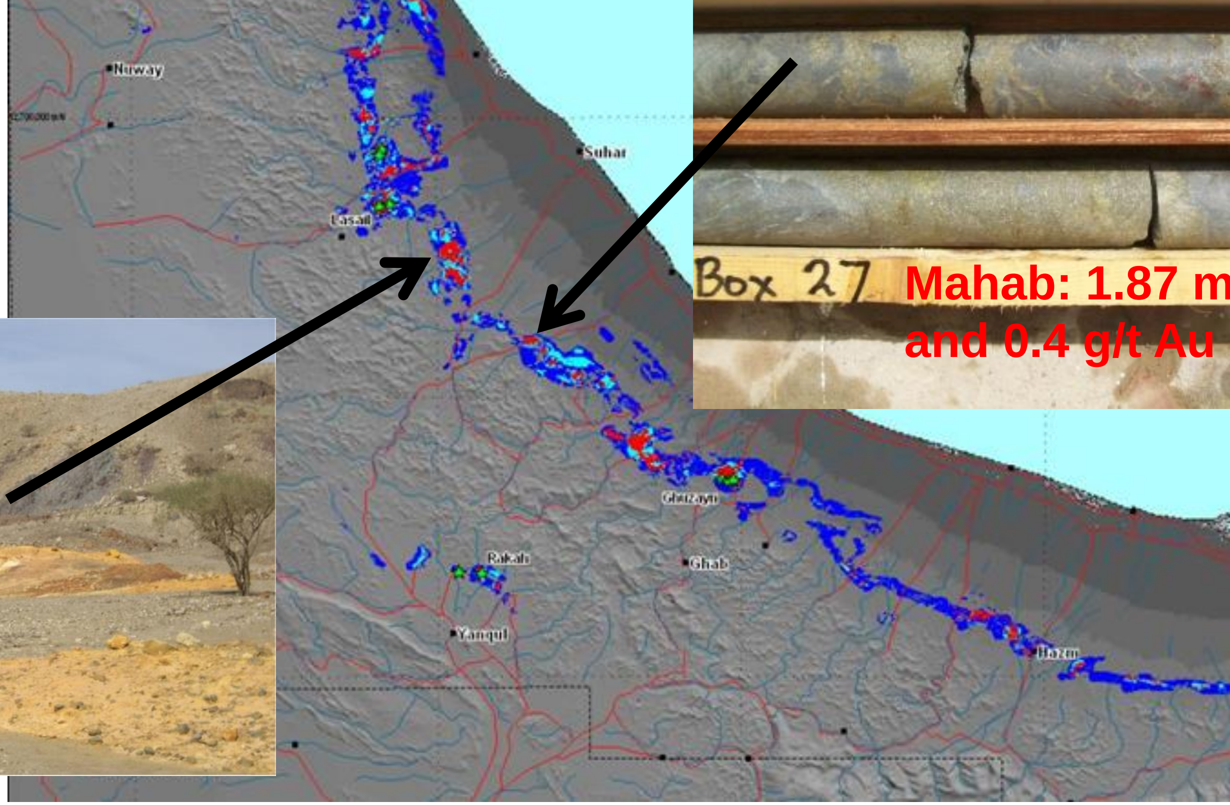
Field Checking Mineral Targets and Discoveries Made Based on SDM



