DIGITAL MAPPING TECHNIQUES 2025

The following was presented at DMT'25
May 18 - 21, 2025

The contents of this document are provisional

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2025

Digital Mapping Techniques

by James Amato & Rachel Toner

A standard format for the digital publication and analysis of Carbon Ore, Rare Earth, and Critical Minerals

UW | School of Energy Resources

UNIVERSITY OF WYOMING

School of Energy Resources

The School of Energy Resources (SER) collaborates with stakeholders at the state, national, and international levels to develop energy technologies and policies to grow and support Wyoming's robust energy sector. SER's mission is to advance energy-driven economic development for the state, and it leads the University of Wyoming's talent and resources for interdisciplinary research and outreach, fulfilling Wyoming's promise to be a global leader in a thriving and sustainable energy future.

GeMS Extension Packs

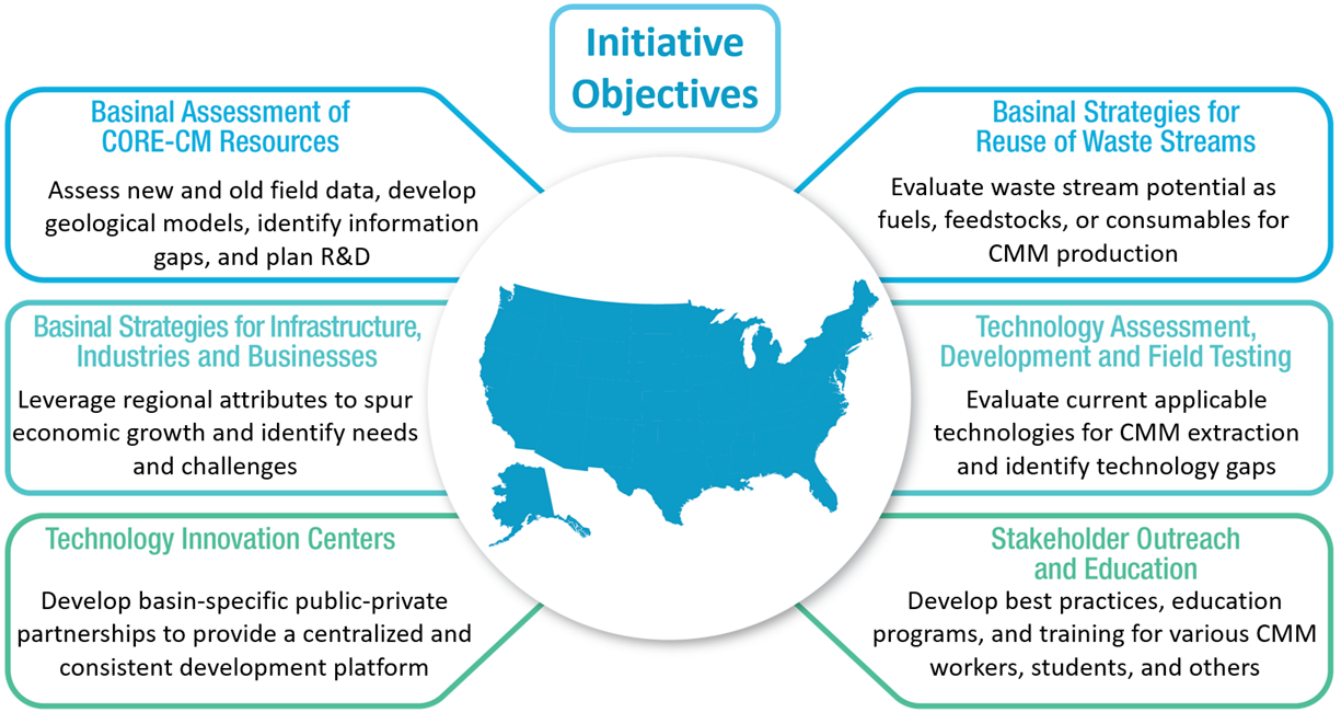
The **CORE-CM extension** provides for the encoding of the content pertaining to Carbon Ore, Rare Earth, and Critical Minerals *(in review)*.

