

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

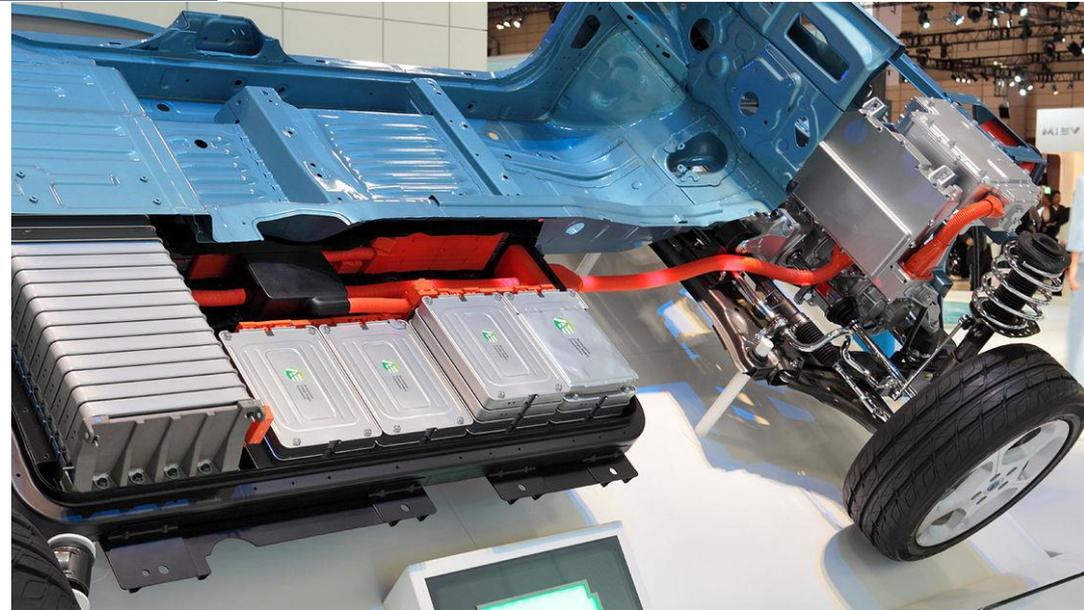
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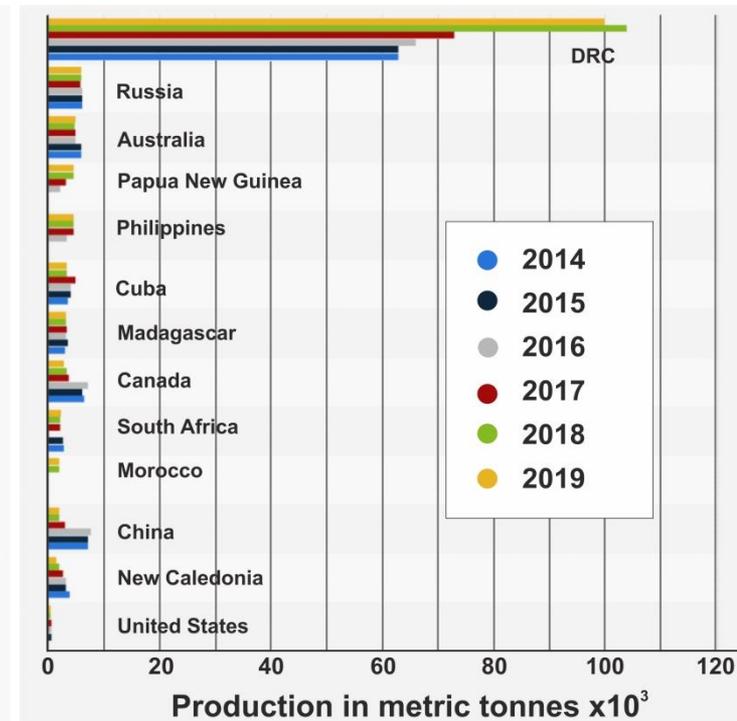
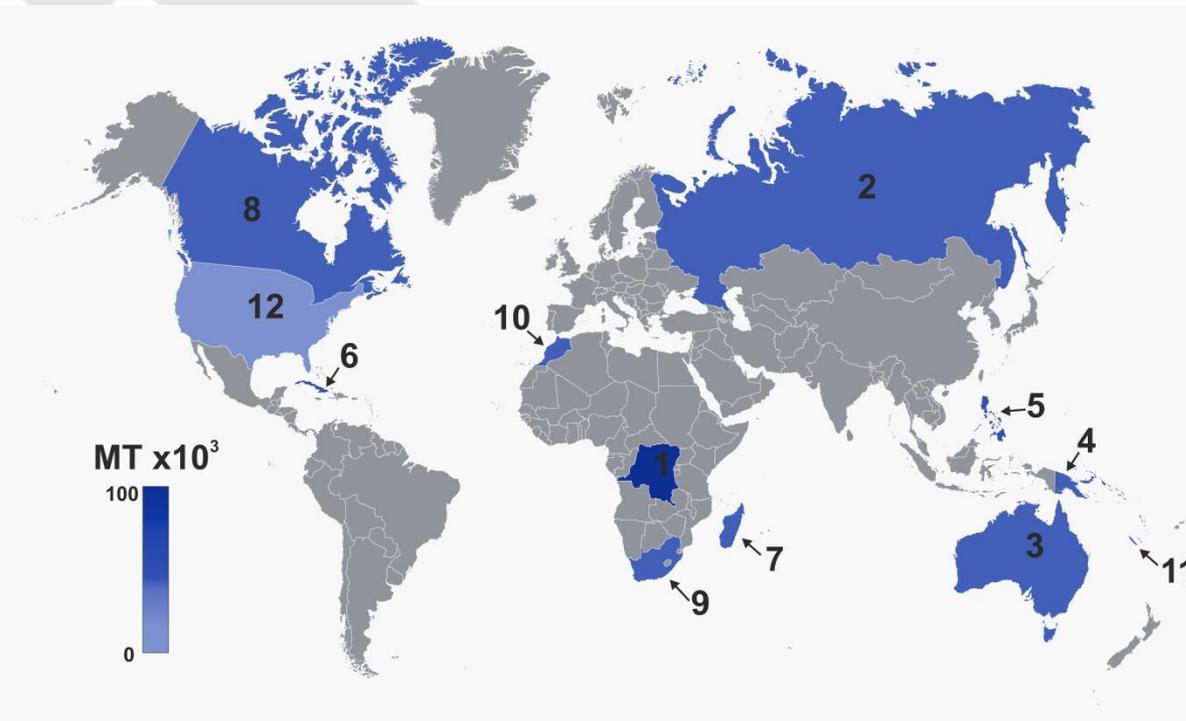
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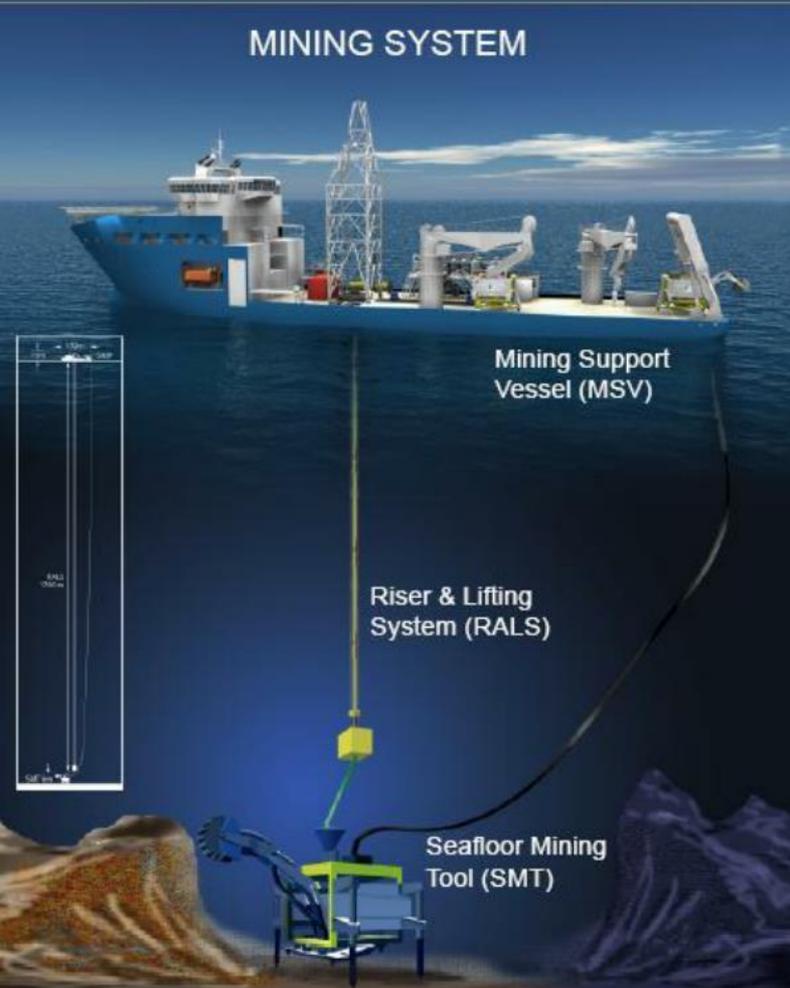
Use of Li-Co batteries is increasing in smartphones, tablets but also and for their use in electric vehicles (EVs).