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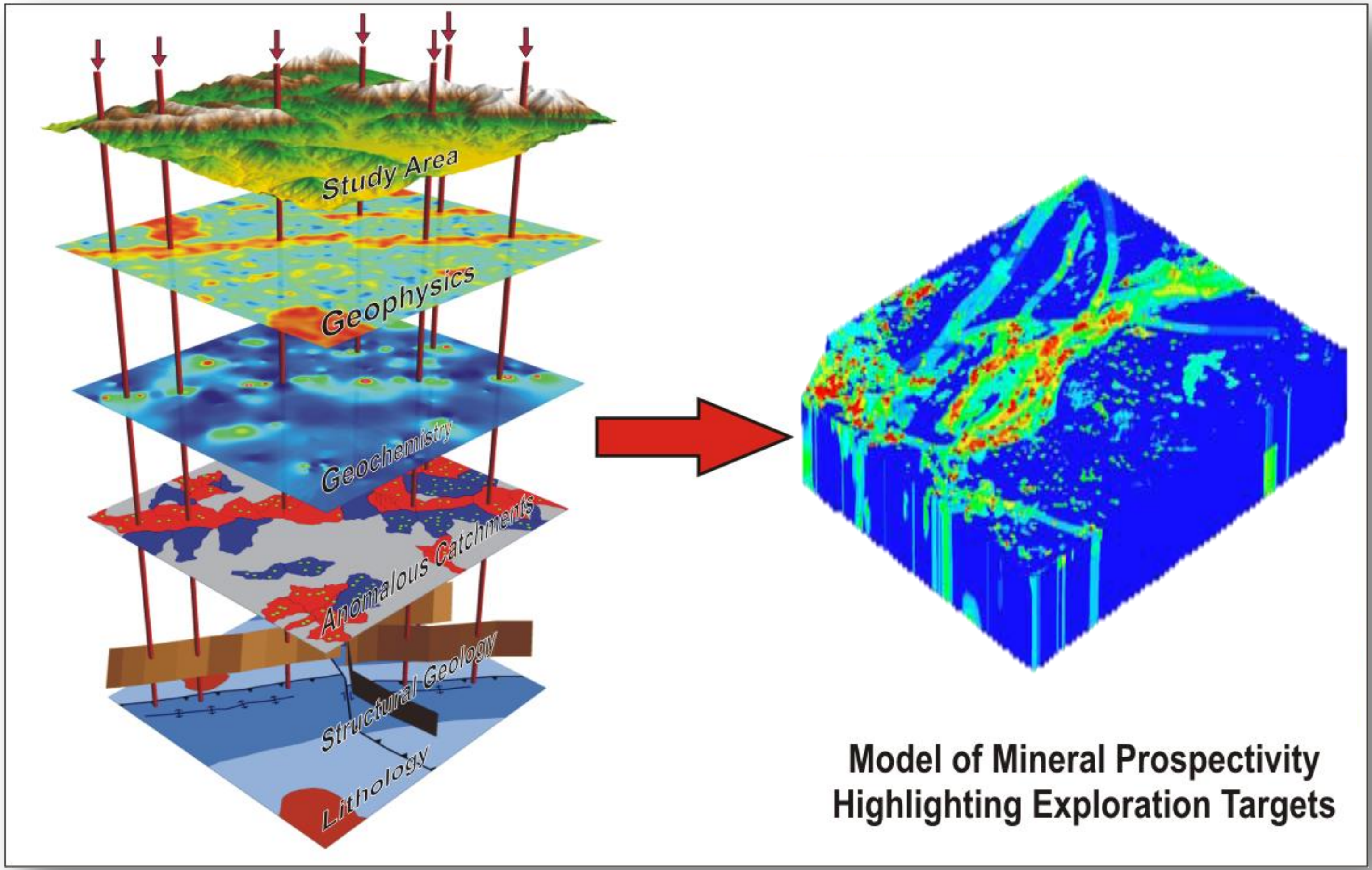
2D SDM Current Status Summary

- SDM Used Successfully by Industry in Exploration Targeting. Mostly 2D and Works Best at Regional Scales.
- The Quality of the Model Depends on the Quality of the Data and Geological Ability to Map Key Features.
- WoE Preferred as it Copes with Missing Data and Gives an Understanding of Spatial Relationships of Map Data.
- Works Best at Regional Scales as 3D Less Important.
- Rare Combination of Skills: Geological Mapping, GIS and Understanding of Mineral Systems - Training.
- Rubbish in Rubbish Out Even if the Software Can Create a Model. Data Quality Remains an Issue.
- But Geology is 3D not 2D and Depth Extension Important at Prospect and Mine Camp Scales.

