

Seafloor Massive Sulphide Assessment

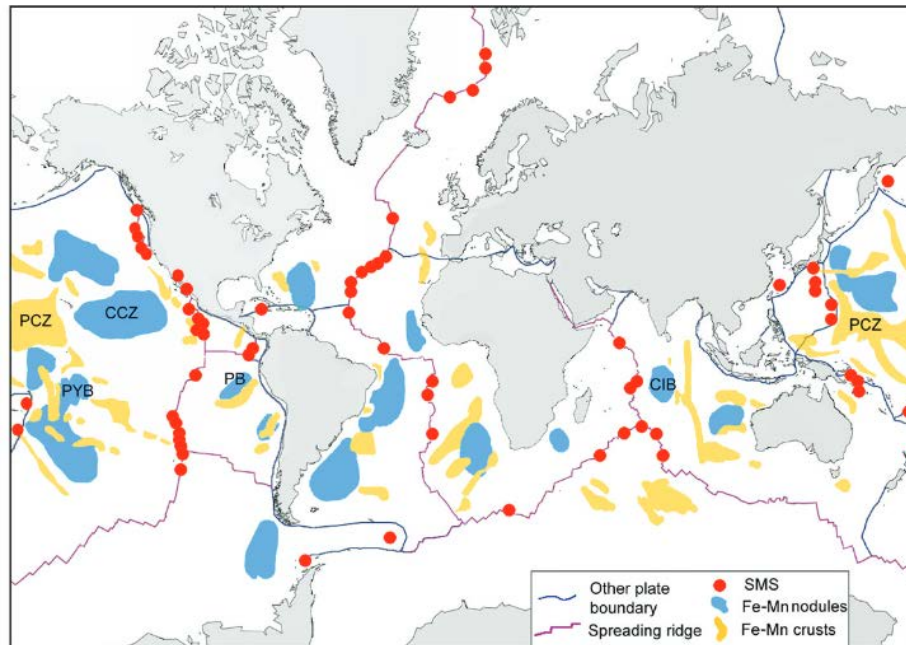
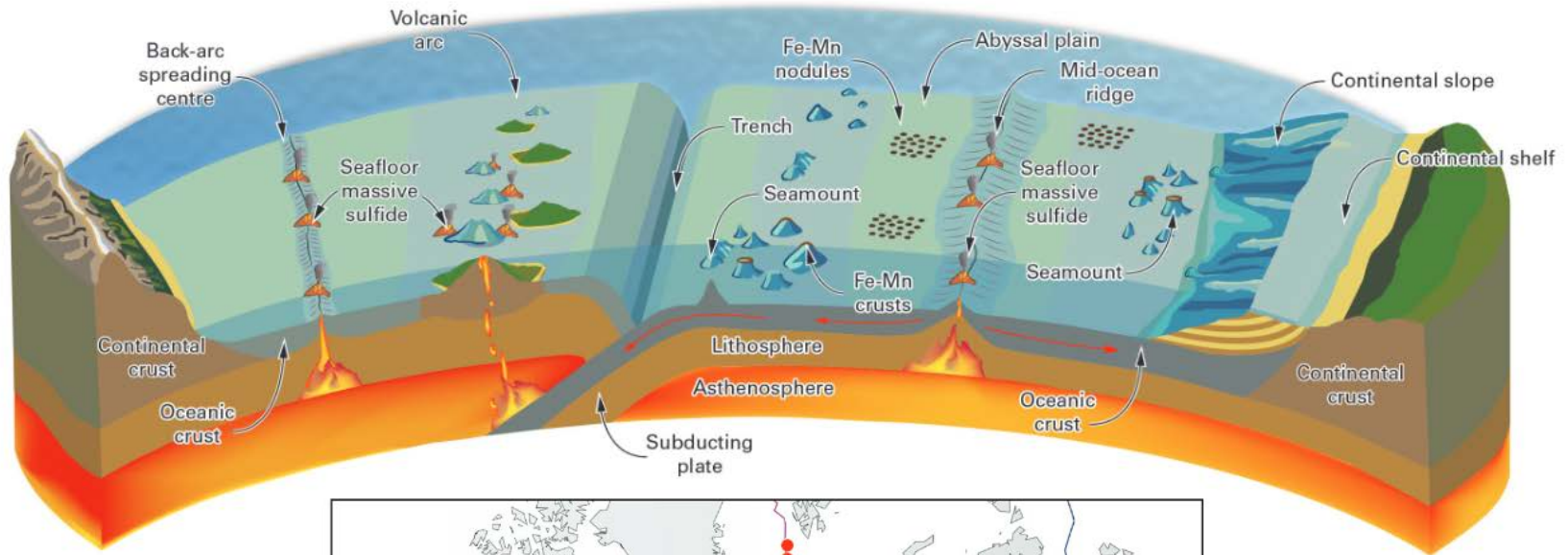
The Rainbow Area

Raw materials MAP

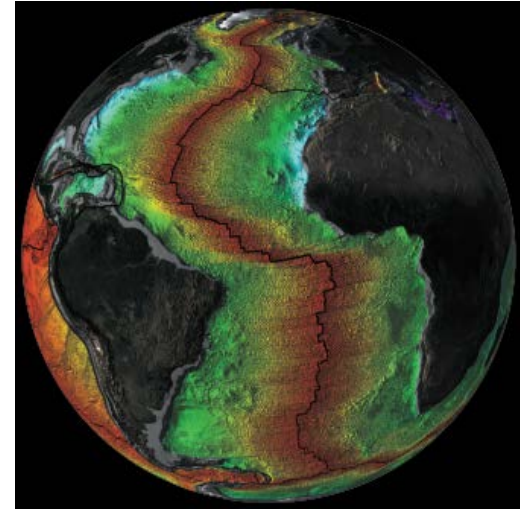
Steinar L. Ellefmo and Cyril Juliani, Department of Geoscience and Petroleum, NTNU

