DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

OPEN-FILE REPORT
79-1473
MARSHALL PASS MINING DISTRICT, CO

Base from U.S. Geological Survey, Chester and Pahlone Peak quadrangles, 1967

Geology mapped in 1975-78

CONTOUR INTERVAL 40 FEET

PRELIMINARY GEOLOGIC AND STRUCTURAL MAPS AND SECTIONS OF THE MARSHALL PASS MINING DISTRICT, SAGUACHE, GUNNISON, AND CHAFFEE COUNTIES, COLORADO

By
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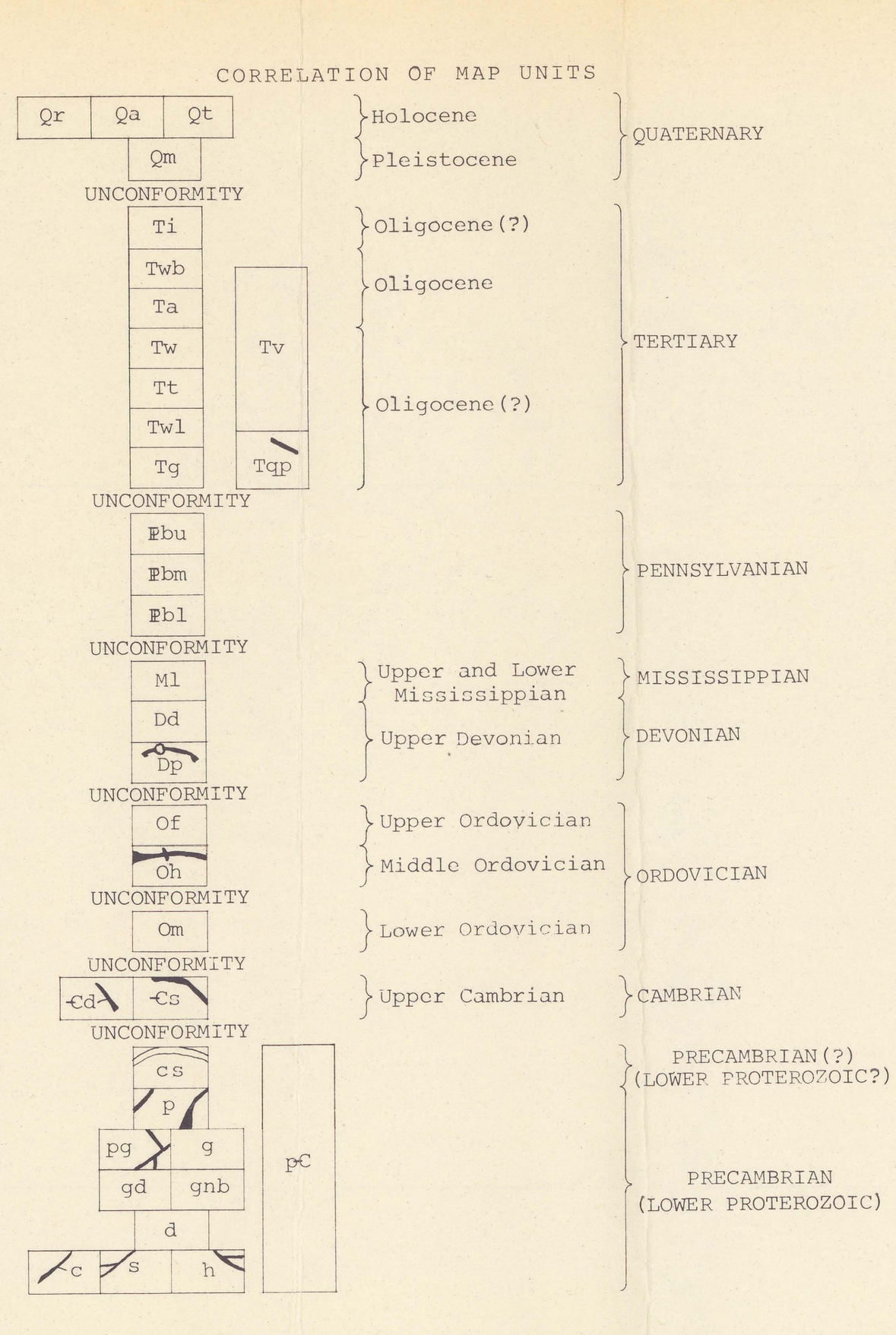
CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qr ROCK GLACIER DEPOSIT (HOLOCENE)--Tongue-shaped, lobate deposit composed of angular rock fragments as large as boulders, generally lacking fine-grained material on the upper surface

Qa ALLUVIUM (HOLOCENE)--Poorly sorted gravel, sand, and silt deposits containing boulders and cobbles of various Precambrian, Paleozoic, and Cenozoic rocks. Thickness commonly several meters

Qt TALUS OR LANDSLIDE DEPOSITS (HOLOCENE)--Poorly sorted, incoherent, locally derived rock fragments and soil deposited chiefly by gravity on or at the foot of a slope. Thickness commonly several meters

Qm GLACIAL DEPOSITS (PLEISTOCENE)--Till composed of unsorted sand, gravel, clay, and boulders deposited as ground, lateral, and terminal moraines; characterized by hummocky surface. Thickness several meters

Ti INTRUSIVE RHYOLITE (OLIGOCENE?)--Fine-grained to felsitic rhyolite, in part having steeply dipping, platy, planar flow structure. Perlitic obsidian in thin zone near contact. Forms two small plugs cutting Rawley Andesite near mouth of Duncan Creek

