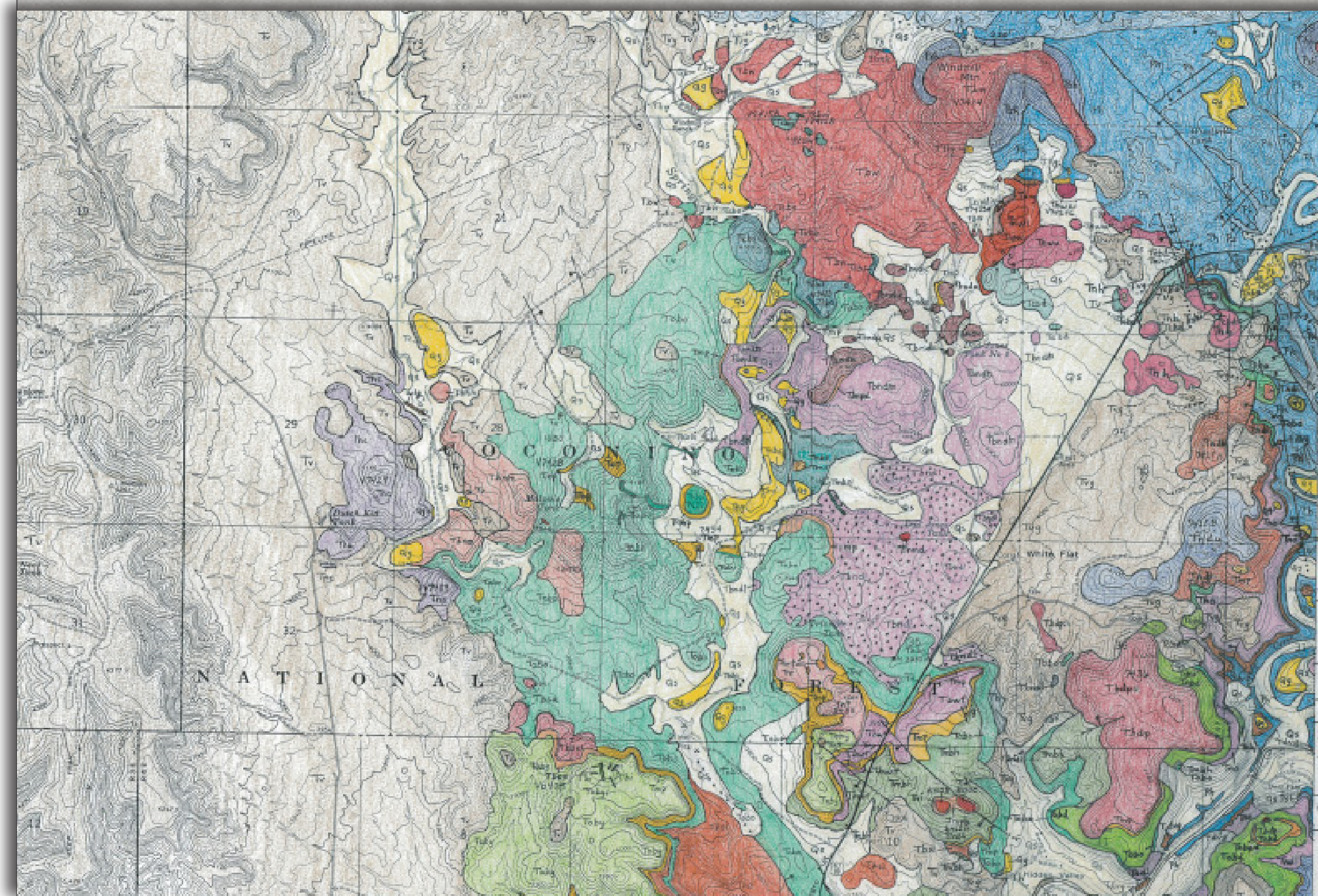
Geologic map of the Page Springs 7.5-Minute Quadrangle, Yavapai County, Arizona

Richard F. Holm



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Arizona Geological Survey Contributed Map Series

GEOLOGIC MAP OF THE PAGE SPRINGS 7.5-MINUTE QUADRANGLE, ARIZONA
YAVAPAI COUNTY

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Introduction

The Page Springs Quadrangle is in the northern part of Verde Valley in north-central Arizona, at the northern edge of the Transition Zone between the Colorado Plateau and the Basin and Range (Fig. 1). Paved access to the southeast quadrant of the map is provided by Arizona State Route 89A (formerly US89A) and Yavapai County Route 50; other parts of the map area can be reached by graded and ungraded U.S. Forest roads and informal tracks appropriate for 4-wheel drive vehicles.

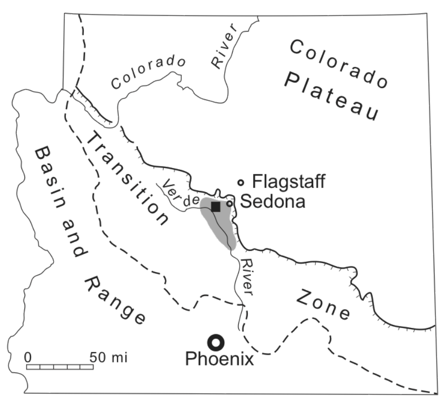

Fig. 1. Location map. Verde Valley is shaded; quadrangle is black rectangle.

The western half of the quadrangle is covered by fluvial and lacustrine rocks of the Miocene and Pliocene Verde Formation, and Miocene volcanic rocks occupy most of the eastern half; Permian sedimentary rocks underlie the northeast corner. All geologic contacts and faults in the volcanic area were traced in the field; aerial photographs supplemented field mapping in tracing contacts and faults in the Permian strata. Volcanic map units were defined on the bases of lithology, structure, and morphology, and stratigraphic relations were determined in the field on the basis of traditional geologic principles such as superposition and cross-cutting relations.

The research plan was to map all lava flows, vent structures, intrusions, and pyroclastic deposits that could be distinguished in the field as discrete units, and to trace each flow to its source. However, multiple contiguous lava flows of the same lithology from the same vent, and individual flow units of compound lava flows and lava-flow fields were not mapped separately. Forty-nine volcanic constructs and intrusions were mapped in the quadrangle. Out of 26 lavas that flowed distally from extrusion points, only one could not be linked with an identifiable or probable source (olivine basalt lava flow, Tob1). Thin felsic tuff beds, also of unknown source, might have erupted from dacite volcanoes in the Hackberry Mountain area near Camp Verde, Arizona. Two lava-flow map units have probable sources outside of the quadrangle: the clinopyroxene-olivine basalt flow of Dry Creek (Tcbd) could have erupted from a dike in Cathedral Rock on the Sedona Quadrangle (Paul Lindberg, oral commun.,September 14, 2014), and the House Mountain lava flows (Th) likely erupted from vents on or near the summit of House Mountain, also on the Sedona Quadrangle.

The Correlation of Map Units was constructed with much confidence. Successions of several lava flows in local areas could be determined because closely spaced vents (see Sheet 3) caused the flows to overlap. A key map unit of wide extent (older olivine basalt, Tobo) allowed correlation across most of the volcanic part of the quadrangle.

