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Detailed Geologic Map of the Southern Portion of the Three Peaks 7.5' Quadrangle, Iron County, Utah: A Record of Sevier Orogenesis, Iron-Oxide-Apatite Mineralization, and Basin and Range Extension

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INTRODUCTION AND ABSTRACT

The Three Peaks range lies ~12 km NW of Cedar City, Utah in a fault block near the eastern edge of the Basin and Range Province. Here, field relationships are vital in understanding Sevier orogenesis, emplacement of iron oxide-apatite (IOA) deposits, and water resources management adjacent to an expanding Cedar City. While the area was previously mapped in the late 1940s, our work provides new insights through the recognition of previously unknown faults and map units.
Exposed in the map area are Jurassic to Cretaceous sedimentary rocks, including the synorogenic Iron Springs Formation (ISF), deformed in the hanging wall of the Iron Springs thrust, the Paleogene Claron Formation, deformed, along with the older rocks, by laccolith intrusion, the Miocene Three Peaks laccolith, and Paleocene to modern unconsolidated alluvial fan sediments. Regional extension contributed to recent deformation. Our mapping was motivated by the following goals: update the stratigraphic nomenclature of the ISF, define petrographically distinct units in the Three Peaks laccolith, and refine the mapping of unconsolidated deposits on the alluvial fan complex.

Based on our results, the ISF at Three Peaks is subdivided into five distinct informal members: The Marshall Creek breccia (which we consider to be the basal member of the Iron Springs Formation), the recently discovered Three Peaks Tuff Member, the lower ISF, consisting of interbedded limestone, sandstone, mudstone, and conglomerate, the middle ISF, consisting predominately of mudstone interbedded with thin intervals of sandstone with sparse pebble to cobble conglomerate lenses, and the upper ISF, marked by the appearance of a cobble to boulder conglomerate. We recognize three petrographically distinct units in the laccolith, separated by gradational contacts; unit 1 has a color index (CI) of ~7-10, unit 2 has a CI of ~ 4-8, and unit 3 has a CI of less than 4. The alluvial fan complex was remapped using updated terminology and units.

Our map provides crucial contextual field relationships necessary for understanding the origin of the IOA deposits, the stratigraphy of the Iron Springs Formation, and deformation related to the regional tectonism; it is also useful to land managers for evaluating seismic risk from Basin and Range faults, and aquifer properties of unconsolidated sediments.

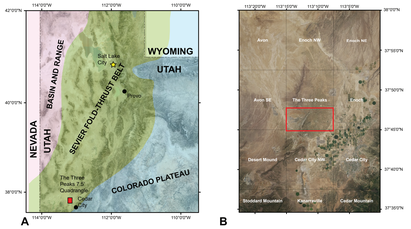
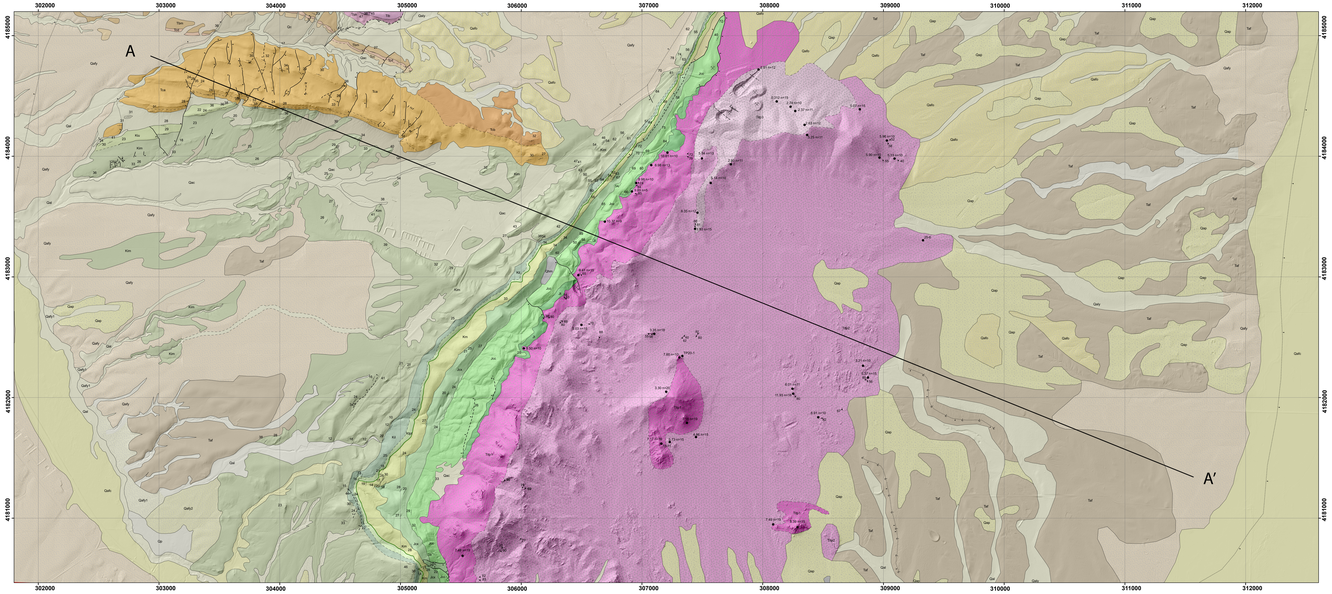


