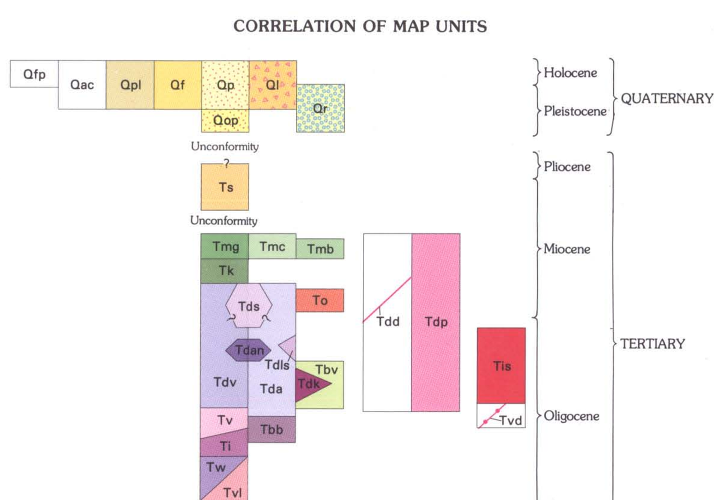
CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qfp **Flood-plain alluvium (Holocene)**—Silt, sand, and gravel, locally cobbly and bouldery, along the Sevier River. Maximum thickness about 5 m

Qac **Undivided alluvium and colluvium (Holocene and upper Pleistocene)**—Silt, sand, and gravel deposited by intermittent and perennial streams in channels, on bordering flood plains, and in terminal alluvial fans. Locally includes colluvium, sheetwash alluvium, talus, and alluvial-fan deposits. Maximum thickness about 5 m

Qpl **Playa-lake deposits (Holocene and upper Pleistocene)**—Lacustrine clay, silt, and sand in undrained depressions. Thickness may exceed 15 m

Qf **Undivided alluvial-fan and talus deposits (Holocene and upper Pleistocene)**—Heterogeneous mixture of silt, sand, and gravel. Mostly alluvial material of small intermittent streams emptying into Sevier River valley, together with small accumulations of talus. Maximum thickness about 10 m

Qp **Piedmont-slope alluvium (Holocene and upper Pleistocene)**—Poorly to moderately sorted silt, sand, and subordinate gravel that underlie broad piedmont-slope surfaces. The piedmont-slope surfaces, which are well developed in several parts of the map area, are underlain 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

Ql **Landslide debris (Holocene and upper Pleistocene)**—Mostly angular, poorly sorted rock debris moved by gravity from nearby bedrock areas. Includes talus, colluvium, and, near the crest of Circleville Mountain, valley-glacier moraine deposits. Thickness locally as much as 30 m

Qr **Rock-glacier deposits (Pleistocene)**—Angular, poorly sorted cobble- and boulder-size gravel derived from mafic lava flows of Circleville Mountain (Tmc). Occurs as lobate masses in cirques east and just below crest of Circleville Mountain. Maximum thickness about 10 m

Qop **Older piedmont-slope alluvium (Pleistocene)**—Poorly sorted, unconsolidated to poorly consolidated, silt, sand, and gravel occurring as remnants of old piedmont-slope alluvium. Deposits occur on surfaces on many levels and of different ages, all of which are dissected by present streams. May include river-terrace deposits. Lower part may be correlative with Sevier River Formation along Sevier River. Especially apparent on remnants of a broad, high-level erosion surface above Circleville Canyon that represents pediments cut before, or at the start of, development of through-flowing drainage of Sevier River and its tributaries (see Anderson, 1987). Maximum thickness about 15 m

Ts **Sevier River Formation (Pliocene? and Miocene)**—Poorly to moderately consolidated, light-gray, tan, pinkish-gray, and white, silty, pebbly sandstone and conglomerate. Deposited largely by streams in valleys in downwarped or downfaulted areas. Defined by Callaghan (1939). Interbedded airfall tuff beds in Clear Creek area about 40 km to the north have yielded fission-track ages of 14.2±0.9 and 7.1±0.7 Ma (mega-annum) (Steven and others, 1979), indicating a Miocene age. Upper part, however, locally may be Pliocene or even as young as Pleistocene. Contacts poorly exposed and approximately located. Maximum thickness about 80 m

