



# Periodic Table of Elements

**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

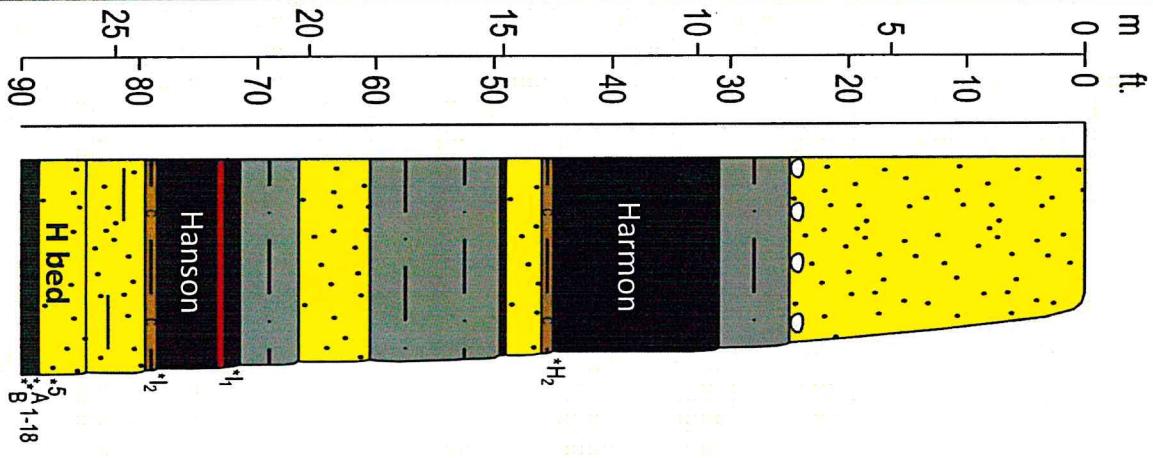
1 H Hydrogen	2 He Helium
3 Li Lithium	4 Be Beryllium
11 Na Sodium	12 Mg Magnesium
19 K Potassium	20 Ca Calcium
37 Rb Rubidium	38 Sr Strontium
55 Cs Cesium	56 Ba Barium
87 Fr Francium	88 Ra Radium
57 La Lanthanum	58 Ce Cerium
89 Ac Actinium	90 Th Thorium
91 Pa Protactinium	92 U Uranium
93 Np Neptunium	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	

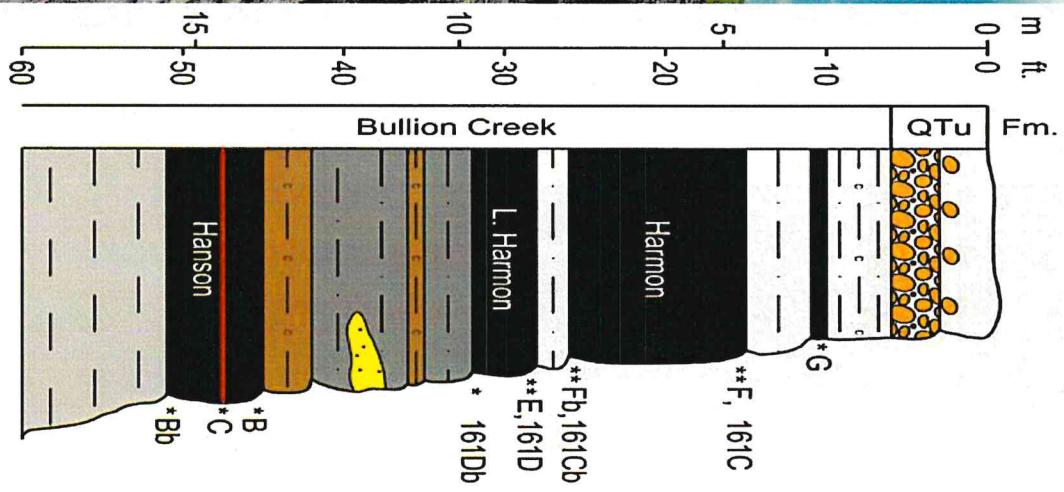
5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon
21 Sc Scandium	22 Ti Titanium	23 Cr Chromium	24 Mn Manganese	25 Fe Iron	26 Co Cobalt
39 Y Yttrium	40 V Vanadium	41 Cr Chromium	42 Mn Manganese	43 Fe Iron	44 Co Cobalt
56 Ba Lanthanides	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium
89-103 Ac 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 Nh Nihonium	113 Fl Flerovium	114 Mc Moscovium
115 Ds Livermorium	116 Rg Tennessine	117 Lv Oganesson	118 Ts Livermorium	119 At Tennessine	120 Rn Oganesson
121 Lu Lutetium	122 Yb Ytterbium	123 Tm Thulium	124 Ho Holmium	125 Er Erbium	126 Dy Dysprosium
127 Tb Terbium	128 Gd Gadolinium	129 Eu Europium	130 Sm Samarium	131 Pm Promethium	132 Nd Neodymium
133 Pr Praseodymium	134 Ce Neodymium	135 Eu Europium	136 Sm Samarium	137 Pm Promethium	138 Nd Neodymium
139 La Lanthanum	140 Ce Cerium	141 Pr Praseodymium	142 Nd Neodymium	143 Pm Promethium	144 Sm Samarium
145 Ce Lanthanum	146 Pr Cerium	147 Nd Praseodymium	148 Pm Neodymium	149 Sm Promethium	150 Eu Samarium
151 Eu Lanthanum	152 Pr Cerium	153 Nd Praseodymium	154 Pm Neodymium	155 Sm Promethium	156 Eu Samarium
157 La Lanthanum	158 Ce Cerium	159 Pr Praseodymium	160 Nd Neodymium	161 Pm Promethium	162 Sm Samarium
163 Eu Lanthanum	164 Pr Cerium	165 Nd Praseodymium	166 Pm Neodymium	167 Sm Promethium	168 Eu Samarium
169 Gd Lanthanum	170 Pr Cerium	171 Nd Praseodymium	172 Pm Neodymium	173 Sm Promethium	174 Eu Samarium
175 Tb Lanthanum	176 Pr Cerium	177 Nd Praseodymium	178 Pm Neodymium	179 Sm Promethium	180 Eu Samarium
181 Ho Lanthanum	182 Pr Cerium	183 Nd Praseodymium	184 Pm Neodymium	185 Sm Promethium	186 Eu Samarium
187 Tm Lanthanum	188 Pr Cerium	189 Nd Praseodymium	190 Pm Neodymium	191 Sm Promethium	192 Eu Samarium
193 Yb Lanthanum	194 Pr Cerium	195 Nd Praseodymium	196 Pm Neodymium	197 Sm Promethium	198 Eu Samarium
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# 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
Dysprosium	permanent magnets, data storage devices, and lasers	Ruthenium	catalysts, electrical contacts & chip resistors in computers
Erbium	fiber optics, optical amplifiers, lasers, and glass colorants	Samarium	magnets, an absorber in nuclear reactors, cancer therapy
Europium	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
Gadolinium	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	Thulium	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
Holmium	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
Lanthanum	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
Lutetium	medical imaging scintillators, electronics, cancer therapy	Zirconium	high-temperature ceramics and corrosion-resistant alloys

