Seabed Minerals Authority
Runanga Takere Moana
COOK ISLANDS

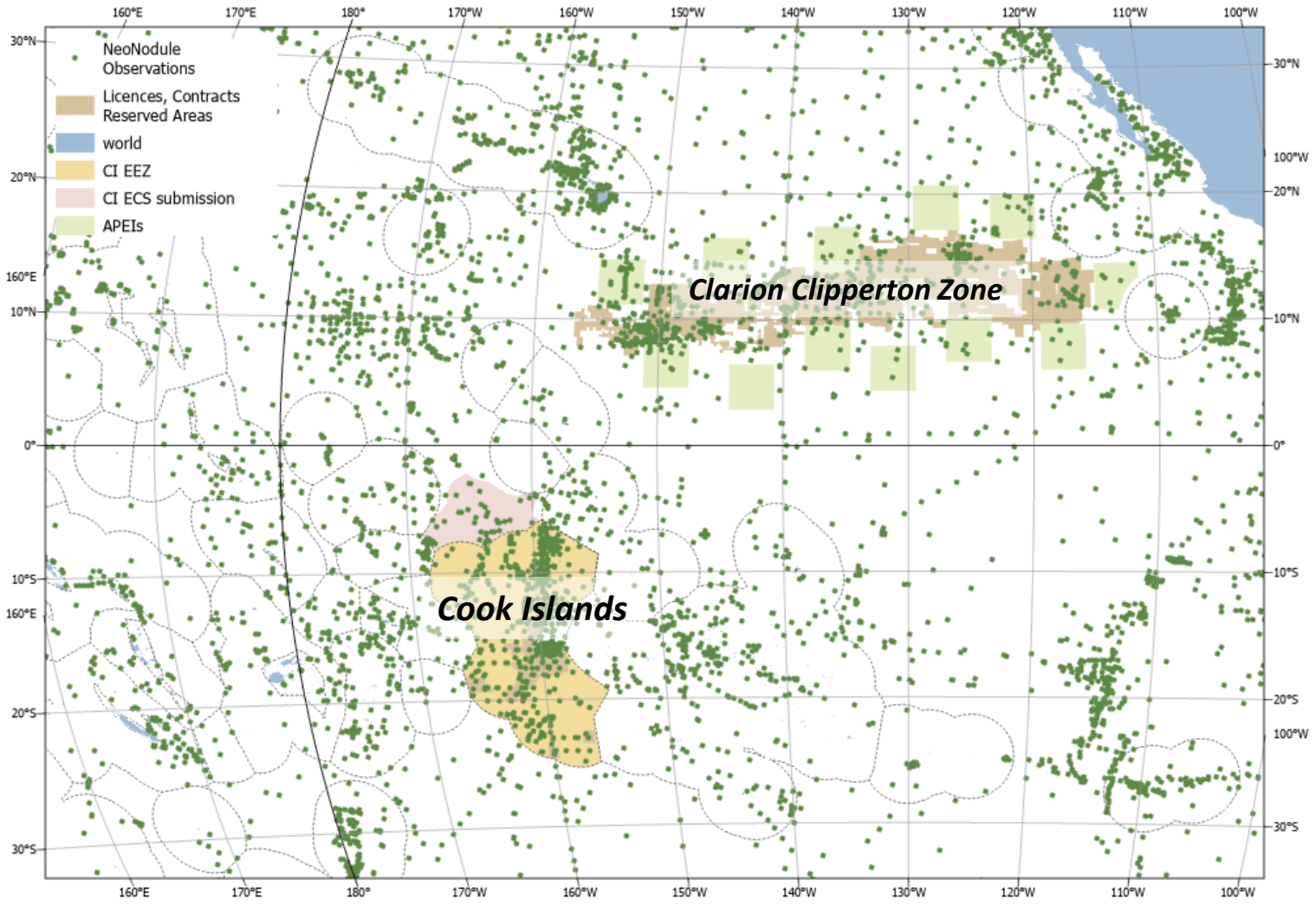
Updated mineral resource assessment for polymetallic nodules in the Cook Islands exclusive economic zone

Rima Browne, John Parianos

October 2022

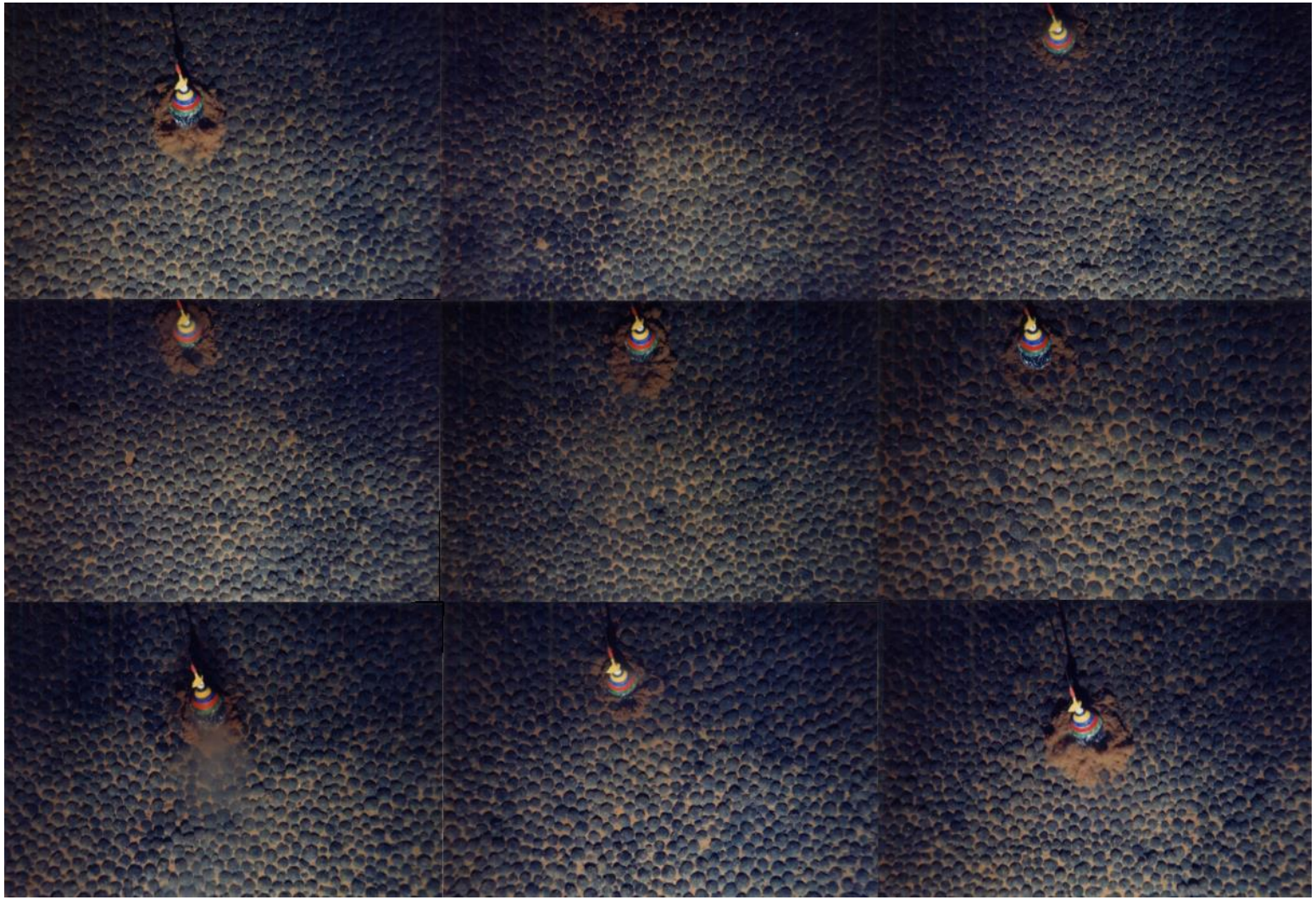
Nodules in the South Pacific

- The Cook Islands are one of a handful of major defined nodule provinces and the only one within territorial waters
- Compared to the CCZ the Cook Islands nodules are found over a greater range of latitudes and at frequently greater depths (~5500 m vs 4500 m)
- The mode of formation for the Cook Island nodules correspondingly varies internally and compared to the CCZ



The major defined nodule provinces are CCZ, Indian Ocean Nodule Field, Peru Basin and Cook Islands

