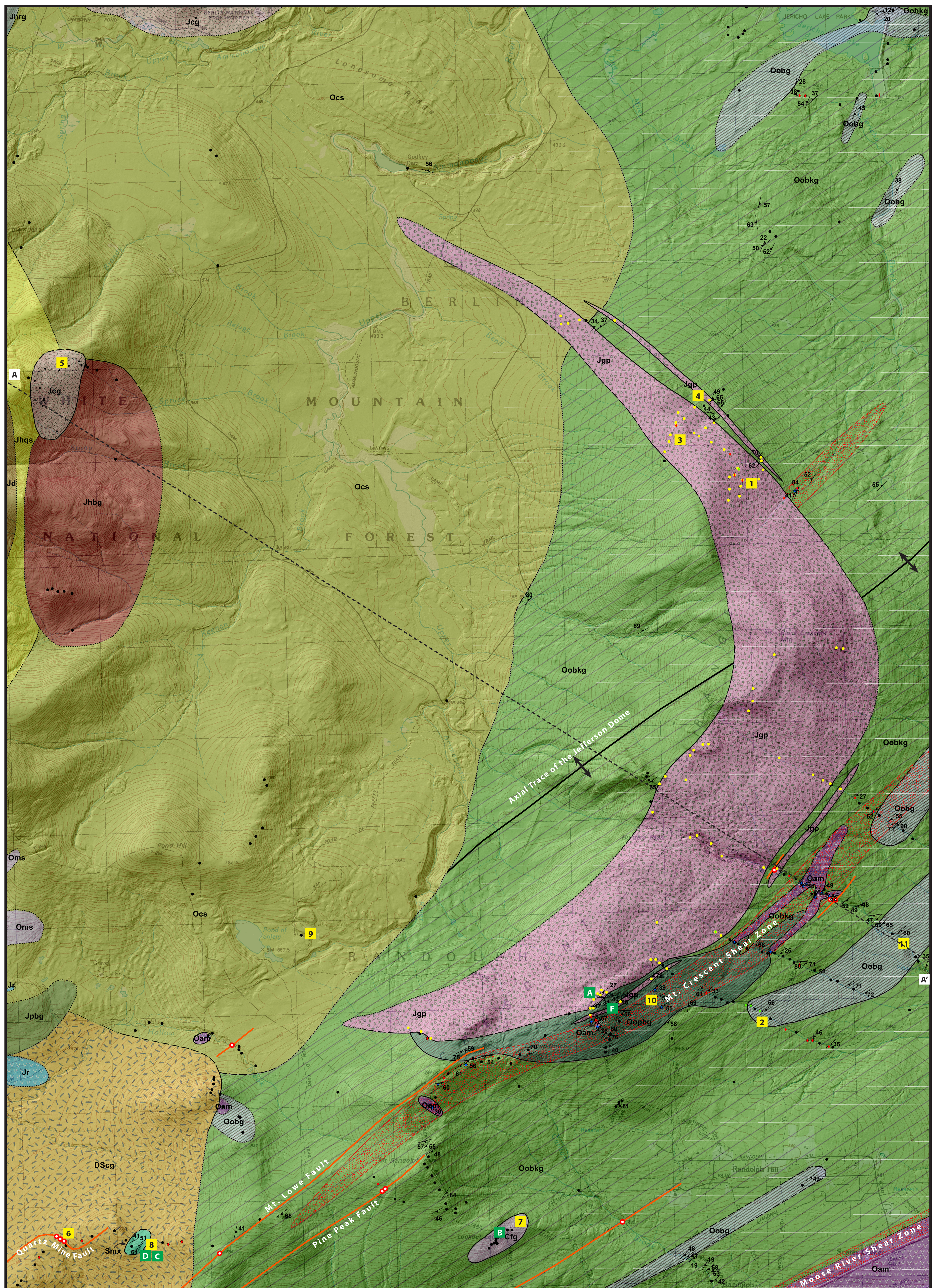


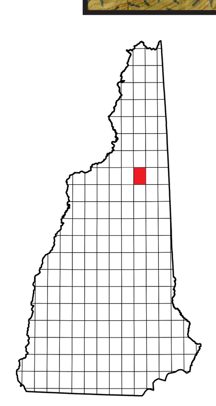
U.S.G.S 7.5' topographic 1995 base
contour interval 6 m
Tranverse Mercator projection
LiDAR base from NH GRANIT

Scale 1:24,000

0 0.5 1 2 3 4 5 Miles

0 0.5 1 2 3 4 5 Kilometers

MN 17 N



Mt. Crescent Quadrangle, New Hampshire - Bedrock Geology

Bedrock mapping by:
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This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program under StateMap award number #G17AS00006, 2018 and award number #G18AS00006, 2019.