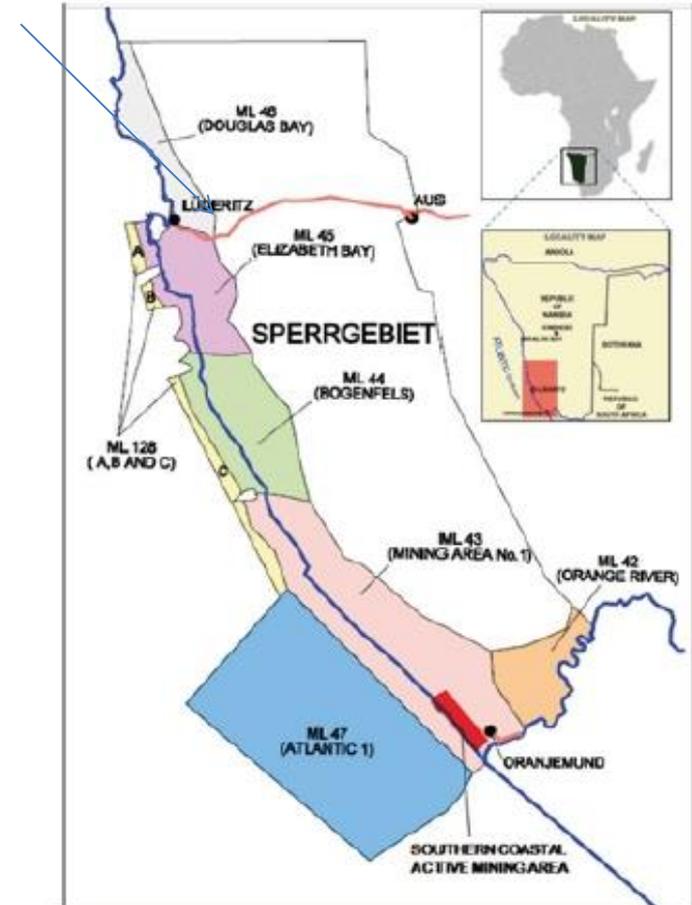
Land based mining of Co (as by-product of Ni and Cu) is headed by DRC with the 60% of the production, that in the last two years doubled its production.



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

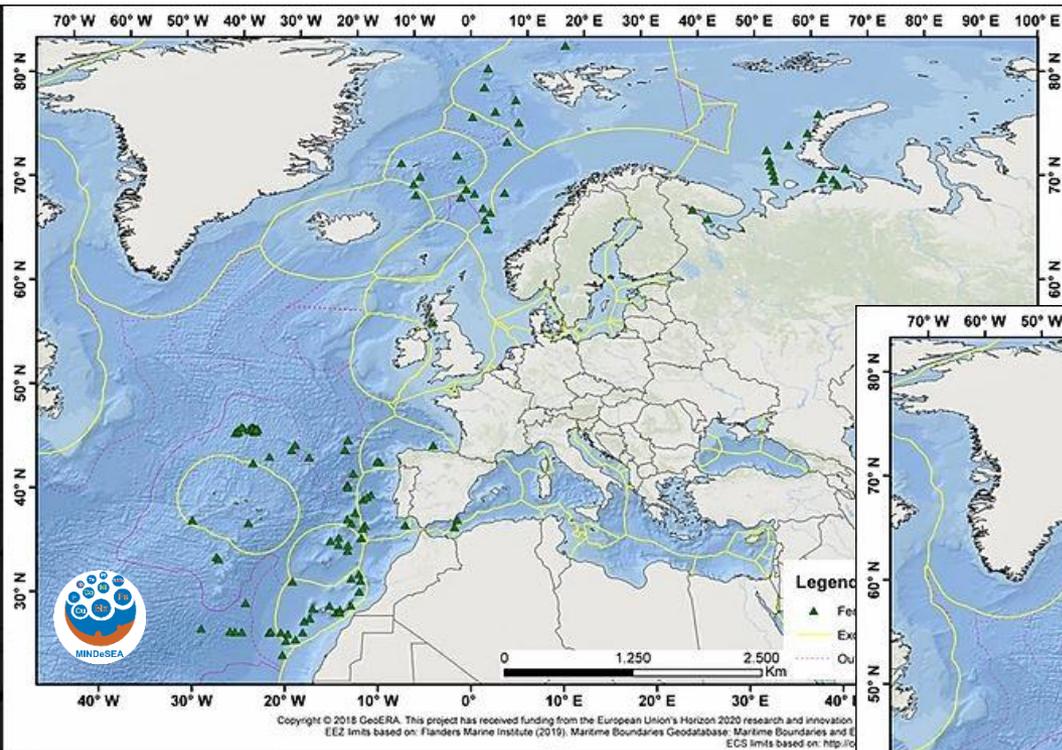


Marine mining is already a reality:
-several placers, as in Namibia, have been mined for gold, diamond and other minerals