The polymetallic nodule resource



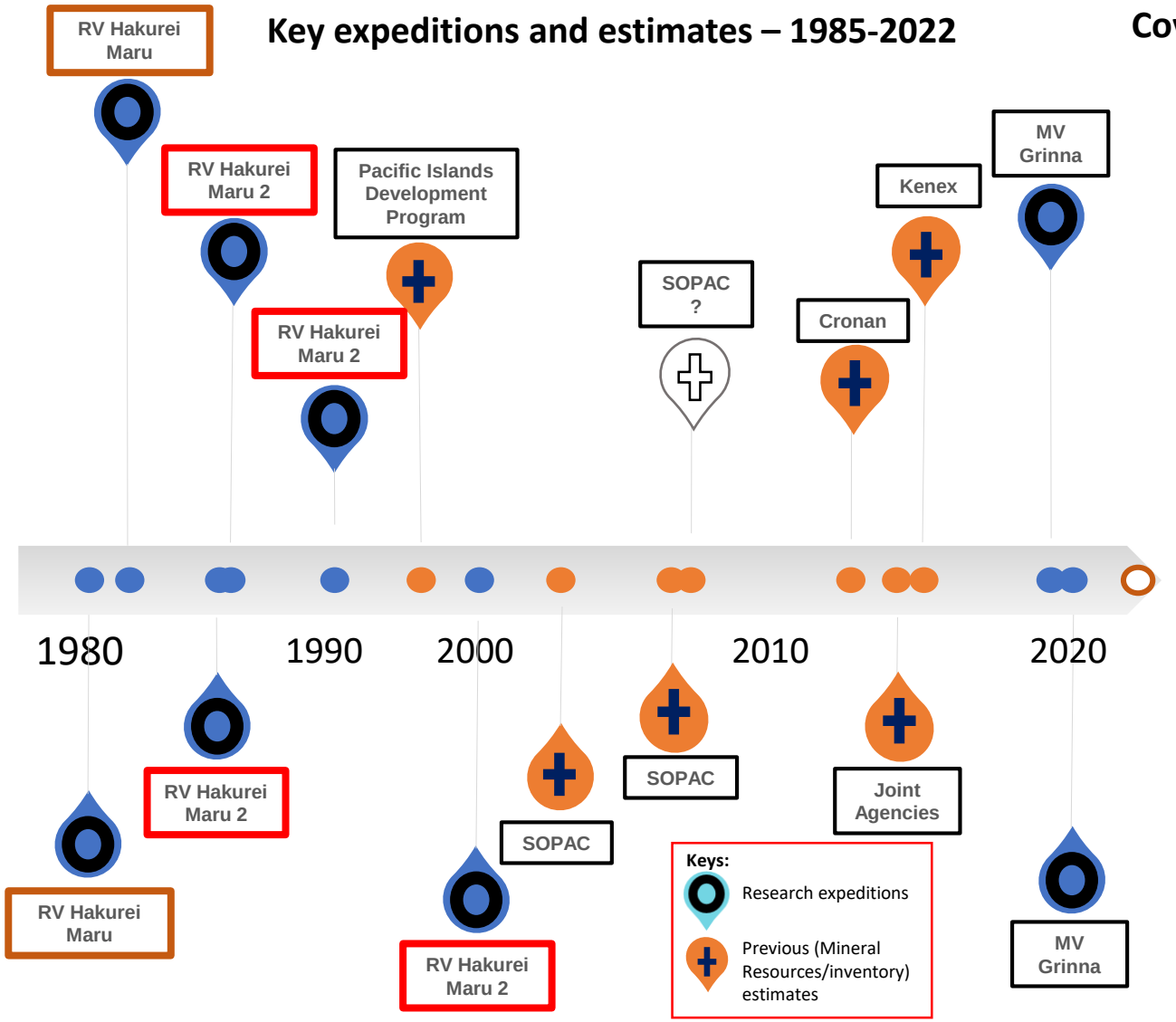
The classic form

Other forms

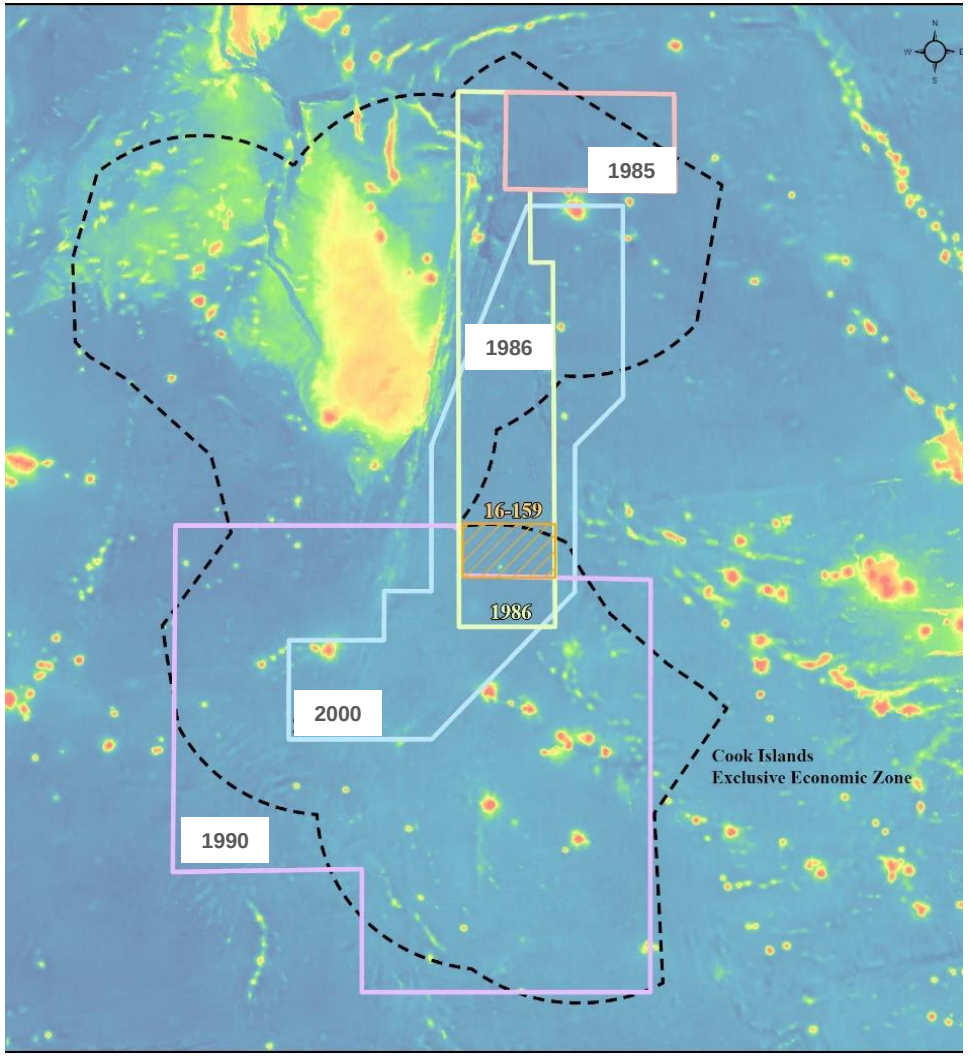
Source: JICA/MMAJ 1986

Historical data sources and mineral inventory estimates

Key expeditions and estimates – 1985-2022

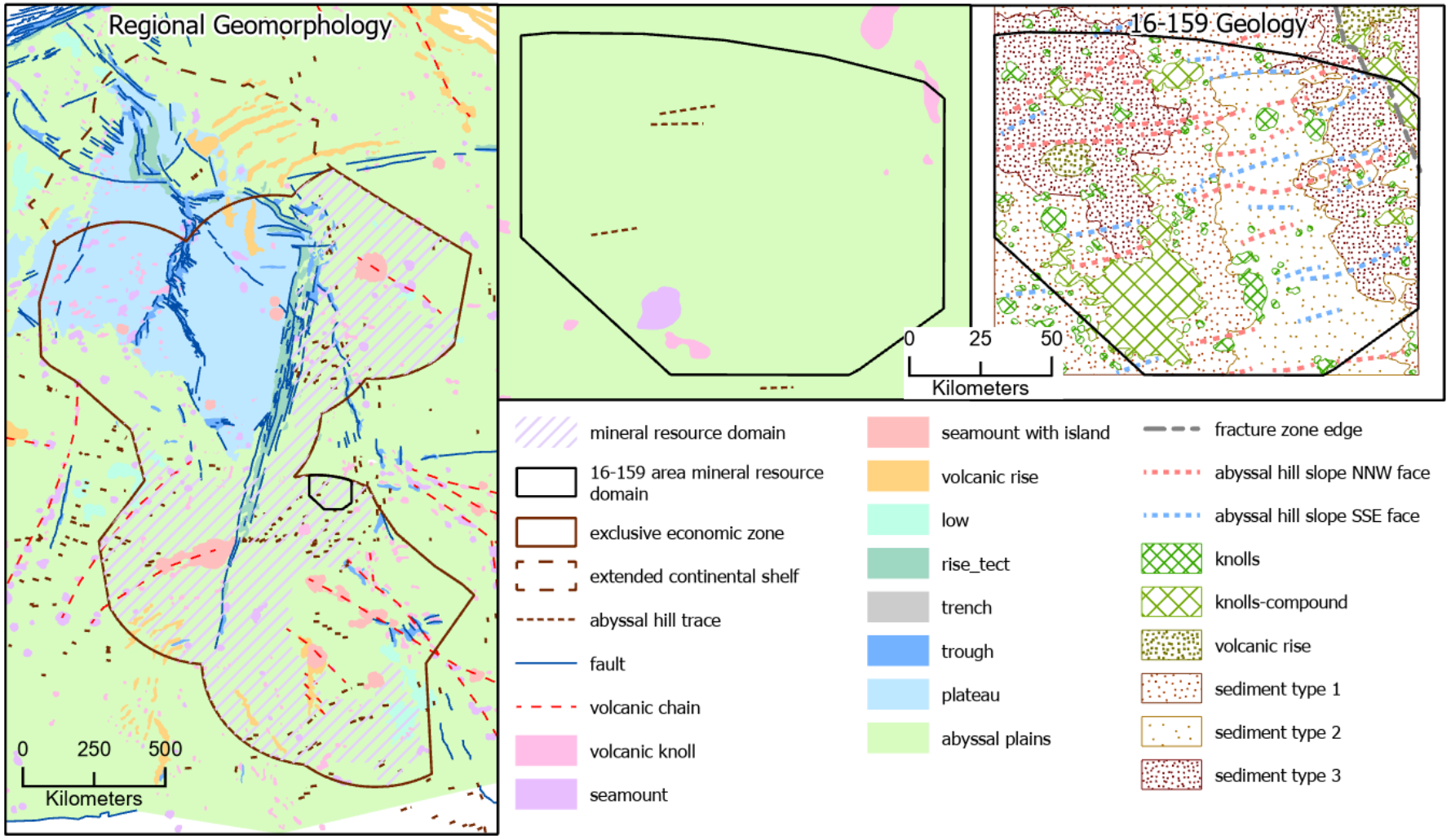


Coverage by JICA/MMAJ as part of SOPAC Studies – 1985-2000



From regional geomorphology to local geology

