

# OreLog<sup>®</sup>



***Downhole elemental logging  
in exploration & mining***

UMWELT- UND INGENIEURTECHNIK GMBH DRESDEN (UIT)  
BELONGS TO  
GENERAL ATOMICS EUROPE GRUPPE  
AND AS SUCH IS PART OF  
THE GLOBAL NETWORK OF GENERAL ATOMICS

GA and affiliated companies  
operate on five continents

The group comprises  
over 15,000 employees

The group occupies more than 3 million  
square feet of engineering, laboratory  
and manufacturing facilities

GA subsidiaries include General Atomics Europe GmbH based in Saxony  
and Brandenburg, Heathgate Resources Pty Ltd (South Australia), GA  
Uranium Resources Group, Diazyme Laboratories Inc. and GA Honeywell  
Uranium Conversion Partnership

General Atomics is a defense and  
diversified technologies company



GLOBAL PROGRESS THROUGH TECHNOLOGY





# LOGGING ORE BUILDING ELEMENTS IN EXPLORATION & MINING

OreLog®

A NEW LOGGING TOOL FOR THE CONTINUOUS QUALITATIV AND QUANTITATIV MEASUREMENT OF DESIRABLE AND UNDESIRABLE ORE BUILDING ELEMENTS ALONG A BOREHOLE.



Boreholes down to 122 mm OD (PQ)



OreLog® in blast holes

OreLog®

THE IMPROVED VERSION OF THE APFN SERIES LOGGING TOOLS DEVELOPED AND APPLIED BY UIT GMBH IN AUSTRALIA AND USA SINCE 2012.

IT WAS CREATED TO HELP IMPROVE AND STREAMLINE EXPLORATION & MINING OPERATION PROGRAMS.

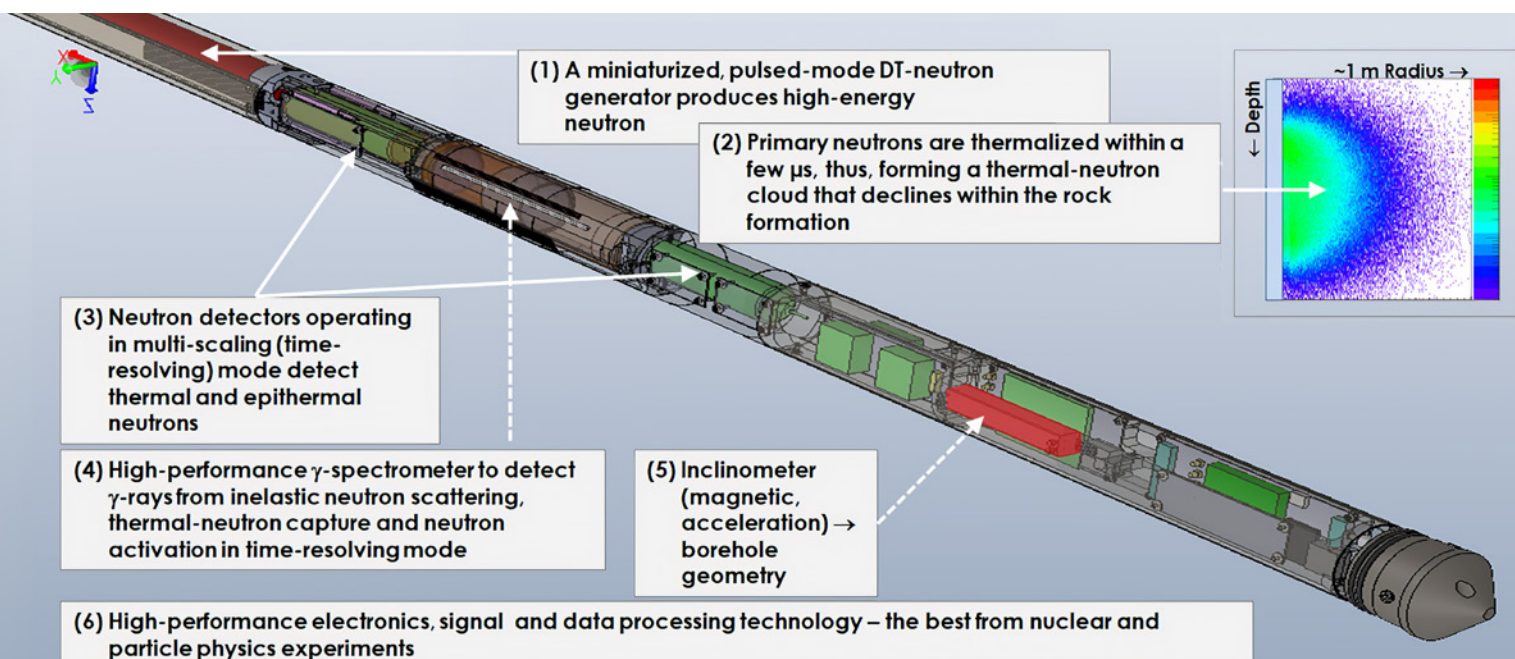
## BOREHOLE TYPES:

