The USGS Mineral Deposit Database Project (USMIN)

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Presented to ASTSWMO
25 October 2018
USGS mineral deposit database project

Outline

• Introduction
• Mineral deposits, especially critical minerals
• Mining topographic symbols
• Calculating mine features for hard rock mines
  • Colorado
  • Western US
• Questions
USGS mineral deposit database project

Objective: Develop a comprehensive 21st century geospatial database that is the authoritative source of the most important mines, mineral deposits, and mineral districts of the United States.

Purpose

• Provide high-quality, landscape scale data for land management to support actions and policies
• Provide electronic database for the minerals industry
• Focus since May 2017 has been critical minerals
• Electronic data and metadata available free on USGS website
Define some terms

• Mine features
  – Individual features produced by current or former mining or prospecting activities
  – In map view, these may be point features, such as shafts and prospect pits, or polygons, such as open pits and tailings ponds

• Mine
  – Workings on an orebody that allow extraction of valuable materials
  – A mine may have several shafts, several adits, and tens to hundreds of km of tunnels

• Active vs inactive vs abandoned mines
USMIN Project

Mineral Deposit Data
- Prospects
- Deposits
- Mines
- Districts

Mine Symbol Data
- Adit, prospect, mine, quarry, pit, glory hole, gravel borrow, shaft, dump, open pit mine, placer mine, sand and gravel pit, settling pond, slag pile, strip mine, tailings, trench.....

Commodity
- Resources
- Production

Geology
- Activity
- History

Deposit Type
- References

Scale:
- 1:62,500
- 1:24,000
- 1:48,000
- 1:62,500

USGS
- science for a changing world
# U.S. Critical Minerals 2018

**Executive & Secretarial Order**

<table>
<thead>
<tr>
<th>Product</th>
<th>Byproduct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>Antimony</td>
</tr>
<tr>
<td>Barite</td>
<td>Arsenic</td>
</tr>
<tr>
<td>Beryllium</td>
<td>Bismuth</td>
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<tr>
<td>Chromium</td>
<td>Cesium and rubidium</td>
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<tr>
<td>Graphite</td>
<td>Cobalt</td>
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<tr>
<td>Helium</td>
<td>Fluorspar</td>
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<tr>
<td>Lithium</td>
<td>Gallium</td>
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<tr>
<td>Magnesium</td>
<td>Germanium</td>
</tr>
<tr>
<td>Manganese</td>
<td>Indium</td>
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<tr>
<td>Niobium</td>
<td>Rhenium</td>
</tr>
<tr>
<td>Platinum group metals</td>
<td>Scandium</td>
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<tr>
<td>Potash</td>
<td>Tellurium</td>
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<tr>
<td>Rare earth elements</td>
<td>Vanadium</td>
</tr>
<tr>
<td>Strontium</td>
<td>Zirconium and Hafnium</td>
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<tr>
<td>Tantalum</td>
<td></td>
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<tr>
<td>Tin</td>
<td></td>
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<tr>
<td>Titanium</td>
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<tr>
<td>Tungsten</td>
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<tr>
<td>Uranium</td>
<td></td>
</tr>
</tbody>
</table>

**Published**

**In Progress**

**In Queue**
USMIN Products—FY18

- Building collaboration with states
- Published
  - *Global distribution of selected mines, deposits, and districts of critical minerals (PP1802)
  - *Rhenium occurrences in the United States
  - *Rare earth element occurrences in the United States
  - *Tin
  - *Tungsten
  - *Cobalt
  - Significant deposits of gold, silver, copper, lead, and zinc in Alaska
  - Mines, mineral occurrences, and mining districts in the Carlin area, Nevada
  - Prospect- and mine-related features from U.S. Geological Survey 7.5- and 15-minute topographic quadrangle maps of the United States
- Ongoing work
  - *Lithium
  - *Platinum group elements

* Elements on DOI critical mineral list
USMIN Project

Mineral Deposit Data
- Prospects
- Deposits
- Mines
- Districts

Mine Symbol Data
- Commodity
- Resources Production
- Geology
- Activity History
- Deposit Type
- References

Adit, prospect, mine, quarry, pit, glory hole, gravel borrow, shaft, dump, open pit mine, placer mine, sand and gravel pit, settling pond, slag pile, strip mine, tailings, trench.....