MAP Final meeting, December 15th, 2020

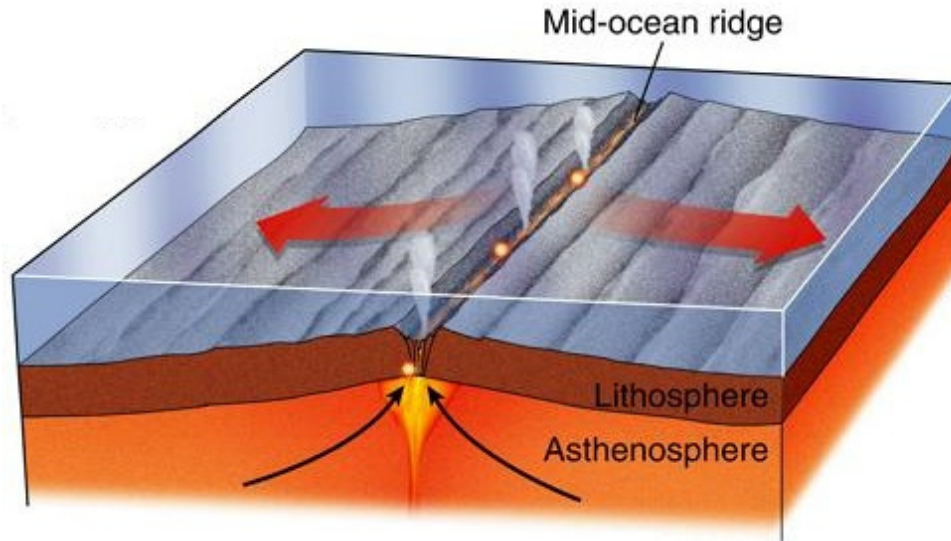
Seabed minerals and settings



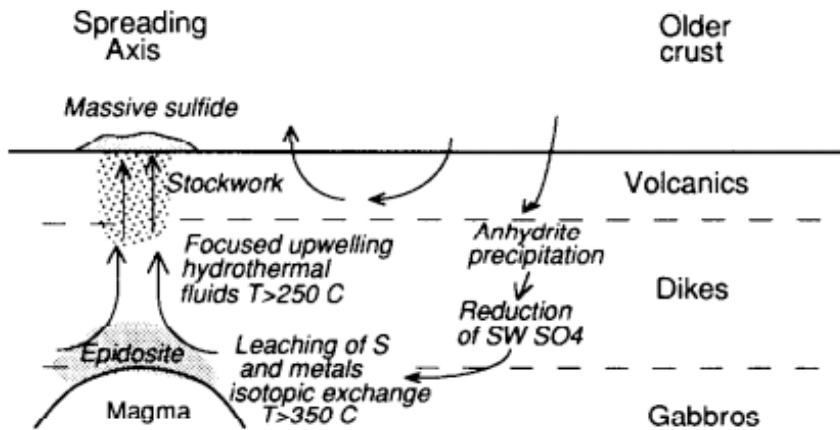
Mid-Ocean Ridges



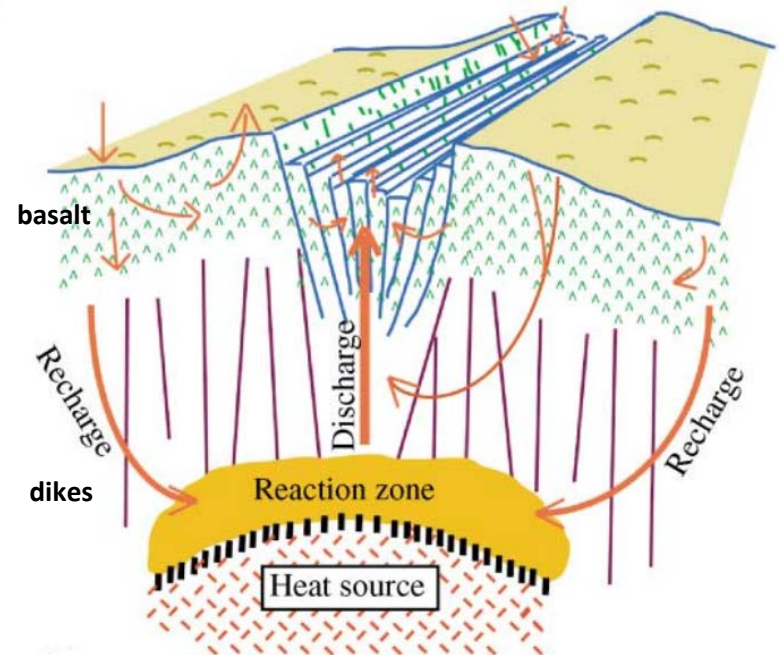
Mueller et al., 2008



© Pearson Prentice Hall, 2006

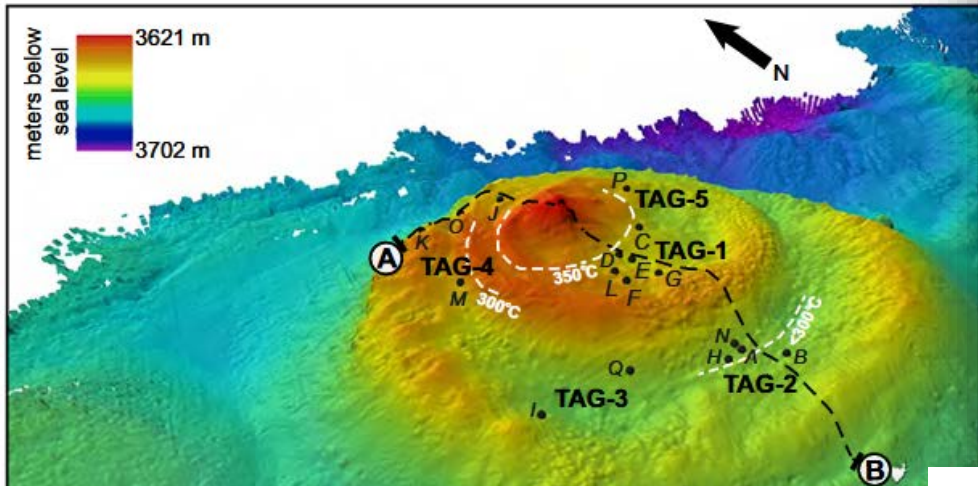


Alt, 1994



German and Von Damm, 2004; after Alt, 1995

Seafloor massive sulfides

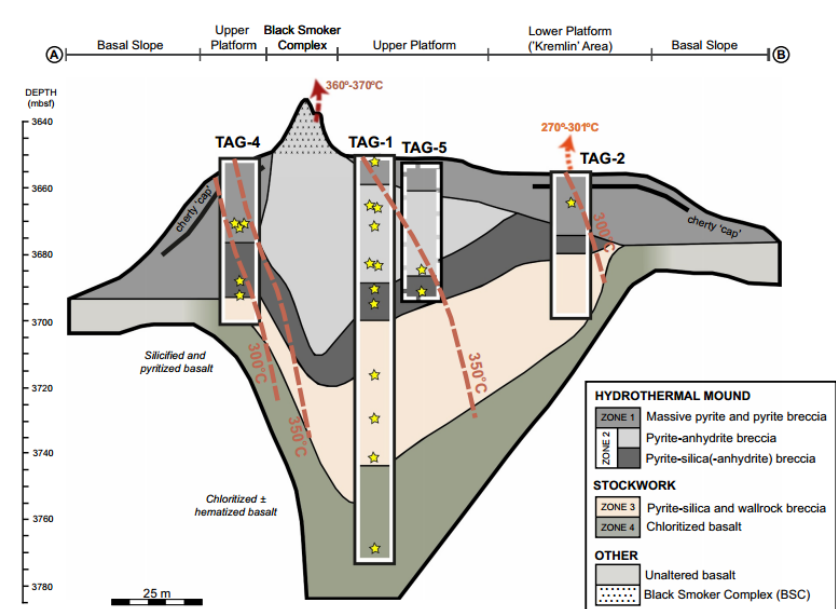
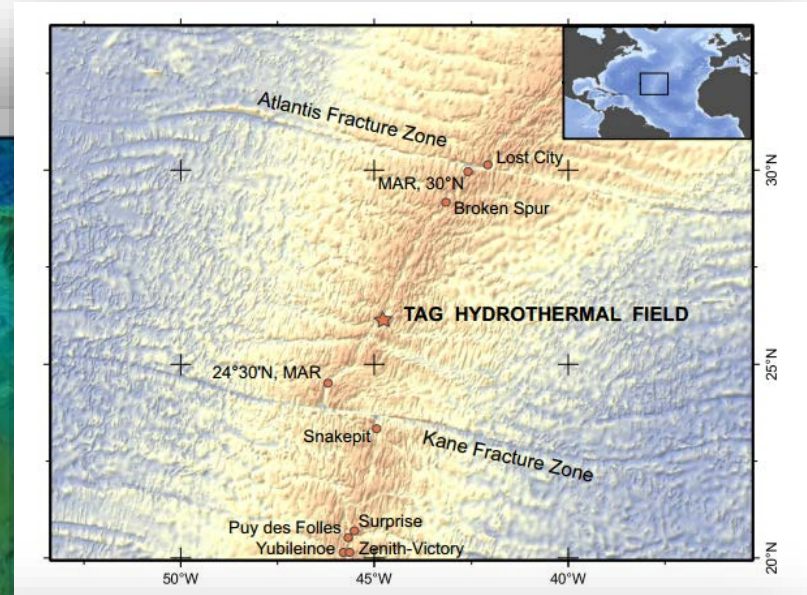
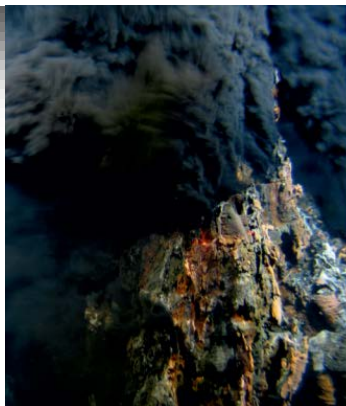


