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Contact Profile Analysis of Resource Estimation Domains: a Case Study on a Laterite Nickel Deposit

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General

- Resource estimation of mineral deposits is based on three-dimensional models of geology, the success of which depends on the quality of the database used.
- The geological model will control the quantities reported as Resources and Reserves, as it will define the volumes that are considered to potentially host ore and thus get estimated using a geomathematical method such as ordinary kriging.
- In certain deposits, ore can be distributed across multiple zones or domains of lithological or grade-controlled character, and in some cases, these domains can be in contact with each other and not separated by totally sterile material.

Contact Profile Analysis

- Identifying estimation domains and modelling their boundaries can be a time-consuming process and the estimation practitioner needs to be able to validate them before moving on to their estimation.

- The Contact Profile Analysis (CPA) technique discussed in this presentation is a useful tool to investigate the behaviour of the transition from one geological unit to another and can be used to improve the use of samples from neighbouring units to estimate the grades of a given geological unit.

Geological Background

- The nickeliferous mineralization in Greece is related to the geotectonic zones of Almopia, Pelagonian and Sub-Pelagonian, - the main metalliferous regions are situated in Locris, Euboea and Kastoria.
- In the area of Agios Ioannis, there are large laterite deposits developed and mined by LARCO GMMSA and belong to the Sub-Pelagonian zone.
- The Tsouka Ni-laterite deposit is characterized by a saprolite zone, 1 m thick, followed by a pelitic-pisolitic horizon, 4 m thick, the upper part of which is comprised of transported material.
- Lower Cretaceous limestone layers alternating with Ni-laterite ore are conformably overlying the mineralized horizon.
- Mining of the Tsouka deposit started before WWI using an underground room and pillar process.
- LARCO started surface mining of the deposit in the 90s.

