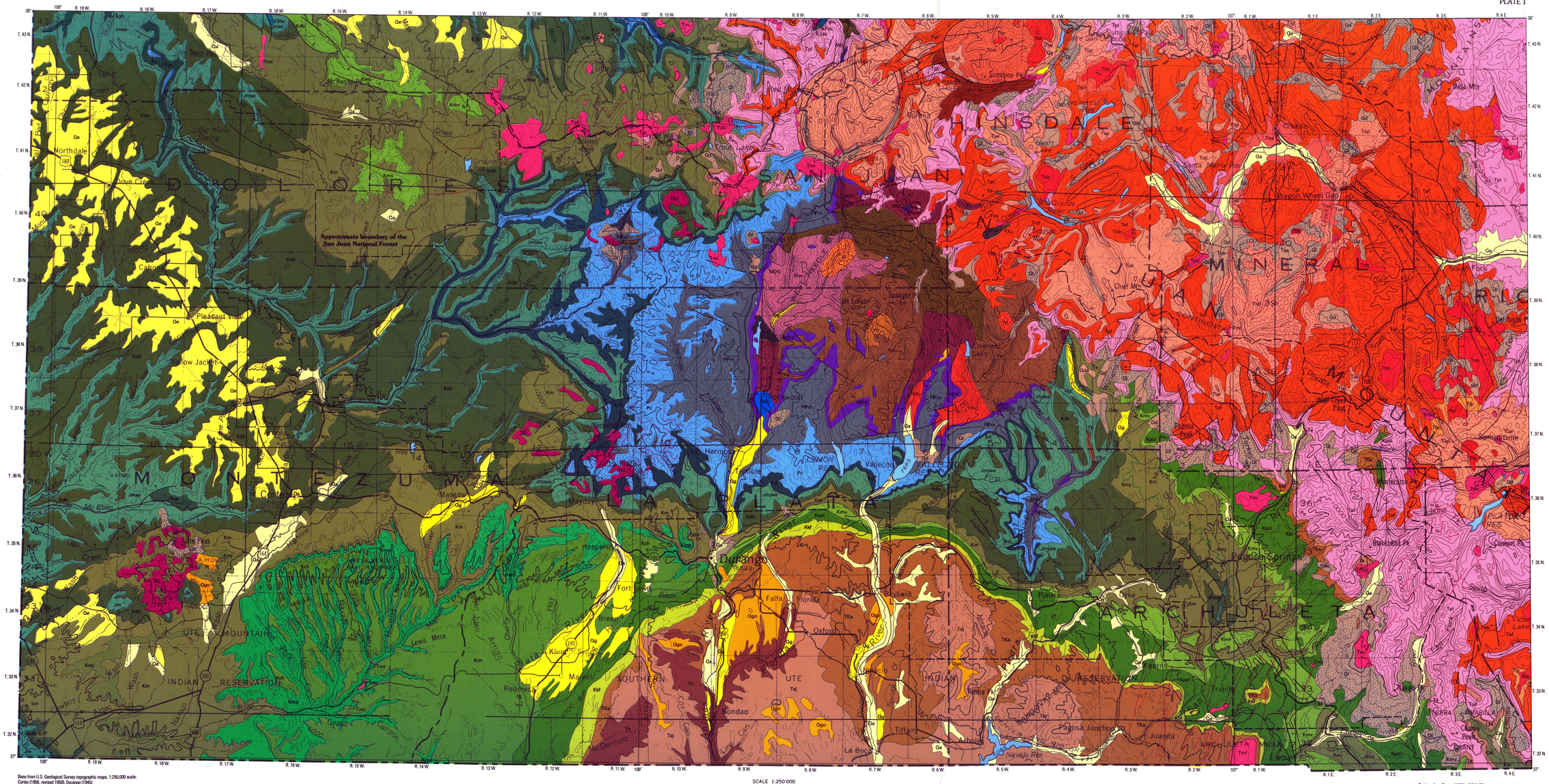

EXPLANATION

UNCONSOLIDATED SURFICIAL DEPOSITS AND ROCKS OF QUATERNARY AGE

Holocene: Qa, Qe, Qd, Ql, Qb
Pleistocene: Qg, Qgo, Qdo

- Qa **Modern alluvium**—Includes Piney Creek Alluvium (Holocene) and younger deposits
- Qg **Gravels and alluviums (Pinedale and Bull Lake age)**—Includes Broadway and Louviers Alluviums (Pleistocene)
- Qgo **Older gravels and alluviums (pre-Bull Lake age)**—Includes Florida, Bridgetimber, and Bayfield Gravels (Pleistocene)
- Qe **Eolian deposits**—Includes dune sand and silt and Peoria Loess (Pleistocene)
- Qd **Glacial drift of Pinedale and Bull Lake glaciations**—Includes some unclassified glacial deposits
- Qdo **Older glacial drift (pre-Bull Lake age)**
- Ql **Landslide deposits**—Locally includes talus, rock-glacier, and thick colluvial deposits
- Qb **Basalt flows (age <1.8 Ma)**

TERTIARY: Tlp, Tos, Tsj, Te, Tn

SEDIMENTARY ROCKS OF TERTIARY AGE

- Tlp **Los Pinos Formation (Miocene and Oligocene)**—Volcaniclastic conglomerate interbedded with basalt flows of Hinsdale Formation (Tfb) on east flank of San Juan Mountains. Grades laterally into Santa Fe Formation of San Luis Valley
- Tos **Oligocene sedimentary rocks**—Includes Creede Formation (tuffaceous siltstone, sandstone, conglomerate)
- Tsj **San Jose Formation (Eocene)**—Siltstone, shale, and sandstone
- Te **Eocene pre-volcanic sedimentary rocks**—Includes Telluride Conglomerate and Blanco Basin Formation (arkosic mudstone, sandstone, and conglomerate)
- Tn **Nacimiento Formation (Paleocene)**—Shale and sandstone

TERTIARY: Pliocene, Miocene, Oligocene, Eocene: Tbb, Taf, Tial, Tbr, Tbrt, Tiql, Tpl, Tui, Tmi

