Base from U.S. Geological Survey, 1:24,000 Buckhorn Flat, Burnt Peak, Greenville Bench, Kane Canyon, 1971

METERS B L A C K >

QTsf

Some thin surficial deposits not shown

Some thin surficial deposits not shown

2000 feet = 610 meters

PAROWAN

Buckhorn Flat

QTs

2000 feet = 610 meters

**DESCRIPTION OF MAP UNITS** [Quaternary surficial deposits are differentiated on the basis of their relative topographic position, degree of dissection of original landforms, soil development, and general tone on aerial photographs. Stratigraphic position and absolute age determinations for most of these units were determined from exposures in the Beaver 15-minute quadrangle (Machette and others, 1984) just north of the

Qfp Flood-plain alluvium (Holocene)—Light-brown to light-gray, medium- to coarse-grained sand and pebbly to bouldery gravel along Beaver River in northwestern part of map area. Thickness at least 5 m Qac Undivided alluvium and colluvium (Holocene and upper Pleistocene)-Light-brown and light-gray sand, silt, and subordinate gravel deposited by mostly small intermittent and perennial streams in channels, on bordering flood plains, and in local depressions. Locally includes colluvium, sheetwash alluvium, talus, and alluvial-fan deposits. Maximum thickness

Qp Undivided piedmont-slope alluvium (Holocene and upper Pleistocene)-Light-brown to light-reddish-brown, poorly to moderately sorted silt, sand, and gravel that underlie broad piedmont-slope surfaces. These piedmont slope surfaces, which are well developed in several parts of the map area, are underlain mostly by coalesced alluvial fans and pediments. Includes alluvium of small streams and, in places, colluvium, alluvial slope wash, and talus. Thickness locally exceeds 30 m

Undivided alluvial-fan and talus deposits (Holocene and upper

Pleistocene)—Heterogeneous mixture of sand, silt, and subordinate gravel deposited at bases of escarpments. Deposits are probably early Holocene and late Pleistocene where mapped in the northwestern part of map area and were mainly deposited at or near the end of Pinedale glaciation. Maximum thickness in fans is about  $10\,\mathrm{m}$  and along channels is less than  $4\,\mathrm{m}$ Landslide debris (Holocene and upper Pleistocene)—Mostly angular, poorly sorted rock debris moved by gravity from nearby areas of bedrock. In cludes local talus and colluvium. Maximum thickness about 30 m Young terrace alluvium (upper Pleistocene)—Light-brown to light-reddish brown, medium- to coarse-grained sand and pebbly to bouldery gravel Mantles broad, slightly elevated river terraces that represent former, coalesced flood plains of Beaver River. Capped by soil that contains a weak argillic B horizon and either is noncalcareous or has a weak (stage I) Cca (calcareous) horizon (stages of Gile and others, 1966). Mainly glacial outwash and associated alluvium of most recent major glaciation, the

Pinedale, which ended about 12,000 to 15,000 years ago.

Mapped only along Beaver River in northwestern part of map area.

Middle terrace alluvium (middle Pleistocene)—Light-gray to light-reddishbrown, medium- to coarse-grained sand and gravel. Forms river terraces 12-13 m above Beaver River in northwestern part of map area. Capped by soil that contains a moderately developed argillic B horizon and stage II-III Cca horizon. Mainly glacial outwash and associated alluvium of the Bull Lake glaciation, here considered to have ended about 140,000 years ago. Mapped only in northwestern part of map area. Maximum thickness

Thickness at least 4 m

Qop Undivided older piedmont-slope alluvium (middle Pleistocene)—Poorly sorted, unconsolidated to poorly consolidated, silty sand and gravel occurring as remnants of middle and old piedmont-slope alluvium (Qpm and Qpo, respectively). Deposits form at many topographic levels during different ages; all deposits are dissected by present streams. Maximum thickness 10-15 m

Qpy Young piedmont-slope alluvium (upper Pleistocene)—Light-brown to lightreddish-brown, poorly to moderately sorted silt, sand, and gravel. Inter tongues with or overlies young terrace alluvium (Qty). Capped by soil that contains a weak argillic B horizon and stage I to weak stage II Cca horizon. Surface smooth and relatively undissected. Mapped only in Beaver basin (see index map) in northwestern part of map area. Maximum thickness