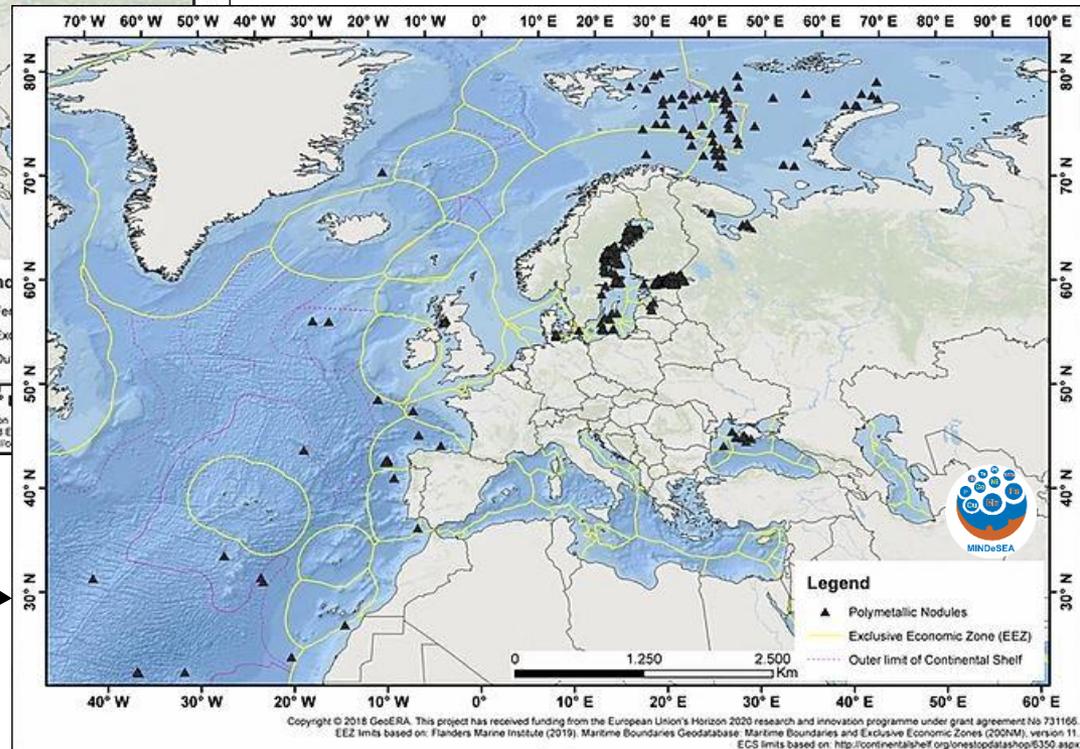


-Deep sea mining have been started by Nautilus Minerals mining massive sulphides in Papua New Guinea

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



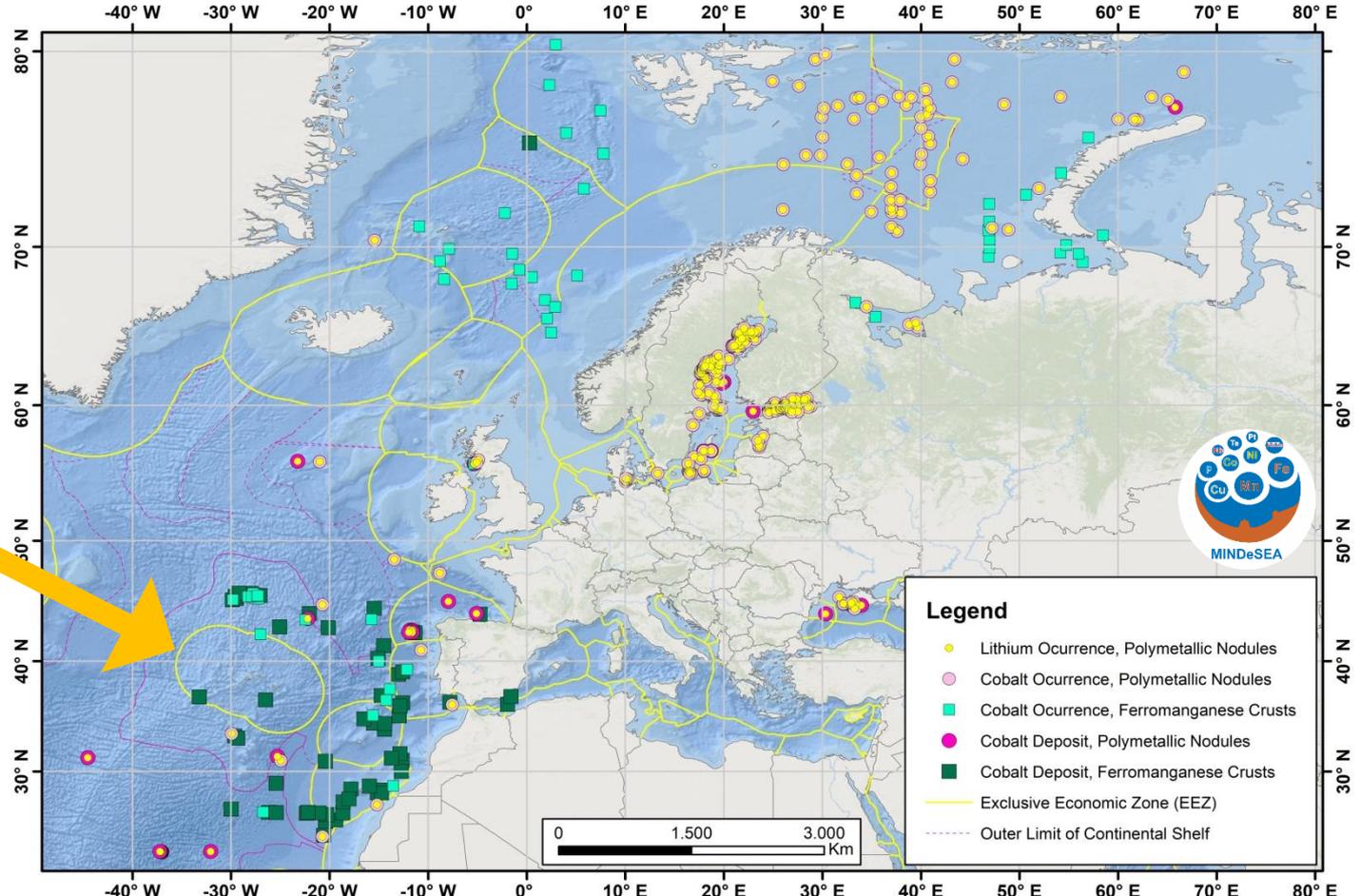
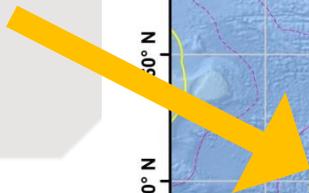
← **Fe-Mn crusts deposits**