Moving Into 3D Environment



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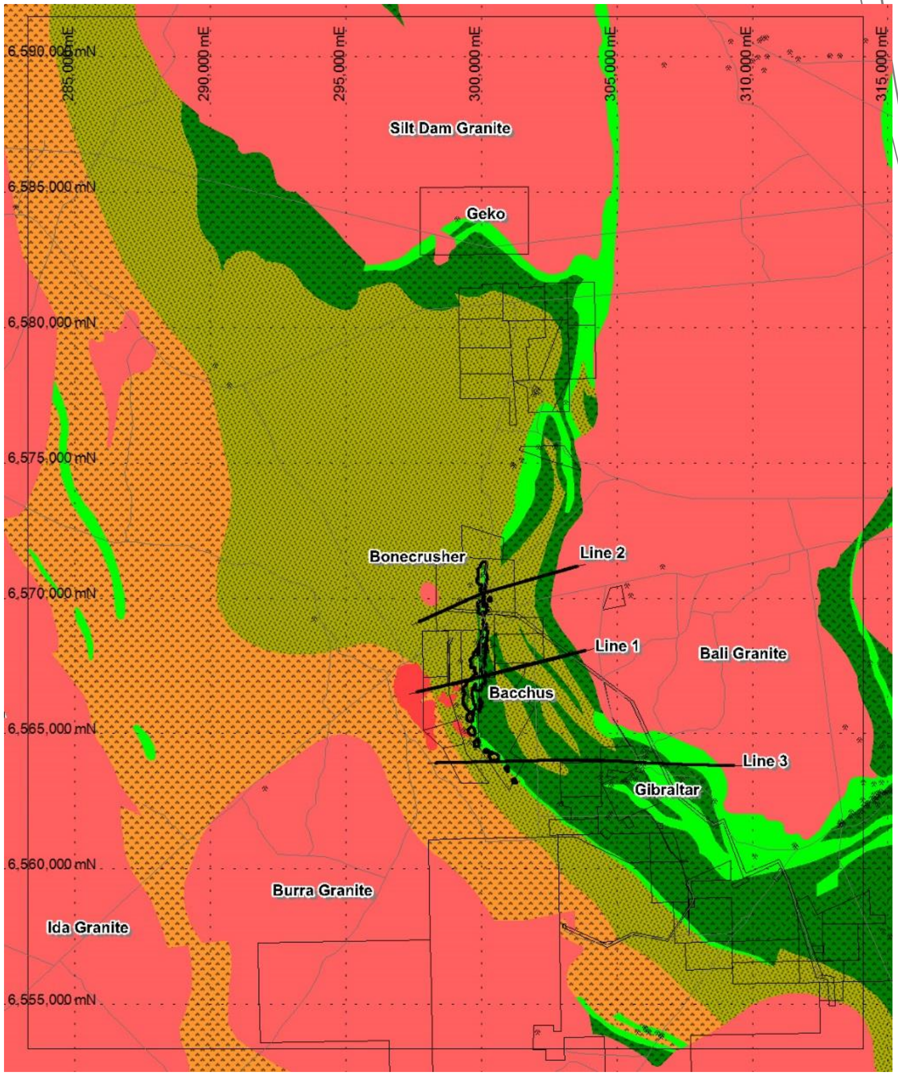
3D Spatial Data Modelling Workflow

- **Compile Data Generally 2D GIS: MapInfo, Arc GIS**
- **2D to 3D Using Field Data, Drilling, Geophysics or Seismic: GoCad, Geomodeller, UBC**
- **Develop 3D Maps of Geology, Structure, Geochemistry and Geophysics using Leapfrog, GoCad, Geomodeller.**
- **Use Weights of Evidence to Analyse and Optimise Predictive Maps: GoCad.**
- **Combine Predictive Maps Using Expert (Fuzzy Logic, Multiclass Binary Index) or Data Driven Techniques (Weights of Evidence, Logistic Regression): GoCad.**

Bullabulling and the Power of 3D

- 65km South West of Kalgoorlie WA, West of Coolgardie. Previous Production 372K oz.
- Nine Gold Pits Along Mineralised 12km Zone.
- No 3D Work During Early Mining.
- Acquisition Strategy to Take Old Data and Use SDM (2D and 3D) to Assess and Plan Development of Project.



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Mineral Resource Located Along 6.0km Portion of 12km Strike

Aerial photo looking south along Bullabulling Trend (approx. 500m wide) from Phoenix pit (foreground) to Bacchus pit

