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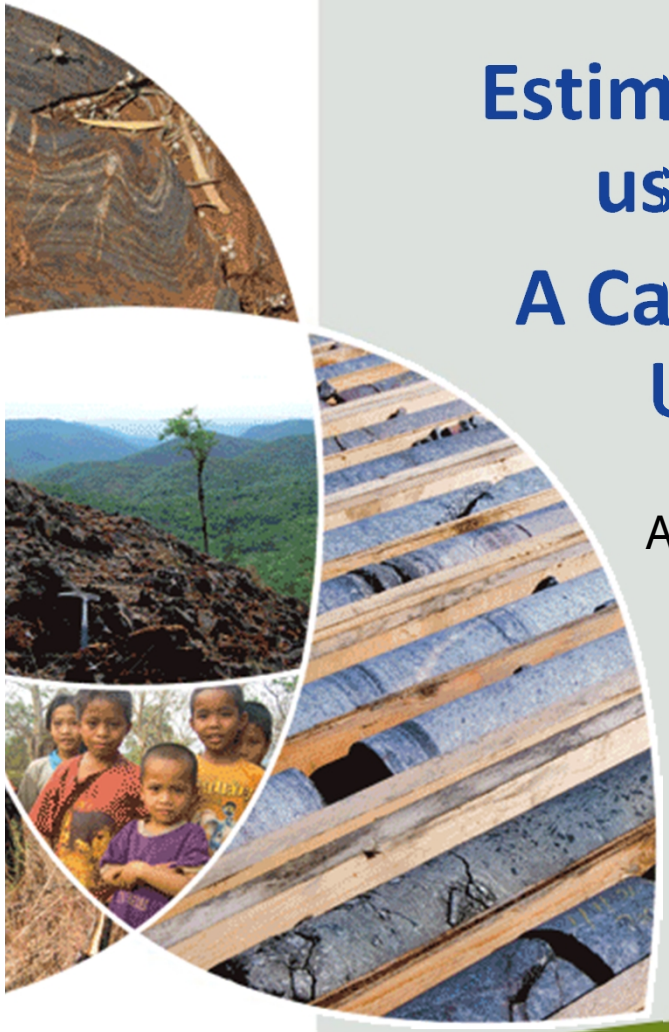

Estimating Recoverable Resources using Uniform Conditioning – A Case Study at the Mkuju River Uranium Project, Tanzania

AusIMM Uranium 2012, Adelaide, 13th June 2012

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Geovariances

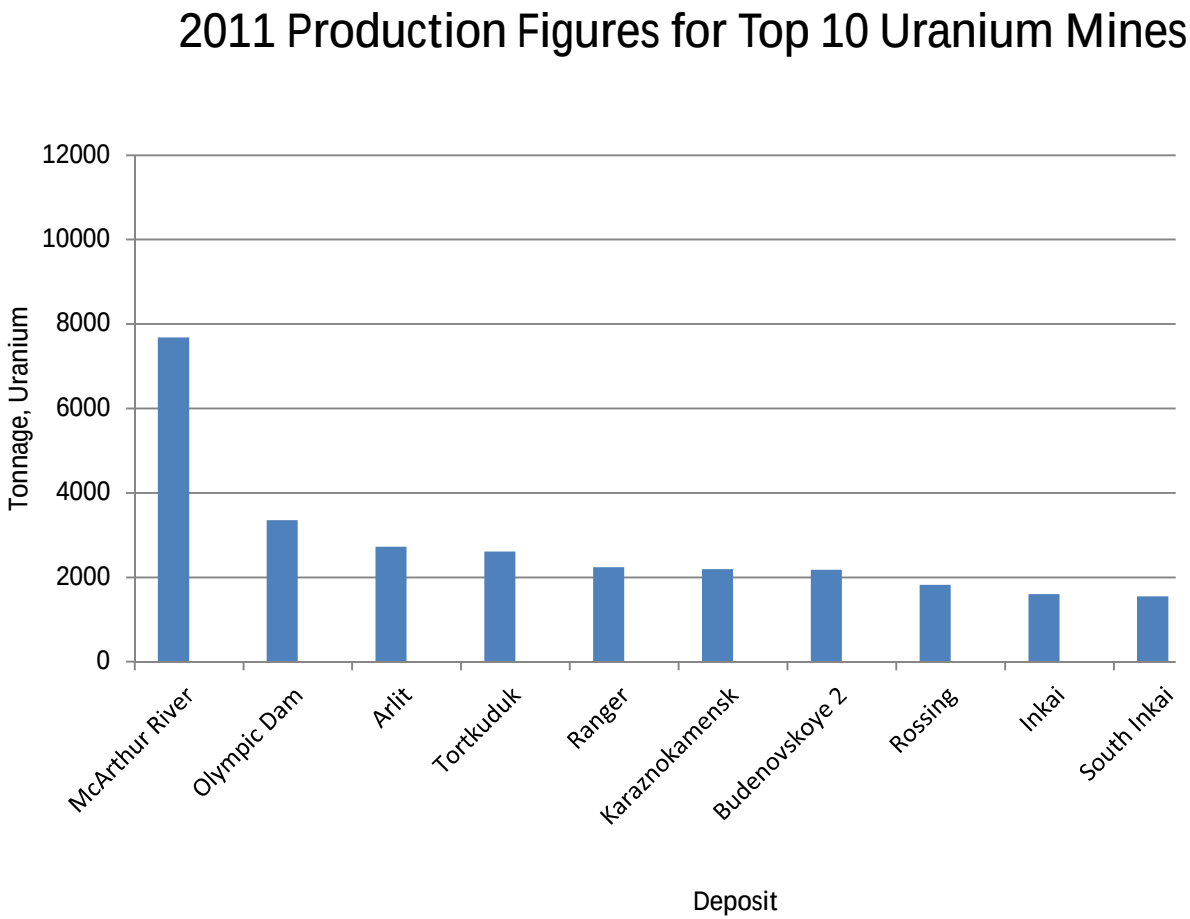
Outline

- Geology and mineralisation at Uranium One's Mkuju River Uranium Project, Tanzania ('MRP')
- Requirements for a Recoverable Resource Estimate
- The choice of a method ('UC')
- Beyond Theoretical optimality, Practical advantages
- Conclusions

