

# Hydrogenetic Fe-Mn crusts from European seas: source of potentially economic cobalt mining

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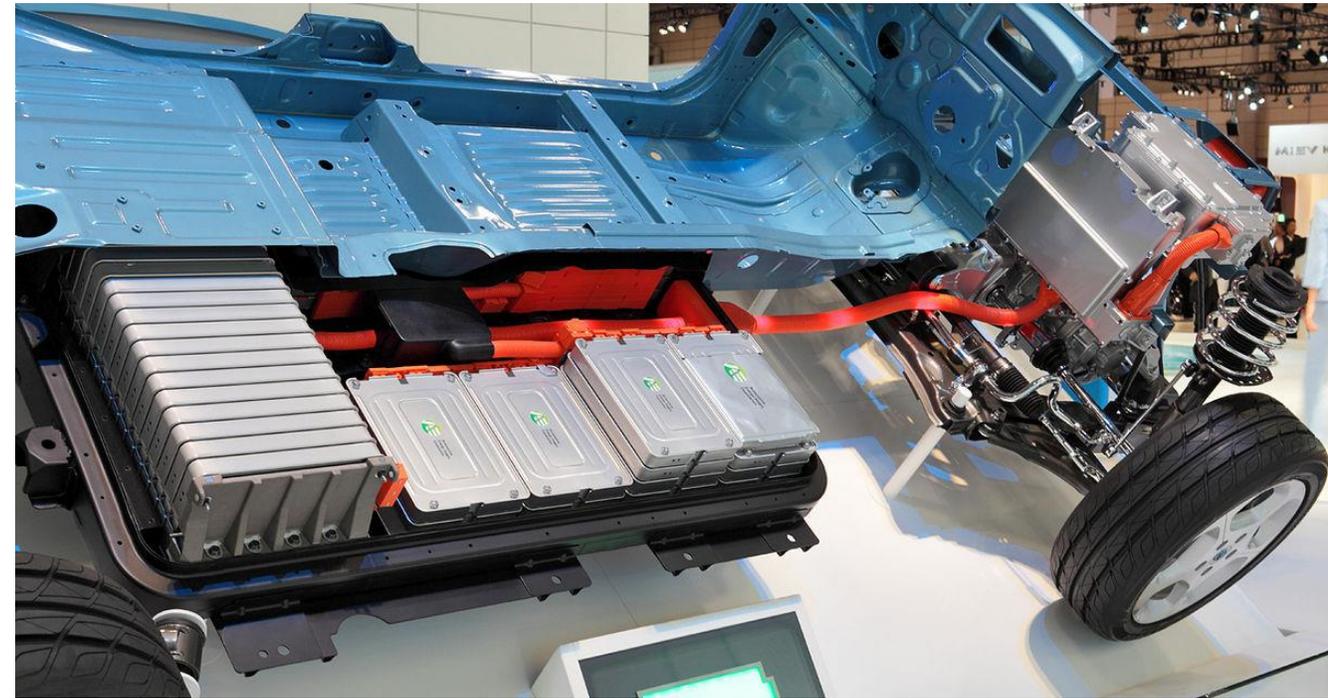
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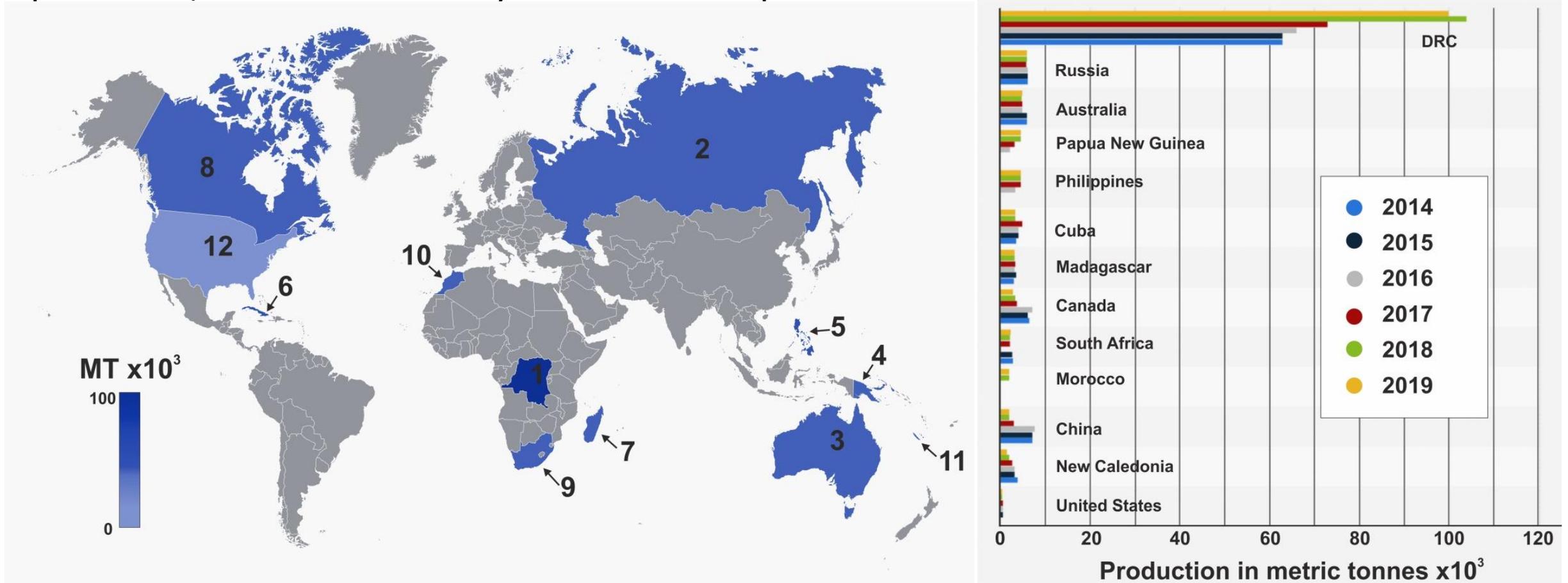