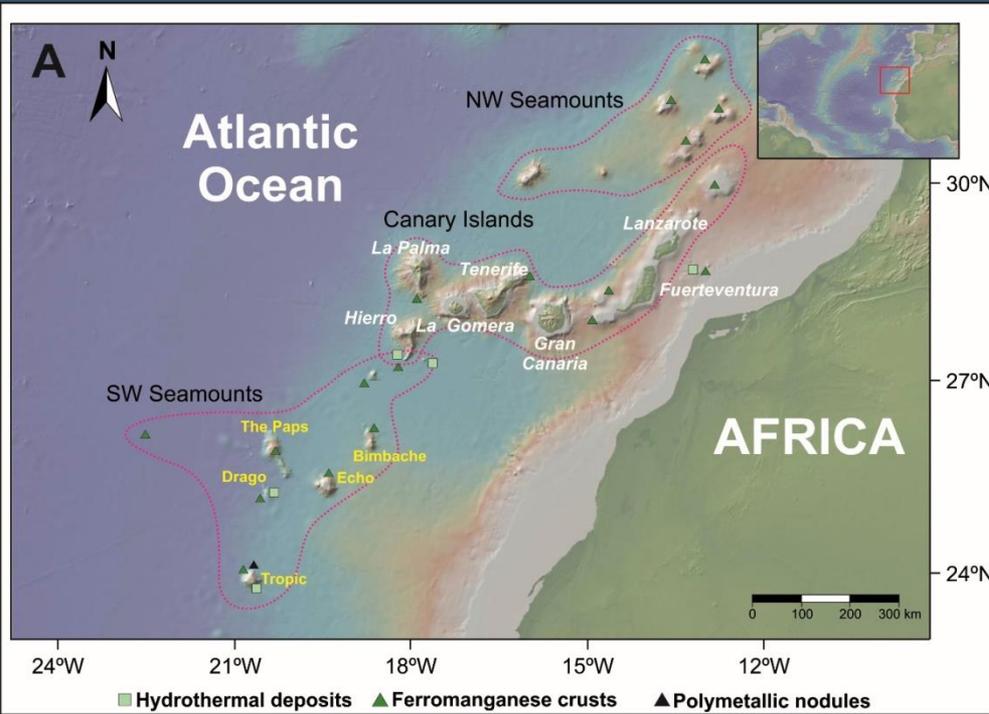
Polymetallic nodules deposits →

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

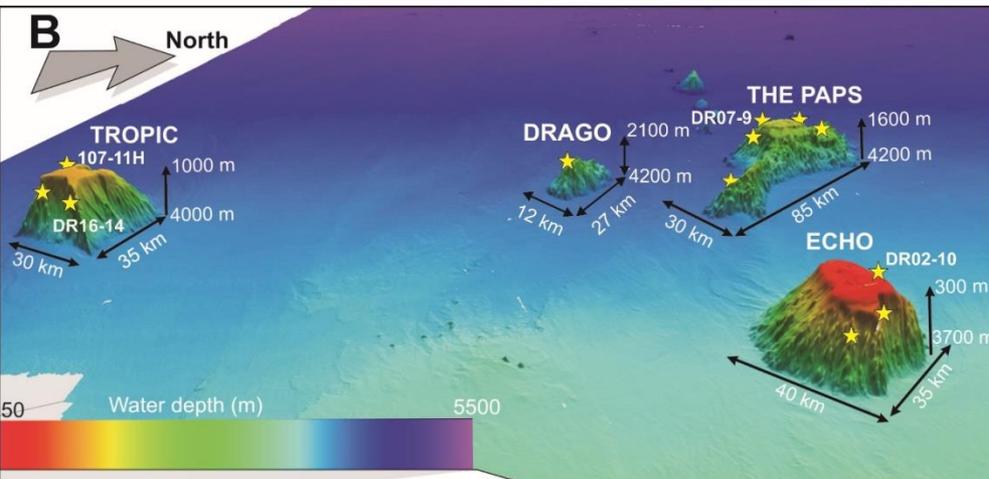
In the Macaronesia there is the higher concentration of deposits found in pan-European seas



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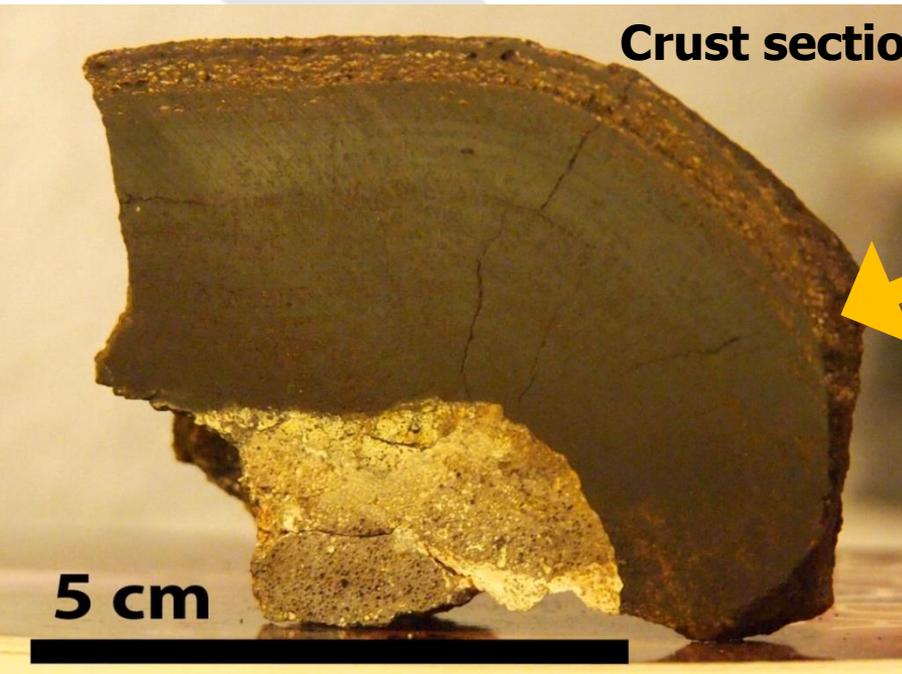


In **Canary Islands Seamount Province (CISP)** have been found hundreds of seamounts and much of them are covered by thick Fe-Mn crusts.

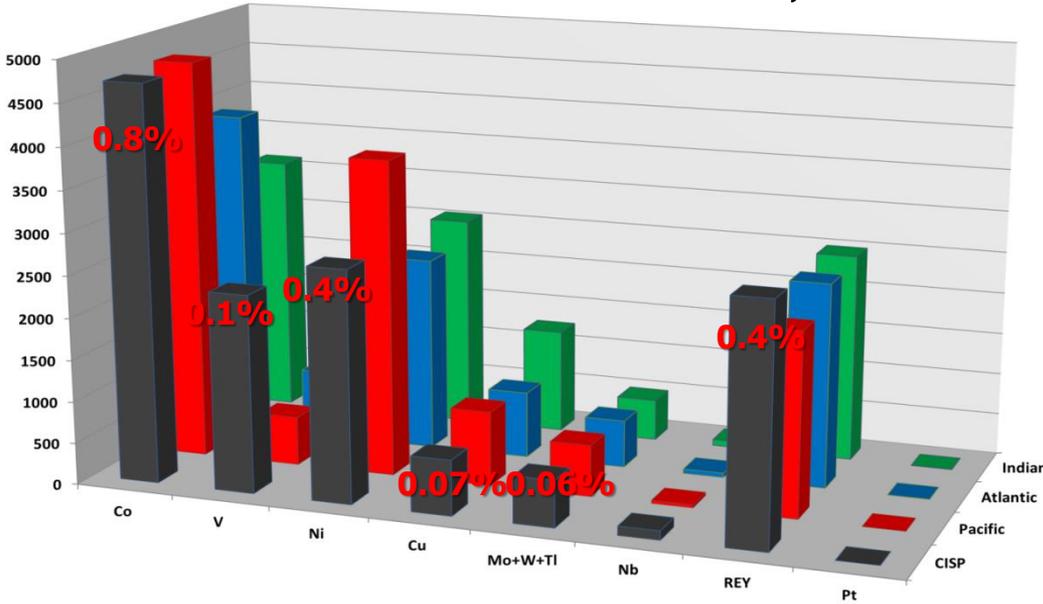


These crusts have been studied as part of a PhD project resulting in high average content of several **SCRM** as **Mn, Ni, Cu, V, Mo, REY** and especially **cobalt**, with average contents of **0.6 wt. %**.