Geology

Three Permian formations mapped in the quadrangle follow the stratigraphic nomenclature of Blakey and Middleton (1998): Schnebly Hill Formation, Hermit Formation, and Esplanade Sandstone of the Supai Group; these formations were mapped as the lower and middle parts of the Supai Formation by Levings, 1980, and by Weir and others, 1989. The Schnebly Hill Formation is preserved only in four locations where it has been protected by overlying lava flows and a plug: Anderson Butte, Windmill Mountain, a plug on the east border of the quadrangle (Lobo Butte, Twenter and Metzger, 1963, Plate 1), and at the east border of the quadrangle near Deer Pass Ranch; maximum preserved thickness is about 220 feet. The Hermit Formation occupies moderately sloping terrain in the northeast part of the map, below the Verde Formation in the northwest part of the map, and locally below Tertiary gravel and volcanic rocks along Oak Creek on the east side of the map. Measured on the map, the Hermit Formation is approximately 220 feet thick. The Esplanade Sandstone is exposed along incised drainages in the north part of the map, and locally along Dry Creek on the east side of the map; about 180 feet of the sandstone is exposed at Loy Canyon.

Tertiary gravel deposits of local and distant sources were identified and mapped in accordance with the classification of Holm (2001). Locally derived gravel was transported south from the Mogollon Rim and from areas between the rim and the quadrangle; older deposits lack volcanic clasts, and younger deposits contain clasts of basalt and sparse basanite. Gravel composed of far-travelled clasts was derived from distant sources to the south, probably in central Arizona; however, elevations of the distant gravel indicate south-southeast transport within the quadrangle. Exotic clasts include Precambrian, lower Paleozoic, and lower to middle Tertiary (?) volcanic rocks.

Ages of the volcanic rocks are poorly known. The second oldest lava flow in the quadrangle (basanitic nephelinite flows of Oak Creek, Tno) has a K-Ar age of 13.47 Ma (Ranney, 1988), and a dike of similar composition at Casner Butte 12 miles (19 km) east-southeast of the quadrangle has a K-Ar age of 8.22 Ma (L. Peters, written commun. 1998). The volcanic rocks underlie the Verde Formation, which is mostly younger than 8.3 Ma (see below). On the basis of this sparse information, the volcanism is considered to be Middle to Late Miocene. The quadrangle contains the largest number of vent structures and intrusions (49) in a volcanic field that extends southeast from Anderson Butte to Casner Butte, where it merges with volcanoes in the Mormon volcanic field on the Colorado Plateau (Holm and others, 1998, Holm and others, 1989). The House Mountain shield volcano is the principal central volcano in this northern Verde Valley volcanic field; its summit is 1.5 miles (2.4 km) east of the quadrangle. Highly alkaline rocks such as basanitic nephelinite and basanite are the predominant igneous products within the quadrangle, and are notable components at House Mountain and Casner Butte (Wittke and Holm, 1996, Holm and others, 1998). Small pods and lenses of phaneritic nepheline monzosyenite and nepheline monzodiorite in all of these locations are noteworthy because of their unusual occurrence in Arizona. The most prominent volcano in the quadrangle is Windmill Mountain, an exogenous lava dome of basanite; camptonite lava formed an exogenous lava dome near Page Springs. Lava cones are the most common type of volcano in the quadrangle: basanitic nephelinite (7), basanite (5), composite (1); cinder cones of these lithologies have been eroded or are covered by associated lava flows. Shield volcanoes were constructed by basalt lava (1) in the center of the quadrangle near Malpais Tank, and by basanitic nephelinite (1), which is now buried below the west flank of House Mountain. Most basaltic volcanoes were cinder cones fed by dikes, but the cones have been eroded (possibly 8 to 14); basaltic cinders occur only where they have been buried by lava flows or protected by plugs. Dikes and plugs are nearly equally represented by the three principal mafic lithologies (basanitic nephelinite, basanite, basalt).

The Verde Formation ranges in age from Late Miocene to Pliocene; K-Ar ages of basalt lava flows interbedded with the sedimentary rocks are: 8.3 Ma, 5.5 Ma, and 4.5 Ma (Nations and others, 1981). Principal lithologies are lacustrine limestone, fine-grained sandstone, and cemented gravel (conglomerate). The gravel facies mostly underlies the lacustrine facies, but locally it is interbedded. Within the Verde Formation map unit (Tv) local occurrences of the gravel facies are indicated on the map with symbols (vg, tvg); these deposits probably mark active drainages at the time the Verde basin was filling with sediment. Everywhere that the Verde Formation is in contact with volcanic rocks, the former is on top. The highest elevation of Verde Formation in the quadrangle is 4,500 feet on an isolated patch of limestone at the north border, 160 feet below the highest preserved elevation of limestone on the south flank of House Mountain (4,660 feet, Twenter and Metzger, 1963, section 12). In the southwest corner of the quadrangle, the Verde River has eroded the Verde Formation down to elevation 3,280 feet, which indicates considerable erosion during the Quaternary.

Faults occur throughout the parts of the quadrangle covered by Paleozoic strata and volcanic rocks, but are uncommon, or not recognized, in the areas covered by the Verde Formation. Nations and others (1981) suggest that the mesa-capping lacustrine limestones of the Verde Formation in the northern part of the Verde basin are Pliocene. These relations imply that most faulting in the quadrangle was Miocene, but some faults in the Paleozoic strata could be older. The faults are high-angle, and, where measureable, have low to moderate offsets of 10 to 220 feet. Most faults trend NW-SE, but NE-SW trends are common, and E-W and N-S traces are represented.

Maps

Sheet 1. Geologic Map of Page Springs Quadrangle, Arizona.

Sheet 2. Geologic Map of Page Springs Quadrangle, Arizona, Uncolored.

Sheet 3. Geologic Map of Page Springs Quadrangle, Arizona Showing Locations of Vent Structures and Intrusions; includes explanation of Geologic Map Symbols.

Sheet 4. Geologic Map of Page Springs Quadrangle, Arizona Showing Locations of Analyzed Samples.

DESCRIPTION OF MAP UNITS: Page Springs, AZ 7.5'

Sedimentary Map Units

Qs — **SURFICIAL DEPOSITS (HOLOCENE AND PLEISTOCENE)**—Alluvium along modern drainages; talus and colluvium on slopes; thick soil

Ql — **LANDSLIDE DEPOSITS (PLEISTOCENE)**—Two small landslide deposits that contain blocks of Tc on the west side of Page Springs Road in the extreme northeast corner of section 22

Qg — **GRAVEL (PLEISTOCENE)**—Unconsolidated gravel on low to high terraces above modern drainages; rounded pebbles, cobbles, boulders of Precambrian, Paleozoic, and Tertiary lithologies. Sand and gravel deposits east of Verde River near Page Springs consist principally of Tertiary mafic volcanic pebbles, cobbles, and small boulders, but also contain cobbles of Verde Formation limestone; these deposits range from unconsolidated to weakly to moderately cemented by caliche