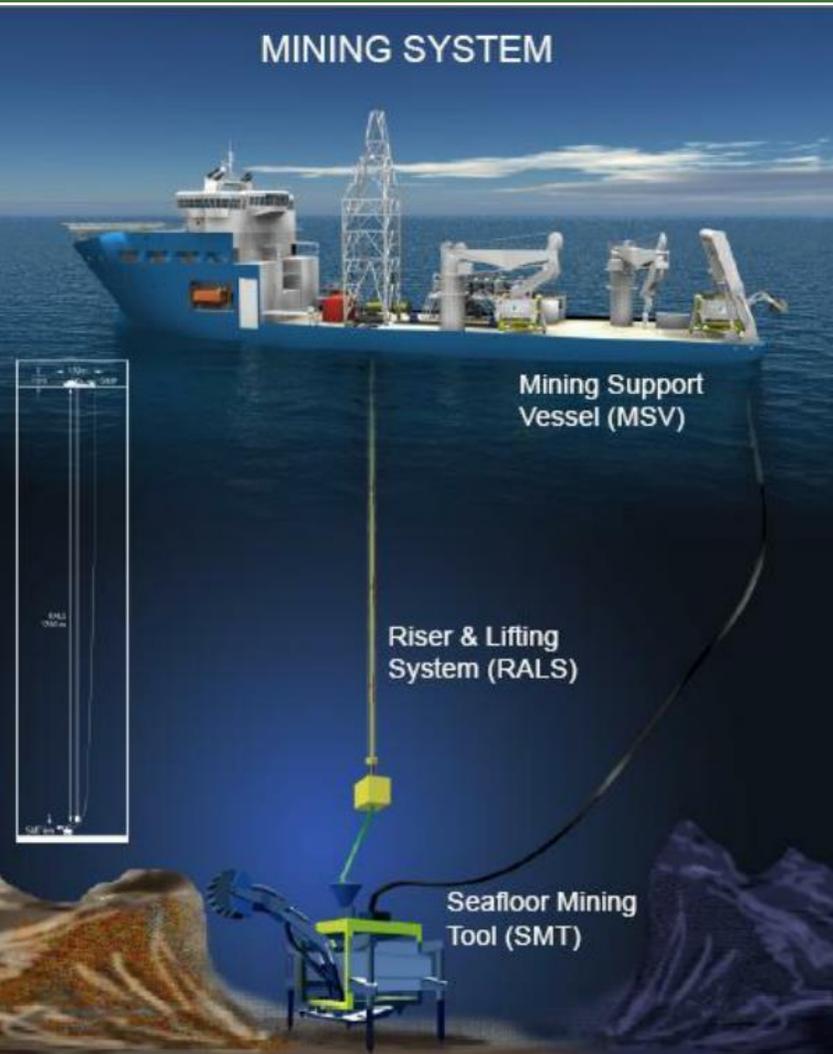
Use of Li-Co batteries is increasing in smartphones, tablets but also and for their use in electric vehicles (EVs).



Land based mining of Co (as by-product of Ni and Cu) is headed by DRC with the 60% of the production, that in the las two years doubled its production.

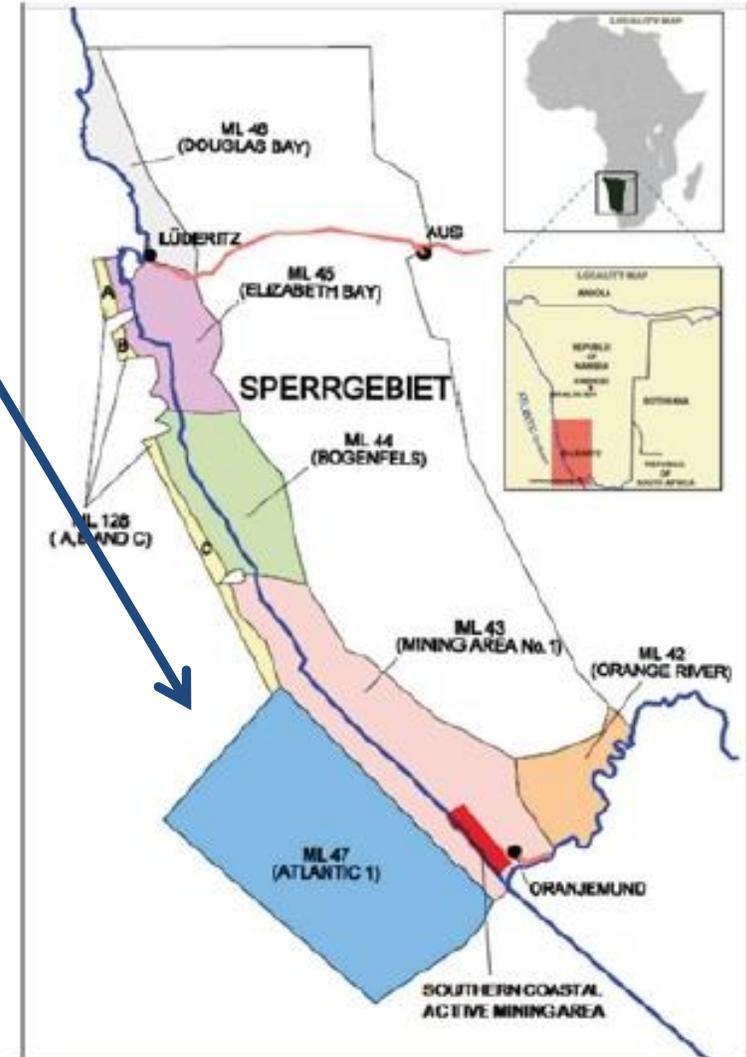


The rest of the producers barely pass the 5000 MT of annual production.



Marine mining is already a reality:

-several placers, as in Namibia, have been mined for gold, diamond and other minerals



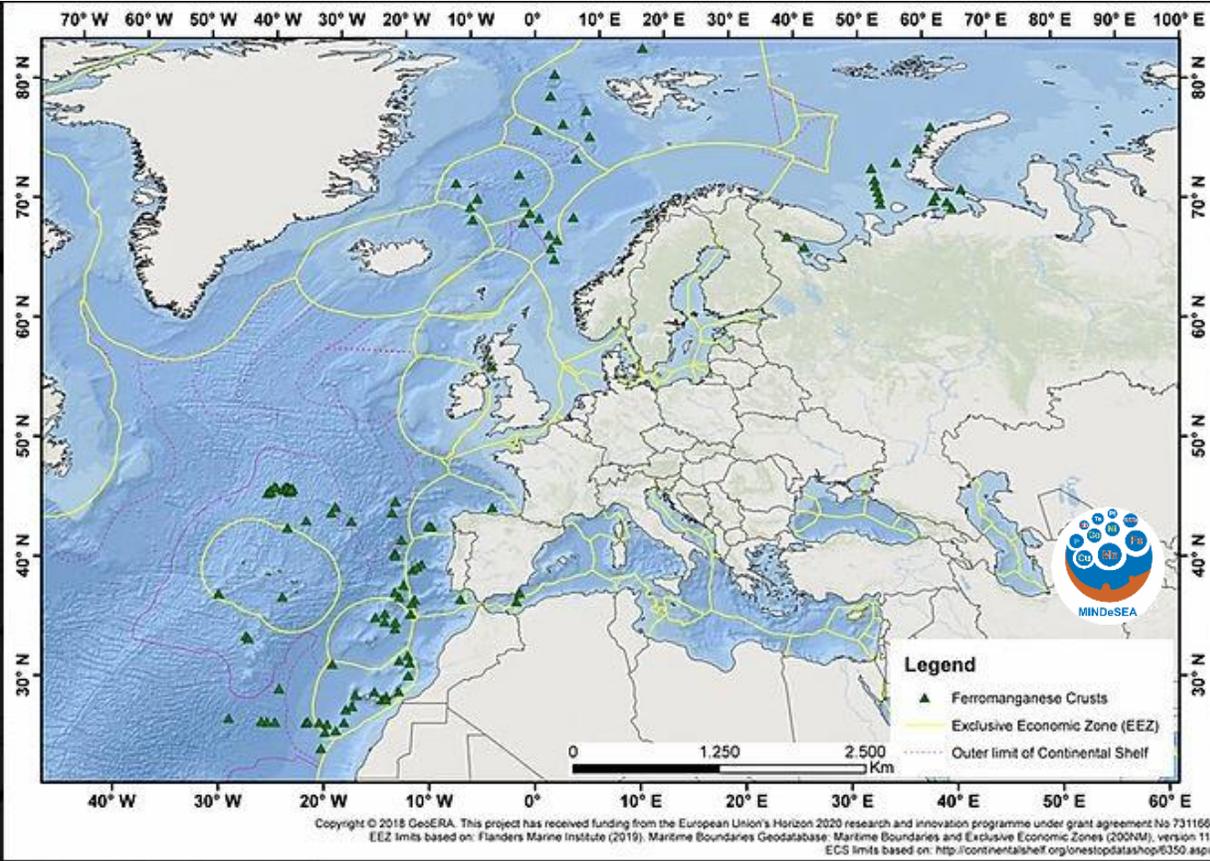
-Deep sea mining have been started by Nautilus Minerals mining massive sulphides in Papua New Guinea



