UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

LITHOLOGY AND AGGREGATE QUALITY ATTRIBUTES

FOR

THE DIGITAL GEOLOGIC MAP OF COLORADO

By

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INTRODUCTION

The Geologic Map of Colorado (Tweto, 1979) was digitized and imported into ARC/INFO by Green (1992). The polygons containing each of the map units were attributed with a unique identification number for each map unit and the geologic symbol used to identify each unit and its age. These limited attributes allow the Geologic Map of Colorado to be plotted at any scale and individual units, or combinations of units, to be plotted separately. Langer and others (1997) prepared additional attributes that estimate the potential of those map units exposed along the Front Range urban corridor for natural aggregate used in Portland cement concrete. These attributes provide evaluations of the physical and chemical qualities of each map unit and a generalized lithologic descriptor for each unit. With these attributes, that part of the digital data for the Geologic Map of Colorado along the Front Range urban corridor can be searched for potential natural aggregate sources, as well as units with broadly classified lithologic characteristics.

To further increase the utility of the digital Geologic Map of Colorado, the digital data set has been reattributed to extend the capability of identifying natural aggregate potential to the entire state and expand the flexibility in searching for more specific lithologic characteristics; these datasets are included on the CDROM and are discussed in more detail below. Two sets of attributes have been defined for the lithologic units contained on the Geologic Map of Colorado (Tweto, 1979). In addition to the identification number, map unit symbol, and age symbol based on Green (1992), the first set describes the mode of formation, composition, texture, and variability of the mapped units according to descriptions on the Explanation of the Geologic Map of Colorado. The second set estimates the physical and chemical properties of each unit for use as natural aggregate in Portland cement concrete and identifies other known uses of each unit for construction materials. Together, these newly-defined attributes can be used to search the digital Geologic Map of Colorado database (Green, 1992) for units with a broad range of lithologic characteristics, as well as to evaluate natural aggregate potential on a statewide basis.

DESCRIPTION OF DIGITAL FILES

This database was developed to enhance the usefulness of the Digital Geologic Map of Colorado. The database on this CDROM can be joined to an existing copy of the digital Map of Colorado. To use the database in this way, the user must have an ARC/INFO system. Several

software packages can read the ARC/INFO interchange format .e00 files, but these packages do not have the ability to join the databases. Therefore, we have also included the reattributed version of Digital Geologic Map of Colorado as a separate subdirectory. For completeness, a copy of the original USGS open file report 92-0507 is also included as a separate subdirectory.

CONTENTS OF THE CD-ROM

CONTENTS.TXT	Text file that contains this section, Contents of the CD-ROM text.
OF99-29.DOC	This document, Open-File 99-29, in MS Word format.
OF99-29.PDF	This document, Open-File 99-29, in Adobe Acrobat.
OF99-29.WP5	This document, Open-File 99-29, in WordPerfect 5.1 format.

Subdirectories

VALUE	A subdirectory that contains the value added lithology and aggregate quality attribute file and an ARC/INFO AML that can load and join the file to an existing ARC database.
JOINED	For those sites without a full version of ARC/INFO this subdirectory contains a version of the Digital Geologic Map of Colorado with the lithology and aggregate quality attributes.
COLORADO	An unattributed original version of Digital Geologic Map of Colorado, USGS OFR-92-0507 just in case.

THE ATTRIBUTING PROCESS

Table 1 is a list of the new attributes; a complete list with detailed definitions is shown in Appendix A, and the comma-delimited text file of the attributes for each mapped unit is in Appendix B. The attributes are grouped in Table 1 according to the type and source of the

ATTRIBUTE	SOURCE
SYMBOL	**From Green (1992); SYMBOL and AGE were originally included in an attribute called NAME.**
P1	
AGE	
UNITS_1	**Verbatim text from the Explanation of the Geologic Map of Colorado (Tweto, 1979)**
UNITS_1A	
UNITS_2	
UNITS_2A	
LITHO_1	**Interpreted from the Geologic Map of Colorado and its Explanation (Tweto, 1979)**
LITHO_2	
LITHO_3	
LITHO_4	
VV (Vertical variability)	
HV (Horizontal variability)	
GENERAL_LITHO	**Estimates of aggregate suitability of rocks and sediments based on U. S. Geological Survey Open-File Report 95-582 (Langer and Knepper, 1995)**
PHYS	
PHYS_COMMENT	
CHEM	
CHEM_COMMENT	
KNOWN_SOURCE	**Active Permitted Mine Operations in Colorado, 1995-96 (Colorado Geological Survey Information Series 41, 1996)**
OTHER_USE	

Table 1. List of attributes assigned to each map unit on the digital Geologic Map of Colorado (Green, 1992) and the sources of the information entered in the attributes.

information contained in the attributes. The first grouping (SYMBOL through AGE) was adapted from the attributes supplied to the digital Geologic Map of Colorado by Green in 1992. The next grouping (UNITS_1 through UNITS_2A) is the complete verbatim text of the Explanation of the Geologic Map of Colorado (Tweto, 1979). This text describes the Groups-Formations-Members that have been combined into the map unit, as well as information on the lithologies of the units and their geographic distribution. The grouping that includes LITHO_1 through LITHO_4 provides the mode of formation and major and minor lithologic and textural characteristics of each map unit as interpreted from the Explanation of the Geologic Map of Colorado. While most of the information in LITHO_1 through LITHO_4 is also contained in UNITS_1 through UNITS_2A, the structure of LITHO_1 through LITHO_4 provides a logical and more organized means of constructing searches for specific types of deposits and lithologies.

The next series of attributes (GENERAL_LITHO through CHEM_COMMENT) provides a generalized rock/deposit name for each map unit such as might be used in the aggregate industry, and estimates the physical and chemical quality of each of the mapped units for use as natural aggregate in Portland cement concrete based on the properties of common rock types and deposits as outlined in Langer and Knepper (1995). The last grouping (KNOWN_SOURCE through OTHER_USE) identifies whether the units are a known source of natural aggregate and what other construction materials may have been extracted from the unit.

APPLYING THE ATTRIBUTES

The key to using the digital Geologic Map of Colorado to explore a geologic question is to formulate the question in terms of the available attributes (or to reattribute the map in terms of the question). The user should become familiar with the lithologic attributes (Appendix A) and the range of properties they include. In formulating an effective search of the digital database, the user should refer to Appendix A to identify those attribute properties that are fundamental to the geologic question being asked.

NATURAL AGGREGATE POTENTIAL

The second set of attributes, beginning with GENERAL_LITHO (Appendix A), provides estimates of the potential of the various map units on the Geologic Map of Colorado for use as natural aggregate in Portland cement concrete. Most of the units mapped on the Geologic Map of Colorado are compound units composed of several formations. Physical quality (PHYS) and

chemical quality (CHEM) estimates are based on whether any of the included formations contain rocks that may be considered satisfactory for use as aggregate in Portland cement concrete. Therefore, only parts of some units on the Geologic Map of Colorado are actually of satisfactory physical and chemical quality, and the spatial distribution of these units provides a maximum estimate of where quality aggregate source rock may be present; detailed geologic maps must be consulted to determine the exact locations of quality aggregate sources.

Attributes for comments on the physical (PHYS_COMMENT) and chemical (CHEM_COMMENT) quality estimates provide the user with an explanation of some estimates. Another attribute, KNOWN_SOURCE, identifies those map units that have been used as sources of natural aggregate for Portland cement concrete. The attribute OTHER_USES identifies those map units that have been used as sources for other types of construction materials.

LITHOLOGIC UNITS

Applications for natural aggregate studies are relatively straightforward; however, the primary utility of the new attributes lies in the organization of the lithologic information.