Twb ASH-FLOW TUFF ON CONTINENTAL DIVIDE (OLIGOCENE)--Several white, cream to grayish-brown welded ash-flow tuffs of probable quartz latitic composition in area on Continental Divide west of Windy Peak. Varieties range from crystal-poor (10-15 percent) to crystal-rich (30-40 percent) in various units. Phenocrysts are of biotite, clear rectangular feldspar (in grains as large as 1x2 mm), quartz, and a few small crystals of magnetite and hornblende. Eutaxitic structure shown by collapsed pumice fragments and shards. One to 5 percent inclusions of darker andesite or quartz latite are present in some units. Cavities locally present in vapor-phase alteration zone. Probably correlative with Bonanza Tuff of Bonanza district to southeast. Thickness of erosional remnant is about 80-90 m

Ta RAWLEY ANDESITE (OLIGOCENE)--Dark-grayish-brown andesite, mostly porphyritic with phenocrysts of plagioclase, augite, biotite, magnetite, and sparse hornblende and olivine or its alteration products, in a dark-gray, pilotaxitic aphanitic or glassy groundmass. Includes lesser amounts of dark quartz latite, somewhat lighter in color than andesite, and dark olivine-bearing basalt. Lath-shaped plagioclase phenocrysts commonly 0.1-3 mm in diameter. Named for locality in Bonanza district (Burbank, 1932) to the east. Similar Rawley Andesite flows on the northeast side of the Bonanza volcanic center dated by Van Alstine and Marvin (Lipman and others, 1970, p. 2336-2337) as 34.2 and 33.4 million years in age. Thickness of groups of flows in southern part of district is as much as 550 m

Tv VOLCANIC BRECCIA, TUFF, AND VOLCANIC CONGLOMERATE (OLIGOCENE?)-Purplish-to reddish-brown or cream-colored tuff breccia, flow breccia, lapilli tuff, and volcanic conglomerate, containing clasts of locally derived Precambrian rocks, andesite, quartz latite, pumice, and sparse Paleozoic limestone, in a matrix of volcanic ash with detrital sand grains in places. Crude, coarse layering present locally. Tuffaceous matrix commonly contains 10-45 percent phenocrysts of feldspar and biotite; pumice fragments as much as 1 cm in diameter. Quartz latite clasts also contain plagioclase, sanidine and biotite phenocrysts in a reddish felsitic or glassy matrix. Precambrian rock fragments, typically about 5-8 cm in diameter although many exceed 1 m, were apparently shed from an uplifted block to northwest and deposited on slopes of a subsiding basin. The two fault-bounded blocks containing Leadville Dolomite and rocks from the lower part of the Belden Formation on the north side of Millswitch Creek are probably allochthonous masses shed from a nearby uplift, moved down-slope under gravity, and incorporated in the unit Tv. The above units are interlayered with flows, waterlaid tuff, and gravel which are included in the formation in some areas where poor exposures make differentiation of units difficult. Thickness as much as 350 m in area of Millswitch Creek and upper Marshall Creek where it appears to have filled east- or southeast-plunging trough

Tw QUARTZ LATITE ASH-FLOW TUFF (OLIGOCENE?)--Light-colored quartz latite, occurring in several welded ash-flow tuff units, most of which contain 10-30 percent phenocrysts of biotite, plagioclase, and quartz in a felsitic red-brown to light-gray matrix. Fragments of white pumice, as large as 2 cm but commonly 1-4 mm in diameter, constitute as much as half of some tuffs, and an eutaxitic structure is caused by gray to black, partly glassy, lenticular collapsed pumice fragments. Spherulitic texture common. Sparse inclusions of older rocks including volcanics and waterlaid tuff are not uncommon. Ash flows are at base of Tertiary volcanics in places and are also interlayered with andesitic flows, waterlaid tuff, and other Tertiary units. Thickness 0-100 m

Tt WATERLAID TUFF (OLIGOCENE?)--White to light-brown fine-grained thin-bedded waterlaid tuff; fine biotite grains commonly present. Commonly soft and easily eroded but in places is hard, brittle, and platy. Minor admixture of sand grains or other nontuffaceous detritus. A few rare yellow-brown sandstone units, not mapped separately, are as much as 10-15 m thick. Underlies Rawley Andesite (Ta) and thus is probably older than 34 m.y. Pollen spores from this formation in eastern part of district were reportedly determined to be Eocene in age by Estella Leopold of the U.S. Geological Survey (Ranspot, 1958, p. 14). Thickness 20-200 m

Twl LOWER WELDED ASH-FLOW TUFF (OLIGOCENE?)--Quartz latitic, densely welded, ash-flow tuff composed of flattened pumice lapilli, fragments of Precambrian rocks and andesite, and small phenocrysts of plagioclase and potassic feldspar, biotite, opaque minerals, and partly resorbed quartz in a devitrified or black vitric matrix. Represents two or more ash flows, separated by thin gravel deposits, with combined thickness about 60 m, at base of Tertiary volcanic section

Tqp QUARTZ PORPHYRY DIKES (OLIGOCENE?)--White to purplish-gray felsitic matrix, with fluidal structure, containing sparse small phenocrysts of quartz and feldspar as much as 2 mm in diameter. Found near Porphyry Creek in northwest corner of quadrangle; thickness ranges from about 1 to a few meters. A thicker body of similar porphyry about 2.4 km west of quadrangle boundary has been dated 34.4±3.3 m.y. by Naeser and Cunningham (1976)

Tg GRAVEL AND CONGLOMERATE (OLIGOCENE?)--Gravel deposits, locally consolidated, containing rounded boulders as much as several meters in diameter largely of Precambrian and Paleozoic rocks, less commonly including Tertiary volcanic rocks. Transported from sources as much as several kilometers distant, the gravels are found generally at the base of the Tertiary volcanic section and locally between flows. Thickness 0-60 m

