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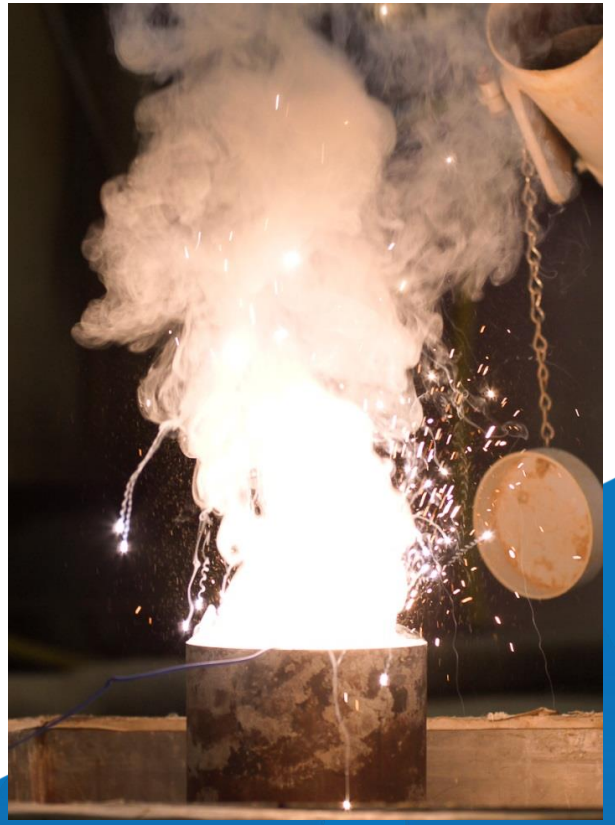
High Purity Concentrate Production – A Challenge for TLEM Developers



Technology and Low Emission Minerals Conference (TLEM)

13th/14th November 2018

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Minerals Business Unit, New Illawarra Rd, Lucas Heights, NSW 2234

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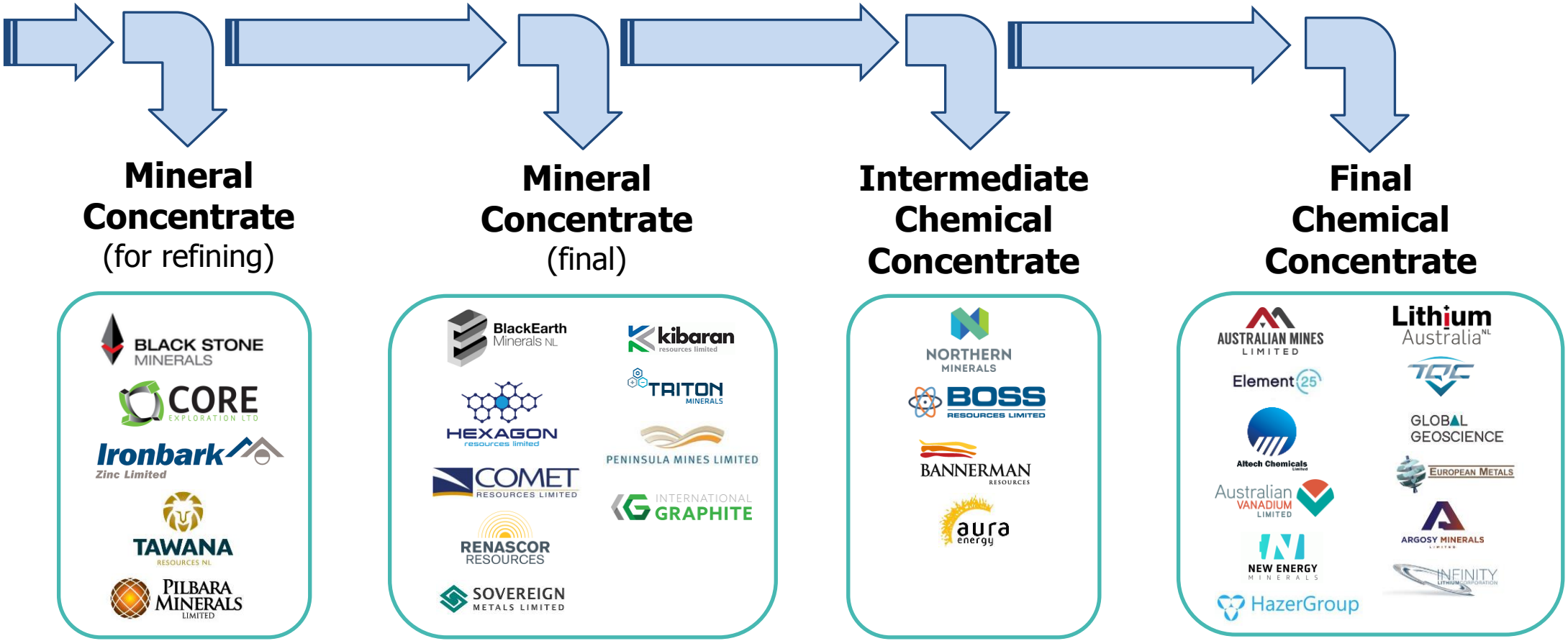
Context



- Majority of projects focussed on ‘final, high purity products’

Three (3) Key Questions

- **Question 1.** "What is high purity?"
- **Question 2.** "How do different high purity concentrate specifications compare?"
- **Question 3.** "What's the problem with analysing high purity concentrates?"

