



# Periodic Table of Elements

## Geological Survey Critical Minerals Study

Critical Elements (U.S. Dept. of Interior 2018, 2022)

Elements identified as promising in ND coals by the NDGS

Rare earth elements

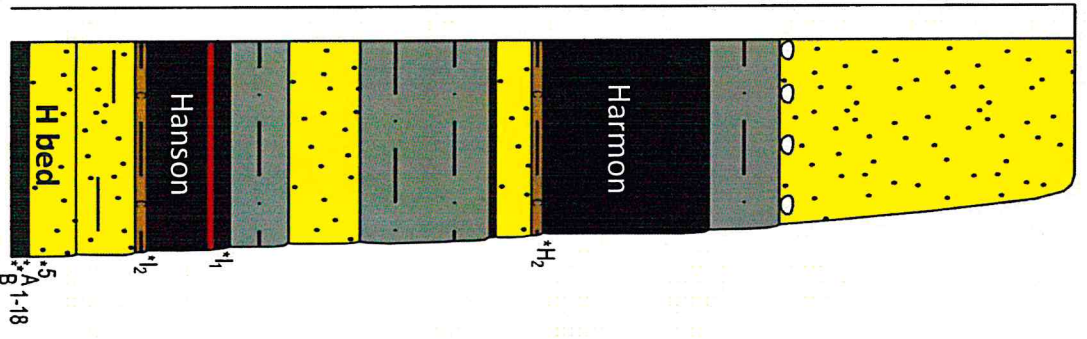
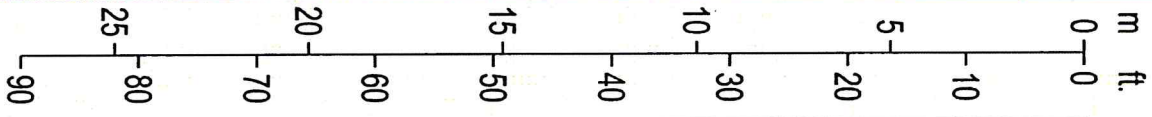
Other critical elements

1 H Hydrogen	2 He Helium																																																
3 Li Lithium	4 Be Beryllium	5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon	11 Na Sodium	12 Mg Magnesium	13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon	19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton																
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon	55 Cs Cesium	56 Ba Barium	57-71 Lanthanides	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon														
87 Fr Francium	88 Ra Radium	89-103 Actinides	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138												
57 La Lanthanum	58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103			
89 Ac Actinium	90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138

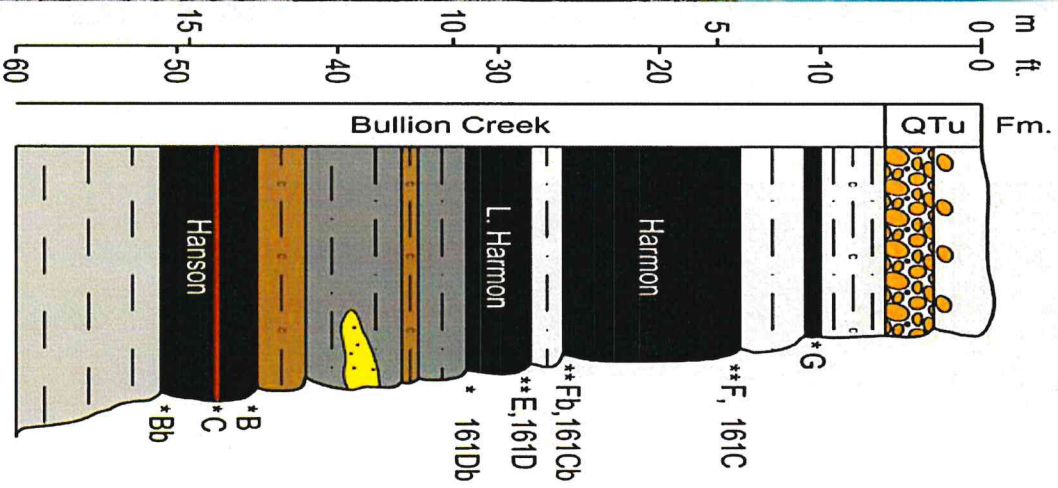
# CRITICAL MINERALS (elements)