1:62,500
1:24,000
1:48,000
1:62,500
Mine symbols on historic USGS topographic maps
Pre-1942 historic mines - based on print date of topographic map
Possible application of USMIN data to inactive mines

• Topographic features show
  – Location of features
  – Number of features
  – Type of features

• Can query the data to show
  – Number of mine features
  – Density of mine features on the landscape
Information from Jeff Graves

• Director, Inactive Mine Reclamation Program, Colorado Department of Natural Resources, Division of Reclamation, Mining and Safety, Inactive Mine Reclamation Program

• 1980 to 1982 – Conducted physical inventory of AMLs within the State
  – Emphasis on Coal AMLs
  – ~8,000 mine hazards inventoried
    • 900 coal sites; 7,300 hardrock sites
  – 12 Active underground coal mine fires
  – >46,000 acres of land subject mine related subsidence
  – >170 adits with acid mine drainage
  – 95 waste and tailings piles impacting water quality

• Estimated >23,000 AML physical hazards throughout the State

• Never digitized
U.S. Forest Service Abandoned Mine Land Inventory Project

- Areas with natural acid rock drainage were also noted
- ~18,000 abandoned mine-related features inventoried
- ~900 features shave significant environmental problems and warrant further investigation
• ~18,000 abandoned mine-related features inventoried
• US Forest Service: 45,729 sq km in Colorado
• Colorado has 269,837 sq km
• So ~106,000 abandoned mine features in Colorado?
• No… Many parts of Colorado have few mine features
  – Mineral deposits mostly in the mountainous areas, where Forest Service lands are
• Best estimate: >20,000 abandoned mine-related features
A thought experiment: Colorado data

- Active mine database from Jeff Graves – State of Colorado
- USMIN topo data: 15,569 hard rock mining features, not including prospect pits
- 39,985 with prospect pits
- 1,426 features are inside active hard rock and permit buffers
- 4% of mines and prospect pits
- 10% of hard rock mining features
- So, removing the active mines from the USMIN topo data has a negligible effect

Topo symbols – active mines = inactive mines
Calculating inactive mine features – Colorado example

*Topo symbols – active mines = inactive mines*

- USMIN topo data
  - 15,569 hard rock mining features, not including prospect pits
  - 39,985 with prospect pits

- Colorado Department of Public Health and Environment (1980-1982) >23,000 AML physical hazards throughout the State

- Colorado Geologic Survey’s estimate (US Forest Service 1991-1999): >20,000 abandoned mine-related features

- Errors not accurately and precisely known
Complexities

8 major coal regions
>1,700 coal mine operations
Complexities

Uranium in western Colorado

The yellowcake is then shipped to a plant where the concentration of U-235 is raised to about 4% for use in fuel rods for nuclear power plants.
Complexities

• Complexities could be addressed in GIS with (relatively) simple queries
• However, to build those queries, you’d need the right databases
• Non-trivial and time consuming
<table>
<thead>
<tr>
<th></th>
<th>USMIN topographic database feature classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Adit</td>
</tr>
<tr>
<td>2</td>
<td>Air shaft</td>
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<tr>
<td>3</td>
<td>Bentonite pit</td>
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<tr>
<td>4</td>
<td>Borrow pit</td>
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<tr>
<td>5</td>
<td>Caliche pit</td>
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<tr>
<td>6</td>
<td>Cinder pit</td>
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<tr>
<td>7</td>
<td>Clay pit</td>
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<td>8</td>
<td>Coal mine</td>
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<tr>
<td>9</td>
<td>Diggings</td>
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<tr>
<td>10</td>
<td>Disturbed surface</td>
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<tr>
<td>11</td>
<td>Disturbed surface - pit</td>
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<tr>
<td>12</td>
<td>Evaporation pond</td>
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<tr>
<td>13</td>
<td>Glory hole</td>
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<tr>
<td>14</td>
<td>Gravel pit</td>
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<tr>
<td>15</td>
<td>Gravel/borrow pit - undifferentiated</td>
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<td>16</td>
<td>Hydraulic mine</td>
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<tr>
<td>17</td>
<td>Iron pit</td>
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<td>18</td>
<td>Leach pond</td>
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<tr>
<td>19</td>
<td>Lignite pit</td>
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<tr>
<td>20</td>
<td>Mill site</td>
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<tr>
<td>21</td>
<td>Mine</td>
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<tr>
<td>22</td>
<td>Mine dump</td>
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<tr>
<td>23</td>
<td>Mine shaft</td>
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<tr>
<td>24</td>
<td>Open pit mine</td>
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<tr>
<td>25</td>
<td>Open pit mine or quarry</td>
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<tr>
<td>26</td>
<td>Ore stockpile/storage</td>
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<tr>
<td>27</td>
<td>Placer mine</td>
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<tr>
<td>28</td>
<td>Prospect pit</td>
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<tr>
<td>29</td>
<td>Pumice pit</td>
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<tr>
<td>30</td>
<td>Quarry</td>
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<tr>
<td>31</td>
<td>Quarry - gypsum</td>
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<tr>
<td>32</td>
<td>Quarry - limestone</td>
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<tr>
<td>33</td>
<td>Quarry - pumice</td>
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<td>34</td>
<td>Quarry - rock</td>
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<td>35</td>
<td>Salt evaporator</td>
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<td>36</td>
<td>Sand and gravel pit</td>
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<tr>
<td>37</td>
<td>Sand pit</td>
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<td>38</td>
<td>Scoria pit</td>
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<td>Settling pond</td>
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<td>Shell pit</td>
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<td>42</td>
<td>Silica mine</td>
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<td>43</td>
<td>Slag pile</td>
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<tr>
<td>44</td>
<td>Strip mine</td>
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<td>45</td>
<td>Tailings - dredge</td>
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<td>46</td>
<td>Tailings - mill</td>
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<td>47</td>
<td>Tailings - placer</td>
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<tr>
<td>48</td>
<td>Tailings - pond</td>
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<tr>
<td>49</td>
<td>Tailings - undifferentiated</td>
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<tr>
<td>50</td>
<td>Tipple</td>
</tr>
<tr>
<td>51</td>
<td>Trench</td>
</tr>
<tr>
<td>52</td>
<td>Uranium mine</td>
</tr>
</tbody>
</table>
USMIN topographic database feature classes: KISS