Mkuju River - World class uranium deposit

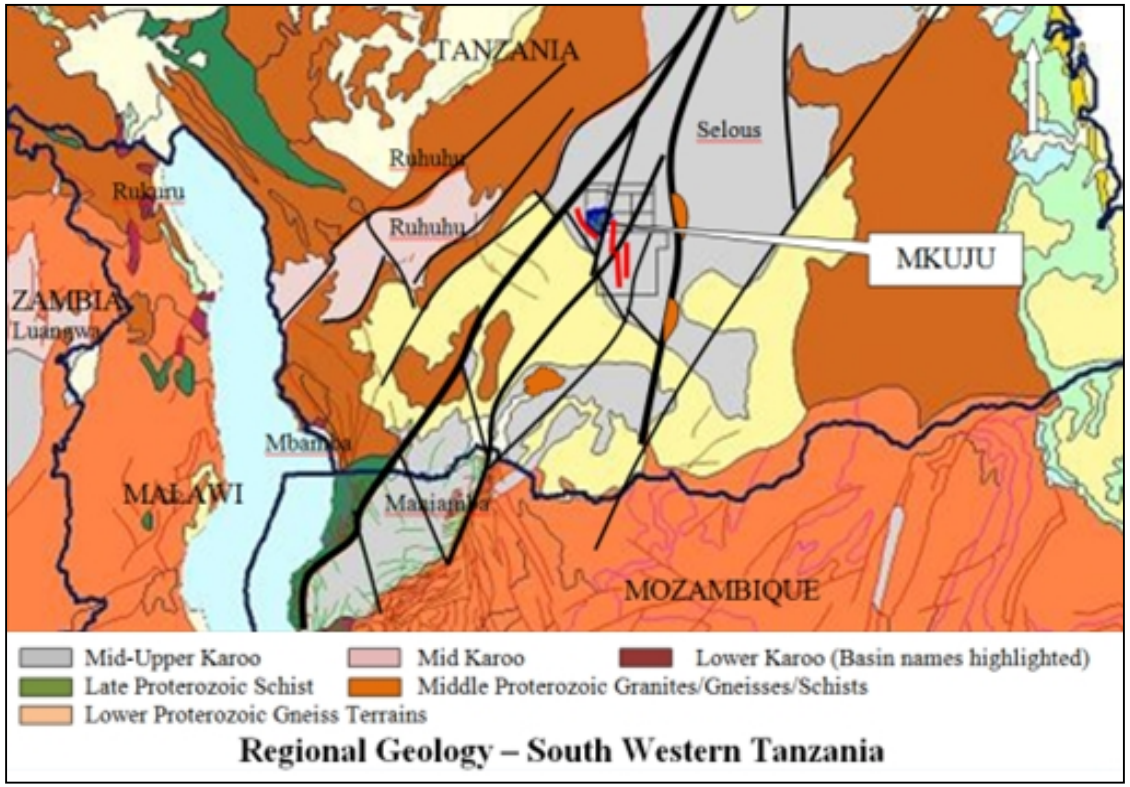
Mkuju River Project – Nyota Prospect Mineral Resource Estimate as at 27th September, 2011 Reported at a lower cut-off grade of 100 ppm U_3O_8			
	Tonnage (million tonnes)	Grade (U_3O_8 ppm)	Contained U_3O_8 (million pounds)
Measured Resource	80.3	313	55.3
Indicated Resource	59.3	291	38.0
Total Measured & Indicated	139.6	303	93.3
Inferred Resource	42.5	278	26.1
Grand Total	182.1	298	119.4

Mkuju River - World class uranium deposit

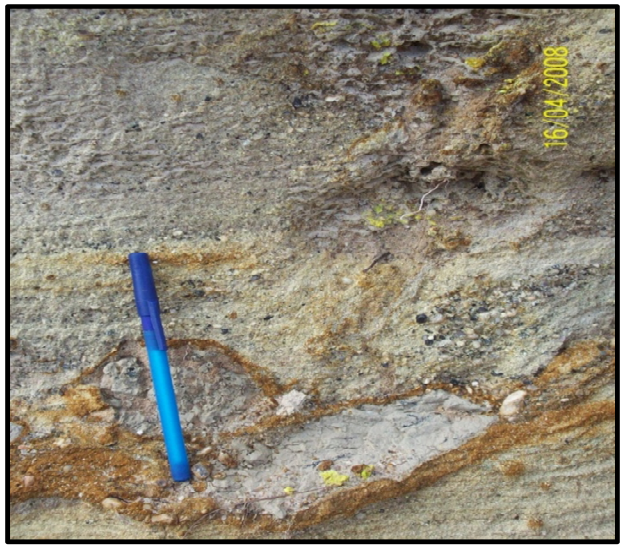


Mkuju River Uranium Project, Tanzania
Location and Regional Geology

- Uranium hosted in Karoo sandstone in the Selous sedimentary basin, SW Tanzania



Mkuju River Uranium Project, Tanzania
Project Geology

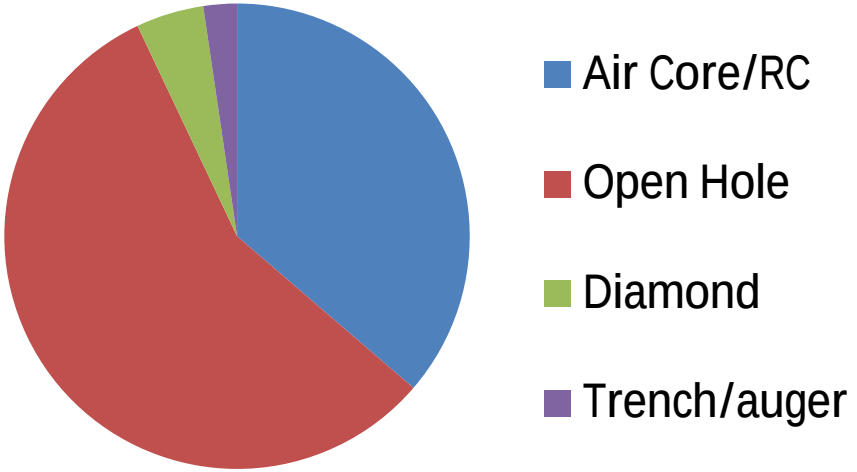


- Rifting associated with break up of Gondwanaland during Permian; East African Rift, late Cretaceous, early Tertiary
- Tabular deposit
- Redox: Porous, oxidised sandstones meet reduced shale units and uranium is often concentrated

