Salt Partners

Salt and water from sea water – *What else?*

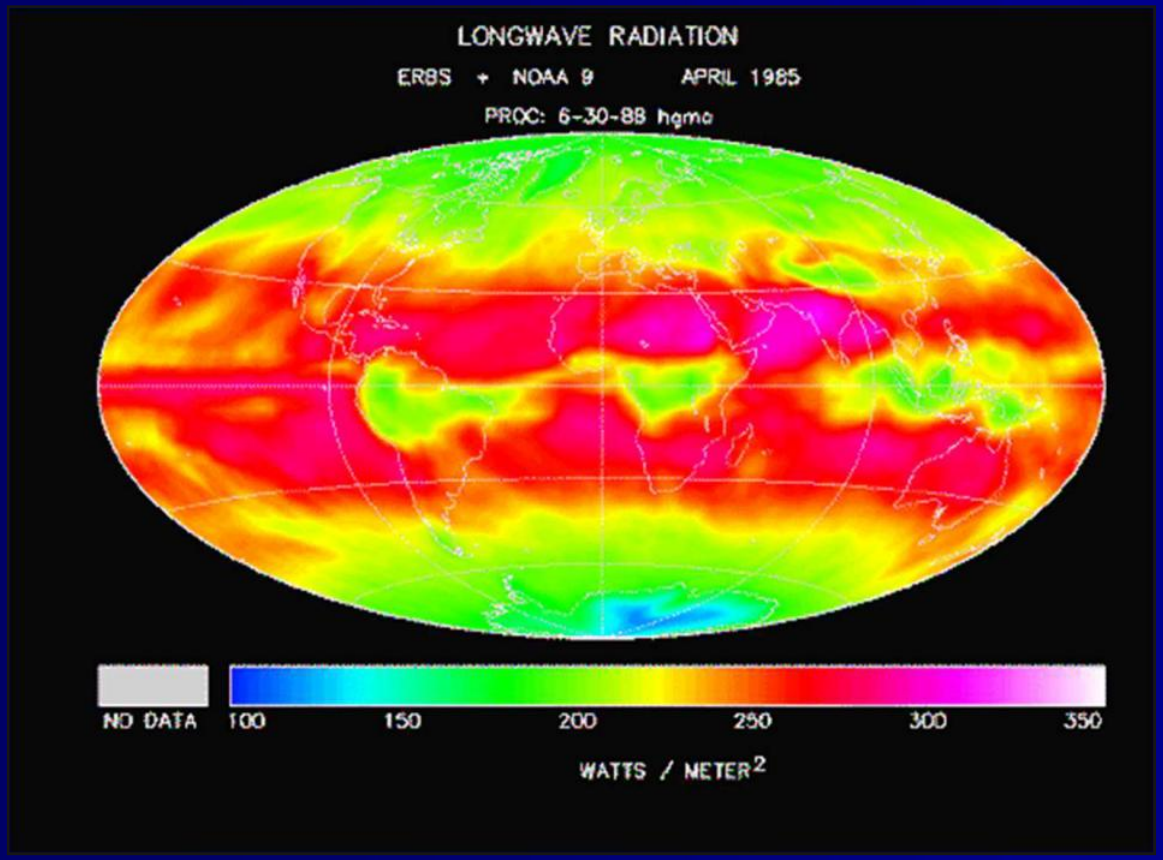
New technologies focus on recovery of metals from solar saltworks bitterns and from desalination rejects

Vladimir M. Sedivy MSc (Hons) Chem Eng, IMD
President
Salt Partners Ltd, Erlenbach ZH, Switzerland

Roskill Salt 2019 Conference, 26.- 27.3.2019, Marriott Hotel Amsterdam, Netherlands