Middle piedmont-slope alluvium (middle Pleistocene)—Light-brown to lightreddish-brown, poorly to moderately sorted silt, sand, and gravel. Intertongues with or overlies middle terrace alluvium (Qtm). Capped by soil that contains moderately developed argillic B horizon and stage II to II Cca horizon. Surface irregular and moderately dissected. Mapped only in northwestern part of map area. Maximum thickness about 10 m Old piedmont-slope alluvium (middle Pleistocene)—Light-brown to light

reddish-brown, poorly to moderately sorted silt, sand, and gravel. Capped by soil that contains a well-developed, thick argillic B horizon and stage III Cca horizon. Uranium-trend age is about 250,000 years (Machette, 1985). Surface highly dissected; young (Qpy) and middle (Qpm) piedmont-slope alluvium were deposited in channels cut into the surface of this unit. Mapped only in northwestern part of map area. Maximum thickness about 4 m

Gravel of Last Chance Bench (middle Pleistocene)—Light- to reddish-brown pebbly sand to sandy gravel on remnants of a widespread pediment cut on all facies of basin-fill deposits (QTs). Unit named for a major surface just north of Beaver (Machette, 1985). Capped by soil that has a very well developed, reddish-brown argillic B horizon and (or) a well developed stage III to weak IV K horizon (see Gile and others, 1965, for definition of K horizon). Age of about 500,000 years is based on uranium-trend determinations and on soil development (Machette, 1985). The gravel lies on a widespread pediment developed when stream drainage from Beaver basin was integrated with Escalante Desert about 15 km west of map area (Machette, 1985). Gravel extensively deformed by faults, which were most recently active during the late Pleistocene. Maximum thickness at least 5 m

Undivided sedimentary basin-fill deposits of Beaver basin (lower? Pleistocene to upper? Miocene)—Includes six informal units composed of poorly to moderately consolidated fluvial and lacustrine deposits that comprise two major sedimentary sequences in the Beaver basin (Machette and others, 1984; Machette, 1985). Only the three units from the upper sequence are mapped separately here; they are exposed in the northwestern part of map area. Upper sequence consists of a gradational succession of lacustrine (QTsI), piedmont (QTsp), and fanglomeratic (QTsf) basin-fill sediments deposited in a closed basin occupied by Lake Beaver, a former shallow perennial lake (Machette, 1985); sequence is early(?) Pleistocene to late Pliocene. Lower sequence consists of moderately oxidized (in surface exposure), calcareous, indurated, fine-grained deposits and a medial conglomeratic unit; sequence is Pliocene and late(?) Miocene and may be correlative with upper part of Sevier River Formation (Ts). The lower sequence was deposited during more saline (arid?) conditions than the upper sequence, as evidenced by the presence of gypsum and calcium carbonate. Where undivided basin-fill deposits of Beaver basin are mapped, they are poorly exposed but generally consist of the upper sequence. Deposition of basin-fill deposits occurred concurrently with structural development of Beaver basin from at least 9 Ma (mega-annum) until sometime between 1.1 and 0.5 Ma when stream drainage from the basin was integrated with the Escalante Desert (Steven and others, 1982;

Geology mapped in 1963-65, 1969, 1978, 1981

LOWER BEAR VALLEY

MOUNTAINS

PLATEAU

VALLEY

QTsl Lacustrine facies (lower? Pleistocene to upper Pliocene)—Light- to medium-green silty clay and silt interbedded with well-bedded, light-gray to light-brown, fine sand grading laterally into pebbly sand. Erodes to low badlands. Unit contains at least six water-laid tephra (volcanic ash) beds, the second, from the top down, being the 2.0-Ma Huckleberry Ridge ash bed (formerly the Pearlette type-B ash; Izett and Wilcox, 1982). Top of unit is eroded; base is covered in map area. Exposed thickness at least 200 m in Beaver basin

Machette, 1985)

Piedmont facies (lower? Pleistocene to upper Pliocene)—Light-brown to light-reddish-brown (where oxidized) sequence of interbedded subrounded, fluvial-channel and deltaic(?) sand, light-gray and light-brown, subangular to subrounded, pebble to cobble gravel, and minor mudflow breccia that are all derived from and that coarsen toward the mountains. Generally erodes to low hills. Gravel contains zones of abundant manganese cementation. Contacts with lacustrine facies (QTsI) and fanglomerate facies (QTsf) are poorly exposed, gradational, and intertonguing and thus are approximately located. Minimum exposed thickness 100 m; base covered Fanglomerate facies (lower? Pleistocene to upper Pliocene)-Lightreddish-brown and tan, uniformly coarse-grained, sandy, subangular pebble to cobble gravel and pebbly coarse-grained sandstone along the western front of the Tushar Mountains and the northern part of the Black Mountains. Generally erodes to moderately sloping, rounded hills. Base covered;

thickness at least 200 m Sevier River Formation (Pliocene? and Miocene)—Shown only on cross section **B-B**' in southern part of map area. Sandstone, conglomerate, and siltstone, mostly of fluvial origin. Generally equivalent to undivided sedimentary basin-fill deposits of Beaver basin (QTs), but found in areas drained by the Sevier River and its tributaries in the High Plateaus province (index map; see discussion of drainage history by Anderson, 1987). May include deposits of Pleistocene age