Mkuju River Uranium Project, Tanzania
Exploration Data

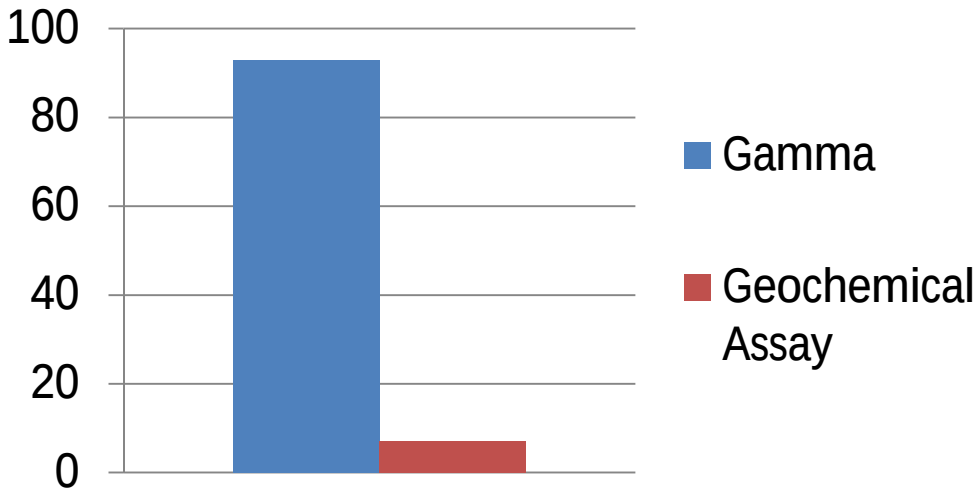
Drilling

- Open hole: 2,123 for 142,825m
- Air Core/RC: 1,513 for 91,483m
- Diamond: 185 for 11,870m
- Trench and auger: 451 for 5,866m

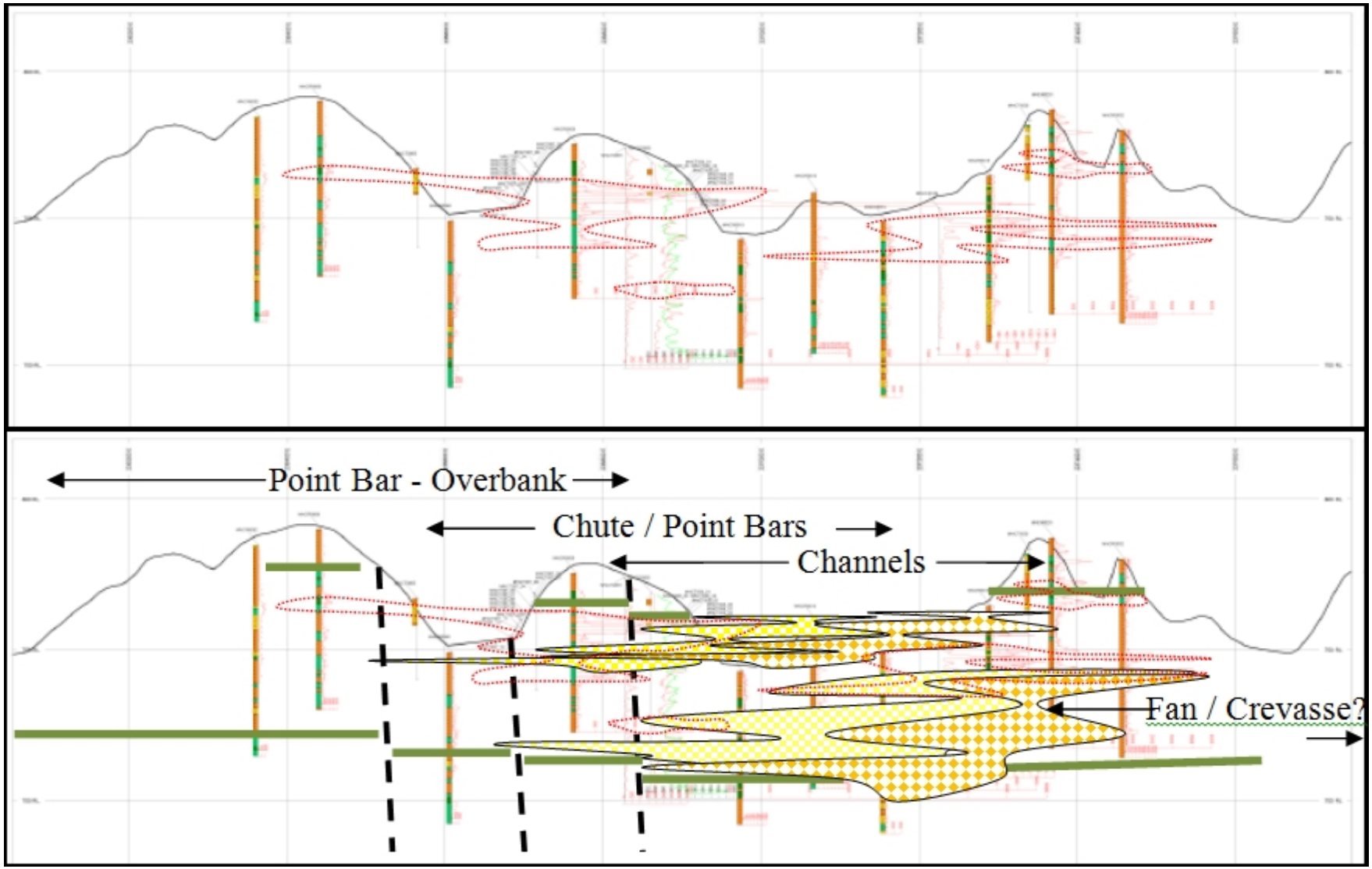


Measurement of Uranium

- Geophysical analysis (gamma probe)
- Geochemical analysis (XRF assay)



The Mkuju River Uranium Project, Tanzania
Mineralisation Interpretation



After Brigden (2009)

Outline

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Requirements for a Recoverable Estimate

1. Metallurgical Test-work: Multiple grade cut-offs

- Phase 1: Resin-In-Pulp ('RIP') technology
- Phase 2: Possible heap leaching of low grade ore