Tv — **VERDE FORMATION (PLIOCENE AND MIOCENE)**— Composed mostly of limestone and sandstone, but gravel is the principal deposit locally. Overlies all volcanic rocks. Light gray to white limestone and pink to orange, fine- to medium-grained sandstone cover most of the western part of the map, and locally overlie gravel and coarse sandstone facies in the eastern part of the map. Coarse gravel and sandstone on the west and east sides of modern Oak Creek and west side of Dry Creek that contain pebbles, cobbles, and boulders (to 60 cm) of rounded to subangular basanite, basanitic nephelinite, minor basalt, and Permian limestone and sandstone are either included with the dominant limestone facies (vg symbol shows locations of the gravel) or are mapped separately (tvg symbol shows locations); lenses of pink sandstone in the gravel generally are less than 1 m thick. These coarse deposits, up to 200 ft (60 m) thick, fill paleodrainages and gullies of the ancestral Oak Creek drainage system. Elsewhere in the quadrangle, coarse gravel and sandstone composed of Mogollon Rim sedimentary and volcanic lithologies (Permian limestone and sandstone, basalt, and Precambrian clasts reworked from older Tertiary deposits (distant plateau gravel, Holm, 2001)) are mapped separately in sections 15, 16, 17 in the north part of the map (tvg symbol shows locations; vg symbol shows locations where not mapped separately); these are deposits of ancestral Spring Creek. Similar conglomerate and sandstone along Bill Gray Road in sections 7 and 18 in the northwest part of the map are deposits of ancestral Coffee Creek. All clastic beds are firmly cemented by calcite, which distinguishes Verde Formation gravel from Pleistocene gravel deposits Qg. Volcanic clasts in the Verde Formation gravels are little weathered. Locally on the east and west sides of Spring Creek in sections 15 and 16 in the north part of the map thin limestone beds that are interlayered with gravel (tvg) are mapped separately (tvl symbol shows locations)

Tulg — **UPPER LOCAL VALLEY GRAVEL (MIOCENE)**—Rounded to subrounded pebbles, cobbles, boulders; volcanic clasts are mostly basalt; basanite is sparse; Permian limestone and sandstone, and Devonian dolostone. Imbrication is south. Exposed in road cut along Page Springs Road in section 15, and by Coffee Creek in section 28. Volcanic clasts are more strongly weathered than those in overlying Verde Formation gravel. Paucity of alkaline mafic volcanic clasts suggests deposition prior to eruption of most of the basanite and basanitic nephelinite lavas in the quadrangle. Thickness ranges 0-50 ft (0-15 m)

Tdvg — **DISTANT VALLEY GRAVEL (MIOCENE AND OLIGOCENE)**—Pebbles and cobbles of quartzite, granite, mylonite, diorite, greenstone, felsic volcanic rocks, chert, Martin Fm dolostone, Redwall Fm limestone. Well rounded to subrounded to subangular clasts. Locally includes angular chert pebbles reworked from the lower local valley gravel (Tllg). Consolidated and cemented with calcite. One outcrop in sections 23 and 24 south of Windmill Mtn, and discontinuous outcrops along Dry Creek and Oak Creek on eroded Hermit Formation. Underlies the volcanic rocks. Thickness ranges 0-60 ft (0-18 m). Age is assigned from field relations elsewhere (Peirce and others, 1979; Holm, 2001)

Tllg **LOWER LOCAL VALLEY GRAVEL (OLIGOCENE)**—Poorly sorted pebbles, cobbles, boulders of angular chert and rounded to subangular Coconino Fm sandstone and Kaibab Fm limestone. Three outcrops in sections 23 and 24 south of Windmill Mtn. Deposited on eroded Paleozoic strata. Overlain and intruded by volcanic rocks. Age is assigned from field relations elsewhere (Peirce and others, 1979; Holm, 2001)

Psh **SCHNEBLY HILL FORMATION (LOWER PERMIAN)**—Orange to red sandstone, thick beds, cross beds

Ph **HERMIT FORMATION (LOWER PERMIAN)**—Pink to brick red sandstone, pinkish gray dolostone, conglomerate at bottom; thin beds. Thickness is 220 ft (67 m)

Ps **SUPAI GROUP (Esplanade Fm) (LOWER PERMIAN)**—Light pink sandstone, thick beds, cross beds

Volcano, Lava Flow, and Intrusive Map Units

Identification Numbers

Vent structures (cinder cones, lava cones, lava domes, shields) and intrusions (dikes and plugs) are identified with a 4-digit number based on location according to the township, range, and section system. The first digit is the second integer of the township; the second digit is the second integer of the range; the last two digits identify the section. Vent structures are prefixed with V and intrusions are prefixed with I. If two or more structures are in a section they are identified with letter suffixes A, B, C, etc. For example, V7423, and V7428A, I7428B.

General Petrography of Mafic Rocks

Most of the map units in the quadrangle are mafic volcanic rocks that include basalt, basanite, and basanitic nephelinite. These lithologies are gradational between plagioclase (P) and feldspathoid (F) in the QAPF double triangle of the modal mineral scheme of classification recommended by the International Union of Geological Sciences (Streckeisen, 1979) . Common outcrop features are described here; if a feature is characteristic of a specific map unit it is included in the map-unit description. Some volcanoes erupted lava flows that have compositions near or overlapping the dividing line between basanite and basanitic nephelinite and specimens appear to be of either lithology; such composite map units have both lithologies in their names. Four samples have chemical analyses (Table 1), and chemical classifications of Le Bas and others (1986) and Le Bas (1989) are given in Table 2

Basalts are medium to dark gray, and typically they display conspicuous plagioclase microlites on weather-etched surfaces, which is useful for field identification. Most weather tannish gray. A few are aphyric or microporphyritic (olivine phenocrysts < 1 mm), but most have a few percent (generally less than 10%) of olivine phenocrysts (2-4 mm) in aphanitic matrices; some carry scattered phenocrysts of dark green to black clinopyroxene (1-2 mm). Basalts range from dense to microvesicular (vesicles < 1 mm) to vesicular to amygdaloidal, and may be massive or platy.

Basanites are very dark gray, and typically weather dark reddish brown. If the typical thin (~1 mm) weathering rind is absent, careful examination with a lens of weather-etched surfaces might locate a few plagioclase microlites. Olivine phenocrysts (2-4 mm, < 10%) are typical and very abundant microphenocrysts are ubiquitous; clinopyroxene occurs in some basanites as microphenocrysts. Matrices are aphanitic. Basanites are massive and dense, rarely vesicular. Thus, the presence of abundant microphenocrysts of olivine and sparse microlites of plagioclase distinguishes basanites from basalts.

Basanitic nephelinites are very dark gray to black, and typically weather dark reddish brown. Without exception, plagioclase microlites are not seen on weather-etched surfaces. Olivine phenocrysts (1.5-3 mm, < 10%) and abundant olivine microphenocrysts are ubiquitous; clinopyroxene occurs in some specimens as microphenocrysts. Basanitic nephelinites are massive, dense, have aphanitic matrices, and may display felsic schlieren (< 1 to 2 mm thick) in outcrop. If microlitic plagioclase is not seen in hand specimen, thin section examination is necessary to distinguish between basanites and basanitic nephelinites.