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Question 1

- "What is high purity?"

  > relative to context – mineral versus elemental

  e.g. 99% mineral purity vs 99% chemical compound

- Exclusively concerned with chemical purity, typically for a given chemical species

  e.g. Li_2CO_3, $LiOH.H_2O$, $NiSO_4.6H_2O$ etc

- In some case, at very high purities, only the specification for impurities might be provided

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Question 2

- "How do different high purity concentrate specifications compare?"
- The intention is to not focus in-depth on each specification, but to simply understand the variation and typical minimum / maximum values of impurities
- Includes lithium, uranium, rare earths, manganese, cobalt, nickel and silica/quartz (ANSTO exposure)
- Not intended as exhaustive listing. Obvious extension to HPA & V

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Lithium

Source		CLPC BG1	FMC Lithium	EV Grade#
Spec. Type		Low	High	V. Low
Li2CO3 (min)	%	99.5	99.5	99.6
H2O*	wt%	ns	0.5	0.1
Al	ppm	5	10	5
B	ppm			5
Ca	ppm	60	400	20
Cr	ppm			1
Cu	ppm	5	5	1
F	ppm			50
Fe	ppm	10	5	5
K	ppm	10		5
Mg	ppm	10		10
Mn	ppm	5		1
Na	ppm	20	500	10
Ni	ppm		6	5
Pb	ppm	20		1
Si	ppm	40		
Zn	ppm		5	
Cl	ppm	35	100	10
S	ppm	10	334	50
SO4	ppm	30	1,000	150
Acid insolubles	wt%		0.02	
d50	µm	2-8	6	
d90	µm		11	
d100	µm			10

Source		FMC Lithium	Clariant	SMM
Spec. Type		Low	High	Alt.
LiOH (min)	%	56.5	56.5-58.5	56.5
H2O*	wt%	Determined by weight loss		
Al	ppm	10		
Ca	ppm	15	100	150
Cd	ppm			1
Cr	ppm	5		1
Cu	ppm	5	10	
Fe	ppm	5	20	7
Hg	ppm			1
K	ppm	10	50	200
Mg	ppm		50	
Na	ppm	20	100	80
Ni	ppm	10		
Pb	ppm	10		1
Si	ppm	30		200
Zn	ppm	10	70	5
Cl	ppm	20	50	50
S	ppm	33	100	
SO4	ppm	100	300	150
Sn	ppm			1
CO2	wt%	0.3	0.5	0.5
Acid insolubles	wt%	0.01		
d100	µm	ns		

Li_2CO_3 Footnotes
CLPC - China Lithium Products Tech.
BG - Battery Grade
* at 500C / 30 min.
# undisclosed source
ns - not specified
ppm quoted at maximum value

LiOH Footnotes
SMM - Shanghai Metals Market
* at 500C / 30 min.
ns - not specified
ppm quoted at maximum value