## Rare Earth Elements



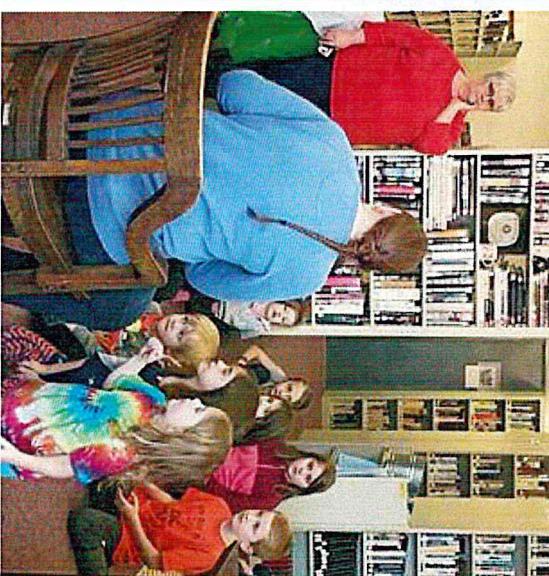


# Current Fossil Exhibit- Walhalla Library

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.



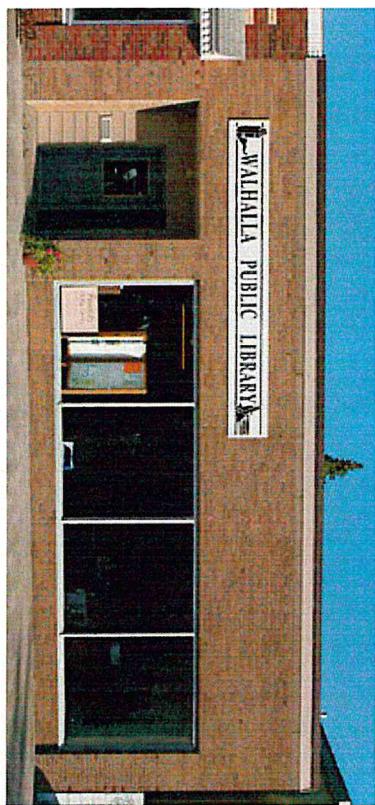
**Current Fossil Exhibit:** The first mosasaur fossils collected in the Pembina Gorge.