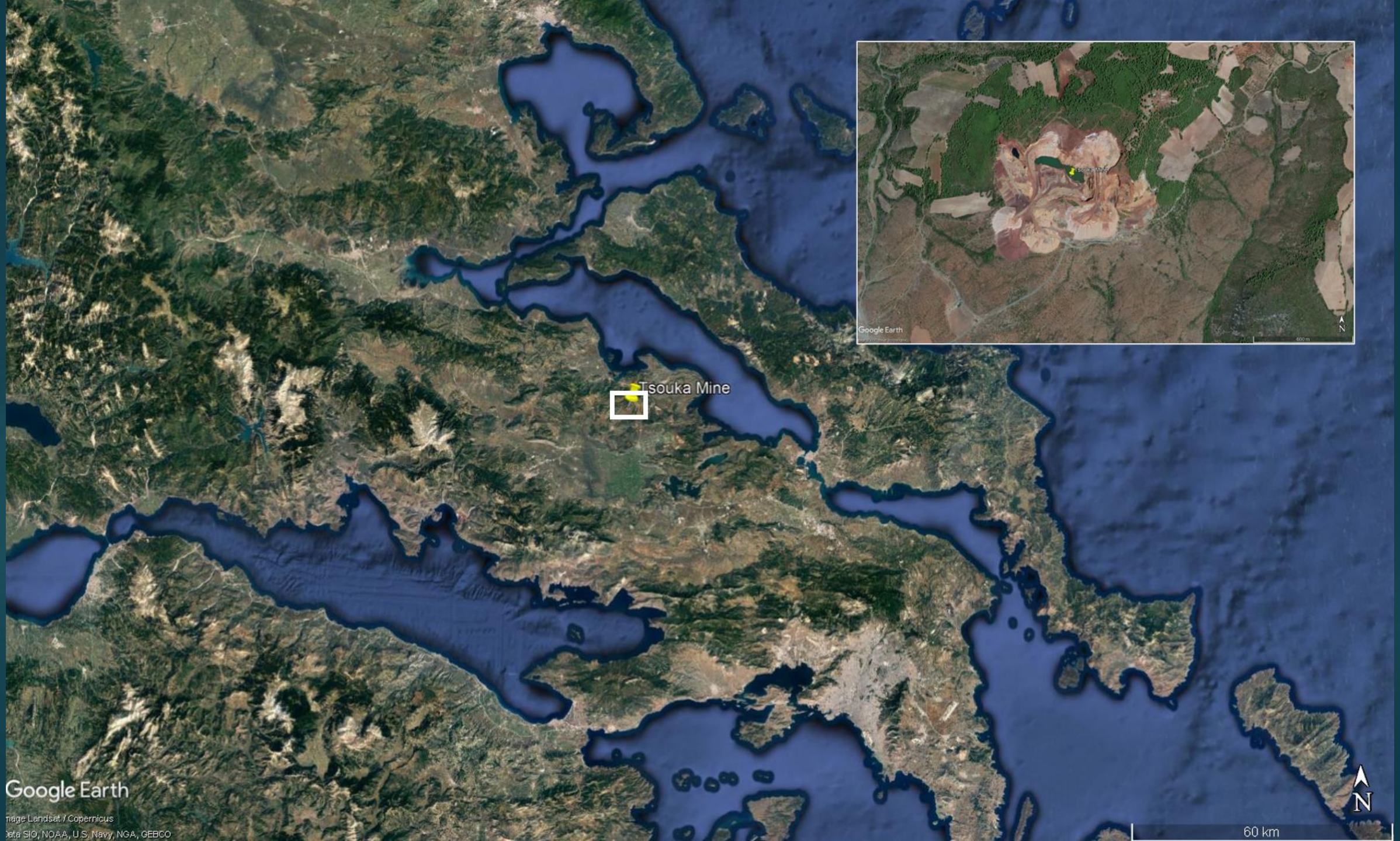
Tsouka Mine
Google Earth
N
60 km
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