Salt Partners

Solar energy (insolation) on the planet Earth



NASA

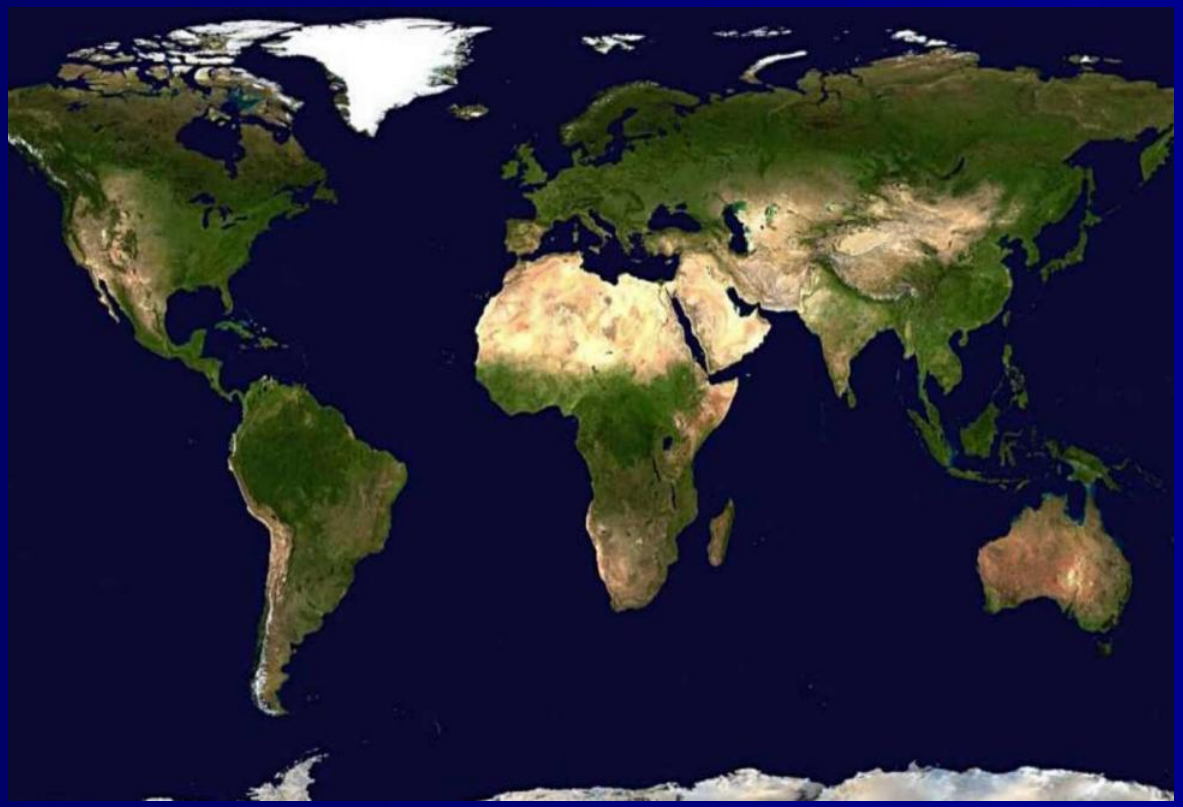
The Earth is receiving approx. 1'368 W/m2 of solar energy. Part of the solar energy is absorbed by the clouds. No solar energy is received during the night. Thus the solar energy received on the planet surface – the insolation – is only a fraction of the total solar energy received. Most insolation is received in:

Caribbean Sea
North Africa
South Africa
Middle East
Western India
Western Australia

Vladimir M. Sedivy
Salt Partners Ltd, Erlenbach ZH, Switzerland

Salt Partners

Water scarcity on the planet Earth



NASA

Locations with the highest insolation are also locations with the highest rates of evaporation and highest scarcity of water. Sea water available along the seashore of these locations is – after desalination – the source of water.