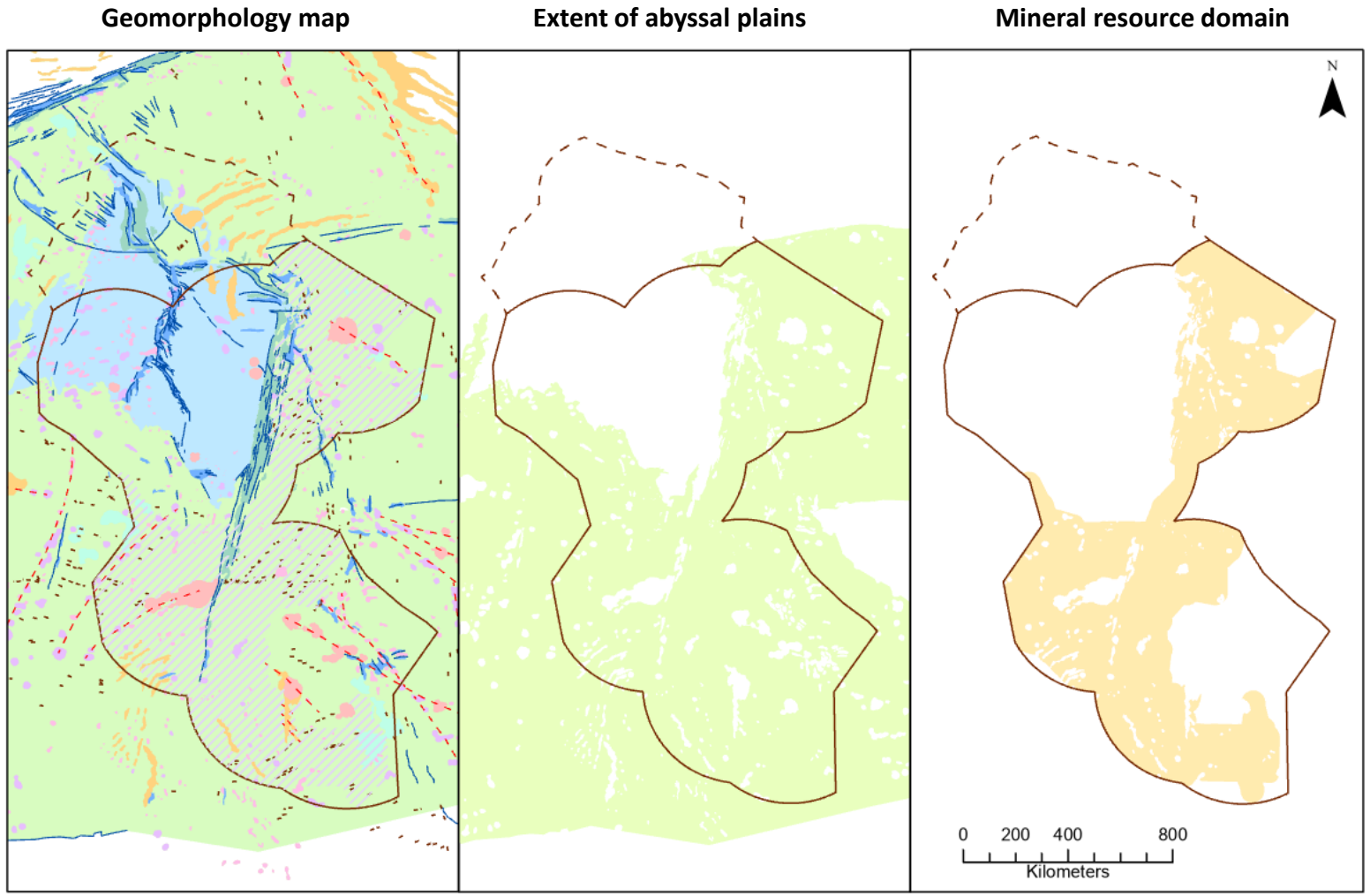
- The regional geomorphology map is mostly based on the GEBCO 2021 grid and is drawn at 1:3,000,000 scale
- The local geology map is a mostly based on a small block of 15 kHz MBES data collected by JICA/MMAJ in 2000, and is drawn at 1:500,000 scale



Geological domains for inferred

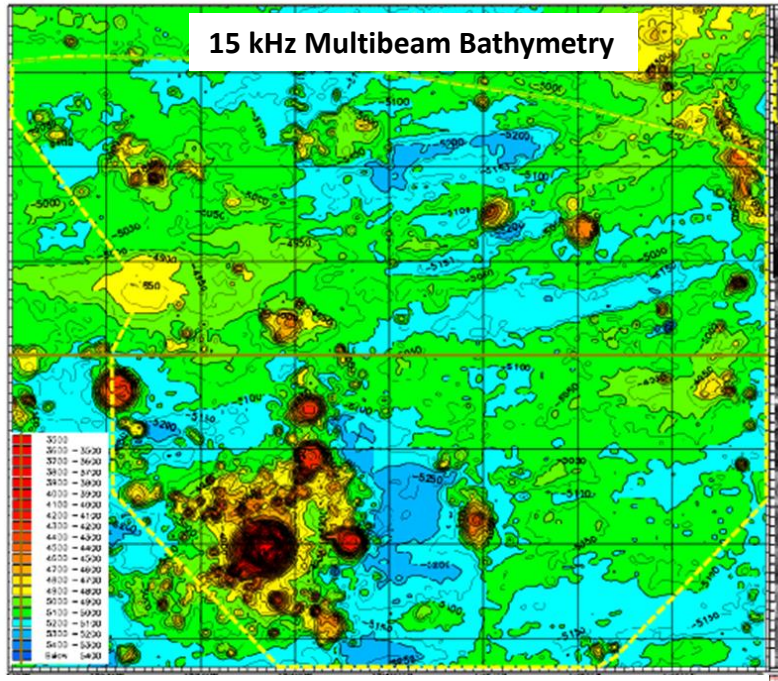
The nodule estimate was limited to:

- the mapped extent of abyssal plains
- The Cook Islands EEZ

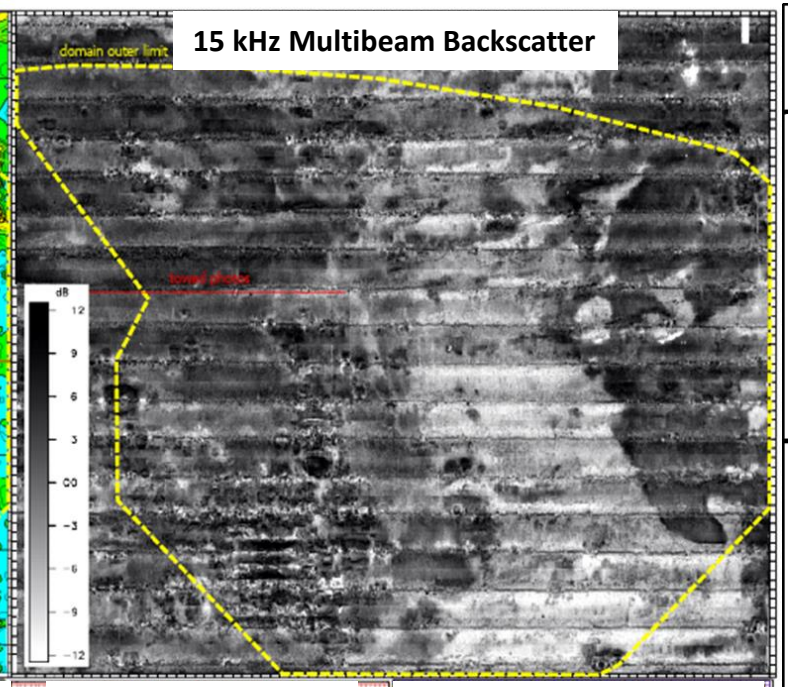


Geological support for indicated

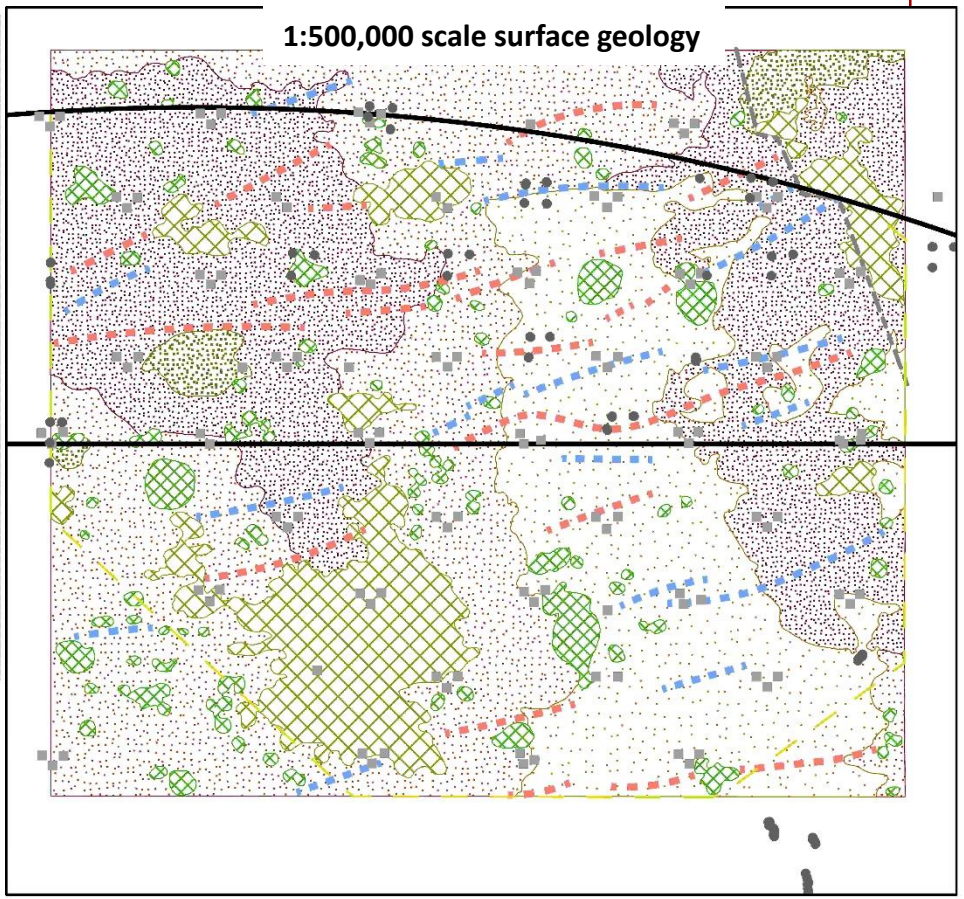
15 kHz Multibeam Bathymetry



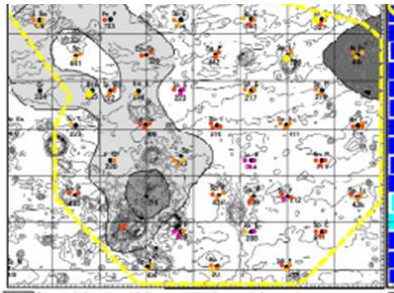
15 kHz Multibeam Backscatter



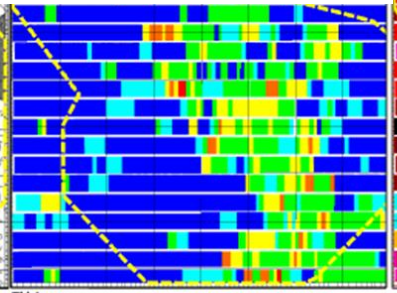
1:500,000 scale surface geology



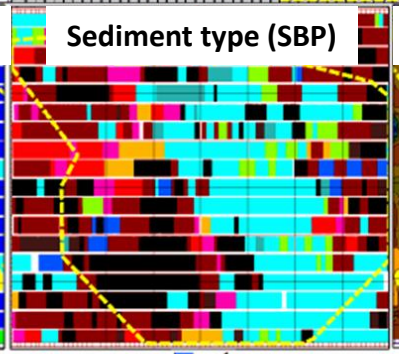
Nodule types/abundance



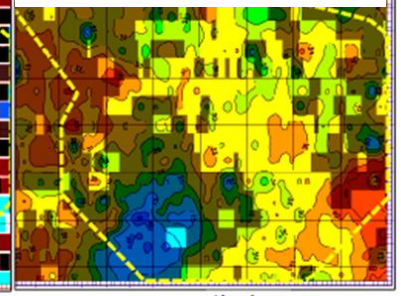
Thickness transparent layer



Sediment type (SBP)



MFES nodule abundance



knolls	singular volcanic knolls or groups of singular knolls
knolls-compound	edifices comprised of superposed volcanic knolls
volcanic rise	higher abyssal hills (~200 m) without clear knolls
sediment type 1	brown clays of medium backscatter reflectance
sediment type 2	brown clays with low backscatter reflectance and ~10 m + acoustically transparent upper layer
sediment type 3	brown clayes with high backscatter reflectance, likely impermeable brown clays and possible FeMn crusts
fracture zone edge	western limit of Rakahanga Rifts
abyssal hill slope	
abyssal hill slope	
domain outline	
OML/CSR samples	
JICA/other samples	
Exploration Licence	