The **CCS extension** provides for the encoding of the content pertaining to Carbon Capture and Storage *(in progress)*.

CORE-CM

The Carbon Ore, Rare Earth, and Critical Minerals (**CORE-CM**) initiative is a U.S. Department of Energy (DOE) program designed to develop domestic supply chains for rare earth elements and critical minerals from unconventional resources such as coal, industrial byproducts, mine tailings, produced waters, and more.

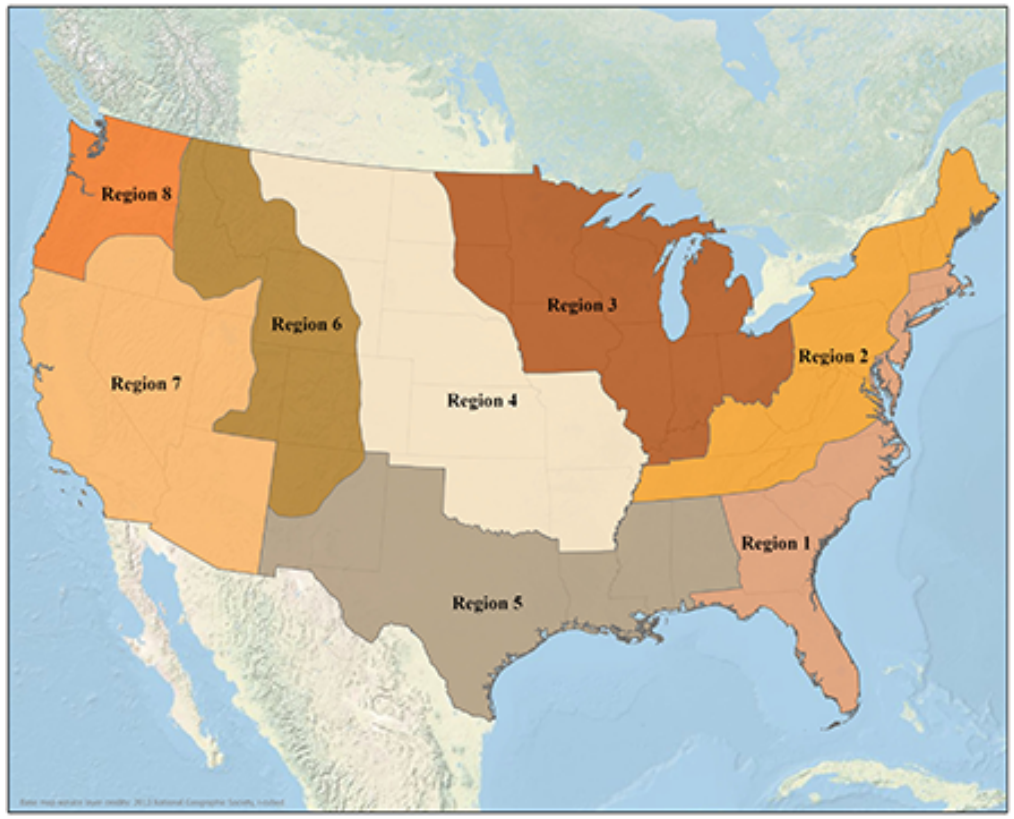
The initiative aims to reduce reliance on foreign-controlled REE/CM supply chains, ensure domestic access to key materials for energy, defense, and consumer technologies, convert industrial waste and byproducts into valuable materials, and create new economic opportunities, especially in regions affected by local industry decline.