BELDEN FORMATION (PENNSYLVANIAN)

₽bu Upper sandstone and shale member--Composed chiefly of buff or drab colored, medium- to coarse-grained sandstone, interbedded siltstone and gray shale, and minor conglomeratic sandstone. Interpreted to have formed chiefly by shallow-water, near-shore marine deposition of medium-and fine-grained clastic sediments in a northwest-trending trough just off the northeast edge of the Uncompahgre highland, from which the clastics were eroded, and by coarser grained fluvial clastic deposition. Considered generally similar to and probably at least partly correlative with the Gothic Formation of Langenheim (1952) and Bartleson (1972) and the Minturn Formation described in the area to the east by DeVoto (1972). Top removed by erosion; thickness 200 m or more

₽bm Middle limestone and shale member--Composed of layers of blue-gray limestone, partly fossiliferous, a few centimeters to as much as 30 m thick, interbedded with gray to purplish-red shale, siltstone, and fine sandstone. Exposures are generally poor, but the relatively abundant limestone fragments in sandy or silty soil help distinguish this unit from those above and below. Drill holes commonly show predominance of shale and fine sandstone over limestone in subsurface. Thickness 30-120 m

₽bl Lower sandstone, carbonaceous shale, and limestone member--Red or brown fine-grained sandstone and shale interbedded with 1-3 m layers of black shale or mudstone containing coaly carbonaceous material and locally with red or yellowish shale; lenticular white, gray, or reddish-brown arkosic or quartzose, micaceous, gritty, coarse-grained sandstone, quartzite, and conglomeratic sandstone occur mostly near base and in lower part of unit. Conglomeratic sandstone is composed of subrounded to subangular quartz grains commonly 0.2-1 mm in diameter with sparse interstitial iron oxides and clay minerals, containing pebbles and cobbles of quartz, Precambrian rocks, and lesser amounts of limestone in various proportions. A few thin medium-gray fine granular detrital limestone beds, from several centimeters to 30 m thick, occur near top of unit. Deposited unconformably on irregular surface of Leadville Dolomite (Ml). In southern part of district, poorly exposed contacts of Belden with Precambrian rock are shown on the map as faults, although the possibility exists that such contacts may locally be depositional unconformities. Grades upward into middle Belden unit with increasing proportion of limestone beds. This heterogeneous unit is interpreted to have formed from detritus eroded from the rising Uncompahgre highland area nearby to the southwest and deposited chiefly in fluvial, deltaic, coastal-plain environments. Lithology is generally similar to Kerber Formation in area to southeast as described by Burbank (1932, p. 13), with which it may be at least partly correlative. Total thickness of unit 40-100 m

Ml LEADVILLE DOLOMITE (MISSISSIPPIAN)--Massive blue-gray to brownish-gray dolomite and subordinate but abundant limestone; calcite veinlets plentiful. Lower part near base is commonly thin bedded blue-gray sandy limestone. A grayish-brown dolomite with white flecks of dolomite, termed "salt-and-pepper" dolomite was noted several places in 20-m zone near middle of section. Massive thin-bedded dolomite and limestone common in upper part. Near top, thin quartz veins, minor chert bodies, karst features, brecciated appearance, and minor replacement of limestone by limonite and hematite locally give evidence of pre-Belden weathering and erosion at surface of unconformity. Gray dolomite is brecciated in large fault-bounded area 2 km south-southwest of Pitch mine. Thickness, about 100-130 m, varies owing to unequal erosion during post-Leadville, pre-Belden time

CHAFFEE GROUP (UPPER DEVONIAN)

Dd Dyer Dolomite--Upper part, mostly thin-bedded sandy dolomite, locally fossiliferous; few massive cream-colored dolomite layers. Lower part, white to creamy gray or light-tan, thin-bedded, commonly sandy dolomite and limestone. Characteristically weathers to small brownish yellow fragments and chips that have a smooth surface. Possibly contains strata of Early Mississippian age in uppermost part. Thickness 45-50 m

Dp Parting Quartzite--Red, green, and gray mudstone or shale; coarse-grained, locally conglomeratic, quartzite as much as 2 m thick; and shaly limestone. Thickness about 3-6 m

Of FREMONT DOLOMITE (UPPER ORDOVICIAN)--Bluish-gray, commonly mottled, massive crystalline dolomite and limestone. Most fossiliferous formation in area; fetid odor common when broken; chert blebs present locally but much less abundant than in Manitou Dolomite (Om); cliff forming. Upper 15 m is less resistant thin-bedded shaly to sandy dolomite. Thickness about 55 m

Oh HARDING QUARTZITE (MIDDLE ORDOVICIAN)--Quartzite and minor black shale. Upper third, medium- to coarse-grained, fossiliferous, limonitic quartzite; black carbonaceous shale 5-15 cm thick common at top; uranium-mineralized limonitic zone 1-2 m thick, with carbonaceous material, fish scales and other fossil remains, and asphaltic pellets, about 2-3 m below top of formation. Lower two thirds, white medium- to fine-grained silica-cemented quartzite. Beds in the mineralized zone are mostly 5-20 cm thick and are chiefly sandstone or quartzite with a few 5-10 cm thick shale beds. Four samples from this zone ranged from 19 to 250 ppm Ra_eU, from 2 to 31.6 ppm Th, and from 0.56 to 2.3 percent K. Uranium content of the mineralized zone is as much as 250 ppm at many places in the district and exceeds that locally. Is a distinctive marker bed in the predominantly carbonate Paleozoic section. Total thickness 10-12 m

Om MANITOU DOLOMITE (LOWER ORDOVICIAN)--Bluish-gray to light-gray dolomite, commonly pinkish cast on fresh surface; thin-bedded (lower part) to massive; cliff forming; characteristic nodules and lenses of chert along bedding planes, especially in lower half. Deposited unconformably on Precambrian crystalline rocks or on thin, discontinuous beds of Sawatch Quartzite (€s). Thickness 75-90 m