Basaltic lava flows (Miocene)—Dark-gray to black, resistant, locally vesicular or amygdaloidal, but most commonly dense, lava flows of olivine basalt or olivine-bearing mafic rock. Contain phenocrysts of olivine (altered in whole or in part to iddingsite), augite, and plagioclase in a glassy to aphanitic groundmass. One lava flow near the western edge of map area has a K-Ar (potassium-argon) age of  $6.4 \pm 0.3$  Ma, and another just west of map area has a K-Ar age of  $7.6\pm0.3$  Ma (Best and others, 1980). Maximum thickness about 20 m

Rhyolite of Teddys Valley (Miocene)—Moderately resistant, light-gray, black, and pink, conspicuously flow-banded, locally vesicular, alkalic rhyolite lava flows forming a small volcanic dome in west-central part of map area. Lacks phenocrysts, and thus consists entirely of glass that is largely devitrified; obsidian "apache tears" are abundant, however. A K-Ar age of 7.9 ± 0.5 Ma was determined by H.H. Mehnert on "apache tears" analytical data are given in the table and sample locality is shown on map. Similar in age and structural setting to the following nearby small rhyolite masses: (1)  $7.6 \pm 0.4$ -Ma rhyolite of Blue Ribbon Summit (Mehnert and others, 1978; Rowley and others, 1978; age corrected for new decay constants of Steiger and Jäger, 1977), located in the adjacent quadrangle about 9 km west of rhyolite of Teddys Valley; (2)  $7.5 \pm 0.25$ -Ma rhyolite south of Minersville Reservoir (Evans and Steven, 1982; T.A. Steven, written commun., 1984), located in the adjacent quadrangle about 12 km northwest of rhyolite of Teddys Valley; and (3) rhyolite of Beaver airport (Trb), located 6 km northeast of rhyolite of Teddys Valley and discuss-

Trb Rhyolite of Beaver Airport (Miocene)—Resistant, light-gray, black, and lightpinkish-purple, conspicuously flow-banded, locally spherulitic and vesicular, alkalic rhyolite lava flows and basal autoclastic flow breccia forming a small volcanic dome about 4 km south of Beaver airport in the northwestern part of map area. Lacks phenocrysts and thus consists entirely of glass, which is largely devitrified and locally perlitic; obsidian "apache tears" are abundant, however. Dome is cut by a 1- to 2-m-wide dike of olivine basalt; olivine phenocrysts in the basalt are largely weathered to iddingsite. A K-Ar age of 8.3 ± 0.3 Ma was determined by H.H. Mehnert on "apache tears"; analytical data are given in the table and the sample locality is shown on map. Dome is part of a string of alkalic rhyolite bodies that fall along the east-trending Blue Ribbon lineament of Utah and Nevada (Mehnert and others, 1978; Rowley and others, 1978); these rhyolite bodies are generally younger from west to east (Rowley and others, 1981). Rhyolite bodies of an age similar to that of the map unit surround Beaver basin (Evans and Steven, 1982). Thickness of dome about 35 m

Tmb Mafic lava flows of Birch Creek Mountain (Miocene)—Moderately resistant, dark-gray to black, vesicular to dense lava flows of olivine basalt(?) or olivine-bearing mafic rock. Phenocrysts are generally anhedral olivine (altered in whole or in part to iddingsite), augite, and plagioclase (labradorite) generally less than 1 mm long. Groundmass is largely devitrified glass containing microlites of plagioclase, augite, and Fe-Ti (irontitanium) oxides. Wickstrom (1982) suggested that the rock is probably a trachybasalt of the potassic alkaline series according to the classification of Irvine and Baragar (1971). Correlative with potassium-rich mafic lava flows mapped by Anderson and others (1980, 1981), Cunningham and others (1983), and Machette and others (1984) in the southern Tushar Mountains; these rocks are considered to mark the start of extensional tectonism in southwestern Utah. Samples from nearby areas have yielded K-Ar ages of  $23.2 \pm 1.0$  Ma (Best and others, 1980) and  $22.9 \pm 0.4$ ,  $22.8 \pm 0.4$ , and  $22.4 \pm 0.4$  Ma (older basalts of Fleck and others, 1975; ages corrected for new decay constants of Steiger and Jäger, 1977). Thickness typically 40 m; maximum thickness about 150 m