IGNEOUS ROCKS OF TERTIARY AGE

- Tbb **Basalt flows and associated tuff, breccia, and conglomerate of late-volcanic bimodal suite (age 3.5–26 Ma)**—Includes basalts of Hinsdale Formation in San Juan Mountains
- Tbr **Rhyolitic intrusive rocks and flows of late-volcanic bimodal suite**
- Tbrt **Ash-flow tuff of late-volcanic bimodal suite (age 22–23 Ma)**
- Taf **Ash-flow tuff of main volcanic sequence (age in San Juan Mountains 26–30 Ma)**—Includes many named units
- Tial **Intra-ash-flow andesitic lavas**
- Tiql **Intra-ash-flow quartz latitic lavas**
- Tpl **Pre-ash-flow andesitic lavas, breccias, tuffs, and conglomerates (general age 30–35 Ma)**—Includes several named units
- Tui **Upper Tertiary intrusive rocks (age <20 Ma)**—Intermediate to felsic compositions
- Tmi **Middle Tertiary intrusive rocks (age 20–40 Ma)**—Intermediate to felsic compositions

TERTIARY: Paleocene, Upper Cretaceous: TKa, TKi

SEDIMENTARY AND IGNEOUS ROCKS OF EARLY TERTIARY AND LATE CRETACEOUS AGE

- TKa **Animas Formation (Paleocene and Upper Cretaceous)**—Arkosic sandstone, shale, and conglomerate; contains abundant volcanic materials; Upper Cretaceous volcaniclastic McDermott Member at base
- TKi **Laramide intrusive rocks (age 40–72? Ma)**—Mainly intermediate to felsic compositions; some mafic

CRETACEOUS: Kd; JURASSIC: Kdb

SEDIMENTARY ROCKS OF CRETACEOUS AND JURASSIC AGES

[See under headings immediately preceeding and following for compositions and age designations of formations]

- Kd, Kdb **Dakota, Burro Canyon, Morrison, Wanakah, and Entrada Formations**

CRETACEOUS: Upper Cretaceous, Lower Cretaceous: Kkf, Kpcl, Kch, Kmp, Kmv, Km, Kmj, Kd, Kdb

