COLORADO GEOLOGICAL SURVEY

Online Series ON-007-03

Mineral Resource Potential Derivative Map

HOW TO USE THIS MAP

Mineral resource potential derivative maps are constructed using 7.5 minute quadrangles published under the current CGS STATEMAP geological mapping program. Derivative maps are qualitative generalizations of detailed geological information that are used to assist with evaluating complex geological information. These maps were created from digital geologic map data and historical mine locations to provide information on the general distribution of select potential mineral resources. They may be used as a general guide, however, a more detailed analysis would be required to determine the economic viability of the indicated units. Mineral evaluations and maps were created by John W. Keller and Michael K. O'Keeffe. Online map viewer by F. Scot Fitzgerald.

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Direct to the GIS map: ON-007-03M Mineral Resource Potential Derivative (Map)

The derivative maps were produced for the following three general resource types:

1) Construction aggregate materials;

2) Industrial minerals; and

3) Placer gold

These resources were further subdivided into the categories presented in **Table 1 (below)**. Ratings were assigned to geological units based on their potential to contain mineral resources based on the geologic maps, geologic interpretation, limited field information, and available mining databases (see references below). The rating system, criteria, and general notes are presented in **Table 2 (below)**. Certain mineral resources were not evaluated because they were not conducive to derivative mapping of surface units (e.g. uranium, coal, oil and gas, bedrock-hosted lode gold/silver, gold/silver/base metal, molybdenum/tungsten, and sediment-hosted copper). For example, these deposits may be deep and unrelated to

the units mapped at the surface. Formations were evaluated the same across the entire quadrangle and no attempt was made to specifically rate a small region within the map due to a nearby mine, mineral occurrence, etc.

Table 1. Resource Categories used in the derivative maps

Resource Categories	
GENERAL RESOURCE TYPE	**CATEGORY AND DESCRIPTION / NOTES**
Construction Aggregate Materials (AGG)	**Sand and Gravel** – Construction aggregate; may also include rip-rap and landscaping material. Does not include fill or borrow material. Other aggregates may be included in the Volcanic Material / Ash category
	Decomposed Granite – Rated only for bedrock units such as Pikes Peak Granite (in-place but friable due to partial weathering). Only rated in the region of the Pikes Peak batholith.
	Crushed Stone – Construction aggregate; may also include rip-rap and landscaping material. Some volcanic material may be included in this category or in the volcanic material resource type. Also, unconsolidated sand and gravel deposits generally were not included in the crushed stone category although deposits containing large cobbles, etc., may be crushed to provide crushed stone for other applications.
Industrial Minerals (IM)	**Clay, Claystone, and/or Shale** – May include any of the following: ball clay, bentonite, common clay, fire clay, Fuller's earth, and kaolin. Also, claystone/shale for lightweight aggregate (see the United States Geological Survey [USGS] commodity reports for clays).
	Corundum
	Fluorite/Fluorspar – In Colorado, usually in vein deposits too narrow to show on 1:24,000 scale geologic maps.
	Graphite
	Gypsum – May include anhydrite.
	Limestone and/or Dolomite – Non-aggregate industrial uses may include any of the following: cement manufacturing, lime manufacturing, fluxing agent, soil conditioning, water, waste treatment, and other miscellaneous uses (see the USGS commodity reports for crushed stone).
	Peat – Includes unconsolidated organic material.
	Pegmatite – Pegmatite-hosted minerals, undivided; principally feldspar, mica, quartz, beryl, and locally lithium in

	Colorado. May also locally contain small resources of rare earth elements (REE's) (e.g. niobium) as well as columbite-tantalite, garnet, and other minerals.
	Perlite – Lightweight aggregate, soil conditioner, filtration, and fillers.
	Evaporite Salts – Includes potential halite and sylvite (a potash source).
	Silica – May include silica sand, quartzite, and high-silica sand/sandstone. Generally, did not include fluvial unconsolidated sand due to impurities (for example, feldspars).
	Dimension Stone – Building construction, flagstone, paver stone, countertops, monuments, ornaments, etc.
	Vermiculite
	Other Volcanic Material / Ash – May also include pumice, cinders, tuff, and scoria used for aggregate/lightweight aggregate, cinder blocks, etc.
Metals (MET)	**Placer Gold**
	Rare Earth Elements (REEs)