The first attribute in Appendix A (SYMBOL) is the symbol used on the geologic map to identify each mapping unit. The second attribute (P1) is a unique number used to identify each mapping unit, and the third attribute (AGE) is that part of the SYMBOL that indicates the age of the mapping unit. UNITS_1, UNITS_1A, UNITS_2, and UNITS_2A are taken directly from the Explanation of the Geologic Map of Colorado (Tweto, 1979); UNITS_1 and UNITS_2 are divided into 2 parts to limit the length of each field to 250 words or less so that they can be loaded into common GIS software, such as ARCVIEW and MAPINFO. Attributes LITHO_1, LITHO_2, LITHO_3, and LITHO_4 describe the lithologies of the mapped units in sufficient detail, based on UNITS_1 and UNITS_2, to allow searches to be performed for a variety of geologic applications. The attributes HV (horizontal variability) and VV (vertical variability) are qualitative estimates of finding a specific lithology in the stratigraphic section or at a geographic location based on the lithologies and the number of mappable units lumped into the map units on the Geologic Map of Colorado (Tweto, 1979). Together, these attributes can be used to determine the spatial distribution of rocks in Colorado by age, deposit type, and lithology.

As an example of the search procedure, consider the question of locating those rocks that may be a potential source for reagent grade calcium carbonate. First, the searcher would want to find all the carbonate rocks in the state. From Appendix A, the searcher can see that broadest category that includes carbonates is LITHO_2; however, LITHO__2 would find only those units that are dominantly composed of carbonate rocks. To find all of the units containing carbonates, it is also necessary to look for those units for which LITHO_3 is either limestone or dolomite and those units for which LITHO_4 is 'with carbonate'. This search procedure will find all of the units in the digital Geologic Map of Colorado that are described on the Explanation as being, or containing, carbonate rocks. If the searcher knew that only the carbonate rocks that were deposited during the Cretaceous have been used as a source for pure calcium carbonate in Colorado, the specification that AGE is 'K' could be added to the search. Other searches could be similarly constructed for other applications, but reference to Appendix A during the process is highly recommended to insure that the search is narrowed to the maximum extent possible with the available information.

REFERENCES

Green, G.N., 1992, The digital geologic map of Colorado in ARC/INFO format: U.S. Geological Survey Open-File Report OF-92-0507.

Langer, W.H., Green, G.N., Knepper, D.H., Jr., Lindsey, D.A., Moore, D.W., Nealey, L.D., and Reed, J.C., Jr., 1997, Distribution and quality of potential sources of aggregate, Infrastructure Resources Project Area, Colorado and Wyoming: U.S. Geological Survey Open-File Report 97-477, CDROM.

Langer, W.H., and Knepper, D.H., Jr., 1995, Geologic characterization of natural aggregate – A field geologist's guide to natural aggregate resource assessment: US Geological Survey Open-File Report OF-95-582, 32p.

Tweto, Ogden, 1979, Geologic map of Colorado: U.S. Geological Survey Special Geologic Map, 1:500,000.

APPENDIX A

Properties and data definitions for the add-on lithology and aggregate quality attributes file as applied to the digital Geologic Map of Colorado.

GENERAL ATTRIBUTES

SYMBOL - The label used on the geologic map to indicate the age and formations or lithologic unit(s) that have been included in a single mapping unit.

P1 - A number assigned to each specific mapping unit.

AGE - That part of the SYMBOL (above) that indicates geologic age.

UNITS_1 - The formations, or the broad description of lithologies that are not formally named, included in the mapping unit (from the explanation of the Geologic Map of Colorado).

UNITS_1A –The continuation of UNITS_1, where necessary.

UNITS_2 - Textural and compositional descriptions of lithologies in the mapping unit (from the Explanation of the Geologic Map of Colorado).

UNITS_2A –The continuation of UNITS_2, where necessary.

LITHO_1 – Primary mode of formation.	Interpreted from the *Explanation* of the *Geologic Map of Colorado* (See LITHOLOGIC DESCRIPTORS)
LITHO_2 – Primary composition(s) or deposit type(s).	
LITHO_3 – Dominant rock type(s) or texture(s).	
LITHO_4 - Rock type modifier, if any.	

VV - Vertical Variability - An estimate of the lithologic variability of a cross-section of a map unit at any particular geographic location.

Low - Only a small amount of lithologic variation in the stratigraphic cross-section.
Moderate - A moderate amount of lithologic variation in the stratigraphic cross-section.
High - The map unit contains numerous lithologies that vary frequently from the base of the unit to the top.

HV - Horizontal Variability - An estimate of the variation in the lithologic characteristics of a map unit from one geographic area to another.

Low - Only a small amount of lithologic variation between geographic areas.
Moderate - A moderate amount of lithologic variation between geographic areas.
High - The lithology of the map unit varies widely from one geographic area to another.

ESTIMATES/EVALUATIONS FOR AGGREGATE POTENTIAL ASSESSMENT

Estimates/evaluations are based on the general suitability of common rock types and sedimentary deposits for use as aggregate in Portland cement concrete as outlined in USGS Open-File Report 95-582 (Langer and Knepper, 1995).

GENERAL_LITHO - A generalized description of the mapped unit for natural aggregate potential assessment purposes.

PHYS - An estimate of the physical quality of a map unit as a potential source of aggregate for use in Portland cement concrete based on the lithologic descriptions in the Explanation of the Geologic Map of Colorado (see Langer and Knepper, 1995):

sat (satisfactory) - Particles are hard to firm, relatively free from fractures, and not chiplike; capillary absorption is very small or absent; and the surface texture is relatively rough.

fair (fair) - Particles exhibit one or two of the following qualities: firm to friable; moderately fractured; capillary absorption small to moderate; flat or chiplike; surface relatively smooth and impermeable; very low compressibility; coefficient of thermal expansion approaching zero or being negative in one or more directions.

poor (poor) - Particles exhibit one or more of the following qualities: friable to pulverant; slake when wetted and dried; highly fractured; capillary absorption moderate to high; marked volume change with wetting and drying; combine three or more qualities under "fair".

PHYS_COMMENT - A brief explanation of the Physical Quality estimate when appropriate.

CHEM - An estimate of whether a map unit contains constituents that react adversely with Portland cement concrete (Chemical Quality) based on the lithologic descriptions in the Explanation of the Geologic Map of Colorado (see Langer and Knepper, 1995):

inc (innocuous) - Particles contain no constituents which dissolve or react chemically to a significant extent with constituents of the atmosphere, water, or hydrating Portland cement concrete while enclosed in concrete or mortar under ordinary conditions.

del (deleterious) - Particles contain one or more constituents in significant proportion which are known to react chemically under conditions ordinarily prevailing in Portland cement concrete or mortar in such a manner as to produce significant volume change, interfere with the normal course of hydration or Portland cement, or supply substances which might produce harmful effects upon conc2rete or mortar.

CHEM_COMMENT - A brief explanation of the Chemical Quality estimate when appropriate.

KNOWN_SOURCE - Has the map unit been a source of gravel or crushed stone used in Portland cement concrete (see Hemborg, 1996)?

yes - There is at least one active permitted mine operation in this map unit.

no - There are no known active permitted mine operations in the map unit.

OTHER_USE - This is a list of construction materials, other than sand/gravel and crushed stone used in Portland cement concrete, that have been extracted from this map unit.

- LITHOLOGIC DESCRIPTORS -

These descriptive terms are based on the ***Explanation*** of the ***Geologic Map of Colorado***. They do not represent a complete rock classification scheme, but only lithologic descriptors that are required to describe the units on this map. Therefore, each term is used at least once.

LITHO_1	LITHO_2	LITHO_3	LITHO_4
UNCONSOLIDATED (uncon)	alluvium eolian glacial drift landslide	loess coarse +mixed sand gravel	
SEDIMENTARY (sed)	clastic carbonate volcaniclastic evaporite	+fine +coarse +mixed gypsum salt +mixed arkosic limestone dolomite	tuffaceous with coal arkosic with carbonate organic volcanic debris interbedded volcanics with gypsum conglomerate oil shale shale with clastics sandstone semi-consolidated carbonaceous red beds +mixed arkosic
INTRUSIVE (int)	mafic felsic intermediate alkalic	granite basalt rhyolite diabase gabbro diorite	
EXTRUSIVE (ext)	mafic felsic intermediate	ashflow andesite basalt quartz latite	
METAMORPHIC (meta)	gneiss quartzite slate phyllite schist	metasedimentary metavolcanic	calc-silicate

+ Fine refers to the finer-grained rocks: siltstone, claystone, mudstone, shale. Coarse refers to the coarser-grained rocks: sandstone, conglomerate, breccia. Mixed refers to a mixture of coarse- and fine-grained lithologies in the section. Similarly, mixed arkosic refers to a mixture of coarse- and fine-grained arkosic rocks in the section.