- Exploration and production holes (blast holes in open pits mines)
- Uncased or CI-free plastic casing, empty or water filled
- PQ boreholes. OD minimum 122 mm (4,8 ")
- Logging depth up to 1,000 m
- Vertical or semi-vertical boreholes



OreLog® for exploration

## INTEGRATIVE TECHNOLOGY



### OreLog® tool :

- 3 m (9.8 ft) length, 76 mm (3") OD, 30 kg (66 lbs) weight
- Pressure rating 10 MPa (1,450 psi)
- Operating temperature < 50 °C
- Logging depth: 1000 m

### Pulsed neutron generator:

- DT-neutron source within a miniaturized accelerator tube
- Neutron source strength: approximately 100 million neutrons/s

### Detectors:

- Several neutron- and gamma-detectors logging in time
- High-performance  $\gamma$ -ray spectrometer
- $\gamma$ -ray energy range from 0.5 MeV up to 10 MeV, multi-scaling spectroscopy

### Data output:

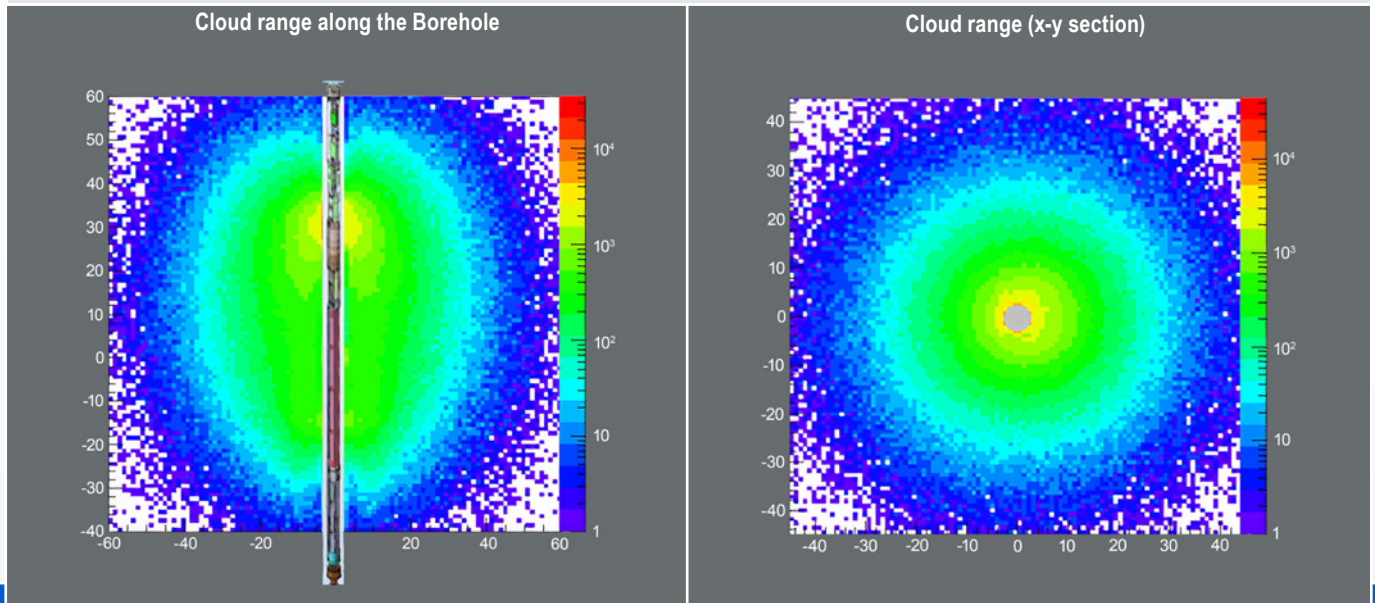
- LAS file including operational parameters and all logging data/
- Deduced parameters, suitable for direct input into WellCAD or
- Other logging data processing software
- Direct import into 3D geological modelling software (Leapfrog)