€d SANDSTONE DIKES (CAMBRIAN)--Dikes of Sawatch Quartzite (€s), interpreted to have formed by filling of open fractures by sand, from above, at time of Sawatch deposition. The two known dikes trend north-northwest in the northwest corner of the quadrangle and are less than 6 m thick. Thin sections show that rounded quartz grains, some with quartz overgrowths, constitute more than 95 percent of the rock, with only a small percentage of microcline and plagioclase grains, muscovite, and interstitial calcite

€s SAWATCH QUARTZITE (UPPER CAMBRIAN)--White, vitreous, medium-grained quartzite composed largely of rounded quartz grains 0.1-0.7 mm in diameter. Less than 1 m thick in southernmost exposures on Lime Ridge to several meters thick near the head of Brier Creek in northwestern part of quadrangle

PRECAMBRIAN(?) (LOWER PROTEROZOIC?) ROCKS

cs Ultramafic rocks--Dark-green schistose to massive ultramafic dike rocks (peridotite) composed of chlorite, colorless to very pale green amphibole, pyroxene, olivine and its alteration products, serpentine, magnetite, biotite, and minor plagioclase. Peridotite east of the north end of the Pitch mine was analyzed by N. Skinner (written commun., 1978) of the U.S. Geological Survey as follows, in percent: SiO_2, 43.3, Al_2O_3, 7.9; Fe_2O_3, 3.8; FeO, 5.4, MgO, 25.4; CaO, 6.6; Na_2O, 0.23; K_2O, 0.07; TiO_2, 0.43, P_2O_5, 0.17; MnO, 0.14; H_2O^+, 5.4, H_2O^-, 0.18; CO_2, 0.01; and Sum, 99. Dike-like bodies about 1-60 m thick. Found in at least 6 places in hanging wall block within 800 m of Chester reverse fault, suggesting possible intrusion into fractures related to deep faulting

PRECAMBRIAN (LOWER PROTEROZOIC) ROCKS

P Pegmatite--White to pink very coarse-grained granitic pegmatite dikes composed chiefly of plagioclase, microcline, quartz, muscovite, and biotite, minor tourmaline, and magnetite. Magnetite crystals in Harry Creek area are as large as 7 cm in diameter. One dike was mined for feldspar in sec. 13, T. 48 N., R. 6 E. Only the more conspicuous bodies have been mapped; most are less than 50 m thick but some are as large as 100 m

pg Pegmatitic granite--White to pink coarse-grained or pegmatitic, gneissic granite composed of plagioclase microcline, quartz, biotite and muscovite, minor apatite, and magnetite; inclusions of metamorphic rocks common. Cut by pegmatite and rare aplite dikes

g Medium-grained quartz monzonite--Light-gray to red holocrystalline, granular, gneissic quartz monzonite composed of the following in percent: oligoclase, 19-35; microcline, 33-45, quartz, 22-33; disseminated parallel flakes of biotite, 2-9; muscovite, trace to 1, magnetite, 1-2, sphene, trace to 2.5; and rare green hornblende and zircon. Occurs as batholithic body and as small dikes cutting older gneissic granite and metamorphic rocks. Contains small pegmatite streaks locally. In one area east of Harry Creek, a fine-grained porphyritic variant occurs in thick layers with schist and migmatite that may represent metamorphosed siliceous metavolcanics or quartz porphyries, although origin is obscured by recrystallization

gn Porphyritic gneissic quartz monzonite--Light-colored porphyritic gneissic quartz monzonite; numerous tabular or rectangular phenocrysts of microcline, 1-2 cm long, in subparallel orientation

gnb Porphyritic gneissic biotite quartz monzonite--Gray coarse- to medium-grained, porphyritic gneissic quartz monzonite similar in composition to unit gn but darkened by more abundant biotite. Included in and cut by the lighter-colored medium-grained quartz monzonite (g). Modal analysis of a typical sample near Old Monarch Pass contains the following in percent: quartz, 23; microcline, 33; oligoclase, 28; myrmekite, 0.6; biotite, 9; hornblende, 2.8, sphene, 2.5, opaque minerals, 1.2; and zircon, 0.3

d Gneissic hornblende diorite--Gneissic rock composed of about 25-45 percent green hornblende grains 1-5 mm long, 40-65 percent plagioclase, 5-10 percent biotite, as much as 5 percent quartz, and minor chlorite and apatite; more uniform than other hornblendic units Epidote common in joints. A sample of the small intrusive body south of Lime Creek analyzed by N. Skinner (written commun., 1978) of the U.S. Geological Survey contains the following in percent: SiO_2, 52.1; Al_2O_3, 17.8; Fe_2O_3, 3.4; FeO, 5.6; MgO, 6.6; CaO, 5.0; Na_2O, 2.6; K_2O, 2.7; TiO_2, 0.74; P_2O_5, 0.29, MnO, 0.15, H_2O^+, 1.6, H_2O^-, 0.20; CO_2, 0.01; and Sum, 99. The diorite is cut by dikes of granite and pegmatite. Several thin (1 meter?) veinlike bodies of magnetite-rich rock composed of magnetite, aggregates of secondary hornblende, phlogopite(?), and magnetite; chalcedony; amphibole; and highly altered rectangular feldspar(?) grains, not shown on map, occur near and are probably genetically associated with the diorite body south of Lime Creek

c Marble--Layer of marble about 1-2 m thick on slope west of South Fooses Creek, in northeast trending zone in which calc-silicate rocks are relatively common in the metamorphic rock sequence