TAG mound + stockwork
at least **30,000 tonnes** of metals
2.83 wt% Cu, 0.42 wt% Zn, 0.53 ppm Au, 14 ppm Ag

(Hannington et al., 1998)



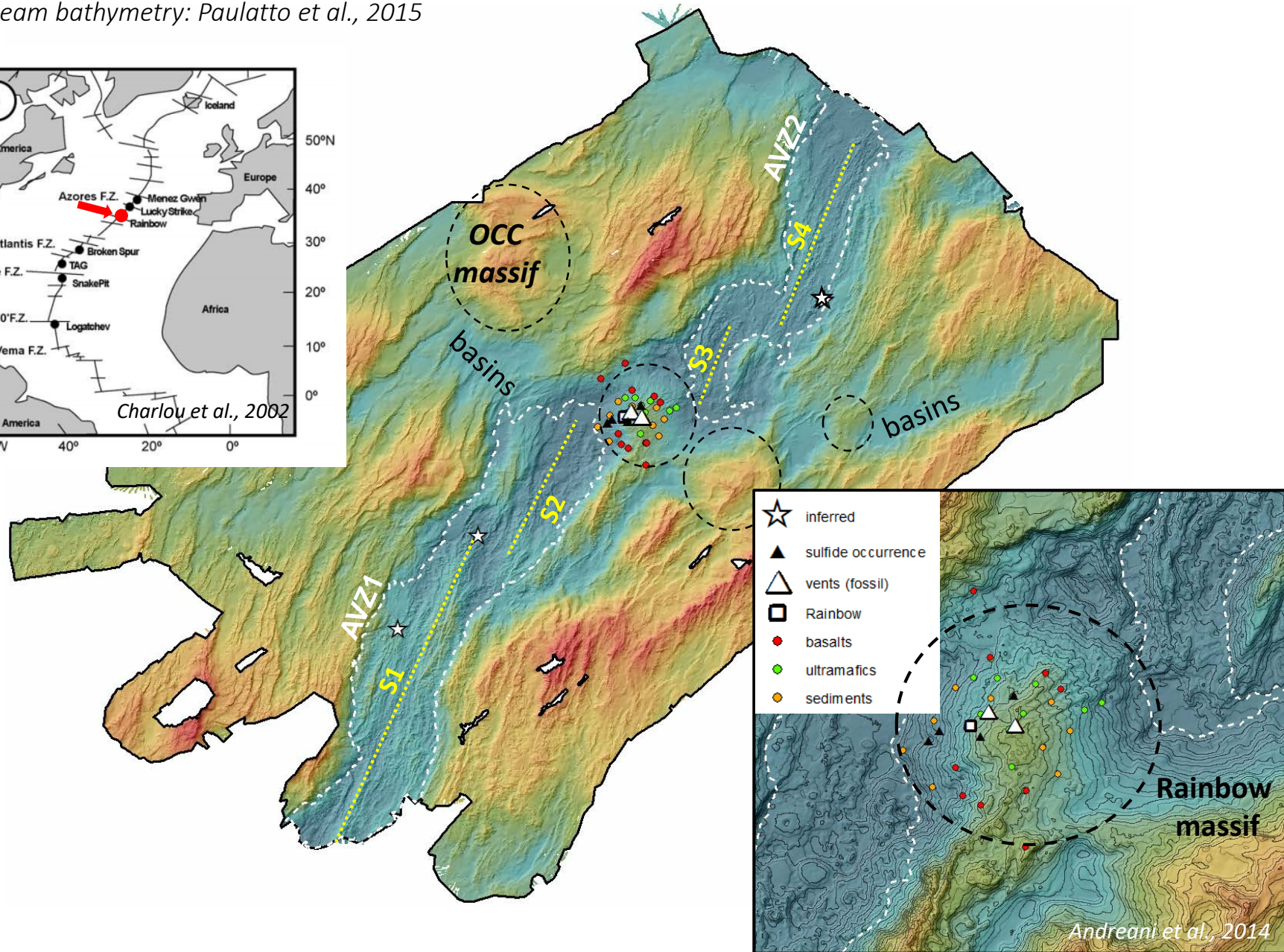
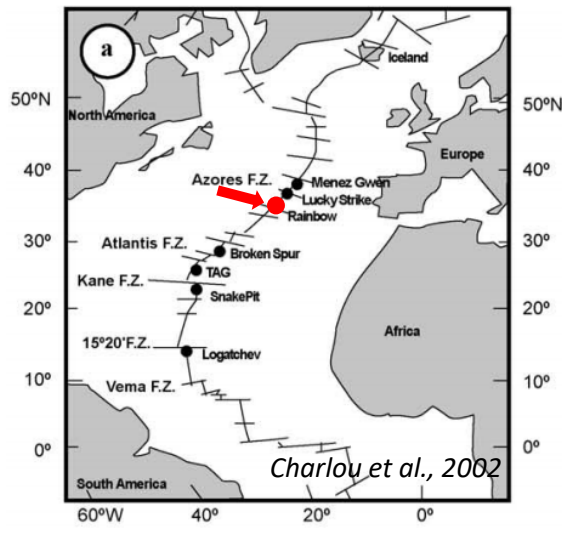
Grant et al., 2018



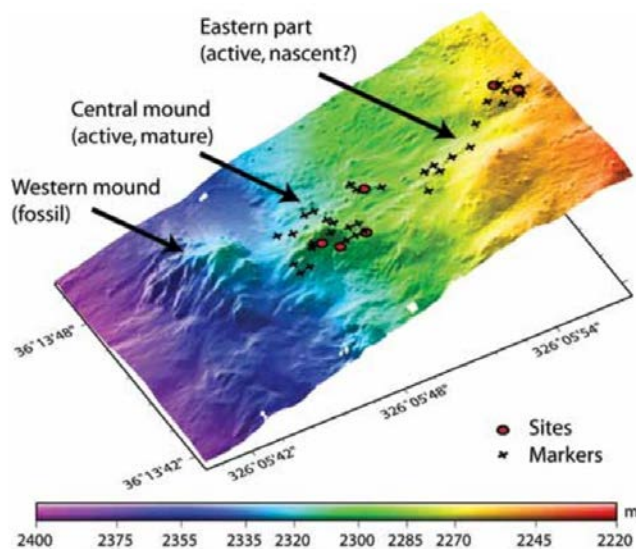
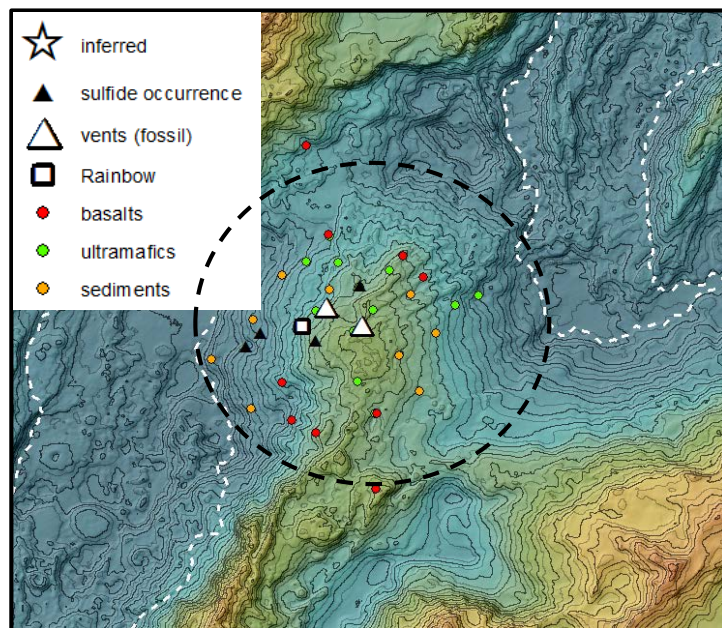
Lusty and Murton, 2018