CORE-CM Phase II

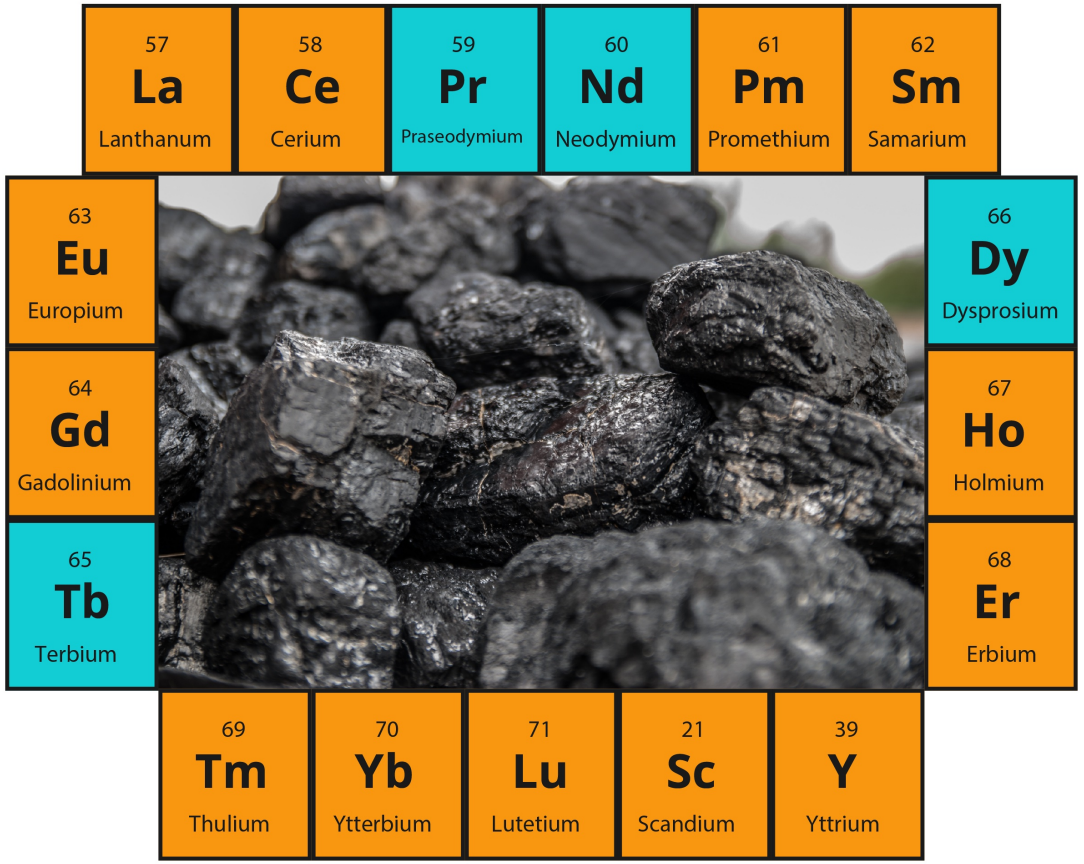
In January 2025, the DOE's Office of Fossil Energy and Carbon Management (FECM) announced $45 million in federal funding for six projects to create regional consortia to accelerate the development of critical mineral and materials supply chains.

The University of Wyoming (UW), School of Energy Resources (SER) will oversee Region 4 and participate in Regions 5 and 6.



With vast amounts of geochemical information being collected and compiled, there is a need to develop data standardization methods capable of being used across all regions to aid in the population of a federated database for organized and safe storage.

The objective of this project was to develop a relational database schema (standard format) for the digital publication and analysis of CORE-CM datasets across Regions 4, 5, and 6.