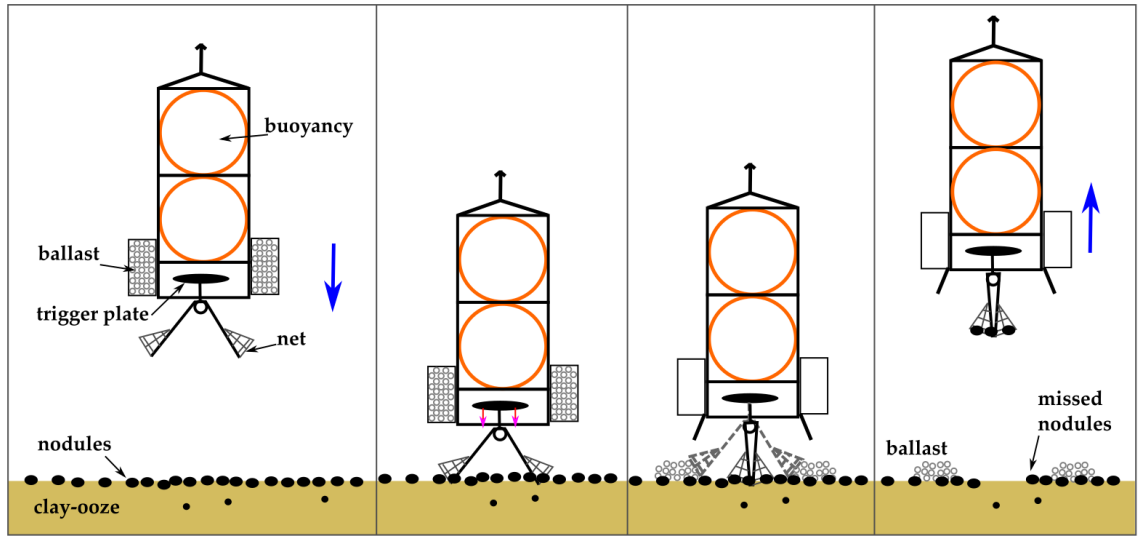
N

0 20 40 80

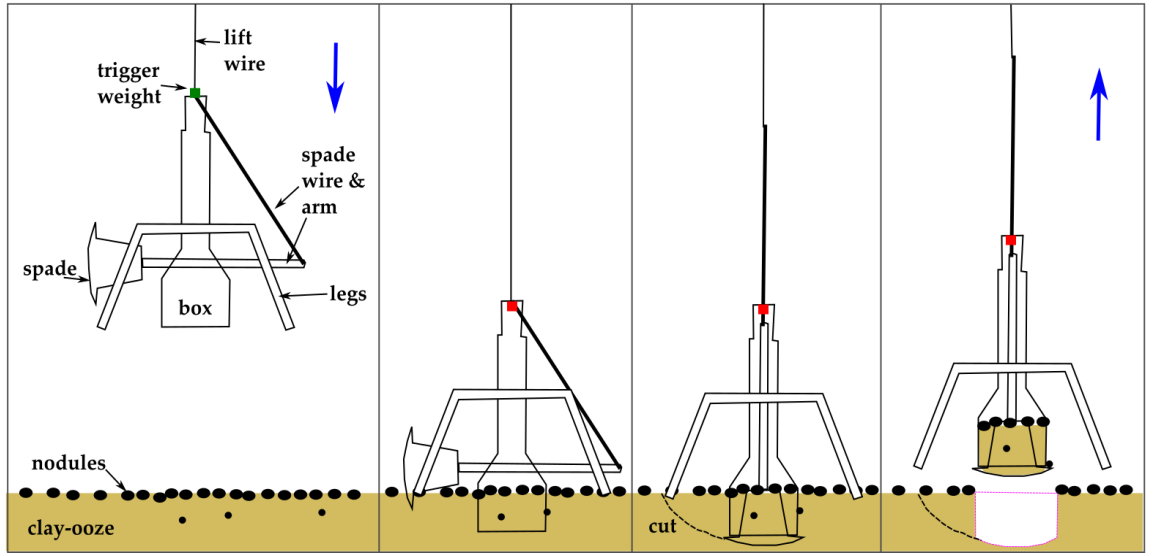
Kilometers

Methods - sampling

Free-fall grabs were used extensively by JICA/MMAJ and also by MSRs in 2019



Spade cores (Box-cores) were sometimes used by JICA/MMAJ



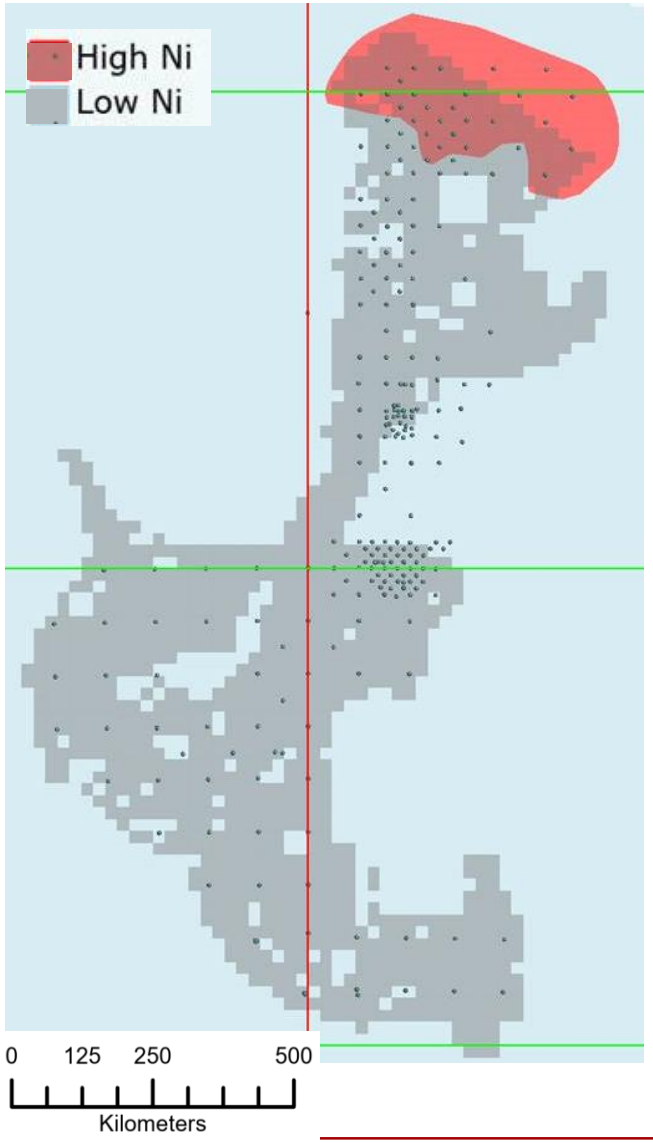
Measurement of nodules from photos supported JICA/MMAJ abundance estimates

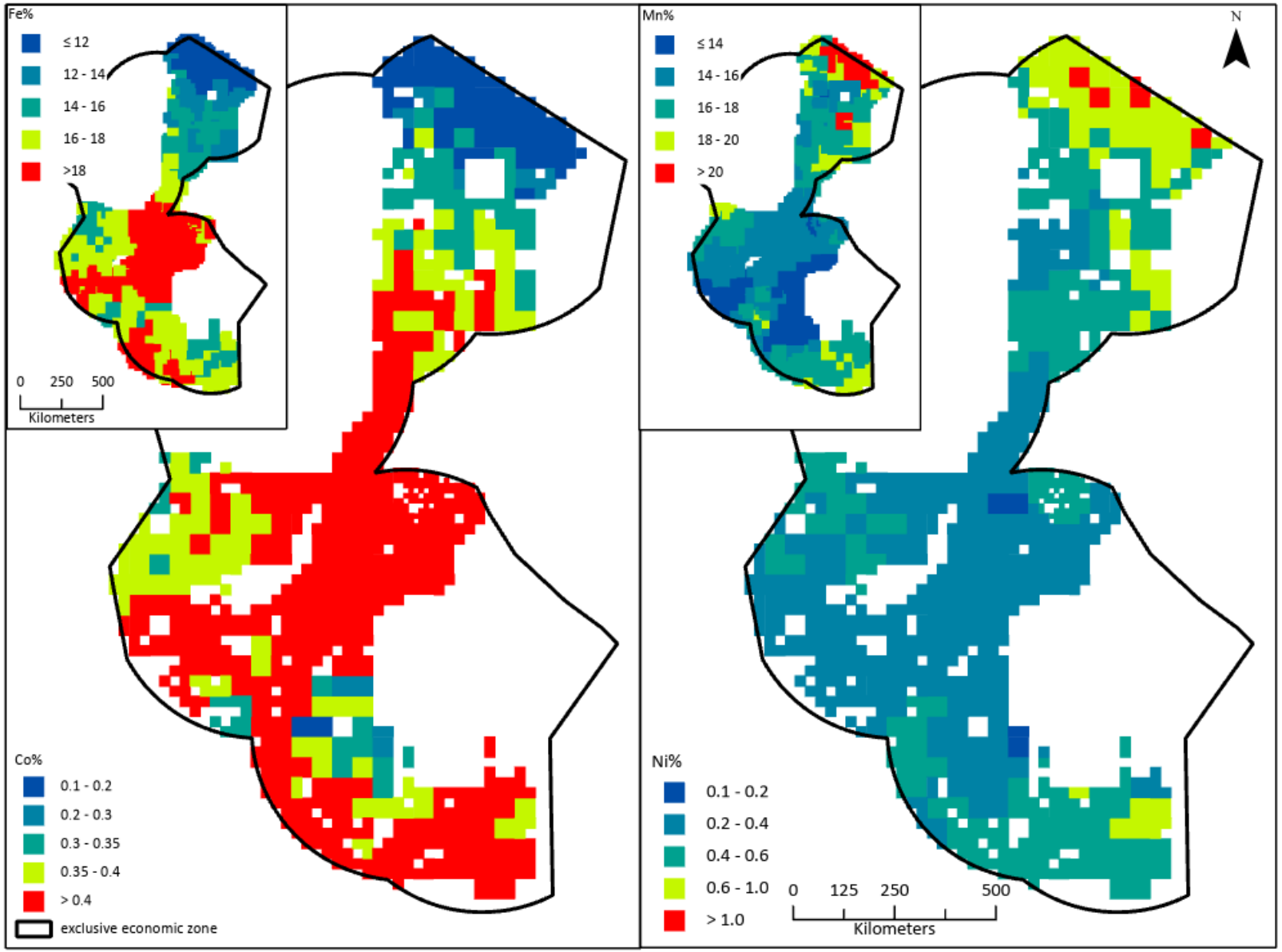
$$\text{Distribution abundance (kg/m}^2\text{)} = (1.9505 \times r^{2.1875} \times N) / 1000 \times (0.157 \times r + 0.3992)$$

where r = average size (cm), N = numbers of manganese nodule (number/m^2)

Grade estimation

Working with consultants





Data quality map

Sample Type:

acknowledges sampling support

1 = box-cores

5 = free-fall grabs

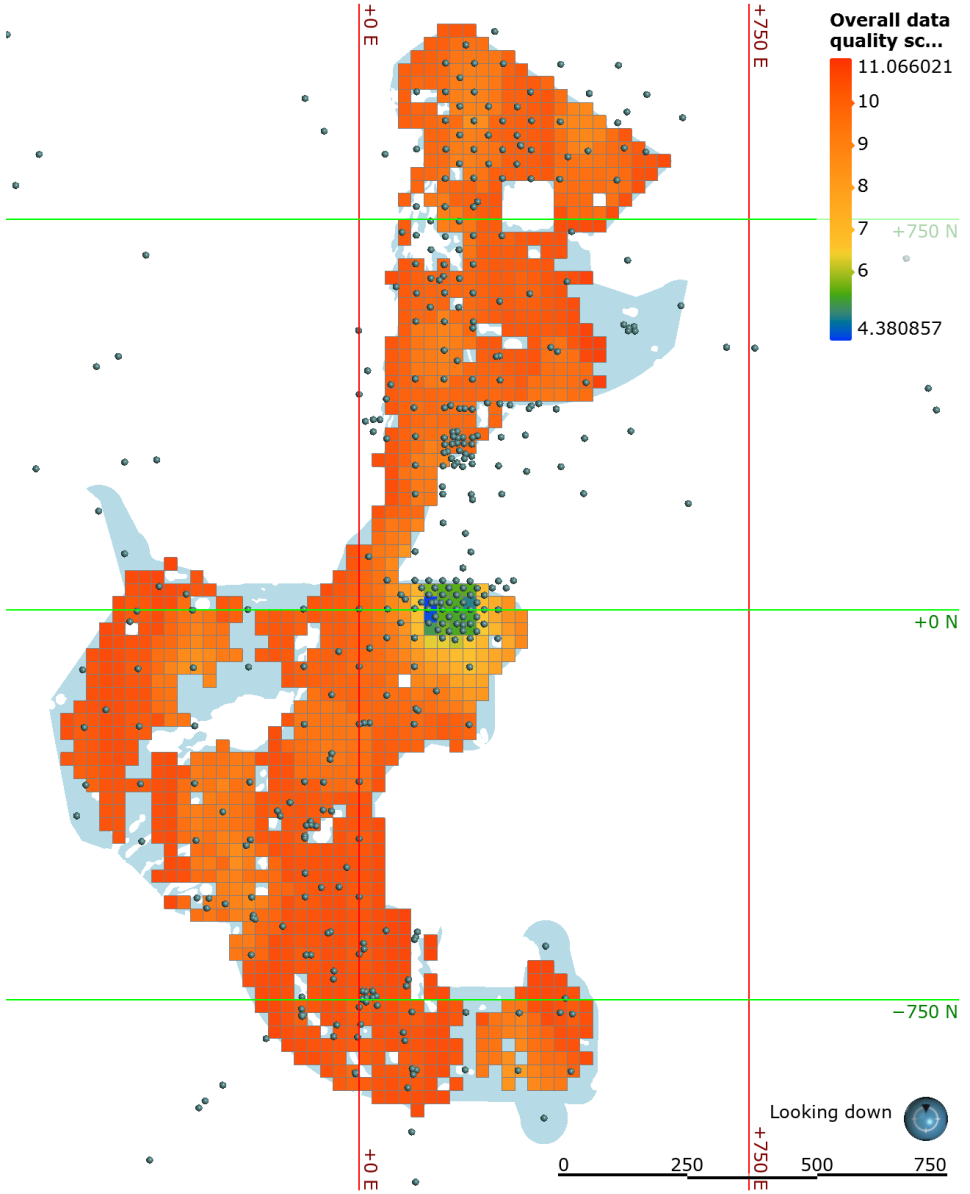
Geological Risk:

geological interpretation for the area reviewed.