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September, 2019

BEDROCK GEOLOGY OF THE MT. CRESCENT, NH 7.5' QUADRANGLE

Introduction: The bedrock geology of the Mt. Crescent (formerly Pliny East), NH 7.5' quadrangle has been remapped at a publication scale of 1:24,000 during the field seasons of 2017 and 2018. The work was done in conjunction with Bates College Department of Geology and the New Hampshire Geological Survey and supported by the United States Geological Survey's StateMap Program. The quadrangle lies along the eastern edge of the Bronson Hill Belt and is dominated by two principal rock units, the Ordovician Oliverian Jefferson Dome and the Jurassic Mt. Crescent ring complex. Previous maps of the region were made at 1:62,500 scale by Billings et al. (1979) and a regional compilation that includes the area was completed for the New Hampshire Bedrock geologic map (Lyons et al., 1997). Bates geology majors Kurt Niiler ('18) and Thorn Merrill ('18) accompanied Prof. Dykstra Eusden for the mapping and worked on senior honors theses related to the project (Niiler, 2018; Merrill, 2018). Dr. Paul O'Sullivan of GeoSeps Services coordinated the geochronology analyses of magmatic and detrital zircons for samples from the study area.

Rock Types: The mapping reveals the following from oldest to youngest on the map: 1) several narrow, highly sheared lenses of Middle (?) Ordovician Ammonoosuc Volcanics (Oam), an amphibolite within the Bronson Hill Belt; 2) Late Ordovician weakly to non-foliated coarse and fine syenite (Ocs and Oms); 3) a variety of gray (Oobg) to pink (Oobkg), variably foliated and sheared, and rarely porphyritic (Oopbg) Late Ordovician Oliverian granitic gneisses; 4) an Early Silurian folded, bedded, volcaniclastic roof pendant (Smx); 5) a Devonian to Silurian coarse-grained granite (DScg) surrounding the roof pendant; 6) a Carboniferous fine grained granite (Cfg); 7) the crescent-shaped Jurassic Mt. Crescent monozogranite porphyry (Jgp), a cone sheet (?) with a narrow secondary segmented ring fracture on its east flank; 8) minor occurrences of other Jurassic cone sheets, coming from the Pliny complex to the immediate west, of hornblende syenite (Jhqs), pink biotite granite (Jpbg), and Jefferson rhyolite (Jr) ; and 9) rare Jurassic (?) mafic and felsic dikes. Regions of Triassic (?) silicified zones marking late brittle faults (the largest of which are the Mt. Lowe and Pine Peak Faults) were also found. Regions of late Devonian (?) mylonitic fabrics with S-C mylonites and rotated porphyroblasts form the distinct Mt. Crescent Shear Zone.

Geochronology: Zircon U-Th-Pb ages were determined for six samples from the study area by Laster Ablation Inductively Coupled Plasma Mass Spectrometry. These included three crystallization ages from the Oliverian granites (Oobg, Oopbg, and Cfg), one crystallization age from the granite porphyry of the Mt. Crescent cone sheet (Jgp), one detrital age from the metasedimentary roof pendant (Smx) found in the southwest corner of the quadrangle, and one crystallization age from the granite, DScg, surrounding the Smx. Two of the three samples believed to be part of the Oliverian yielded concordant zircon ages of 440.6 +/- 2.3 Ma (Oobg) and 447.7 +/- 2.1 Ma (Oopbg), supporting their inclusion as part of the Late Ordovician Jefferson Dome. The third Oliverian sample yielded a concordant zircon age of 335.8 +/- 1.7 Ma, surprisingly indicating a Carboniferous age of intrusion (Cfg). This sample also contained older zircons that were Ordovician in age, suggesting that it inherited them from the surrounding Oliverian Jefferson Dome rocks during intrusion. The sample of the Mt. Crescent cone sheet (Jgp) yielded a concordant zircon age of 178.8 +/- 1.1 Ma, supporting its Jurassic age designation. The metasedimentary roof pendant (Smx) yielded a maximum Silurian depositional age of 440.1 +/- 1.7 Ma, and has a unimodal zircon age population suggesting that it is volcaniclastic, and nearly coeval with the Oobg age. The enveloping coarse granite (DScg), previously designated as Ordovician, is much younger at 417.0 +/- 15 Ma.