Tni **BASANITIC NEPHELINITE PLUG OR DIKE (MIOCENE)**—One plug, I6410B, in section 10 north of Hidden Valley. Intrudes Tmph

Tbi **BASANITE PLUG OR DIKE (MIOCENE)**—Five plugs intruded into Paleozoic strata in northeast part of the map, I7411A, I7411B, I7412, I7413, I7518, and one intruded in the northwest corner of the Sedona Quadrangle, I7507; an elongated plug, I6410D, intruded into Tmph north of Hidden Valley in section 10. Five radial dikes, I6409C, each about 3 ft (1 m) thick, cut Toby on 4,085 ft knob on mesa west of Spring Creek in section 9. The five northeastern plugs are aligned on regional northwest fault trends; three of these plugs carry granite xenoliths several cm in diameter. The elongated plug intruded a fault that strikes N58W. Felsic schlieren in vertical to steep fractures are common to sparse. Plug ¾ mile west of Red Canyon Road has monzonite dike 2 cm thick and pods of nepheline monzosyenite that contain miarolitic cavities lined with zeolite crystals

Tnwu **UPPER BASANITIC NEPHELINITE FLOW OF WINDMILL MOUNTAIN (MIOCENE)**—Flow extruded from plug (I7424A) southeast of Windmill Mtn. in section 24. Flow overlies Tnwl and Tcbd in section 23. Lava flowed south; thickness at southwest end is 20 ft (6 m)

Tnwui **UPPER BASANITIC NEPHELINITE PLUG OF WINDMILL MOUNTAIN (MIOCENE)**—Plug, I7424A, intruded into lower local valley gravel (Tllg) and Hermit Formation (Ph) in section 24 southeast of Windmill Mtn. Plug, 500 ft (150 m) in diameter, fed Tnwu lava. Paleozoic xenoliths

Tnh **BASANITIC NEPHELINITE FLOW OF HIGHWAY 89 (MIOCENE)**—Preserved in seven outcrops separated by erosion and surrounded by the overlying Verde Formation and surficial deposits in sections 24, 25, 19, 30 near U.S. 89A west of Dry Creek. Flow spread south on Tcbd from feeder dikes (Tnhi). Thickness is 60 ft (18 m) on south edge. Flow contains rare cm-scale pods of fine-grained nepheline monzodiorite

Tnhi **BASANITIC NEPHELINITE DIKES OF HIGHWAY 89 (MIOCENE)**—Two dikes, I7424B and I7424C, that fed Tnh lava in section 24. One dike, 85 ft (25 m) thick and 750 ft (225 m) long, is crossed by U.S. 89A west of Dry Creek. Strikes are N10W and N35W. Dikes cut the clinopyroxene-olivine basalt of Dry Creek (Tcbd). Vertical felsic schlieren 1-4 mm thick strike N10-27W

Tbnm **BASANITE AND BASANITIC NEPHELINITE FLOWS OF MALPAIS TANK (MIOCENE)**—Lava flows erupted from two parasitic vents on southwest side of Tobo shield volcano near Malpais Tank in sections 28 and 33, V7428A and V7433A. Flows overlie Tobo. One flow appears to have flowed southwest between two separately erupted parts of Tnc by Coffee Creek in sections 28 and 33, and another flowed north along ancestral Coffee Creek between Tobo and Tnc. Felsic schlieren and pods in all flows. Thickness is 40 ft (12 m) at distal ends

Tbnmi **BASANITE DIKE OF MALPAIS TANK (MIOCENE)**—Dike, I7428B, 16 ft (5 m) thick, cuts Tobo shield volcano near Malpais Tank in section 28; strike is N50W. Dike is on strike with faults to the southeast

Tbdp **BASANITE LAVA CONE OF DEER PASS (MIOCENE)**—Flows spread south and west from vent V7436 at 4,204 ft knob in section 36 northwest of Deer Pass Ranch; an erosional remnant of the flow crops out south of Oak Creek on the knob south of Deer Pass Ranch. Flow overlies Tobo, Tmbh, Tobd. Thickness ranges from 80 ft (24 m) to 180 ft (55 m)

Tndu

UPPER BASANITIC NEPHELINITE AND BASANITE LAVA CONE OF DRY CREEK (MIOCENE)—Lavas flowed southwest from vent V7425B at 4,257 ft knob in section 25 on west side of Dry Creek. Lava appears to have been deflected westward by a barrier imposed by the north edge of Tobd, which was more than 140 ft (43 m) high. Mafic tuff about 7 m thick is between Tndu and underlying Tndl. Multiple flow units; 100 ft (30 m) thick at distal end

Toby

YOUNGER OLIVINE BASALT (MIOCENE)—Flows erupted from vent(s) V6409A at 4,085 ft knob in section 9 at north end of mesa between Sheepshead Canyon and Spring Creek; three lava flows in stratigraphic section on east and south sides of mesa above Spring Creek. Flows spread east to small mesa in northwest corner of section 10 on east side of Spring Creek, and southward to the small mesa in west half of section 15, where the flows might have spilled into a gully in ancestral Spring Creek drainage system. Flows overlie Tnt, Tbwf, Tobo, Tbsl, Tbsu; intruded by basanite dikes (Tbi) in the vent area. Includes thin mafic pyroclastic deposits between flow units. Outcrop characteristics: scattered olivine phenocrysts to 4 mm, plagioclase-rich matrix, holocrystalline; vesicles in top and bottom flow are 2-4 cm long and up to 14 cm long in the middle flow. Maximum thickness is 120 ft (37 m)

Tobyi

YOUNGER OLIVINE BASALT DIKE (MIOCENE)—Feeder dike, about 16 ft (5 m) thick, of the youngest of three flows of Toby on mesa between Sheepshead Canyon and Spring Creek. Strike is N20W; length is 450 ft (140 m)

Tcbw

CLINOPYROXENE-OLIVINE BASALT FLOW OF WINDMILL MOUNTAIN (MIOCENE)—Four small erosional remnants of lava flow on top of Tbw flow between Spring Creek and Windmill Mtn. in sections 15, 22, 23. Platy shear fractures are spaced 2-5 mm apart. Fed from dike Tcbwi

Tcbwi

CLINOPYROXENE-OLIVINE BASALT DIKE OF WINDMILL MOUNTAIN (MIOCENE)—Small east-striking dike, I7415, that cuts Tbw in southeast corner of section 15 west of Windmill Mtn. Feeder of Tcbw lava flow

Tm

MUGEARITE LAVA FLOW (MIOCENE)—Small erosional remnant of lava flow that covers the vent, V7417, and caps Anderson Butte in northwest part of the map. Outcrop characteristics: very dark gray, massive, vesicles to 10 mm, olivine phenocrysts to 3 mm, sparse clinopyroxene microphenocrysts, rare brown amphibole phenocrysts to 1.3 mm, conspicuous plagioclase microlites seen with lens on weather-etched surface, aphanitic matrix. Overlies Tmc cinder deposit

Tcbd

CLINOPYROXENE-OLIVINE BASALT FLOW OF DRY CREEK (MIOCENE)—Lava flow on west and east sides of U.S. 89A in northeast part of map. Petrography and geochemistry are similar to a basalt dike at Cathedral Rock on the Sedona Quadrangle, which could be the source (Paul Lindberg, oral commun., September 14, 2014). Overlies Tnwl and Tobo, and underlies Tnwu and Tnh. Thickness ranges from 40 ft (12 m) at west edge to over 100 ft (30 m) next to Dry Creek