SEDIMENTARY ROCKS OF CRETACEOUS AGE

- Kkf **Kirtland Shale and Fruitland Formation (Upper Cretaceous)**—Shale, sandstone, and major coal beds
- Kpcl **Pictured Cliffs Sandstone and Lewis Shale (Upper Cretaceous)**
- Kch **Cliff House Sandstone (Upper Cretaceous) of the Mesaverde Group**
- Kmp **Menefee Formation (sandstone, shale, and coal) and Point Lookout Sandstone (Upper Cretaceous) of the Mesaverde Group**
- Kmv **Mesaverde Group (Upper Cretaceous), undivided**—Sandstone and shale
- Km **Mancos Shale (Upper Cretaceous)**—Lower part contains Juana Lopez Member (Kmj)
- Kmj **Juana Lopez Member**—Calcareous sandstone; a thin but persistent unit distinguished only locally
- Kd **Dakota Sandstone (Upper Cretaceous)**
- Kdb **Dakota Sandstone (Upper Cretaceous) and Burro Canyon Formation (Lower Cretaceous)**—Sandstone, shale, and conglomerate

JURASSIC: Jm, Jmjw, Jmse, Jmjwe

SEDIMENTARY ROCKS OF JURASSIC AGE

- Jm **Morrison Formation (Upper Jurassic)**—Variegated claystone, mudstone, sandstone, and local beds of limestone
- Jmjw **Morrison Formation (Upper Jurassic), Junction Creek Sandstone (Upper Jurassic), and Wanakah Formation (Middle Jurassic; sandstone, shale, limestone, and local gypsum; Pony Express Limestone Member at base)**
- Jmse **Morrison Formation (Upper Jurassic), Summerville Formation (Middle Jurassic; shale and siltstone) and Entrada Sandstone (Middle Jurassic)**
- Jmjwe **Morrison Formation (Upper Jurassic), Junction Creek Sandstone (Upper Jurassic), Wanakah Formation (Middle Jurassic), and Entrada Formation (Middle Jurassic)**

JURASSIC, TRIASSIC: Upper Jurassic, Lower Jurassic, Upper Triassic: JTRgc, JTRkc, TRd

SEDIMENTARY ROCKS OF JURASSIC AND TRIASSIC AGE

- JTRgc **Glen Canyon Group (Lower Jurassic) and Chinle Formation (Upper Triassic)**—Glen Canyon Group consists of Navajo Sandstone, Kayenta Formation (red siltstone, shale, and sandstone), and Wingate Sandstone; Chinle is red siltstone
- JTRkc **Kayenta Formation (Lower Jurassic; red siltstone, shale, and sandstone), Wingate Sandstone (Lower Jurassic), and Chinle Formation (Upper Triassic; red siltstone and sandstone)**
- TRd **Dolores Formation (Upper Triassic)**—Red siltstone, shale, sandstone, and limestone-pellet conglomerate

TRIASSIC, PERMIAN, PENNSYLVANIAN: Upper Triassic, Lower Permian, Upper Pennsylvanian, Middle Pennsylvanian, Lower Pennsylvanian: TRPdc, Pc, IPh, PIPvh

SEDIMENTARY ROCKS OF TRIASSIC, PERMIAN, AND PENNSYLVANIAN AGES

- TRPdc **Dolores Formation (Upper Triassic) and Cutler Formation (Lower Permian)**—Red siltstone, sandstone, and conglomerate
- Pc **Cutler Formation (Lower Permian)**—Arkose, sandstone, siltstone, and conglomerate
- IPh **Hermosa Group (Upper and Middle Pennsylvanian)**—Arkosic sandstone, conglomerate, shale, and limestone; gypsum and salt in Paradox Formation (Middle Pennsylvanian) present in salt anticlines near Utah border
- PIPvh **Rico Formation (Lower Permian and Upper and Middle Pennsylvanian) and Hermosa Group (Upper and Middle Pennsylvanian)**—Arkosic sandstone, conglomerate, shale, and limestone. Includes at base in some areas siltstone and shale of Molas Formation (Middle and Lower Pennsylvanian) or Larsen Quartzite (Middle Pennsylvanian)

MISSISSIPPIAN, DEVONIAN, ORDOVICIAN, CAMBRIAN: Lower Mississippian, Upper Devonian, Upper Cambrian: MDC, MD