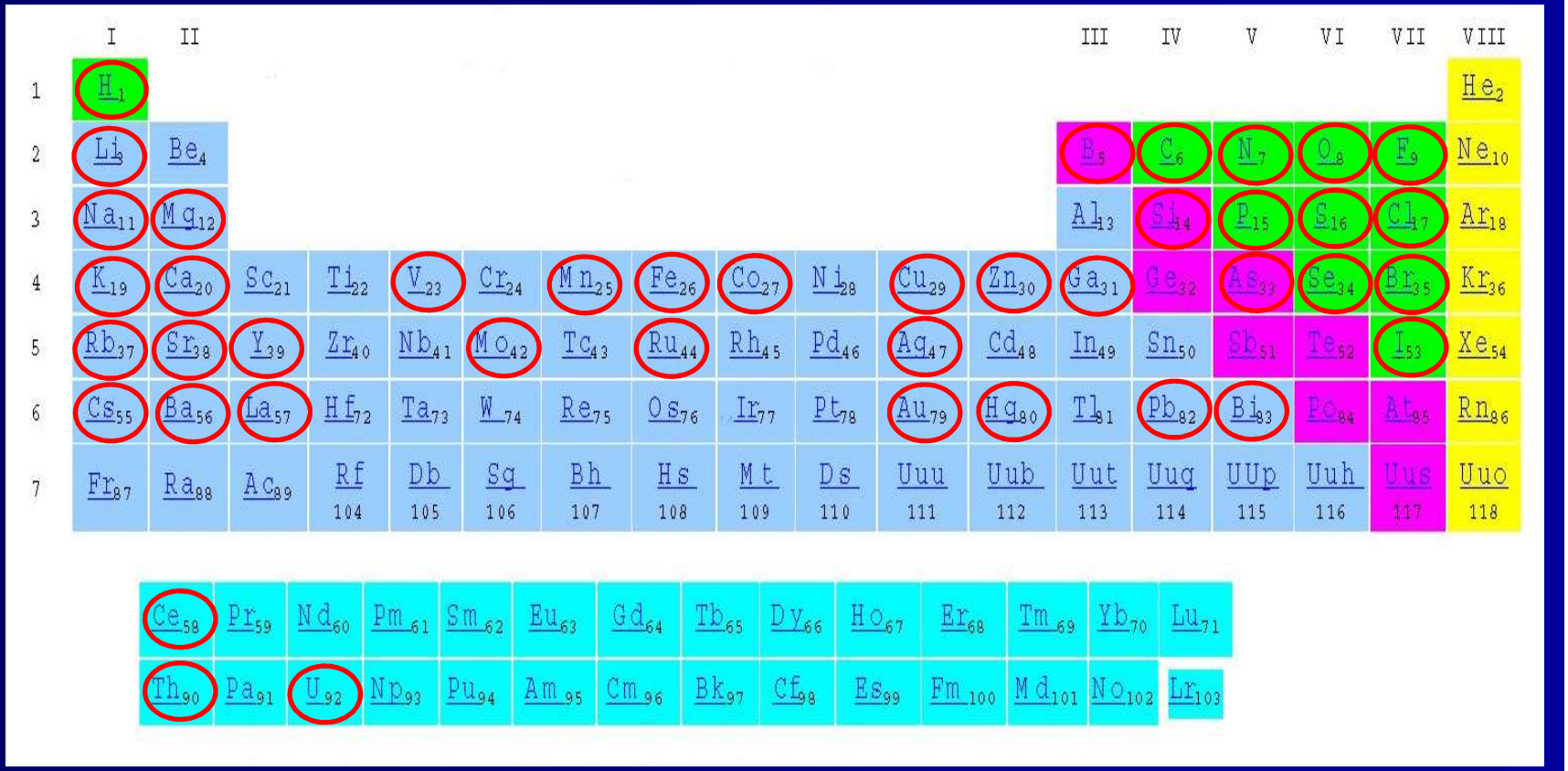
The same locations are suitable for solar salt production.

Both desalination reject and solar saltworks bitterns are potential sources of valuable metals and minerals.

Vladimir M. Sedivy
Salt Partners Ltd, Erlenbach ZH, Switzerland

Salt Partners

What metals and minerals are there in sea water?



Vladimir M. Sedivy
Salt Partners Ltd, Erlenbach ZH, Switzerland

Salt Partners

What is the concentration of these elements in the sea water?

