GEOCHRONOLOGY OF THE CLARNO IGNEOUS ACTIVITY
IN THE MITCHELL QUADRANGLE, WHEELER COUNTY, OREGON

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Introduction

Detailed mapping of the geology of the Mitchell quadrangle by Oles and Enlows (1971) led to the discovery that those rocks lying above the Cretaceous and below the John Day Formation which Merriam (1901) had referred to his Clarno Formation might best be termed a "group." Two sequences of rock, each ascribed to the Clarno in the Mitchell quadrangle, are separated by an angular unconformity. The authors, therefore, refrerred to the two sequences informally as Lower Clarno and Upper Clarno.

The Lower Clarno consists of about 4000 feet of andesite flows and intrusions, basaltic intrusions, volcanic breccia and tuffaceous sediments. The Upper Clarno consists of 2000 feet of similar andesite flows, mudflows, tuffaceous sediments, and dikes of both basaltic and andesitic composition chiefly associated with Keyes Mountain, an exhumed Oligocene volcano.

Although separated by an angular unconformity, the lithology, petrography and chemistry of all Clarno flows are so similar that they are considered comagmatic.

Procedure and Analytical Techniques

In order to determine the time span of Clarno volcanic activity in the Mitchell quadrangle, a sequence of samples was collected, including specimens from the oldest and the youngest flows, dike rocks, and two of the older plug intrusions. To these can be added two Clarno samples collected by R. L. Hay and reported in Evernden, et al. (1964).

Sample KA 818 collected by Hay near the center of the SW$\frac{1}{4}$ sec. 8, T. 11 S., R. 21 E. is described as, "Pyroxene andesite from 100 foot lava flow about 100 feet above base of a 400 foot series of flows forming the uppermost part of the Clarno Formation (approximately 5000 feet of Clarno here)." Although collected near the top of the Clarno sequence in this location, it is actually near the top of the lower Clarno as defined by Oles and Enlows (1971). Sample KA 824A was collected by Hay from a bentonite claystone 20 feet thick which underlies KA 818.

Three samples of the John Day Formation collected in the Mitchell area by Hay and reported by Evernden et al. (1964) have been used in an attempt to define the top of the Clarno.

K-Ar dates for all the rock specimens mentioned above, both Clarno and John Day, are listed in Tables 1 and 2.

Clarno specimens were processed at the Kline Geology Laboratory of Yale University of Donald Parker. Mineral separates were recovered from the 40- to 100-mesh sieve fraction of crushed rock using a vibrating shape sorter, magnetic separators, and heavy liquids. Whole rock samples were prepared by crushing the rock and recovering the 5-mesh material for the Ar analysis. The material was then further ground for the K analysis.

The K analyses were done with a model 303 Perkin-Elmer atomic absorption spectrophotometer using a Na-Li alkali buffer. The Ar analysis was done by typical isotope dilution analysis procedures in the static mode on a modified Nier type 60° sector mass spectrometer (Armstrong, 1970). The total analytical error is given with the dates in Table 2.

Table 1 illustrates the time span of Clarno igneous activity in the Mitchell quadrangle. Lowermost Clarno rests on Cretaceous strata of Cenomanian age. Clarno igneous activity lasted for about 16 million years, from about 46 million years before present to 30 million years before present. Apparently deposition of the John Day Formation began very soon after extrusion of the last Upper Clarno flow. In the northwestern part of the Mitchell quadrangle the John Day Formation rests with angular discordance on a regolith-mantled terrane of Lower Clarno flows. Unfortunately in the southeastern part of the quadrangle where John Day rests upon Upper Clarno the contact is poorly exposed and the relationships of the units are obscure. Both formations are gently inclined. John Day, however, does rest upon an irregular Upper Clarno topography, and occasional inliers of Upper Clarno interrupt the John Day cover.