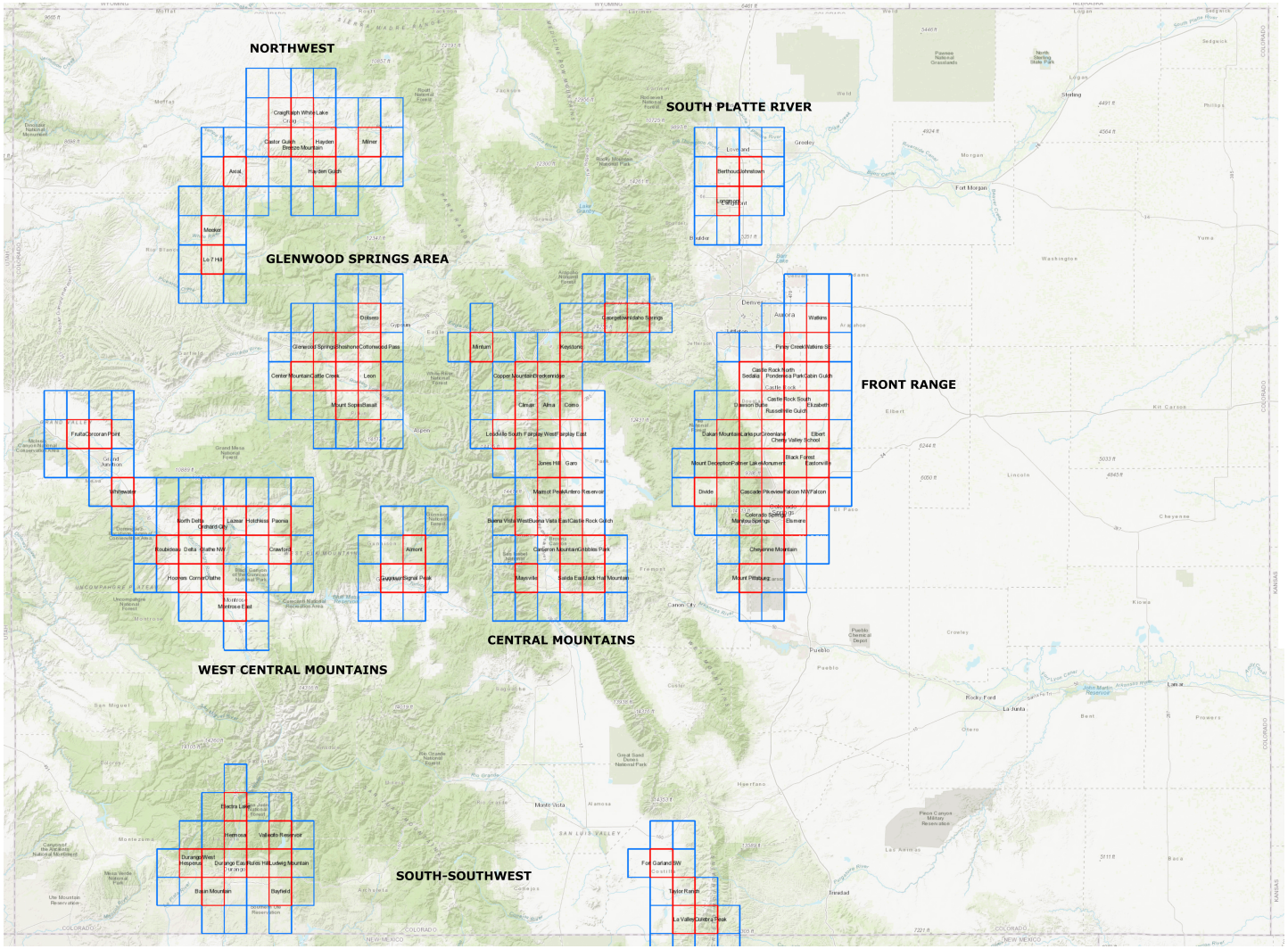
Table 2. Mineral potential numeric rating system used in the derivative maps