Structural Geology: Overall the structures support a Devonian Acadian or Neoacadian timing of deformation for the dome with subsequent shearing, followed by later Permian or Triassic brittle faulting. Three different types of foliations were found in the dome: 1) zones of no foliation; 2) zones of single foliations that are likely related to doming; and 3) mylonitic S-C foliations defining cross-cutting ductile shear zones. The zones of no foliation are somewhat randomly distributed. Similarly the dips of the singly foliated rocks are variably distributed across the dome. Equal area projections of the single dome foliations indicate a classic anticlinal dome shape with a trend and plunge of 65.4°, 12.7°. However, the spatial distribution of the single foliation data does not support the dome shape. Instead, as shown on the cross section, the limbs of the dome steepen progressively toward the apex of the dome and do not become flatter toward the center as would be expected. Narrow zones striking NE-SW with abundant mylonitic foliations that present S-C fabrics and sigma porphyroclasts show primarily reverse dip slip shear and cut the single and no foliation zones. These form a complex shear zone, called the Mt. Crescent Shear Zone, and agree with kinematics from the Moose River fault in the adjacent Mt. Washington 7.5' quadrangle. Aligned silicified pods, up to 10 m in width, can be connected by LiDAR hillshade troughs and are interpreted to be late brittle faults that strike NE-SW and NW-SE. These are correlative to similar structures seen in adjacent regions. The main faults of this type are the Mt. Lowe, Pine Peak, and Quartz Mine Faults.

Sequence of Geologic and Tectonic Events: The Middle Ordovician Ammonoosuc Volcanics (Oam) were erupted during the Taconic Orogeny and Late Ordovician Oliverian Jefferson Dome (Oopbg, Oobg, and Oobkg) intruded during the Salinic Orogeny. Both rocks were emplaced in volcanic arc settings. The Oliverian magmatism was contemporaneous with the intrusion of the relatively undeformed coarse and fine syenites (Ocs and Oms) and also near coincident with a period of Early Silurian marine, volcaniclastic, sedimentation over the Oliverian granites as indicated by the roof pendant (Smx). The Smx rocks are foliated and isoclinally folded by either the Early Silurian Salinic or the earliest Devonian Acadian Orogeny but at least prior to the encapsulating unfoliated granite (DScg) that postdates this deformation. Doming probably occurred in the Late Devonian Neoacadian Orogeny and was immediately followed by the Mt. Crescent Reverse (?) Slip Ductile Shear Zone that brought up slivers of Ammonoosuc Volcanics. The fine grained Carboniferous granite (Cfg) was weakly deformed to produce a poorly developed foliation during the waning Neoacadian Orogeny. There are no silicified zones within the Jurassic granite porphyry (Jgp), a partial cone sheet. This suggests the silicified zones formed in the Permian or Triassic, earlier than the intrusion of the Jgp, but younger than the Carboniferous fine-grained granite. Mafic and felsic dikes are found cutting the Jgp suggesting they are perhaps late Jurassic or Cretaceous in age. Jgp, silicified zone faults , and dikes are all probably related to the Mesozoic breakup of Pangea.