ALL BY ONE TOOL !



## VOLUMETRIC CAPTURE ALONG THE BOREHOLE

- Neutron 'cloud' Range:
- 0.4m -1 m (horizontal resolution)
  - 1.5 – 2 m (vertical resolution)
  - At travel speed from 1 to 3 m/min



### SOPHISTICATED CALIBRATION MODEL

- Validation of algorithms against mineralogical assays from core hole samples including mineral abundances/elemental concentrations and density, porosity, estimated hydrological permeability
- Correction of measured parameters for systematic influences of formation characteristics (in particular neutron absorption strength) and borehole radius (washout effects in sediment rocks)
- Decomposition of  $\gamma$ -spectra (measured in various time windows) by sophisticated unfolding algorithms (template matching) applied to both natural and neutron-induced  $\gamma$ -spectra
- Field specific calibration in well documented reference boreholes

### DIGITAL CALIBRATION USING MONTE CARLO NUMERICAL MODELLING



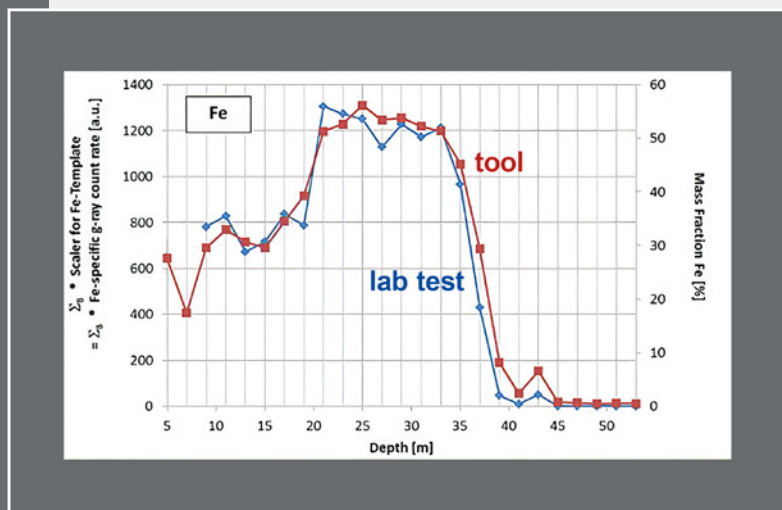
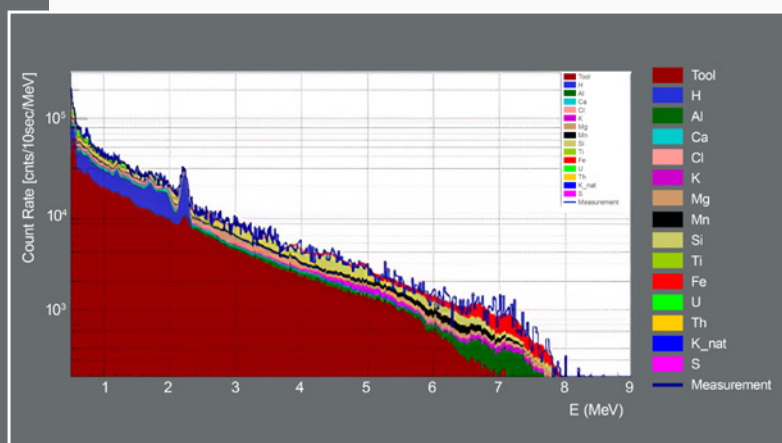
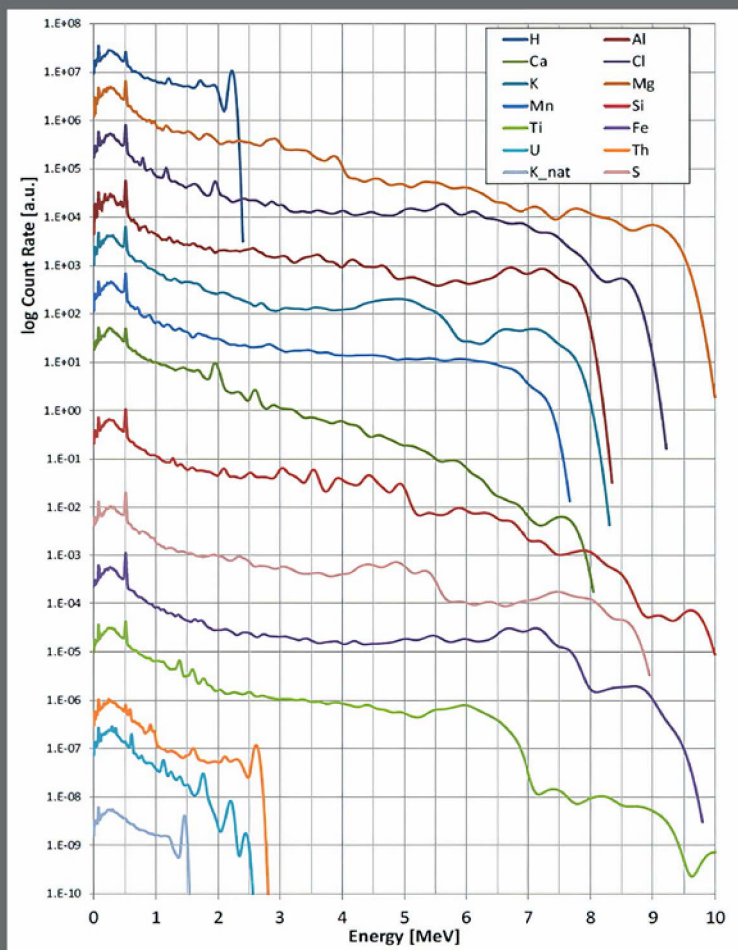
Field specific calibration

## DIRECT ACCESS TO ORE CHEMISTRY

### *From content of ore building elements ...*

MEASURING PRINCIPLE	LOGGED AND DEDUCED PARAMETERS
(n-generator on)	Mineral abundance
	Main elemental concentrations
γ-spectroscopy in passive mode	Abundance of K, U and Th

OreLog® allows in-situ characterization of ore formations by neutron/γ-ray spectroscopy