Fig 1. A. Study area in relation to geologic provinces of Utah. The Three Peaks quadrangle is just west of the Colorado Plateau near the eastern edge of the Sevier fold-and-thrust belt. Sevier structures here are overprinted by younger Basin and Range extension. Modified from Yonkee and Weil (2015). Hillshade data from ArcGIS basemaps. B, Three Peaks and nearby 7.5' quadrangles. Study area shown by the shaded box. Quadrangle boundaries from ArcGIS Online. Orthophoto basemap from U.S. Geological Survey's National Agriculture Imagery Program, and the Utah Geospatial Resource Center's Automated Geographic Reference Center.

Fig. 2. Field photo showing a typical exposure of an iron-oxide-apatite dike along the margin of the Three Peaks laccolith. Geologist for scale.

GEOLOGIC MAP AND CROSS SECTION



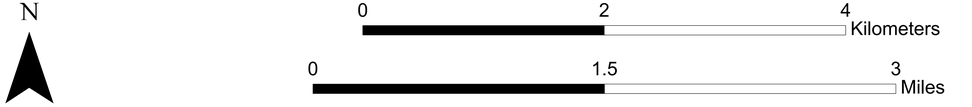


Fig. 3. Left: A meter-scale clastic dike near the top of Kim. Rock hammer for scale. Right: A typical exposure of Marshall Creek breccia. Rock hammer for scale.

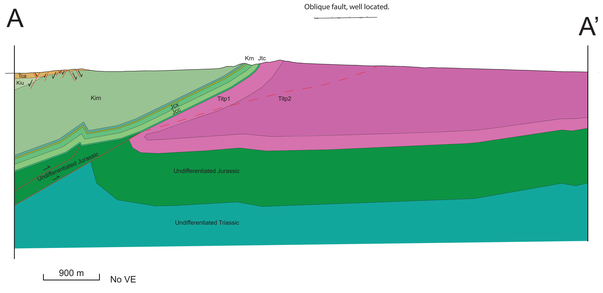


Fig. 4. Cross section A-A'. Some interpretation at depth after the seismic sections in Van Kooten, 1988.

DESCRIPTION OF MAP UNITS

Qhm: Mine waste and talus pilings.

Qafy: Quaternary Youngest fan alluvium. Consists of unconsolidated deposits of locally derived sand to boulder clasts.

Qafy1 and Qafy2: Youngest fan alluvium. Same as Qafy, except that active (Qafy1) fan lobes are separated from inactive fan lobes (Qafy2).

Qal: Quaternary alluvium. Unconsolidated alluvial deposits. Restricted to established fluvial channels and overbank areas.

Qac: Quaternary alluvium and colluvium. Unconsolidated mixed alluvial and colluvial deposits.

Qc: Quarternary colluvium. Unconsolidated colluvium. Found on steep slopes, especially over the easily eroded mudstones of the Claron.

Qap: Quaternary pediment. Unconsolidated pediment deposits. Typically formed on Taf and in the Three Peaks laccolith.

Qafo: Quartenary older fan alluvium. Fan morphology is no longer preserved. May be overlain by a more well developed soil than Qafy.

Qafc: Quaternary coalesced fan alluvium. Suggested by Knudsen and Biek (2014) to be derived from the nearby Hurricane Cliffs.

Qp: Quaternary Playa deposits. Unconsolidated sediment deposited in a small playa in the southwest portion of the map.

Taf: Tertiary fan alluvium. Semi-consolidated deposits of fan alluvium; weathers to a characteristic pinkish orange. Contains clasts not found in modern drainages. Forms a characteristic "rough and patchy" weathering pattern observable in high resolution digital elevation models.

Tib: Baldhills Tuff Member of the Isom Formation. Poorly exposed in the map area. Where exposed the lower part of the Baldhills Tuff Member forms a thin ridge of purplish tuff containing rounded to elliptical pumice fragments, contains abundant (8-12 percent) euhedral biotite, and interlocking quartz, k-spar, and quartz floating in a matrix. Crystals are large; with the largest biotite grains approaching 3mm and quartz and feldspar grains approaching 2mm.
The upper part of the Baldhills Tuff is composed of a thicker, crystal poor resistant layer of purple tuff weathering dark brown and containing minor magnetite.

Tbh: Middle Volcaniclastic Member of the Brianhead Formation. Contains volcanic tuff and a lower bed of poorly exposed chalcedony. Described by Knudsen and Biek (2014) as consisting of volcanic ash, mixed siliciclastics and micrite. Exposure is limited to a very few outcrops across the map area.

Tip1: Tertiary Three Peaks Laccolith Facies 1. Similar to the peripheral shell phase of Mackin and Rowley (1976). Greenish white granite porphyry with a color index around 7 to 10; contains mafic enclaves and yields magnetic susceptibility values around 7*10^3 to 12*10^3 SI. Cross cut by magnetite dikes. Contacts with Facies 2 and 3 are gradational.

