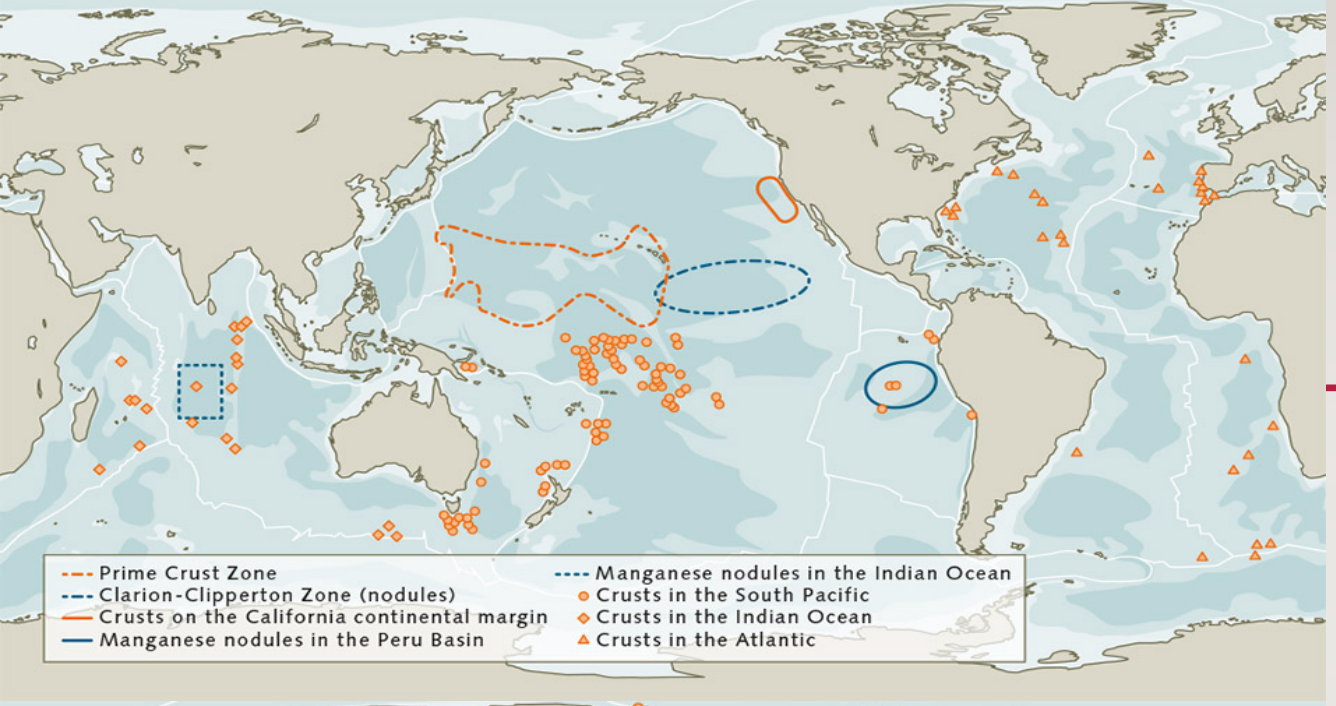
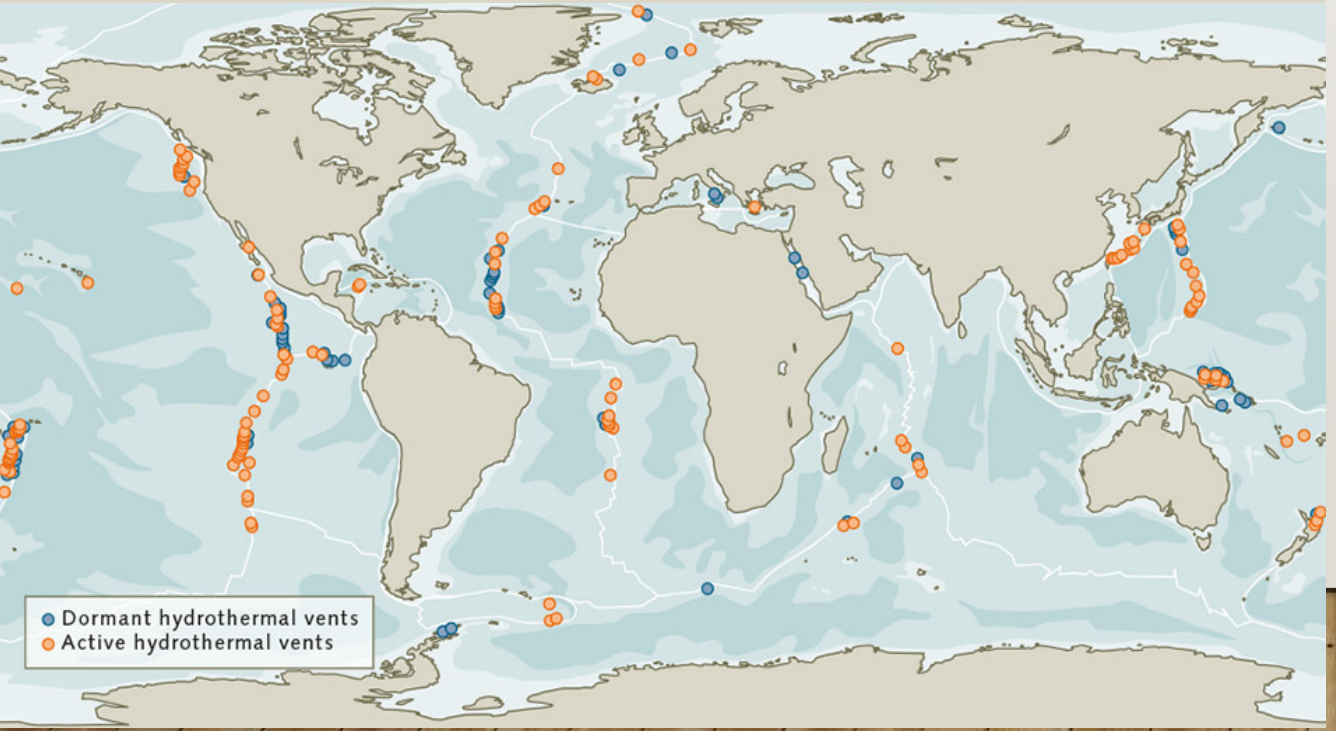
ON THE METAL CONTENTS OF OCEAN FLOOR NODULES, CRUSTS AND MASSIVE SULPHIDES AND A PRELIMINARY ASSESSMENT OF THE EXTRACTABLE AMOUNTS