Summary

In the Mitchell quadrangle for a period of 16 million years, from approximately 46 to 30 million years before present, a series of hornblende and/or hypersthene andesite flows of markedly similar texture and composition with associated dikes and volcanic-derived sediments built up a rock mass some 6000 feet thick. A basal sequence, informally termed Lower Clarno, is apparently of upper Eocene (Uintan and Duchesnean) age. Sometime in the period between 37.5 and 32.7 million years ago in lowermost Oligocene (Chadronian) time, these rocks were subjected to orogenic activity and major folds were produced. Following or during the period of orogeny, weathering and dissection formed a topography of considerable relief upon which was deposited a younger sequence of similar flows and volcanic-derived sediments (informally termed Upper Clarno) approximately 2000 feet thick. This second period of volcanic and sedimentary activity lasted until about 30 million years before present and was immediately succeeded by the deposition of the extensive volcanoclastic sediments of the John Day Formation.

Table 1. Geochronology of the Clarno Rocks of the Mitchell Quadrangle

Epoch	Time in millions of years before present	Clarno rocks	John Day rocks near Mitchell	Age	North American land mammal stages
MIOCENE (lower)	-20- -25-		Upper tuff Mid. ignimbrite	24.9my* 25.3my*	Arikareean -- 25.6 --
OLIGOCENE	-30- -35-	Nelson Creek dikes Keyes Mtn. flows Airport dikes Lower Clarno bentonite** Uppermost Lower Clarno flow	Lower John Day tuff	29.4my 31.1my* 32.7my 33.3my 36.5my* 37.5my*	Whitneyan -- 29 ? -- Orellan -- 31.6 -- Chadronian -- ? --
EOCENE	-40- -45- -50- -55-	White Butte (whole rock) Lowermost Lower Clarno flow Marshall Butte White Butte (hornblende)		40.5my 43.3my 44.8my 46.1my	Duchesnean -- 40 -- Uintan -- 45.4 --

(In left columns vertical labels: UPPER CLARNO, LOWER CLARNO, Orogeny***, Indicated span of Clarno igneous activity in the Mitchell Quadrangle)

Time scale after Harland, W. B., et al., 1964

   * From Evernden, et al., 1964

  ** Stratigraphically below uppermost Lower Clarno flow

 *** Orogeny occurred sometime between 37.5 and 32.7 million years ago

=== Precise boundaries between Epochs unknown

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Table 2. K-Ar dates on Clarno and John Day rocks
of the Mitchell quadrangle

EMT-11

Material: Diabase dike, whole rock analysis
Locality: Nelson Creek, sec. 2, T. 12 S., R. 21 E.
Stratigraphy: Cuts Cretaceous sedimentary rocks and upper Clarno flows
Data first analysis:
    K = 0.8810, 0.8750, 0.8660   Avg. = 0.8740%
    Ar 40/38 = 0.52722
    Age = 29.3317 $\pm$ 0.5866 m.y.
Data second analysis:
    K = 0.8810, 0.8750, 0.8660   Avg. = 0.8740%
    Ar 40/38 = 0.60354
    Age = 29.4461 $\pm$ 0.5889 m.y.

M-859

Material: Diabase dike, whole rock analysis
Locality: West of landing strip, sec. 26, T. 11 S., R. 21 E.
Stratigraphy: Cuts Cretaceous sedimentary rocks
Data first analysis:
    K = 0.8360, 0.8280, 0.8250   Avg. = 0.8297%
    Ar 40/38 = 1.5636
    Age = 33.4757 $\pm$ 1.2738 m.y.
Data second anlysis:
    K = 0.8360, 0.8280, 0.8250   Avg. = 0.8297%
    Ar 40/38 = 1.48080
    Age = 33.2966 $\pm$ 1.2327 m.y.

KFO-901

Material: Andesite flow, whole rock
Locality: Keyes Creek, SW$\frac{1}{4}$ sec. 32, T. 11 S., R. 22 E.
Stratigraphy: Upper Clarno flow off Keyes Mountain
Data first analysis:
    K = 0.1290, 0.1310   Avg. = 0.1300%
    Ar 40/38 = 0.17265
    Age = 35.5886 $\pm$ 3.4077 m.y.
Data second analysis:
    K = 0.1290, 0.1310   Avg. = 0.1300%
    Ar 40/38 = 0.22100
    Age = 30.0923 $\pm$ 4.7059 m.y.

Table 2. Continued

W-3-58

Locality: White Butte SE$\frac{1}{4}$ sec. 17, N$\frac{1}{2}$ sec. 20, T. 12 S., R. 21 E.
Stratigraphy: Intrudes Cretaceous sedimentary rocks and Lower Clarno
                 volcanic breccia

  A. Material   Hornblende from hornblende andesite
      Data   K = 0.4710, 0.4880   Avg. = 0.4795%
              Ar 40/38 = 0.21901
              Age = 46.1110 + 3.9601 m.y.