SEDIMENTARY ROCKS OF PRE-PENNSYLVANIAN PALEOZOIC AGE

- MDC **Leadville Limestone (Lower Mississippian), Ouray Limestone (Upper Devonian), Elbert Formation (Upper Devonian; shale and sandstone), and Ignacio Quartzite (Upper Cambrian)**
- MD **Leadville, Ouray, and Elbert Formations**

PROTEROZOIC: IGNEOUS ROCKS: Ytr, Ye, Yc, Yp, Xb, Xt; METASEDIMENTS: YXu, YXv, Xi, Xtw

SEDIMENTARY, METAMORPHIC, AND IGNEOUS ROCKS OF PRECAMBRIAN AGE

- Ytr **Trimble Granite (Middle Proterozoic)**—Pale-red, massive, commonly porphyritic, fine- to medium-grained biotite granite
- Yel **Electra Lake Gabbro (Middle Proterozoic)**—Medium- to dark-gray gabbro, diorite, quartz diorite, and granodiorite
- Ye **Eolus Granite (Middle Proterozoic)**—Predominantly pink to brick-red, massive, homogeneous porphyritic biotite-hornblende quartz monzonite
- Yuc **Melasyenite of Ute Creek (Middle Proterozoic)**—Green to dark-gray, massive hornblende-biotite melasyenite
- Yc **Granite of Cataract Gulch (Middle Proterozoic)**—Red, massive, coarse-grained, homogeneous biotite quartz monzonite and granodiorite
- Yp **Quartz diorite of Pine River (Middle Proterozoic)**—Gray, massive, medium-to coarse-grained, homogeneous biotite-hornblende-augite quartz diorite
- YXu **Uncompahgre Formation (Middle and Early Proterozoic)**—Gray, green, and black slate, phyllite, and schist and light-gray, maroon, pale-green, thick- to thin-bedded quartzite containing a few thin layers of quartz-pebble conglomerate and sericitic siltstone
- YXv **Vallecito Conglomerate (Middle and Early Proterozoic)**—Gray, thin- to thick-bedded conglomerate and quartzite
- Xb **Bakers Bridge Granite (Early Proterozoic)**—Pale-red, massive, medium- to coarse-grained granite
- Xt **Tenmile Granite (Early Proterozoic)**—Pink to light-gray, foliated, medium- to coarse-grained granite
- Xi **Irving Formation (Early Proterozoic)**—Metavolcanic and metasedimentary rocks consisting of interlayered amphibolite, plagioclase-bearing gneiss, quartzite, minor iron-formation, and biotite and muscovite schist
- Xtw **Twilight Gneiss (Early Proterozoic)**—Largely fine- to medium-grained quartzofeldspathic biotite, and amphibolite gneiss and quartzite

- **Contact**
- **Fault**—Dotted where concealed. Bar and ball on downthrown side
- **Inferred fault in and beneath valley-fill deposits**—Bar and ball on downthrown side
- **Tertiary dikes**
- **Fold lines**—General locations of major folds shown where space allows. Dotted where concealed
- **Anticline**
- **Syncline**