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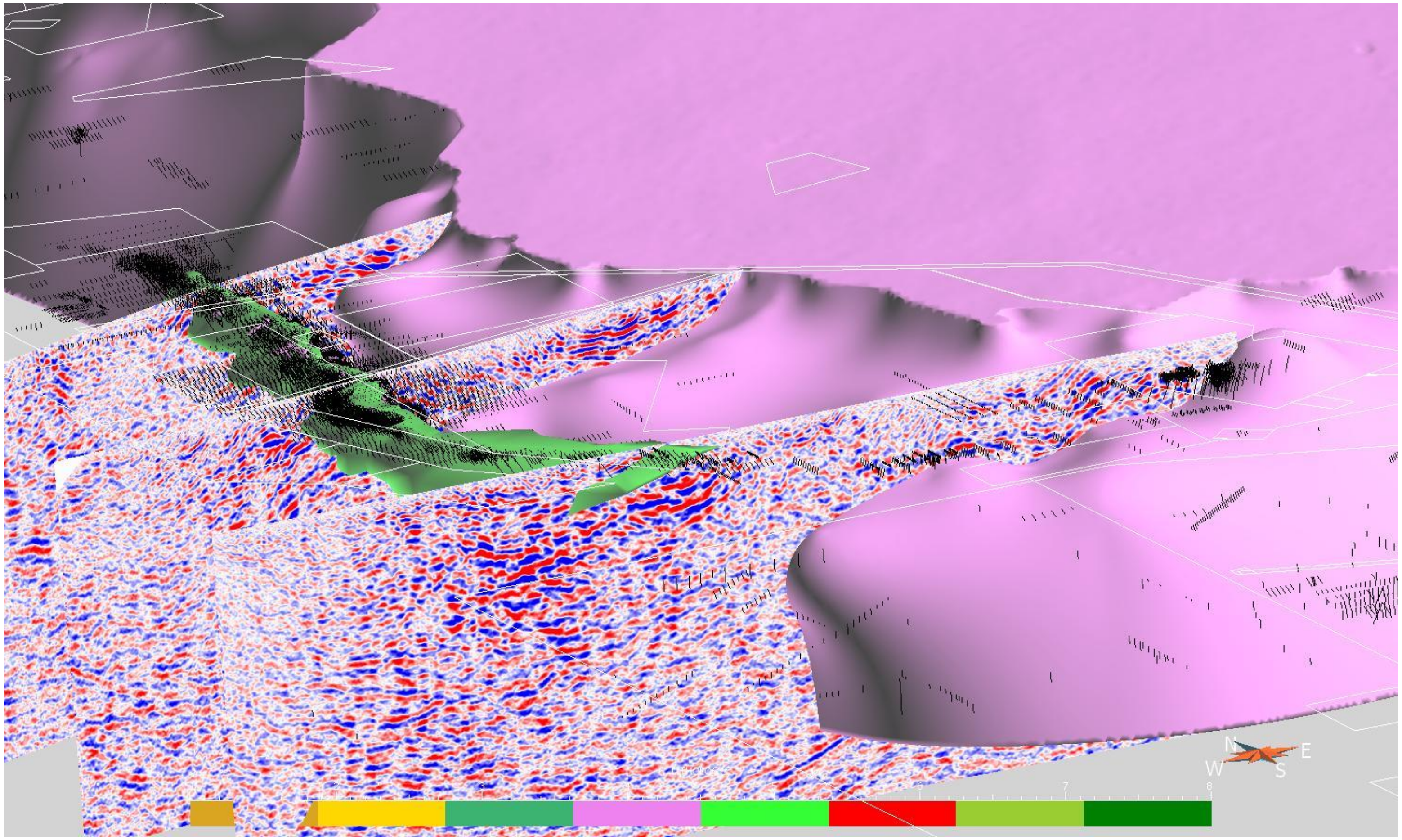
Bullabulling 3D Drilling and Seismic



