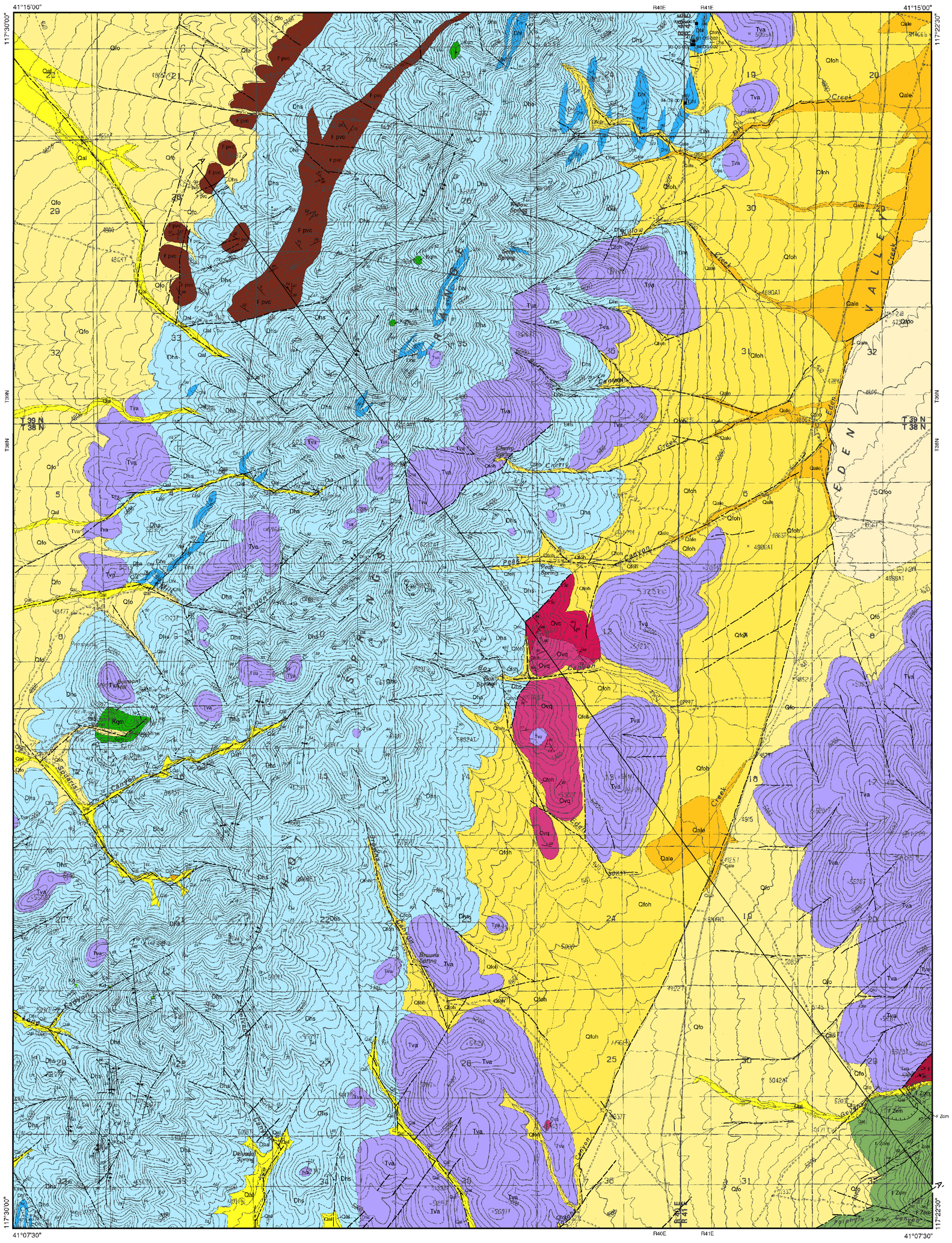


Scale 1:24,000

0 0.5 1 kilometer

0 0.5 1 mile

0 1000 2000 3000 4000 5000 feet

CONTOUR INTERVAL 40 FEET

Base map: U.S. Geological Survey Delvada Spring 7.5' Quadrangle, 1988
Digital Raster Graphic (DRG)

GEOLOGIC MAP OF THE DELVADA SPRING QUADRANGLE, NEVADA

A. Elizabeth Jones

1997

CENOZOIC ROCKS

Qal **Channel deposits (Quaternary)** Unconsolidated alluvium in active channels of alluvial fans and within highlands. Composed of silt, poorly sorted sand, and cobble-size clasts.