Concentration higher than 1 ppm

Element	Concentration (ppm)	Element	Concentration (ppm)
Cl	19’000	C	30
Na	10’600	Sr	15
Mg	1’300	B	5
S	900	Si	4
Ca	400	Al	2
K	380	F	1.5
Br	65	N	1

Vladimir M. Sedivy
Salt Partners Ltd, Erlenbach ZH, Switzerland

Salt Partners

What is the concentration of these elements in the sea water?

Concentration less than 1’000 ppb

Element	Concentration (ppb)	Element	Concentration (ppb)
Rb	200	Fe	20
Li	100	Zn	15
P	100	Mn	10
Cu	90	Pb	5
Ba	50	Se	4
I	50	Sn	3
As	25	Cs	2

Vladimir M. Sedivy
Salt Partners Ltd, Erlenbach ZH, Switzerland

Salt Partners

What is the concentration of these elements in the sea water?

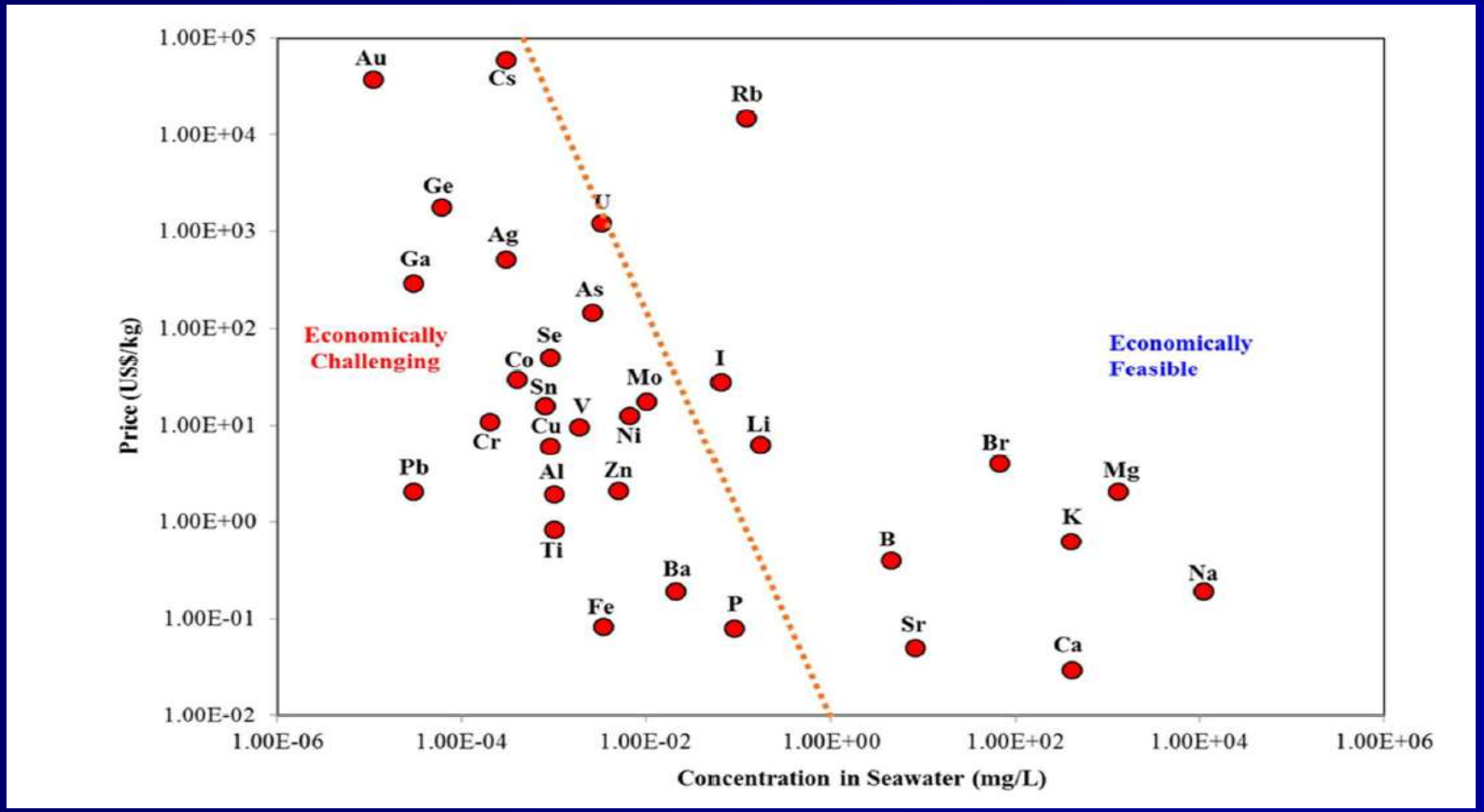
Concentration 2 ppb and less

Element	Concentration (ppb)	Element	Concentration (ppb)
Mo	2	La	0.3
U	1.5	Y	0.3
Ga	0.5	Hg	0.3
Ni	0.5	Ag	0.3
Th	0.5	Bi	0.2
Ce	0.4	Co	0.1
V	0.3	Gold	0.01

Vladimir M. Sedivy
Salt Partners Ltd, Erlenbach ZH, Switzerland

Salt Partners

Which of these elements / metals are being considered to be economically recoverable?



Vladimir M. Sedivy
Salt Partners Ltd, Erlenbach ZH, Switzerland

Salt Partners

What are the prices of these economically recoverable elements?

Element	Price Range (EUR/t)	Average Price (EUR/t)
B	3’500 – 4’600	4’100
Li	47’500 – 50’700	50’000
Mg	350 – 4’100	1’290
K	800 – 3’100	950
Rb	1’250’000 -31’250’000	2’630’000
Sr	300 – 44’600	1’690

Prices quoted in internet by Fastmarkets MB, Shanghai MM, Made-in-China, Alibaba, Africa Fertiliser, Fischer Scientific, Chemical Book, USGS and private communication.

Vladimir M. Sedivy
Salt Partners Ltd, Erlenbach ZH, Switzerland

Roskill Salt 2017 Middle East Conference, 14.- 15.11.2017, Marriott Hotel Al Jaddaf, Dubai

Salt Partners

What technologies are being developed for recovery of these elements?