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



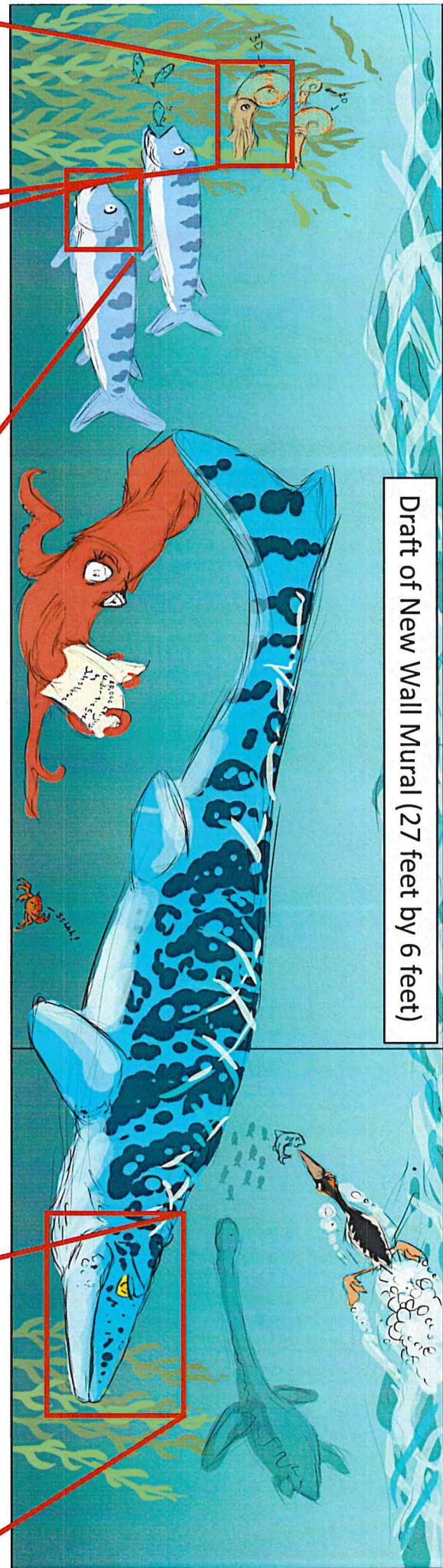
**Proposed Location:** This wall and the one to the left will be the location of the new mural/exhibit.



# Proposed New Fossil Exhibit – Walhalla Library

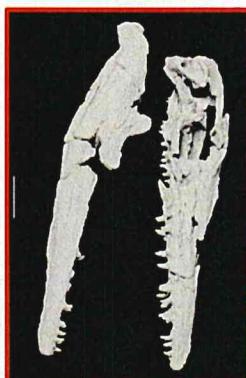
The exhibit will consist of a large, kid friendly mural showing life in the Walhalla area during the Cretaceous. A 3D printed copy of the skull of the new mosasaur species will emerge from the wall, along with a cast of the skull of the large fish we are currently collecting in the Pembina Gorge and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

Draft of New Wall Mural (27 feet by 6 feet)

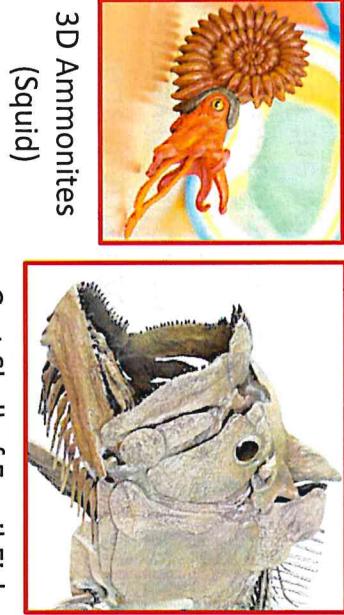


Projected Exhibit Costs

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>



3D Print of Mosasaur Skull



3D Ammonites

Cast Skull of Fossil Fish

Target Completion Date: July 1, 2023

### Field Inspector Costs to Hire and Train

<b>Combined Total Costs      \$30,932.42</b>		
<b>Hiring Process</b>		
HR - 4 hours	\$166.88	\$166.88
(administering hiring process)		
Average applications	10	\$682.20
Scoring - 0.5 hr/applicant	5	\$136.44
Interviewing-1 hr/applicant	4	\$136.44
Average # of interviews	4	\$545.76
First day orientation hours	8	\$1,817.48
Combined average rate	52.83	\$422.64
(HR, Payroll, IT, Supervisor)		
<b>Total Hiring Costs</b>		
		<b>\$1,817.48</b>
<b>Total Training Costs</b>		
		<b>\$29,114.94</b>
Average supervisor's hourly rate	120	\$67.57
Supervisor's hours-3 weeks	120	\$67.57
SR. Inspector hours - 8 weeks	320	\$60.53
Average Sr. Inspector's hourly rate	320	\$60.53
Ride-a-long Training		<b>\$19,369.60</b>
		<b>\$8,108.40</b>
<b>Safety Training</b>		
HAZWOP training		\$500.00
First Aid/CPR Training		\$20.00
		<b>\$520.00</b>
		<b>\$516.94</b>
Safety Equipment		
Hard Hats		\$15.99
Hard Hat Liner		\$35.00
SCBA Facemask		\$332.00
Medical Questionnaire & Fit Test		\$75.00
Safety Glasses		\$10.00
Gloves		\$10.00
Ice Cletes		\$38.95
		<b>\$600.00</b>
Safety Clothing		
FR Clothing		\$400.00
Boots		\$200.00
		<b>\$600.00</b>