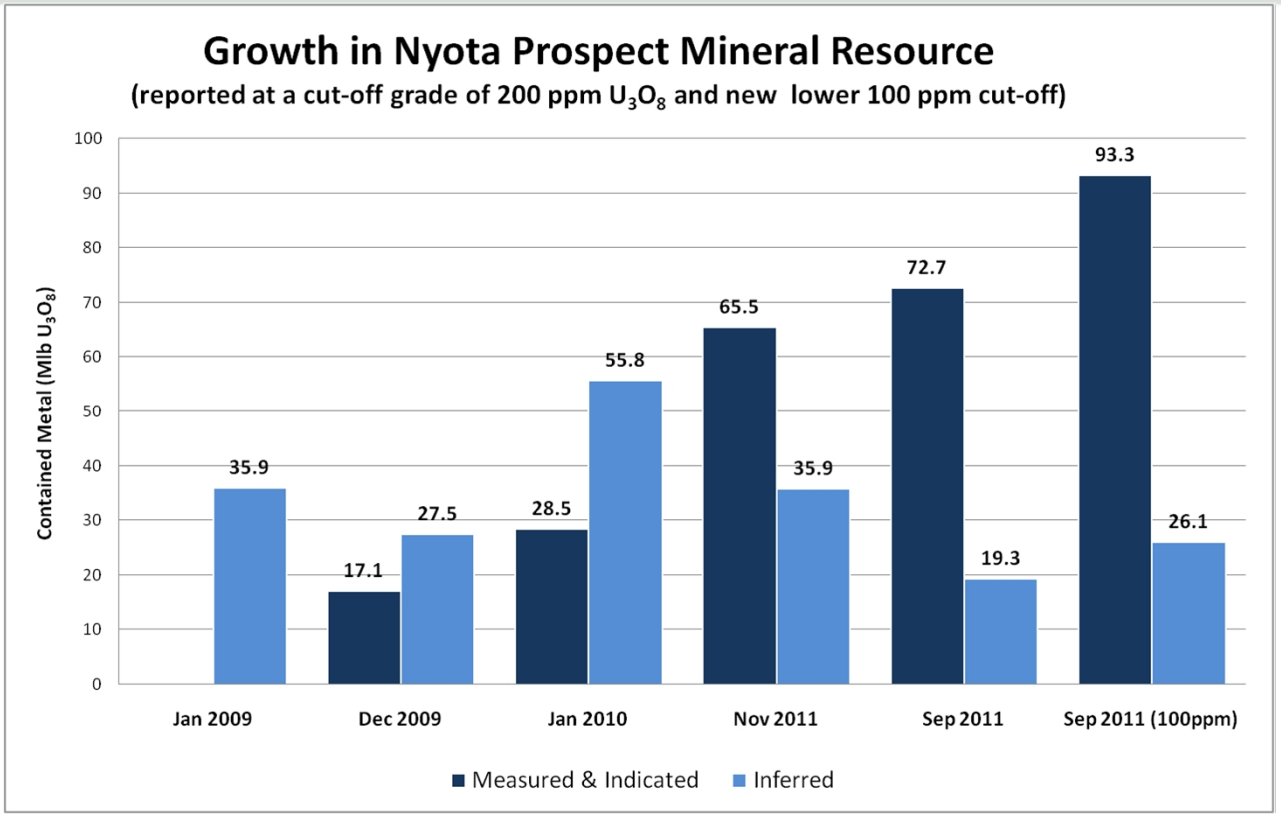
2. Selective Mining Unit ('SMU')

- Drill coverage suggested a block size of 50 x 50 x 4 metres (X x Y x Z)
- A possible mining selectivity of 10 x 10 x 4 metres

Reliable estimate required for:

1. Multiple grade cut-offs
2. A mining selectivity that is lower than the block size

Evaluation Studies – 2007 to 2011



2007: Exploration. Feasibility evaluations

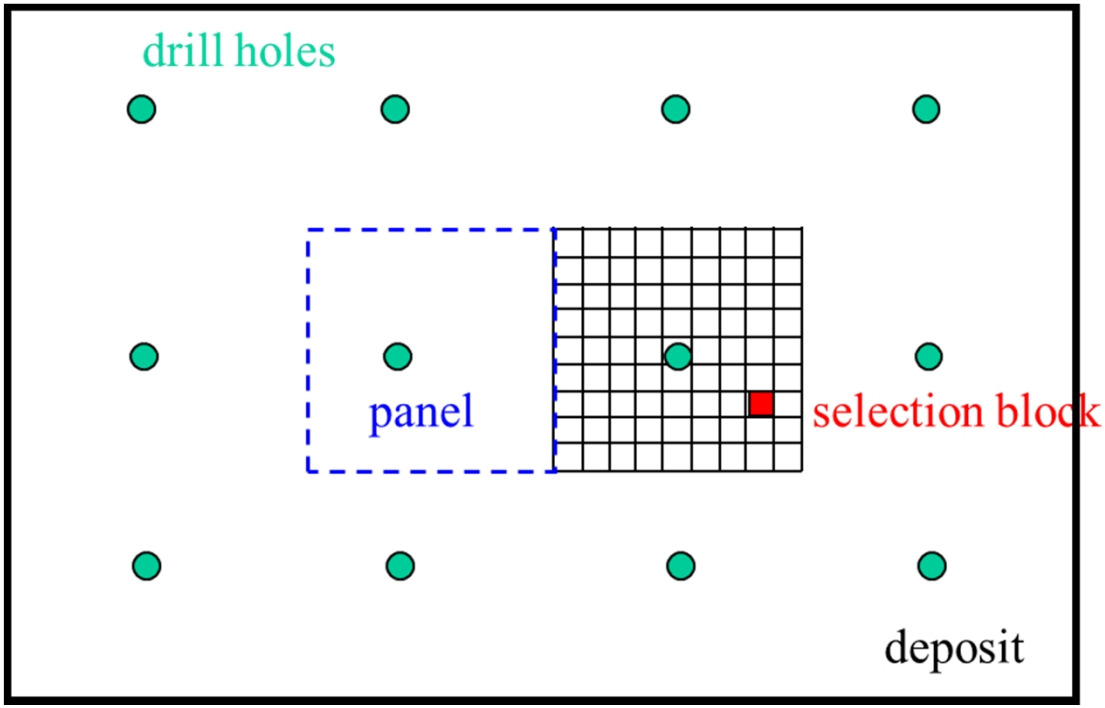
2009: Maiden MRE, Scoping Study completed; PFS commenced

2010: PFS completed; 2 processing options proposed

2011: DFS Completed

Recoverable Resources

- Selection eventually made on blocks v (Selective Mining Unit/SMU)
- In situ estimation made on panels V



Recoverable Resources

We estimate for a selection block v: 