Tmg **Mafic gravels of Gunsight Flat (Miocene)**—Poorly consolidated, gray conglomerate and fanglomerate made up almost exclusively of gravel derived from mafic lava flows of Birch Creek Mountain (Tmb) and Circleville Mountain (Tmc). Gravels apparently were shed northward from paleo-fault scarps located near present-day Kents Lake, in northwestern part of map area. Contacts between mafic gravels and the two sequences of lava flows from which they were derived are poorly exposed, and therefore they are only approximately located on map. Some mafic lava flows of Birch Creek Mountain, however, occur interbedded with or on top of the gravels. Considered to be generally contemporaneous with mafic lava flows of Birch Creek Mountain and Circleville Mountain; age therefore probably is about 23-22 Ma. Maximum thickness about 300 m

Tmc **Mafic lava flows of Circleville Mountain (Miocene)**—Resistant, medium-gray to black, mostly dense lava flows and autoclastic flow-breccia of porphyritic basalt(?) or basaltic andesite(?). Locally markedly vesicular and amygdaloidal. Contains abundant (10-20 percent), conspicuous, large (2-10 mm), subhedral phenocrysts and glomerocrysts of augite and minor hypersthene, and minor small (about 1 mm) plagioclase. Groundmass is hyalopilitic, with microlites of plagioclase, pyroxene, and Fe-Ti oxides. Unit occurs as thick (10-30 m) massive flows, resembling plateau basalts, that were extruded in rapid succession. Near Circleville Mountain the flows apparently were emplaced in structural and (or) erosional lows. One flow yielded a K-Ar (potassium-argon) age of 22.8±0.4 Ma (Fleck and others, 1975; age corrected for new decay constants of Steiger and Jäger, 1977); the sample locality is shown on map. This age is about the same as determinations made on samples of mafic lava flows of Birch Creek Mountain (Tmb), but most mafic lava flows of Circleville Mountain appear to overlie mafic lava flows of Birch Creek Mountain. Contact relations between the two, however, are obscured by dense forest cover, and on the map the contact is approximately located. Star symbol east of Little Dog Valley in central part of map area indicates a source area where several large, composite dikes of the same lithology cut strata of Mount Dutton Formation. Thickness varies greatly, from a few meters near distal margin to perhaps as much as 350 m near Circleville Mountain

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 seemingly conformably overlying strata of either vent facies of Mount Dutton Formation (Tdv) or lava flows of Kents Lake (Tk). Contains generally anhedral phenocrysts of 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 (iron-titanium) 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 two flows have yielded K-Ar ages of 22.9±0.4 and 22.4±0.4 Ma (older basalts of Fleck and others, 1975; ages corrected for new decay constants of Steiger and Jäger, 1977); sample localities are shown on map. Thickness typically 60 m; maximum thickness about 150 m

Tk **Lava flows of Kents Lake (Miocene)**—Moderately resistant, light- to medium-gray, dense, medium- to thick-bedded andesite porphyry lava flows containing 20-40 percent phenocrysts of plagioclase (1-10 mm, typically 2-4 mm in size), subordinate amounts of pyroxene (0.1-3 mm, typically 0.5 mm), and minor amounts of Fe-Ti oxides (0.1-1 mm), amphibole (0.1-0.5 mm), and biotite (0.1-0.3 mm) in a partly devitrified glassy groundmass commonly containing numerous alined microlites, chiefly plagioclase. Includes at least one ash-flow tuff containing the same mineral assemblage but in a densely welded glass groundmass. Lava flows commonly exhibit pronounced sub-horizontal platy parting that reflects primary flow lamination. Distinguished from the bulk of vent facies of Mount Dutton Formation (Tdv) by presence of biotite and from Beaver Member of Mount Dutton Formation, west of map area, by absence of quartz. Considered by Anderson and Rowley (1975) to be correlative with Dry Hollow Formation (Callaghan, 1939), but with abandonment of Dry Hollow Formation as a rock stratigraphic unit (Steven and others, 1979), it now is designated by the present informal name. A K-Ar age determination of 33.7±0.5 Ma was made by Fleck and others (1975; age corrected for new decay constants of Steiger and Jäger, 1977) on a sample of "andesite" from lava flows of Kents Lake; locality of sample is shown on map. This age is anomalous, however, and is disregarded; instead, the stratigraphic position of unit is considered to be close to that of Osiris Tuff, which is about 23 Ma (Fleck and others, 1975). Age therefore is probably Miocene. Thickness over most of outcrop area, which is almost entirely within map area, is between 40 and 80 m; maximum thickness about 250 m. Location of source vents unknown