s Mica gneiss and schist--Biotite-muscovite-quartz gneiss, schist, and migmatite in layers of variable composition and probable metasedimentary origin; contains microcline, plagioclase, sillimanite, garnet, and magnetite. Includes small interlayered units of various metasedimentary rock types such as calc-silicate rocks; biotite-epidote quartzite; several blue-gray quartzite beds as much as 20 m thick near Peel Point that resemble metachert; coarse silvery muscovite schist; and spotted schists with eye-shaped lenses of quartz or of quartz and muscovite. Micaceous schists and gneisses are heterogeneous; most are interpreted to have been fine sandstone or siltstone. Quartz is generally the most abundant mineral; microcline content is quite variable, becoming more abundant in some areas of gneissic or migmatitic structure. Development of migmatite ranges from negligible to incipient growth of feldspar crystals to strongly migmatitic with numerous pegmatitic streaks and layers. Spotted gneiss and schist, found in some areas in the eastern part of the quadrangle, have light-colored lenticular spots about 2-7 mm across that are composed chiefly of interlocking quartz grains, like the matrix, together with muscovite or fibrous sillimanite; the spots lack the small biotite plates that darken the matrix of the rock. Calc-silicate rocks containing epidote, quartz, garnet, calcite, and biotite are present in layers one to several meters thick, noted particularly in a 1-km-wide zone trending northeastward from the mouth of Burned Timber Creek across the Continental Divide north of Peel Point, thence northeastward toward corner of quadrangle

h Hornblende gneiss and schist--Fine- to coarse-grained gneiss and schist composed of plagioclase, gray- to blue-green amphibole, chlorite, quartz, epidote, garnet, and sphene. Some retrograde development of chlorite from hornblende. Interlayered with various mica gneisses and probably represents hornblendic units of both metasedimentary and metavolcanic origin. Hornblende schist of probable metasedimentary origin shows layering and a relatively high quartz content which varies in different layers. Hornblende, and in many places epidote, poikilitically enclose finer-grained quartz and plagioclase. Locally, as on slopes east of Green Creek on the northeast border of the quadrangle, hornblende schist containing fine granular quartz in angular to eye-shaped fragments as much as 4x10 mm in size is interpreted to have been a metamorphosed conglomeratic sandstone. Hornblende schist or gneiss that may be of volcanic origin is less common but is suggested for some mapped layers by the presence of round white spots, similar to amygdules or spherulites, and curved fractures and textural variations that resemble poorly defined pillow structures

p€ PRECAMBRIAN ROCKS, UNDIVIDED--Precambrian rocks of various lower Proterozoic units described above found in cross sections

CONTACT--showing dip

FAULT--Showing dip. Dashed where inferred; dotted where concealed. U, upthrown side; D, downthrown side

QUARTZ VEIN

STRIKE AND DIP OF BEDS
- Inclined
- Vertical
- Horizontal

STRIKE AND DIP OF FOLIATION
- Inclined
- Vertical

BEARING AND PLUNGE OF LINEATION--May be combined with foliation symbol

Faults

The Chester Fault is a complex reverse fault zone 60 to more than 100 m wide, dipping eastward from about 20° to nearly vertical. The lower dips are found near the Little Indian No. 36 mine north of Lime Ridge, whereas steeper dips occur to the south. The displacement exceeds 430 m. The Chester fault zone is the contact between Precambrian and Paleozoic rocks for about 6 km. South of this interval it is buried by Oligocene volcanic rocks, whereas to the north it becomes less evident, because of poor exposures and absence of Paleozoic rocks, and toward the Monarch Pass area it branches into several divergent smaller faults flanked by Precambrian rocks on both sides.

Another reverse fault forms the contact of Precambrian granite and Belden Formation on the slope west of Tank Seven Creek. It seems likely that this fault extends west-northwest across areas where rocks and contacts are poorly exposed, at least as far as Milk Creek, beyond which it is buried by Rawley Andesite. To the east-southeast the inferred fault zone is buried by Rawley Andesite and other volcanics, but it may be related to the Kerber Creek fault system exposed about 27 km to the S 55° E, as both are inferred to have been near the northeast edge of the Uncompahgre uplift at the time of deposition of Pennsylvanian clastic sediments.

A pre-volcanic fault zone that is probably related to the above is inferred from local structural complexity shown by poor exposures near the mouth of Tank Seven Creek. This fault zone probably extends northwestward in or near Marshall Creek valley but is not exposed. This interpretation is perhaps strengthened by the structure contours drawn on the pre-volcanic surface, which show a pre-volcanic northwest-trending ridge just north of Marshall Creek.

Uranium deposits

Mineral exploration in the Marshall Pass district has been concentrated chiefly on uranium, although minor iron workings occur near the Leadville-Belden unconformity and feldspar workings occur in two Precambrian pegmatites. Radioactivity and uranium were discovered in carbonaceous shale of the Belden Formation near the mouth of Indian Creek in 1955, followed by discoveries in the Harding Quartzite northwest of Indian Creek, in the Harding at Little Indian No. 36 mine, and in Precambrian shear zones in the Harry Creek area.

Drilling and exploration of the large deposit at the Pitch (Pinnacle) mine was started in 1956 (Baker and Scott, 1961): it was mined by small underground workings from 1958 until 1962 and yielded about 1 million lb U_3O_8. Later exploration from 1972 to 1978 established a reported reserve of 2.1 million tons of ore, average grade 0.17 percent U_3O_8, containing 7.14 million lb. of U_3O_8 (Ward, 1978). Open-pit mining of the deposit by the Homestake Mining Company began about November 1978. Uranium mineralization at the Pitch mine is in beds of the Belden Formation and Leadville Dolomite where they are steeply upturned and brecciated in the footwall of the Chester reverse fault. Uranium minerals reported from the Pitch mine are uraninite, sabugalite, and meta-torbernite (Ward, 1978).