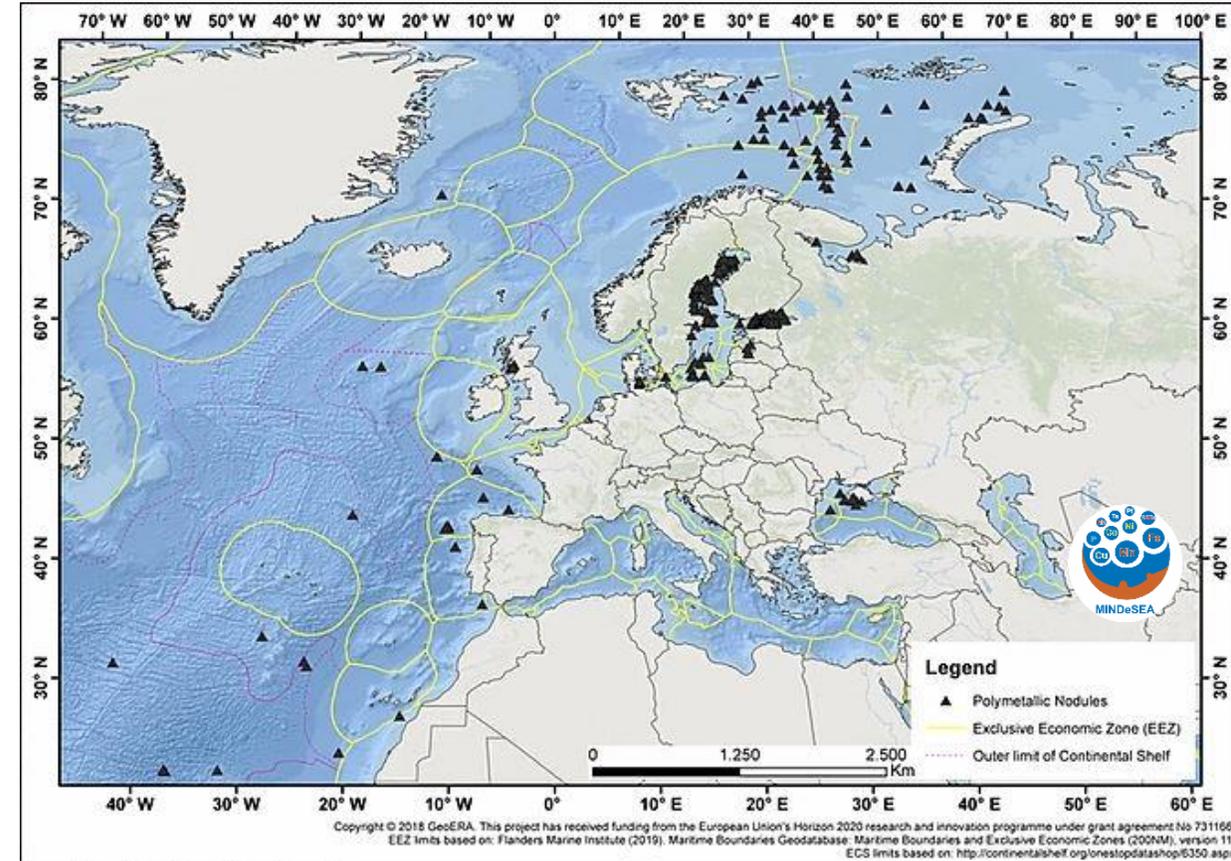
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**MINDeSEA** resumed objectives are to characterize marine deposits, obtain their **CRM** contents and develop harmonized mineral maps for the pan-European seas.



← **Fe-Mn crusts deposits**



**Polymetallic nodules deposits** →

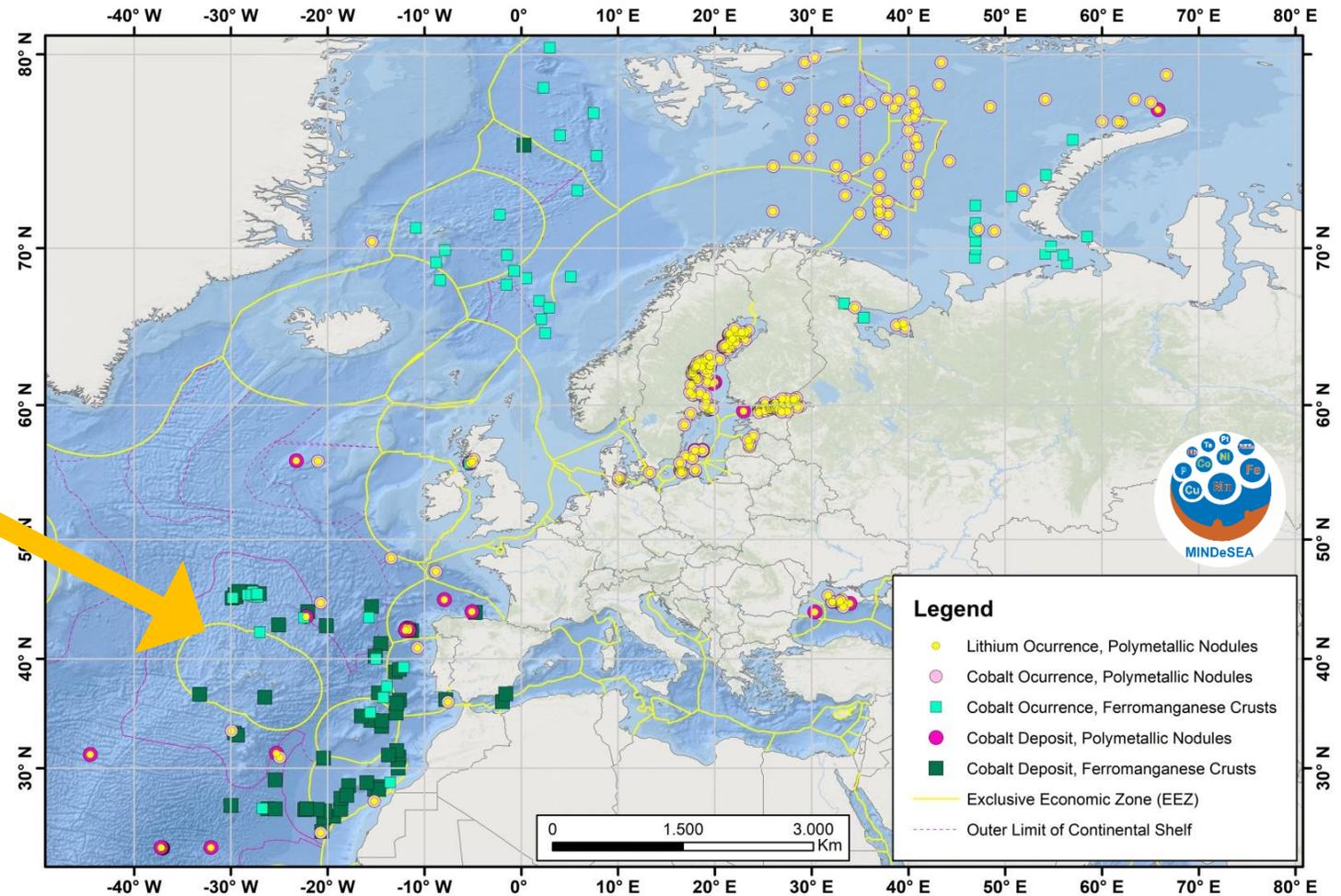
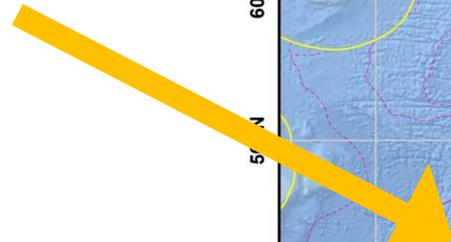