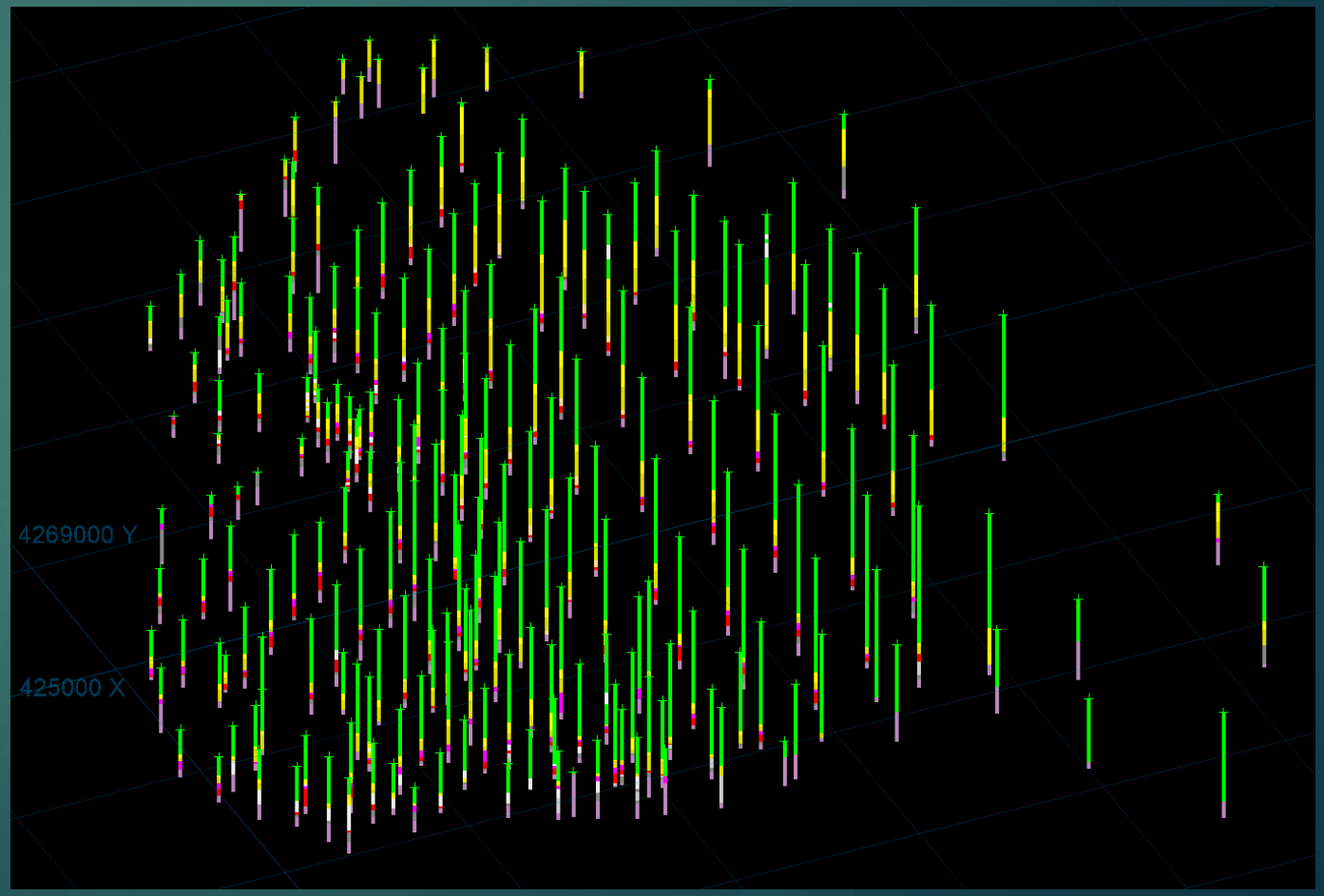
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Resource Estimation Domains Modelling