- *CATAGORIES FOR* ***GENERAL_LITHO*** *FIELD* -

UNCONSOLIDATED DEPOSITS **(uncon)**

sand and gravel
sand
loess
glacial
landslide
water

SEDIMENTARY ROCKS **(sed)**

sandstone
shale
conglomerate
carbonate
mixed carbonates
evaporite
seds and volcanics
mixed seds

EXTRUSIVE VOLCANIC ROCKS **(ext)**

basalt
andesite
intermediate volcanics
quartz latite
ashflow

INTRUSIVE ROCKS **(int)**

granite
rhyolite
felsic intrusive
intermediate intrusive
mafic intrusive
basalt
alkalic intrusive

METAMORPHIC ROCKS **(meta)**

quartzite
gneiss
metasedimentary

APPENDIX B: Text of Attribute Text File

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$SYMBOL,P1,AGE,UNITS_1,UNITS_1A,UNITS_2,UNITS_2A,LITHO_1,LITHO_2,LITHO_3,L
ITHO_4,VV,HV,GENERAL_LITHO,PHYS,PHYS_COMMENT,CHEM,CHEM_COMMENT,KNOWN_SOURC
E,OTHER_USE
$,,,,,,,,,,,,,,,,

Qa,1,Q,MODERN ALLUVIUM,,Includes Piney Creek Alluvium and younger
deposits,,uncon,alluvium,mixed,,mod,high,sand and gravel,sat,,inc,,yes,

Qg,2,Q,GRAVELS AND ALLUVIUMS (PINEDALE AND BULL LAKE AGE),,Includes
Broadway and Louviers Alluviums,,uncon,alluvium,coarse,,mod,high,sand and
gravel,sat,,inc,,yes,
Qgo,3,Q,OLDER GRAVELS AND ALLUVIUMS (PRE-BULL LAKE AGE),,Includes Slocum
Verdos Rocky Flats and Nussbaum Alluviums in east and Florida Bridgetimber
and Bayfield Gravels in southwest,,uncon,alluvium,coarse,,mod,high,sand
and gravel,poor,,del,,yes,barrow

Qe,4,Q,EOLIAN DEPOSITS,,Includes dune sand and silt and Peoria
Loess,,uncon,eolian,sand,loess,low,low,sand,unsuitable,,,,no,sand

Qeo,5,Q,OLDER EOLIAN DEPOSITS - INCLUDES LOVELAND
LOESS,,,,uncon,eolian,loess,,low,low,loess,unsuitable,,,,,no,
Qd,6,Q,GLACIAL DRIFT OF PINEDALE AND BULL LAKE GLACIATIONS,,Includes some
unclassified glacial deposits,,uncon,glacial
drift,mixed,,high,high,glacial,unsuitable,,,,yes,

Qdo,7,Q,OLDER GLACIAL DRIFT (PRE-BULL LAKE AGE),,,,uncon,glacial
drift,,,mod,high,glacial,sat,local Qa and outwash,inc,,yes,

Ql,8,Q,LANDSLIDE DEPOSITS,,Locally includes talus rock-glacier and thick
colluvial deposits,,uncon,landslide,mixed,,low,high,landslide,unsuitable,
,,,no,
Qb,9,Q,BASALT FLOWS (AGE <1.8 M.Y.
1),,,,ext,mafic,basalt,,low,low,basalt,sat,,inc,,no,
QTsa,10,QT,UNCLASSIFIED SURFICIAL DEPOSITS AND UNDERLYING ALAMOSA
FM(GRAVEL SAND AND SILT) IN SAN LUIS VALLEY,,,,uncon,alluvium,
mixed,,high,mod,sand and gravel,poor,weathered,del,clay,no,

QTa,11,QT,ANCIENT ALLUVIUM,,In isolated patches that may not all be of the
same age,,uncon,alluvium,mixed,,low,mod,sand and gravel,poor,highly
weathered,del,clay,no,

To,12,T,OGALLALA FM,,Loose to well-cemented sand and gravel,,sed,
clastic,coarse,semi-consolidated,low,mod,sand and gravel,poor,
weathered,inc,clay,no,
Tgv,13,T,BOULDERY GRAVEL ON OLD EROSION SURFACES IN FRONT RANGE AND NEVER
SUMMER MOUNTAINS,,gravel,,uncon,alluvium,gravel,,low,low,sand and gravel,
poor,weathered,del,clay,no,