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The analysis of Fe-Mn deposits result in the develop of the lithium-cobalt map in which are differentiated **occurrence** and **deposits** for cobalt and Li

In the Macaronesia there is the higher concentration of deposits found in pan-European seas

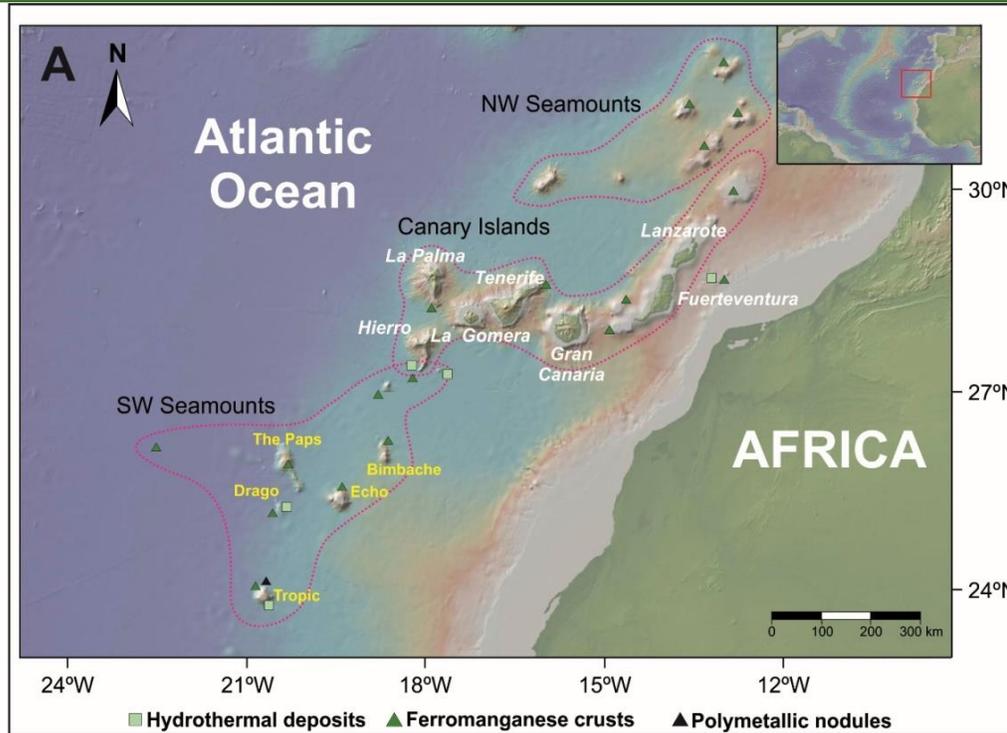


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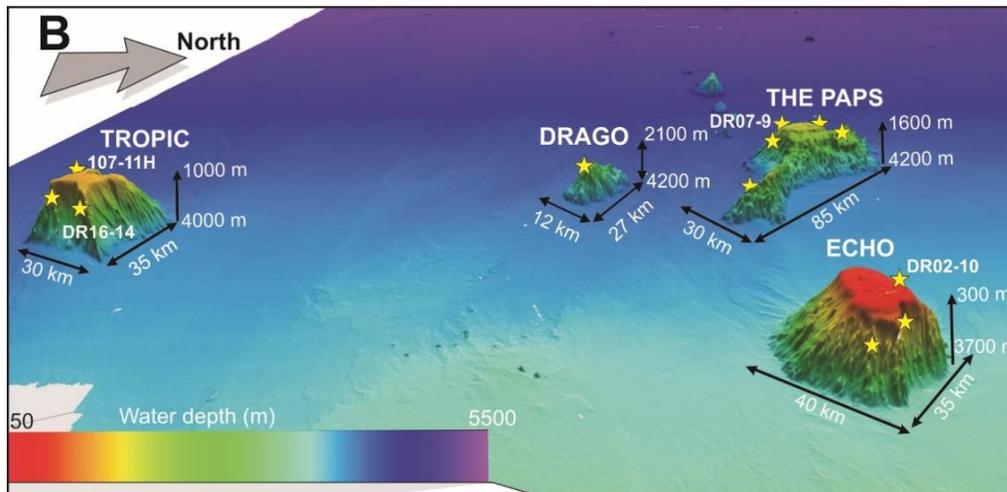


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In **Canary Islands Seamount Province (CISP)** have been found hundreds of seamounts and much of them are covered by thick Fe-Mn crusts.