Tip2: Tertiary Three Peaks Laccolith Facies 2. Granite porphyry similar to facies 1, but has a color index around 4-8, contained intermediate to felsic porphyritic enclaves and microgranite dikes, and had MS values around 4*10^3 to 8*10^3 SI. Cross cut by magnetite dikes. Contacts with Facies 1 and 3 are gradational.

Tip3: Tertiary Three Peaks Laccolith Facies 3. Leucrocratic granitic porphry. Facies 3 contains sparse enclaves, and forms treeless hills. MS values are around 0.2 * 10^3 SI to 2.7*10^3 SI.

Tbm: Tertiary conglomerate at Boat Mesa. Reddish clast supported conglomerate and interbedded sandstone. Clasts range from granule to cobble size, are imbricated and well rounded. Clasts consist of chert, quartzite, and limestone. 30-40m thick.

Tcd: Tertiary Claron Fm. Member D. Member D (as defined by Mackin and Rowley (1976) is a thin, 10-20 m thick resistant, white micritic limestone that forms a distinctive marker bed. It is distinguished from the underlying Tcc based on weathering characteristics.

Tcc: Tertiary Claron Fm. Member C.Thickly to massively bedded light tannish brown micritic limestone weathering whitish grey. This interval weathers into a distinctive slope beneath Tcd. 20m-30m thick.

Tcb: Tertiary Claron Fm. Member B. Poorly exposed in the Three Peaks area, defined by Mackin and Rowley (1976) as interbedded sandstone, shale, limestone, and conglomerate. Similar to Tca. 60-100 m thick.

Tca: Tertiary Claron Fm. Member A. Massive to thickly bedded purple micritic limestones and interbedded sandstone, shale, and conglomerate. An interval of interbedded sandstone and pebble to boulder conglomerate ~24 m marks the base of Tca. The aproximate upper bound of the lower interval is shown on the map with a dashed line. Aprx. 200 m thick.

Ku: Cretaceous Upper Conglomerate Mbr. of Iron Springs Fm. (informal). Massively bedded cobble to boulder conglomerate. Clasts are dominately quartzite. Truncated along strike by the angular unconformity between the Iron Springs and the Claron. 0-70m.

Kim: Cretaceous Middle Iron Springs Member (informal). Consists dominantly of channelized sandstone bodies with interbedded, poorly exposed mudstone with local pebble conglomeratite lenses. A tuff approximately 43 meters above the base of the Middle Iron Springs yields a U-Pb zircon age of 98.63 Ma +/- 0.034. A ~3-5m thick tabular body of cobble to boulder conglomerate with well rounded clasts of quartzite and limestone is traceable over much of the northern part of the map area ~45 meters above the base of the member. ~900m thick.

Kil: Cretaceous Lower member (informal) of the Iron Springs Formation. The Lower Iron Springs Member is an informal mapping unit comprised of sandstone, lesser amounts of conglomerate than typically observed below the Three Peaks Tuff, mudstone, and several resistant sandy and silty limestone ledges. 25-30m thick.

KTpt: Cretaceous Three Peaks Tuff Member of the Iron Springs Formation. The Three Peaks Tuff Member of the Iron Springs directly overlies the Marshall Creek breccia and consists of multiple purple and white tuff beds of variable thickness. The Three Peaks Tuff Member is an important marker bed and is persistent throughout the Three Peaks area. The Three Peaks Tuff contains glass shards and fragmented phenocrysts (Quick et al., 2020); zircons yield an age of 100.18 Ma. The Tuff is comprised of at least three distinct cooling units. In the southern portion of the map area, a ~2m thick lens of blue grey limestone separates tuff layers. The Three Peaks Tuff contains at least three distinct cooling units and ranges in thickness from 5m-18m.

Km: Cretaceous Marshall Creek breccia: Distinct limestone breccia interbedded with conglomerates of the Middle Iron Springs Formation. Redefined as interval between the J3 unconformity and the base of the Three Peaks tuff and suggested to be the lowermost member of the Iron Springs Formation at Three Peaks. The breccia changes character dramatically along strike from matrix supported breccia with well rounded to angular clasts mostly consisting of limestone granules to boulders with sparse quartzite pebbles to minimally brecciated limestone with evidence of soft sediment deformation. Interpreted as deposited in alluvial fan and lacustrine depositional environments. 20m-60m thick.

Jcx: Jurassic Crystal Creek Member of the Carmel Formation. Interbedded reddish mudstone and white channelized sandstone. 50m-80m thick.

Jcc: Jurassic Co-op Creek Limestone Member of the Carmel Formation. Light grey Dunham mudstone. Contains sparse algal laminations and sparse brachiopod fossils. Forms a distinctive grey band across its outcrop exposure. Aprox. 70 m thick.

Jt: Jurassic Temple Cap Formation: Poorly exposed yellowish sandstone and mudstone. Only about 15 m is exposed in the Three Peaks area where it is discontinuously exposed along the western margin of the intrusion.

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