Ta,14,T,ARIKAREE FM,,Sandstone - contains abundant volcanically derived
material,,sed,clastic,coarse,volcanic debris,low,low,sandstone,unsuitable,
,,,no,
```

Twr,15,T,WHITE RIVER FM OR GROUP,,Ashy claystone and sandstone - Includes Castle Rock Conglomerate in region southeast of Denver - Ashy claystone in North Park,,sed,clastic,mixed,tuffaceous,low,mod,mixed seds,unsuitable,,,, no,

Th,16,T,HUERFANO FM,,Shale and sandstone - Includes Farisita Conglomerate in northwestern Huerfano County,,sed,clastic,mixed,,mod,mod,mixed seds, unsuitable,,,,no
Tcu,17,T,CUCHARA FM,,Sandstone and shale,,sed,clastic,mixed,,low,low,mixed seds,unsuitable,,,,no

Tpc,18,T,POISON CANYON FM,,Arkosic conglomerate sandstone and shale,,sed, clastic,mixed arkosic,,mod,mod,mixed seds,unsuitable,,,,no
Tdu,19,T,UPPER PART OF DAWSON ARKOSE,,Arkosic sandstone conglomerate and shale - Includes Green Mountain Conglomerate south of Golden,,sed,clastic, mixed arkosic,,mod,mod,mixed seds,unsuitable,,,,no

Tbp,20,T,BROWNS PARK FM,,Sandstone and siltstone west of Park Range,,sed, clastic,mixed,,low,low,mixed seds,unsuitable,,,,no
Tt,21,T,TROUBLESOME FM,,Sandstone and siltstone in Middle Park,,sed, clastic,mixed,,low,low,mixed seds,unsuitable,,,,no

Tnp,22,T,NORTH PARK FM,,Sandstone siltstone and conglomerate in North Park and Laramie basin,,sed,clastic,mixed,conglomerate,mod,mod,mixed seds, unsuitable,,,,no

Tos,23,T,OLIGOCENE SEDIMENTARY ROCKS,,Includes Duchesne River Fm (sandstone and shale - includes some rocks of Eocene age) and Bishop Conglomerate near Utah border in northwest - Includes Florissant Lake Beds (tuffaceous shale and tuff) and Antero Fm (limestone tuff - [continued], tuffaceous sandstone and conglomerate) in south-central - Includes Creede Fm (tuffaceous siltstone sandstone conglomerate) and gravels interbedded with volcanic rocks northeast and southeast of Gunnison in southwest,sed, clastic,mixed,interbedded volcanics,high,high,mixed seds,poor,weathered, del,clay,no,

Tu,25,T,UINTA FM,,Sandstone and siltstone in Piceance basin - Formerly Evacuation Creek Member of Green River Fm,,sed,clastic,mixed,,low,low, mixed seds,unsuitable,,,,no

Tb,26,T,BRIDGER FM,,Claystone and mudstone - Sand Wash basin,,sed,clastic, fine,,low,low,mixed seds,unsuitable,,,,no,
Tg,27,T,GREEN RIVER FM,,Marlstone sandstone and oil shale,,sed,clastic, mixed,oil shale,mod,low,mixed seds,unsuitable,,,,no

Tgp,28,T,GREEN RIVER FM,,Parachute Creek Member--Oil shale marlstone and siltstone in Piceance basin,,sed,clastic,fine,oil shale,low,low,mixed seds,unsuitable,,,,no

Tgl,29,T,GREEN RIVER FM,,Lower part--Shale sandstone marlstone and limestone in Anvil Points Garden Gulch and Douglas Creek Members in Piceance basin,,sed,clastic,mixed,with carbonate,mod,low,mixed seds, unsuitable,,,,no

Tglm,30,T,LOWER PART OF GREEN RIVER FM AND WASATCH FM,,Shale and sandstone,,sed,clastic,mixed,,mod,low,mixed seds,unsuitable,,,,no

Tgt,31,T,GREEN RIVER FM,,Tipton Tongue--Claystone and oil shale in Sand Wash basin - In extreme northwest includes rocks of Wilkins Peak Member, ,sed,clastic,fine,oil shale,low,mod,shale,unsuitable,,,,no
Tglu,32,T,GREEN RIVER FM,,Luman Tongue--Carbonaceous shale and marlstone in Sand Wash basin,,sed,clastic,fine,carbonaceous ,low,low,shale, unsuitable,,,,no

Tglw,33,T,LOWER PART OF GREEN RIVER FM AND WASATCH FM,,Shale and sandstone,,sed,clastic,mixed,,mod,low,mixed seds,unsuitable,,,,no
Tw,34,T,WASATCH FM,,Claystone shale and sandstone,,sed,clastic,mixed,,mod, low,mixed seds,unsuitable,,,,no

Twc,35,T,GREEN RIVER FM,,Cathedral Bluffs Tongue--Claystone mudstone and sandstone in Sand Wash Basin,,sed,clastic,mixed,,mod,low,mixed seds, unsuitable,,,,no

Twn,36,T,GREEN RIVER FM,,Niland Tongue--Mudstone sandstone and carbonaceous shale in Sand Wash basin,,sed,clastic,mixed,carbonaceous, mod,low,mixed seds,unsuitable,,,,no
Two,37,T,WASATCH FM (INCLUDING FORT UNION EQUIVALENT AT BASE) AND OHIO CREEK FM,,Claystone mudstone sandstone and conglomerate,,sed,clastic, mixed,,mod,low,mixed seds,unsuitable,,,,no

Tf,38,T,FORT UNION FM,,Shale sandstone and local coal beds,,sed,clastic, mixed,with coal,mod,mod,mixed seds,unsuitable,,,,no
Tc,39,T,COALMONT FM,,Arkosic sandstone conglomerate and shale - coal in lower part in North Park,,sed,clastic,mixed arkosic,with coal,high,mod, mixed seds,unsuitable,,,,no

Tm,40,T,MIDDLE PARK FM EXCLUSIVE OF WINDY GAP MEMBER,,Arkosic sandstone and conglomerate containing abundant volcanic materials,,sed,clastic,mixed arkosic,volcanic debris,low,low,mixed seds,unsuitable,,,,no

Td,41,T,DRY UNION FM,,Siltstone sandstone and conglomerate - Includes Wagontongue Fm (Miocene) in South Park,,sed,clastic,mixed,,mod,high,mixed seds,poor,weathered,del,clay,no

Ts,42,T,SANTA FE FM,,Siltstone sandstone and conglomerate,,sed,clastic, mixed,,mod,mod,mixed seds,poor,weathered,del,clay,no
Tsp,43,T,SOUTH PARK FM,,Arkosic sandstone and shale volcaniclastic conglomerate and andesite flows and breccia,,sed,clastic,mixed arkosic,interbedded volcanics,high,high,seds and volcanics,sat, andesites,inc,,no

Tlp,44,T,LOS PINOS FM,,Volcaniclastic conglomerate interbedded with basalt flows of Hinsdale Fm (Tbb) on east flank of San Juan Mountains - Grades laterally into Santa Fe Fm of San Luis Valley,,sed,volcaniclastic,coarse, interbedded volcanics,high,high,seds and volcanics,sat,basalts,inc,,no

Tsj,45,T,SAN JOSE FM,,Siltstone shale and sandstone,,sed,clastic,mixed, ,mod,low,mixed seds,unsuitable,,,,no

Te,46,T,EOCENE PREVOLCANIC SEDIMENTARY ROCKS,,Arkosic sand and bouldery gravel of Echo Park Alluvium in south-central - Includes Telluride Conglomerate and Blanco Basin Fm (arkosic mudstone sandstone and conglomerate) in southwest,,sed,clastic,mixed arkosic,conglomerate,mod, mod,sand and gravel,poor,weathered,del,clay,no

Tn,47,T,NACIMIENTO FM,,Shale and sandstone,,sed,clastic,mixed,,mod,low,
mixed seds,unsuitable,,,,no
Tbb,48,T,BASALT FLOWS AND ASSOCIATED TUFF BRECCIA AND CONGLOMERATE OF
LATEVOLCANIC BIMODAL SUITE (AGE 3.5-26 M.Y.),,Includes basalts of Hinsdale
Fm in San Juan Mountains - Servilleta Fm in San Luis Valley and many other
occurrences,,ext,mafic,basalt,interbedded sediments,low,low,basalt,sat,,