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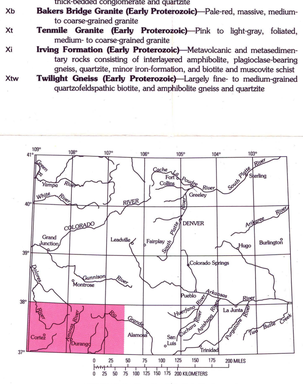
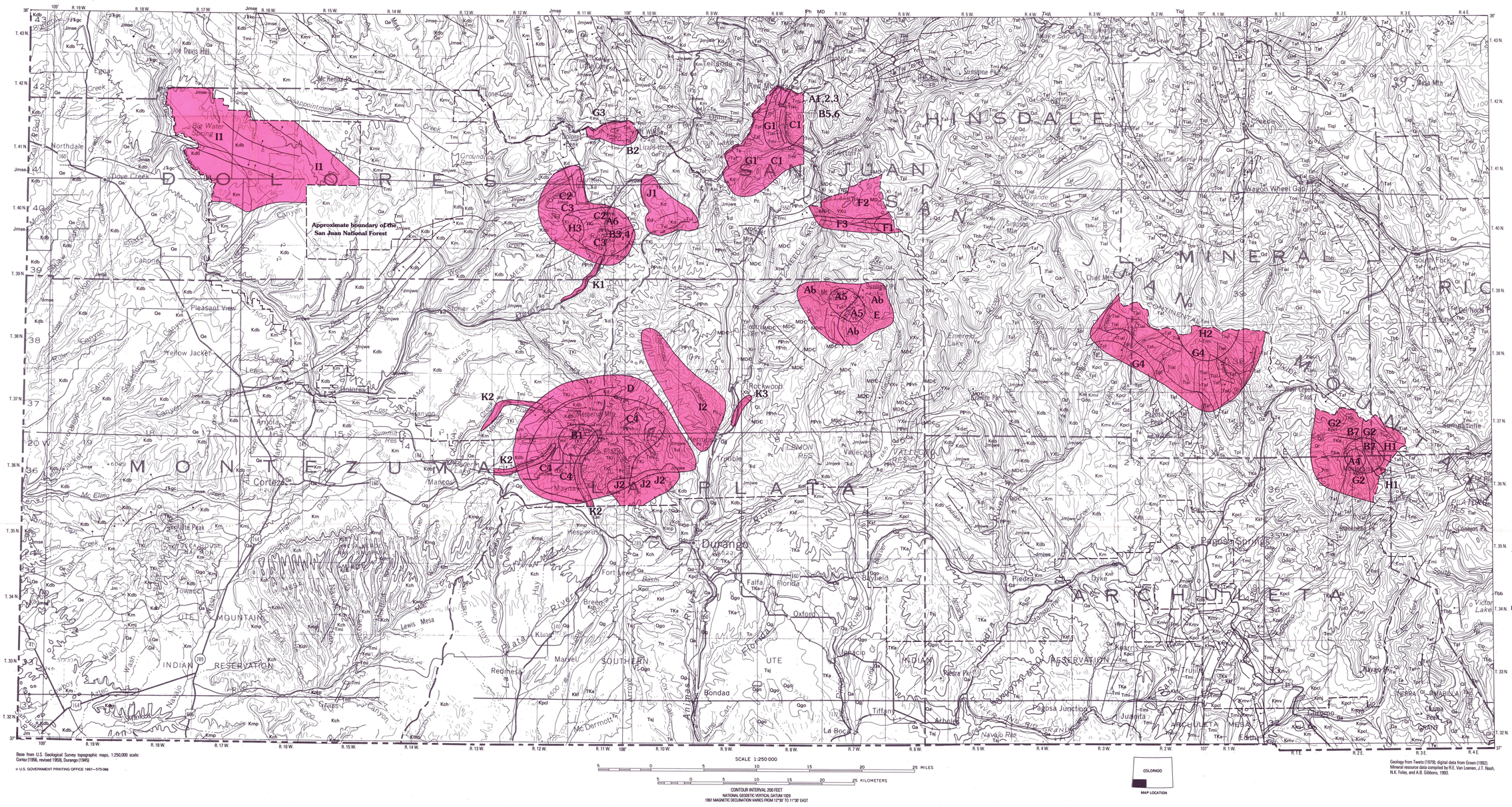


INDEX MAP OF COLORADO SHOWING AREA OF GEOLOGIC MAP

GEOLOGIC MAP OF THE SAN JUAN NATIONAL FOREST AND VICINITY, COLORADO



MAP SHOWING GEOLOGY AND AREAS FAVORABLE FOR LOCATABLE MINERALS IN THE SAN JUAN NATIONAL FOREST, COLORADO

EXPLANATION

[See plate 1 for explanation of geologic symbols]