Tnt

BASANITIC NEPHELINITE LAVA CONE OF TRIANGLE TANK (MIOCENE)—Small lava flow from vent V7435A at 4,086 ft knob in section 35 between Spring Creek and U.S. 89A. Flow overlies mafic pyroclastic deposit Tmp, Tbwf, and Tobo, and underlies Toby. Flow contains m-scale pods of nepheline monzodiorite (Tnmt). Thickness at north edge is 80 ft (24 m)

Tnmt

NEPHELINE MONZODIORITE (MIOCENE)—Meter-scale pods of phaneritic nepheline monzodiorite in the lava flow of Tnt. Pods appear to be too large to have differentiated from the lava flow after extrusion, and may have been carried up by the lava from a large differentiated chamber in the crust. Medium gray; medium-grained framework crystals of plagioclase, nepheline, clinopyroxene, and anorthoclase, and interstitial fine crystals of the same minerals plus sanidine, opaque oxide, zeolite, and carbonate; inclusions of vesicular basanitic nephelinite are up to 3 cm in diameter

Tnwl **LOWER BASANITIC NEPHELINITE LAVA CONE OF WINDMILL MOUNTAIN (MIOCENE)**—Lava flows overlie cinder deposit (Tnpw) and dikes (Tnwli) at the vent, V7423, south of Windmill Mtn. in section 23; lava flowed south. Overlies Tbw, and underlies Tcbd and Tnwu. Thickness at vent is 50 ft (15 m)

Tnwli **LOWER BASANITIC NEPHELINITE DIKES OF WINDMILL MOUNTAIN (MIOCENE)**—Two dikes in cinder cone below Tnwl lava flows in section 23 south of Windmill Mtn. Dikes strike N18E and N60W, and, respectively, are 16 ft (5 m) and 7 ft (2 m) thick

Tnc **BASANITIC NEPHELINITE LAVA CONES OF COFFEE CREEK (MIOCENE)**—Flows from two vents, V7429 and V7433B, on west side of Coffee Creek in section 29 (4,146 ft knob) and section 33. Southern flow overlies Tobo. Flow lobe of Tbnm appears to have entered a valley between the two vent structures. Largest vent structure (V7429) is a lava cone over 180 ft (55 m) high; vertical felsic schlieren strike N25W to N20E; partly melted granite xenoliths are sparse. Vertical fractures in the small vent structure (V7433B) strike N70W

Tbsu **UPPER BASANITE FLOWS OF SPRING CREEK (MIOCENE)**—Small lava flows and vent structure west of Spring Creek in sections 33, 8, 9; vent area has vertical fractures that strike N10W to N48W. Overlies Tobo; covered by cinders (Tbps) of the vent structure, V6408; covered by the lava flows of Toby. Thickness is 60 ft (18 m)

Tbwf **BASANITE LAVA CONE OF WHITE FLAT (MIOCENE)**—Lavas cover the vent, V7435B, in the southeast part of section 35 on the east side of U.S. 89A; flow direction was southwest. Overlies Tmbh and Tobo; underlies Tnt and Toby. Lava flows are interlayered with mafic tuff Tmp. Thickness at southwest end is 50 ft (15 m)

Tbw **BASANITE FLOWS OF WINDMILL MOUNTAIN (MIOCENE)**—Vent structure, V7414, forms Windmill Mtn., a steep-sided lava dome above thin deposit of red cinders on eroded Schnebly Hill Fm (Psh). Flows spread southeast and southwest away from probable fault scarp on north side of vent. Overlies Tobo, Tcbs, Tbndu, and underlies Tnwl, Tcbw. Thickness at the vent is 190 ft (58 m); western edge of unit is 60 ft (18 m) thick

Tbndu **UPPER BASANITIC NEPHELINITE FLOW OF DAD JONES TANK (MIOCENE)**—Lava flow covers cinder deposit (Tbnpd) at vent V7426A in section 26 south of Windmill Mtn. Lava flowed northeast, possibly into drainage that was tributary to ancestral Dry Creek. Overlies Tbndm and Tobo, and underlies Tbw. Sparse felsic schlieren; rare granite xenoliths. Thickness at vent is 60 ft (18 m)

Tndl **LOWER BASANITIC NEPHELINITE AND BASANITE FLOWS OF DRY CREEK (MIOCENE)**—Lavas erupted from vent V7425A in the east part of section 25 west of Dry Creek, and flowed northeast and south, apparently along ancestral Dry Creek. Overlies Tobo and Tno; underlies Tndu. Relations with Tmbh and Tobd are equivocal. Mafic tuff about 7 m thick separates Tndl from underlying Tno. Vertical felsic schlieren at vent strike N12-37E. Thickness at south end is 160 ft (49 m)

Tcbs **CLINOPYROXENE-OLIVINE BASALT FLOWS OF SPRING CREEK (MIOCENE)**—Lava flows erupted from dike I7422 in sections 22 and 23 southwest of Windmill Mtn. Overlies Tobo and underlies Tbw. Thickness at north end is 60 ft (18 m)

Tcbsi **CLINOPYROXENE-OLIVINE BASALT DIKE OF SPRING CREEK (MIOCENE)**—Feeder dike, I7422, of Tcbs flows in sections 22 and 23 southwest of Windmill Mtn. Dike is 600 ft (180 m) long; strike is N35W

Tobd **OLIVINE BASALT FLOWS OF DEER PASS (MIOCENE)**—Multiple flows erupted from vent V6412 on knob south of Deer Pass Ranch. Lavas spread north up ancestral Dry Creek, and west down ancestral Oak Creek. Overlies Tobo, Tmbh, and Tno; underlies Tbdp. Lavas filled gullies cut into Psh, Th, and Tno by ancestral Oak Creek drainage system. Green atoll clinopyroxene surrounds quartz xenocrysts. Thickness along Oak Creek ranges from 140 ft (43 m) to over 200 ft (60 m)

Tmbh **MICROPORPHYRITIC OLIVINE BASALT FLOWS OF HIDDEN VALLEY (MIOCENE)**—Vent, V6410C, is in northeast part of section 10. Vent structure (Tmph) was intruded by a basanitic nephelinite plug (I6410B) and a basanite plug (I6410D). Lavas spread in all directions from the vent, but principally southward. Overlies Tno, Tobo and Tbsl; underlies Tbwf, Tbdp, Tobd. Abundant olivine microphenocrysts (<1 mm); typically microvesicular, but locally dense; atoll clinopyroxene surrounds quartz xenocrysts. Thickness at south end is 120 ft (37 m)

Tbsl **LOWER BASANITE FLOWS OF SPRING CREEK (MIOCENE)**—Lava flows erupted from at least three vents on the east side of Spring Creek: 3,858 ft knob in section 9, V6409B; 3,820 ft knob in section 10, V6410A; 3,920 ft knob in section 15, V6415A; principal flow direction was south. Flows underlie and are interlayered with Tobo flows. Overlain by Toby and Tmbh. Younger flows overlie Tc in section 15, and older flows underlie Tc in section 22. Flow overlies Hermit Formation (Ph) in southeast quarter of section 15 northwest of Page Springs. Includes thin (~1 m) mafic tuff beds between flow units. Maximum thickness exceeds 200 ft (60 m)