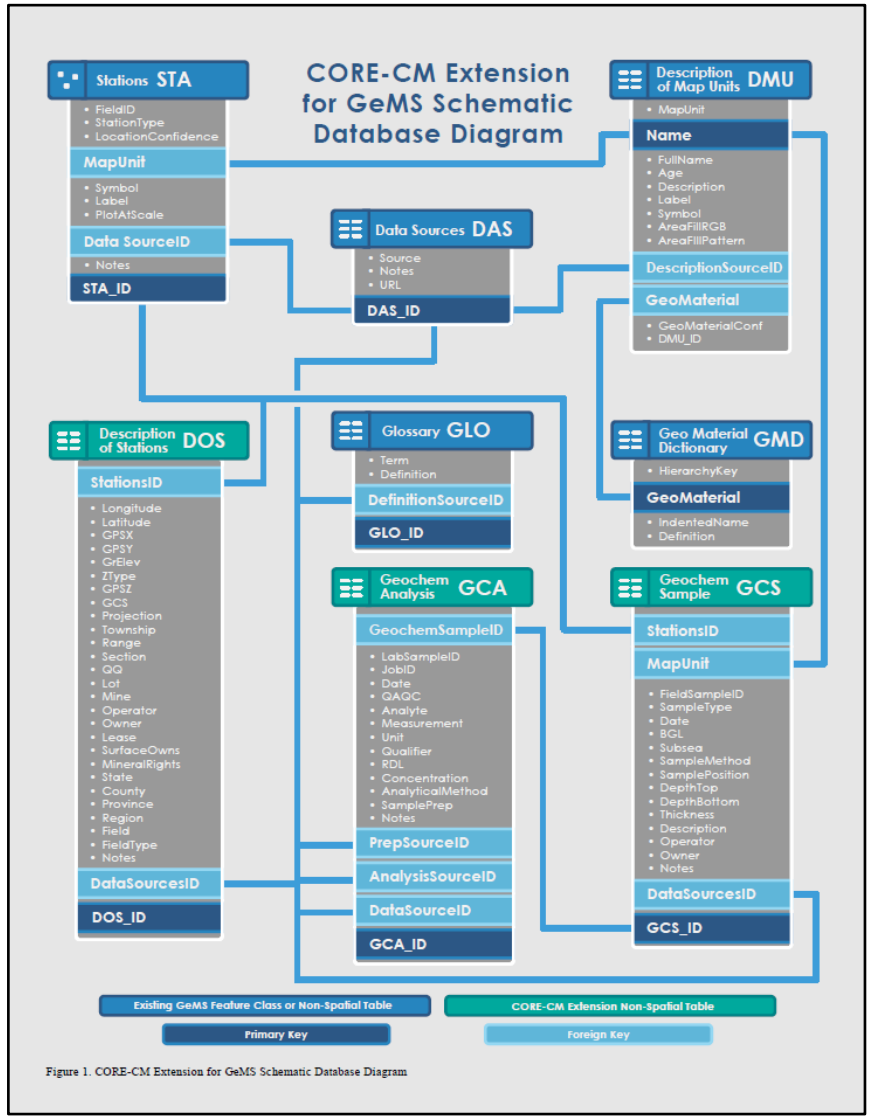


Figure 1. CORE-CM Extension for GeMS Schematic Database Diagram

Existing GeMS features and non-spatial tables

- Stations (STA)
- Description of Map Units (DMU)
- Data Sources (DAS)
- Glossary (GLO)
- Geo Material Dictionary (GMD)

CORE-CM extension non-spatial tables

- Description of Stations (DOS)
- Geochem Sample (GCS)
- Geochem Analysis (GCA)

The **Stations** (**STA**) point feature class represents the geographic locations where geological data is collected. Each station serves as a designated monitoring or sampling point and can support a variety of study types or operational needs. Stations may include locations for exploration wells, surface water, geologic outcrops, soil or rock exposures, prospect pits, waste streams, and byproduct.

Field Name	Data Type	Number Format	Length	Decimal	Domain	Required	Key
FieldID	Text		50				
StationType	Text		254		✓	✓	
LocationConfidence	Float	Numeric		0		✓	
MapUnit	Text		50		✓	✓	F
Symbol	Text		254				
Label	Text		50				
PlotAtScale	Float	Numeric		0			
DataSourceID	Text		50			✓	F
Notes	Text		3000				
STA_ID	Text		50			✓	P

STA.**StationType**: *(New attribute)*: Specifies type of point feature represented by this Station . Examples include “exploratory well” or “natural surface exposure”. Null values are not permitted. Selection is made from a domain: artificial exposure; byproduct; disposal well; exploration well; gas well; groundwater well; injection well; in-situ recovery well; monitor well; natural exposure; oil well; prospect pit; surface mine; surface water; underground mine; waste stream; water source well. Values defined in the Glossary table.

~~**ObservedMapUnit:**~~ (*Hidden GeMS attribute*): Records map unit identified in field (or interpreted from remote sensing) as cropping out at this station. Foreign key to Description of Map Units table.