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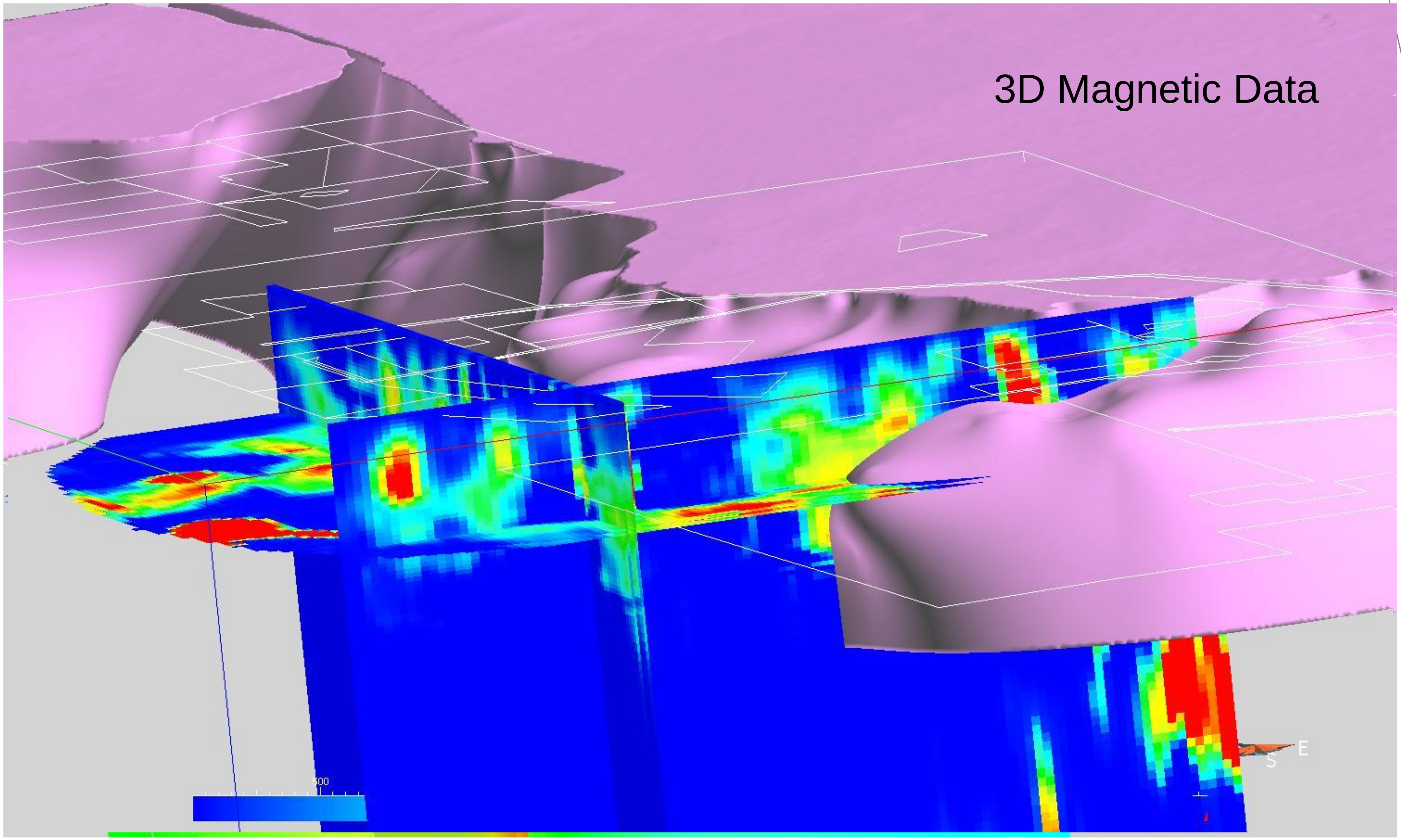
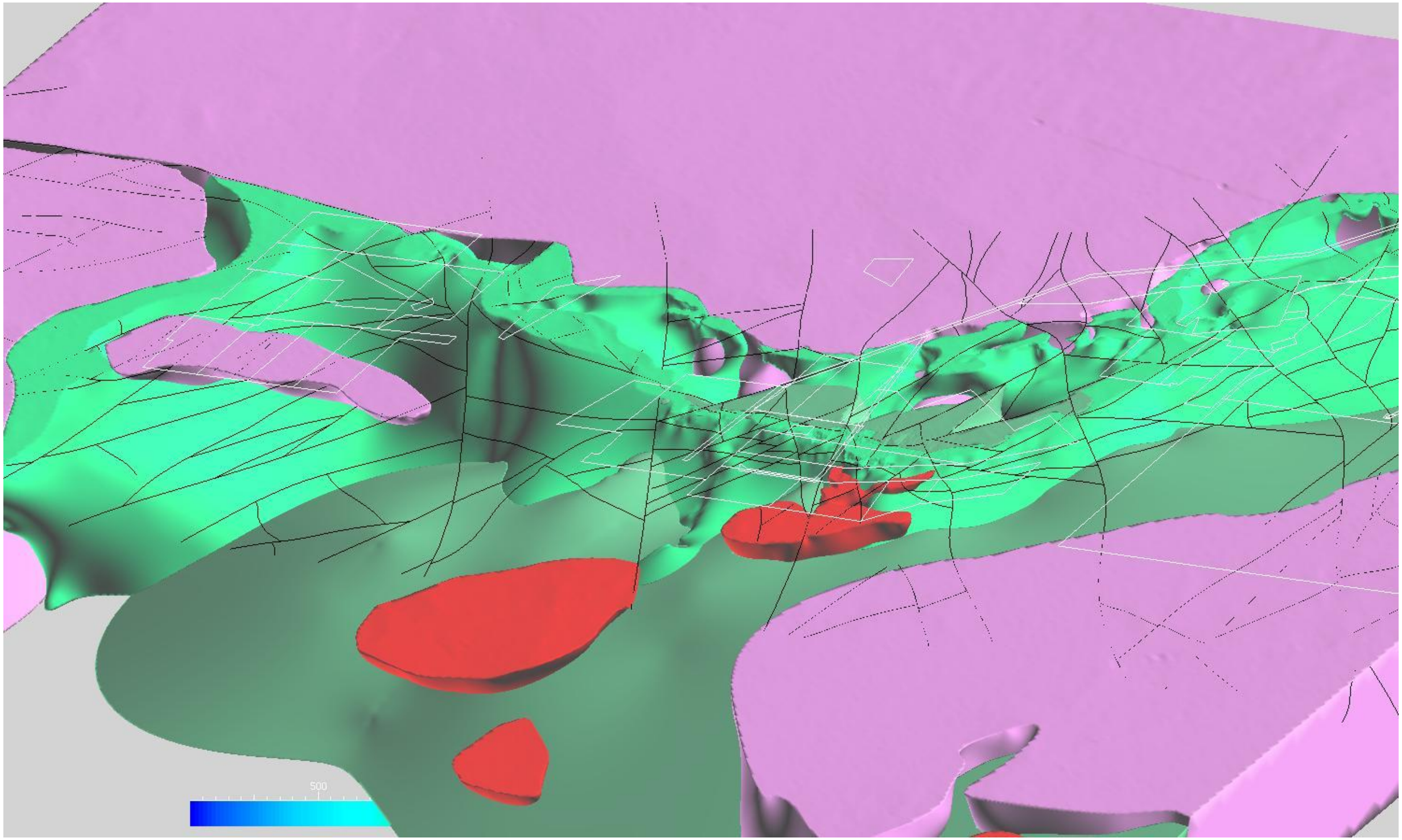
Bullabulling 3D Geophysics