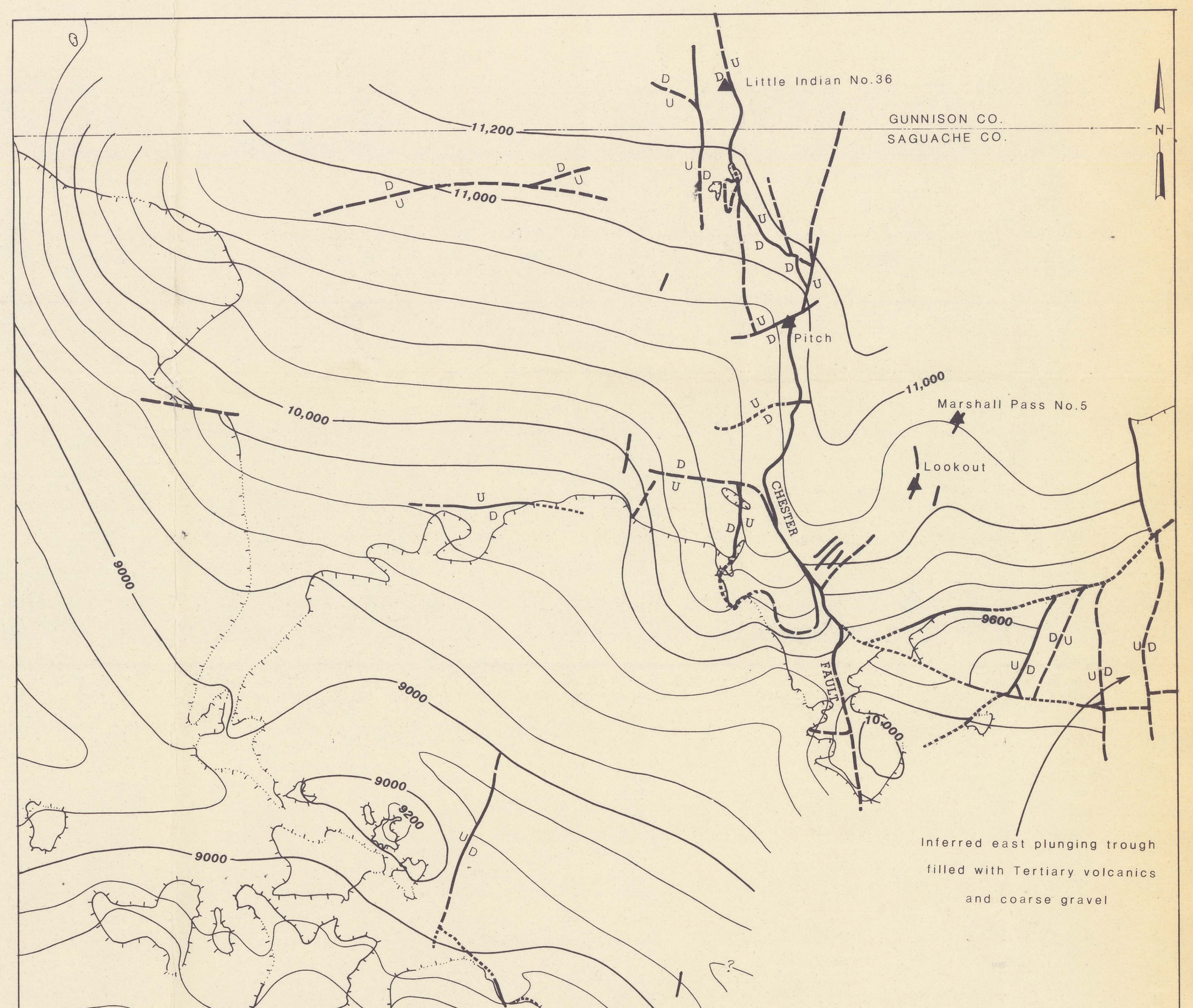
In the Harding Quartzite, the 1 to 2 m-thick mineralized zone generally ranges from 100 to 300 ppm U and contains 250 ppm U at many places in the district. The uranium is associated with pyrite, hematite, and goethite in the zone characterized by organic material, fish scales, and asphaltic pellets 2-3 m below the top of the formation. The 8,152 tons of ore mined prior to 1971 at the Little Indian No 36 mine is reported to have yielded 71,762 lbs. U_3O_8 at an average grade of 0.44 percent U_3O_8 (Nelson-Moore and others, 1978, p. 175). This higher grade ore was mined where the beds dip steeply adjacent to the Chester fault. Uranium minerals reported from the Harding Quartzite at this locality include uranophane, uraninite, autunite, gummite, and boltwoodite.

Mineralized shear zones in Precambrian rocks in the Harry Creek area have also yielded a small uranium production totaling 14,251 lb. of U_3O_8 from 595 tons of ore (Nelson-Moore and others, 1978, p. 391-392) from the Lookout and Marshall Pass groups of claims. Uranium minerals identified by Gross (1965) from the Lookout No. 22 mine are uraninite, schoepite, epiianthinite, becquerelite, soddyite, boltwoodite, uranophane, zeunerite, metazeunerite, and hydrated autunite.