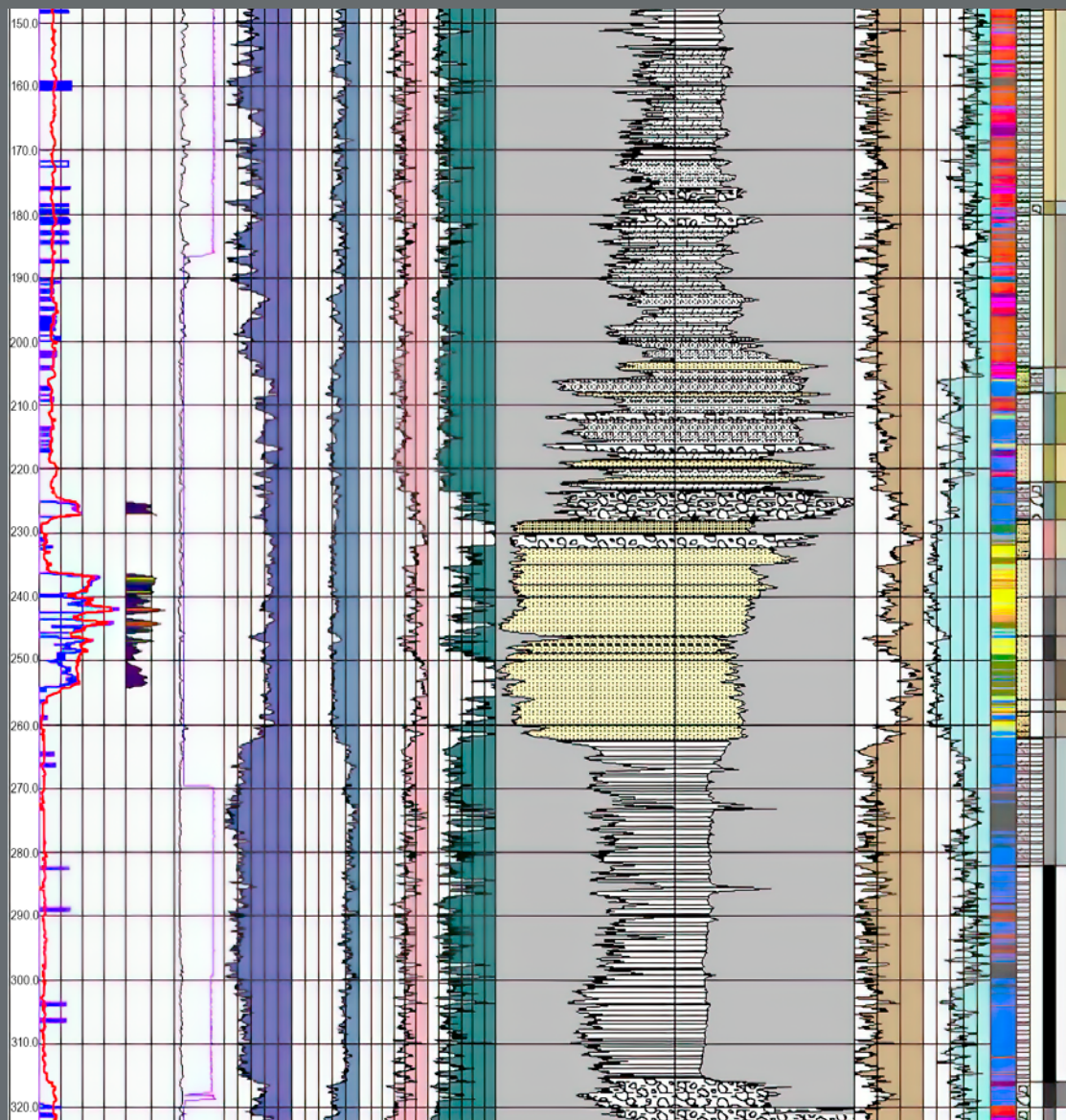
With continuous results along the borehole, OreLog® provides detailed element abundance and variability of the formation.