Bullabulling 3D Geology



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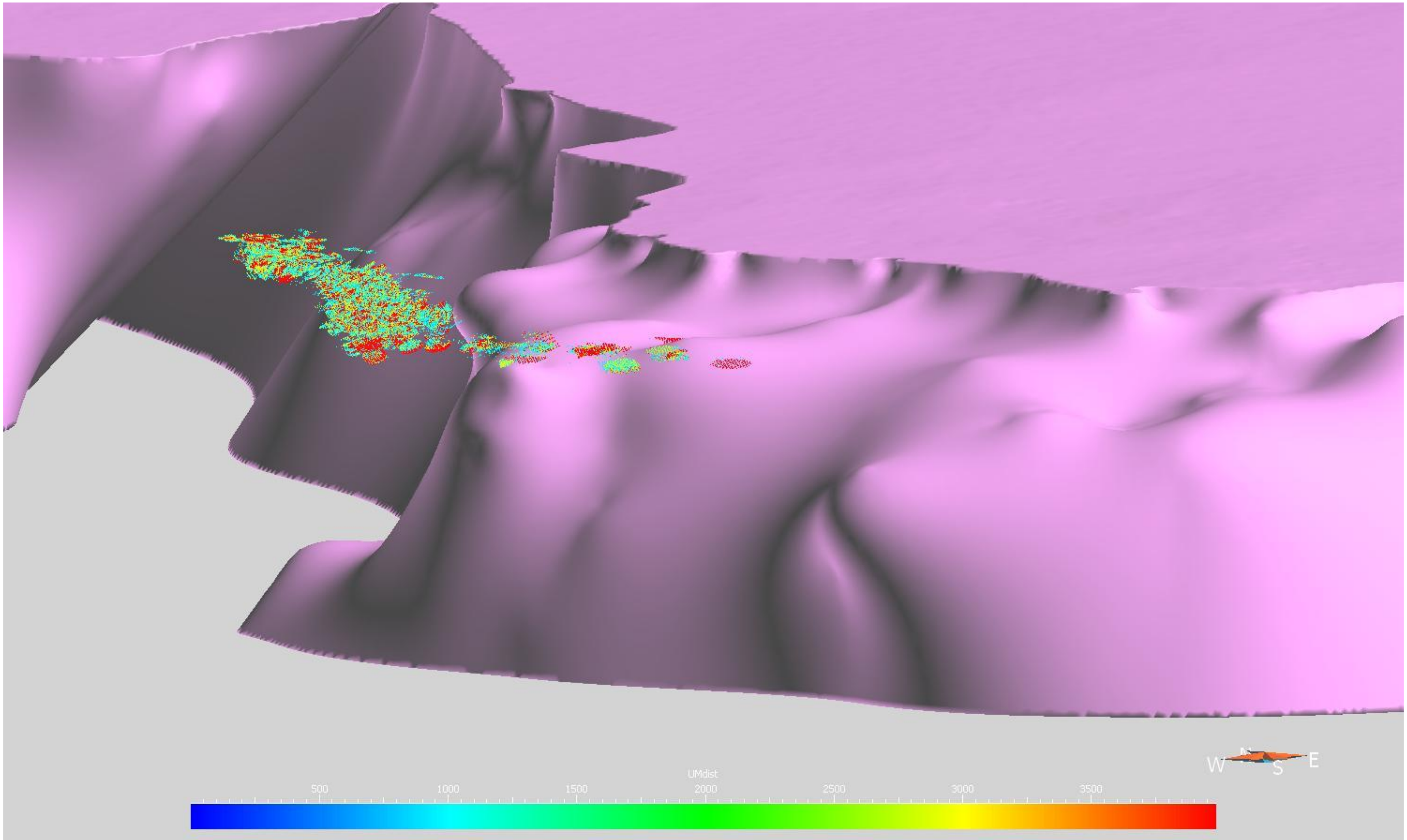
Bullabulling 3D Gold Distribution and Training Data