The principal control for uranium vein formation is the faulting or fracturing of the rocks and, in the case of the Harding Quartzite deposits, a relatively permeable layer in sandstone, that formed channelways for uranium-bearing solutions. The known deposits are inferred to have been overlain at shallow depth by ash-flow tuff and waterlaid tuff of Oligocene(?) age, as indicated by the inferred structure contours on the pre-volcanic surface shown on the accompanying map. The waterlaid tuff indicates lacustrine conditions in an area of at least 30 sq. km in the district. Similar lacustrine deposits have been noted by Dings and Robinson (1957, p. 33) and Raines (1971, p. 28) in the Tomichi Creek valley north of Sargents. The light-colored siliceous, tuffaceous units are spatially associated with the deposits and are a likely potential source from which uranium may have been leached and carried by ground water. Except for two small rhyolite plugs near the mouth of Duncan Creek, Phanerozoic intrusive rocks that might suggest a hypogene source are not known in the district.

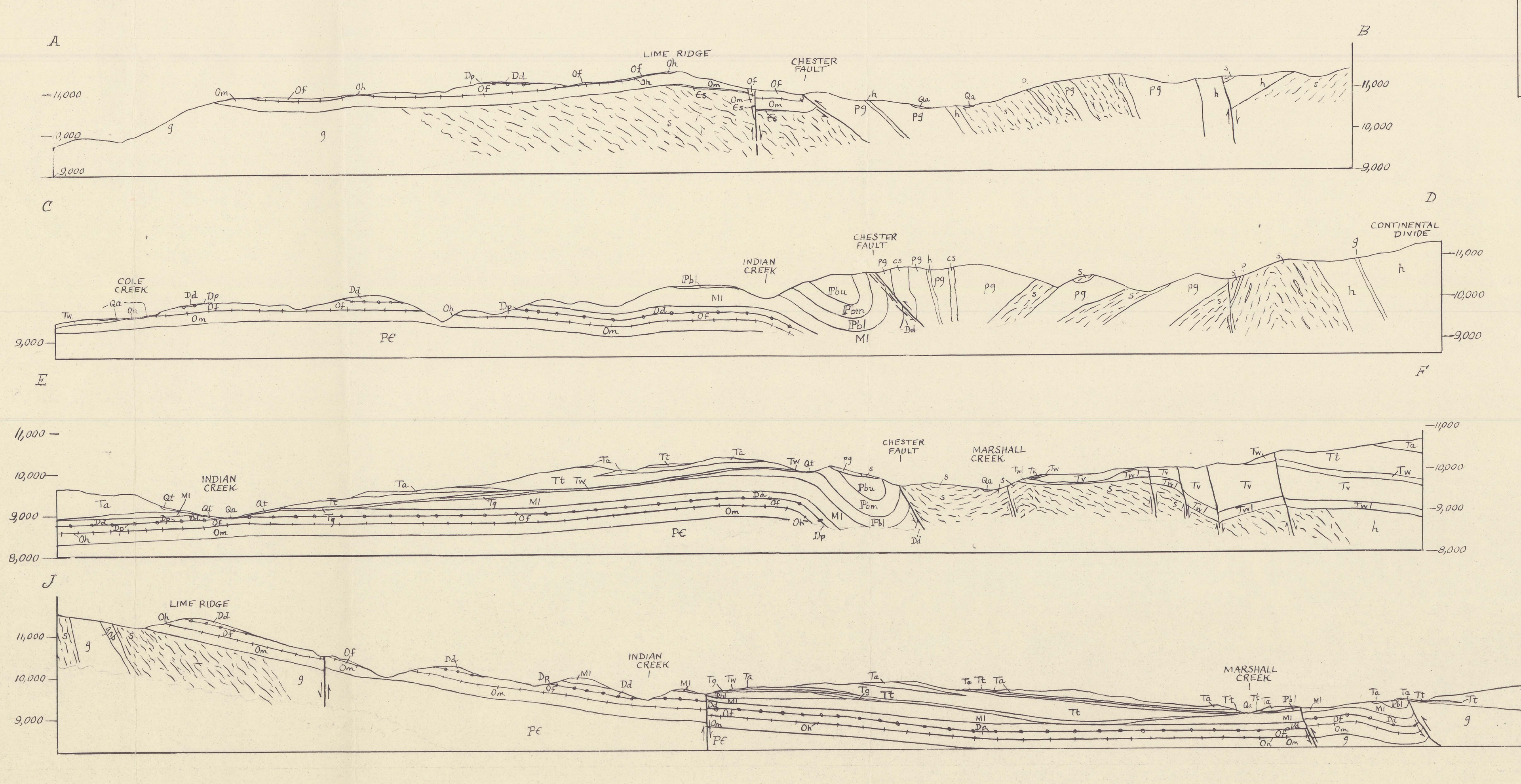
References

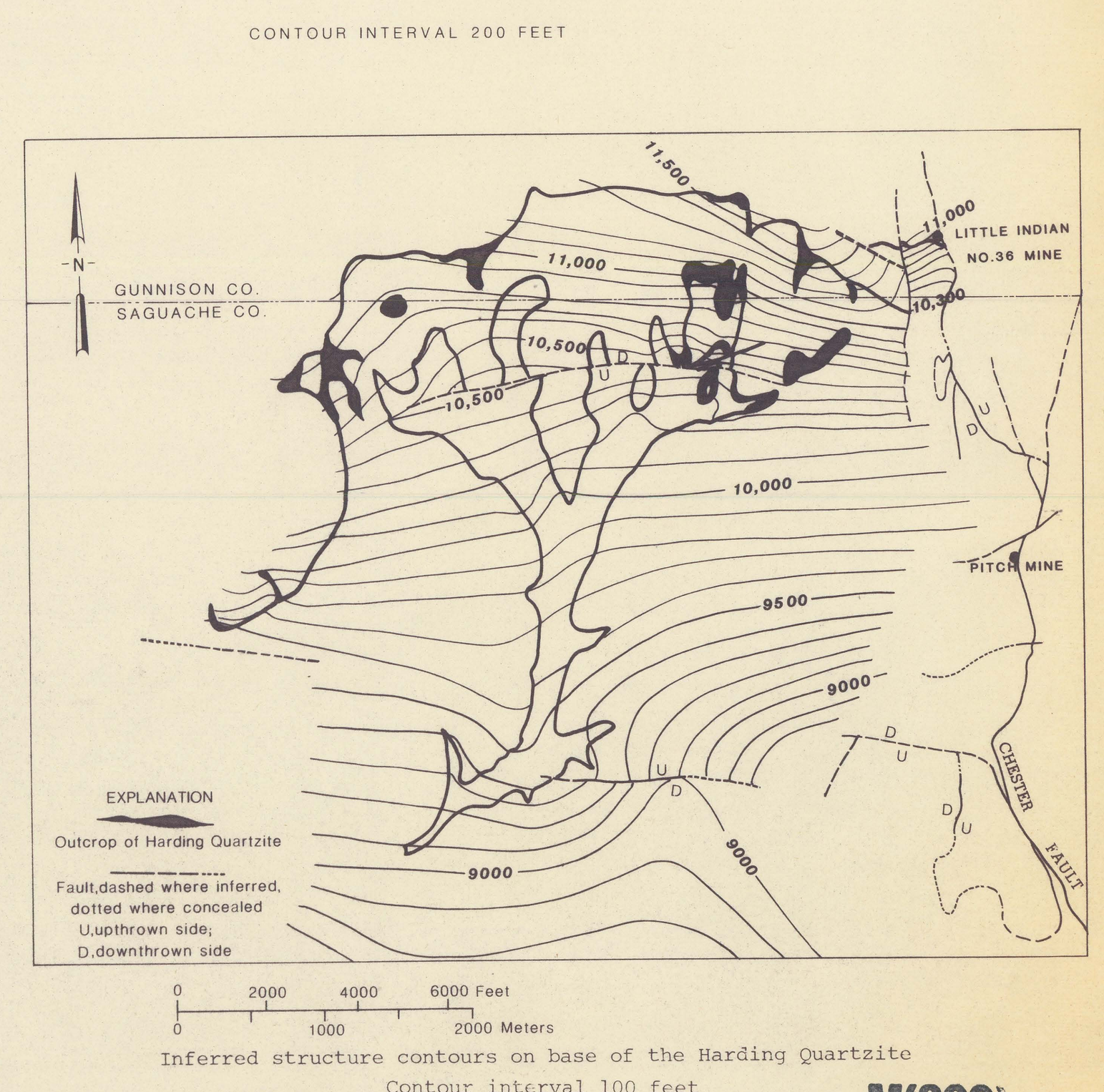
Baker, Arthur, III, and Scott, B. C., 1961, Past problems, present purpose at Pitch: Mining Engineering, p. 488-491.
Bartleson, Bruce, 1972, Permo-Pennsylvanian stratigraphy and history of the Crested Butte-Aspen region: Quarterly of Colorado School of Mines, v. 67, no. 4, p. 187-248.
Burbank, W. S., 1932, Geology and ore deposits of the Bonanza mining district, Colorado: U.S. Geological Survey Professional Paper 169, 166 p.
DeVoto, R. H., 1972, Pennsylvanian and Permian stratigraphy and tectonism in Central Colorado. Quarterly of Colorado School of Mines, v. 67, no. 4, p 139-185.
Dings M. G., and Robinson, C. S., 1957, Geology and ore deposits of the Garfield quadrangle, Colorado: U.S. Geological Survey Professional Paper 289, 110 p.