Tns **BASANITIC NEPHELINITE LAVA CONES OF SPRING CREEK (MIOCENE)**—Three lava cones, V6422, V6426, V6427, by Spring Creek and Oak Creek in sections 22, 26, 27 near the south border of the quadrangle; short flows spread west, south, and east from the cones. Flows overlie Th and Tc, and overlie and underlie Tobo. The northern cone on the border of sections 22 and 27 has felsic schlieren (< 1 mm thick) that strike N30W. Cones are 60-160 ft (18-49 m) high

Tc **CAMPTONITE LAVA DOME (MIOCENE)**—Lava dome, V6415B, composed of several bulbous flow lobes caps the south end of the mesa between Spring Creek and Oak Creek northwest of Page Springs. The longest lobe flowed about 1 mi (1.6 km) south down ancestral Spring Creek; thickness at south end is 140 ft (43 m) Overlies Tobo and the oldest flows of Tbsl; underlies Tns and youngest flows of Tbsl. Lava is medium to dark gray, dense, massive; weathers medium tannish gray; weathered surfaces display spots of poikilitic analcime. Phenocrysts and microphenocrysts of biotite, hornblende, clinopyroxene, and sparse olivine, are set in aphanitic matrix along with xenoliths of granite and xenocrysts of feldspar and quartz surrounded by reaction rims of green clinopyroxene

Tobo **OLDER OLIVINE BASALT (MIOCENE)**— Principal structure is a deeply dissected shield volcano in the southwest quarter of section 27 between Coffee Creek and Spring Creek. Volcano constructed by lava flows from plugs, dikes, and cinder cones in sections 27 and 34, I7427C, I7427D, V7427E, V7434. Shield covers a cinder cone (Top) at Malpais Tank in sections 27 and 28. Lava flowed 5 mi (8 km) south down ancestral Spring Creek to within one-half mile of the south border of the quadrangle. Some lavas flowed southeast and entered ancestral Oak Creek near Hidden Valley, and others flowed 3 mi (5 km) east through sections 23 and 24 (south of Windmill Mtn.) to ancestral Dry Creek and then 2 mi (3 km) south to enter ancestral Oak Creek near Deer Pass Ranch. Includes mafic pyroclastic deposits between flow units. Interlayered with Tbsl and Tns. Overlies Tbndm, Tbndl, Tno, and Th; underlies Tbnm, Tnc, Tbsu, Tcbs, Tbndu, Tbw, Tnt, Tbwf, Tmbh, Toby, Tcbd, Tndl, Tobd, and Tc. Thickness ranges from more than 240 ft (73 m) at the shield volcano to 20 ft (6 m) at the distal ends of flows. Distal sections typically consist of one to three thin (6-18 ft; 2-6 m) flow units. Outcrop characteristics are: holocrystalline texture; smooth-wall vesicles 5 mm to 5 cm in diameter, locally stretched to 10 cm; amygdules; dark-red weathered surface. Map unit locally includes small, black, aphanitic, and poorly vesicular olivine basalt flows

Toboi **OLDER OLIVINE BASALT DIKES AND PLUG (MIOCENE)**—Six dikes and one large plug 700 ft (210 m) in diameter in sections 27 and 34 west of Spring Creek, I7427C, I7427D; feeders for Tobo lava flows

Tbndm **MIDDLE BASANITE AND BASANITIC NEPHELINITE FLOWS OF DAD JONES TANK (MIOCENE)**—Lava flows spread mostly east toward ancestral Dry Creek from vents southwest of Windmill Mtn. at the 4,131 ft knob in section 27, V7427A, and at the small knob due east on the east side of Spring Creek, V7427B; short flows also advanced north and south from the vents. At vent V7427A felsic schlieren fill fractures that strike N40E and dip 60 SE to vertical; vertical fractures at vent V7427B strike N5-25W. Overlies Tmbs; underlies Tbndu and Tobo. Thickness exceeds 60 ft (18 m) at the east edge

Tmbs **MICROPORPHYRITIC OLIVINE BASALT FLOW OF SPRING CREEK (MIOCENE)**—Lava erupted from a dike, I7426C, in section 26 west of Red Canyon Road, and flowed north, possibly into a drainage that was tributary to ancestral Dry Creek. Flow contains schlieren and small pods of feldspathoid-bearing monzodiorite. Bottom is not exposed; overlain by Tbndm. Thickness exceeds 40 ft (12 m)

Tmbsi **MICROPORPHYRITIC OLIVINE BASALT DIKE OF SPRING CREEK (MIOCENE)**—Feeder dike, I7426C, of Tmbs in section 26 west of Red Canyon Road. The dike cuts Tbndl. Dike is 1,100 ft (335 m) long; average strike is N34W

Tms **FELDSPATHOID-BEARING MONZODIORITE (MIOCENE)**—Area mapped in section 27 west of Red Canyon Road contains many centimeter-scale pods of phaneritic feldspathoid-bearing monzodiorite within the Tmbs lava flow. The pods might be post-eruption differentiated segregations from the host basalt. Outcrop characteristics: medium gray, medium grained, granular, vesicles to 10 mm. Principal crystals are plagioclase, clinopyroxene, olivine, opaque oxide, brown amphibole, sanidine, and nepheline

Tbndl **LOWER BASANITE AND BASANITIC NEPHELINITE FLOWS OF DAD JONES TANK (MIOCENE)**—Lava flows erupted from vent V7426B at the 4,010 ft knob in section 26 west of the Red Canyon Road. Lavas flowed south, and appear to overlie Th in a gully in the southeast quarter of section 35 east of U.S. 89A; underlies Tbndm and Tobo; intruded by Tmbsi

Tnmd **NEPHELINE MONZODIORITE (MIOCENE)**—Area mapped in sections 26 and 35 west of U.S. 89A contains centimeter-scale pods of nepheline monzodiorite in a Tbndl lava-flow unit

Th **HOUSE MOUNTAIN LAVA FLOWS (MIOCENE)**—Undivided basaltic andesite, hawaiite, and mugearite lava flows from vents on or near the summit of the House Mountain shield volcano approximately 2 mi (3 km) east of the quadrangle. The volcanic section is more than 650 feet (200 m) thick in the southeast part of the quadrangle, where multiple basaltic andesite flows form cliffs above 3,800 ft elevation on the west side of House Mountain near Page Springs; the flows dip about 4° west. Most of the lavas are basaltic andesite, but the section includes one mugearite flow on top of a roadcut on the east side of the Page Springs Road in section 25, another mugearite flow higher in the section on the Sedona Quadrangle, and one or possibly two, hawaiite flows below the cliff-forming basaltic andesite. This stratigraphy on the lower west flank of House Mountain is similar to that mapped in the summit area (Holm and Wittke, 1996). Basaltic andesite flows that crop out in the gully north of Hidden Valley probably flowed north from a source at House Mountain; eroded surfaces on the flow, overlain by Tobo, are at elevations of 3,840 ft at the north end of the gully and 3,700 ft at the south end. Twenty feet of the elevation difference is accounted for by a fault between the two outcrops, but the rest (120 ft) could be due to erosion of the basaltic andesite by an ancestral Oak Creek drainage system before the south-flowing Tobo lavas entered the ancestral valley. A section of four basaltic andesite flow units along Spring Creek on the south border of the quadrangle is over 200 ft (60 m) thick, and the same section exceeds 230 ft (70 m) along Oak Creek on the north border of the Cornville Quadrangle. Unit overlies Tno and Tnop, and underlies Tobo, Tobd, Tns, and possibly