Qale **Alluvium of Eden Creek (Quaternary)** Active alluvium and alluvial fans of Eden Creek, Eden Valley, east side of the Hot Springs Range.

Qfo **Older alluvial fan deposits (Quaternary)** Unconsolidated fluvial and debris-flow deposits of older alluvial fans (relative to younger alluvial fan deposits [Qfy] in the Hot Springs Peak Quadrangle to the north) draining westward off the west side of the Hot Springs Range into Paradise Valley, and westward off the Osgood Mountains into Eden Valley. Composed of poorly sorted sand, silt, and gravel. Moderately incised upper surface. Not necessarily contemporaneous with older alluvial fan deposits (Qfoh) on the east side of the Hot Springs Range in Eden Valley.

Qfoh **Older alluvial fan deposits, east side Hot Springs Range (Quaternary)** Unconsolidated fluvial and debris-flow deposits of older alluvial fans draining eastward off the east side of the Hot Springs Range. Composed of poorly sorted sand, silt, and gravel. Moderately incised upper surface. Not necessarily contemporaneous with older alluvial fan deposits (Qfo) on the west side of the Hot Springs Range in Paradise Valley, or the older alluvial fan deposits on the west side of the Osgood Mountains in Eden Valley (Qfoo). The nearest age data for alluvium comes from the valley east of Eden Valley on the east side of the Osgood Mountains. Fission-track dating of zircons from volcanic ash in channel lenses 30 m down in alluvium above the Rabbit Creek gold deposit gave ages of 2.8±0.8 Ma and 2.7±1.0 Ma (Madden-McGuire and others, 1991b).

Qfoo **Older alluvial fan deposit, west side Osgood Mountains (Quaternary)** Unconsolidated fluvial and debris-flow deposits of older alluvial fans draining westward off the west side of the Osgood Mountains. Composed of poorly sorted sand, silt, and gravel. Moderately to deeply incised upper surface. More deeply incised than other older alluvial fan deposits (Qfo) on the west side of the Osgood Mountains in Eden Valley. Not necessarily contemporaneous with the older alluvial fan deposits on the east side of the Hot Springs Range in Eden Valley (Qfoh).

Qoa **Older alluvium (Quaternary)** Consolidated stream gravel composed of angular clasts of Harmony Formation set in a calcareous cement. This unit is only exposed at the head of a small canyon south of Sodarisi Canyon.

Tva **Vesicular basaltic andesite (early Miocene)** Vesicular aphanitic basaltic andesite is black with a fine sugary texture on a fresh surface, and weathers to reddish brown. Elongate 1-2 cm pipe vesicles are common at certain horizons. Weathered casts of hornblende needles are visible at some horizons. Red to black volcanic clasts define a breccia horizon interpreted to represent the base of a flow layer intermittently exposed across the area. To the north in the Hot Springs Peak Quadrangle this unit has steeply east-dipping foliations at several localities on the east side of the range, and foliation that dips gently west on the west side of the range. Some of these dips may represent structural fabric imposed on the rock. Although the massive character and poor exposure of this unit prevent observation of many compaction foliation measurements that would indicate a primary dip, the contact between the volcanic rocks and the underlying Harmony Formation consistently followed a map trace indicating a moderate eastward or southeastward dip of the volcanic unit. This is well exposed south of Willow Creek. This unit correlates with Hotz and Willden's (1964) unit Tva. Erickson and Marsh (1974) identified this unit (Ta) as 22.0±0.7 Ma based on whole-rock K-Ar analysis by M. L. Silberman.

MESOZOIC ROCKS

Kqm **Quartz monzonite (Cretaceous?)** Exposed as a 400-m-diameter plug in the Dutch Flat mining district, and as three small (<50m) plugs farther north on the west side of the range. There are no known age data for these rocks. Their only age constraints in the Hot Springs Range are post-Late Devonian, the youngest known age of the Harmony Formation.

Kd **Dacite (Cretaceous?)** Exposed as three small (20-30 m) plugs in the southwestern region of the quadrangle. There are no known age data for these rocks. Their only age constraints in the Hot Springs Range are post-Late Devonian, the youngest known age of the Harmony Formation.