# DIRECT ACCESS TO ORE CHEMISTRY

## ... to lithology

MEASURING PRINCIPLE	LOGGED AND DEDUCED PARAMETERS
Intensity of back-scattered neutrons	Formation density (bulk, matrix, dry)
Neutron intensity in center and at periphery of thermal neutron cloud	Hydrogen Index (HI) → Porosity → Deduced hydrological permeability
Thermal-neutron decline in center and at periphery of thermal neutron cloud	Bulk neutron absorption cross section $\Sigma_a$
	Indicative clay content
	Post-burst neutron decline



OreLog® our complementary tool for lithology determination

OreLog® represents a new exploration and ore recovery technique for exploration & mining

## *Your benefits*

- Quantitative mineral logging based on high-performance γ-ray spectroscopy for quantifying the abundances of main elements/minerals in a formation
- Comprehensive depth-specific formation data
- Detailed mineralogical analysis in complex deposits
- Greater volumetric information (~1,0 m radius from the core material)
- Better sampling statistics and reliability in resource estimation (exploration campaign)

## *Saving money*

### BY EXPLORATION CAMPAIGNS

- Partial substitution of core boreholes by cheaper RC drilling (previous calibration of the OreLog® algorithms)
- Collection and analysis of fewer samples
- Logging data for direct import into the main commercial geological modelling software (saving time and better quality assurance)
- Backup of raw data for re-processing at any time

### BY OPEN PIT MINING (BLAST HOLES)

- Fast and reliable sorting of low-grade and high-grade material
- Energy saving by avoiding crushing, milling and processing of waste or poor material (under the cut-off-grade)
- Avoids sending rich material to waste stock piles



### Safety

OreLog® is not a permanent radioactive tool.

It is equipped with an electric neutron tube that can be active (ON) or inactive (OFF).

OreLog® is activated only inside the boreholes without risks for the operators.

During the surface handling operations or any necessary cases the tool can be turned OFF at any time.