Rainbow area (Mid-Atlantic Ridge, 35-37°N)

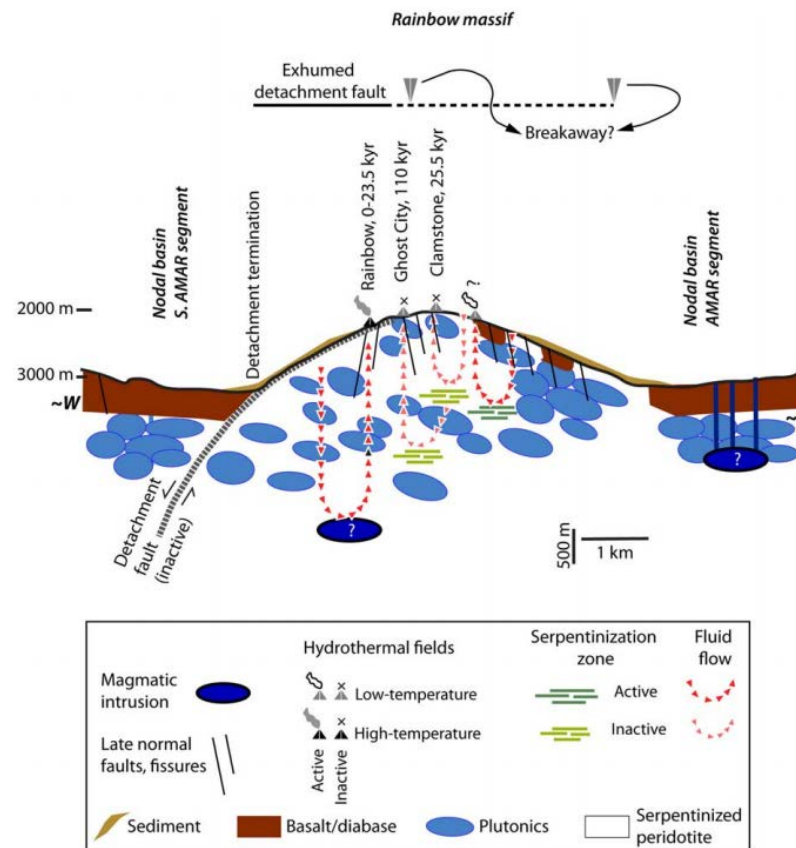
Multibeam bathymetry: Paulatto et al., 2015



Ultramafic-hosted SMS



Dyment et al., 2009



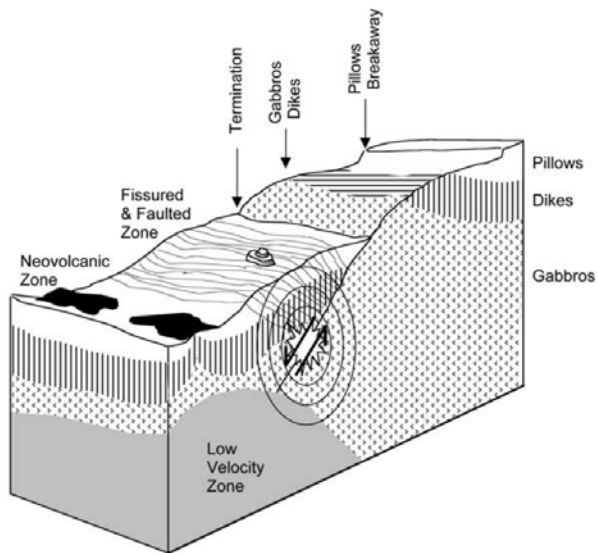
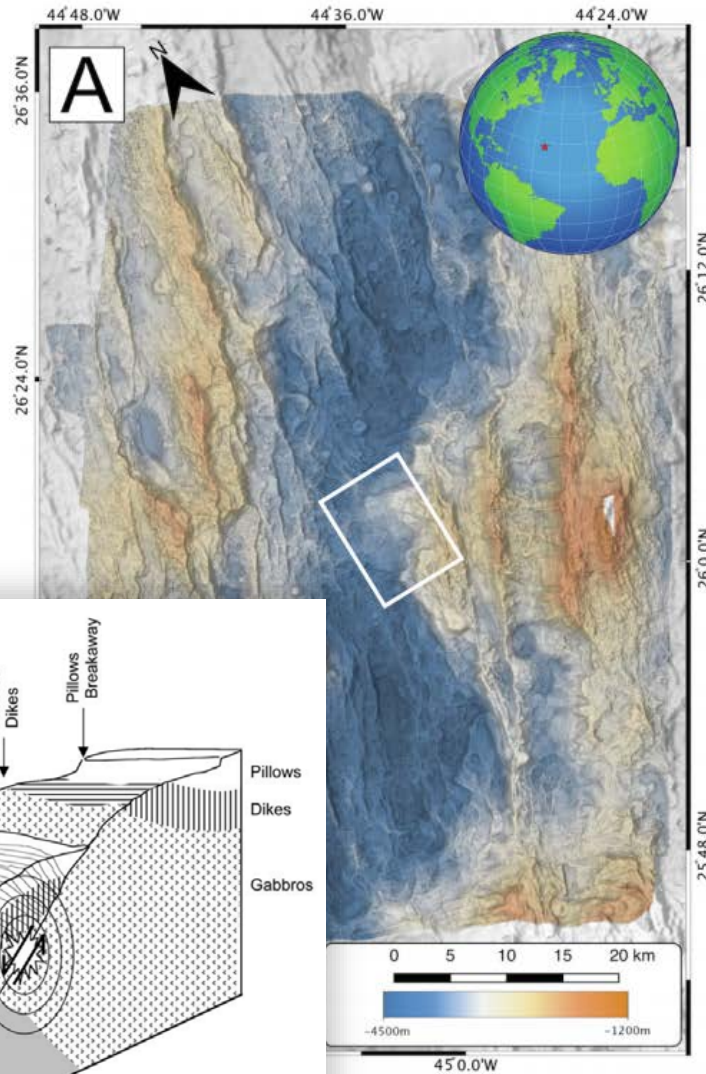
Andreani et al., 2014

Sulfide mineralization: Co–Au–Cu assemblage (sub-seafloor stockwork and massive sulfide)