Fe-Mn crusts recovered during the DRAGO0511 cruise

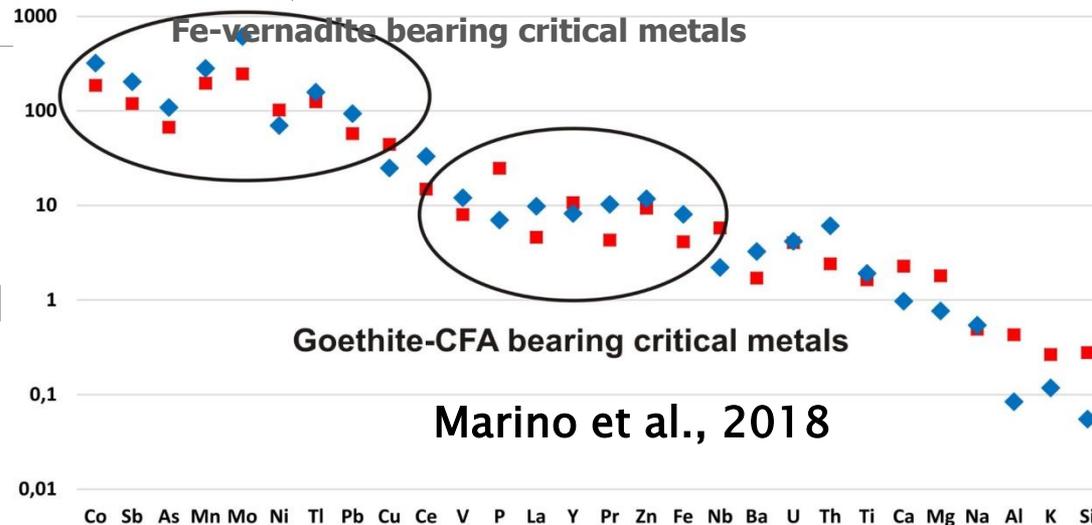


Marino et al., 2017b

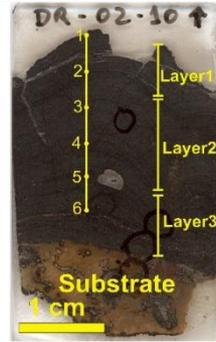
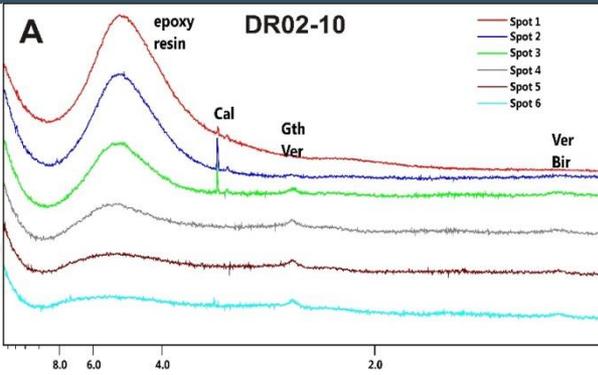


Average contents compared with similar deposits

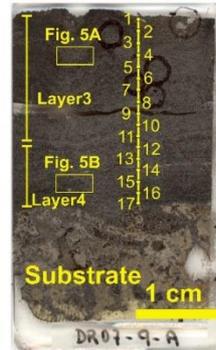
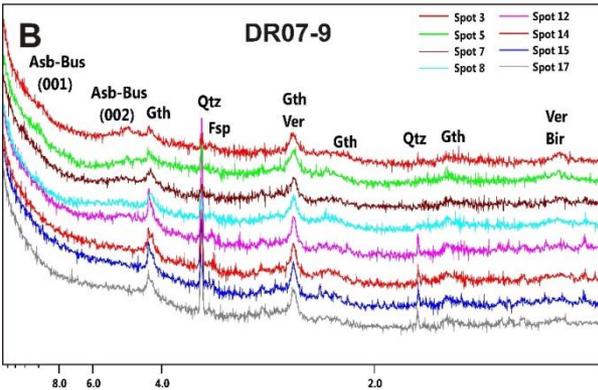
Elemental contents compared with Continental Crust



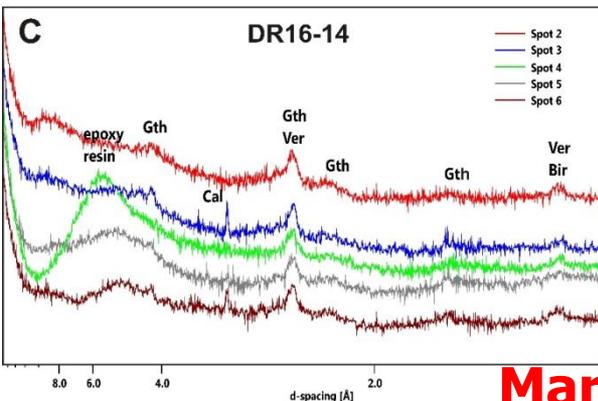
Cutting edge technics: High resolution analysis



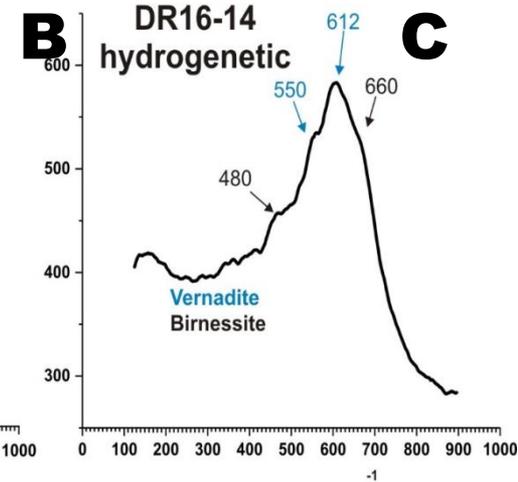
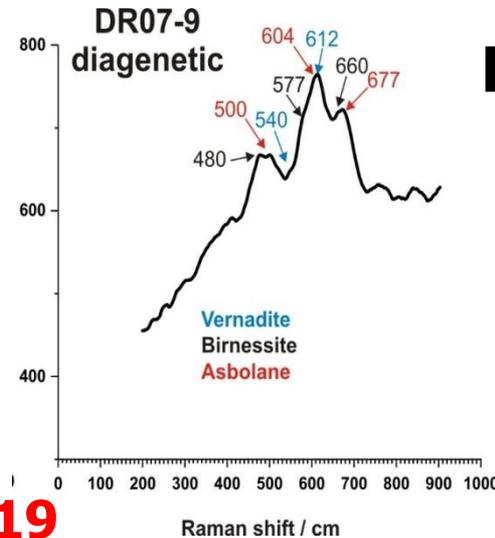
The use of **Micro Raman** and micro **X-Ray diffraction** can detect mineralogy in laminae of less than 20 microns.