To **Osiris Tuff (Miocene)**—Ledge-forming, reddish-brown to pinkish- or purplish-gray, densely welded, crystal-poor 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 texture and appearance of unglazed porcelain. Commonly includes a brownish-black basal vitrophyre 1-5 m thick. In many places contains pancake-shaped tuff lenticules, and in some places upper part is a light-gray to cream, vesicular, vapor-phase zone. Secondary flowage and brecciation features also are common in upper part. Intertongues with upper part of Mount Dutton Formation. Source area 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, 20 km north 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). K-Ar age is about 23 Ma (Fleck and others, 1975; age corrected for new decay constants of Steiger and Jäger, 1977). Maximum thickness about 30 m; locally it pinched out against pre-eruptive topography

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. Locally source areas are tightly clustered and depositional units from one source are intertongued with or are overlain by those that have opposing dip directions and are derived from another source. Vent-facies rocks grade outward into and intertongue with alluvial facies rocks, which consist of a broad apron of mostly volcanic mudflow breccia (intertonguing is shown in cross section ***A-A'***). The formation, its facies, and its 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 decay constants of Steiger and Jäger, 1977) and indicate a late Oligocene and Miocene age (Anderson and Rowley, 1975)

Tds **Upper sandstone member (Miocene and Oligocene?)**—Light- to dark-gray, greenish-gray, and yellowish-gray, friable, eolian and fluvial tuffaceous sandstone, fluvial conglomerate, and minor mudflow breccia at or near top of Mount Dutton Formation. Volcanic sandstone is made up largely of subangular to subrounded volcanic rock fragments containing 5-25 percent plagioclase and subordinate hornblende, pyroxene, and Fe-Ti oxides that are poorly cemented by zeolite (clinoptilolite?). Conglomerate consists of granule- to cobble-sized clasts of volcanic rock in a matrix of volcanic sandstone. Locally intensely silicified by hydrothermal activity; such silicified rock has striking pale-pastel colors of blue, green, pink, and other rainbow shades. In places where exposures are few and poor, the upper sandstone member was mapped within vent- or alluvial-facies rock of Mount Dutton Formation (Tdv, Tda). Equivalent to sandstone member of Mount Dutton Formation in area to west (Anderson, Rowley, and others, 1989). Age is probably Miocene on the basis of its stratigraphic position, but it may be partly Oligocene as well. In most places only a few tens of meters thick; maximum thickness about 150 m

Tdv **Vent facies (Miocene and Oligocene)**—Moderately resistant, generally medium- to dark-gray, grayish-brown, and tan, generally dense, andesitic to dacitic lava flows and autoclastic flow breccia and subordinate volcanic mudflow breccia, conglomerate, sandstone, felsic airfall tuff, water-laid tuff, and ash-flow tuff. Aphanitic or contain small, sparse phenocrysts of plagioclase, hornblende, and (or) augite in a microcrystalline and largely devitrified glassy groundmass. Locally hydrothermally altered. Individual lava flows range in thickness from a few meters to several tens of meters. Mudflows typically contain more than 50 percent monolithologic clasts in a muddy matrix. Excellent exposures occur along highway U.S. 89 in Circleville Canyon (Rowley and Anderson, 1975, p. 25; Shawe and others, 1978, p. 25). Vent-facies rocks, and probably their underlying source plutons, are defined by significant aeromagnetic highs in map area (Zietz and others, 1976; Mabey and Virgin, 1980).

Distribution, lithology, structural relations, and physiographic expression of some rocks of facies define individual stratovolcanoes, whose inferred former vents are shown on map by a star symbol. Vent southwest of The Cove, in east-central part of map area, is defined by small plugs containing steeply-dipping flow foliation and by dark-gray and pink rock containing small plagioclase and pyroxene phenocrysts and microlites. Volcanic center south of Chokecherry Creek and west of Circleville Canyon is marked by a plug (Tdp) and surrounding crater etched out by streams; lava flows and mudflow breccia of light-yellow- to light-green-weathering, gray and tan aphanitic rock containing sparse hornblende phenocrysts are well exposed around and southeast of the crater and at stream level where Chokecherry Creek enters Circleville Canyon. Here these rocks are overlain by steeply south-dipping lava flows of dark-gray, pyroxene-bearing, aphanitic rock derived from a stratovolcano just north of this point. This stratovolcano is defined by radiating dips and by a subdued exhumed cone that is obvious on aerial photos. Two additional centers were discovered and described by Blackman (1985); one, in Oak Basin Canyon, is made up of outward-dipping, two-pyroxene, hornblende andesite lava flows and mudflows as well as numerous dikes; the other, in Cottonwood Creek to the southwest, is made up of a younger sequence of outward-dipping, hornblende-bearing, two-pyroxene andesite lava flows and flow breccia surrounding a dike-like source plug exposed in two places. Other hypabyssal rocks also may have accumulated in stratovolcano edifices, as in upper South Creek drainage basin, where a number of large dikes of amphibole andesite (Tdd) cut mostly tuffaceous sandstone included within vent facies. A dike swarm that probably fed a stratovolcano also occurs in central Circleville Canyon. A K-Ar age of 23.5±0.4 Ma was determined on a lava flow in vent facies in Chalk Hollow, near western edge of map area; another K-Ar age of 26.7±0.8 Ma was determined on a flow in vent facies located 0.6 km west-northwest of northeast corner of map area (Fleck and others, 1975; ages corrected for new decay constants of Steiger and Jäger, 1977). Maximum thickness within map area is about 1,000 m, thinning south and east