# Range of UIT services

Electrons per shell																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1 <b>H</b> Hydrogen 1.008	2 <b>He</b> Helium 4.0026	3 <b>Li</b> Lithium 6.94	4 <b>Be</b> Beryllium 9.0122	5 <b>B</b> Boron 10.81	6 <b>C</b> Carbon 12.011	7 <b>N</b> Nitrogen 14.007	8 <b>O</b> Oxygen 15.999	9 <b>F</b> Fluorine 18.998	10 <b>Ne</b> Neon 20.180	11 <b>Na</b> Sodium 22.990	12 <b>Mg</b> Magnesium 24.305	13 <b>Al</b> Aluminium 26.981	14 <b>Si</b> Silicon 28.085	15 <b>P</b> Phosphorus 30.974	16 <b>S</b> Sulfur 32.06	17 <b>Cl</b> Chlorine 35.45	18 <b>Ar</b> Argon 39.948
19 <b>K</b> Potassium 39.098	20 <b>Ca</b> Calcium 40.078	21 <b>Sc</b> Scandium 44.956	22 <b>Ti</b> Titanium 47.88	23 <b>V</b> Vanadium 50.942	24 <b>Cr</b> Chromium 51.996	25 <b>Mn</b> Manganese 54.938	26 <b>Fe</b> Iron 55.845	27 <b>Co</b> Cobalt 58.933	28 <b>Ni</b> Nickel 58.693	29 <b>Cu</b> Copper 63.546	30 <b>Zn</b> Zinc 65.38	31 <b>Ga</b> Gallium 69.723	32 <b>Ge</b> Germanium 72.630	33 <b>As</b> Arsenic 74.922	34 <b>Se</b> Selenium 78.971	35 <b>Br</b> Bromine 79.904	36 <b>Kr</b> Krypton 83.798
37 <b>Rb</b> Rubidium 85.468	38 <b>Sr</b> Strontium 87.62	39 <b>Y</b> Yttrium 88.906	40 <b>Zr</b> Zirconium 91.224	41 <b>Nb</b> Niobium 92.906	42 <b>Mo</b> Molybdenum 95.95	43 <b>Tc</b> Technetium (98)	44 <b>Ru</b> Ruthenium 101.07	45 <b>Rh</b> Rhodium 102.91	46 <b>Pd</b> Palladium 106.42	47 <b>Ag</b> Silver 107.87	48 <b>Cd</b> Cadmium 112.41	49 <b>In</b> Indium 114.82	50 <b>Sn</b> Tin 118.71	51 <b>Sb</b> Antimony 121.76	52 <b>Te</b> Tellurium 127.6	53 <b>I</b> Iodine 126.90	54 <b>Xe</b> Xenon 131.29
55 <b>Cs</b> Caesium 132.91	56 <b>Ba</b> Barium 137.33	57-71 Lanthanides		72 <b>Hf</b> Hafnium 178.49	73 <b>Ta</b> Tantalum 180.95	74 <b>W</b> Tungsten 183.84	75 <b>Re</b> Rhenium 186.21	76 <b>Os</b> Osmium 190.23	77 <b>Ir</b> Iridium 192.22	78 <b>Pt</b> Platinum 195.08	79 <b>Au</b> Gold 196.97	80 <b>Hg</b> Mercury 200.59	81 <b>Tl</b> Thallium 204.38	82 <b>Pb</b> Lead 207.2	83 <b>Bi</b> Bismuth 208.98	84 <b>Po</b> Polonium (209)	85 <b>At</b> Astatine (210)