Micro X-Ray diffraction



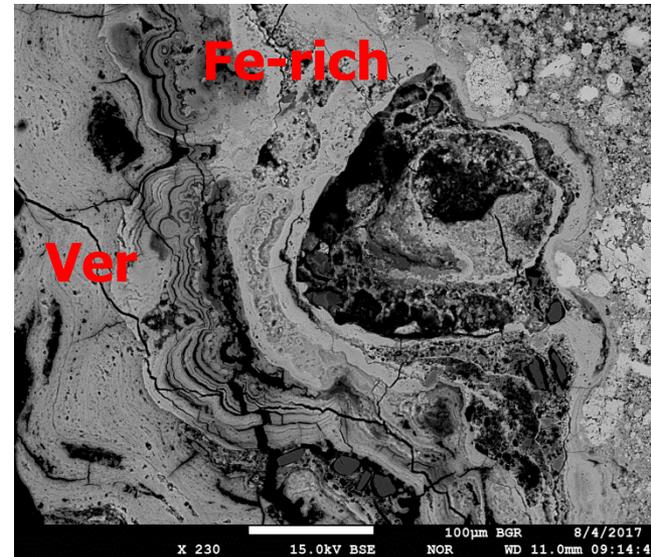
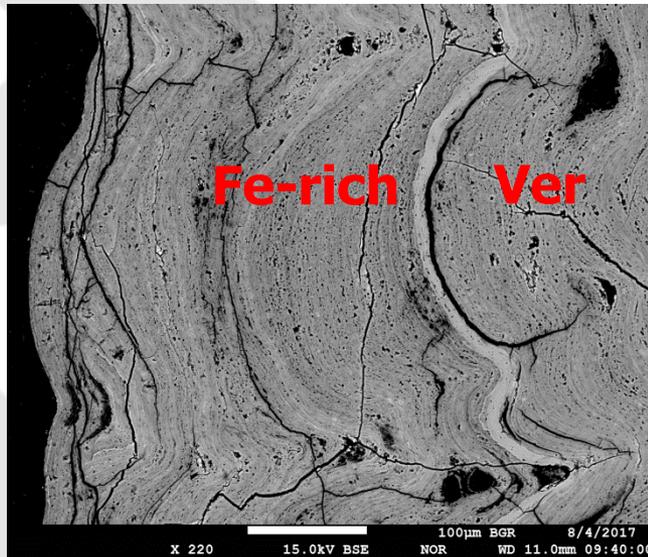
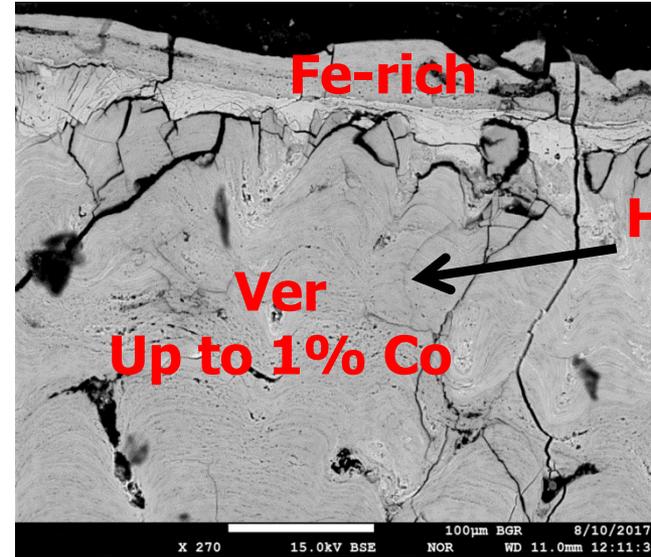
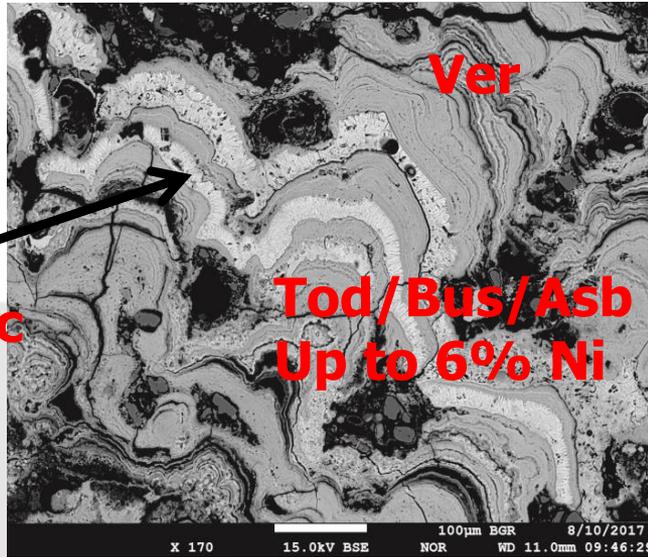
Micro Raman



Marino et al., 2019

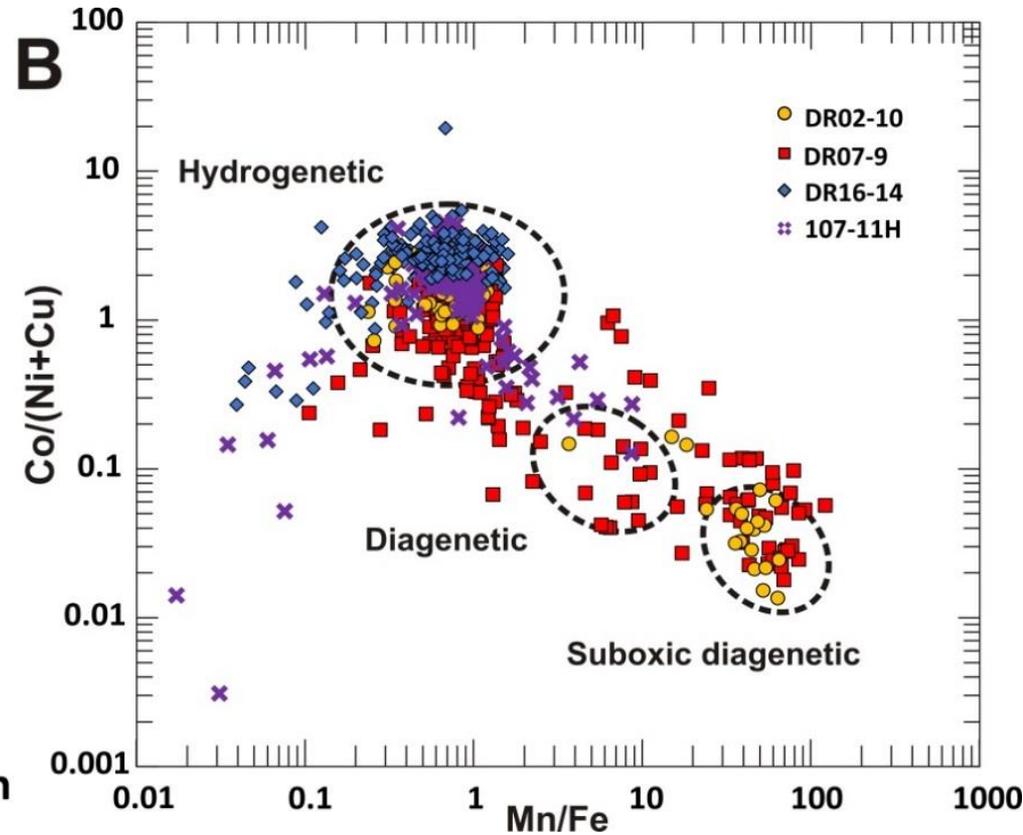
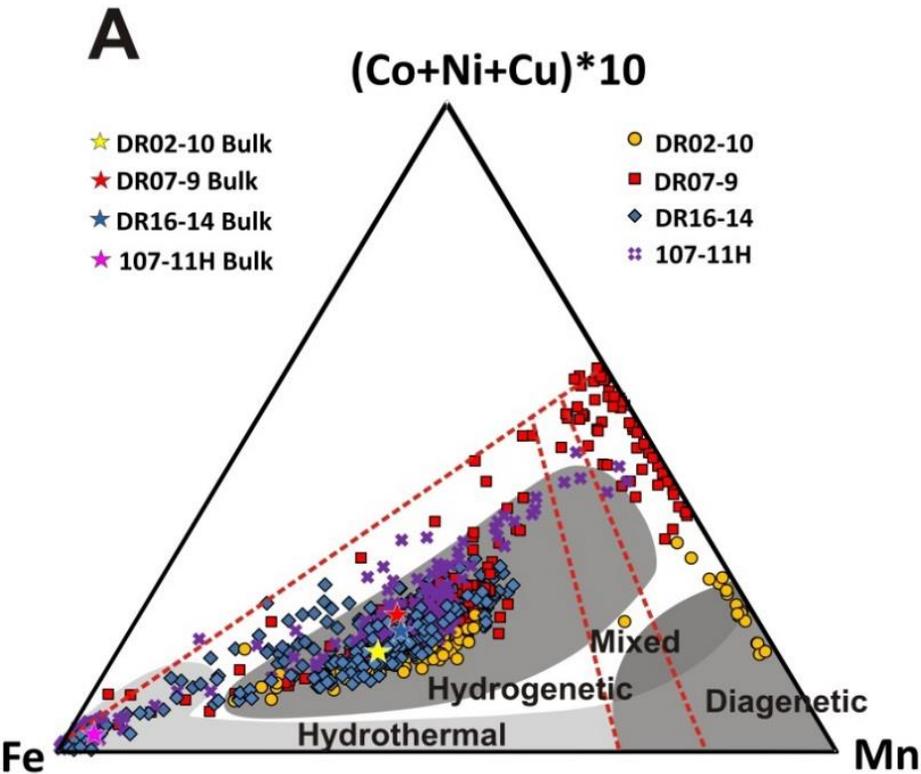
With **Electron probe micro analyzer (EPMA)** is possible to obtain high resolution images and the main geochemistry of the different laminae.