Tda **Alluvial facies (Miocene and Oligocene)**—Soft to moderately resistant, mostly light- to dark-gray, brown, tan, pink, green, and yellow 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 sub-rounded 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 to sandy 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 a meter or two 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. A tuffaceous sandstone bed at the base of a thin sequence of alluvial-facies rocks about 8 km southwest of Circleville contains logs of petrified wood as long as 1 m, some in growth position. Age is based on interfingering with vent facies. At least 800 m thick

Tdd **Dikes (Miocene and Oligocene)**—Porphyritic amphibole andesite and dacite cutting strata of Mount Dutton Formation. In all ways similar in lithology to flows and clasts in Mount Dutton Formation. Dike complex in central Circleville Canyon consists of dikes 1-15 m wide of both dense and autobrecciated dacite intruding lithologically similar volcanic mudflow breccia and flow breccia of vent facies (Tdv) that were derived from the dikes

Tdp **Plugs (Miocene and Oligocene)**—Light- to dark-gray andesite containing plagioclase and subordinate pyroxene and hornblende. Small intrusive masses, some if not all of which are feeders for volcanic rocks of Mount Dutton Formation. Plugs in some places hydrothermally altered the adjacent volcanic rocks. One just south of Oak Basin Canyon, in northeastern part of map area, consists of light-gray to tan andesite containing phenocrysts of plagioclase and hornblende. Two plugs in Cottonwood Creek represent parts of the same dike-like body that fed a stratovolcano, the edifice of which surrounds the body. Plug south of Chokecherry Creek in center of map area is the source of a sequence of gray and tan, aphanitic, hornblende-bearing lava flows and mudflow breccia that surround the plug; plug is somewhat coarser than surrounding volcanic rocks

Tdan **Antimony Tuff Member (Oligocene)**—Resistant brownish-red, brown, black, gray, and tan, densely welded, crystal-poor ash-flow tuff. Contains phenocrysts of plagioclase, subordinate sanidine, and minor pyroxene and Fe-Ti oxides in a groundmass of devitrified glass shards. Includes abundant lithic inclusions. Flattened, dark pumice lenticules and secondary flow structures such as elongated vesicles and subvertical flow foliation are locally present. Base marked by a black vitrophyre as much as 6 m thick. Exposed only in two places, one east and one west of Circleville Canyon. Defined for exposures near the town of Antimony, 22 km east of map area (Anderson and Rowley, 1975), but its source may be near Joseph, 40 km north of map area (Rowley, Cunningham, and others, 1988a). Member has a K-Ar age of 25.4±0.9 Ma (H.H. Mehnert, unpub. data). Thickness about 10 m

Tdls **Lower sandstone member (Oligocene)**—Local eolian tuffaceous sandstone, similar to that of upper sandstone member (Tds), that occurs low in Mount Dutton section in southwestern part of map area. Originally mapped by Anderson (1965) as Bear Valley Formation (Tbv), which it resembles in all details; here reassigned to Mount Dutton Formation on the basis of later fieldwork. Incomplete section, about 50 m thick

Tdk **Kingston Canyon Tuff Member (Oligocene)**—Resistant, black and reddish-brown, densely welded, crystal-poor ash-flow tuff. Contains small phenocrysts of plagioclase and minor pyroxene, Fe-Ti oxides, and biotite in a groundmass of glass shards. Includes abundant lithic inclusions, flattened pumice, and vesicles. Composed in large part of black vitrophyre. Exposed only as a small lens in south-central part of map area, where it intertongues with Bear Valley Formation (Tbv). Defined for exposures in Kingston Canyon, east of the town of Kingston, which is 6 km east of map area (Anderson and Rowley, 1975). It has a K-Ar age of 25.8±0.4 Ma (Fleck and others, 1975; age corrected for new decay constants of Steiger and Jäger, 1977). Maximum thickness about 1 m