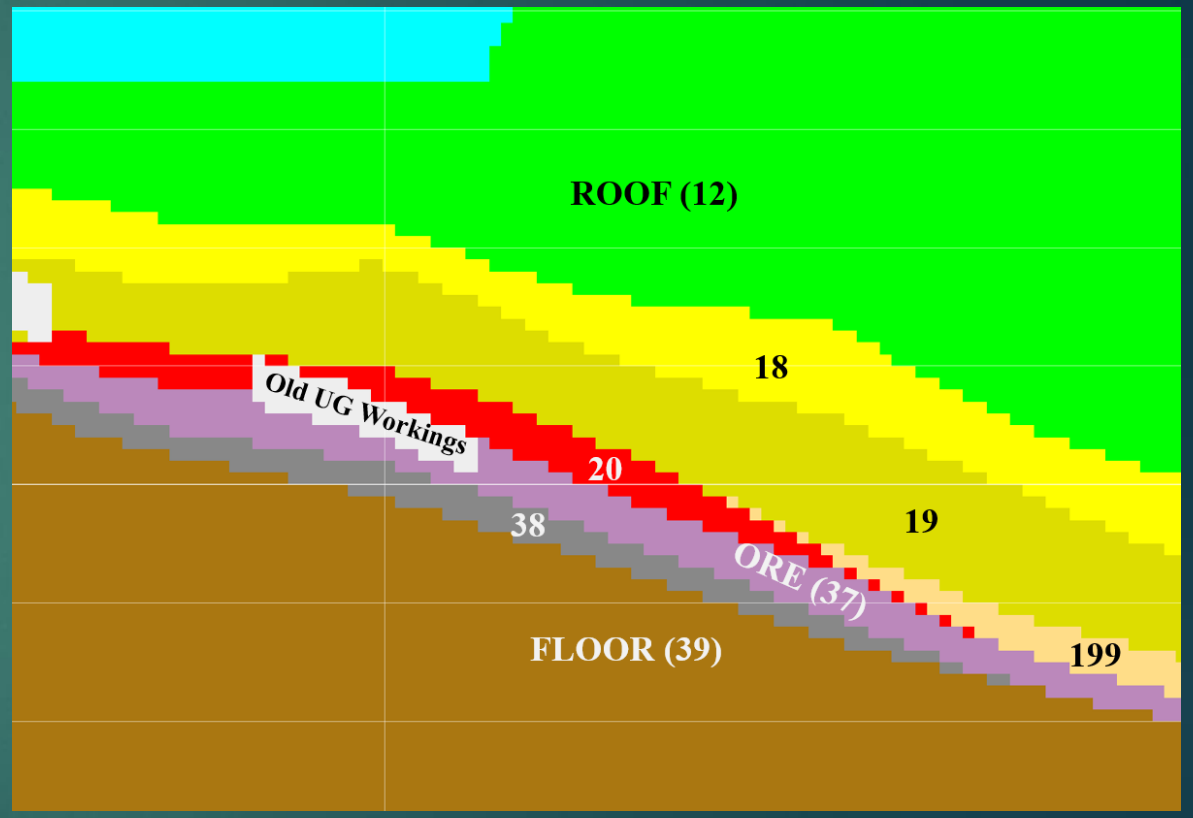
- Modelling and estimation of the Tsouka deposit was based on a dataset consisting of 218 drillholes providing a total of 12,473 1m composite samples.
- Samples have been assigned to different domains based on lithology, and Fe-Ni grades.
- The boundaries between domains have been modelled using a mostly stratigraphic approach and have been used to flag blocks in the model before Resource estimation.