PALEOZOIC ROCKS

Dutch Flat terrane

The Dutch Flat terrane is composed of three rock units, the Cambrian Paradise Valley Chert, a Cambrian limestone, and the Late Devonian Harmony Formation. The Cambrian limestone is only exposed in the central part of the Hot Springs Peak Quadrangle. They are grouped together into a single terrane because: a) they have historically been interpreted as depositionally related, b) they have a similar structural history, and c) they are known to be structurally separate from other Paleozoic rocks in this quadrangle and throughout the region.

Dh **Harmony Formation (Late Devonian)** The southern two-thirds of the Hot Springs Range is underlain by coarse graded beds of turbiditic arkosic sandstone, siltstone, and shale of the Harmony Formation. Two members of the Harmony Formation are recognized: Dhs, a feldspathic sandstone member; and Dhl, a turbiditic limestone member.

The age of the Harmony Formation has been controversial. It was originally tentatively assigned a Mississippian age, based on an interpreted depositional relationship with inferred Mississippian rocks at Battle Mountain (Ferguson and others, 1952). The age was later revised to Late Cambrian based on three Late Cambrian fossil localities in the Hot Spring Range and one locality in the Osgood Mountains (Hotz and Willden, 1964). Late Cambrian trilobites were found in "discontinuous limestone beds or lenses" associated with blocks of the Harmony Formation in "sheared shale and sandstone" in Goughs Canyon in the Osgood Mountains (Hotz and Willden, 1964). Late Cambrian fossils were also extracted from limestone interpreted to be part of the Harmony Formation at the northern end of the Hot Springs Range in the Hot Springs Peak Quadrangle (Palmer, *in* Hotz and Willden, 1964). Late Cambrian fossils were also discovered in two locations in the Paradise Valley Chert which has usually been interpreted to be depositional beneath the Harmony Formation (Hotz and Willden, 1964). More recently, Late Cambrian to Early Ordovician acritarchs were identified at the type locality of the Harmony Formation in Kluncy Canyon in the northern Sonoma Range (Madden-McGuire and others, 1991a), but these results were later demonstrated to be unreliable (D.J. Madden-McGuire, pers. commun., 1994). Recently it has also been recognized that the Cambrian age from the Osgood Mountains used to date the Harmony was derived from fossils in a limestone block in a large melange unit that also contains fossils as young as Pennsylvanian in age (Jones, 1991; McCollum and McCollum, 1991). Thus, the unit in the Osgood Mountains referred to as "Harmony Formation" is actually a heterogeneous, disrupted structural unit that contains, among other things, blocks of Cambrian limestone, and blocks of feldspathic sandstone identical to the Harmony Formation.

Preliminary results from two limestone samples collected at the northeast edge of the Delvada Spring Quadrangle indicate that the turbiditic limestone interbedded with the sandstone of the Harmony Formation is Late Devonian in age (J.E. Repetski, pers. commun., 1994). The results are reported in table 1. In this case, the limestone is clearly interbedded with the bedded feldspathic sandstone. These massive beds are not part of a melange unit with discontinuous blocks, as in the Osgood Mountains and parts of the Sonoma Range, but rather they form continuous beds that extend for significant distances across the range. Unlike the limestone locality at the north end of the Hot Springs Range, the relation of the limestone horizon to the feldspathic sandstone is clearly depositional. Further sampling to confirm this age is in progress. The relation between the Cambrian ages assigned to the Paradise Valley Chert and the Harmony Formation remains unknown. Because of the turbiditic nature of the limestone, this age can only be taken as a maximum age constraint. The Harmony Formation could be younger, but it cannot be older than Late Devonian. The nearest rock unit of similar age and lithology is in the Osgood Mountains on the east side of Eden Valley. There, earliest Mississippian radiolarian-bearing chert of the Dry Hills subterrane (Jones, 1991), the Farrel Canyon Formation of Hotz and Willden (1964), is interbedded with a feldspathic sandstone compositionally nearly identical to the Harmony Formation.

Harmony Formation *(continued)*

Dhs **Harmony Formation, sandstone member** Graded beds of turbiditic arkosic sandstone grade to finer siltstone and olive-brown and hematite-red shale. Large (1-3 mm) quartz and feldspar clasts are common in the coarser beds. The sandstone is clast supported with 80-90% quartz grains and 5% white feldspar fragments. It has as much as 10% matrix in places. Where beds are clearly graded, facing directions indicate that the beds are folded with a westward vergence along generally northeast-trending, shallowly plunging fold axes. Detailed lithologic descriptions of this unit have been provided by Hotz and Willden (1964) and Rowell and others (1979).