Tis **Spry intrusion (Oligocene)**—Resistant, light-gray (where fresh) to pink and medium-reddish-orange (where weathered) quartz latite porphyry. First noted by Callaghan and Parker (1962), first mapped by Anderson (1965) and Rowley (1968), named as an informal unit by Anderson (1971), and described in detail by Grant (1979) and Grant and Anderson (1979). Typically consists of abundant phenocrysts of plagioclase, subordinate amphibole, and minor biotite, Fe-Ti oxides, quartz, pyroxene, and sanidine in a microcrystalline groundmass of sanidine, quartz, and plagioclase. Lithologicially similar to the somewhat older volcanic rocks of Bull Rush Creek (Tv) and their related dikes (Tvd). This similarity implies that all these rocks are cogenetic; thus the volcanic rocks of Bull Rush Creek are considered to be ejecta that accumulated above a magma chamber that later evolved into a pluton, Spry intrusion, that rose and emplaced itself into its own volcanic edifice. Spry intrusion intruded into and arched Claron Formation, so it may be a laccolith, as is the case with several other Tertiary plutons in the Markagunt Plateau that arched Claron Formation (Anderson and Rowley, 1975; Anderson, Rowley, and others, 1989). Outer shell of intrusion is characteristically autobrecciated. At places near intrusive contact in Granite Knolls area, Claron Formation has been mineralized and silicified, resulting in small amounts of cinnabar, hematite, limonite, fluorite, and gypsum; chemical analyses have disclosed anomalous amounts of gold, silver, chromium, strontium, vanadium, and gallium, but no ore has been shipped (Doelling, 1975). A glassy lava flow that is lithologically similar to Spry intrusion but is mapped as volcanic rocks of Bull Rush Creek (Tv) yielded a K-Ar age on hornblende of 31.2±1.5 Ma (Damon, 1968; age corrected for new decay constants of Steiger and Jäger, 1977) and thus Spry intrusion was formerly interpreted to be the oldest pluton in the Marysvale field (Anderson and Rowley, 1975); fresh hornblende crystals of middle Tertiary age, however, are notorious for having excess argon. A plagioclase age of 26.1±1.8 Ma recently was determined by H.H. Mehnert on Spry intrusion from a sample collected from a roadcut along highway U.S. 89. Sample locality is shown on map and analytical data are given in table 1. The new age indicates that pluton is much younger than previously thought. The intrusion arches up Buckskin Breccia (Tbb) and Bear Valley Formation (Tbv) in Hawkins Canyon and thus postdates these rock units, so it may actually be closer to an age of 25 Ma. Aeromagnetic data (Zietz and others, 1976; Mabey and Virgin, 1980) indicate that the pluton extends south of map area and thus has batholithic dimensions

Tbv **Bear Valley Formation (Oligocene)**—Generally soft, light-gray and locally yellow and green, moderately to well sorted, fine-to medium-grained, "salt-and-pepper" tuffaceous sandstone of eolian and fluvial origin and minor, resistant, gray, and light-pink volcanic mudflow breccia, white airfall tuff, and red and brown, highly welded ash-flow tuff. Two members can be distinguished on the basis of composition (Anderson, 1971). Upper member, which makes up most of formation in map area, contains, in addition to pyrogenic minerals (plagioclase, sanidine, pyroxene, amphibole, biotite, Fe-Ti oxides, and rare quartz), considerable amounts of subangular to angular, pristine glass shards contributed by contemporaneous volcanism. Lower member is made up largely of subangular to well-rounded volcanic rock fragments and the same pyrogenic mineral grains. Both members are generally poorly to moderately well cemented by zeolite (clinoptilolite) that locally is altered to chlorite, which in places imparts a striking green color. Most of unit outside map area is eolian and strongly crossbedded; measurement of crossbed attitudes indicates that wind directions were from the south and west (Anderson, 1971). Contact with overlying Mount Dutton Formation is locally gradational over about 10-20 m. Formation and members defined by Anderson (1971); type section is 3 km south of map area, where it is best exposed and studied (Anderson and Rowley, 1987). K-Ar ages of about 25 Ma have been determined from two volcanic beds of formation, and Kingston Canyon Tuff Member of 26 Ma is interbedded within the formation (Fleck and others, 1975; ages corrected for new decay constants of Steiger and Jäger, 1977). Thickness within map area is as much as 300 m