inc,,no

Tbbi,49,T,BASALTIC INTRUSIVE ROCKS RELATED TO BASALT FLOWS (Tbb),,In dikes
and plugs,,int,mafic,basalt,,low,low,basalt,sat,,inc,,no,

Tbr,50,T,RHYOLITIC INTRUSIVE ROCKS AND FLOWS OF LATE-VOLCANIC BIMODAL
SUITE,,,,int,felsic,rhyolite,,low,low,rhyolite,sat,,del,microcrystalline
quartz,no,
Tbrt,51,T,ASH-FLOW TUFF OF LATE-VOLCANIC BIMODAL SUITE (AGE 22-23
M.Y.,,,,ext,felsic,ashflow,,mod,low,ashflow,sat,,del,microcrystalline
quartz,no,

Taf,52,T,ASH-FLOW TUFF OF MAIN VOLCANIC SEQUENCE (AGE IN SAN JUAN
MOUNTAINS 26-30 M.Y. - IN SOUTH PARK 29-32 M.Y.),,Includes many named
units,,ext,felsic,ashflow,,high,high,ashflow,sat,,del,microcrystalline
quartz,no,

Tial,53,T,INTRA-ASH FLOW ANDESITIC LAVAS,,,,ext,intermediate,andesite,,
low,low,andesite,sat,,inc,,no,
Tiql,54,T,INTRA-ASH FLOW QUARTZ LATITIC LAVAS,,,,ext,felsic,quartz
latite,,low,low,quartz latite,sat,,inc,,no,

Tpl,55,T,PRE-ASH-FLOW ANDESITIC LAVAS BRECCIAS TUFFS AND CONGLOMERATES
(GENERAL AGE 30-35 M.Y.),,Includes several named units,,ext,intermediate,
andesite,interbedded sediments,high,high,andesite,fair,possible
alteration,del,,no,

Twm,56,T,WALL MOUNTAIN TUFF (OLDER THAN TUFFS OF SAN JUAN PROVENANCE; AGE
35-36M.Y.),,Early ash-flow tuff of Sawatch Range provenance,,ext,felsic,
ashflow,,low,low,ashflow,sat,,del,,no,
Tv,57,T,VOLCANIC ROCKS IN NORTHWESTERN COLORADO (AGE <7-33 M.Y.),,Mainly
of intermediate compositions,,ext,intermediate,,,low,low,intermediate
volcanics,sat,,inc,,no,

Tui,58,T,UPPER TERTIARY INTRUSIVE ROCKS (AGE <20 M.Y.),,Intermediate to
felsic compositions,,int,intermediate/felsic,,,low,low,felsic
intrusive/intermediate intrusive,sat,,inc,,no,

Tmi,59,T,MIDDLE TERTIARY INTRUSIVE ROCKS (AGE 20-40 M.Y.),,Intermediate to
felsic compositions,,int,intermediate/felsic,,,low,low,felsic
intrusive/intermediate intrusive,sat,,inc,,no,
TKda,60,TK,DENVER AND ARAPAHOE FMS,,Sandstone mudstone claystone and
conglomerate; Denver is characterized by andesitic materials,,sed,clastic,
mixed,volcanic debris,high,mod,mixed seds,unsuitable,,,,no,
Tdv,61,T,BASALTIC FLOWS IN DENVER FM NEAR GOLDEN (AGE 62-64 M.Y.),,,,ext
,mafic,basalt,,low,low,basalt,sat,,inc,,no,

TKdl,62,TK,DENVER FM OR LOWER PART OF DAWSON ARKOSE,,Arkosic sandstone
shale mudstone conglomerate and local coal beds,,sed,clastic,mixed
arkosic,coal,high,high,mixed seds,unsuitable,,,,no,clay

TKr,63,TK,RATON FM,,Arkosic sandstone siltstone and shale - contains major coal deposits in Raton Basin,,sed,clastic,mixed arkosic,coal,mod,high, mixed seds,unsuitable,,,,no,

TKa,64,TK,ANIMAS FM,,Arkosic sandstone shale and conglomerate - contains abundant volcanic materials - Upper Cretaceous volcaniclastic McDermott Member at base,,sed,clastic,mixed arkosic,volcanic debris,mod,low,mixed seds,unsuitable,,,,no,

TKec,65,TK,TELLUTIDE CONGLOMERATE OF EOCENE PREVOLCANIC SEDIMENTARY ROCKS (Te) AND CIMARRON RIDGE FM (UPPER CRETACEOUS - VOLCANIC BRECCIA AND CONGLOMERATE - AGE ABOUT 66 M.Y.),,In northwestern San Juan Mountains,, sed,clastic,coarse,conglomerate,mod,high,conglomerate,poor,weathered,del, clay,no,

TKi,66,TK,LARAMIDE INTRUSIVE ROCKS (AGE 40-72? M.Y.),,Mainly intermediate to felsic compositions - some mafic,,int,intermediate/felsic,,,low,mod, felsic intrusive/intermediate intrusive,sat,,inc,,no,

Kl,67,K,LARAMIE FM,,Shale claystone sandstone and major coal beds,,sed, clastic,mixed,with with coal,mod,low,mixed seds,unsuitable,,,,no,brick clay

Kf,68,K,FOX HILLS SANDSTONE,,,,sed,clastic,coarse,sandstone,low,low, sandstone,unsuitable,,,,no,brick clay

Klf,69,K,LARAMIE FM AND FOX HILLS SANDSTONE,,,,sed,clastic,mixed,,mod,mod, mixed seds,unsuitable,,,,no,brick clay

Kvt,70,K,VERMEJO FM AND TRINIDAD SANDSTONE,,Shale sandstone and major coal beds,,sed,clastic,mixed,with coal,mod,mod,mixed seds,unsuitable,,,,no,

Kp,71,K,PIERRE SHALE UNDIVIDED,,,,sed,clastic,fine,shale,low,low,shale, unsuitable,,,,no,

Kpu,72,K,PIERRE SHALE,,Upper unit,,sed,clastic,fine,shale,low,low,shale, unsuitable,,,,no,

Kpm,73,K,PIERRE SHALE,,Middle unit--In Boulder-Fort Collins area contains Richard Larimer Rocky Ridge Terry and Hygiene Sandstone Members; elsewhere shale between zones of Baculites reesidei and B. scotti,,sed,clastic,fine, shale,mod,high,shale,unsuitable,,,,no,

Kpl,74,K,PIERRE SHALE,,Lower unit--Sharon Springs Member (organic-rich shale and numerous bentonite beds) in lower part,,sed,clastic,fine, organic,low,low,shale,unsuitable,,,,no,

Kn,75,K,NIOBRARA FM,,Calcareous shale and limestone,,sed,clastic,fine,with carbonate,mod,low,mixed carbonate,fair,soft,inc,,no,cement

Kcg,76,K,CARLILE SHALE GREENHORN LIMESTONE AND GRANEROS SHALE,,,,sed, clastic,fine,with carbonate,low,low,mixed carbonate,fair,soft,inc,,no,

Kc,77,K,COLORADO GROUP--NIOBRARA FM (Kn) and either BENTON SHALE or CARLILE GREENHORN and GRANEROS FMS (Kcg),,,,sed,clastic,fine,with

carbonate,high,high,mixed carbonate,fair,soft,inc,,no,cement hi-Ca limestone brick clay

Kpg,78,K,PIERRE SHALE (Kp) NIOBRARA (Kn) AND CARLILE GREENHORN AND GRANEROS (Kcg) FMS UNDIVIDED,,,,sed,clastic,fine,with carbonate,high, high,mixed carbonate,fair,soft,inc,,no,cement

Kdp,79,K,DAKOTA SANDSTONE AND PURGATOIRE FM,,Sandstone and shale,,sed, clastic,mixed,,low,low,mixed seds,unsuitable,,,,no,fire clay

Kd,80,K,DAKOTA SANDSTONE,,,,sed,clastic,coarse,sandstone,low,low, sandstone,unsuitable,,,,no,dimension fire clay

Kmw,81,K,WINDY GAP MEMBER (UPPER CRETACEOUS?) OF MIDDLE PARK FM,,Andesitic breccia and conglomerate,,sed,volcaniclastic,coarse,volcanic debris,high, low,mixed seds,unsuitable,,,,no,

Kls,82,K,LEWIS SHALE,,,,sed,clastic,fine,shale,low,low,shale, unsuitable,,,,no,

Kmv,83,K,MESAVERDE FM (UNDIVIDED),,Major coal beds in lower part - Rollins Sandstone Member at base in Delta Gunnison and Pitkin Counties,,sed, clastic,mixed,with coal,mod,mod,mixed seds,unsuitable,,,,no,brick clay fire clay

Kmvu,84,K,MESAVERDE GROUP OR FM,,Upper part--In Moffat and Rio Blanco Counties:sandstone shale and coal beds above Sego Sandstone - Along Grand Hogback south of Colorado River:sandstone and shale above coal-bearing sequence,,sed,clastic,mixed,with coal,high,mod,mixed seds,unsuitable,,, ,no,