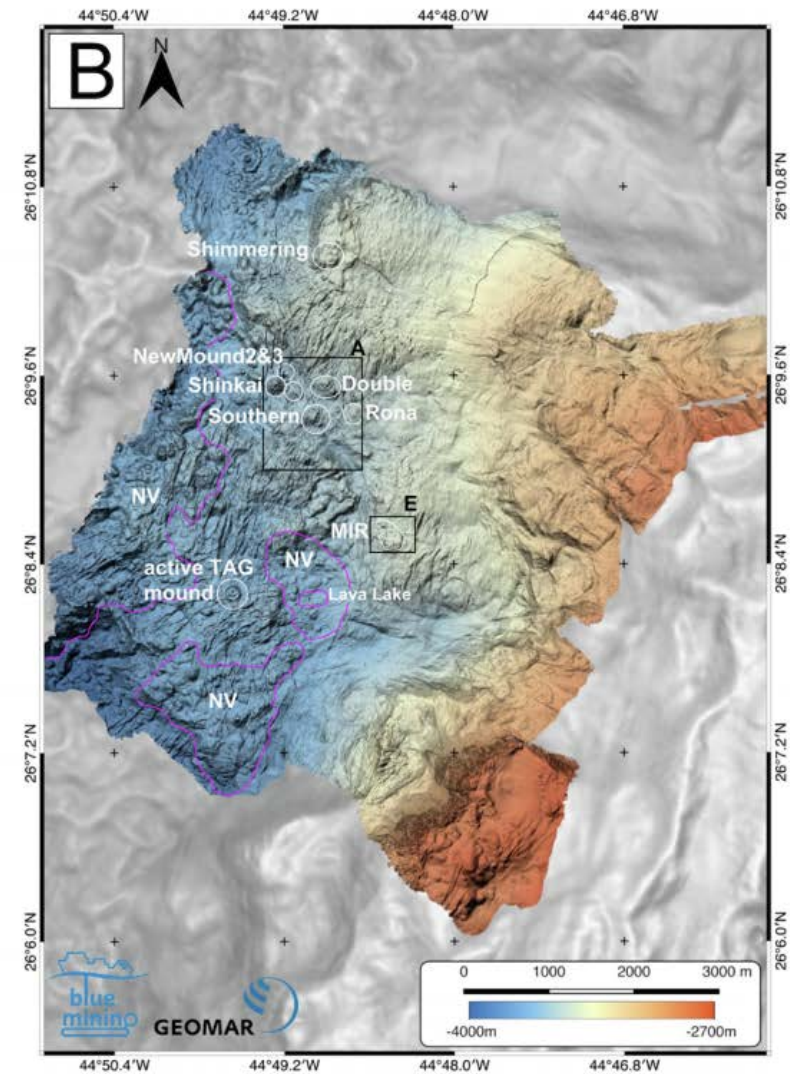
Assemblage	Bulk Sulfide Geochemistry Vent						
	Cu %	Zn %	Co ppm	Ni ppm	Au ppm	Pb ppm	Ag ppm
Po+ISS/Ccp+Sp	8.4	5.1	6300	<1	5.8	65	46.2
Cu-MS	28	0.1	4770	<1	6.3	40	5
SMS (n=4)	11.3	0.09	2335	325	2.3	28.75	5.4

Douville et al., 2002; Marques et al., 2006

Examples of mafic-hosted SMS – Inside Rainbow area?

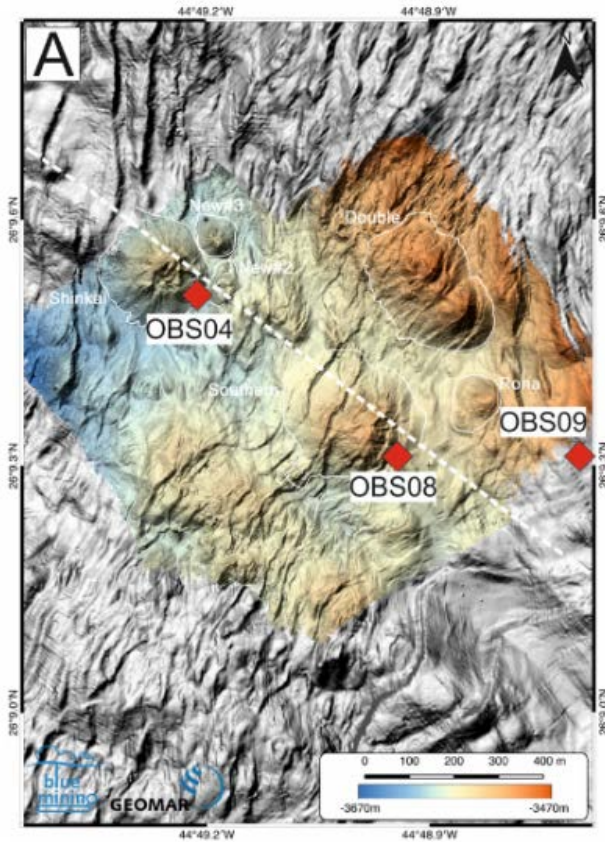


Tivey et al., 2003

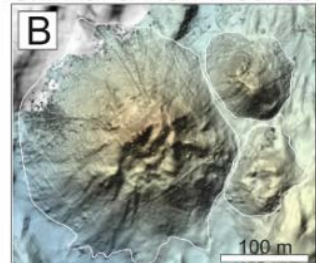


Murton et al., 2019

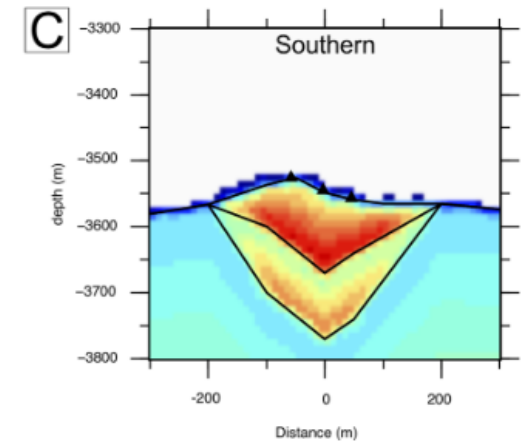
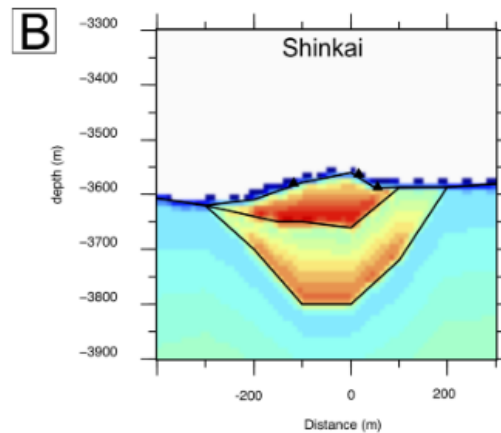
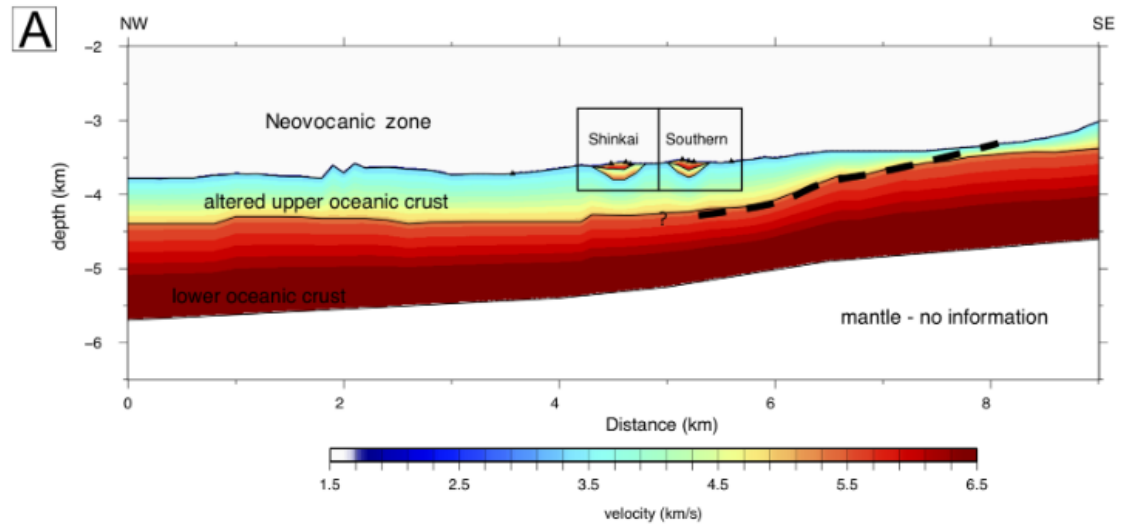
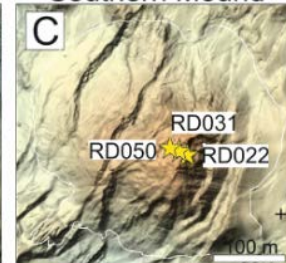
Examples of mafic-hosted SMS – Inside Rainbow area?