87 <b>Fr</b> Francium (223)	88 <b>Ra</b> Radium (226)	89-103 Actinides		104 <b>Rf</b> Rutherfordium (261)	105 <b>Db</b> Dubnium (268)	106 <b>Sg</b> Seaborgium (269)	107 <b>Bh</b> Bohrium (270)	108 <b>Hs</b> Hassium (270)	109 <b>Mt</b> Meitnerium (278)	110 <b>Ds</b> Darmstadtium (281)	111 <b>Rg</b> Roentgenium (282)	112 <b>Cn</b> Copernicium (285)	113 <b>Nh</b> Nihonium (284)	114 <b>Fl</b> Flerovium (289)	115 <b>Mc</b> Moscovium (290)	116 <b>Lv</b> Livermorium (293)	117 <b>Ts</b> Tennessine (294)
57 <b>La</b> Lanthanum 138.91	58 <b>Ce</b> Cerium 140.12	59 <b>Pr</b> Praseodymium 140.91	60 <b>Nd</b> Neodymium 144.24	61 <b>Pm</b> Promethium (145)	62 <b>Sm</b> Samarium 150.36	63 <b>Eu</b> Europium 151.96	64 <b>Gd</b> Gadolinium 157.25	65 <b>Tb</b> Terbium 158.93	66 <b>Dy</b> Dysprosium 162.50	67 <b>Ho</b> Holmium 164.93	68 <b>Er</b> Erbium 167.26	69 <b>Tm</b> Thulium 168.93	70 <b>Yb</b> Ytterbium 173.05	71 <b>Lu</b> Lutetium 174.97	72 <b>Hf</b> Hafnium 178.49	73 <b>Ta</b> Tantalum 180.95	74 <b>W</b> Tungsten 183.84
89 <b>Ac</b> Actinium (227)	90 <b>Th</b> Thorium 232.04	91 <b>Pa</b> Protactinium 231.04	92 <b>U</b> Uranium 238.03	93 <b>Np</b> Neptunium (237)	94 <b>Pu</b> Plutonium (244)	95 <b>Am</b> Americium (243)	96 <b>Cm</b> Curium (247)	97 <b>Bk</b> Berkelium (247)	98 <b>Cf</b> Californium (251)	99 <b>Es</b> Einsteinium (252)	100 <b>Fm</b> Fermium (257)	101 <b>Md</b> Mendelevium (258)	102 <b>No</b> Nobelium (259)	103 <b>Lr</b> Lawrencium (261)	104 <b>Rf</b> Rutherfordium (261)	105 <b>Db</b> Dubnium (268)	106 <b>Sg</b> Seaborgium (269)

OreLog®

REE (Sc,Y)

U recovery (ISR)

Main PGM refining

NORM removal (REE)

REE recovery/refining

Radiometric

Magnet REE refining

Sc recovery/refining

PGM (other noble metals)

Ti/Zr/Nb/Ta recovery

Cu-Ag-Au recovery

Energy storage



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