Anna Hulda Ólafsdóttir[1], Harald U. Sverdrup[1], Kristín Vala Ragnarsdóttir[2]

[1]FACULTY OF INDUSTRIAL ENGINEERING, UNIVERSITY OF ICELAND, REYKJAVÍK, ICELAND
[2]INSTITUTE OF EARTH SCIENCES, UNIVERSITY OF ICELAND, REYKJAVÍK, ICELAND





NODULES, COBALT CRUSTS AND MASSIVE SULPHIDES IN THE OCEAN FLOORS

THE AVAILABLE AMOUNTS APPEARS TO BE HUGE AT FIRST SIGHT,

…..BUT CAN WE REALLY GET THEM UP?

SUBSEA REMOTE CONTROLLED MINING EQUIPMENT. PROTOTYPES READY FOR OPERATIONAL TESTING IN SMALLER SCALE PROJECTS. THESE THREE MACHINES ARE PLANNED TO BE USED ON A COMMERCIAL SCALE IN 2019. PICTURES FROM **NAUTILUS MINERALS**

AREA COVER, METAL ORE DENSITY AND CONTENTS OF DIFFERENT METALS IN NODULES, CRUSTS AND MASSIVE SULPHIDES ON THE OCEAN FLOOR.

Area	Size	Density	Amount	Fe	Mn	Cu	Zn	Ni	Co	PGM	Au	Ag
	mill. km^2	kg/m^2	billion ton	% weight						g/ton		
Deep sea nodules												
Clarion-Clipperton	9.0	2.3	21	18	22	0.2	0.4	0.4	0.5	5	1	10
Peru Basin	4.5	10	45	18	22	0.2	0.4	0.4	0.5	5	1	10
Penrhyn	0.75	25	19	18	22	0.2	0.4	0.4	0.5	5	1	10
Atlantic	0.20	25	4.8	18	22	0.2	0.4	0.4	0.5	5	1	10
Indian Ocean	0.75	5	3.8	18	22	0.2	0.4	0.4	0.5	5	1	10
Cobalt crusts												
Northeast Pacific	9.0	0.84	7.55	17.8	22.9	0.2	0.4	0.5	0.8	3	20	200
Southwest Pacific	4.5	0.7	3.2	18.1	21.7	0.1	0.2	0.5	0.8	3	20	200
Penrhyn	0.75	0.7	0.53	14.5	20.9	0.2	0.4	0.4	0.5	2	20	200
Atlantic	0.20	0.7	0.15	15.0	20	0.2	0.4	0.4	0.5	2	6	200
Indian ocean	0.75	0.7	0.53	17.0	22.3	0.23	0.4	0.5	0.6	2	20	200
Massive sulphides and brines												
Pacific CC+PB	13.5	0.22	3.000	10	0.2	3.5	13	0.1	0.7	1	3	150
Penrhyn	0.75	1.25	1.000	10	0.5	8.5	7	0.1	0.7	1	3	80
Atlantic	1.50	1.3	2.000	10	0.5	8.5	7	0.1	0.7	1	3	80
Indian Ocean	0.75	0.3	0.250	10	0.5	0.9	4	0.1	0.7	2	2	100

ESTIMATED SEAFLOOR METAL RESOURCES, ASSESSMENT OF TECHNICAL EXTRACTABILITY.

Area	Fe	Mn	Cu	Zn	Ni	Co	Mo	PGM	Au	Ag
	Million ton							ton		
Sum nodule	19,509	22,069	930	1,860	1,219	196	53	63,000	217,000	2,270,000
Sum crusts	4,383	5,636	27	9	105	163	13	41,500	6,000	55,500
Sum sulfides	625	222	85	604	13	44	44	12,000	125,000	1,250,000
Sum	24,517	27,727	1,042	2,473	1,337	403	110	116,000	348,000	3,505,000
Considering different extractability in the total picture of all extractable metal resources. The URR estimates are very approximate.										
Ocean, 25%	6,129	6,932	261	618	334	100	26	29,000	87,000	876,300
Ocean, 5%	1,226	1,386	53	124	67	20	6	5,800	17,400	175,260
Land	340,000	5,600	4,030	2,676	300	32	80	210,000	150,000	3,700,000
How much metal resources do we have on land and ocean floors? The estimates are very approximate										
URR low	341,226	6,986	3,823	2,800	367	52	86	215,800	167,400	3,900,000
URR high	346,129	12,532	4,291	3,294	634	132	106	229,000	237,000	4,576,000
% on land	99-98	81-41	98-96	96-81	82-49	62-24	94-79	97-91	90-66	87-95

CONCLUSIONS

- Much technology development is needed for ocean mining to work economically. The conditions are challenging and the operations costly. Only viable for high-value metals and materials
- The environmental issues remains to be assessed and developed
- There is much more technically extractable resources available on land than in the oceans
- Ocean mining may be interesting and helpful for cobalt, nickel, silver, gold and platinum