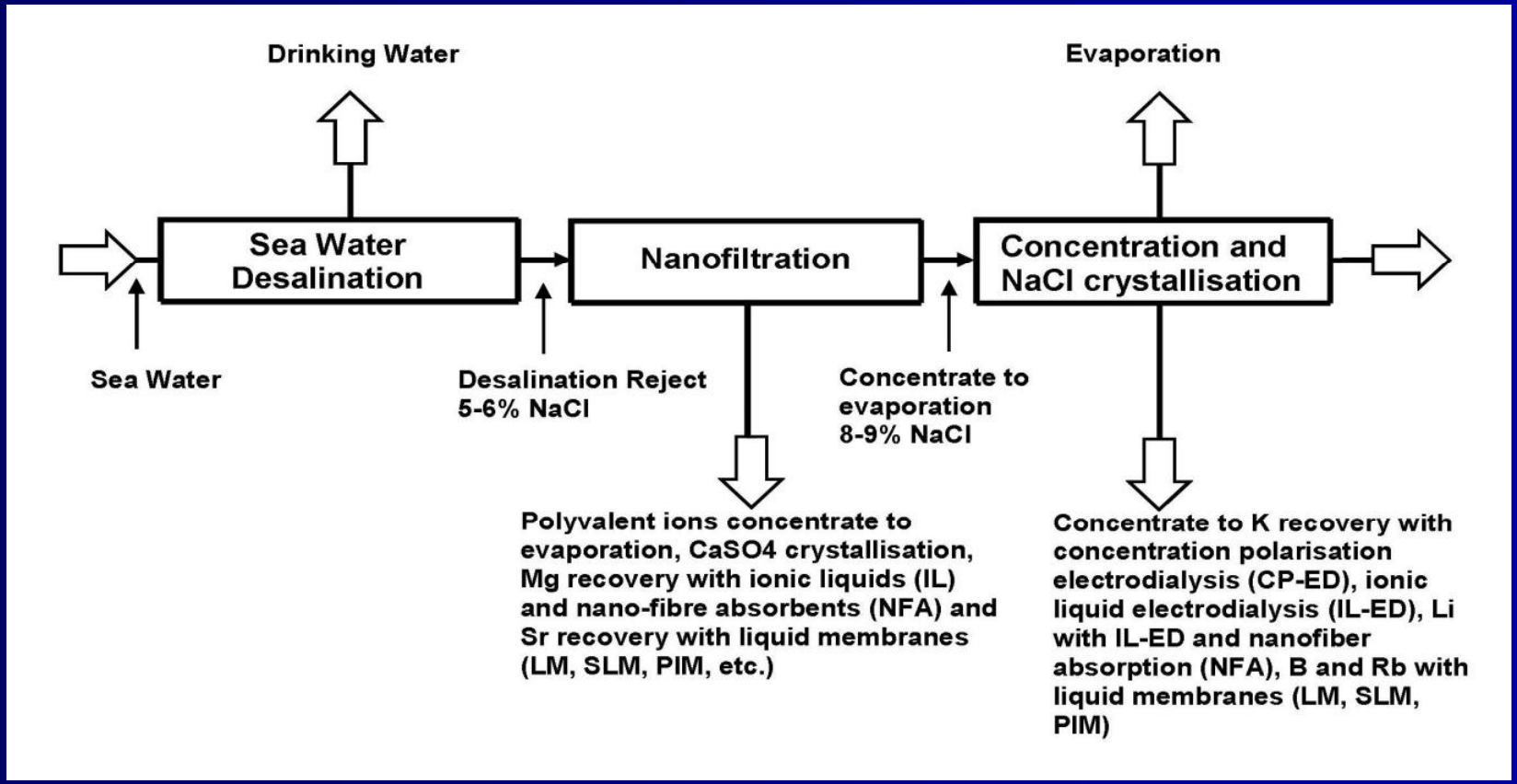
Following technologies are presently being developed:

- Improved nanofiltration (NF) with >95% polyvalent ion rejection
- Ion selective electrodialysis (IL-ED) differentiating between Na+ and K+
- Ionic liquid electrodialysis (IL-ED) for Li recovery
- Nanofiber absorbents (NFA) for Li separation
- Nanofiber absorbents (NFA) for Mg recovery
- Bipolar electrodialysis (BP-ED) for in situ precipitation of Mg(OH)2
- Polymer inclusion membranes (PIM) for boron and rubidium separation
- Supported liquid membranes (SLM), alternative to PIM
- Deep eutectic solvents (DES), alternative to ionic liquids

Vladimir M. Sedivy
Salt Partners Ltd, Erlenbach ZH, Switzerland

Salt Partners

New SWRO-NF-New Technologies process



Vladimir M. Sedivy
Salt Partners Ltd, Erlenbach ZH, Switzerland

Salt Partners

How much sea water is being processed in Europe?

Purpose	Sea Water in	All Salts in
	(t/y)	(t/y)
Desalination	1’000’781’000	37’563’000
Solar saltworks	305’157’000	11’351’000
Total	1’305’938’000	48’914’000

Vladimir M. Sedivy
Salt Partners Ltd, Erlenbach ZH, Switzerland

Salt Partners

What is the value of the considered elements?

Element	Annual quantity (t/y)	Average price (EUR/t)	Annual value (EUR/y)
B	6’176	4’100	25’321’600
Li	286	50’000	14’300’000
Mg	1’807’296	1’290	2’311’400’000
K	543’489	950	516’310’000
Rb	292	2’630’000	767’960’000
Sr	16’902	1’690	28’564’380
Total			**3’663’855’980**

Vladimir M. Sedivy
Salt Partners Ltd, Erlenbach ZH, Switzerland

Salt Partners

Why not turn your salt into gold?

Vladimir M. Sedivy
Salt Partners Ltd, Erlenbach ZH, Switzerland

10th World Salt Symposium 2018, Park City, Utah, USA