Evans, J. L., 1973, Geology of the Upper Marshall Creek drainage basin, Saguache County Colorado Colorado School of Mines M.S. Thesis, 78 p.
Gross, E. B., 1965, A unique occurrence of uranium minerals, Marshall Pass, Saguache County Colorado. American Mineralogist, v. 50, nos. 7-8, p. 909-923.
Langenheim, R. L., Jr., 1952, Pennsylvanian and Permian stratigraphy in Crested Butte quadrangle, Gunnison County, Colorado: Bulletin of the American Association of Petroleum Geologists, v. 36, no. 4, p. 543-574.
Lipman, P. W., Steven, T. A., and Mehnert, H. H., 1970, Volcanic history of the San Juan Mountains, Colorado, as indicated by potassium-argon dating: Geological Society of America Bulletin, v. 81, p. 2329-2352.
Malan, R. C., 1959, Geology and uranium deposits of the Marshall Pass district, Gunnison, Saguache, and Chaffee Counties, Colorado: Paper presented at Colorado Mining Association Meeting, Feb. 5, 1959.
Naeser, C. W., and Cunningham, C. J., 1976, Fission-track ages of zircons from three Tertiary porphyries near Tincup, Colorado: U.S. Geological Survey Open-File Report, 76-831, 3 p.
Nelson-Moore, J. L., Collins, D. B., and Hornbaker, A. L., 1978, Radioactive mineral occurrences of Colorado and bibliography: Colorado Geol. Survey Bull. 40, 1054 p.
Raines, G. L., 1971, Geology of the Sargents area, Gunnison and Saguache Counties, Colorado: Colorado School of Mines M.S. Thesis, 55 p.
Ranspot, H. W., 1958, Geology and uranium deposits of the Indian Creek area, Gunnison and Saguache Counties, Colorado: M.S. Thesis, University of Colorado, 57 p.
Ward, J. M., 1978, Paper presented at American Institute of Mining and Metallurgical Engineers meeting, Denver, Colorado, Feb. 26-March2, 1978.



INFERRED STRUCTURE CONTOURS ON BASE OF TERTIARY VOLCANICS AND GRAVELS

CONTOUR INTERVAL 200 FEET





Inferred structure contours on base of the Harding Quartzite

Contour interval 100 feet