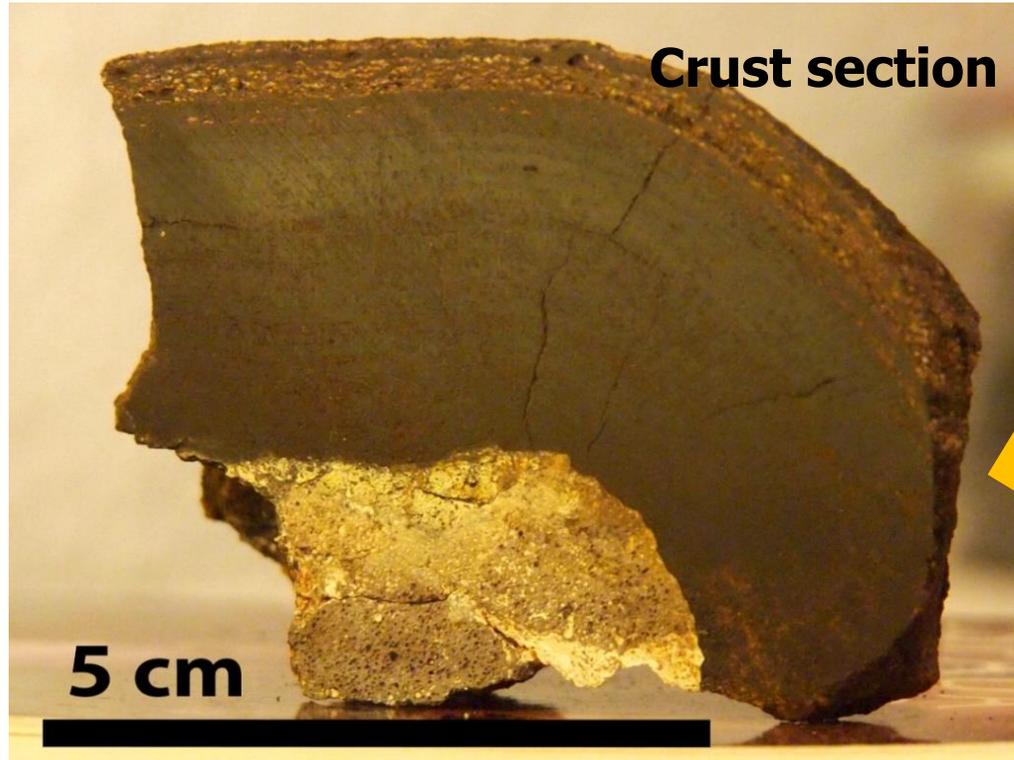


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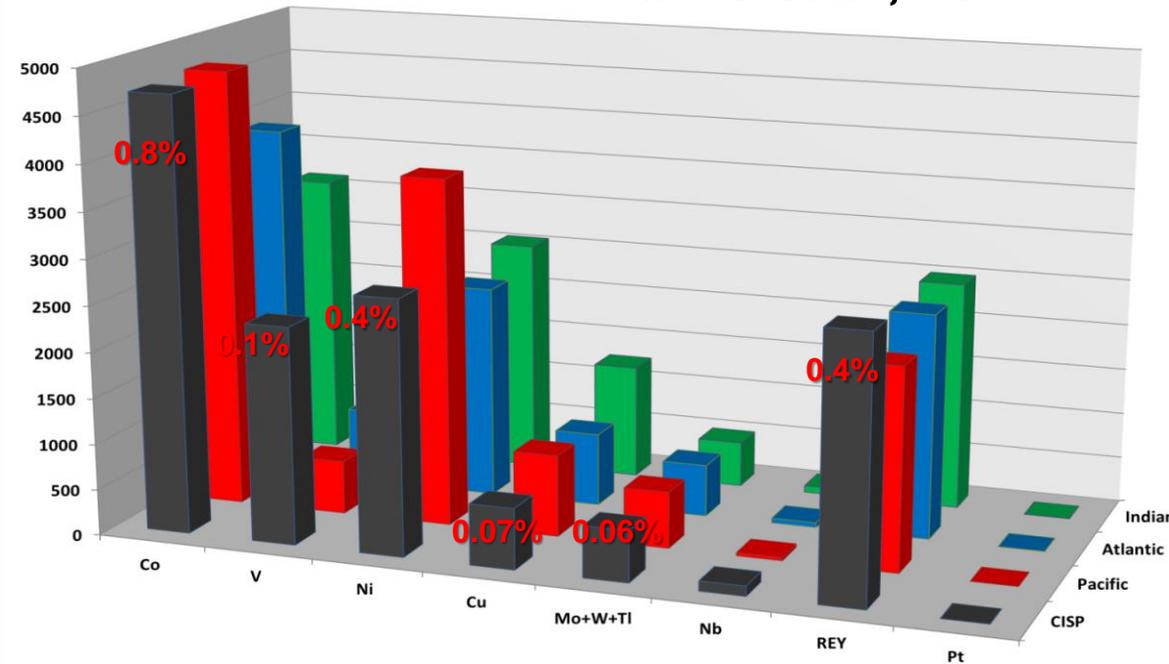


These crusts have been studied as part of a PhD project resulting in high average content of several **SCRM** as **Mn, Ni, Cu, V, Mo, REY** and especially **cobalt**, with average contents of **0.6 wt. %**.