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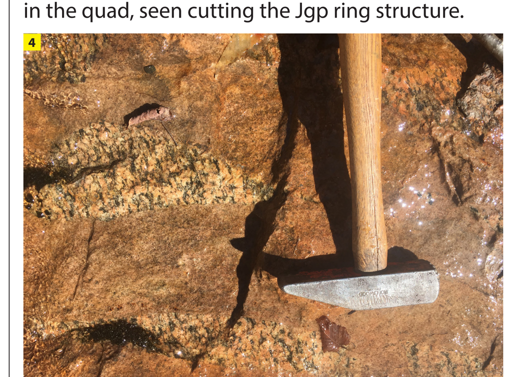
ROCK PHOTO GALLERY

numbers keyed to map

1 Mafic dike, one of the youngest bedrock elements in the quad, seen cutting the Jgp ring structure.

2 Felsic dike, another young bedrock element in the quad, seen cutting Oobg. Inset: sample from brook.

3 Jgp granite porphyry exhibiting characteristic mafic blobs indicative of commingling



4 Xenoliths of foliated Oobkg enveloped by Jgp, the granite porphyry

5 Jcg, pink Conway-type granite

6 Left: Silicified zone with massive quartz and later quartz veins. Right: quartz mine tunnel.

7 Cfg fine grained pink unfoliated granite

8 Folded Smx metasedimentary roof pendant in contact with DScg coarse-grained pink unfoliated granite

9 Ocs gray coarse-grained unfoliated syenite

10 Oopbg porphyritic biotite granite mylonite with S-C fabrics

11 Oobg gray biotite granite with foliation

12 Sheared Oam Ammonoosuc Volcanics and Oobkg pink biotite kspar granite, Crystal Mine Trail.

EXPLANATION OF ROCK UNITS

JURASSIC

Jgp, Granite porphyry. Medium-grained pink to gray granite porphyry with phenocrysts of quartz and lesser ksp. Distinctive round 2-5 cm diameter mafic blobs commonly found in the granite.

Jr, Jefferson Rhyolite. Very fine-grained rock, generally orange to pink in color, with characteristic mm-scale flow banding and spherulitic texture. Often occurs in narrow 1 m wide dikes.

Jcg, Conway Granite. Coarse-grained pink granite, normally found as round-shaped stocks. Mineralogy: ksp+plag+qtz+bio+/-hbl.

Jpbg, Pink biotite granite. Medium to fine-grained pink granite. Mineralogy: ksp, plag, qtz, bio.

Jhbg, Hastingite-biotite granite. Fine to medium grained pink granite. Mineralogy: ksp, qtz, plag, hast, bio.

Jhrg, Hastingsite-riebeckite granite. Medium-grained white to buff granite with characteristic interlocking crystalline texture. Mineralogy: ksp, plag, qtz, bio, hast.

Jhqs, Hornblende quartz syenite. Medium-grained white to gray quartz syenite. Mineralogy: ksp, hbl, bio, qtz.

Jd, Diorite. Medium-grained dark gray diorite, Mineralogy: plag, hbl, bio, mag.

CARBONIFEROUS

Cfg, Fine-grained granite. Fine-grained pink to gray granite with pegmatite veins up to 50 cm long, exhibits weak foliation. Mineralogy: ksp, qtz, plag.

DEVONIAN

SILURIAN

DScg, Coarse-grained granite. Coarse-grained pink granite sometimes featuring pegmatite. Mineralogy: ksp, plag, qtz, hbl, bio, mag.

Smx, Metasedimentary roof pendant. Metasedimentary rock with alternating cm-scale bands of light gray quartzite and dark gray schist, exhibits strong foliation and minor isoclinal folding. Mineralogy: qtz, plag, ksp, bio, musc, hbl.

ORDOVICIAN

Ocs, Coarse syenite. Coarse-grained pink to white syenite with large ksp phenocrysts, exhibiting weak to no foliation. Mineralogy: ksp, plag, hbl.

Oms, Medium syenite. Medium-grained pink to white syenite with weak to no foliation. Mineralogy: ksp, plag, hbl, mag.

Oopbg, Oliverian porphyritic biotite granite. Porphyritic pink-gray granite, exhibits strong foliation. Mineralogy: ksp, plag, qtz, bio.

Oobg, Oliverian biotite monzogranite. Fine to medium-grained gray granite, exhibits weak to strong foliation. Mineralogy: qtz, plag, ksp, bio.

Oobkg, Oliverian biotite k-feldspar monzogranite. Medium to coarse-grained pink granite, exhibits good to strong foliation. Mineralogy: ksp, plag, qtz, bio, musc.