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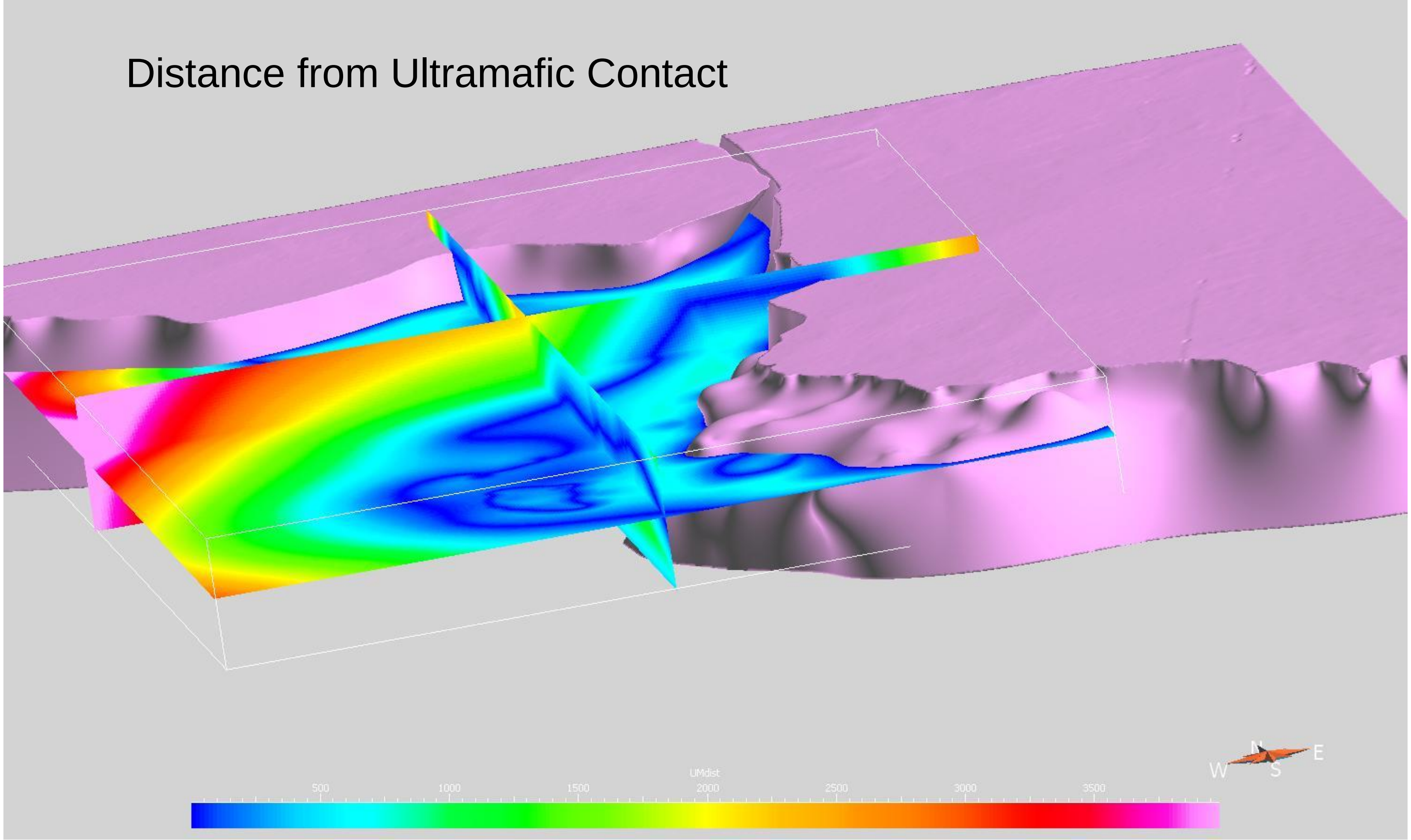
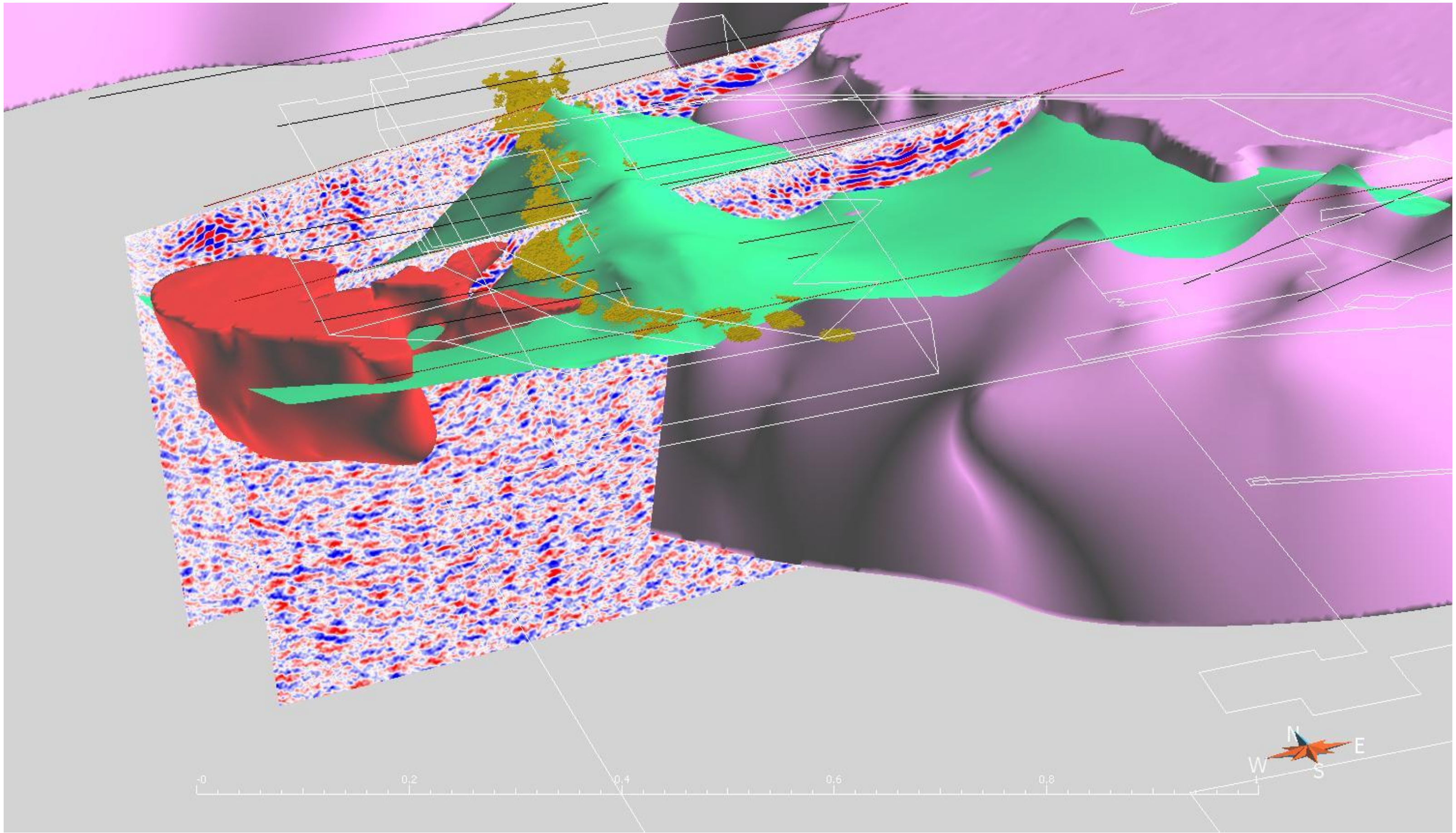
Bullabulling 3D Predictive Maps