Kmvl,85,K,MESAVERDE GROUP OR FM,,Lower part--Sandstone shale and major coal beds,,sed,clastic,mixed,with coal,high,mod,mixed seds,unsuitable,,,, no,brick clay fire clay

Kw,86,K,WILLIAMS FORK FM,,Sandstone shale and major coal beds,,sed, clastic,mixed,with coal,mod,low,mixed seds,unsuitable,,,,no,

Ki,87,K,ILES FM,,Sandstone and shale - Trout Creek Sandstone Member at top - coal beds in upper half,,sed,clastic,mixed,with coal,mod,mod,mixed seds, unsuitable,,,,no,

Kh,88,K,HUNTER CANYON FM,,Sandstone and shale,,sed,clastic,mixed,,mod, low,mixed seds,unsuitable,,,,no,

Ksc,89,K,SEGO SANDSTONE BUCK TONGUE OF MANCOS SHALE AND CASTLEGATE SANDSTONE,,,,sed,clastic,coarse`sandstone,,mod,low,sandstone,unsuitable,,, ,no,

Kmgs,90,K,MOUNT GARFIELD FM AND SEGO SANDSTONE,,Sandstone and shale - major coal beds in lower part of Mount Garfield,,sed,clastic,mixed,with coal,mod,mod,mixed seds,unsuitable,,,,no,

Km,91,K,MANCOS SHALE,,Intertongues complexly with units of overlying Mesaverde Group or Fm - lower part consists of a calcareous Niobrara equivalent and Frontier Sandstone and Mowry Shale Members - in areas where the Frontier and Mowry Members (Kmfm)or - [continued],these and the Dakota

Sandstone (Kfd) are distinguished map unit (Km) consists of shale above Frontier Member,sed,clastic,fine,shale,mod,high,shale,unsuitable,,,, no,brick clay/fire clay

Kmfm,92,K,MANCOS SHALE,,Frontier Sandstone and Mowry Shale Members and intervening shale zone,,sed,clastic,mixed,,mod,low,mixed seds,unsuitable, ,,,no,brick clay/fire clay

Kfd,93,K,FRONTIER SANDSTONE AND MOWRY SHALE MEMBERS OF MANCOS SHALE AND DAKOTA SANDSTONE,,Locally includes - at base - Burro Canyon Fm (shale and sandstone) or Cedar Mountain Fm(conglomerate and shale) in western Moffat County,,sed,clastic,mixed,,mod,high,mixed seds,unsuitable,,,,no,

Kdb,94,K,DAKOTA SANDSTONE AND BURRO CANYON FM,,Sandstone shale and conglomerate,,sed,clastic,mixed,,mod,low,mixed seds,unsuitable,,,,no,sand/ fire clay

Kkf,95,K,KIRTLAND SHALE AND FRUITLAND FM,,Shale sandstone and major coal beds,,sed,clastic,mixed,with coal,mod,low,mixed seds,unsuitable,,,,no,

Kpcl,96,K,PICTURED CLIFFS SANDSTONE AND LEWIS SHALE,,,,sed,clastic,mixed,, mod,low,mixed seds,unsuitable,,,,no,

Kch,97,K,CLIFF HOUSE SANDSTONE,,,,sed,clastic,coarse,sandstone,low,low, sandstone,unsuitable,,,,no,

Kmp,98,K,MENEFEE FM (SANDSTONE SHALE AND COAL) AND POINT LOOKOUT SANDSTONE,,,,sed,clastic,mixed,with coal,mod,mod,mixed seds,unsuitable, ,,,no,

Kmj,99,K,MANCOS SHALE,,Juana Lopez Member--Calcareous sandstone - a thin but persistent unit distinguished only locally,,sed,clastic,coarse, sandstone,low,low,sandstone,unsuitable,,,,no,

KJdm,100,KJ,DAKOTA AND MORRISON FMS,,,,sed,clastic,mixed,,mod,mod,mixed seds,unsuitable,,,,no,none

KJdj,101,KJ,DAKOTA BURRO CANYON MORRISON AND JUNCTION CREEK FMS,,Burro Canyon is locally absent,,sed,clastic,mixed,,high,high,mixed seds, unsuitable,,,,no,

KJdw,102,KJ,DAKOTA BURRO CANYON MORRISON AND WANAKAH FMS,,,,sed,clastic, mixed,,high,mod,mixed seds,unsuitable,,,,no,

KJdr,103,KJ,DAKOTA GROUP AND MORRISON AND RALSTON CREEK FMS AT MOUNTAIN FRONT BETWEEN BOULDER AND COLORADO SPRINGS - DAKOTA PURGATOIRE MORRISON AND RALSTON CREEK FMS IN CANON CITY AREA,,,,sed,clastic,mixed,,mod,high, mixed seds,unsuitable,,,,no,fire clay

KJde,104,KJ,DAKOTA PURGATOIRE MORRISON RALSTON CREEK AND ENTRADA FMS IN SOUTHEAST - DAKOTA MORRISON AND ENTRADA FMS IN CENTRAL MOUNTAINS - DAKOTA BURRO CANYON MORRISON WANAKAH AND ENTRADA FMS IN GUNNISON RIVER AREA - DAKOTA MORRISON CURTIS AND -[continued],ENTRADA FMS IN NORTHWEST,,,sed, clastic,mixed,,high,high,mixed seds,unsuitable,,,,no,none

KJds,105,KJ,DAKOTA MORRISON AND SUNDANCE FMS,,,,sed,clastic,mixed,,mod, mod,mixed seds,unsuitable,,,,no,none

Jm,106,J,MORRISON FM,,Variegated claystone mudstone sandstone and local beds of limestone,,sed,clastic,fine,with carbonate,mod,low,mixed seds, unsuitable,,,,no,none

Jmj,107,J,MORRISON FM AND JUNCTION CREEK SANDSTONE,,In Gunnison River area east of wedgeout of all units of Wanakah Fm (Jmw) except the Junction Creek Member,,sed,clastic,mixed,,mod,high,mixed seds,unsuitable,,,,no,

Jmc,108,J,MORRISON FM AND CURTIS FM (GLAUCONITIC SANDSTONE AND LIMESTONE), ,,,sed,clastic,mixed,with carbonate,mod,low,mixed seds,unsuitable,,,,no,

Jmw,109,J,MORRISON FM AND WANAKAH FM (SANDSTONE SHALE LIMESTONE AND LOCAL GYPSUM - JUNCTION CREEK SANDSTONE MEMBER AT OR NEAR TOP - PONY EXPRESS LIMESTONE MEMBER AT BASE),,,,sed,clastic,mixed,with carbonate,high,mod, mixed seds,unsuitable,,,,no,

Jmr,110,J,MORRISON AND RALSTON CREEK FMS,,Claystone sandstone limestone and gypsum,,sed,clastic,mixed,with carbonate,high,mod,mixed seds, unsuitable,,,,no,fire clay

Jme,111,J,MORRISON FM AND ENTRADA SANDSTONE,,,,sed,clastic,mixed,,mod, low,mixed seds,unsuitable,,,,no,

Jms,112,J,MORRISON FM AND SUNDANCE FM,,Sandstone shale claystone and limestone,,sed,clastic,mixed,with carbonate,high,mod,mixed seds, unsuitable,,,,no,

Jmse,113,J,MORRISON FM SUMMERVILLE FM (SHALE AND SILTSTONE) AND ENTRADA SANDSTONE,,,,sed,clastic,mixed,,mod,mod,mixed seds,unsuitable,,,,no,

Jmce,114,J,MORRISON CURTIS AND ENTRADA FMS,,In extreme southwestern Moffat County includes thin wedge of Carmel Fm (red siltstone and sandstone) beneath Entrada,,sed,clastic,mixed,,high,mod,mixed seds,unsuitable,,,,no,

Jmre,115,J,MORRISON RALSTON CREEK AND ENTRADA (OR EXETER) FMS,,,,sed, clastic,mixed,,high,mod,mixed seds,unsuitable,,,,no,fire clay

Jmwe,116,J,MORRISON WANAKAH AND ENTRADA FMS,,,,sed,clastic,mixed, ,mod,mod,mixed seds,unsuitable,,,,no,

J@g,117,J@,GLEN CANYON SANDSTONE,,In northwest,,sed,clastic,coarse, sandstone,low,low,sandstone,unsuitable,,,,no,

J@gc,118,J@,GLEN CANYON GROUP AND CHINLE FM,,In southwest Glen Canyon Group consists of Navajo Sandstone Kayenta Fm (red siltstone shale and sandstone) and Wingate Sandstone - Chinle is red siltstone,,sed,clastic, mixed,redbeds,mod,mod,mixed seds,unsuitable,,,,no,

J@mg,119,J@,MORRISON CURTIS ENTRADA AND GLEN CANYON FMS,,Curtis is absent along Grand Hogback,,sed,clastic,mixed,,mod,high,mixed seds,unsuitable, ,,,no,