Oam, Ammonoosuc Volcanics. Dark green to black medium grained amphibolite and minor biotite schist both always with strong foliation. Mineralogy: hbl, plag, qtz, bio.

Mineral abbreviations: hbl=hornblende, plag=plagioclase feldspar, ksp=potassium feldspar, qtz=quartz, bio=biotite, musc=muscovite, mag=magnetite, hast=hastingsite

EXPLANATION OF SYMBOLS

Silicified zone. Massive white quartz deposit often with cross cutting quartz veins

Brittle fault. A Mesozoic normal fault that connects silicified zones often marked by LiDAR lineaments

Mylonite. Region of mylonitic fabrics, mostly S-C foliations and sigma porphyroclasts. Most show at least dip slip and many show reverse slip kinematics

Ductile shear zone. A Paleozoic (Devonian to Carboniferous?) shear zone connecting zones of mylonite. Post dates the foliation development of the Jefferson Dome

Mafic dike. 10 cm to 2 m wide mafic, basaltic dikes. Along with the felsic dikes these are the youngest bedrock element in the quadrangle.

Felsic dikes. 10 cm to 2 m wide felsic, rhyolitic dikes often with flow banding. Along with the mafic dikes these are the youngest bedrock element in the quadrangle.

Jgp outcrop location

Outcrop location of mapped unit, no structural measurement

Strike and dip of inclined bedding only found in the metasedimentary roof pendant Smx

Strike and dip of inclined foliation. In ductile shear zones this records the C fabric orientation and elsewhere the foliation of the Jefferson Dome

Contact - accurate

Contact - inferred

Contact - approximate

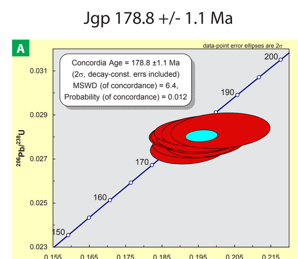
A **Geochronology sample, see chart below**

1 **Photo locality, keyed to map**

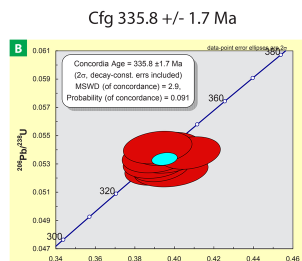
GEOCHRONOLOGY

Analyses by Dr. Paul O'Sullivan, GeoSeps Services

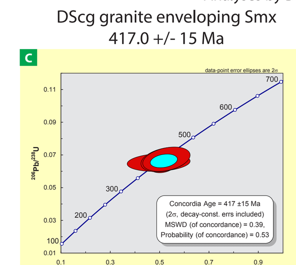
Jgp 178.8 +/- 1.1 Ma



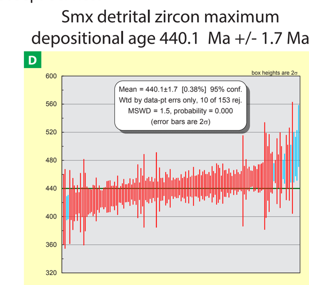
Cfg 335.8 +/- 1.7 Ma



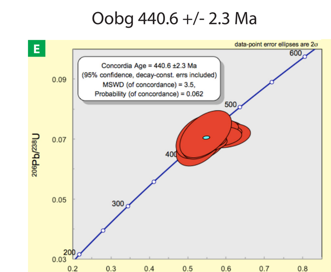
DScg granite enveloping Smx 417.0 +/- 15 Ma



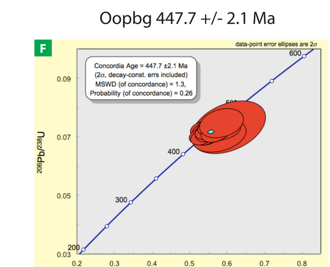
Smx detrital zircon maximum depositional age 440.1 Ma +/- 1.7 Ma



Oobg 440.6 +/- 2.3 Ma



Oopbg 447.7 +/- 2.1 Ma



INTERPRETIVE CROSS SECTION - NO VERTICAL EXAGGERATION