- Ore Tonnage at cut-off: $T(z) = 1_{Z(v) \geq z_c}$

- Metal Content at cut-off: $Q(z_c) = Z(v) 1_{Z(v) \geq z_c}$

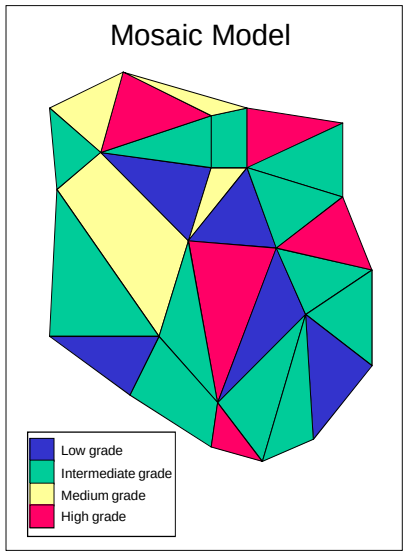
Recoverable Resources: Methods

Indicator Based vs Gaussian Based Methods

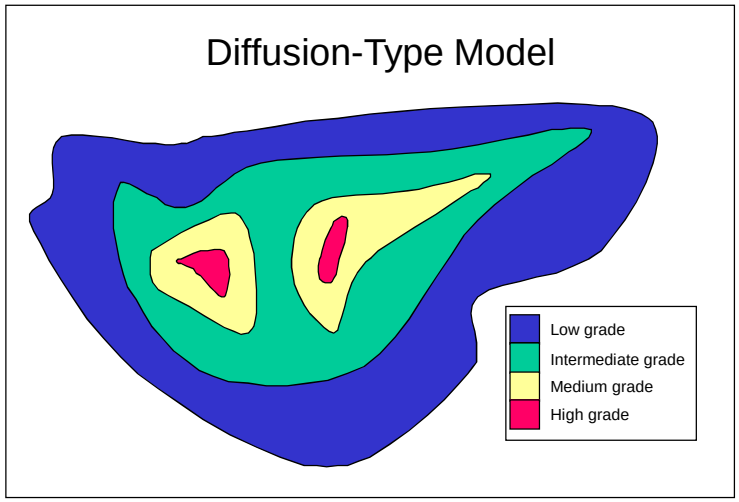
Multiple Indicator Kriging
Residual Indicator Kriging

Disjunctive Kriging
Uniform Conditioning (UC)

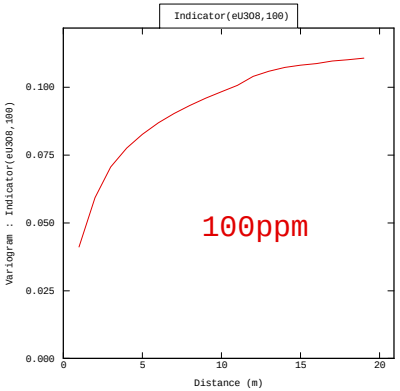
Mosaic Model



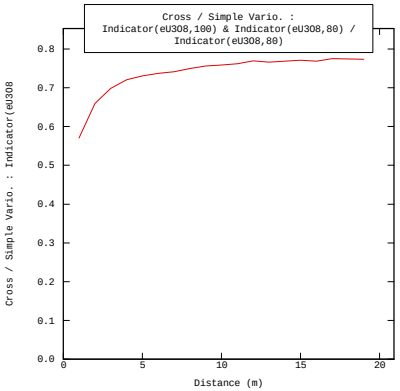
Diffusion Model

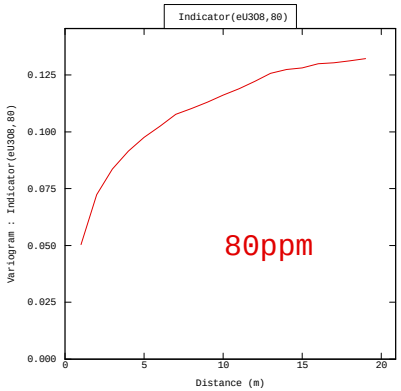


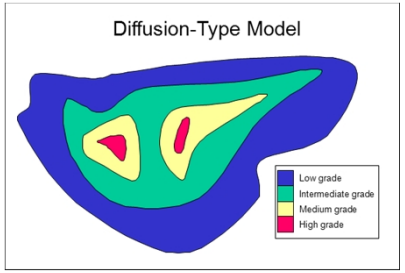
Recoverable Resources: Methods

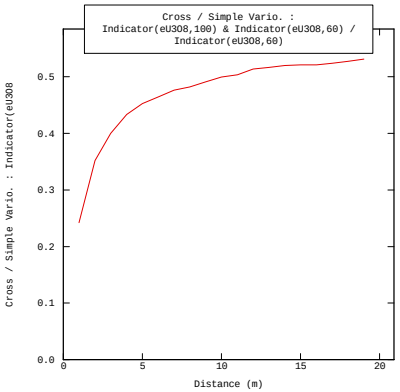


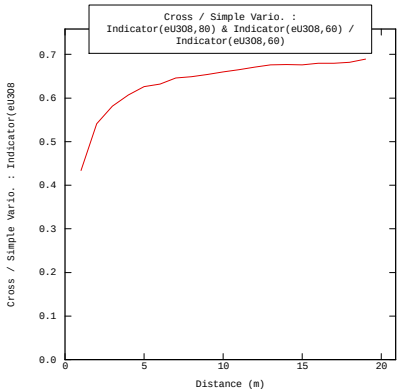
$$\text{RatioTest} = \frac{g_{Z_{0c}Z_{ic}}(h)}{g_{Z_{0c}}(h)}$$