The **Description of Map Units** (**DMU**) table is a non-spatial table that provides detailed information about the map units represented within the database. While map units themselves are typically depicted spatially, this table captures the descriptive attributes that define and characterize each unit.

Field Name	Data Type	Number Format	Length	Decimal	Domain	Required Field	Key
MapUnit	Text		50		✓	✓	
Name	Text		254		✓	✓	P
FullName	Text		254		✓	✓	
Age	Text		254		✓	✓	
Description	Text		3000				
Label	Text		30				
Symbol	Text		254				
AreaFillRGB	Text		254				
AreaFillPattern	Text		254				
DescriptionSourceID	Text		50				F
GeoMaterial	Text		254		✓	✓	F
GeoMaterialConfidence	Text		254			✓	
DMU_ID	Text		50			✓	

DMU.**Name**: Primary key. Short name of formal or informal map unit. Examples include “Wasatch”, “Fort Union”, and “Wyodak-Anderson”. Should not contain unit types (i.e., bed, zone, member, or formation) as these are included in the FullName field. Null values are not permitted. Selection made from a domain.

~~**HierarchyKey**~~ (*Hidden GeMS attribute*): Text string that indicates place of map unit or heading within DMU hierarchy Text string has form of “n-n-n”, “nn-nn”, “nn-nn-nn”, “nnn-nnn”, or similar; each dash-delimited fragment of string (1) is numeric, (2) has same length as others in string and in Description Of Map Units table, and (3) is left-padded with zeroes if values are greater than 9 .

~~**ParagraphStyle**~~ (*Hidden GeMS attribute*): Name of user-defined paragraph style that indicates hierarchy of map units and headings within DMU Examples of values are “DMUHeading1”, “DMUHeading2”, “DMUUnit1”, “DMUUnit2”. Values must be defined in Glossary table.

SCHEMA DEVELOPMENT

The **Description of Stations** (**DOS**) table is a non-spatial table that captures detailed information related to the features stored in the Stations feature class. While the feature class provides the geographic location of each station, this table complements it by storing comprehensive descriptive attributes that may not be easily represented spatially.

Field Name	Data Type	Number Format	Length	Decimal	Domain	Required	Key
StationsID	Text		50			✓	F
Longitude	Double	Numeric		6		✓	
Latitude	Double	Numeric		6		✓	
GPSX	Double	Numeric		2		✓	
GPSY	Double	Numeric		2		✓	
GrElev	Double	Numeric		2		✓	
ZType	Text		50		✓		
GPSZ	Double	Numeric		2			
GCS	Text		254				
Projection	Text		254				
Township	Text		5			✓	
Range	Text		5			✓	
Section	Float	Numeric		1		✓	
QQ	Text		4		✓		
Lot	Short	Numeric		0			
Mine	Text		254				
Operator	Text		254				
Owner	Text		254				
Lease	Text		254				
SurfaceOwns	Text		50		✓	✓	
MineralRights	Text		50		✓	✓	
State	Text		2		✓	✓	
County	Text		254		✓	✓	
Province	Text		254		✓	✓	
Region	Text		254		✓	✓	
Field	Text		254		✓		
FieldType	Text		50		✓	✓	
Notes	Text		3000				
DataSourceID	Text		50			✓	F
DOS_ID	Text		50			✓	P

SCHEMA DEVELOPMENT

The **Geochem Sample** (**GCS**) table is a non-spatial table that captures detailed information about the geochemistry samples collected and managed within the database. Each record in the table represents an individual sample, linking critical attributes such as field identification numbers, sampling methods, descriptions, and associated station locations.