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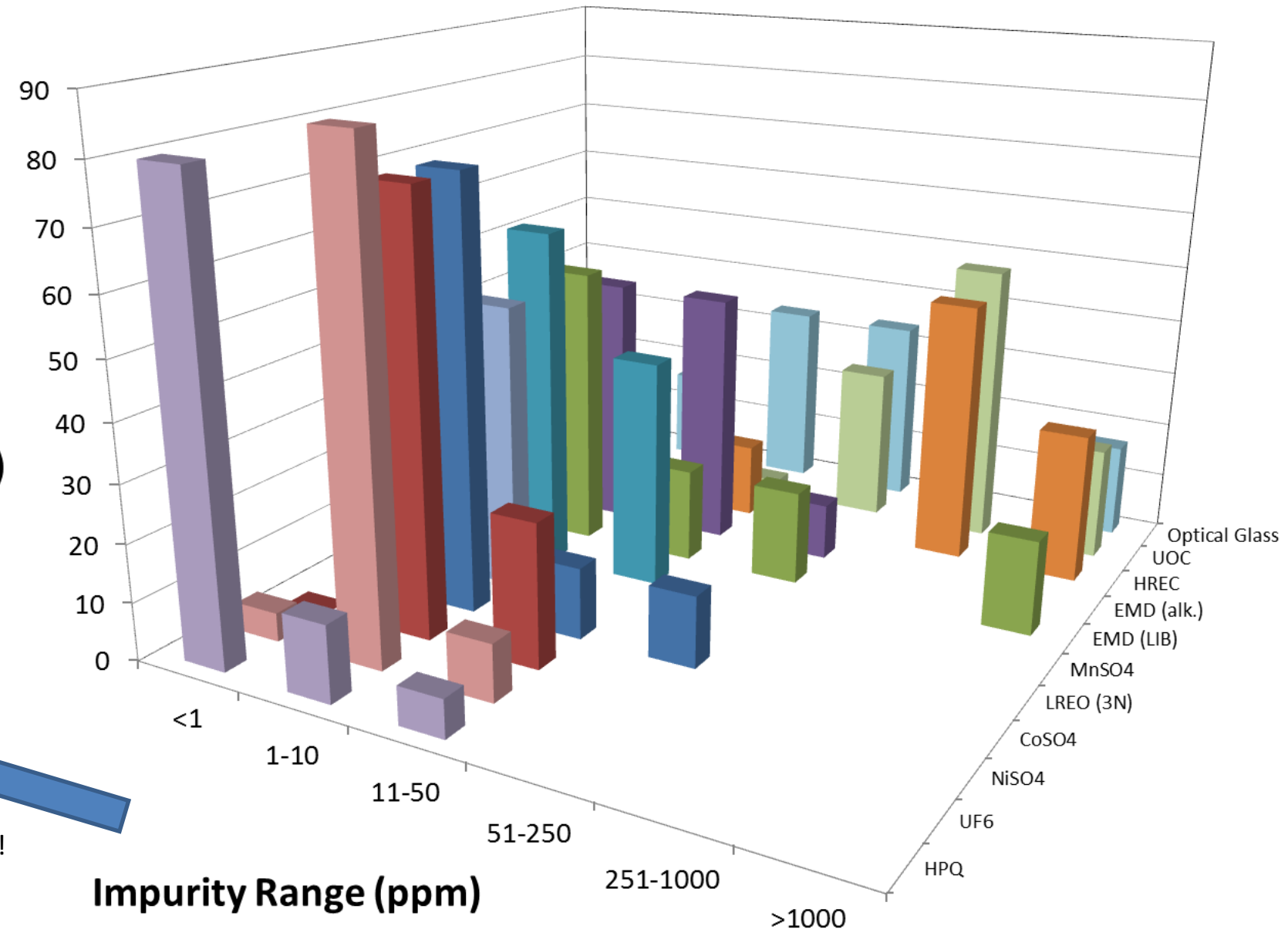
Specification Snapshot



$1x10^{-5}$

for $^{238}U/^{232}Th$

+ daughters!!!

Analysis

Element	Technique	Units	Dection Limit (DL)	Comment
Al,As,B,Be,Ca,Fe,K,Li,Mg,Na,P,S,	ICP-OES	ppm	2.5	Digest and analysis at minimum dilution
Si	ICP-OES	ppm	2.5-12.5	Digest and analysis at minimum dilution
Cd,Co,Cr,Cs,Cu, Mn,Mo,Ni,Pb,Rb,Sn,Th,Ti,U,Zn,Zr	ICP-MS	ppm	0.25-1.0	Digest and analysis at minimum dilution
Cl,F	ISE	ppm	2.5-12.5	Digest and analysis at minimum dilution
CO2/Ctotal	LECO	ppm	100	Direct measurement
Mass Loss	TGA	ppm	20	Based on % of 25 mg

- Refers to 'routine' analysis methods
- Alternative method development possible – MS vs OES
- Total Dissolved Solids (TDS) plays a key role
- But if target (ppm) approaches the DL (ppm)….