Tif Tuff of Lion Flat (Miocene)—Poorly consolidated, pink, white, tan, gray, and yellow, unwelded to moderately welded, crystal-poor ash-flow tuff and minor airfall and water-laid tuff of alkalic rhyolite composition. Consists of about 10 percent phenocrysts of sanidine, subordinate plagioclase, and minor biotite, Fe-Ti oxides, and augite in a groundmass of devitrified shards. Also contains 1-4 percent lithic clasts, including those of Osiris Tuff. Named and mapped by Lanigan (1980), Anderson and others (1981), and Machette and others (1984) in the area east of Beaver, just north of map area; described by Wickstrom (1982). Steven and others (1984) suggested that the caldera source may underlie its outcrop area east of Beaver. Age is closely constrained between underlying 23-Ma Osiris Tuff and overlying formation of Lousy Jim (Sigmund, 1979), which is about 22 Ma ("Dry Hollow Formation" in Fleck and others, 1975, a term abandoned by Steven and others, 1979; ages corrected for new decay constants of Steiger and Jäger, 1977). Exposed only east of Little Valley, in the central part of map area, where the thickness is as much as 60 m To Osiris Tuff (Miocene)—Ledge-forming, reddish-brown to pinkish- or purplishgray, densely welded, crystal-poor, dacitic ash-flow tuff made up of 10-20

percent phenocrysts of plagioclase, subordinate sanidine, and minor biotite, augite, and Fe-Ti oxides in a groundmass of devitrified glass shards. In many places has the texture and appearance of unglazed porcelain. In most places includes a brownish-black basal vitrophyre 1-5 m thick. Commonly contains pancake-shaped tuff lenticules, and in some places the upper part is a light-gray to cream, vesicular vapor-phase zone. Secondary flowage and brecciation features are common in upper part. Consists of two cooling units in the extreme northern part of map area, but elsewhere only one is present. Osiris Tuff intertongues with the upper part of Mount Dutton Formation. Source area of Osiris Tuff is Monroe Peak caldera (Cunningham and others, 1983; Steven and others, 1984; Rowley, Williams, and Kaplan, 1986a,b; Rowley, Cunningham, and others, 1988a,b) in northern Sevier Plateau, 32 km northeast of map area. Osiris Tuff was informally named by Williams and Hackman (1971) and defined by Anderson and Rowley (1975). Earlier mapped by Callaghan and Parker (1961) and Willard and Callaghan (1962) in Sevier Plateau and other areas to the east and north as quartz latite member of Dry Hollow Formation, a term abandoned by Steven and others (1979). Tuff of Beaver River and tuff of Black Mountain, two informal units formerly considered to be local ash-flow sheets occurring only east of Beaver, just north of map area (Lanigan, 1980; Anderson and others, 1981; Machette and others, 1984), have been shown by detailed petrography to be separate cooling units of Osiris Tuff (Lanigan and Anderson, 1987). K-Ar age is about 23 Ma (Fleck and others, 1975; ages corrected for new decay constant of Steiger and Jäger, 1977); one dated sample, with an age of  $22.7 \pm 0.4$  Ma, was collected from east of Nevershine Hollow, in the north-central part of map area. Maximum thickness about 30 m; locally

Mount Dutton Formation (Miocene and Oligocene)-Volcanic rock of intermediate (andesite to dacite) composition, together with local interbedded accumulations of felsic volcanic rock and tuffaceous sandstone. In accordance with the concepts of Parsons (1965, 1969) and Smedes and Prostka (1973), most is subdivided into a near-source vent facies (Tdv) and a more distal alluvial facies (Tda), both products of a series of stratovolcanoes oriented generally east-west across what today composes the southernmost Tushar Mountains (Rowley and others, 1978; Anderson, 1986; Anderson, Rowley, and Blackman, 1986). Vent-facies rocks consist mostly of lava flows and autoclastic flow breccia together with volcanic mudflow breccia in beds containing primary dips indicating that they were deposited on the flanks of a volcano. Rocks of this facies grade outward into and intertongue with alluvial-facies rocks, which consist of a broad apron of mostly volcanic mudflow breccia. The formation, its facies, and most members were originally defined by Anderson and Rowley (1975). K-Ar ages of 27-21 Ma were determined by Fleck and others (1975; ages corrected for new constants of Steiger and Jäger, 1977) indicate a late Oligocene and Miocene age (Anderson and Rowley, 1975) Undivided rocks (Miocene and Oligocene)—Either vent facies (Tdv) or alluvial facies (Tda). Mapped only in areas transitional between the two facies where exposures are inadequate to determine percentage of each present in the stratigraphic section. In places may include strata of sand-