Resource Estimation Domains

The following domains have been identified and modelled in the Tsouka deposit according to the domain naming system used by LARCO:

- 12 (Roof): overburden – limestone
- 18: conglomerate
- 19: poor clay horizon
- 199: poor mineralisation with slightly higher Fe concentration than 19
- 20: poor mineralisation with high Fe content
- 37 (Ore): main mineralisation
- 38: red ophiolite with some rich spots
- 39: green ophiolite (bedrock)
- KENO (Void): old underground workings (room and pillar)

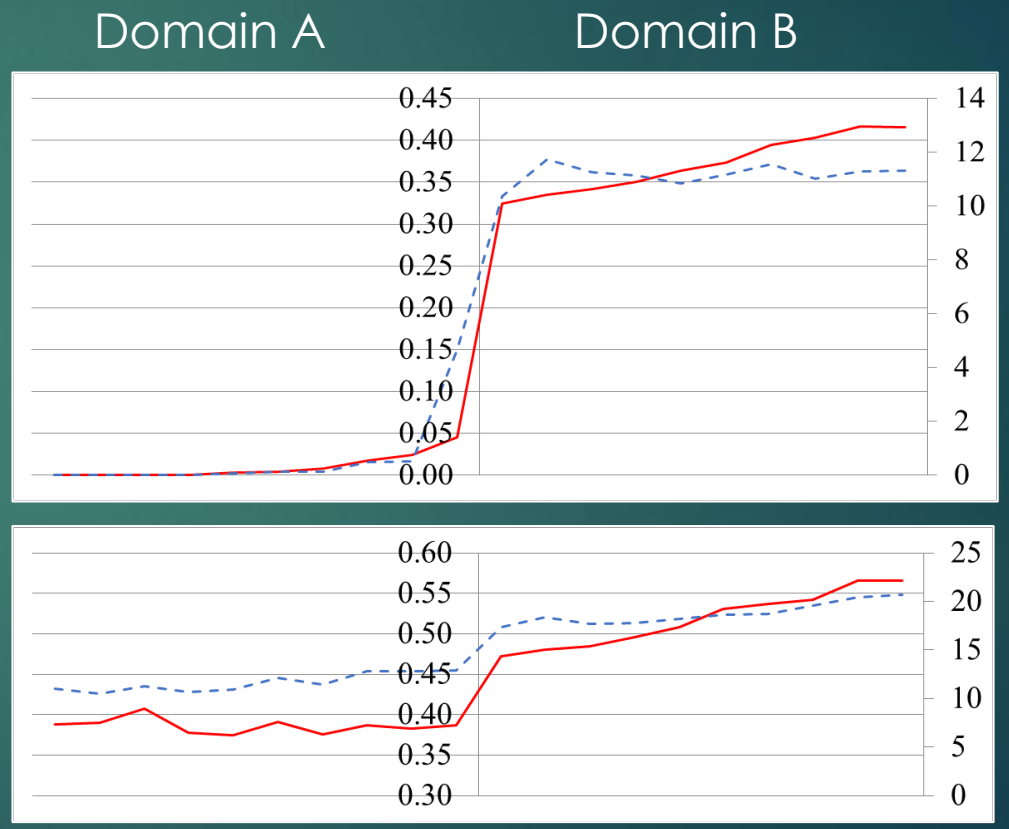


Contact Profile Analysis – How it Works

- The **Contact Profile Analysis** (CPA) tool included in Maptek Vulcan™, was used to investigate the relationship between grades when moving from one estimation domain to another to validate the domains and possibly justify and control the use of samples from neighbouring domains during estimation.
- Samples from each domain were **paired** with samples from a neighbouring domain based on a **separation distance**.
- The pairs were constructed over an **increasing** separation distance.
- For each separation distance, the **average grade** of the first domain was plotted against the average grade of the second.
- Average grades from the first domain were plotted on negative distances so the differences could be observed within the graph.

Contact Profile Analysis – Soft vs. Hard Boundary

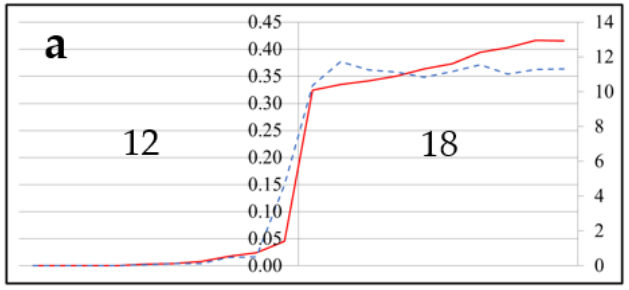
- Careful examination of the produced graphs allowed the determination of the type of boundary (soft or hard) and a safe distance or width in the case of a soft boundary between estimation domains for sharing samples.
- The different scale of each of the contact profile graphs should be considered when comparing them.

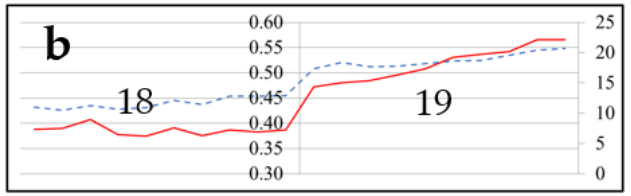


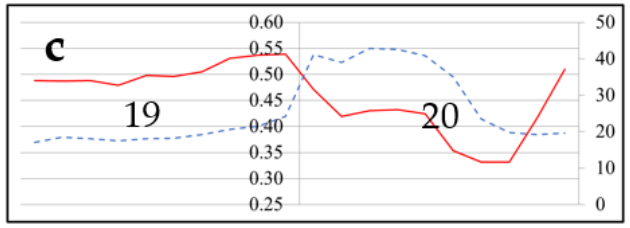
Examining the Results

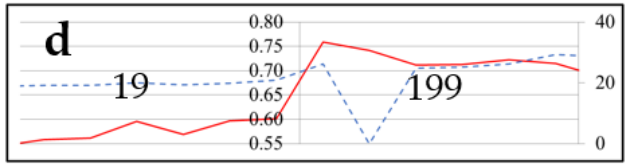
- Starting from the top, the contact profile between overburden material (12) and the conglomerate layer (18) was constructed.
- The values near the interface between the two domains were considerably different, producing a sudden jump in Ni grade when moving from domain 12 to 18 - more than Ni 0.25% and a similar change in Fe grade (more than 10%) in less than a meter of distance.
- This was considered a hard boundary and no samples from 12 were used to estimate domain 18.
- Basic sample statistics also supported the exclusion of any domain 12 samples from estimating domain 18.
- The clear difference between samples from the two domains near their interface and the produced contact profile graph were considered as evidence of validity of the modelled boundary between them.