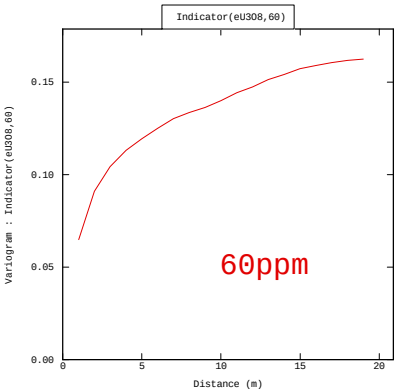








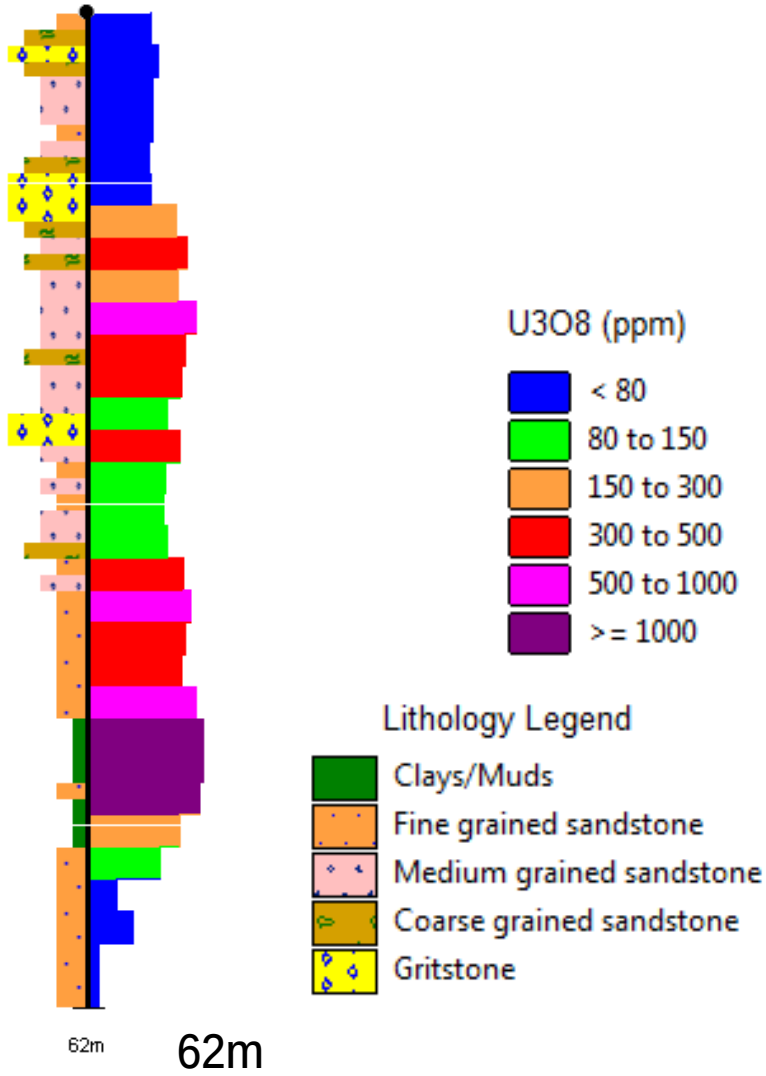




Mineralisation Style – Diffusion Model

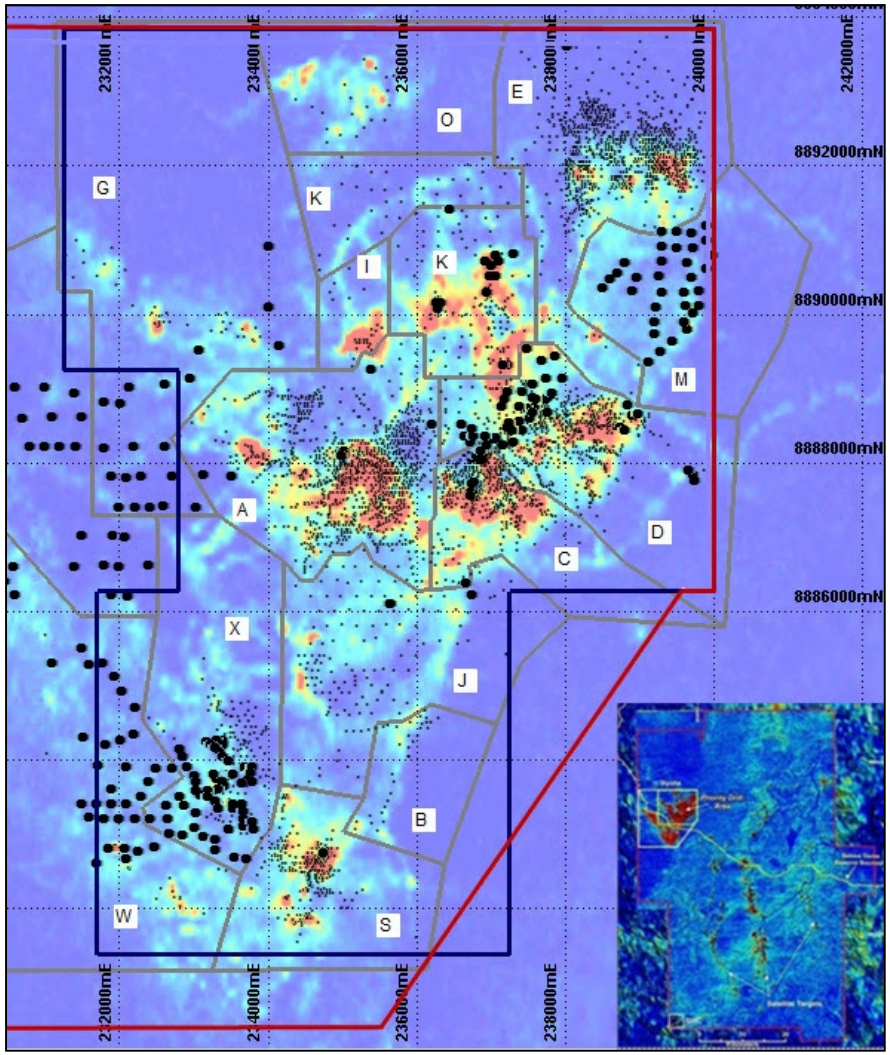
Diffusion Model

- Grade tends to move from lower to higher values in a continuous way
- The Gaussian model used in Uniform Conditioning is suitable for mineralisation that is ‘diffusive‘ in style