1= Good geological data (e.g. MBES bathymetry, paired with additional support info)

2= Good geological data but less certainty (e.g. lies on boundary between different geomorphological units)

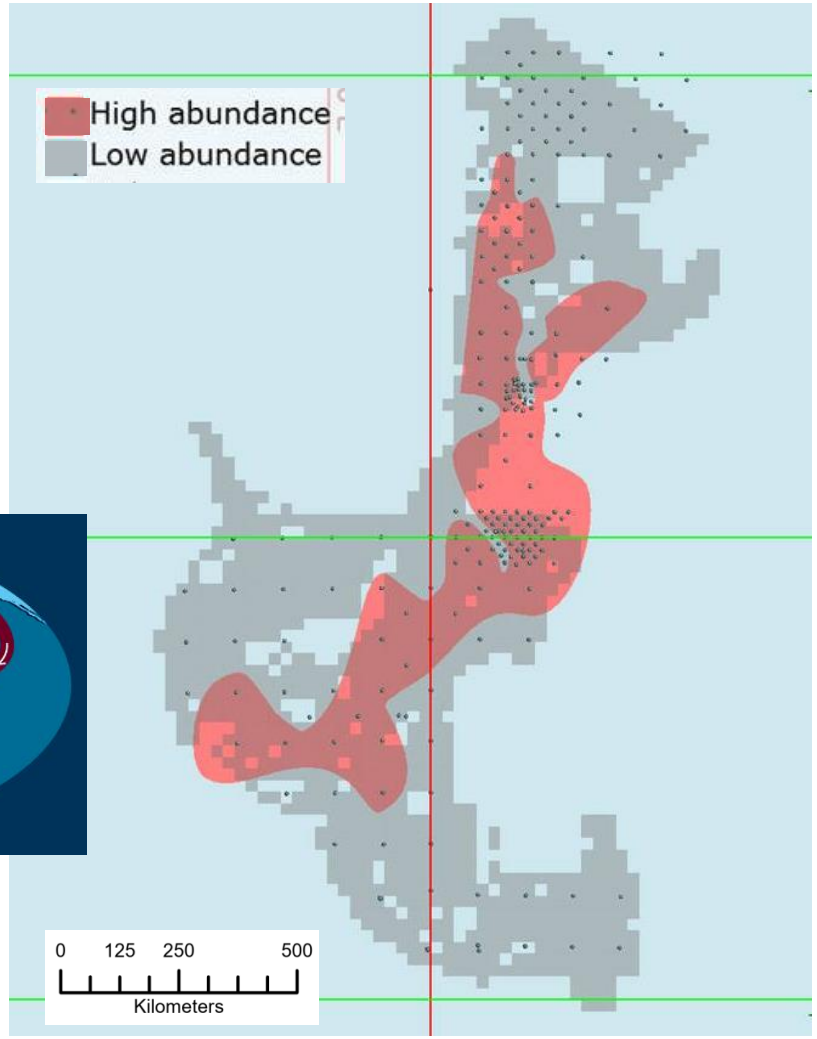
4 = GEBCO bathymetry defined abyssal plains

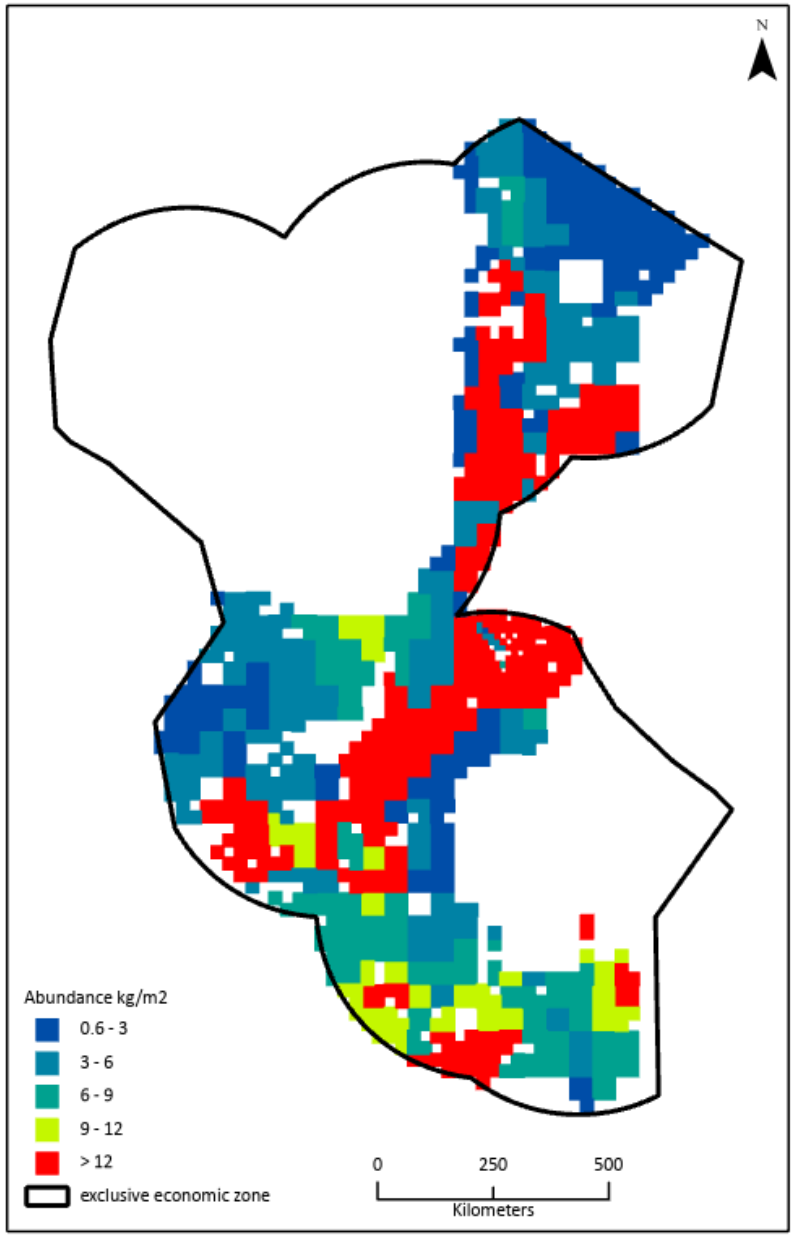


Abundance estimation

- The high abundance trend is consistent with models of movement of a deep water mass (Antarctic bottom water) from south to north

https://www.whoi.edu/know-your-ocean/





Four chemical classes of nodules

Situation 1, high cobalt (Co) nodules (hc):

up to double the Co of other known occurrences. Very low sedimentation and highly oxygenated bottom water promotes a high proportion of slow hydrogenetic growth.

Variant 1, low Co, low nickel nodules (lcln):

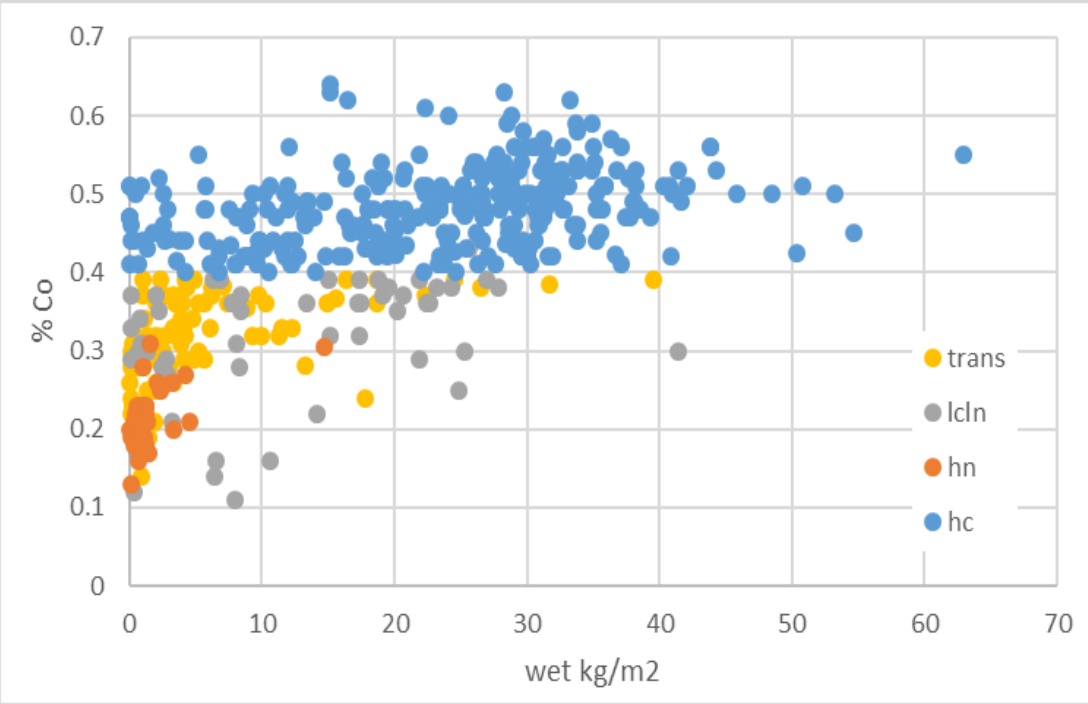
near identical chemistry to the high Co nodules (apart from Co itself). Maybe due to less effective function of the bottom water (above).