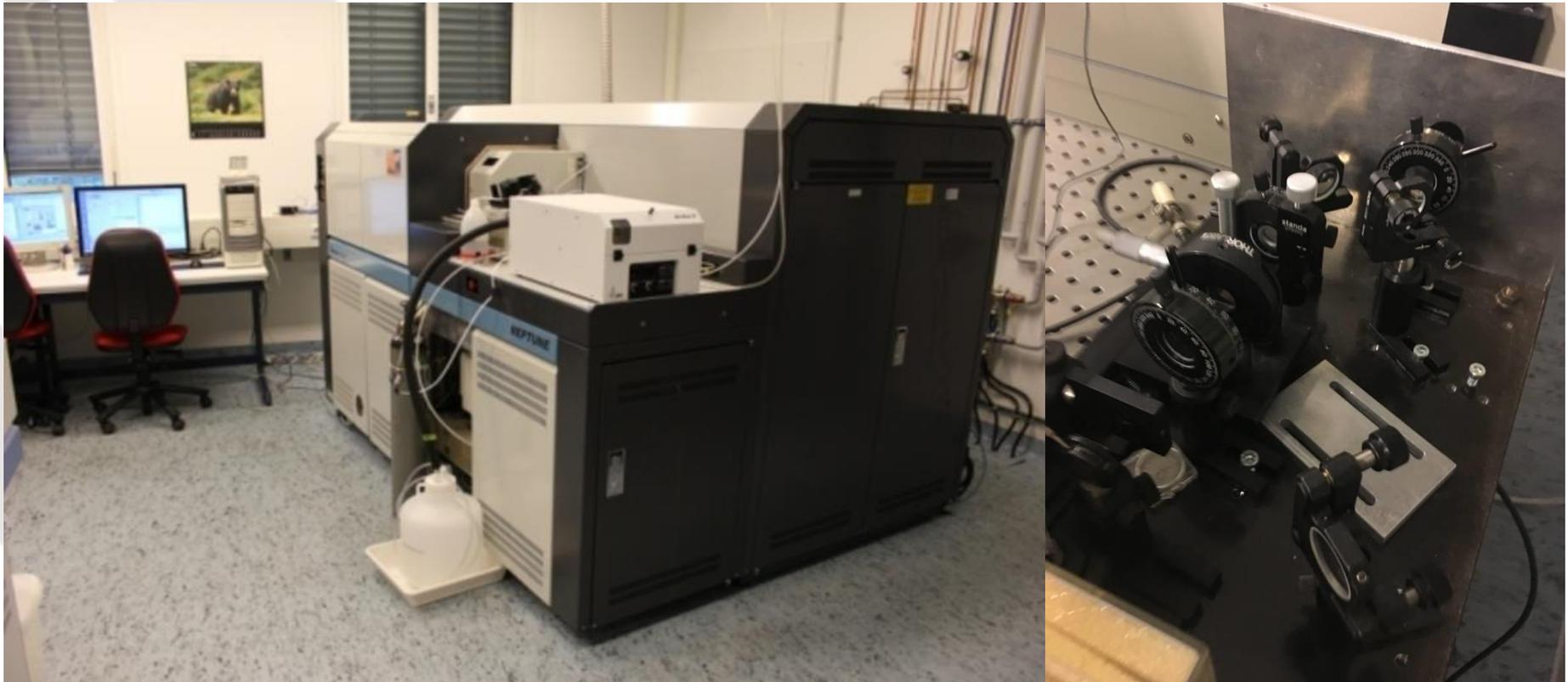
Marino et al., 2019

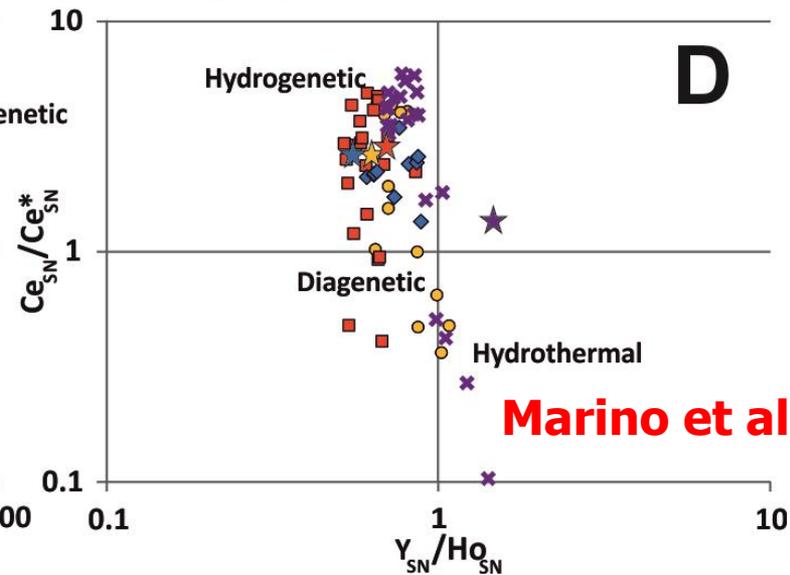
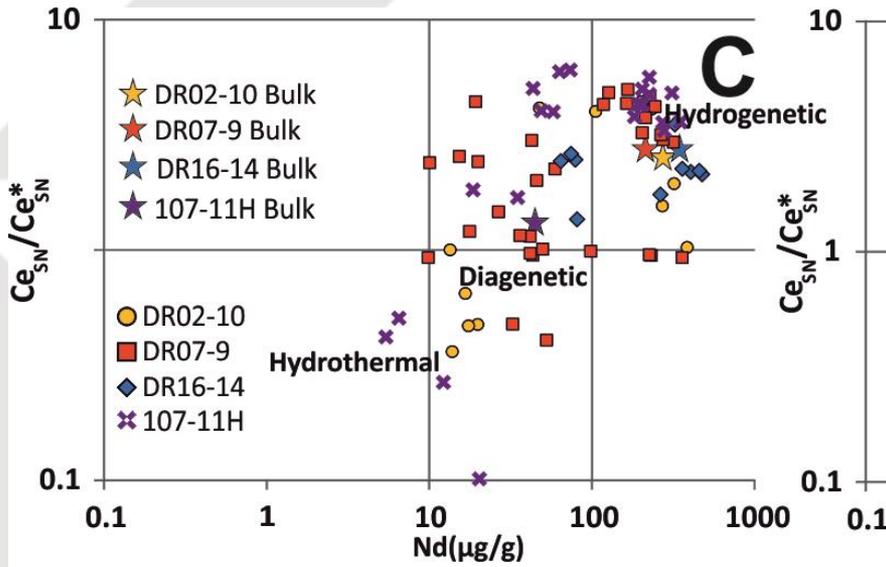
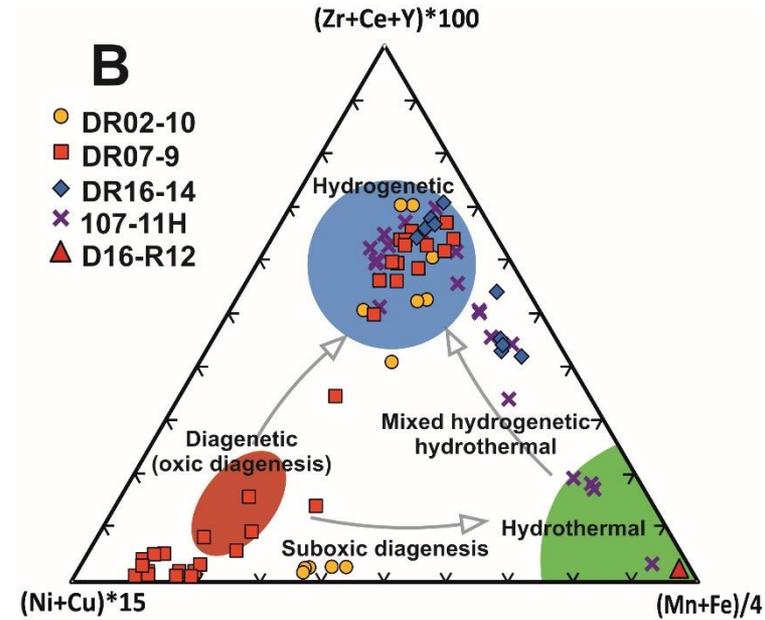
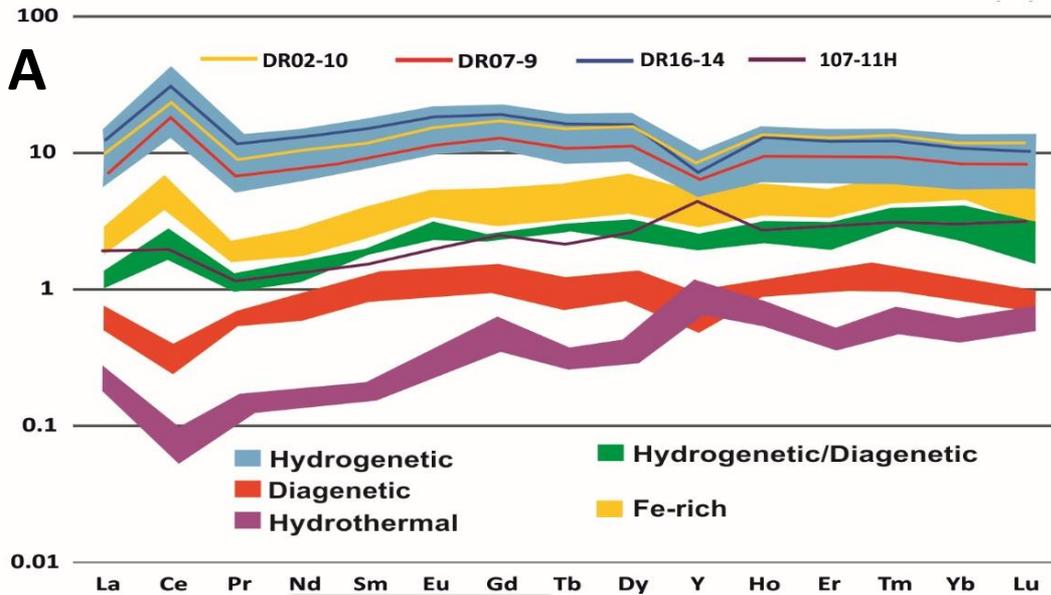
EPMA geochemistry is also useful to individuate de origin of the different laminae



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

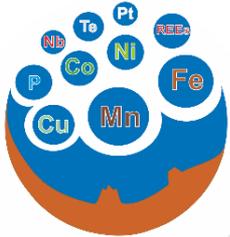
Deep sea minerals as Fe-Mn crusts and nodules are enriched in cobalt. In pan-European waters the higher concentration of economic Co deposits is in the Macaronesian region.

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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MINDeSEA



EMODnet



EXPLOSEA
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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](#).

Hein et al. (2013). Deep-ocean mineral deposits as a source of critical metals for high- and green-technology applications: comparison with land-based resources. *Ore Geol. Rev.* 51:1–14. [Ore Geology Reviews](#).

Marino et al. (2017). Strategic and rare elements in Cretaceous-Cenozoic cobalt-rich ferromanganese crusts from seamounts in the Canary Island Seamount Province (Northeastern tropical Atlantic). *Ore Geol. Rev.* 87, 41-61. [Ore Geology Reviews 2017](#).

Marino et al. (2018). High-Resolution Analysis of Critical Minerals and Elements in Fe–Mn Crusts from the Canary Island Seamount Province (Atlantic Ocean). *Minerals*, 8 (7), 285. [Minerals 2018](#).

Marino et al. (2019). Hydrogenetic, Diagenetic and Hydrothermal Processes Forming Ferromanganese Crusts in the Canary Island Seamounts and Their Influence in the Metal Recovery Rate with Hydrometallurgical Methods. *Minerals*, 9, 439. [Minerals 2019](#).

Schüler et al. (2018). Social, economic and environmental challenges in primary lithium and cobalt sourcing for the rapidly increasing electric mobility sector. Strategic Dialogue on Sustainable Raw Materials for Europe (STRADE). European Commission.

Sharma (2017). Deep-Sea Mining. Resource Potential, Technical and Environmental Considerations. Springer International Publishing AG 2017, 535 pp. [Deep-Sea Mining](#).

Thank you



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