**Fe-Mn crusts recovered during the DRAGO0511 cruise**



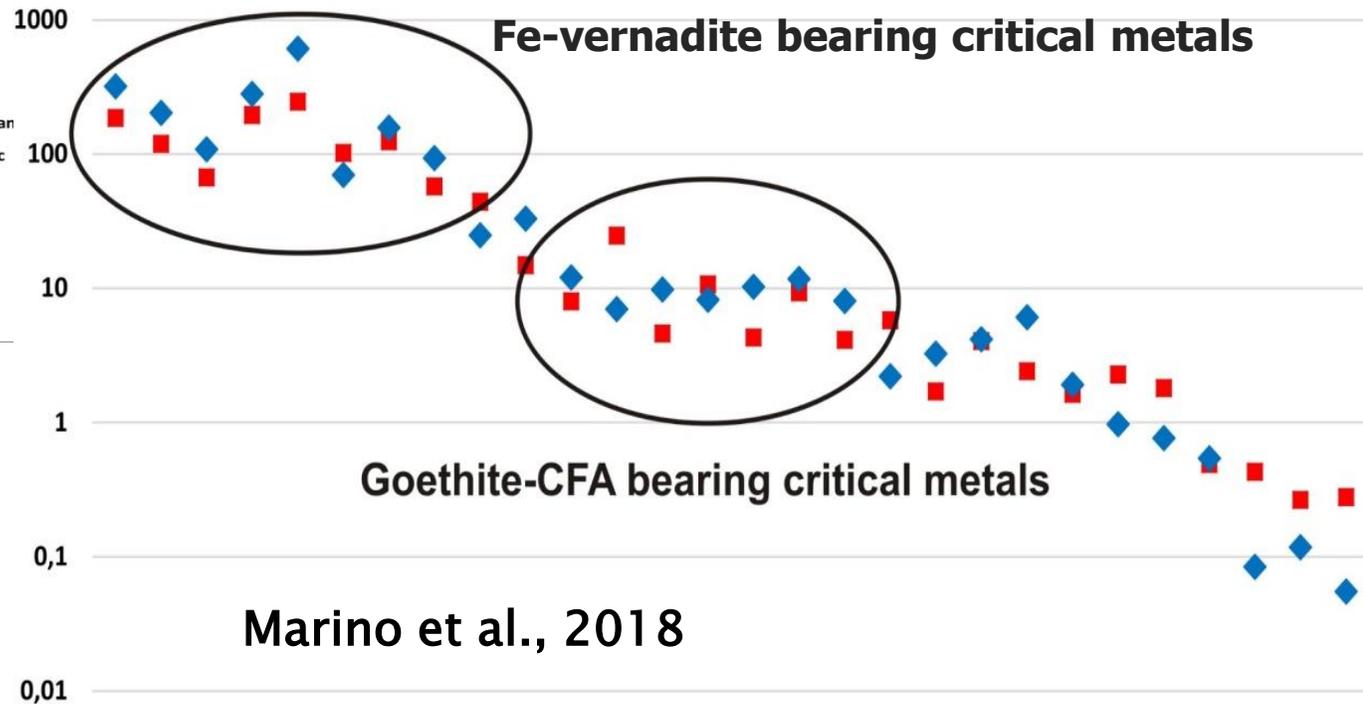
Marino et al., 2017



Elemental contents compared with Continental Crust



Average contents compared with similar deposits



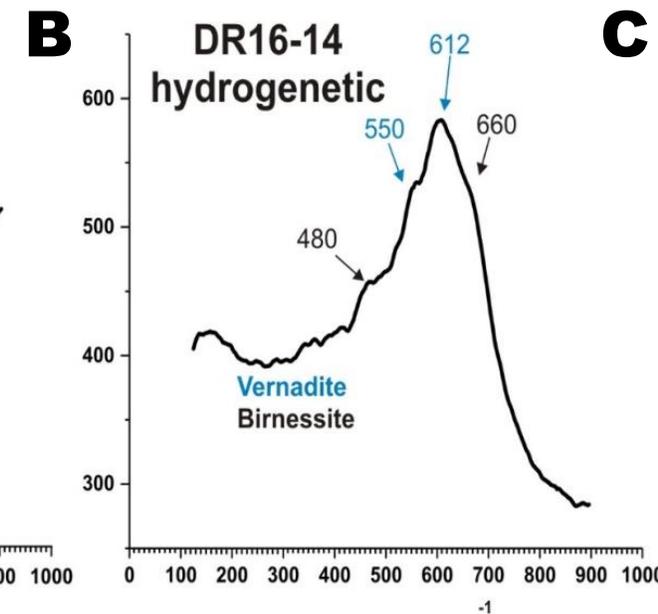
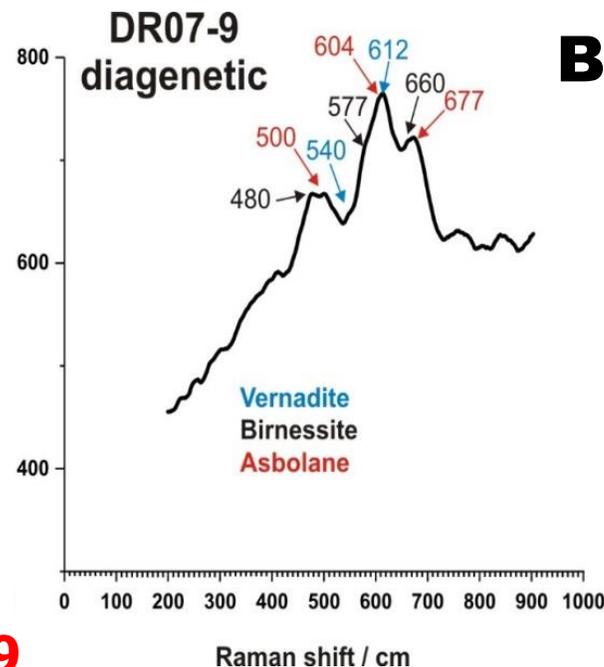
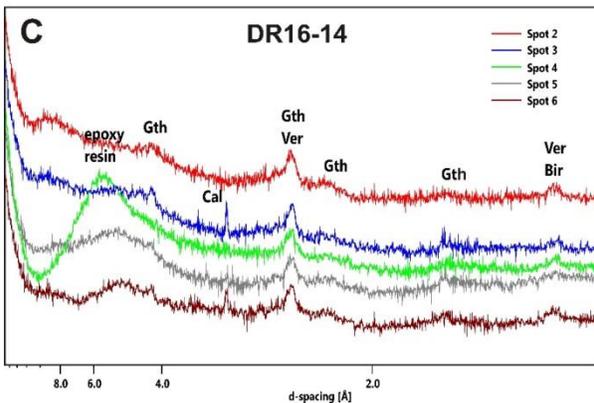
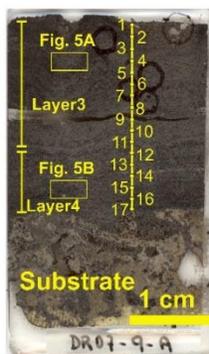
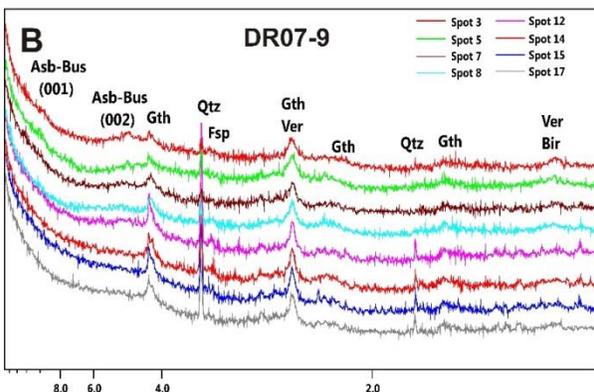
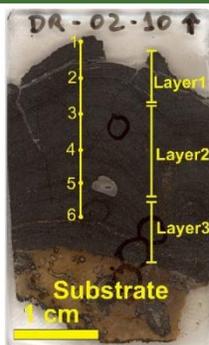
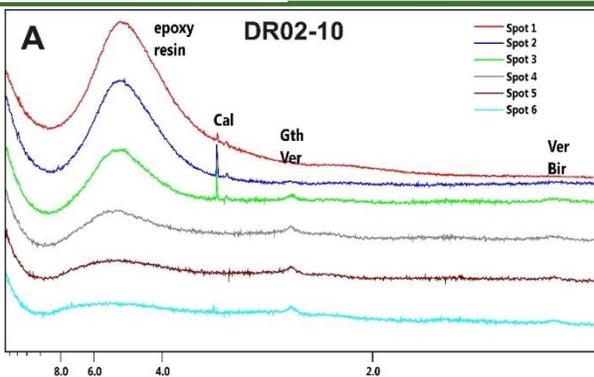
Marino et al., 2018



The use of **Micro Raman** and micro **X-Ray diffraction** can detect mineralogy in laminae of less than 20 microns.

## Micro X-Ray diffraction

## Micro Raman



**Marino et al., 2019**



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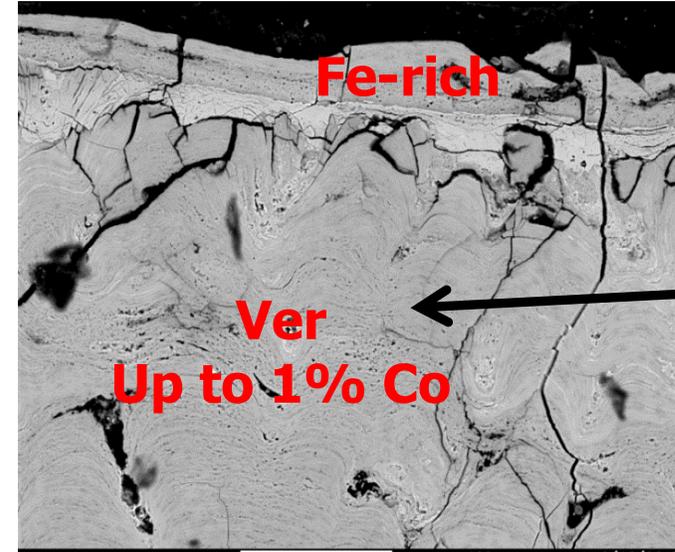
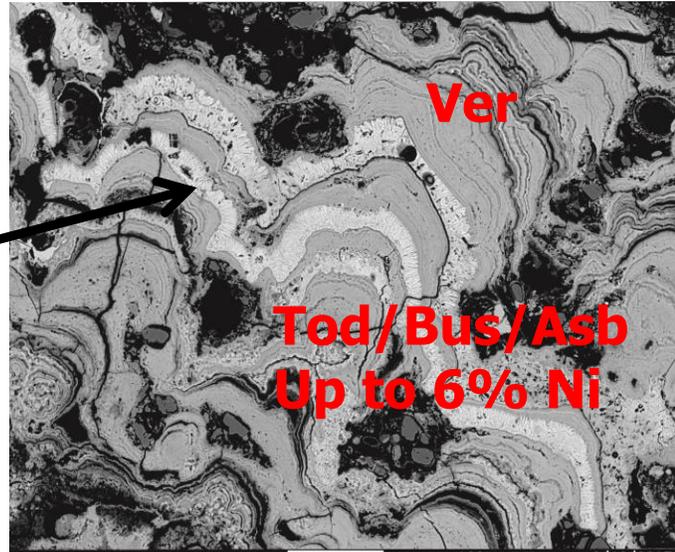


With **Electron probe micro analyzer (EPMA)** is possible to obtain high resolution images and the main geochemistry of the different laminae.