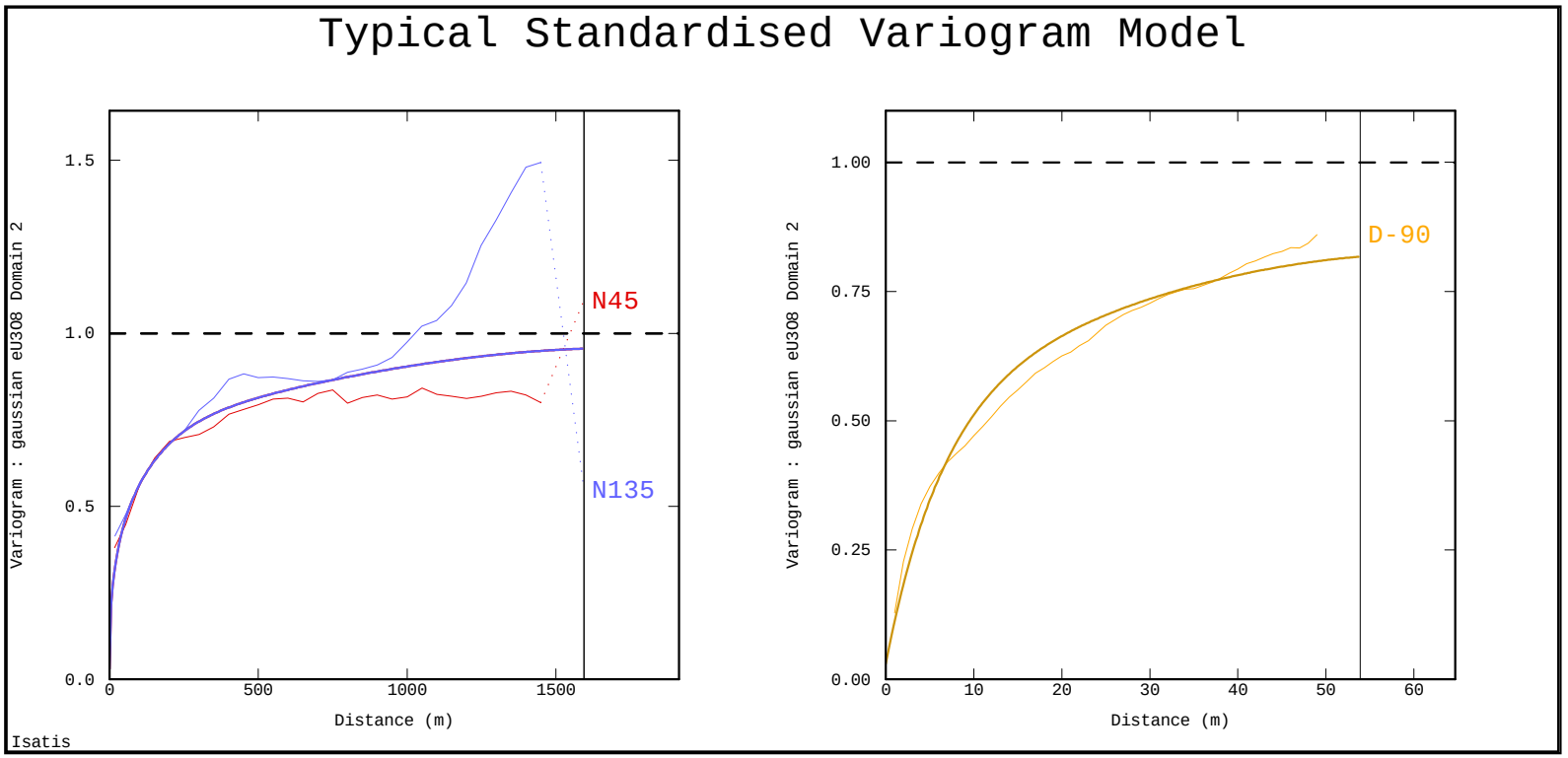


UC Workflow by Domain

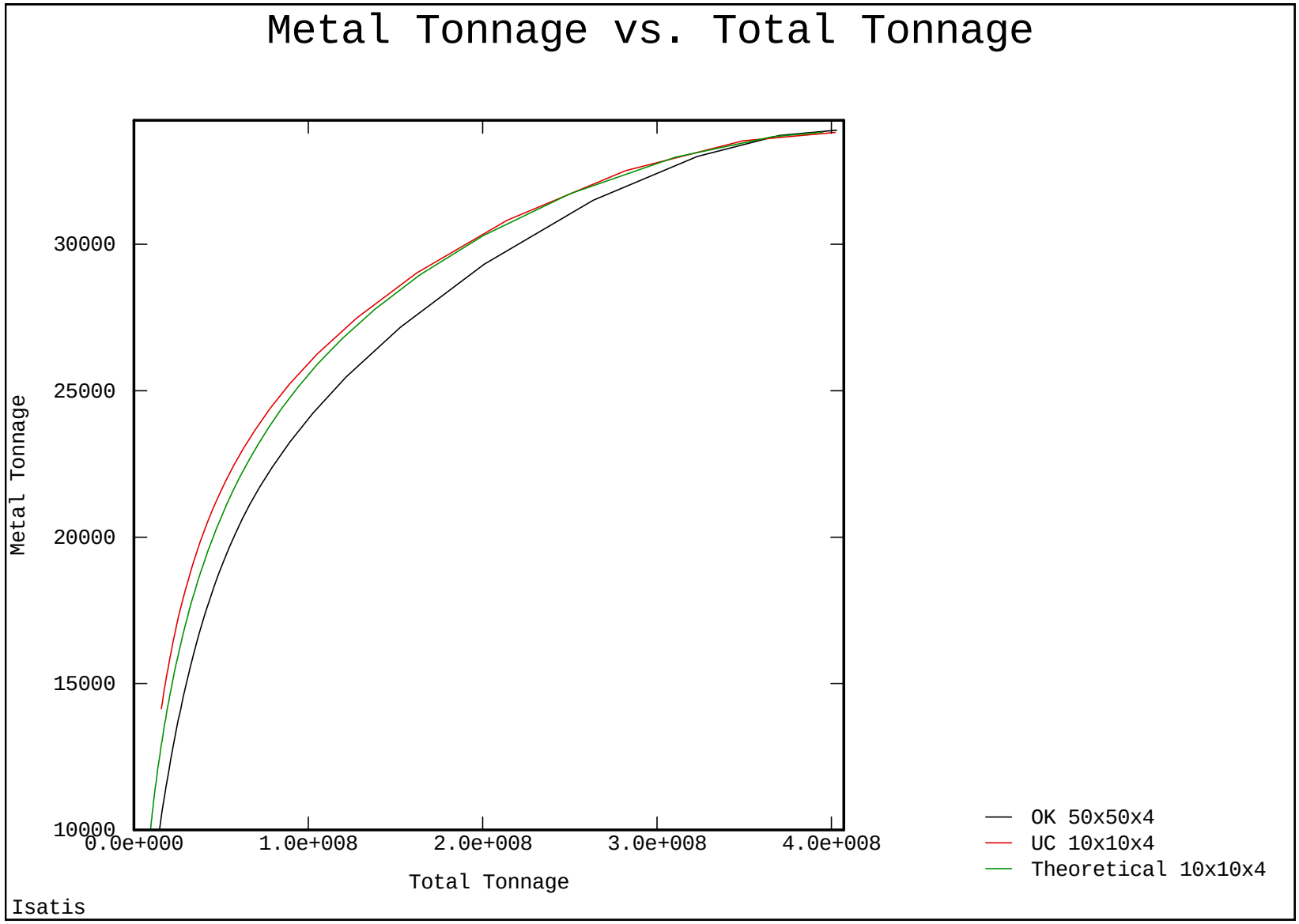
- Declustering analysis
- Variography
- Change of Support Modeling (derive smu distributions from point distributions)
- OK (in situ resource)
- UC (recoverable resource)
- Localisation procedure (LUC)