3D Predictive Map Analysis and Controls on Mineralisation



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3D Modelling at Bullabulling: Not Just Prospectivity Modelling

- **2D Modelling Identified the Areas for More Work, Constrained Geology and Mineralisation and also Constrained Possible Spatial Relationships.**
- **3D Modelling Confirmed Geological, Grade Continuity, Helped Explain Possible Geological Controls and Provided New Prioritised Targets and Aided Development Strategy.**
- **Confirmed Geological Ideas in a Non Biased Way, Identified High Priority Areas for Follow up, Optimised Drilling, Gave Confidence to Continue Investment for Data Collection.**
- **Led to Project Acquisition, 130,000m of Infill Drilling and Upgrade of Resource from 410,000 Oz to 3.7 Million Oz at Discovery Cost of $5 per Oz.**
- **3D Modelling is Very Effective Tool for Visualisation, Decision Making and Planning, but is Only a Tool.**

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3D Modelling Issues

- **Complexity and Errors Increase**
- **Software More Complex, Difficult to Use and Less Stable.**
- **Technical Requirements Increase, Lack of Training, Mismatch between Software Operators and Understanding of Mineral Systems and Geology.**
- **Data Availability, Geology More Complex in 3D, Data Generally Missing, More Errors and Interpretation, More Geological Data Like Dips on Contacts, Faults etc.**
- **Quality Control More Complex and More important. Need to Incorporate Data Uncertainty in Modelling.**
- **Important to Carry Out 2D Studies Before 3D Modelling to Help Constrain Data and Spatial Relationships.**

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The Future is 3D But:

- Need Improved Digital Geology Maps: Structure of Contacts, Orientation of Faults, Temporal Relationships.
- Prospect Scale Data Limited Compared to Regional and Mine Scale Data.
- Mineral Occurrences: Develop 3D Shapes of Ore Bodies They are Currently Treated as Points.
- Software that Is Easier to Use, More Comprehensive and Less Expensive.
- More Seismic Data in Hard Rock Terranes.
- Training.
- The Techniques Work Well in 2D. Initial Work in 3D is Very Promising but Wait For Drill Testing.

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