  B. Material   Hornblende andesite, whole rock
      Data   K = 1.5100, 1.4900   Avg. = 1.5000%
              Ar 40/38 = 1.96280
              Age = 40.5524 ± 0.9020 m.y.

KFO - 1112

Material: Andesite, whole rock
Locality: Bridge Creek, sec. 21, T. 11 S., R. 21 E.
Stratigraphy: Lower Clarno flow, initial Clarno deposition in this region
Data first analysis:
     K = 0.9250, 0.9500   Avg. = 0.9375%
     Ar 40/38 = 0.89660
     Age = 42.3114 ± 0.8462 m.y.
Data second analysis:
     K = 0.9250, 0.9500   Avg. = 0.9375%
     Ar 40/38 = 0.99160
     Age = 43.3548 ± 0.8671 m.y.

KFO - 1702B

Material: Melabasalt, whole rock
Locality: Marshall Butte, sec. 29, T. 11 S., R. 22 E.
Stratigraphy: Intrudes Cretaceous sedimentary rocks, is overlain by Upper
                 Clarno mudflows
Data first analysis:
     K = 1.2000, 1.2000, 1.1900   Avg. = 1.967%
     Ar 40/38 = 1.07110
     Age = 45.0299 ± 0.9006 m.y.
Data second analysis
     K = 1.2000, 1.2000, 1.1900   Avg. = 1.967%
     Ar 40/38 = 1.10430
     Age = 44.8056 ± 0.8961 m.y.

Table 2. Continued

*KA 818

Material: Pyroxene andesite, whole rock
Locality: Near center SW$\frac{1}{4}$ sec. 8, T. 11 S., R. 21 E.
Stratigraphy: Pyroxene andesite from 100-foot lava flow about 100 feet above
               base of 400-foot series of flows forming the uppermost part of
               the Clarno Formation
Data:

K = 0.972%

A_{40}^{at} = 54%

Age = 37.5 m.y.

*KA 824A

Material: Sanidine
Locality: Near SE corner sec. 2, T. 11 S., R. 20 E.
Stratigraphy: Sanidine from a crystal-rich bentonite claystone 20-foot thick
               bed which underlies the pyroxene andesite of KA 818
Data:

K = (4.59 $\pm$ 0.15)%

A_{40}^{at} = 14%

Age = 36.5 $\pm$ 0.9 m.y.

*KA 489

Material: Sanidine
Locality: NW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 1, T. 11 S., R. 20 E.
Stratigraphy: From 8-foot sequence of tuffs interbedded 165 feet above base
               of John Day Formation, which is at least 2000 feet thick in
               this area. Bridge Creek flora well developed in beds both
               above and below tuff.
Data:

K = 5.71%

A_{40}^{at} = 54%

Age = 31.1 m.y.

* Taken from Evernden, J. F., et al., 1964, Potassium-argon dates and
  the Cenozoic mammalian chronology of North America: Amer. Jour.
  Sci., v. 262, p. 145-198.

Table 2. Continued

*KA 648

Material: Obsidian
Locality: SW¼ sec. 31, T. 10S., R. 21 E.
Stratigraphy: 1100 to 1135 feet above base of John Day Formation 1-inch
lapilli (only interior fragments used for run) from widespread
ignimbrite unit which has been commonly used to separate
middle and upper members of John Day Formation, Early Ari-
kareean fossils abundant below, Late Arikareean fossils above.
Data:

$K = 4.51\%$

$A_{40}^{at} = 58\%$

$Age = 25.3 \text{ m.y.}$

*KA 649A

Material: K-albite
Locality: SW corner sec. 29, T. 10 S., R. 21 E.
Stratigraphy: Approximately 1550 feet above base of John Day Formation
Data:

$K = 1.43\%$

$A_{40}^{at} = 70\%$

$Age = 24.9 \text{ m.y.}$

* Taken from Evernden, J. F., et al., 1964, Potassium-argon dates and
the Cenozoic mammalian chronology of North America: Amer. Jour.
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