Tv **Volcanic rocks of Bull Rush Creek (Oligocene)**—Soft to moderately resistant, tan, light- to dark-gray, pink, and light-greenish-yellow sequence of complexly interbedded volcanic mudflow breccia, conglomerate, sandstone, lava flows, poorly welded ash-flow tuff rich in lithic clasts, vent(?) breccia, and autoclastic flow breccia. Lava flows and most clasts have identical and distinctive lithology, consisting of pink, gray, and black quartz latite porphyry with abundant phenocrysts of plagioclase, subordinate amphibole, and minor Fe-Ti oxides, with or without minor biotite and pyroxene, in a microcrystalline groundmass of sanidine, quartz, and plagioclase, or, less commonly, in a groundmass of glass. Very similar in hand specimen to Spry intrusion (Tis), but contains more biotite and less quartz and sanidine phenocrysts; also, phenocrysts are larger (as much as 1 cm) than those in Spry intrusion. Petrographically identical to clasts in Buckskin Breccia (Tbb), which is made up mostly of ash-flow tuff derived from same source as volcanic rocks of Bull Rush Creek but which outran these local volcanic rocks. Clasts commonly are as large as 4 m in diameter. Pebbles from Claron Formation, including red and gray limestone, claystone, and sandstone, also were noted locally. Clasts of Mount Dutton lithology are abundant, even predominant, in some mudflow breccia or other sedimentary beds; their presence suggests local contemporaneous eruption of rocks of Mount Dutton Formation, although in most places Mount Dutton Formation rests unconformably on Spry intrusion (Tis) and volcanic rocks of Bull Rush Creek. Upper part of sequence consists mostly of conglomerate, mudflow breccia, and sandstone, which are best exposed west of Horse Valley in southeastern part of map area. Volcanic mudflow breccia, exposed along Horse Valley Creek, makes up middle part of unit. Lower part consists mostly of resistant, pink, massive, locally autobrecciated, flow-foliated lava flows, each 10-40 m thick, that are exposed best along Horse Valley Creek and south of Bull Rush Creek. In some places, flows form one or more volcanic domes that locally have intrusive contacts with other volcanic rocks of Bull Rush Creek. A K-Ar age on hornblende from the glassy base of a flow by Damon (1968) of 31.2±1.5 Ma is now considered to be too old due to excess argon, a problem that commonly affects middle Tertiary hornblende crystals. Informally named here for exposures south and north of Bull Rush Creek. Mapped only in southeastern part of map area. Base of unit is not exposed; an incomplete section is about 250 m thick

Tbb **Buckskin Breccia (Oligocene)**—Moderately resistant to soft, light- to medium-gray and grayish-pink, poorly to moderately welded, crystal-poor dacitic ash-flow tuff, autoclastic flow breccia(?), volcanic mudflow breccia, conglomerate, and sandstone. Characterized by abundant (as much as 50 percent of the rock volume), distinctive, porphyritic lithic clasts petrologically identical to volcanic rocks of Bull Rush Creek (Tv) and similar to Spry intrusion (Tis). 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 airfall tuff, and sedimentary rocks. Clasts are set in a devitrified glass matrix that commonly includes vaguely defined glass shards as well as fragmented grains of plagioclase, sanidine, hornblende, biotite, augite, and Fe-Ti oxides. The volcanic mudflow breccia, conglomerate, and sandstone also contain abundant clasts of volcanic rocks of Bull Rush Creek. Consists in places of at least four well-bedded depositional units, bedded sequentially or separated by a few meters of tuffaceous sandstone. Thin section study reveals that at least three units are 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) and described in detail by Yannacci (1986). Only mapped west of Circleville Canyon; in southwestern part of map area, ash-flow tuffs that resemble those in Buckskin Breccia but that cannot be correlated with certainty are instead included within volcanic rocks of Bull Rush Creek. Age is based on interfingering relationship with Isom Formation just west of map area (Anderson, Rowley, and others, 1989). Maximum thickness about 80 m

Tvd **Dikes of Bull Rush Creek (Oligocene)**—Resistant, black to dark-gray, locally flow-foliated, quartz latite porphyry vitrophyre dikes as much as 30 m wide. Petrographically identical to volcanic rocks of Bull Rush Creek (Tv). Dikes cut volcanic rocks of Bull Rush Creek but not Spry intrusion (Tis). May be feeders for some of the volcanic rocks of Bull Rush Creek. Two new K-Ar ages were determined by H.H. Mehnert from a dike; one on fresh hornblende of 29.4±2.2 Ma is considered too old due to excess argon, and one of 26.4±3.2 Ma on plagioclase is considered to be close to the true age. Sample locations are shown on map; analytical data on new ages are given in table 1