Field Name	Data Type	Number Format	Length	Decimal	Domain	Required Field	Key
StationsID	Text		50			✓	F
MapUnit	Text		50		✓	✓	F
FieldSampleID	Text		50				
SampleType	Text		254		✓	✓	
Date	Date only	M/D/YYYY					
BGL	Float	Numeric		2		✓	
Subsea	Float	Numeric		2		✓	
SampleMethod	Text		254		✓	✓	
SamplePosition	Text		254				
DepthTop	Float	Numeric		2			
DepthBottom	Float	Numeric		2			
Thickness	Float	Numeric		2			
Description	Text		3000				
Operator	Text		254				
Owner	Text		254				
Notes	Text		3000				
DataSourceID	Text		50			✓	F
GCS_ID	Text		50			✓	P

SCHEMA DEVELOPMENT

The **Geochem Analysis** (**GCA**) table is a non-spatial table that captures detailed information about the geochemical analyses performed on samples collected and stored within the database. Each record in the table corresponds to an individual analytical result, linking to a specific sample from the GCS non-spatial table.

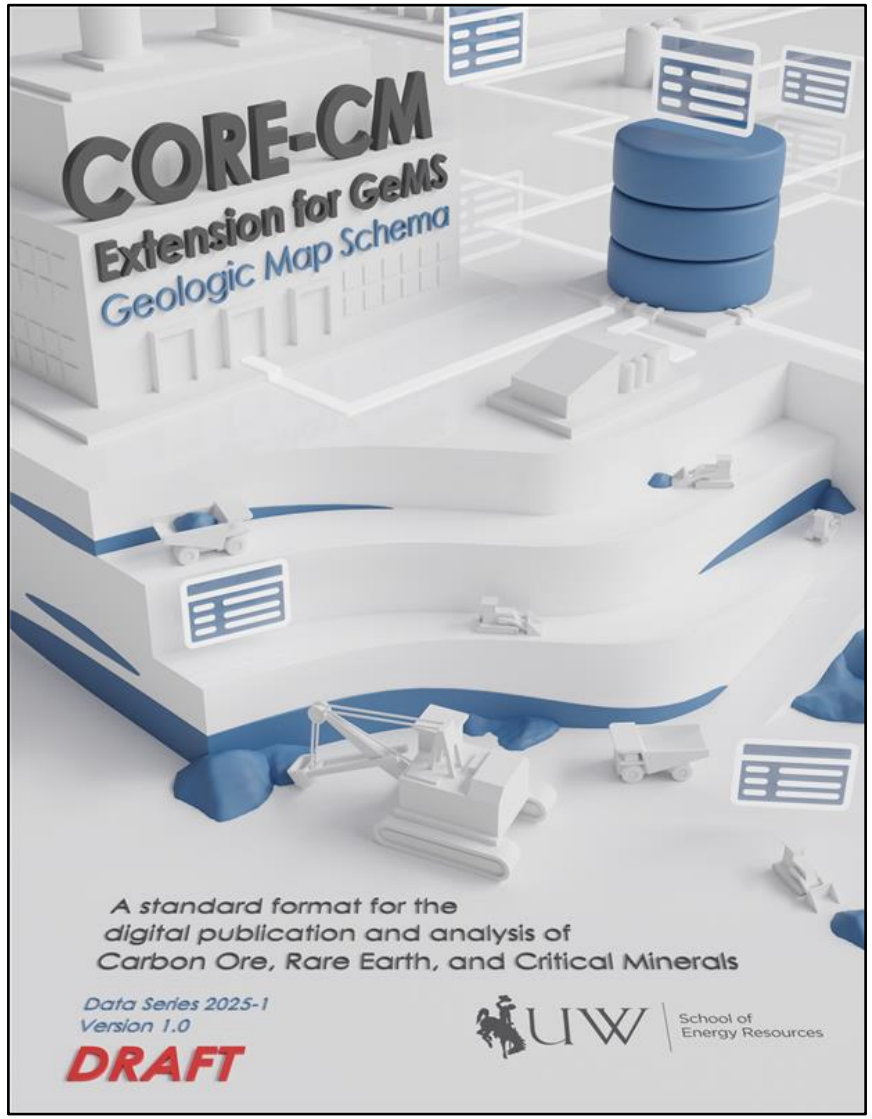
Field Name	Data Type	Number Format	Length	Decimal	Domain	Required Field	Key
GeochemSampleID	Text		50			✓	F
LabSampleID	Text		50			✓	
JobID	Text		50				
Date	Date only	M/D/YYYY				✓	
QAQC	Text		254		✓		
Analyte	Text		254		✓	✓	
Measurement	Double	Numeric		3		✓	
Unit	Text		5		✓	✓	
Qualifier	Text		5		✓		
RDL	Double	Numeric		3			
Concentration	Text		254		✓	✓	
SamplePrep	Text		254				
AnalyticalMethod	Text		254		✓		
Notes	Text		3000				
PrepSourceID	Text		50				F
AnalysisSourceID	Text		50				F
DataSourceID	Text		50			✓	F
GCA_ID	Text		50			✓	P