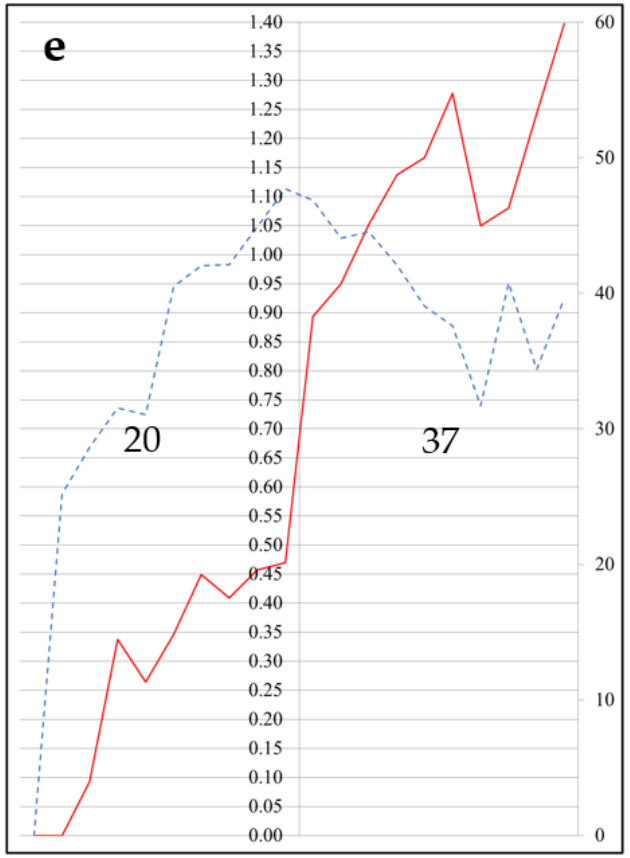
Contact Profiles Between Resource Domains