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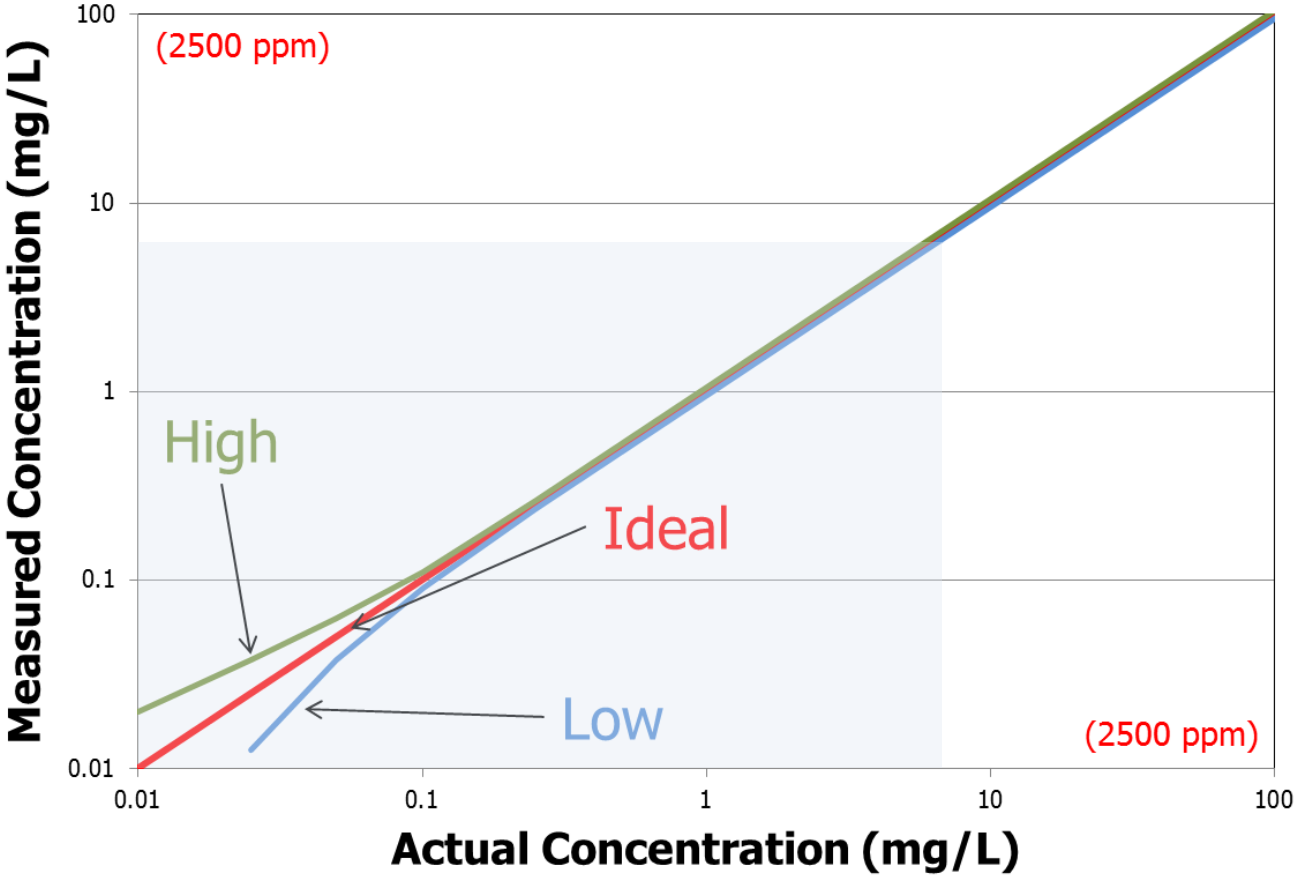
Analysis – The Challenge

- Uncertainty defines that analysis ‘at or near’ the DL means is prone to error even in the absence of matrix effects, interferences etc



Analysis – The Challenge

- Tabulated data presentation
- Comparison of effect of reduced detection limit (at 12.5 ppm)
- Requires a change to mindset – analysis, interpretation and expectation
- At ↓low levels, conventional analysis methods <u>are likely to be inappropriate</u>

Measured (ICP-MS)	Assumed Error	Calculated Solid Analysis (ppm)		
		Ideal	High	Low
(mg/L)	(%)		(ppm)	
5	5	125	131	119
2.5	5	63	66	59
1	5	25	26	24
0.5	5	12.5	13	12
0.25	5	6.3	6.6	5.9
0.1	10	2.5	2.8	2.3
0.05	25	1.25	1.6	0.9
0.025	50	0.625	0.9	0.3
0.01	100	0.25	0.5	0.0

Measured (ICP-OES)	Assumed Error	Calculated Solid Analysis (ppm)		
		Ideal	High	Low
(mg/L)	(%)		(ppm)	
50	5	1250	1313	1188
25	5	625	656	594
10	5	250	263	238
5	5	125	131	119
2.5	5	62.5	66	59
1	10	25	28	23
0.5	25	12.5	16	9
0.25	50	6.25	9	3
0.1	100	2.5	5	0

Take Home Messages

Take Home Messages

- "Don't look, and you are guaranteed to not find anything wrong."

"To combat the issue, the company will build a US$25 million ion exchange system to remove the uranium, with commissioning expected by the end of June 2019 quarter, subject to approvals."

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Take Home Messages

- Specifications varying depending on the intended application and purpose – little value in comparing 'apples with oranges'
- Any specification dealing with >99.5% purity is going to 'tight' on a number or for most elements
- ALL projects which target such products will be challenged
- A change to mindset is required w.r.t. analysis, interpretation and expectation involving project development teams, service providers and vendors alike

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Thank you