Dhl **Harmony Formation, limestone member** Graded sandy limestone is interbedded with the Harmony sandstone in a northeast-trending zone that runs across most of the length of the range. The beds appear discontinuous on the map because of the complex folding of the formation, as well as the interfonguing of the two units. Individual beds, however, can be followed for tens of meters, and seen to be interlayered with feldspathic sandstone. Two-meter-thick beds contain as much as 40% 1- to 2-mm well-rounded quartz grains, white lithic fragments, and black chitinous fragments. Finer grained layers have crossbeds, ripples, and laminae.

F pvc **Paradise Valley Chert (Late Cambrian)** Dark-green to black beds of the Paradise Valley Chert are folded together with the Harmony Formation in the northwest region of the quadrangle. The dark chert is opaque, and is often characterized by cloudy lenses and spots of limonite within the 5- to 20-cm-thick beds. Hotz and Willden (1964) recovered Late Cambrian trilobites from shaly limestone horizons within the Paradise Valley Chert at two locations in the Hot Springs Range. Finely laminated and foliated, red, black, green, and light-brown shales are common near the contact with the Harmony Formation. The contact between the Paradise Valley Chert and the Harmony Formation has always been interpreted as depositional. Structural evidence presented here supports the interpretation that it is at least conformable. The presence of Late Devonian fossils clearly interbedded with the feldspathic sandstone of the Harmony Formation, however, calls into question the depositional contact between the Harmony Formation and the Paradise Valley Chert. This raises the possibility that the contact may be a structure. For the contact to be depositional, there would likely be a major disconformity between the two units. Alternatively, the fossils that have been recovered from the Paradise Valley Chert could be reworked and thus not representative of the true age of the formation.

F ls **Limestone (Late Cambrian)** This unit is only exposed in the central part of the Hot Springs Peak Quadrangle to the north. It is a fossiliferous, fine-grained, micritic limestone. Cambrian fossils were found by Hotz and Willden (1964) and in this study (see table 1 of the Hot Springs Peak Quadrangle, Jones, 1997) in this rock unit. This limestone does not crop out, but is represented by poorly exposed float across the hillside. The lithologic characteristics of the Cambrian limestone are very distinct from the characteristics of the Late Devonian turbiditic limestone interbedded with the Harmony Formation. There is no question they represent different rock units. While this limestone is close to exposures of both the Harmony Formation and the Paradise Valley Chert, there is no demonstrable stratigraphic relation between the Cambrian limestone and either the Paradise Valley Chert or the Harmony Formation in these quadrangles. The Cambrian limestone may be part of a melange unit, similar to that exposed in the Osgood Mountains to the east, which also contains blocks of exotic Cambrian limestone. It may also be related to the Paradise Valley Chert where Hotz and Willden (1964) also found Cambrian fossils of similar age.

Getchell terrane

Ov **Valmy Formation (Ordovician)** The Valmy Formation has two members Ovc, a chert member, and Ovq, a massive quartzite member. Although the two members are clearly in depositional contact, polyphase folding within the unit prevents recognition of the relative ages of members.

Ovc **Valmy Formation, chert member** Greenish-white to black thinly bedded chert is isoclinally folded into steeply plunging folds. The contact with Ovq shows a north-plunging folded contact at the map scale. At outcrop scale, the contact is much more convoluted, and bedding orientation is highly variable. The lithologic characteristics of this unit are very similar to those of the Valmy Formation that is exposed elsewhere in northern Nevada. The nearest exposure of dated Ordovician Valmy Formation is on the east side of the Osgood Mountains (Hotz and Willden, 1964; Madden-McGuire and Marsh, 1991). The relative ages of the chert and quartzite members of this unit are unknown.

Ovq **Valmy Formation, quartzite member** Gray-blue massive quartzite with very well rounded, moderately to strongly recrystallized grains. In places it is strongly altered and permeated with quartz veins. It is in depositional contact with greenish-white to black thinly bedded chert. The lithologic characteristics of this unit are very similar to those of the Valmy Formation that is exposed elsewhere in northern Nevada. The nearest exposure of dated Ordovician Valmy is on the east side of the Osgood Mountains (Hotz and Willden, 1964; Madden-McGuire and Marsh, 1991).