Ti **Isom Formation (Oligocene)**—Ledge-forming, grayish-red, pale-red, pale-reddish-purple, and grayish-red-purple, densely welded, crystal-poor ash-flow tuff. Typically contains 5-20 percent phenocrysts, 1-3 mm long, of plagioclase and minor augite and Fe-Ti oxides in a groundmass of devitrified glass shards. Generally groundmass has texture and appearance of unglazed porcelain. Includes a dark-gray to brownish-black basal vitrophyre. A single cooling unit, it locally exhibits secondary flow structures, including autobrecciation and flow foliation; it also contains 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. Source area is believed to be in Great Basin west of Iron Spring district of southwestern Utah. Defined by Mackin (1960) and described in greater detail by Fryman (1987). K-Ar age of 25.9±0.4 Ma determined by Fleck and others (1975; age corrected for new decay constants of Steiger and Jäger, 1977). Crops out in only one place at southwestern edge of map area where it is about 10 m thick. Pinches out to north and east against pre-eruptive volcanic rocks

Tw **Wah Wah Springs Formation of Needles Range Group (Oligocene)**—Shown only on cross section ***B-B'***. Crystal-rich ash-flow tuff

Tvl **Local volcanic and tuffaceous sedimentary rocks (Oligocene)**—Heterogeneous assemblage of locally deposited volcanic strata and tuffaceous 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 formation is absent, at base of next regional rock unit of volcanic origin that occurs higher in stratigraphic section. Just west of map area (Anderson, Rowley, and others, 1989), unit includes an ash-flow tuff on which a K-Ar age of 31.9±0.5 Ma was determined (Fleck and others, 1975; age corrected for new decay constants of Steiger and Jäger, 1977). Partial section, about 15 m thick, exposed only at southern edge of map area

Tc **Claron Formation (Oligocene and Eocene)**—In 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 map area. Absence of this, or any other, established means of defining the two members has precluded mapping them separately here, although most strata appear to belong to lower member. East of Circleville Canyon, most rocks consist of light-gray, metamorphosed limestone, sandstone, claystone, and conglomerate in intrusive contact with Spry intrusion (Ti), and thus may belong to the white member. In other parts of map area, formation consists of soft to moderately resistant, red, pink, light-gray, and white limestone, calcareous siltstone, sandstone, claystone, and subordinate conglomerate of fluvial and lacustrine origin. Well bedded, with bed thicknesses mostly between 10 cm and 1 m. Rock types commonly are intertonguing and laterally gradational. 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 Utah. Age has not been established with certainty. Gregory (1950) reported "late Eocene" freshwater fossils from the uppermost "Wasatch" strata at Cedar Breaks National Monument, to southwest of map area, but lowermost strata may be as old as Paleocene or even Late Cretaceous. Thickness of the poorly exposed Claron strata in map area is perhaps as much as 200 m. Included within Claron northwest of Granite Knolls are 10-20 m of clean, white quartzite considered by Doelling (1975) to predate Claron

Contact—Dashed where approximately located (in cross sections)

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. Showing dip of fault plane, where known. Additional details on fault and lineament patterns are given by Anderson (1986), Anderson and Grant (1986), and Anderson, Rowley, and Blackman (1986)

Lineament—Structural lineament identified in field or on aerial photographs. Probably represents trace of a joint or of a fault of small displacement

Altered rocks—Hydrothermally altered rocks of vent facies of Mount Dutton Formation and lava flows of Kent Lake

Silicified rocks—Intensely silicified rocks of upper sandstone member of Mount Dutton Formation

Vent—Inferred vent area of a volcano

36.2 Ma **Sample locality of isotopically dated rock**—Showing age in million years (Ma). Determined by Fleck and others (1975; corrected for new decay constants given by Steiger and Jäger, 1977), Damon (1968; age underlined), and H.H. Mehnert (this report; age underlined by dashed line)