pinched out against pre-eruptive topography

stone member (Tds) that overlies both vent and alluvial facies throughout much of the northeastern part of map area Tds Sandstone member (Miocene)—Light- to dark-gray, greenish-gray, yellowish-gray, and tan, friable, eolian and fluvial tuffaceous sandstone, and minor fluvial conglomerate, locally interbedded with airfall tuff; occurs at or near top of both vent (Tdv) and alluvial facies (Tda) of Mount Dutton Formation in the northeastern part of map area. Commonly crossbedded and made up largely of subangular to subrounded, sandsized volcanic rock fragments containing 5-25 percent plagioclase and subordinate hornblende, pyroxene, Fe-Ti oxides, biotite, quartz, and sanidine that are poorly cemented by zeolite (clinoptilolite?). Locally contains pumice lapilli. In places, where exposures are few and poor, mapped within the undivided Mount Dutton Formation (Tdu). Equivalent to upper sandstone member of Mount Dutton Formation in the area to the east (Anderson, Rowley, and others, 1989). Age is probably Miocene on the basis of member's stratigraphic position. Generally only a few tens

of meters thick, although maximum thickness about 150 m Tdv Vent facies (Miocene and Oligocene)—Moderately resistant, generally medium- to dark-gray and grayish-brown, mostly dense, dacitic to andesitic lava flows and autoclastic flow breccia and subordinate volcanic mudflow breccia, conglomerate, sandstone, and felsic airfall and water-laid tuff. Aphanitic or contain small, sparse phenocrysts of amphibole and (or) augite in a microcrystalline and glassy groundmass. Individual lava flows range in thickness from less than one meter to several tens of meters; generally, however, individual flows are thickest nearest source vents, some of which are just north of map area. Mudflows typically contain more than 50 percent monolithologic clasts in a muddy matrix. A K-Ar age of  $23.0 \pm 0.4$  Ma was determined on vent-facies rock collected near the eastern edge of map area (Fleck and others, 1975; age corrected for new decay constants of Steiger and Jäger, 1977); this sample (no. R-24) was incorrectly reported in Fleck and others (1975) as Osiris Tuff. Partial section at least 500 m thick exposed in the northwestern part of map area; thinning of the section is toward the south and west

Tda Alluvial facies (Miocene and Oligocene)—Soft to moderately resistant, mostly light- to dark-gray and brown volcanic mudflow breccia and subordinate conglomerate and sandstone, lava flows, autoclastic flow breccia, and felsic airfall and water-laid tuff. The predominant mudflow breccia is characterized by subrounded to angular pebble- to boulder-size clasts of volcanic rock that are petrologically identical to rocks of the vent facies and that occur in a muddy matrix most commonly unsupported by direct contact between clasts. Ratio of clasts to matrix varies greatly in different mudflows, but is generally less than in mudflows of the vent facies. Thickness of mudflows ranges from one meter to several tens of meters. Clasts in individual mudflows may be monolithologic or polylithologic. Conglomerate is largely of fluvial origin, and tuffaceous sandstone is both fluvial and eolian; both consist almost exclusively of reworked volcanic detritus derived from the Mount Dutton volcanic pile and occur as local channel fillings and as lenses ranging from a few meters to a few tens of meters thick. Age is based on interfingering with vent facies. At least

700 m thick Beaver Member (Oligocene)—Light- to dark-gray, pink, tan, light-green, vivid-green, reddish-brown (due to oxidation), and yellow, dense, thick to massively bedded andesite porphyry containing 30-50 percent phenocrysts of plagioclase (2-10 mm long) and lesser amounts of biotite (2-5 mm) and hornblende (1-5 mm), with accessory Fe-Ti oxides, pyroxene, and rare quartz in a cryptocrystalline or devitrified glassy groundmass. Most of the unit accumulated as a series of viscous lava flows that form several volcanic domes, but in places also includes autoclastic flow breccia and volcanic mudflow breccia and thin beds of conglomerate and sandstone in which clasts consist largely of the same lithology as the lava flows. In the Blue Valley area, includes a stratified sequence of tuffaceous sandstone, volcanic mudflow breccia, and felsic tuff (Decatur, 1979; Anderson and Decatur, in press); tuff in places is vivid green and contains less than 5 percent phenocrysts of plagioclase, sanidine, biotite, hornblende, guartz, and Fe-Ti oxides and about 1 percent lithic fragments of typical flow rock of the member. K-Ar age determinations on lava flows of  $26.2 \pm 0.5$  and  $25.0 \pm 0.8$  Ma were made by Fleck and others (1975; ages corrected for new decay constants of Steiger and Jäger, 1977) from samples collected from localities shown in map area. Thickness ranges from less than 10 m to more than 200 m, and decreases with distance from source vents, which probably were near Blue Valley Plutonic rock (Miocene or Oligocene)—Light-gray syenodiorite porphyry or