Hogshead Canyon terrane

OF p **Preble Formation (Early Cambrian through Early Ordovician)** The Preble Formation is exposed in a small area adjacent to Tertiary andesite in the Osgood Mountains in the southeast corner of the quadrangle. It consists of greenish-brown phyllites and shales that weather reddish brown. Silty horizons are micaceous, and a brownish-white quartzite bed parallels the pervasive east-striking foliation. It is separated from the Osgood Mountains Quartzite by Quaternary stream deposits, and thus the nature of the contact between these units is unknown in this area. Both depositional and fault contacts between the Preble Formation and the Osgood Mountains Quartzite are found in the southern Osgood Mountains (Hotz and Willden, 1964). Middle and Late Cambrian fossils collected by Hotz and Willden (1964) and Early Ordovician fossils collected in the Osgood Mountains by Madden-McGuire and Palmer (1990), Madden-McGuire (1991), Madden-McGuire and Marsh (1991), and Madden-McGuire and Carter (1988) constrain the age of this unit.

F Zom **Osgood Mountain Quartzite (Late Proterozoic to Early Cambrian)** Massive folded beds of quartzite are exposed on the western side of the Osgood Mountains in the southeastern most corner of the quadrangle. The brownish-white quartzite beds vary from thinly (10 to 50 cm) to thickly (0.5 to 2 m) bedded, and crossbeds are common. The quartzite is distinctly greenish in places, and can be altered to dark brown. No fossils have ever been recovered from the Osgood Mountains Quartzite, but it is known to lie depositionally below the Preble Formation in the Osgood Mountains (Hotz and Willden, 1964).

See accompanying text for references, age data table, and a discussion of the geology of the map area.

Contact Dashed where approximately located, short dashes represent flow layer in Tertiary volcanic rock.

High angle fault Dashed where approximately located, dotted where concealed.

Lineament Determined from aerial photographs.

Anticline Showing trace of axial surface.

Syncline Showing trace of axial surface.

Overturned anticline Showing trace of axial surface, direction of dip of limbs, and plunge.

Overturned syncline Showing trace of axial surface, direction of dip of limbs, and plunge.

Slump boundary Ticks point down slope.

Strike and dip of bedding

55 **Inclined, facing direction unknown** — 90 Vertical — 41 Overturned

79 **Inclined, facing upright** — 90 Vertical, showing top

Strike and dip of foliation

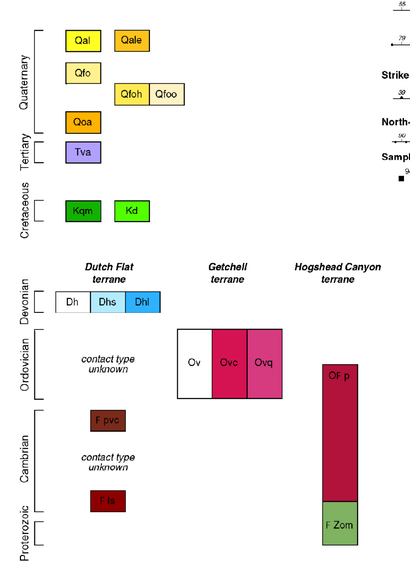
30 **Inclined** — Vertical 90

North-striking, steeply dipping quartz and brecciated quartz vein

90

Sample location for biostratigraphic dating

94-DS-001



Field work done in 1987–1991, 1996.

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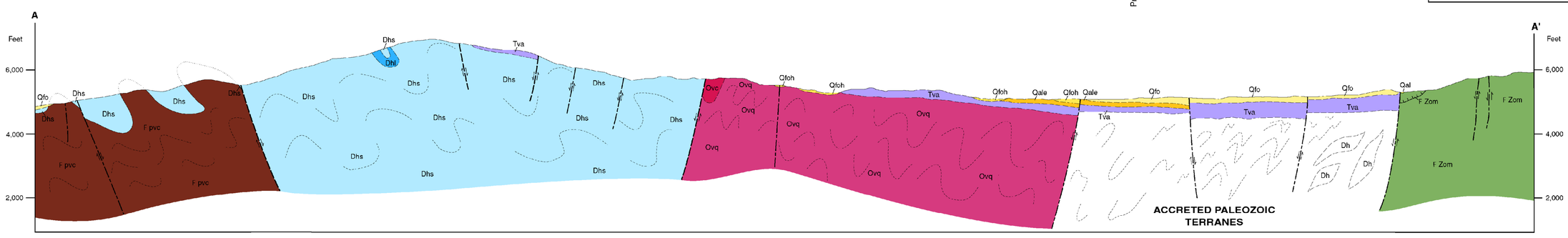
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