1. Adit
2. Mine shaft
3. Prospect pit
4. Borrow pit
5. Gravel pit
6. Quarry
7. Sand pit
8. Open pit mine

- 8 feature classes contain 92% of the data
- Some are most likely associated with hard rock mines
- Others clearly are not
USMIN topographic mine symbols—status

Published - April 2018

Digitizing

Staged

Topographic maps reviewed = 75,000+
Points captured = 485,000+
Polygons captured = 79,000+
Mine-related Features from USGS Topographic Maps (1888-2006)
Most abundant mine-related features

- Prospect pit: 42%
- Gravel pit: 25%
- Quarry: 5%
- Adit: 12%
- Mine shaft: 9%
- Sand pit: 2%
- Open pit mine: 2%
- Borrow pit: 3%
• USMIN topo database can quantify the number of mine-related features on the landscape

• Quantities and distribution of mine features make sense

• Can infer information on locations of hard rock mine features

• Must be mindful of errors

• Must be mindful of complexities
Watersheds with numerous mines coincide with Colorado Mineral Belt
The power of data integration
Red light - green light example with application to inactive mine lands

- Identify mineral deposits with high, medium, and low probability of deleterious environmental impacts
  - High probability of deleterious impacts and greatest density of mine workings – *greatest environmental risk*
  - Moderate probability of deleterious impacts and moderate density of mine workings – *moderate environmental risk*
  - Low probability of deleterious impacts and low density of mine workings – *low environmental risk*
Fit for purpose

• Number of mine features
  – We know that there are errors on this
  – Errors not accurately and precisely known
  – Great starting point for site work

• Density of mine features on the landscape
  – On a regional scale, probably very useful
  – Not so useful for site work
  – Can combine with other data to assess relative risk

• What is the goal?
  – Mitigating damage from the worst sites?
  – Greatest improvement to ecosystems with least cost?
USMIN topo database

Pros

• GIS database
• Seamless
• Consistent
• Very accurate spatially
• Working towards complete (conterminous 48) national inventory
• Available free online
• Happy to collaborate with others
• Errors probably similar throughout database
• Can quantify the number of mine-related features on the landscape
• Can quantify the density of mine-related features on the landscape

Cons

• Not all features captured on USGS topographic maps
• More features on landscape than on USGS topographic maps
• No deposit attributes; just the topographic symbol
• Some features don’t reveal type of deposit
  – e.g., coal, uranium, and gold mines all have shafts and adits
Mineral Park Mine
Copper, molybdenum, silver

Deposit
Copper, molybdenum, silver, turquoise, rhenium

Wallapai District
Copper, molybdenum, silver, turquoise, rhenium, lead, zinc, gold

Mine Feature Type
- Adit
- Borrow Pit
- Mine Shaft
- Open Pit Mine
- Prospect Pit
- Trench

Mineral Park Mine
Wallapai District
Summary

- **USMIN topo database** can quantify the **number** of mine-related features on the landscape
  - In Colorado, similar results to other efforts
  - Western US results make sense
  - Errors
    - More features on landscape than on USGS topographic maps
    - Features don’t indicate type of deposit, e.g., coal vs hard rock
- **USMIN topo database** can quantify the **density** of mine-related features on the landscape
  - Combined with geology, water chemistry, or both, this may provide new insight into areas of greatest risk, and areas where funds can be spent most effectively to provide the greatest improvements
Questions?

And send Jeff an email if you’d like to be added to our distribution list