Tbndl. Basaltic andesites are characterized by olivine phenocrysts (1-3 mm), feldspar-rich matrices, smooth-wall vesicles (1-3 cm), and tan to gray spheroidal weathering; mugearites are medium gray and weather tannish gray, have sparse olivine and clinopyroxene phenocrysts to 2 mm in diameter, and smaller vesicles; hawaiites have more abundant olivine phenocrysts to 2 mm in diameter, dark gray, less feldspathic matrices, and plagioclase microlites visible with a lens on weather-etched surfaces

Tnoi **BASANITIC NEPHELINITE DIKES OF OAK CREEK (MIOCENE)**—Two dikes, I6423A and I6423B, east of Page Springs in section 23 in the southeast corner of the quadrangle that cut Tno lava flows. Strikes are approximately north and east

Tnmoi **NEPHELINE MONZODIORITE OF OAK CREEK (MIOCENE)**—Two sill-like intrusions of phaneritic nepheline monzodiorite in Tno lava flows near vent V6414 northeast of Page Springs. The sills range from about 20 to 30 ft (6 to 9 m) in thickness. Outcrop characteristics: medium gray to pinkish gray, weathers brownish gray, medium to coarse grained, fine-grained pressure-quenched patches and semi-continuous matrices. Large crystals are clinopyroxene (to 10 mm), olivine (to 7 mm), plagioclase (to 7 mm), nepheline (to 2 mm), opaque oxide. Miarolitic cavities (to 10 mm) are open or filled with zeolite and calcite crystals

Tno **BASANITIC NEPHELINITE FLOWS OF OAK CREEK (MIOCENE)**— Principal volcano structure is a small low-profile shield, vent V6414, composed of multiple flow units that range from 40 to 200 feet thick (12-60 m) and interlayered ash and lapilli tuff beds (< 3 ft, 1 m thick); vent is adjacent to Oak Creek 0.75 mi (1.1 km) northeast of Page Springs. Lava flows of House Mountain (Th) buried the shield; where it has been exhumed by Oak Creek, the lava section is over 350 ft (100 m) thick. The south base of the shield is covered by gravel deposits of the Verde Formation about 1.5 mi (2.4 km) south of the vent. The north flank of the shield merged with intravalley lavas from vent V7531A or vent V7531B, or both, which are in the west margin of the Sedona Quadrangle; these lavas, 200 ft (60 m) thick, flowed southwest down ancestral Oak Creek. Along Oak Creek southwest of Deer Pass Ranch a lower flow unit of olivine-phyric nephelinite (olivine up to 3 mm in diameter) is separated from an upper flow unit of olivine microporphyritic nephelinite (olivine 1 mm and less in diameter) by a bed of orange ash and lapilli tuff 3 ft (1 m) thick. Lavas that flowed north up ancestral Dry Creek from the Sedona Quadrange vent or vents are 30 ft (9 m) thick at the north end. Lava flows from the three vents are indistinguishable in the field. Streams of the ancestral Oak Creek drainage system eroded gullies into Tno lava flows that were filled by lavas of Tobd. Overlies Tob1 north of Deer Pass Ranch and Tdvg and Ph along Oak Creek and Dry Creek; underlies Tndl, Tmbh, Tobo, Tobd, and Th. K-Ar age of the lowest lava flow overlying distant valley gravel (Tdvg) in Oak Creek is13.47 +/- 0.4 Ma (Ranney, 1988; Damon and others, 1996)

Tob1 **OLIVINE BASALT LAVA FLOW (MIOCENE)**—Lava flow of unknown source. Underlies Tno on access road to Deer Pass Ranch in section 31; appears to overlie Tdvg. Thickness is 60 ft (18 m)

Pyroclastic Map Units

Tmc **MUGEARITE CINDERS (MIOCENE)**—Deposit of red cinders about 20 ft (6 m) thick below the lava cap on Anderson Butte in northwest part of the map (V7417). Coarse lapilli and scoriaceous bombs up to 12 cm in diameter

Tnpw **BASANITIC NEPHELINITE CINDERS OF WINDMILL MOUNTAIN (MIOCENE)**—Small cone of red cinders in section 23 south of Windmill Mountain, V7423. Cone is cut by Tnwli dikes and is overlain by Tnwl lava flow. Thickness exceeds 40 ft (12 m)

Tbps **BASANITE PYROCLASTIC DEPOSIT (MIOCENE)**—Deposit of coarse red lapilli and small bombs on top of the Tbsu lava flow west of the junction of Coffee Creek and Spring Creek, V6408. Thickness is 40 ft (12 m)

Tmp **MAFIC PYROCLASTIC DEPOSITS (MIOCENE)**— Mafic pyroclastic deposits of unknown or uncertain source, or probably multiple sources. Mostly tan to red ash and lapilli, 0 to 140 ft (0 to 43 m) thick, in sheet-like beds in most outcrops. Includes bombs, probably near vents. Includes basaltic and basanitic pyroclasts where these can't be mapped separately. Coarse red basanitic pyroclasts overlie finer tan basaltic pyroclasts below the younger basalt (Toby) on the mesa between Bill Gray Road and Spring Creek; the coarse deposits are mapped separately as Tbps above the Tbsu lava flow at the north edge of the mesa

Tbnpd **BASANITIC NEPHELINITE CINDERS OF DAD JONES TANK (MIOCENE)**—Deposit of red lapilli and coarse ash below Tbndu lava flow (V7426A). Thickness is 0-10 ft (0-3 m)

Tobpd **OLIVINE BASALT CINDERS OF DEER PASS (MIOCENE)**—Deposit of red cinders 0-40 ft (0-12 m) thick between flow units of Tobd on knob south of Deer Pass Ranch, V6412. Scoriaceous lapilli up to 6 cm in diameter. Calcite cement

Tmph **MICROPORPHYRITIC BASALTIC CINDERS OF HIDDEN VALLEY (MIOCENE)**—Red cinders above Tmbh lava flows in section 10 northwest of Hidden Valley, V6410C. Lithologic features of the lapilli, including microphenocrysts of olivine, and quartz crystals rimmed by light green clinopyroxene, indicate correlation with, and probable vent area of, Tmbh lava flows

Tft2
Tft1 **FELSIC TUFF (MIOCENE)**—Two felsic tuff beds, each 3-6 ft (1-2 m) thick, between basanite lava flows of Tbsl in sections 15 and 16 next to U.S. 89A; 1 = lower, 2 = upper. White, well sorted, inversely graded planar bedding. Tft1 grades up from vitric fine-ash tuff through pumice-rich coarse-ash tuff to crystal-rich coarse-ash tuff; crystals are quartz, alkali feldspar, biotite. Source is unknown, but could be dacite volcanoes in the Hackberry Mountain area about 30 miles (45 km) to the south; if this is correct, the K-Ar age of the tuff beds is 11.3 to 7.9 Ma (McKee and Elston, 1980)

Top **PYROCLASTIC DEPOSITS OF THE OLDER OLIVINE BASALT (MIOCENE)**—Cinder deposits at and near the vents of the shield volcano that erupted Tobo lava flows, V7427E and V7434. A cinder cone buried under Tobo lava flows was exhumed by the gully in the southeast corner of section 28. Ash, lapilli, bombs; local densely welded agglutinate; typically red