UC Workflow by Domain



UC Results and Gains



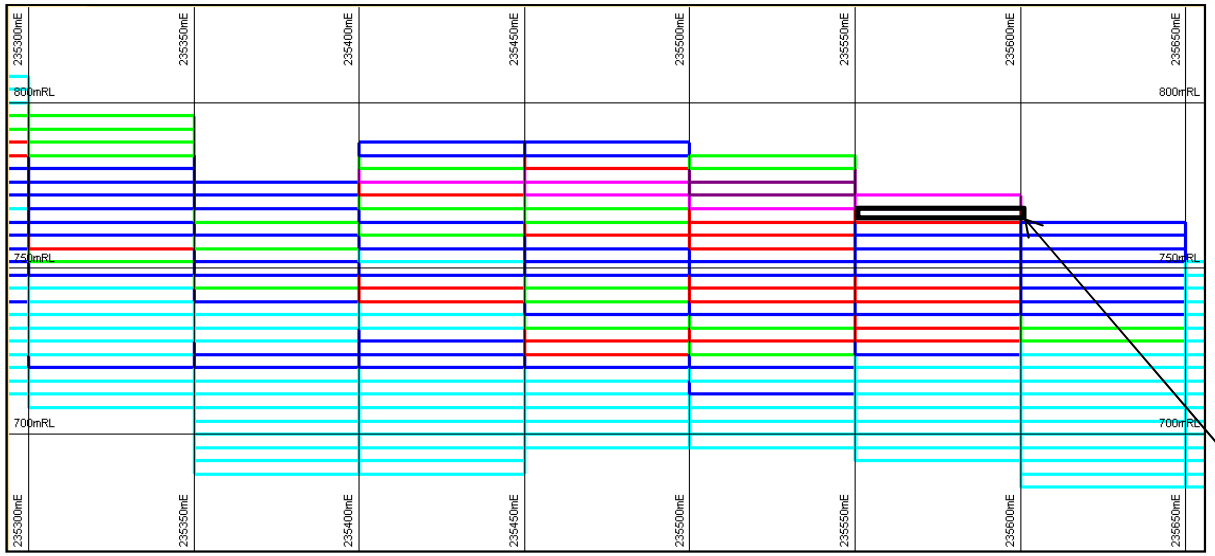
Localisation of UC

- Post-processing of Uniform Conditioning aimed at producing a more “intuitive” presentation of its results;

- Each block (smu) receives a grade such that the distribution of block grades in the panel reconstitute the local grade tonnage curve estimated by UC;

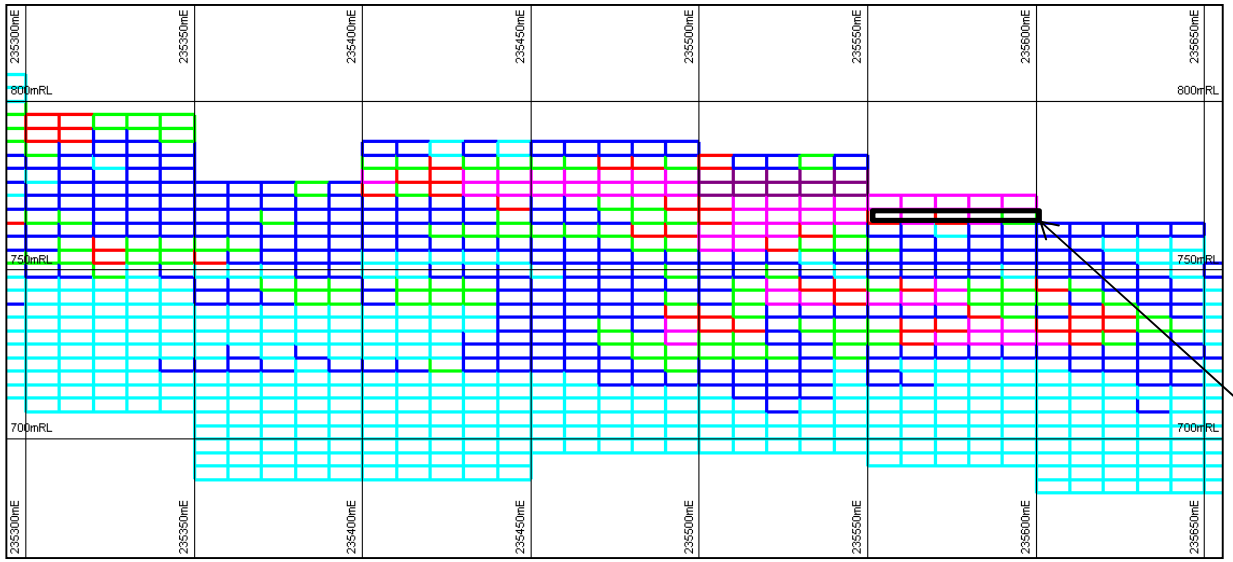
- Distribution respects a priori ranking of smu grades based on OK estimate.

Cross Section of Block Model



Cut-off	Proportion > Cut-off	Grade > Cut-off
0	1.000	501
80	0.972	514
100	0.944	527
120	0.912	542
140	0.876	558
160	0.839	576
180	0.802	595
200	0.766	614
250	0.679	664

502



180 | 291 | 910 | 632

Recoverable Resource Estimate at Multiple Cut-offs

Mkuju River Project – Nyota Prospect Grade and Tonnage Tabulation as at 27th September 2011 – Measured and Indicated									
Class	Grade and Tonnage	U_3O_8 ppm Lower Cut-off							
		80	100	120	140	160	180	200	250
Grand Total Measured Indicated & Inferred	MTonnes	234.8	182.1	148.5	125.2	108.0	94.7	84.1	65.0
	U_3O_8 ppm	248	298	343	384	424	461	496	580
	U_3O_8 MIbs	128.5	119.4	112.2	106.1	100.8	96.2	92.0	83.1

Conclusions

- Mkuju River Uranium Project, Tanzania was an example of a deposit where Uniform Conditioning is a suitable method for estimation of recoverable resources.
- Uniform conditioning was:
  - Adapted to Mineralisation style at Nyota (Diffusion Model);
  - Provides a robust and tractable change of support model – based on variogram model of raw grade;
  - Localised UC easily converts the panel grade tonnages into SMU sized block values for use in detailed mine planning and pit optimisation;
  - Fast re-runs and updates for different SMU sizes and range of cut-offs: critical for the timeline underlying PFS/FS/DFS/BFS studies.

Acknowledgements

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References:

Jim Brigden

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