Strike and dip of beds

Inclined

Horizontal

Strike and dip of flow foliation

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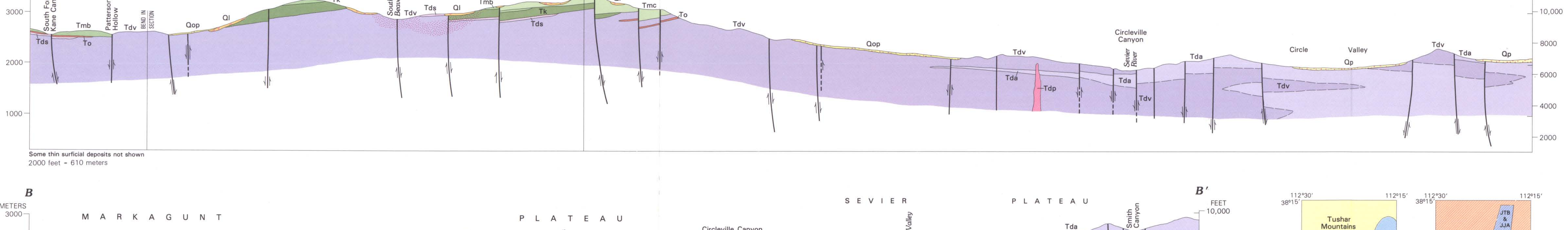
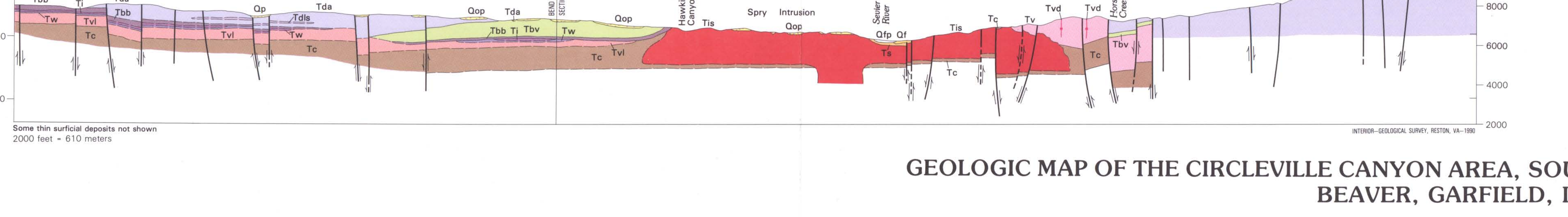
Data For new K-Ar ages of rocks from the Circleville Canyon area, Utah

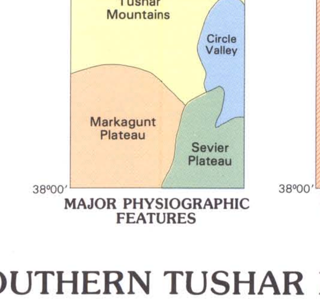
[Ma, mega annum; K_2O determined by isotope dilution; Ar^{40}, radiogenic argon. Constants: $K^{40}\lambda_\epsilon=0.581 \times 10^{-10}$/year; $\lambda_\beta=4.962 \times 10^{-10}$/year. Atomic abundance: $K^{40}/K=1.167 \times 10^{-4}$. Age determinations by H.H. Mehnert]

Sample number	Material analyzed	K_2O (percent)	Ar^{40} (10^{-10} moles/gram)	Ar^{40} (percent)	Age (Ma ± 2σ)	Sample description
84-257	Plagioclase	0.59, 0.58	0.2214	56	26.1±1.7	Fresh rock from Spry intrusion from a roadcut along highway U.S. 89; lat. 38°02'10", long. 112°21'20".
84-259	Plagioclase	0.47, 0.48	0.1820	18.6	26.4±3.2	Sample of fresh glassy dike of Bull Rush Creek, which cuts the volcanic rocks of Bull Rush Creek; lat. 38°01'55", long. 112°19'25".
84-259	Hornblende	0.65, 0.65	0.2771	40	29.4±2.2	Sample of fresh glassy dike of Bull Rush Creek, which cuts the volcanic rocks of Bull Rush Creek; lat. 38°01'55", long. 112°19'25"





INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1990



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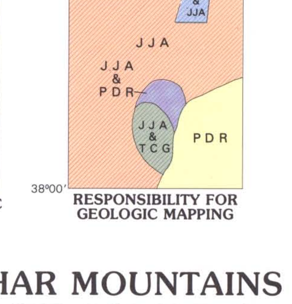

RESPONSIBILITY FOR GEOLOGIC MAPPING

GEOLOGIC MAP OF THE CIRCLEVILLE CANYON AREA, SOUTHERN TUSHAR MOUNTAINS AND NORTHERN MARKAGUNT PLATEAU, BEAVER, GARFIELD, IRON, AND PIUTE COUNTIES, UTAH

By

John J. Anderson, Peter D. Rowley, John T. Blackman, Harald H. Mehnert, and Timothy C. Grant

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