Tnps **BASANITIC NEPHELINITE CINDERS OF SPRING CREEK (MIOCENE)**—Red cinders, 20-80 ft (6-24 m) thick, overlain by Tns lava flows in sections 22, 26, and 27 between Spring Creek and Oak Creek, V6422 and V6426

Tnop **PYROCLASTIC DEPOSITS OF THE BASANITIC NEPHELINITE OF OAK CREEK (MIOCENE)**—Crudely bedded and poorly sorted deposits of coarse ash, scoriaceous lapilli and bombs (up to 90 cm in diameter), agglomerate, agglutinate, and rootless lava flows at vent V6414 next to Oak Creek in section 14; tuff-breccia beds are cemented by calcite. Exposed thickness is 80 ft (24 m). Overlain by Th

GEOLOGIC MAP SYMBOLS

Lithology of Structures	Volcano (V)	Plug/Dike (I)
Basanitic nephelinite	9 (2)	6
Basanite	7	8 (1)
Composite	7	
Basalt	5	5
Nepheline mugearite	1	
Camptonite	1	

Number (ex. V6415B) is structure Identification Number. Letters (ex. Tv) are Map Unit Symbols. See Description of Map Units for explanation.
Subscript gives number of structures; number in parentheses is structure in Sedona Quadrangle in east margin of map.

9 Strike and dip of bedding in sedimentary and pyroclastic rocks.

78 Strike and dip of planar structures in lava flows and intrusions: flow foliation, platy joints, shear fractures.

160 Trace of fault; dotted where concealed by younger rocks and deposits. Bar and ball on down-thrown side. Number by symbol gives throw in feet.

Contact. o = older, y = younger.

tvl Limestone facies of Verde Formation where mapped separately.

tvg Gravel facies of Verde Formation where mapped separately.

vg Location of gravel facies of Verde Formation where not mapped separately.

K-Ar sample location (Ranney, 1988).

Location of sample for modal and chemical analysis (Sheet 4).

Explanation of Geologic Map Symbols is also on Sheet 3.

TABLE 1. CHEMICAL ANALYSES AND CIPW NORMATIVE COMPOSITIONS OF SAMPLES FROM PAGE SPRINGS QUADRANGLE, ARIZONA

Sample	PS356	PS378	PS387-1	PS389
Map Unit	Tnt	Tm	Tobo	Tcbsi
SiO_2	41.30	48.97	51.19	45.58
TiO_2	1.94	1.20	1.49	2.20
Al_2O_3	11.74	14.35	14.35	13.96
FeO	11.58	8.98	11.07	11.42
MnO	0.20	0.16	0.16	0.18
MgO	13.02	7.66	7.82	8.52
CaO	13.04	8.84	8.62	10.91
Na_2O	3.51	5.19	3.60	3.63
K_2O	0.90	1.80	0.85	1.62
P_2O_5	1.69	1.28	0.28	0.99
Total	98.91	98.43	99.44	99.01
LOI	1.64	n.d.	n.d.	n.d.
Sc	23	21	28	17
V	245	206	203	257
Cr	457	300	262	244
Ni	280	90	201	123
Cu	121	101	111	117
Zn	122	136	116	131
Rb	21	17	10	22
Sr	1687	1812	860	1199
Y	26	18	23	20
Zr	257	167	110	187
Nb	56.9	22.5	7.0	41.9
Ba	1263	1210	688	959
La	96	61	36	62
Ce	179	96	56	110
Pb	9	24	5	11
Th	15	8	1	8
Ga	20	23	18	24
Mg #*	66.73	60.34	55.75	57.09
or	5.26	10.56	5.03	9.59
ab	0.54	27.19	32.37	15.76
an	13.47	10.47	20.52	17.06
ne	18.37	11.44	0.00	10.15
di	31.67	19.80	16.37	24.55
hy	0.00	0.00	12.08	0.00
ol	20.98	13.42	7.82	13.86
mt	3.55	2.80	3.13	3.88
il	2.67	1.66	2.08	3.07
ap	3.49	2.66	0.59	2.08
%AN†	96.15	27.80	38.80	51.98

Note: Oxides are in weight percent; trace elements are in parts per million. Chemical analyses are by X-ray fluorescence at WSU GeoAnalytical Laboratory, 2003.

*Mg # = 100MgO/(MgO+FeO), where the oxides are first divided by their molecular weights.

†%AN = 100an/(an+ab)

TABLE 2. MODAL ANALYSES OF SAMPLES FROM PAGE SPRINGS QUADRANGLE, ARIZONA

Sample	PS356	PS358-1	PS358-2	PS378	PS385F(h)*	PS385F(s)*	PS387-1	PS389
Map Unit	Tnt	Tnmt	Tnmt	Tm	Tmbs	Tmbs	Tobo	Tcbsi
Lithology	basanitic nephelinite[§] or olivine melanephelinite**	nepheline monzodiorite[††]	nepheline monzodiorite[††]	basalt[§] or nepheline mugearite[#]	basalt[§]	nepheline-bearing monzodiorite[††]	basalt[§] or hawaiitic subalkali basalt[#]	basalt[§] or basanitic alkali basalt[#]
olivine phenocryst	11.2	--	--	4.5	12.0	--	6.2	5.6
olivine groundmass	4.4	--	--	3.5	1.3	2.6	4.1	4.1
Ti-clinopyroxene phenocryst	--	15.5	9.8	0.6	--	17.0	--	0.9
Ti-clinopyroxene groundmass	63.9	--	--	39.4	45.2	--	40.3	41.9
yellow clinopyroxene	--	2.7	5.2	--	--	0.6	--	--
opaque oxide	8.8	9.6	6.8	9.9	8.8	7.4	12.8	13.4
biotite	--	0.2	0.3	0.8	0.1	1.5	--	--
amphibole	--	--	--	5.2	--	1.8	--	--
zeolite	0.2	6.1	7.2	--	--	4.5	--	--
carbonate	0.3	0.6	1.7	--	--	--	1.0	--
apatite	--	1.2	2.7	0.1	--	2.9	0.4	--
plagioclase	2.9	23.2	17.2	34.4	31.2	50.3	34.2	33.5
anorthoclase	--	10.0	7.3	--	1.4	2.3	--	--
alkali feldspar/sanidine	--	3.2	7.0	1.6	--	6.5	0.7	0.6
nepheline	3.0	27.7	34.7	--	--	2.6	--	--
analcime	5.3	--	0.1	--	--	--	--	--
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
CI[†]	88.3	28.0	22.1	63.9	67.4	30.9	63.4	65.9
points counted	1500	1500	1500	1500	2100	2000	1500	1500

Note: Minerals are in volume percent.
*(h) is mafic host, (s) is felsic segregation.
[†]CI is color index: volume percent of mafic minerals.
[§]name based on mode (plot on QAPF chart for volcanic (aphanitic) rocks, Streckeisen, 1979).
[#]name based on chemistry (plot on total alkali-silica diagram, Le Bas, and others, 1986).
**name based on chemistry (plot on normative ab-normative ne diagram, Le Bas, 1989).
[††]name based on mode (plot on QAPF chart for plutonic (phaneritic) rocks, LeMaitre, 1989.

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