Inefficiencies of ***Column-Based*** Analyte Storage:

- **Scalability Issues** – As the number of analytes increases, adding new columns requires modifying the database schema, making it cumbersome and less adaptable to new data types.
- **Sparse Data Handling** – Different samples may have different analytes reported, leading to a sparsely populated table with numerous null values, which can degrade performance.
- **Limited Metadata Storage** – Qualifiers (e.g., "<" for below detection limits), units, and detection limits must either be stored in separate columns or embedded within the value field, reducing clarity and complicating queries.

Advantages of ***Row-Based*** Analyte Storage:

- **Flexible Data Structure** – New analytes can be added without altering the schema, making it more adaptable for evolving datasets.
- **Efficient Metadata Association** – Each result can be stored alongside its respective unit, detection limit, and qualifier in a structured manner, eliminating ambiguity.
- **Simplifies Queries & Analysis** – Data retrieval and aggregation become more efficient since all analytes are stored in a standardized format rather than requiring dynamic column selection.



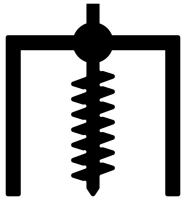
Technical documentation was drafted and will be internally published to support end users and facilitate adoption on a national scale.

- Introduces the scope of the project
- Discusses existing/new features and tables
- Defines attributes and their requirements
- Outlines attribute data types and relationships
- Includes a glossary of key terms

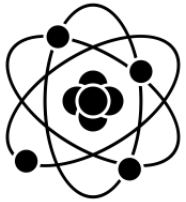
Interested in reviewing and providing feedback? Please email **jamato2@uwyo.edu**

Amato, J.A., Toner, R.N., Brown, T.C., and Bagdonas, D.A., 2025, CORE-CM extension for GeMS (Geologic Map Schema)—A standard format for the digital publication and analysis of Carbon Ore, Rare Earth, and Critical Minerals: University of Wyoming, School of Energy Resources, 3D Visualization Center, Data Series 2025-1, ver. 1.0, 21 p.

Version 2.0



Borehole Geophysics (**BHG**) — This table stores geophysical log data acquired from boreholes. It includes measurements obtained through downhole geophysical tools such as gamma-ray, resistivity, neutron porosity, sonic, and density logs. Each record is associated with a specific borehole and may include associated data such as logging date, tool type, depth intervals, and measured values.



Isotope Analysis (**ISO**) — This table contains isotopic composition data of various chemical elements derived from rock, mineral, fluid, or gas samples collected during geochemical studies. It includes information on isotopic ratios measurement units, analytical techniques, and associated uncertainties. Each record links to a specific sample and may also include contextual data such as collection method, analysis date, laboratory, and quality control flags.

CONCLUSION

The development of the CORE-CM extension is a fundamental step in standardizing geospatial and geoscientific data for the CORE-CM initiative. By leveraging the GeMS framework, the project has been able to incorporate complex geochemical datasets in a compatible format supporting integrated analysis and enhancing interpretative potential.

The CORE-CM extension lays a strong foundation for the analysis of geochemical and geological data related to critical resources. It not only supports existing research needs but also anticipates future trends in geospatial data management that will underpin innovation in resource exploration, energy policy, and economic development.

Continued refinement and national adoption of the schema will enhance its utility and enable it to remain a valuable resource for the broader scientific and industrial communities engaged in the responsible development of critical mineral resources.

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QUESTIONS?

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