Shinkai & New mounds



Southern Mound



A large, light gray circle containing a stylized figure of a person with their arms raised in a 'V' shape. The figure is composed of a small gray circle for the head and a thick green line for the arms. The text 'Assessment Rainbow area' is positioned to the left of the figure.

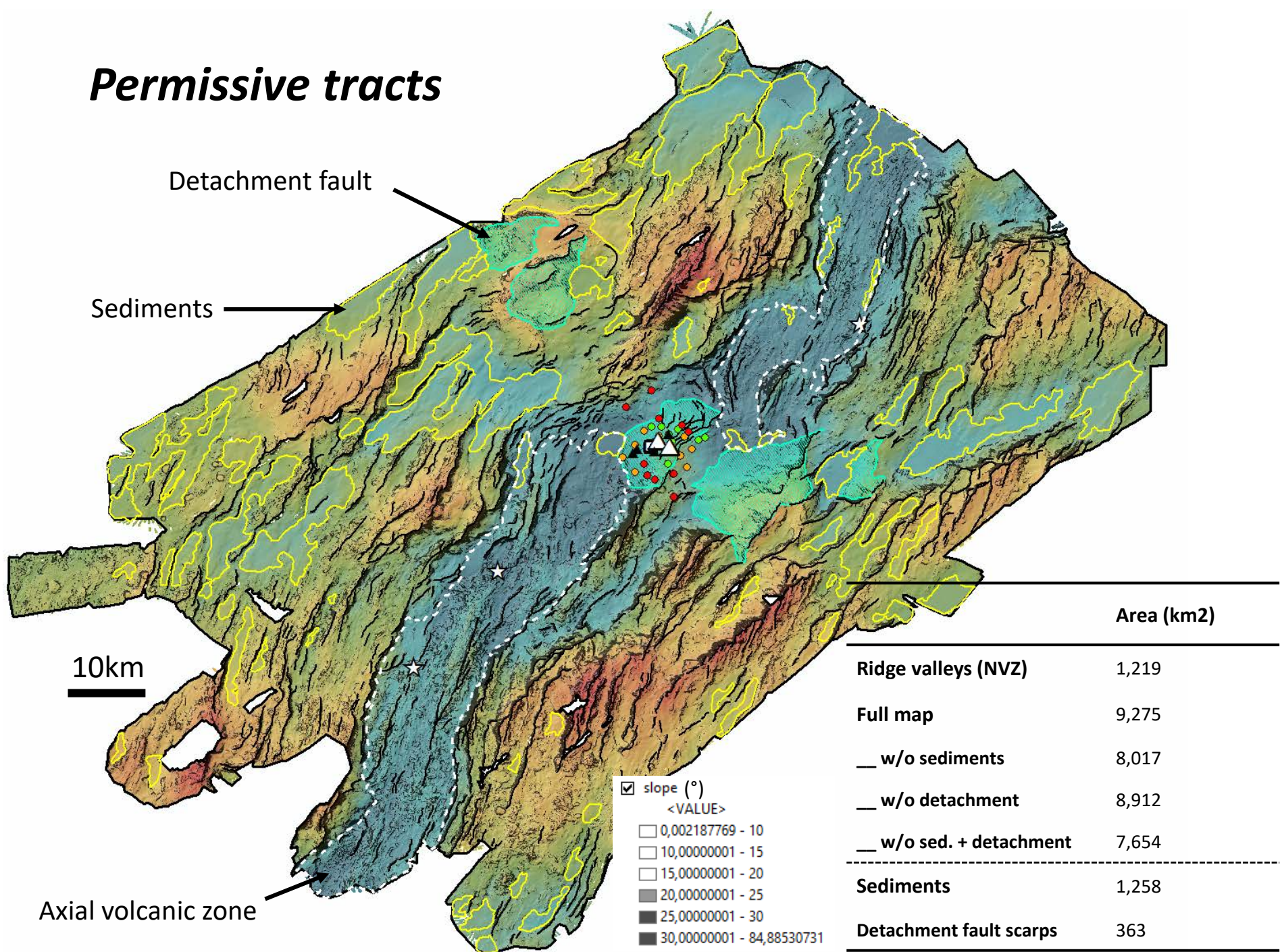
Assessment
Rainbow
area

Workshop,
October 7th to
October 8th, 2020

Workflow

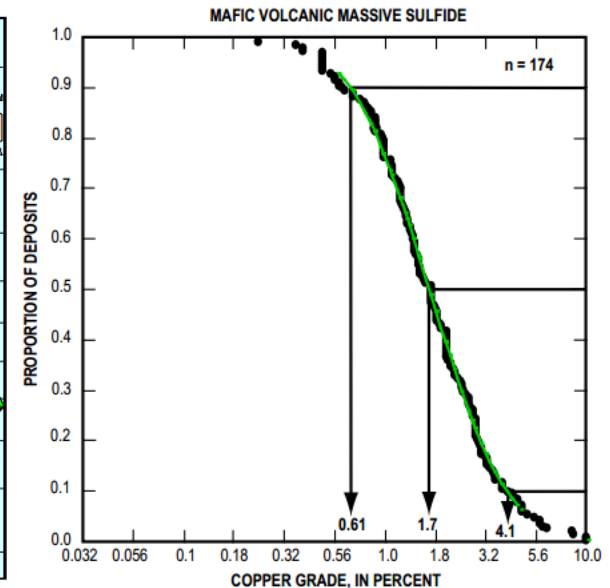
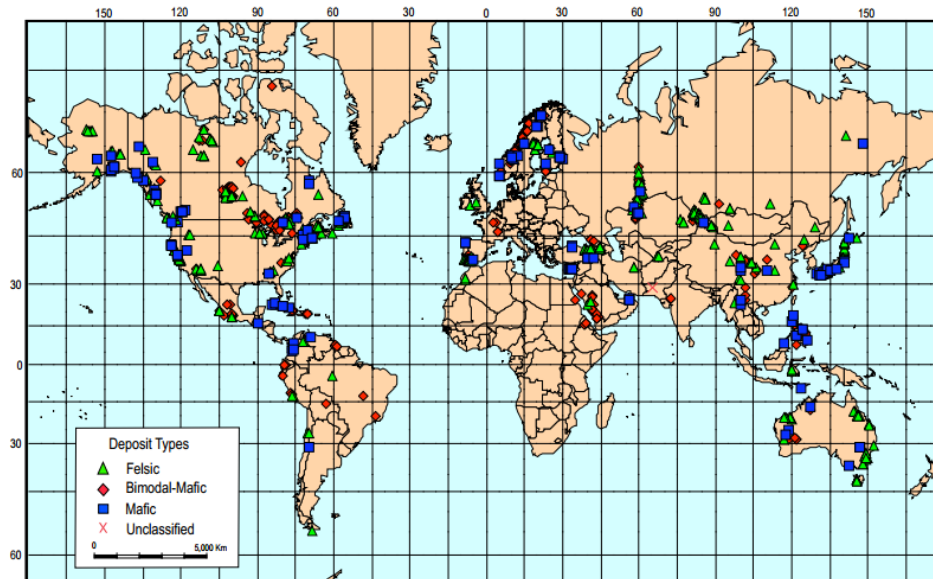
- Where?
 - Permissive tracts
- How big and how rich?
 - Grade and tonnage models
- How many?
 - Density estimation (global models) or expert opinion