J@mc,120,J@,MORRISON ENTRADA AND CHINLE FMS,,Along southern Grand Hogback Chinle is represented only by basal Gartra Sandstone Member,,sed,clastic, mixed,,mod,high,mixed seds,unsuitable,,,,no,

Tkc,121,T,KAYENTA FM (RED SILTSTONE SHALE AND SANDSTONE) WINGATE SANDSTONE AND CHINLE FM (RED SILTSTONE AND SANDSTONE),,,,sed,clastic,mixed,redbeds, high,mod,mixed seds,unsuitable,,,,no,

@wc,122,@,WINGATE SANDSTONE AND CHINLE FM,,,,sed,clastic,mixed,,mod,mod, mixed seds,unsuitable,,,,no,

@m,123,@,MOENKOPI FM,,Red siltstone mudstone sandstone and local gypsum,,sed,clastic,mixed,redbeds/with gypsum,mod,low,mixed seds, unsuitable,,,,no,

@ch,124,@,CHUGWATER FM,,Red sandstone siltstone shale and local limestone and gypsum,,sed,clastic,mixed,redbeds/with carbonate,high,mod,mixed seds, unsuitable,,,,no,

@cc,125,@,CHINLE AND CHUGWATER FMS,,,,sed,clastic,mixed,,mod,mod,mixed seds,unsuitable,,,,no,

@c,126,@,CHINLE FM,,Red siltstone sandstone and limestone-pellet conglomerate,,sed,clastic,mixed,redbeds/with carbonate,mod,low,mixed seds,unsuitable,,,,no,

@d,127,@,DOLORES FM,,Red siltstone shale sandstone and limestone-conglomerate,,sed,clastic,mixed,redbeds/with carbonate,mod,mod,mixed seds,unsuitable,,,,no,

@dg,128,@,DOCKUM GROUP,,Red sandstone siltstone and local limestone,, sed,clastic,mixed,redbeds/with carbonate,mod,mod,mixed seds,unsuitable, ,,,no,

@Pl,129,@P,LYKINS FM,,Red siltstone shale and limestone,,sed,clastic, fine,redbeds/with carbonate,mod,low,mixed seds,unsuitable,,,,no,none

@Ps,130,@P,STATE BRIDGE FM,,Red and orange siltstone and sandstone,,sed, clastic,mixed,redbeds,mod,low,mixed seds,unsuitable,,,,no,

@Pll,131,@P,LYKINS FM AND LYONS SANDSTONE,,,,sed,clastic,mixed,redbeds, low,low,mixed seds,unsuitable,,,,no,dimension

@Pjs,132,@P,JELM LYKINS LYONS AND SATANKA FMS,,Red siltstone shale and sandstone,,sed,clastic,mixed,redbeds,mod,low,mixed seds,unsuitable,,,, no,dimension

@Pcs,133,@P,CHINLE AND STATE BRIDGE FMS,,Red siltstone and sandstone,,sed, clastic,mixed,redbeds,low,low,mixed seds,unsuitable,,,,no,

@Pcp,134,@P,CHINLE MOENKOPI AND PARK CITY FMS,,Red and gray siltstone shale and sandstone,,sed,clastic,mixed,redbeds,mod,mod,mixed seds, unsuitable,,,,no,

@Pr,135,@P,TRIASSIC AND PERMIAN ROCKS,,Red siltstone shale and sandstone - Includes various combinations of Nugget Jelm Popo Agie Chugwater Red Peak Forelle Satanka and Goose Egg Fms near Wyoming border,,sed,clastic,mixed, redbeds,mod,high,mixed seds,unsuitable,,,,no,

@Pdc,136,@P,DOLORES FM (UPPER TRIASSIC) AND CUTLER FM (LOWER PERMIAN),,Red siltstone sandstone and conglomerate,,sed,clastic,mixed,redbeds,mod,mod,

mixed seds,unsuitable,,,,no,

@Pmc,137,@P,MOENKOPI FM (LOWER TRIASSIC) AND CUTLER FM (LOWER PERMIAN),,Red siltstone and sandstone,,sed,clastic,mixed,redbeds,mod,mod, mixed seds,unsuitable,,,,no,

@&lf,138,@&,LYKINS LYONS AND FOUNTAIN FMS,,Red siltstone sandstone and conglomerate,,sed,clastic,mixed,redbeds,mod,low,mixed seds,unsuitable,,,, no,dimension barrow

Pp,139,P,PARK CITY FM,,Calcareous siltstone and sandstone,,sed,clastic, mixed,,low,low,mixed seds,unsuitable,,,,no,

Pu,140,P,UPPER PERMIAN ROCKS UNDIVIDED,,Siltstone dolomite and sandstone in southeast,,sed,clastic,mixed,with carbonate,high,mod,mixed seds, unsuitable,,,,no,

Pc,141,P,CUTLER FM,,Arkosic sandstone siltstone and conglomerate,,sed, clastic,mixed arkosic,,mod,mod,mixed seds,unsuitable,,,,no,

Mz,142,Mz,MESOZOIC ROCKS,,Mainly Lower Cretaceous Jurassic and Triassic Fms,,sed,clastic,mixed,,mod,high,mixed seds,unsuitable,,,,no,

MzPz,143,MzPz,MESOZOIC AND PALEOZOIC ROCKS,,Mainly as in Mesozoic unit (Mz) plus Permian and Pennsylvanian Fms,,sed,clastic,mixed,,high,high, mixed seds,unsuitable,,,,no,

PIPf,144,P&,FOUNTAIN FM,,Arkosic sandstone and conglomerate,,sed,clastic, coarse,mixed arkosic,low,low,sandstone,unsuitable,,,,no,dimension barrow

P&cf,145,P&,CASPER FM (SANDSTONE) AND LOWER PART OF FOUNTAIN FM,,,, sed,clastic,coarse,arkosic,low,low,sandstone,unsuitable,,,,no,

P&if,146,P&,INGLESIDE FM AND FOUNTAIN FM,,Limestone and calcareous sandstone and arkosic sandstone and conglomerate,,sed,clastic,mixed arkosic,with carbonate,mod,mod,mixed seds,unsuitable,,,,no,dimension

P&s,147,P&,SANGRE DE CRISTO FM,,Arkosic conglomerate sandstone and siltstone,,sed,clastic,mixed arkosic,,low,low,mixed seds,unsuitable,,,,no,

P&m,148,P&,MAROON FM,,Arkosic sandstone siltstone conglomerate and local limestone,,sed,clastic,mixed arkosic,with carbonate,mod,mod,mixed seds, unsuitable,,,,no,

P&w,149,P&,WEBER SANDSTONE,,,,sed,clastic,coarse,sandstone,low,low, sandstone,unsuitable,,,,no,

P&wm,150,P&,WEBER SANDSTONE AND MAROON FM,,,,sed,clastic,mixed,arkosic, mod,mod,mixed seds,unsuitable,,,,no,

&m,151,&,MINTURN FM IN WEST-CENTRAL AND SOUTH-CENTRAL AND OTHER UNITS OF MIDDLE PENNSYLVANIAN AGE,,Arkosic sandstone conglomerate shale and limestone - Includes Madera Fm and Sharpsdale Fm of Chronic (1958) in Sangre de Cristo Range and Gothic Fm of Langenheim (1952) in Elk Mountains,,sed,clastic,mixed arkosic,with carbonate,high,high,mixed seds,unsuitable,,,,no,

&b,152,&,BELDEN FM,,Shale limestone and sandstone - Includes Kerber Fm in south-central,,sed,clastic,mixed,with carbonate,mod,high,mixed seds, unsuitable,,,,no,

&mb,153,&,MINTURN AND BELDEN FMS,,,,sed,clastic,mixed,with carbonate,high, high,mixed seds,unsuitable,,,,no,

&e,154,&,EAGLE VALLEY FM,,Siltstone shale and local gypsum,,sed,clastic, fine,with gypsum,mod,mod,mixed seds,unsuitable,,,,no,

&ee,155,&,EAGLE VALLEY FM - EVAPORITIC FACIES,,Gypsum siltstone and shale - salt present in deep borings - Intertongues with Minturn and Lower Maroon Fms - Diapiric structure in many places,,sed,evaporite, gypsum/salt,with clastics,mod,high,evaporite,unsuitable,,,,no,

&mbe,156,&,EVAPORITIC FACIES OF MINTURN AND BELDEN FMS IN SOUTH PARK AND SOUTHWARD,,Gypsum siltstone and shale,,sed,evaporite,gypsum,with clastics, mod,high,evaporite,unsuitable,,,,no,

&h,157,&,HERMOSA FM,,Arkosic sandstone conglomerate shale and limestone - gypsum and salt in Paradox Member present in salt anticlines near Utah border,,sed,clastic,mixed arkosic,with gypsum/salt/carbonate,high,high, mixed seds,unsuitable,,,,no,