Mineral Potential Numeric Rating	**Numeric Rating System Description and General Criteria**
3	**HIGH POTENTIAL (Red)** – Area of mapped geological unit(s) as described has a higher potential to contain economically viable mineral resources and units with similar characteristics may have produced mineral resources locally. Area (e.g. ArcGIS polygon) may contain active or inactive mines. May include "mine waste" areas (e.g. Fairplay, Colorado area placer gold). In exceptional cases, new areas (e.g. ArcGIS polygons) were created where original geologic mapping did not adequately differentiate between a larger host unit and where a mineral deposit of mappable areal extent exists (e.g. the Homestake Pegmatite in the Cameron Mountain quadrangle).
2	**MEDIUM POTENTIAL (Yellow)** – Area of mapped geologic unit(s) as described has a moderate potential to contain economically viable mineral resources based on geologic unit description, other publications specific to the area or formation, and/or past regional resource use patterns. Lithological descriptions indicate that portions of the mapped geologic unit may contain mineral resources and similar geological formations may have been productive

	elsewhere in Colorado.
1	**LOW POTENTIAL (Blue)** – Area of mapped geologic unit(s) as described has a lower potential to contain economically viable mineral resources of this type in the mapped area. NOTE: Placer deposits were generally rated as a “1.”
0	**UNKNOWN or NO POTENTIAL (Light Grey)** – Area of mapped geologic unit(s) as described has little potential to host mineral resources in the mapped area or is unknown/unevaluated. For example, crystalline bedrock units have no potential to contain sand and gravel resources. Also includes areas mapped as water, mined or quarried areas, artificial fill, and landfill.
	Notes and Additional Criteria
(1) Ratings for construction aggregate materials may vary between different areas/polygons of the same formation/lithology on the same quadrangle based on the interpretation of variables associated with economic potential including steepness of terrain, altitude, remoteness (e.g. absence of access roads), variability in deposition environments (e.g., sand and gravel deposits) and the potential for the material to be adversely affected by hydrothermal alteration and/or excessive fracturing. For example, some igneous intrusions may often be rated a “3” for crushed stone aggregate; however, the presence of numerous metal mines in the vicinity indicates the high likelihood that hydrothermal alteration has greatly softened the rock imparting a high degree of physical heterogeneity making it less suitable for use as “Construction Aggregate”. Therefore, it may receive a rating of “2” or “1” due to these factors and the areas/polygons have not been split.	
(2) In general, construction aggregate material resources (e.g. sand and gravel, crushed stone, etc.) areas/polygons should be at least 3 acres in size and have a minimum estimated average exposed width of about 250 feet to qualify for a rating of “2” or above. Small polygons may have high ratings if they are mapped adjacent to larger units, associated with larger units, with similar physical characteristics and higher resource potential.	
(3) Ratings for areas/polygons of some surficial units, particularly Qa (alluvium), Qf (fan deposits), and Qac (alluvium and colluvium), are often rated differently within the same quadrangle map due to differences in clast composition and quality inferred from bedrock mapped in the source area drainages, differences in morphology, size or width of unit, remoteness, and steepness.	
(4) In general, mapped geologic areas/polygons have not been split during this evaluation. The mineral potential rating for areas/polygons is based on the highest rating for any part of the polygon. Portions of the same polygon will in reality have different actual mineral economic potential than other parts. For example, a single mapped area/polygon of Quaternary alluvium may be broad/thick in a low valley area (high potential) and thin/narrow in an upland area (low or medium potential). In this example, the area/polygon will be rated high potential (“3”). In rare cases, new areas/polygons were created where original geological mapping did not adequately differentiate between a larger “host” unit and where a mineral deposit of mappable areal extent exists (e.g. Homestake pegmatite, Cameron Mountain quadrangle).	