Mineral	Application	Mineral	Application
Aluminum	almost all sectors of the economy	Magnesium	an alloy and for reducing metals
Antimony	lead-acid batteries and flame retardants	Manganese	steelmaking and batteries
Arsenic	semi-conductors	<b>Neodymium</b>	permanent magnets, rubber catalysts, lasers
Barite	hydrocarbon production	Nickel	stainless steel, superalloys, and rechargeable batteries
Beryllium	an alloying agent in aerospace and defense industries	Niobium	mostly in steel and superalloys
Bismuth	medical and atomic research	Palladium	catalytic converters and as a catalyst agent
<b>Cerium</b>	catalytic converters, ceramics, glass, and metallurgy	Platinum	catalytic converters
Cesium	research and development	<b>Praseodymium</b>	magnets, batteries, aerospace alloys, ceramics, colorants
Chromium	stainless steel and other alloys	Rhodium	catalytic converters, electrical components, a catalyst
Cobalt	rechargeable batteries and superalloys	Rubidium	research and development in electronics
<b>Dysprosium</b>	permanent magnets, data storage devices, and lasers	Ruthenium	catalysts, electrical contacts & chip resistors in computers
<b>Erbium</b>	fiber optics, optical amplifiers, lasers, and glass colorants	<b>Samarium</b>	magnets, an absorber in nuclear reactors, cancer therapy
<b>Europium</b>	phosphors and nuclear control rods	<b>Scandium</b>	alloys, ceramics, and fuel cells
Fluorspar	manufacture of aluminum, cement, steel, and gasoline	Tantalum	electronic components, capacitors and in superalloys
<b>Gadolinium</b>	medical imaging, permanent magnets, and steelmaking	Tellurium	solar cells, thermoelectric devices, alloying additive
Gallium	integrated circuits and optical devices like LEDs	<b>Terbium</b>	magnets, fiber optics, lasers, solid-state devices
Germanium	fiber optics and night vision applications	<b>Thulium</b>	various metal alloys and in lasers
Graphite	lubricants, batteries, and fuel cells	Tin	protective coatings and alloys for steel
Hafnium	nuclear control rods, alloys, high-temperature ceramics	Titanium	a white pigment or metal alloys
<b>Holmium</b>	permanent magnets, nuclear control rods, and lasers	Tungsten	wear-resistant metals
Indium	liquid crystal display screens	Vanadium	an alloying agent for iron and steel
Iridium	coating of anodes for electrochemical processes, catalyst	<b>Ytterbium</b>	catalysts, scintillometers, lasers, and metallurgy
<b>Lanthanum</b>	catalysts, ceramics, glass, polishing compounds, batteries	<b>Yttrium</b>	ceramic, catalysts, lasers, metallurgy, and phosphors
Lithium	rechargeable batteries	Zinc	in metallurgy to produce galvanized steel
<b>Lutetium</b>	medical imaging scintillators, electronics, cancer therapy	Zirconium	high-temperature ceramics and corrosion-resistant alloys