&rh,158,&,RICO AND HERMOSA FMS,,Arkosic sandstone conglomerate shale and limestone - Includes at base in some areas siltstone and shale of Molas Fm or Larsen Quartzite,,sed,clastic,mixed arkosic,with carbonate,high,high, mixed seds,unsuitable,,,,no,

&mr,159,&,MORGAN FM (LIMESTONE SANDSTONE AND SHALE) AND ROUND VALLEY LIMESTONE,,In far northwest,,sed,clastic,mixed,with carbonate,mod,mod, mixed seds,sat,limestone units,inc,,no,

M_,160,M_,LEADVILLE LIMESTONE (MISSISSIPPIAN) WILLIAMS CANYON LIMESTONE (DEVONIAN) MANITOU LIMESTONE (ORDOVICIAN) AND SAWATCH QUARTZITE (CAMBRIAN) ,,,,sed,carbonate,limestone/dolomite,with clastics,mod,low,mixed carbonates,sat,carbonate,inc,,no,dimension

MDO,161,MDO,LEADVILLE LIMESTONE WILLIAMS CANYON LIMESTONE AND ONE OR MORE ORDOVICIAN FMS: FREMONT LIMESTONE HARDING SANDSTONE AND MANITOU LIMESTONE, ,,,sed,carbonate,limestone,with clastics,mod,mod,mixed carbonates,sat, limestone,inc,,,marble

DO_,162,DO_,WILLIAMS CANYON LIMESTONE MANITOU LIMESTONE AND SAWATCH QUARTZITE,,,,sed,carbonate,limestone,with clastics,low,low,mixed carbonates,sat,limestone,inc,,yes,none

O_,163,O_,MANITOU LIMESTONE AND SAWATCH QUARTZITE IN SOUTHERN FRONT RANGE AND WET MOUNTAINS - ONE OR MORE ORDOVICIAN FMS (FREMONT LIMESTONE HARDING SANDSTONE AND MANITOU DOLOMITE) - DOTSERO FM (CAMBRIAN DOLOMITE IN WHITE RIVER PLATEAU ONLY)- [Continued], PEERLESS FM (CAMBRIAN SANDSTONE AND DOLOMITE) AND SAWATCH QUARTZITE (CAMBRIAN) IN WEST-CENTRAL AND SOUTH-CENTRAL,,,sed,carbonate,limestone/dolomite,with clastics,high,mod,mixed carbonates,sat,,inc,,no,

Or,164,Or,ONE OR MORE ORDOVICIAN FMS,,Fremont Limestone Harding Sandstone and Manitou Limestone,,sed,carbonate,limestone,with clastics,mod,low,mixed carbonates,sat,limestone,inc,,no,

MD,165,MD,LEADVILLE LIMESTONE (MISSISSIPPIAN) GILMAN SANDSTONE (MISSISSIPPIAN OR DEVONIAN) DYER DOLOMITE (MISSISSIPPIAN? AND DEVONIAN) AND PARTING FM (DEVONIAN - QUARTZITE AND SHALE),,,,sed,carbonate, limestone/dolomite,with clastics,high,mod,mixed carbonates,sat, limestone,inc,,no,

MD_,166,MD_,WEST-CENTRAL AND SOUTH-CENTRAL:LEADVILLE GILMAN DYER PARTING AND SAWATCH FMS - UINTA MOUNTAINS:LEADVILLE LIMESTONE (MISSISSIPPIAN) OURAY LIMESTONE (DEVONIAN) ELBERT FM (DEVONIAN SHALE AND SANDSTONE) AND IGNACIO QUARTZITE (CAMBRIAN),,,,sed,carbonate,limestone,with clastics, high,mod,mixed carbonates,sat,,inc,,no,

DO,167,DO,PARTING FREMONT AND HARDING FMS,,,,sed,clastic,coarse,with carbonate,mod,low,mixed seds,sat,limestone-dolomite,inc,,no,

_s,168,_,SAWATCH QUARTZITE,,Locally includes Peerless Fm,,sed,clastic, coarse,sandstone,low,mod,sandstone,unsuitable,,,,no,

Mm,169,M,MADISON LIMESTONE (MISSISSIPPIAN),,Upper part includes equivalents of Upper Mississippian Doughnut and Humbug Fms (shale limestone and sandstone),,sed,carbonate,limestone,with clastics,low, mod,carbonate,sat,limestone,inc,,no,

_l,170,_,LODORE FM (CAMBRIAN),,Sandstone shale and conglomerate,,sed, clastic,mixed,,mod,mod,mixed seds,unsuitable,,,,no,

M_ml,171,M_,MADISON LIMESTONE AND LODORE FM,,,,sed,carbonate,limestone, with clastics,mod,mod,carbonate,sat,limestone,inc,,no,

_am,172,_,INTRUSIVE ROCKS OF CAMBRIAN AGE,,Alkalic and mafic intrusive rocks in small plutons and diabase dikes (age 510-570 m.y.),,int, mafic/alkalic,,,mod,high,mafic intrusive/alkalic intrusive,sat,,inc,,no,

Yu,173,Y,UINTA MOUNTAIN GROUP (AGE 950-1400 M.Y.),,Quartzite conglomerate and shale,,sed,clastic,mixed,,mod,low,mixed seds,sat,quartzite,inc,,no,

YXu,174,YX,UNCOMPAHGRE FM (OLDER THAN GRANITES OF 1400-M.Y. AGE GROUP AND YOUNGER THAN GRANITES OF 1700-M.Y. AGE GROUP),,Quartzite slate and phyllite,,meta,quartzite/slate/phyllite,metasedimentary,,mod,mod,metasedim entary,sat,,inc,,no,

Xb,175,X,BIOTITIC GNEISS SCHIST AND MIGMATITE,,Locally contains minor hornblende gneiss calc-silicate rock quartzite and marble - Derived principally from sedimentary rocks,,meta,gneiss/quartzite, metasedimentary,calc-silicate,high,mod,gneiss,fair,foliation fractures, inc,,no,

Xfh,176,X,FELSIC AND HORNBLENDIC GNEISSES EITHER SEPARATE OR INTERLAYERED, ,Includes metabasalt metatuff and interbedded metagraywacke - locally contains interlayered biotite gneiss - Derived principally from volcanic rocks,,meta,gneiss,metavolcanic,,mod,high,gneiss,sat,,inc,,no,

Xq,177,X,QUARTZITE CONGLOMERATE AND INTERLAYERED MICA SCHIST,,,,meta,

quartzite/schist,metasedimentary,,mod,low,quartzite,sat,,inc,,no,

Wr,178,W,RED CREEK QUARTZITE,,Metaquartzite amphibolite and mica schist - Present only in small area at Utah border in Uinta Mountains,,meta, quartzite/schist,metasedimentary,,mod,low,quartzite,sat,,inc,,no,

Yp,179,Y,ROCKS OF PIKES PEAK BATHOLITH (1000-M.Y. AGE GROUP),,Includes Pikes Peak Mount Rosa Windy Point and Redskin Granites and unnamed rocks,,int,felsic,granite,,mod,mod,granite,poor,highly weathered,inc, ,no,quartz

Yg,180,Y,GRANITIC ROCKS OF 1400-M.Y. AGE GROUP (AGE 1350-1480 M.Y.), ,Includes Silver Plume Sherman Cripple Creek St. Kevin Vernal Mesa Curecanti Eolus and Trimble Granites or Quartz Monzonites - also San Isabel Granite of Boyer (1962) and unnamed granitic rocks,,int,felsic, granite,,low,low,granite,sat,,inc,,no,

Yam,181,Y,ALKALIC AND MAFIC ROCKS IN SMALL PLUTONS AND DIABASE AND GABBRO DIKES,,,,int,mafic/alkalic,diabase/gabbro,,low,mod,mafic intrusive/alkalic intrusive,sat,,inc,,no,

Xg,182,X,GRANITIC ROCKS OF 1700-M.Y. AGE GROUP (AGE 1650-1730 M.Y.),, Includes Boulder Creek -M.Y. AGE GROUP (AGE 1650-1730 M.Y.)--Includes Boulder Creek Cross Creek Denny Creek Kroenke Browns Pass Powderhorn Pitts Meadow Bakers Bridge and Tenmile Granites Quartz Monzonites or Granodiorites – also unnamed granitic rocks,,int,felsic, granite/granodiorite/quartz monzonite,,low,mod,granite,fair,,inc,,no,

Xm,183,X,MAFIC ROCKS OF 1700-M.Y. AGE GROUP,,Gabbro and mafic diorite and monzonite,,int,mafic,gabbro/diorite,,low,mod,mafic intrusive,sat,,inc,,no,

YXg,184,YX,GRANITIC ROCKS OF 1400- AND 1700-M.Y. AGE GROUPS UNDIVIDED OR ROCKS WITH CHARACTERISTICS OF Xg BUT U-Th-Pb ZIRCON AGES OF Yg IN TAYLOR RIVER REGION,,,,int,felsic,granite,,low,mod,granite,fair,,inc,,no,

H2O,200,Q,H2O,,water,,,,,,,,water,unsuitable,,,,no,none