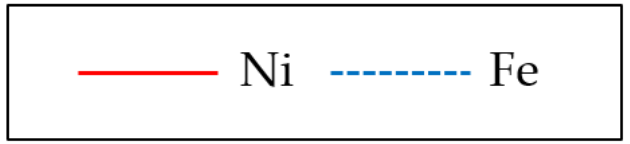


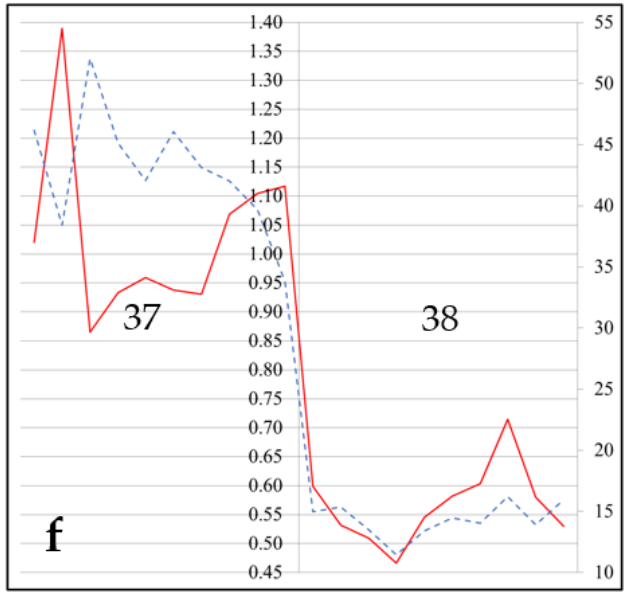


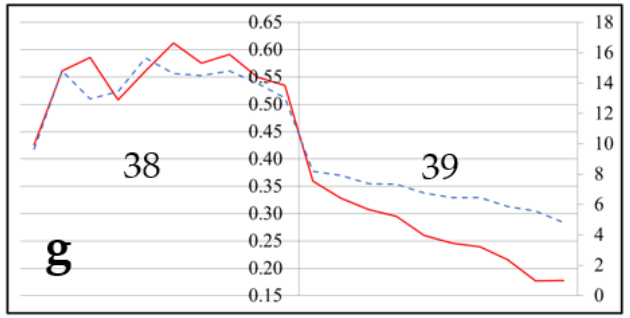


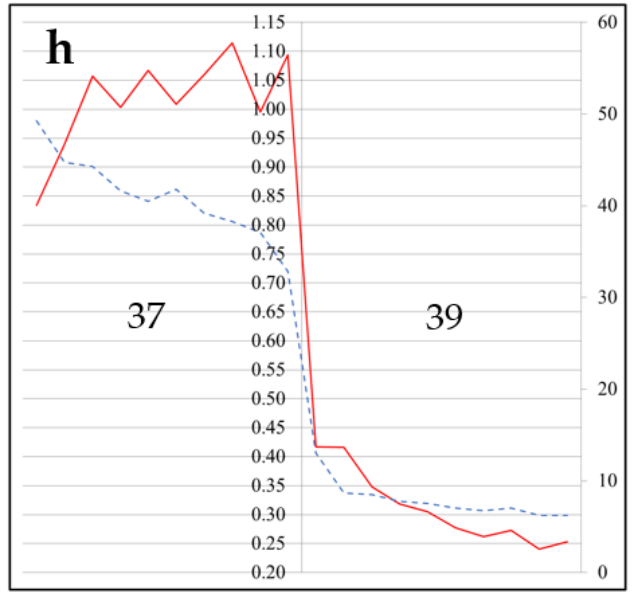


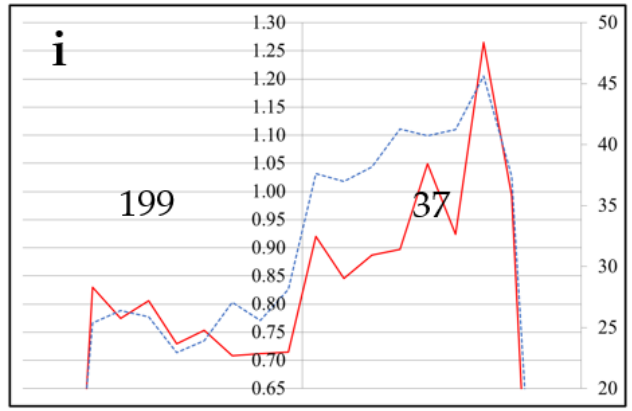












Basic Ni Statistics Comparison Between Resource Domains

Domain	Domain total samples count	Mean of totals	Domain intervals samples count	Mean of intervals	First interval correlation	Type of boundary
12	7116	0.00	1727	0.01	0.00	hard
18	1140	0.38	865	0.36		
18	1140	0.38	833	0.38	0.31	soft
19	1436	0.53	1101	0.52		
19	1436	0.53	472	0.51	0.11	hard
20	311	0.41	246	0.43		
19	1436	0.53	288	0.56	0.02	soft
199	82	0.73	82	0.73		
20	311	0.41	198	0.42	0.03	soft
37	455	1.04	269	1.07		
37	455	1.04	296	1.04	0.08	hard
38	376	0.56	230	0.54		
37	455	1.04	437	1.04	0.03	hard
39	1323	0.28	587	0.30		
199	82	0.73	72	0.73	0.00	soft
37	455	1.04	92	0.95		

Basic Fe Statistics Comparison Between Resource Domains

Domain	Domain total samples count	Mean of totals	Domain intervals samples count	Mean of intervals	First interval correlation	Type of boundary
12	7116	0.07	1727	0.21	0.31	hard
18	1140	11.46	865	11.26		
18	1140	11.46	833	12.03	0.43	soft
19	1436	18.36	1101	18.55		
19	1436	18.36	472	19.91	0.07	hard
20	311	36.42	246	39.92		
19	1436	18.36	288	19.24	0.06	soft
199	82	25.92	82	25.92		
20	312	36.42	200	42.64	0.39	soft
37	456	39.91	270	42.34		
37	456	39.91	297	40.28	0.13	hard
38	376	13.98	230	13.92		
37	456	39.91	442	39.79	0.03	hard
39	1323	6.71	581	7.69		
199	82	25.92	72	26.12	0.22	soft
37	456	39.91	92	39.79		

Conclusions

- Contact Profile Analysis is a technique that can be used to investigate the relationship between grades either side of the boundary between neighbouring domains.
- The results of CPA can be used to increase confidence in the boundaries themselves and how efficiently they separate sample distributions, decide as to the type of the boundary (soft or hard), and in the case of soft boundaries, control the depth of sample exchange between domains.
- Our study demonstrated the practice and benefits of CPA when applied to a laterite Fe-Ni deposit consisting of multiple domains.

Thank you for your attention!