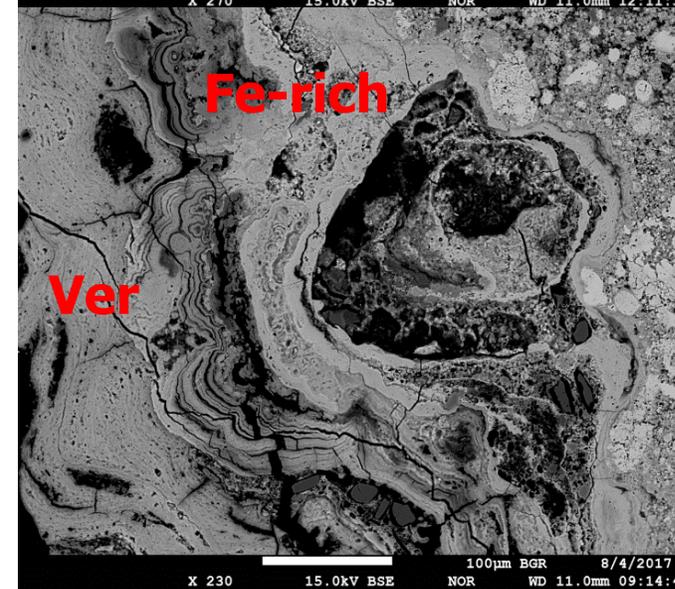
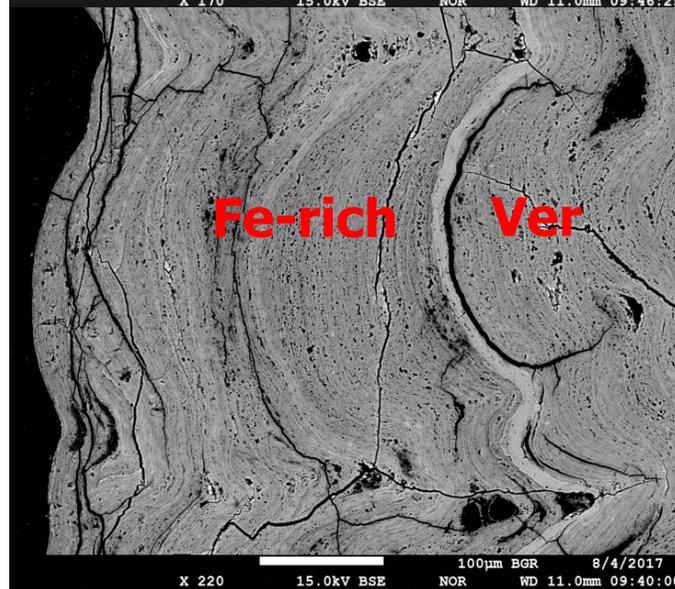