Permissive tracts



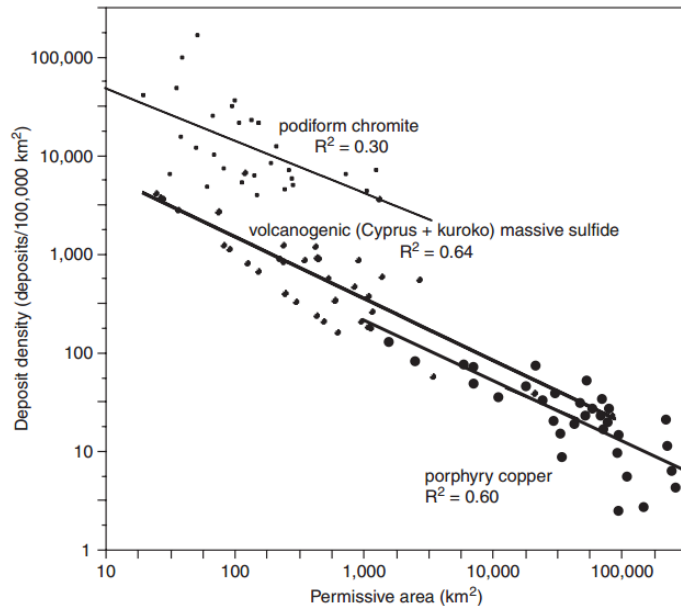
Grade and tonnage models – VMS deposits

Based on the work done by Mosier et al. (2009)



- Cyprus-type: Cu-Zn deposits, mafic volcanic host-rock
- Kuroko-type: Zn-Pb-Cu deposits, host-rock of intermediate to felsic composition

General density model *(Singer and Kouda, 2011)*



$$R_{50} = 4.2096 - 0.4987 \log_{10} \text{area} - 0.2252 \log_{10} \text{size}$$

$$L_{90}, U_{10} = R_{50} \pm t_{y/s,a} \sqrt{\left(\frac{1 + 1/n + (3.175 - \log_{10} \text{area})^2 (-0.3292 - \log_{10} \text{size})^2}{(n-1)S_s S_a} \right)}$$

R_{50} : 50th percentile in the estimates of deposit density (deposit per 100,000 km²)

L_{90} and U_{10} : the 90th and 10th percentiles respectively for the density of deposits

$$N = (\text{permissive area}/100,000) * 10^{\log_{10}(\text{Density})}$$

Number of undiscovered

deposits Confidence

41 10%

15 50%

5 90%

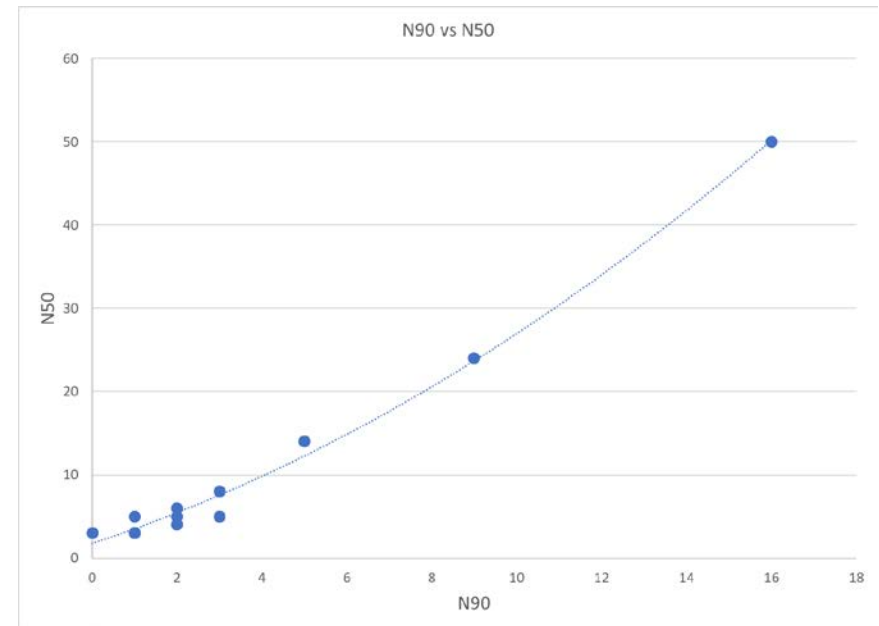
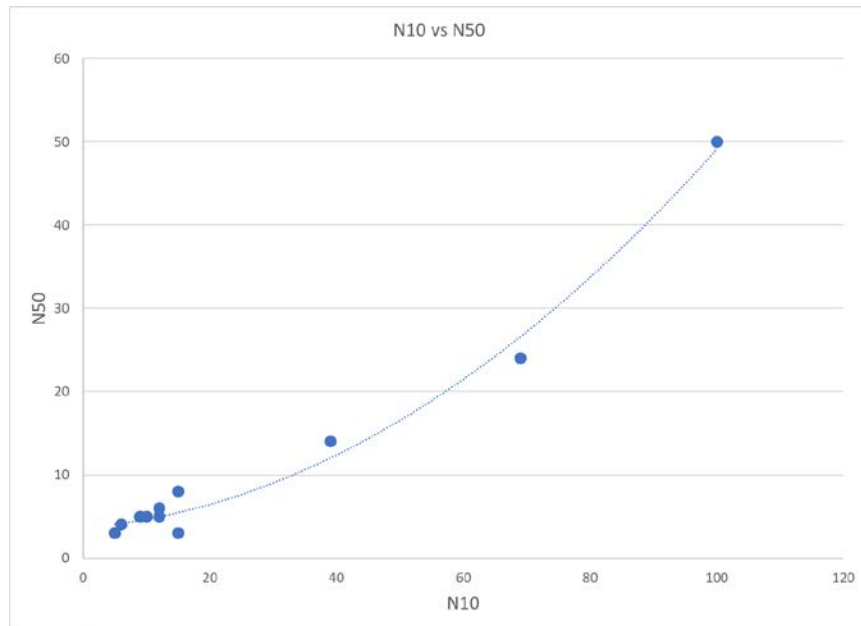
Model: General