(5) In the Keystone quadrangle, all Proterozoic units were given only a moderate rating (“2”) for crushed stone due to abundant shearing, faulting, brecciation and alteration in the hanging wall of the Williams Range thrust fault and numerous other major faults. Additionally, hydrothermal alteration associated with igneous intrusions and “mineral belt” shear zones reduces aggregate potential.
(6) Gold placer deposits were generally rated as a “1” in regions where placer occurrences were notes. Due to their incidental nature, gold placer deposits rated as a “1” would need to be evaluated in detail to determine their true resource potential.
(7) Mass wasting deposits (e.g., landslides, talus, etc.) were generally not evaluated due to the uncertainty of their source based on the geological maps alone. An analysis of the source of the mass wasting deposits was beyond the scope of this evaluation.
(8) Generally, some formations that are dominantly sandstone were rated a “2” for clay due to the presence of clay/shale/mudstone beds within these formations. For example, the Dakota Group was rated as a “2” in most places due to interbedded shales that have been mined especially in the Front Range.

The mineral resource potential derivative maps are spread around several geographic regions as shown following: Front Range, South Platte River, Central Mountains, Glenwood Springs Area, West-Central Mountains, South-Southwest and Northwest. Each region includes a number of mapped 7.5-minute quadrangles.



FRONT RANGE

The Front Range mineral resource potential derivative map areas are listed below and include the following quadrangles:

Black Forest	Divide	Monument
Cabin Gulch	Eastonville	Mount Deception
Cascade	Elbert	Mount Pittsburg
Castle Rock North	Elizabeth	Palmer Lake
Castle Rock South	Elsmere	Pikeview
Cherry Valley School	Falcon	Piney Creek
Cheyenne Mountain	Falcon NW	Ponderosa Park
Colorado Springs	Greenland	Russelville Gulch
Dakan Mountain	Larkspur	Sedalia
Dawson Butte	Longmont	Watkins
	Manitou Springs	Watkins SE

SOUTH PLATTE RIVER

The South Platte River area mineral resource potential derivative map areas are listed below and include the following quadrangles:

Berthoud	Johnstown	

CENTRAL MOUNTAINS

The Central Mountain mineral resource potential derivative map areas are listed below and include the following quadrangles:

Alma	Como	Jones Hill
Antero Reservoir	Copper Mountain	Keystone
Breckenridge	Fairplay East	Leadville South
Buena Vista East	Fairplay West	Marmot Peak
Buena Vista West	Garo	Maysville
Cameron Mountain	Georgetown	Minturn
Castle Rock Gulch	Gribbles Park	Salida East
Climax	Idaho Springs	
	Jack Hall Mountain	

GLENWOOD SPRINGS AREA

The Glenwood Springs region mineral resource potential derivative map areas are listed below and include the following quadrangles:

Basalt	Dotsero
Carbondale	Glenwood Springs
Cattle Creek	Leon
Center Mountain	Mount Sopris
Cottonwood Pass	Shoshone

WEST CENTRAL MOUNTAINS

The West-Central Mountain mineral resource potential derivative map areas are listed below and include the following quadrangles:

Almont	Montrose East
Corcoran Point	North Delta
Crawford	Olathe
Delta	Olathe NW
Fruita	Orchard City
Gunnison	Paonia
Hoovers Corner	Roubideau
Hotchkiss	Signal Peak
Lazear	Whitewater

SOUTH-SOUTHWEST

The South-Southwest mineral resource potential derivative map areas are listed below and include the following quadrangles:

Basin Mountain	Hermosa
Bayfield	Hesperus
Culebra Peak (southern half)	La Valley
Durango East	Ludwig Mountain
Durango West	Rules Hill
Electra Lake	Taylor Ranch
Fort Garland SW	Vellecito Reservoir

NORTHWEST

The Northwest mineral resource potential derivative map areas are listed below and include the following quadrangles:

Axial	Hayden Gulch
Breeze Mountain	Lo7 Hill
Castor Gulch	Meeker
Craig	Milner
Hayden	Ralph White Lake

NOTES

Within the map viewer, the following points will aid in viewing the mineral derivative maps:

1.) Check one of the commodities you would like to view (**NOTE**: only one commodity can be viewed clearly at one time, the map viewer will only show the top commodity that is turned on in the Layer List tab);

2.) Zoom in to the quadrangle or region you would like to view (**NOTE**: the mineral derivative mapping is visible only when zoomed into the map. If you look at the scale in the bottom left of the map, when you get to the “2 Mile” zoom, the polygons will begin to populate);

3.) If you wish to view another mineral derivative commodity, deselect the current one, and then select another commodity further down the list (**NOTE**: the topmost one turned on will be the only one to show);

4.) The “Basemap” feature at the top of the mapviewer allows the user to include recent satellite/aerial imagery, topographic maps, terrain, etc.

5.) Water features are colored a light cyan color.

6.) Black lines within each area are the boundaries of geological formations/units. Geologic formation/unit codes can be displayed by clicking on the area of interest with the “i” button. These geological codes and areas are described in each individual geologic quadrangle map and are included for reference purposes only. The individual geologic quadrangle maps generated by the CGS are also available for free download. Use the SEARCH bar and type in the quadrangle name.

METHODS

The polygon ratings for mineral resource potential were interpreted for each CGS geologic quadrangle maps using the following methods:

- Each CGS STATEMAP geologic map quadrangle, including the accompanying report for the quadrangle and the detailed descriptions of map units, was carefully studied. Many of the map reports contain sections on known mineral resources located in and near the quadrangle, and descriptions of map units often contain the map author’s opinion regarding the mineral potential of map units, particularly for use as construction aggregate.

- An ArcMap 10.1 project was created for each quadrangle, beginning with the ESRI shapefiles or geodatabases that contain the polygons for each mapped geologic unit. Shapefiles were quality-checked with the published .PDF versions of the map to ensure that shapefile polygons corresponded to the final published map product.

- Statewide and regional mineral resource and mining publications and public databases in GIS format were imported into the ArcMap projects and compared to mapped geological units.

- Georeferenced USDA NAIP aerial composite orthoimages from 2011 were imported and used to help determine the actual locations of historic and current mines, quarries, and gravel pits in relation to mapped geological units.

- Numerous non-GIS publications relating to Colorado mineral resources were reviewed.

- Using the above information and other knowledge acquired through professional experience, each geologic polygon or group of polygons were given a rating of 0 (unknown or no potential) to 3 (high potential) for each mineral category evaluated. The highest ratings were given to geological units that have known current or historic mining activity within the quadrangle or adjacent quadrangles. Moderate ratings were applied to geologic units having had at least some statewide or regional mineral production, and whose detailed geologic description indicates

the possibility that the unit contains useful mineral resources. Low ratings (1) were applied when the unit is unlikely to contain economically viable mineral resources under present circumstances. A rating of zero (0) was applied when there is no possibility of that mapped unit containing mineral resources in the category evaluated, or that by definition it cannot contain resources in the category, or if the unit has an unknown mineral resource potential. For example, most unconsolidated Quaternary surficial deposits received a rating of "0" for crushed stone aggregate because for the purposes of this project, crushed stone is defined only as material derived by crushing bedrock units.

- Ratings of polygons on adjacent quadrangles were compared, and any discrepancies between ratings were re-evaluated and made consistent across quadrangle boundaries.

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