monzonite porphyry consisting of generally finely crystalline, subhedral to euhedral phenocrysts of plagioclase, hornblende, and magnetite in a holocrystalline, finely equigranular groundmass made up largely of orthoclase. Exposed only in one small outcrop in the mountains west of Lower Bear Valley, where it gives the impression of being a large dike that discordantly cuts strata of Claron Formation (Anderson, 1965). However, this probably is a cupola extending from a larger laccolithic(?) mass at depth, inasmuch as Claron and other overlying strata, over an area about 5 km in diameter, dip away from a center not far from the outcrop; a radial fault pattern over this center resembles patterns seen above structural domes. Other probable laccoliths occur in the Markagunt Plateau (Anderson and Rowley, 1975, 1987; Anderson and Grant, 1986; Anderson, livari, and Rowley, 1987; Anderson, Rowley, and others, 1989). Age of the intrusion is probably Miocene; it domes and thus post-dates

the Buckskin Breccia, but its age with respect to younger units is unclear

Tbv Bear Valley Formation (Oligocene)—Generally soft, light-gray, yellow, or green, moderately to well sorted, fine- to medium-grained, "salt-and-pepper" tuffaceous sandstone of eolian origin, together with subordinate ash-flow tuff, lava flows, conglomerate, and mudflow breccia. Occurs as only one small outcrop in the southern part of map area, where it consists largely of felsic ash-flow(?) tuff. Widespread elsewhere throughout northern Markagunt Plateau (Anderson, 1965, 1971). Two members can be distinguished on the basis of composition. Upper member contains, in addition to pyrogenic minerals (plagioclase, sanidine, pyroxene, amphibole, biotite, Fe-Ti oxides, and rare quartz), considerable amounts of subangular, pristine glass shards contributed to the sediment by contemporaneous volcanism; it also contains interbeds and lenses of welded and unwelded felsic ash-flow tuff. Lower member is made up largely of sub-angular to well-rounded volcanic rock fragments and the same pyrogenic mineral grains. Both members are poorly to moderately well cemented by zeolite (clinoptilolite) that locally is altered to chlorite, which in places imparts a striking green color. Most of the unit is eolian and strongly crossbedded; measurement of crossbed attitudes indicates that wind directions were from the south and west (Anderson, 1971). Formation and members defined by Anderson (1971). K-Ar ages of about 25 Ma (Oligocene) have been determined from two interbedded volcanic beds within the formation (Fleck and others, 1975; ages corrected for new decay constants of Steiger and Jäger, 1977). Thickness within map area is only several tens of meters;

elsewhere it is greater than 350 m

Buckskin Breccia (Oligocene)—Moderately resistant, light- to medium-gray and grayish-pink, poorly to moderately welded, crystal-poor, dacitic ashflow tuff, autoclastic flow breccia(?), and volcanic mudflow breccia(?). Characterized by abundant (as much as 50 percent of rock volume) distinctive porphyritic lithic clasts identical to volcanic rocks of Bull Rush Creek and similar to Spry intrusion, which units are exposed about 15 km east of map area (Grant and Anderson, 1979; Anderson and Grant, 1986; Anderson, Rowley, and others, 1989). Porphyritic clasts consist of phenocrysts of plagioclase, hornblende, biotite, augite, and Fe-Ti oxides in an aphanitic groundmass of sanidine and quartz. Less common types of clasts include welded and unwelded ash-flow tuff, felsic air-fall tuff, and sedimentary rocks. Clasts are set in a devitrified glass matrix commonly enclosing vaguely defined glass shards as well as fragmented grains of plagioclase, sanidine, hornblende, biotite, augite, and Fe-Ti oxides. Consists in places of at least four separate well-bedded depositional units, bedded sequentially or separated by a few meters of tuffaceous sandstone. Thin sections of three units identify them as ash-flow tuffs exhibiting compressed glass shards and other eutaxitic features. Other units may have had the same origin, but any evidence of this is obscured by devitrification; alternatively, these units may have been emplaced as autoclastic flow breccia or mudflow breccia. Defined by Anderson and Rowley (1975); type section is just south of southeastern corner of map area (Anderson, livari, and Rowley, 1987). Described in detail by Yannacci (1986). Age is Oligocene on the basis of interfingering relationships with Isom Formation in the southeastern part of map area. Thickness varies greatly, from a few meters to more than 200 m