Situation 2, high nickel nodules (hn):

in the northern part of EEZ at similar transitional levels of primary productivity to the CCZ.

Variant 2, Transitional moderate cobalt moderate nickel nodules (trans):

may have formed under mixed environments for the high cobalt and high nickel situations above.



Nodule abundance versus cobalt by grade type

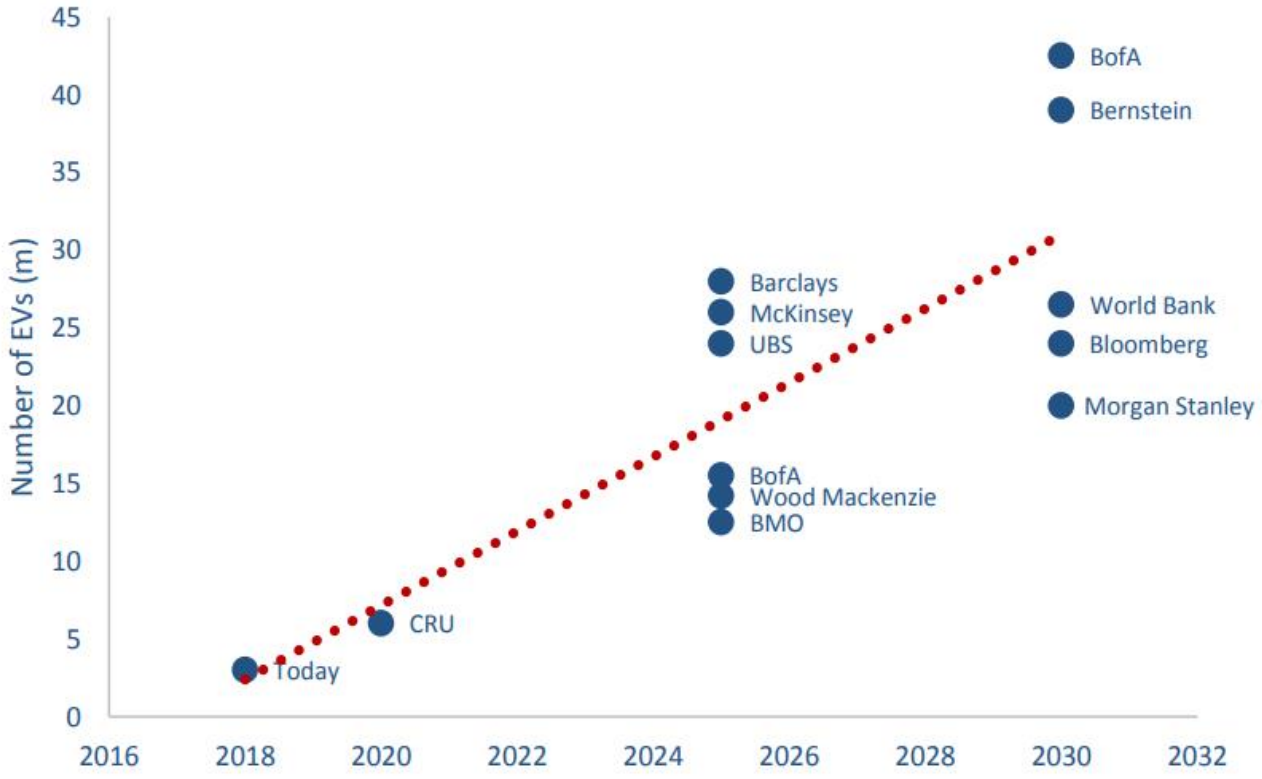
Note that:

1. There is spatial and other grade distinctions between the classes
2. Samples are not de-clustered.

Reasonable prospects of eventual economic extraction

This is a key requirement for a CRIRSCO code. For the Cook Islands nodule deposit it is assessed on the basis of:

- Minerals harvesting (Mining) assumptions;
- Metallurgical and metals market assumptions; and
- Environment and Social Governance assumptions.



Source: (Horizonte Minerals, 2019) from public announcements and media

Meitaki Maata

Contact Us

sbma@cookislands.gov.ck

www.facebook.com/CookIslandsSBMA

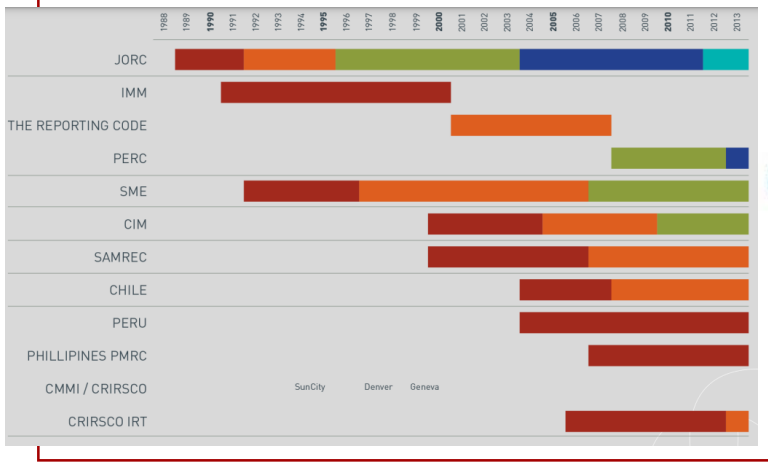
Seabed Minerals Authority
Runanga Takere Moana
COOK ISLANDS

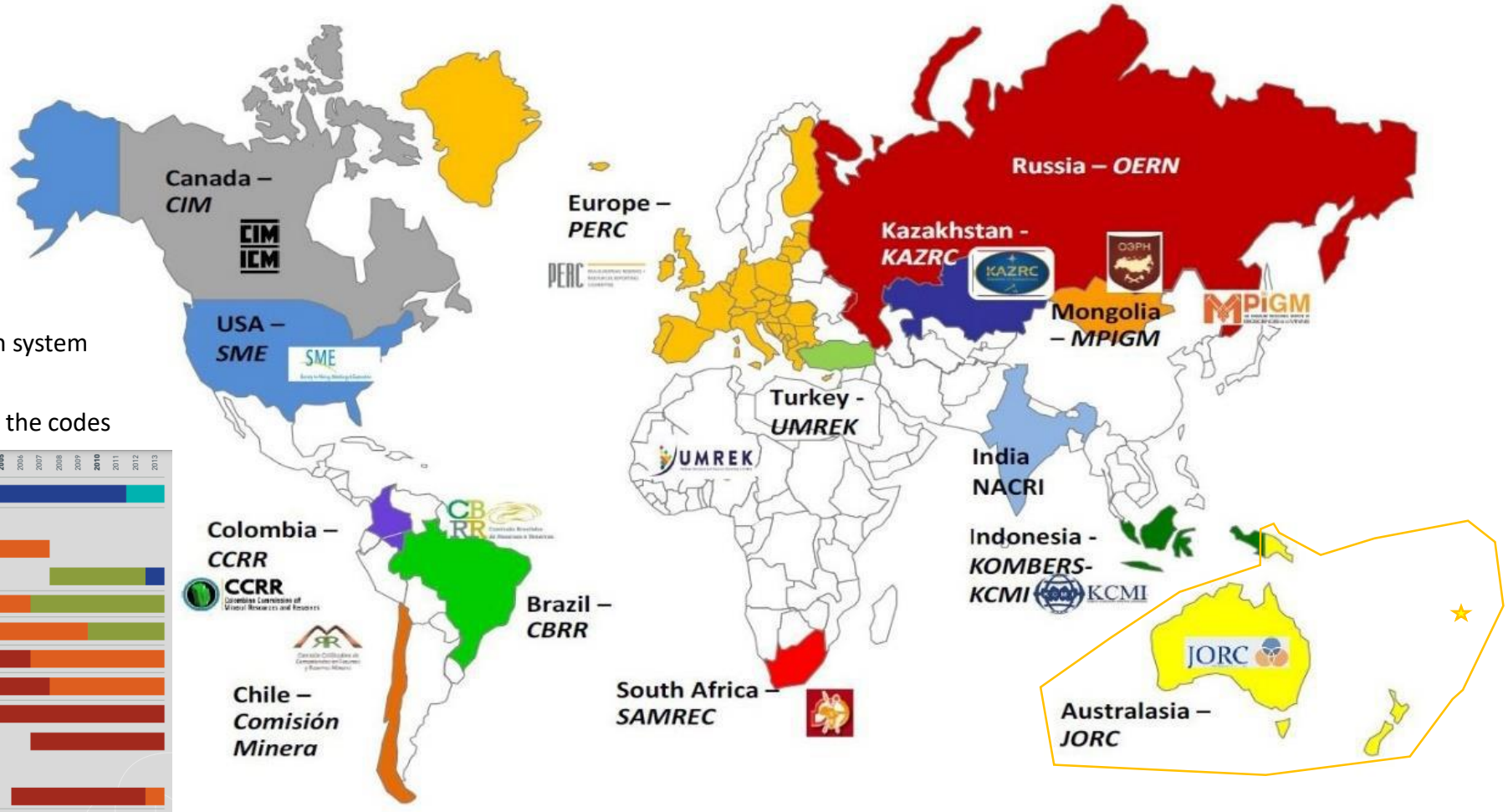
Committee for Mineral Reserves International Reporting Standards (CRIRSCO)