TYPES OF LOCATABLE MINERAL DEPOSITS

I. DEPOSITS GENETICALLY RELATED TO ROCKS OF THE CRETACEOUS–TERTIARY INTRUSIVE TERRANE

- **Aa. Stockwork molybdenum;** deposits are found in or closely associated with small high-silica porphyry intrusive complexes that have multiple intrusive stages. Deposits may also contain tin, tungsten and bismuth. Favorable areas of the Forest are at Rico, an area west of Silverton (**A1, 2, 3**), Chicago Basin (**A5**), and Crater Lake (**A4**).
- **Ab. Polymetallic veins, skarns, and replacement deposits adjacent to molybdenum-mineralized porphyry stocks;** gold, silver, lead, zinc, and copper-bearing veins in Proterozoic rock around the Chicago Basin stock (**Ab**)
- **B. Porphyry copper-molybdenum deposits;** magmatic-hydrothermal mineralization in quartz stockwork veinlets and disseminated in potassic-altered porphyritic stock and adjacent wallrocks. Deposits may also contain Ag and Au. Areas of the Forest considered to be favorable are an area west of Silverton (**B5, 6**), Rico (**B3, 4**), the Allard stock in the La Plata district (**B1**), and Crater Lake (**B7**).
- **C. Polymetallic replacement and skarn deposits;** hydrothermal deposits of Ag, Pb, Zn, and Cu sulfide minerals in massive lenses, pipe-shaped bodies, and associated veins in limestone, dolostone, or other soluble strata that are replaced by ore. Favorable areas are southwest of Silverton (**C1**), the Dunton-Rico area (**C2, 3**), and the La Plata Mountains region (**C4**).
- **D. Au-Ag-Te veins;** hydrothermal deposits associated with alkalic intrusive rocks. Deposits also contain Cu, Pb, and Zn. The large area in the La Plata Mountains is favorable for additional deposits of this type (**D**)
- **E. Vein uranium related to 1.4-Ga and 10-Ma granites intruding Middle and (or) Early Proterozoic rocks;** vein deposits with the older granites serving as both the source of uranium and host to vein deposits. Veins also contain Au and Ag. Area favorable for this type of deposit is in the Needle Mountains (**E**).

II. DEPOSITS RELATED TO ROCKS OF THE TERTIARY VOLCANIC TERRANE

- **F. Epithermal vein deposits hosted by Proterozoic rock.** Includes the following three deposit types.
  - **F1. Epithermal Au-Ag-Te vein deposits;** vein deposits formed from hydrothermal solutions probably related to nearby Tertiary-age igneous intrusive activity. Deposits also contain lead and zinc. Favorable area is within and near the Beartown mining district (**F1**).
  - **F2. Polymetallic epithermal veins;** hydrothermal vein deposits related to nearby Tertiary-age igneous intrusive activity. Deposits also contain Au, Ag, base metals, and U. The area of Whitehead Gulch-Deer Park east to Beartown and south to Elk Park is favorable for this type deposit (**F2**).
  - **F3. Epithermal uranium vein deposit;** hydrothermal deposit in fractures in Uncompahgre quartzite and slates. Area around the Centennial mine near Elk Park is favorable (**F3**).
- **G. Creede epithermal veins hosted in Tertiary volcanic terrane.** Favorable areas are west of Silverton (**G1**), Crater Creek/Quartz Creek (**G2**), Mt. Wilson (**G3**), and Piedra Peak (**G4**).
- **H. Epithermal quartz-alunite gold deposit in Tertiary volcanic terrane;** associated with high-alumina alteration. Deposits also contain silver. Favorable areas are Crater Creek/Quartz Creek (**H1**), Calico Peak (**H3**), and Piedra Peak (**H2**).

III. DEPOSITS GENETICALLY RELATED TO ROCKS OF THE PALEOZOIC–TERTIARY CLASTIC TERRANE

- **I. Sandstone uranium;** stratiform deposits of Salt Wash and related types are found in sandstone in the lower (pre-Cretaceous) part of the clastic terrane. Favorable areas are in the extreme northwest corner (**I1**) of the Forest and in the central part, north of Durango (**I2**).
- **J. Sandstone vanadium-uranium;** stratiform deposits of Placerville type are found in the upper part of the Entrada Sandstone of Middle Jurassic age. Favorable areas are at Graysill, northeast of Rico (**J1**), and in the southern part of the La Plata Mountains (**J2**).

IV. DEPOSITS RELATED TO THE QUATERNARY SURFICIAL TERRANE

- **K. Gold placers;** concentrations of gold in alluvial gravel deposits downstream from lode deposits. Areas favorable are gravel deposits along the Dolores (**K1**), Mancos and La Plata Rivers (**K2**), and Animas River (**K3**).

MINERAL RESOURCE POTENTIAL AND GEOLOGY OF THE SAN JUAN NATIONAL FOREST, COLORADO

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1997