Isom Formation (Oligocene)—Ledge-forming, grayish-red, light-red, and lightreddish-purple, densely welded, crystal-poor ash-flow tuff. Typically contains about 5-20 percent phenocrysts, 1-3 mm long, of plagioclase and minor augite and Fe-Ti oxides in a groundmass of devitrified shards. Generally the groundmass has the texture and appearance of unglazed porcelain. Consists of one or locally two cooling units. Cooling units commonly contain a dark-gray to brownish-black basal vitrophyre. Cooling units locally exhibit secondary flow structures, including autobrecciation and flow-foliation; they also contain numerous horizontal, pancake-shaped, light- to medium-gray tuff lenticules that either represent collapsed pumice or are products of devitrification by trapped gas that probably formed during vapor-phase cooling. Cooling units belong to Baldhills Tuff Member or Blue Meadows Tuff Member, or both. The Baldhills Member and perhaps Blue Meadows Member were derived from the Great Basin west of the Iron Springs district of southwestern Utah. They flowed eastward into the map area, where they intertongued with Buckskin Breccia and locally pinched out against pre-eruptive topography. Defined by Mackin (1960), and described in detail by Fryman (1987). K-Ar age of  $25.9 \pm 0.4$ Ma determined by Fleck and others (1975; age corrected for new decay constants of Steigerand Jäger, 1977) from samples obtained just south of map area. Typically 10-20 m thick Tw Wah Wah Springs Formation of Needles Range Group (Oligocene)-

Ledge-forming, light-red to grayish-pink and salmon, crystal-rich, moderately welded ash-flow tuff. A single cooling unit. Basal meter or two may consist of dark- to medium-gray vitrophyre or it may be more densely welded than the overlying main part of the unit, into which it grades. Conspicuously porphyritic; made up of 30-40 percent phenocrysts, 1-3 mm long, of plagioclase, hornblende, biotite, minor quartz, and Fe-Ti oxides in a groundmass of largely devitrified glass shards. Subparallel lenticular cavities, 1-10 cm long, are generally abundant near the bottom of unit and decrease in size and number toward the top; these probably were formed by weathering of pumiceous inclusions. Erupted from a caldera at the Nevada-Utah state line (Best and Grant, 1983, 1987). Ash-flow tuffs of Needles Range Group are the most extensive regional ash-flow sheets in the southeastern Great Basin and adjacent High Plateaus; unit extends over an area in excess of 50,000 km<sup>2</sup> (Shuey and others, 1976). Exposed only in the southern part of map area. Intertongues with and probably pinches out in local volcanic, tuffaceous, and sedimentary strata (TvI) to the north. Defined by Mackin (1960). An age of  $29.5 \pm 0.5$  Ma was determined by Fleck and others (1975) on a sample obtained just south of the boundary of the map area. Thickness 15 to 25 m Tvl Local volcanic and tuffaceous sedimentary rocks (Oligocene)-Heterogeneous assemblage of locally deposited volcanic strata and tuf-