- Reporting requirements for effective protection of investors on local stock exchanges[1]

1909: Herbert Hoover's classification system

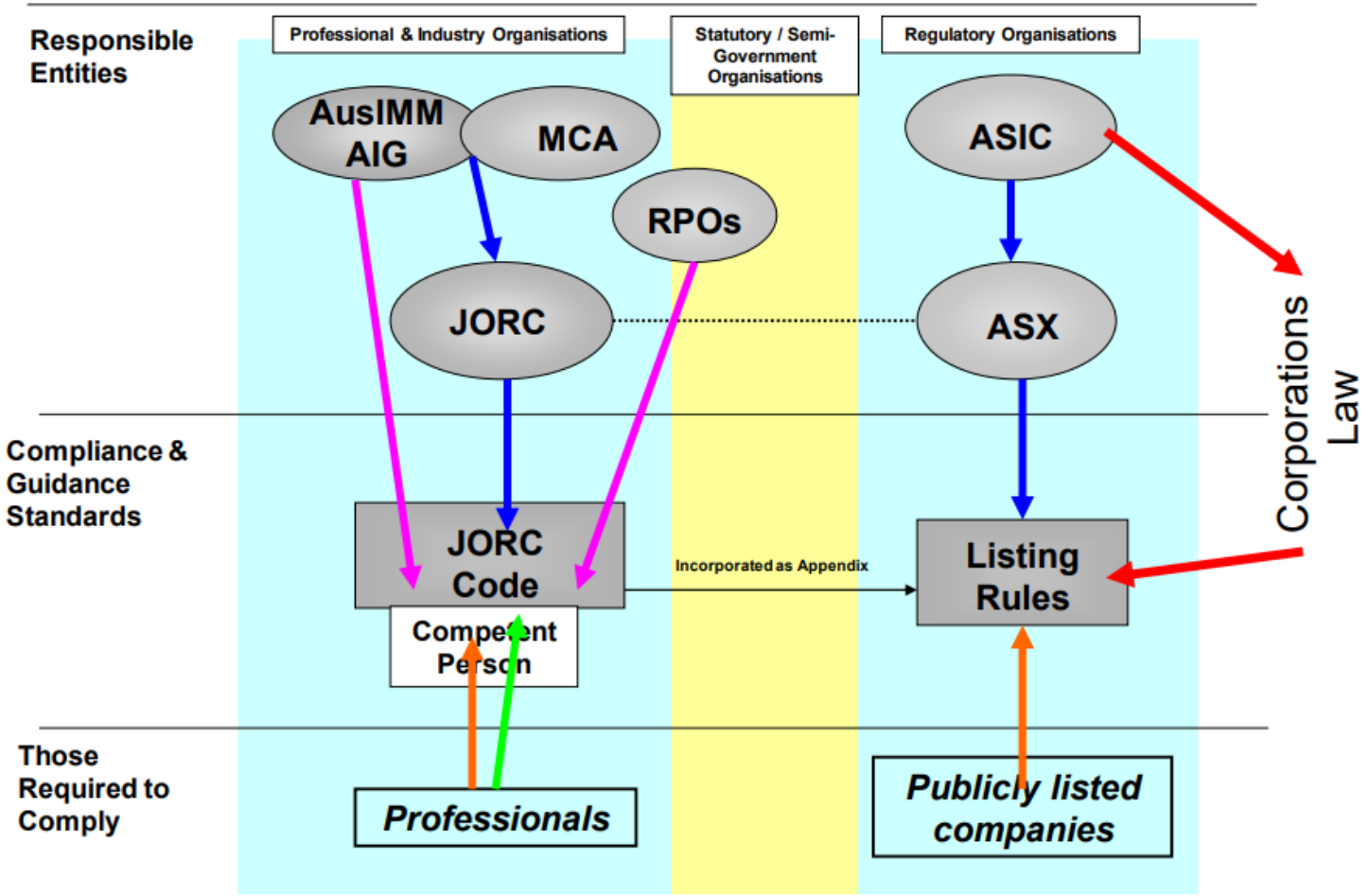
1988: The JORC code is the origin of the codes





[1] a stock exchange is a place where people can buy shares in (listed) companies.

How JORC (and most other codes) works



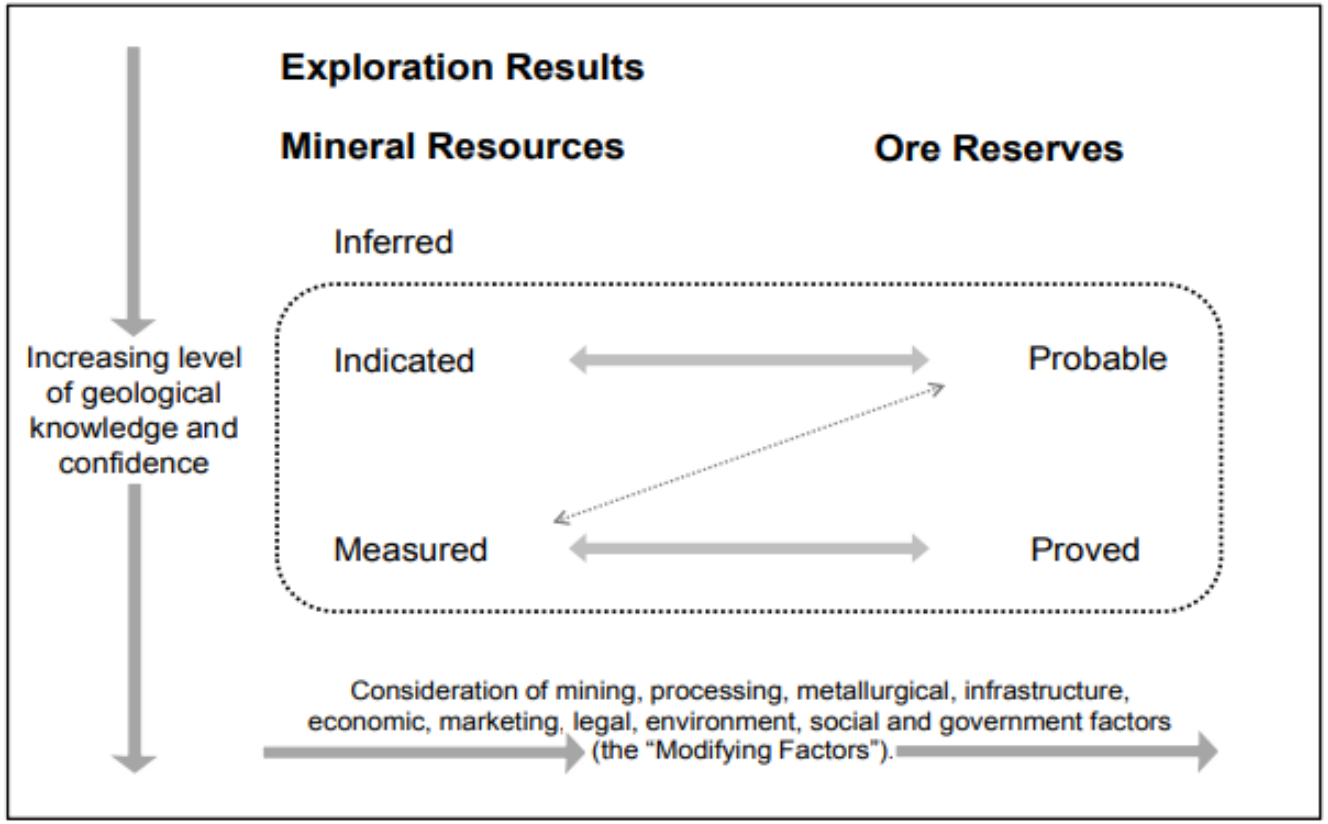
Note that the JORC Code is also required by the Listing Rules of the New Zealand Exchange

after P Stephenson AMC

https://www.csaglobal.com/wp-content/uploads/2019/11/Cambourne-School-of-Mines_JORC-and-International-Mining-Codes_Gerry-Fahey_July_2018.pdf

Key framework

- All the CRIRSCO codes follow the structure here or something very similar.
- Resources are scientific estimates of what is ‘in the ground’. These should only increase as new areas are available…
- Reserves are ‘what can be mined profitably’. Ie after consideration of modifying factors. These can change quickly as some modifying factors are dynamic (eg metals prices)
- Mineral Inventory are ranged estimates from exploration results
- Environmental restrictions are one of the array of Modifying Factors



What is Mineral Inventory versus Mineral Resources

- “Mineral Inventory” can be applied to estimates that precede “Mineral Resource” estimates as supported by a practices required by a CRISCO code
- Under current practice Mineral Inventory should include probabilistic evaluation of Exploration Results
- Historical estimates that would not meet contemporary requirements of a CRIRSCO code are probably best termed Mineral Inventory rather than Mineral Resource even if deterministic in nature.
- “Mining Inventory” is a probabilistic estimate of the Minable material that is also of lower confidence than probable or proven reserves. It can be derived from Mineral inventory or inferred resources or even higher confidence estimates.