Median deposit tonnage (Mt): 0.765

Tract area (km²): 7654

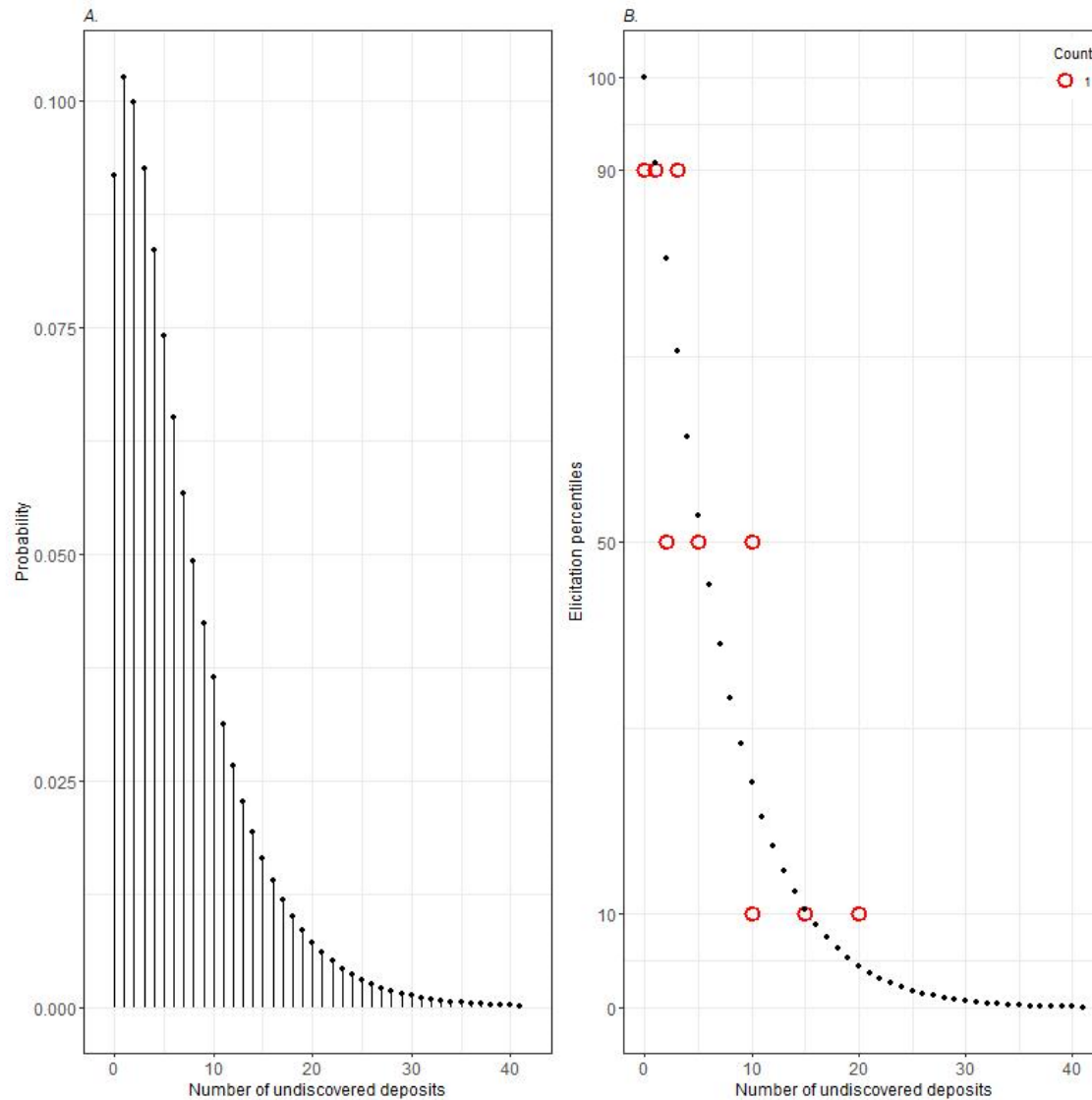
Number of known deposits: 0

Number of deposits – expert opinion



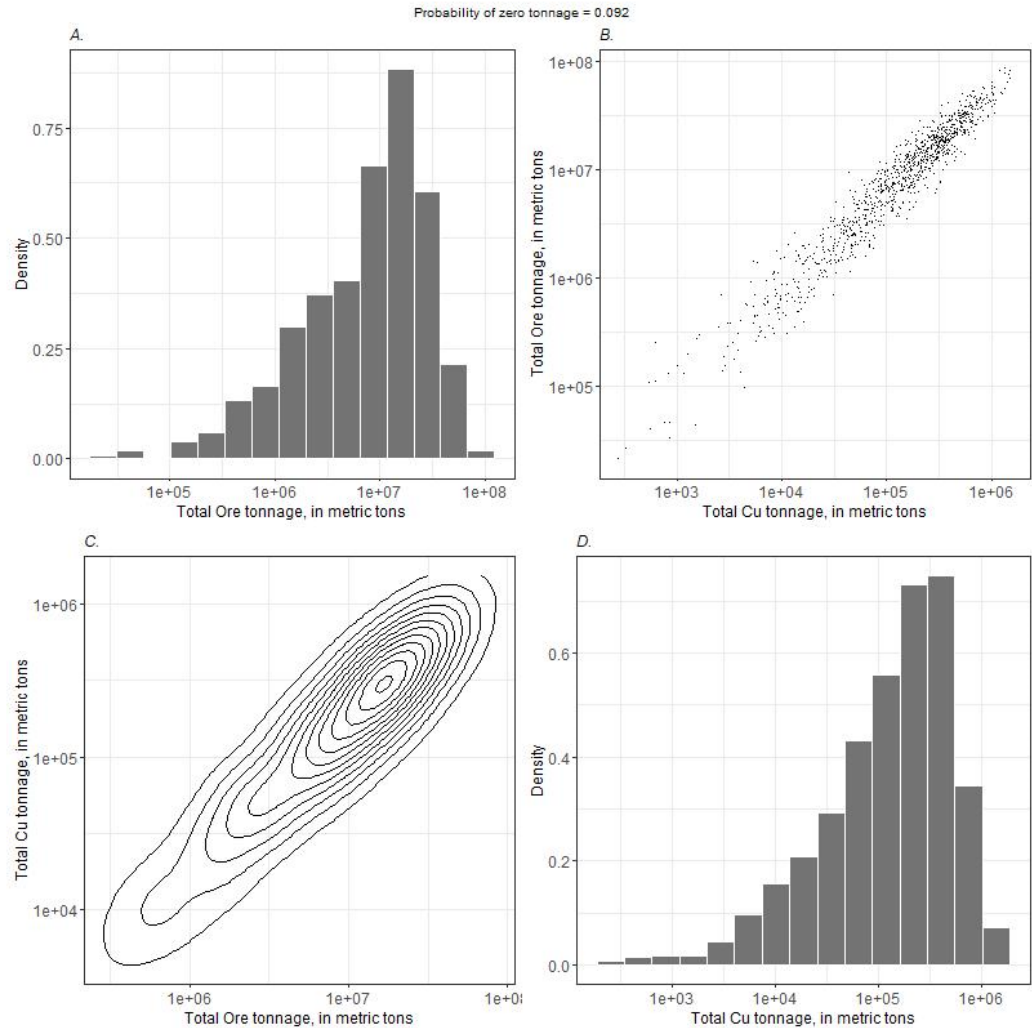
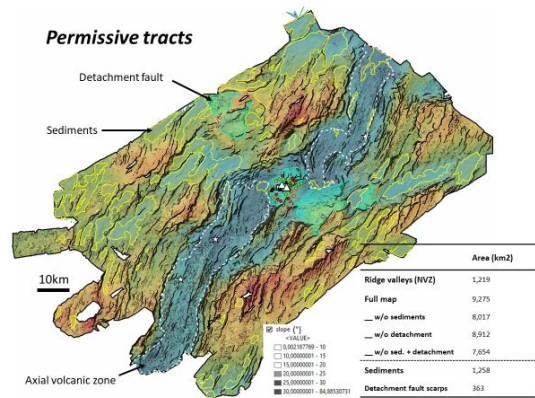
N90 = 90% sure it is at least... N10 = 10% sure it is at least

Number of deposits – expert opinion



From the general model: N10 – 41 deposits, N50 – 15 deposits, N90 – 5 deposits

Results: Ore- and Cu tonnage



Thank you for the attention

Q? Please contact

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MAP Meeting Title

15th December 2020