faceous sedimentary rocks. Base is placed at base of lowest unit of volcanic

origin (lava flow, ash-flow tuff, autoclastic flow-breccia, or volcanic

mudflow breccia, but not air-fall tuff or tuffaceous sandstone). Top is

placed at base of Wah Wah Springs Formation, or, where that forma-

tion is absent, at base of the next regional rock unit of volcanic origin

that occurs higher in the stratigraphic section. Unit includes 10-m thick, densely welded, crystal-poor ash-flow tuff, on which a K-Ar age of  $31.9 \pm 0.5$  Ma was determined (Fleck and others, 1975; age corrected for new decay constants of Steiger and Jäger, 1977); sample locality is in southeastern part of map area. This tuff is overlain by a few tens of meters of tuffaceous sandstone. Maximum thickness 140 m Claron Formation (Oligocene and Eocene)—In the southern High Plateaus, Claron Formation can be subdivided into two informal members, an upper "white" one and a lower "red" one; the contact between the two is placed at the base of a conspicuous, massive, resistant limestone bed, below which rocks are mostly red and above which they are mostly white. No such stratigraphic marker is present within the map area. The absence of this, or any other, established means of defining the two members has precluded mapping them separately here, although about two-thirds of the unit is "red" and the remainder "white." The overall sequence in map area nevertheless is lithologically similar to that south of map area, where the marker bed is present. Upper part consists of mostly soft, lightgray to tan, fluvial siltstone and sandstone and lacustrine limestone. Most rocks are tuffaceous, becoming increasingly so toward top of the section. Bedding is more uniform than that in lower part, which consists of soft to moderately resistant, mostly red, intertongued argillaceous lacustrine limestone and calcareous fluvial siltstone, sandstone, and conglomerate. Conglomerate is the major rock type near base of section but upward conglomerate is less abundant and sizes of clasts are less. Well bedded, with bed thicknesses mostly between 10 cm and 1 m. Normal primary depositional features, such as bedding, body fossils, crossbeds, ripples, and mudcracks have been obliterated in many places by pedogenic processes associated with roots, burrows, and translocation of iron, calcite, and clay. This is attributed by Mullett and others (1988) to accumulation at rates much slower than pedogenic amalgamation. Considered correlative to strata in southern Markagunt Plateau that Gregory (1949, 1950, 1951) assigned to Wasatch Formation; Spieker (1946), however, demonstrated that type Wasatch of northern Utah and adjacent parts of Wyoming does not extend even as far south as central Utah, let alone to the southern part of the state. Anderson and Rowley (1975), following the suggestion of Mackin (1960), discontinued use of the term "Wasatch" in the southern High Plateaus and resurrected the name "Claron," which was first applied by Leith and Harder (1908) to strata equivalent to the Wasatch in Iron Springs district of southwestern

Contact—Dashed where approximately located (in cross section)

Utah. The age has not been established with certainty. Gregory (1950)

reported "late Eocene" freshwater fossils from uppermost "Wasatch" strata

at Cedar Breaks National Monument to the south-southwest of map area,

but lowermost strata may be as old as Paleocene or even Late Cretaceous.

Outline of gravity slide block

Thickness at least 300 m

Fault—Most are high-angle normal faults. Dashed where inferred or approximately located; dotted where concealed; queried where uncertain. Where relative offset is known, bar and ball on downthrown side. Additional details on fault and lineament patterns are given by Anderson and Decatur

----- Lineament-Structural lineament identified in the field or on aerial photographs. Probably represents the trace of a joint or a fault of small Breakaway scarp—Headwall trace of a landslide

as a coherent block; ticks on downthrown side X Sample locality of isotopically dated rock—Showing age in million years (Ma). Determined by Fleck and others (1975; corrected for new constants given by Steiger and Jäger, 1977), Best and others (1980; age underlined), and H.H. Mehnert (this report; age underlined by dashed

Dike—Olivine basalt dike cutting rhyolite of Beaver airport (Trb)

Strike and dip of beds

Strike and dip of flow foliation

Data For new K-Ar ages of rocks from the Nevershine Hollow area, Utah

[ $K_2$ 0 determined by isotope dilution;  $Ar^{40}$ , radiogenic argon. Constants:  $K^{40}\lambda_{\epsilon}=0.581$ 

 $\times$  10<sup>-10</sup>/year;  $\lambda_{\beta}$ =4.962  $\times$  10<sup>-10</sup>/year. Atomic abundance: K<sup>40</sup>/K=1.167  $\times$  10<sup>-4</sup>. Age

78-1695a Obsidian 5.13, 5.09 0.615 83.5 8.34±0.31 "Apache tears" from rhyolite of Beaver Al port; lat. 38°11'40", long. 112°41′10″ "Apache tears" from rhyolite of Teddys Valley; lat. 38 ° 08 '55 ", long 112°43′25″

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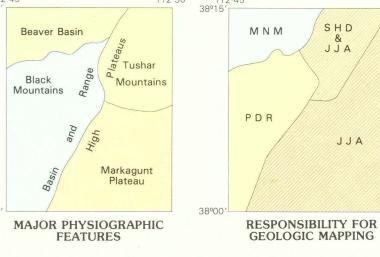
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GEOLOGIC MAP OF THE NEVERSHINE HOLLOW AREA, EASTERN BLACK MOUNTAINS, SOUTHERN TUSHAR MOUNTAINS, AND

NORTHERN MARKAGUNT PLATEAU, BEAVER AND IRON COUNTIES, UTAH

CONTOUR INTERVAL 20 FEET

DATUM IS MEAN SEALEVEL

MOUNTAINS

VALLEY

PAROWAN FAULT ZONE

WITH SUPPLEMENTARY CONTOURS AT 10 FOOT INTERVAL

MARKAGUNT

Hurricane

TUSHAR

BUCKSKIN