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**Diagenetic minerals**



**Hydrogenetic minerals**

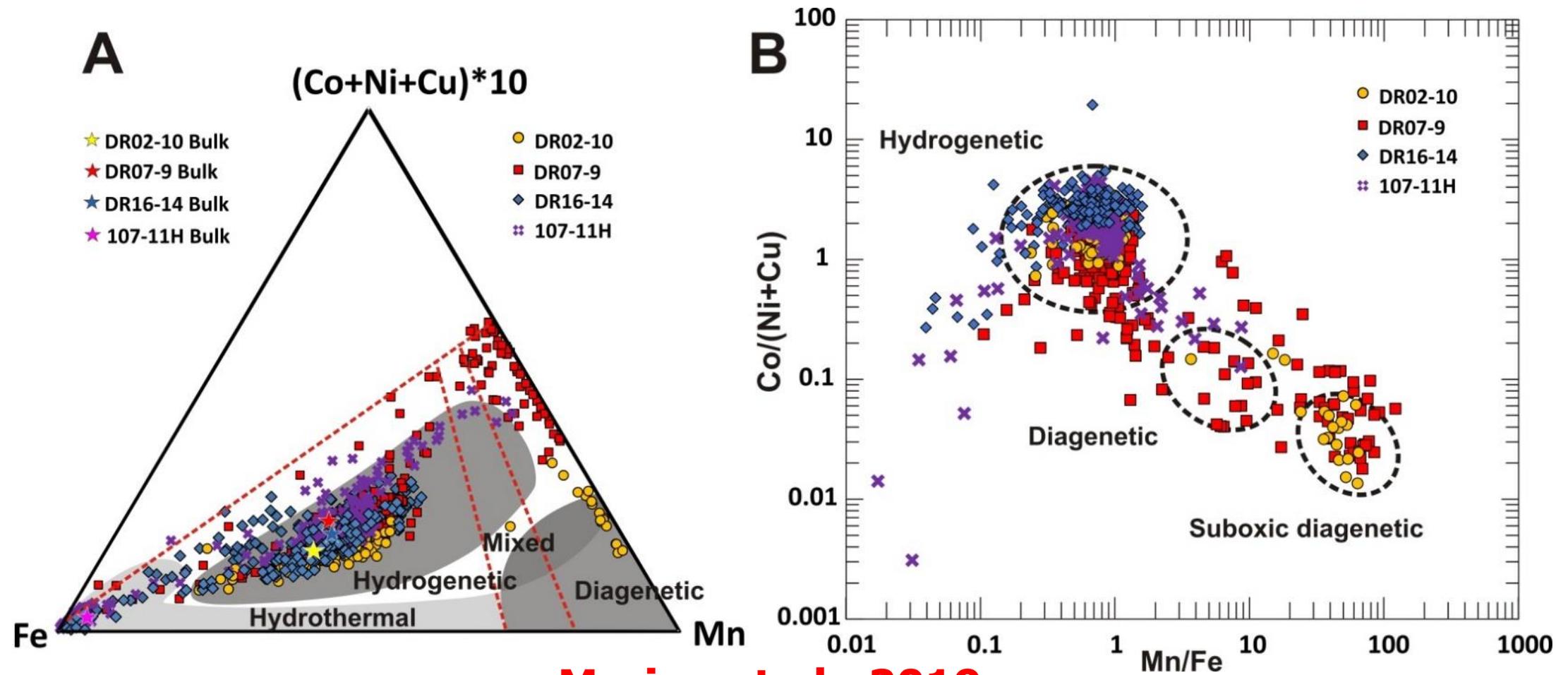


**Marino et al., 2019**

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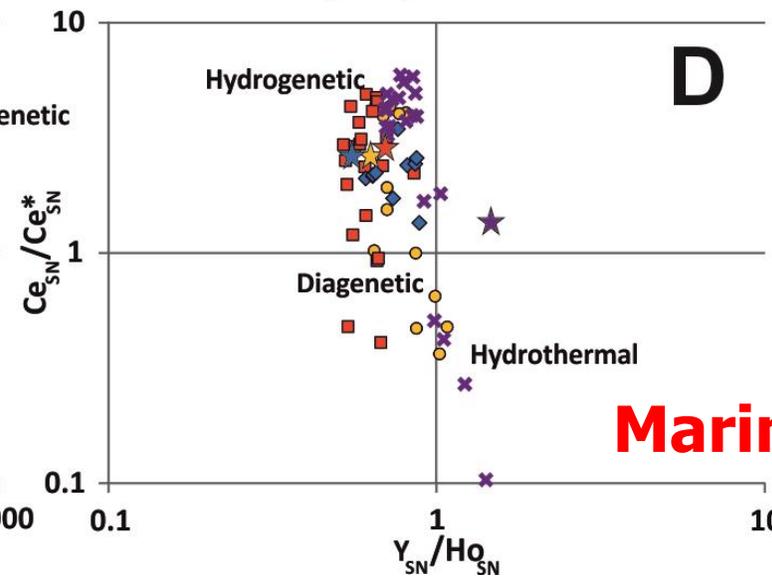
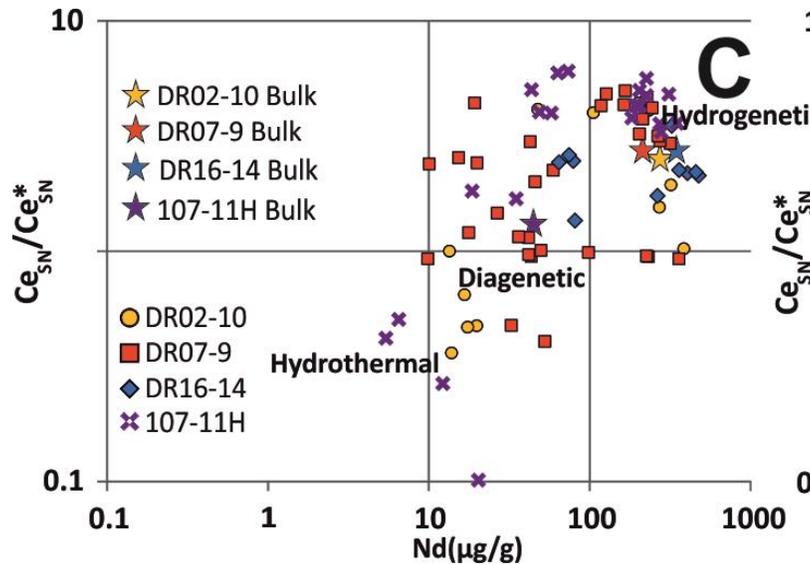
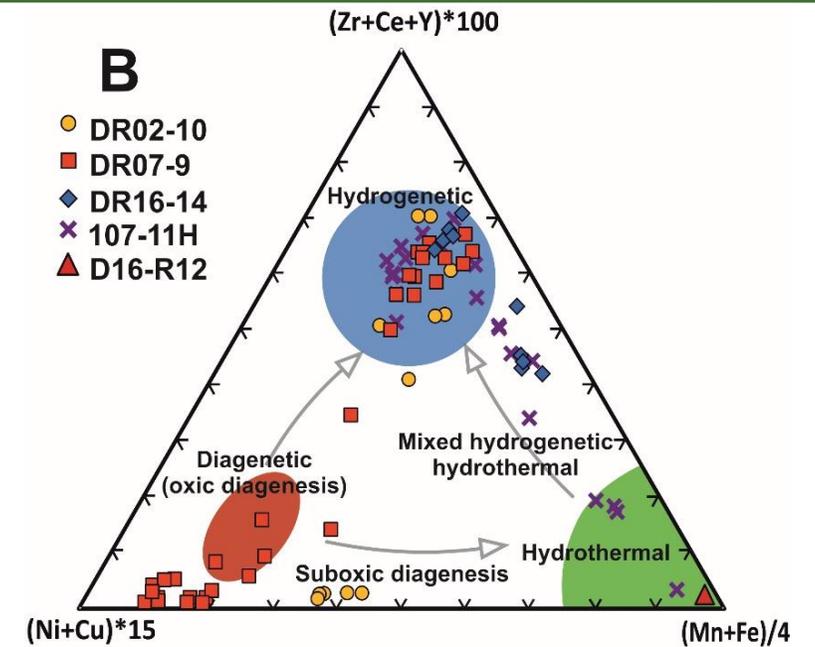
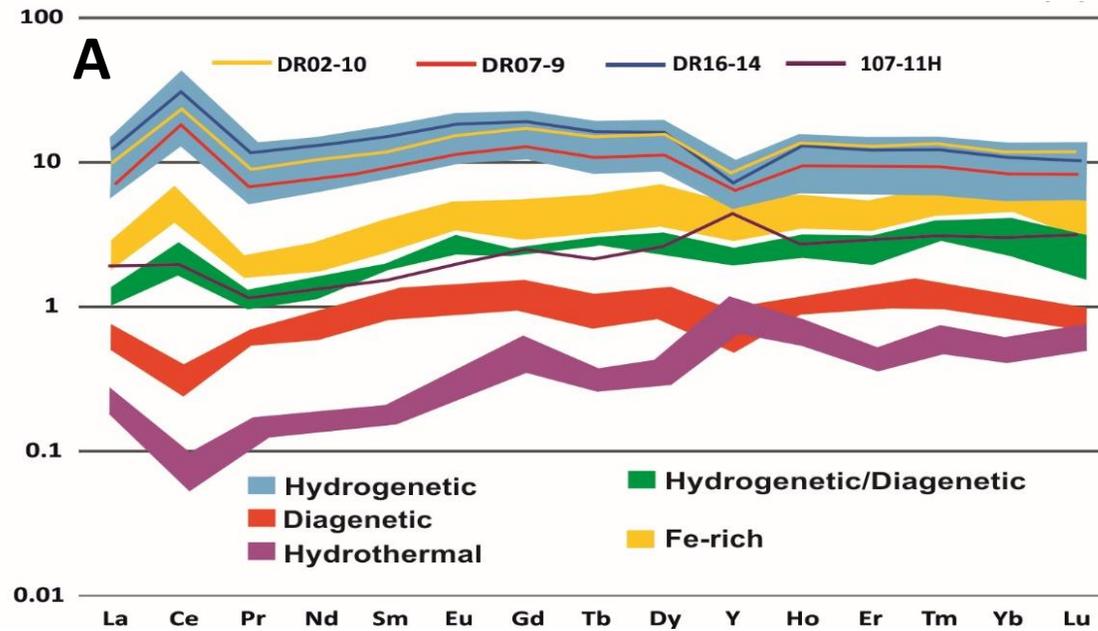
## EPMA geochemistry is also useful to individuate de origin of the different laminae



**Marino et al., 2019**

With Laser Ablation Inductively Coupled Plasma Mass Spectrometry (**LA-ICP-MS**) have been used to obtain the **REY** and other **CRM** contents in selected laminae.





**Marino et al., 2019**



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Deep sea minerals as Fe-Mn crusts and nodules are enriched in cobalt. In pan-European waters the higher concentration of economic Co deposits is in the Macaronesian region.

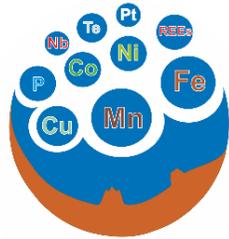
**Fe-Mn crusts** from CISP show **bulk contents** of **Co, Ni, V and REY (8000, 4500, 1000 and 3800 µg/g)**. **Co as other CRM** is linked to the presence and content of hydrogenetic minerals as **vernadite**.

**High resolution mineralogy (Micro XRD and Micro Raman)** allow differentiate the presence of diagenetic and hydrogenetic minerals forming thin laminae through studied crusts.

The use of **high resolution geochemistry (EPMA and LA-ICP-MS)** confirm that diagenetic minerals are enriched in **Ni and Cu up to 6 and 2 wt. %** respectively while hydrogenetic minerals have high contents of **Co up to 1 wt. %** but also other **CRM as REY (up to 0.4 wt. %)**.



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Ministry of Science, Innovation and Universities  
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## We also thanks the funding obtained by:



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## For more Information

**González et al. (2018).** First compilation map of “energy-critical elements” in pan-European seas: ferromanganese deposits. [MINDeSEA](#).

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# Thank you



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