## Rare Earth Elements

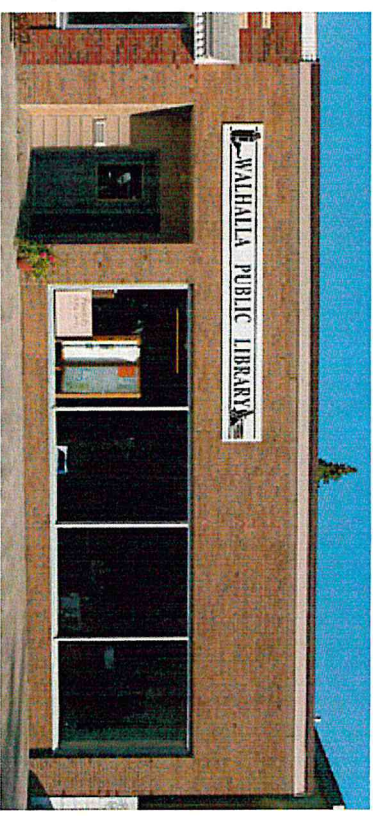


HB 1014



# Current Fossil Exhibit– Walhalla Library

In January of 2020, paleontologists from the North Dakota Geological Survey installed an updated exhibit of the first partial mosasaur skeleton collected from the Pembina Gorge in the Walhalla Library. At that time, NDGS paleontologists and the library staff discussed our desire to have a cast of the new mosasaur species from the Pembina Gorge put on display somewhere in town.



**Current Fossil Exhibit:** The first mosasaur fossils collected in the Pembina Gorge.



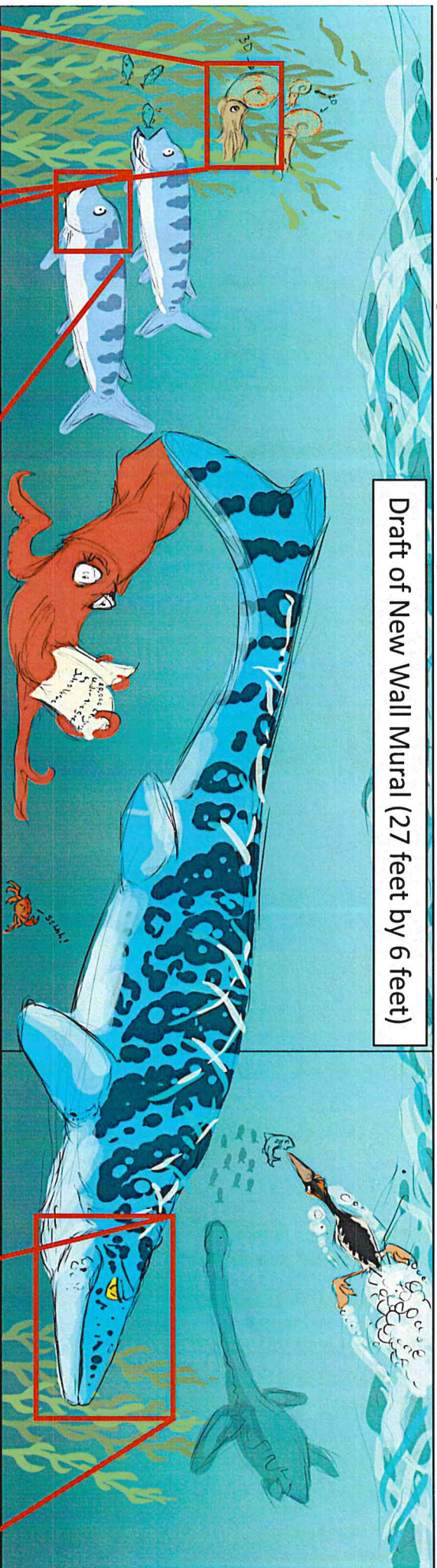
**Story Time:** Paleontologist Becky Barnes reads a book about the Pembina mosasaur.



**Proposed Location:** This wall and the one to the left will be the location of the new mural/exhibit.

# Proposed New Fossil Exhibit – Walhalla Library

The exhibit will consist of a large, kid friendly mural showing life in the Walhalla area during the Cretaceous. A 3D printed copy of the skull of the new mosasaur species will emerge from the wall, along with a cast of the skull of the large fish we are currently collecting in the Pembina Gorge and life reconstructions of ancient fossil squid.



## Projected Exhibit Costs

Expense	Low Estimate	High Estimate
3D Fossil Prints/Casts	\$4,000	\$5,000
Mural Artwork Design	\$5,000	\$7,000
Printing/Application	\$5,000	\$6,500
Molding/Casting Materials	\$1,000	\$1,500
<b>Total:</b>	<b>\$15,000</b>	<b>\$20,000</b>

Target Completion Date: July 1, 2023



3D Ammonites (Squid)



Cast Skull of Fossil Fish



3D Print of Mosasaur Skull



