

SOME VOLCANOLOGIC ASPECTS OF COLUMBIA RIVER BASALT VOLCANISM RELEVANT TO THE EXTINCTION CONTROVERSY; Donald A. Swanson, Cascades Volcano Observatory, U.S. Geological Survey, 5400 MacArthur Blvd., Vancouver, WA 98661

The Columbia River Basalt Group is the youngest and most thoroughly studied flood-basalt province known; information about it should be relevant to questions about the possible relation of flood-basalt volcanism to mass extinctions.

The group has a total volume of about $174,000 \text{ km}^3$ and covers an area of about $164,000 \text{ km}^2$ (Tolan and others, in press). It was erupted between 17.5 and 6 Ma, as measured by K-Ar and ^{40}Ar - ^{39}Ar dates (Long and Duncan, 1982; McKee and others, 1977, 1981; Swanson and others, 1979). Early eruptions (17.5-17 Ma) formed the Imnaha Basalt. More than 85 percent of the group was produced during a 1.5 m.y. period between 17 and 15.5 Ma, forming the Grande Ronde and greatly subordinate Picture Gorge Basalts. Later flows formed the Wanapum Basalt (about 15.5-14.5 Ma), which includes the well-known Roza Member, and the Saddle Mountains Basalt (about 14-6 Ma).

Linear vent systems for many of the flows are known and are located only in the eastern third of the Columbia Plateau (except for the Picture Gorge feeder dikes near the southern limit of the province). Some of the fissure systems are longer than 150 km. No systematic migration of vents occurred throughout the 11.5 m.y. period of activity; this and other considerations make it unlikely that the province is related to a hot spot. Relic spatter and pumice deposits are rarely preserved along the fissure systems; the degree of vesicularity and disruption of spatter and pumice in these deposits resembles that of modern basaltic tephra. Model calculations (Shaw and Swanson, 1970) based on observations that little cooling occurred during flow of hundreds of kilometers suggest eruption and emplacement durations of a few days. The flows ponded against topography and natural levees to form low-aspect-ratio (0.0002-0.0001) lava lakes, generally 30-40 m thick and 200-400 km in diameter, which cooled to ambient temperatures within a few years to a few tens of years (Long and Wood, 1986).

Some voluminous (greater than 100 km^3) flows occur in all formations, but most such flows apparently were erupted during Grande Ronde time. Within the Grande Ronde, at least 110 major flows with volumes of 90 km^3 to greater than $5,000 \text{ km}^3$ are inferred on the basis of correlations based on multiple criteria, including chemical composition, petrography, overall relative sequence, and paleomagnetic polarity, inclination, and declination (S. P. Reidel, written commun., 1988). The average interval between major eruptions was about 13,600 yrs, the average volume for major flows was about $1,350 \text{ km}^3$, and the average magma supply rate was $0.1 \text{ km}^3/\text{yr}$. This average supply rate is identical to that calculated for historical time at Kilauea (Swanson, 1972; Dzurisin and others, 1984). On this basis, there is no need to postulate a larger heat source for the Grande Ronde Basalt than for modern Kilauea. Clearly an important distinction between the two provinces is that Kilauea "leaks" lava nearly continuously, whereas the Grande Ronde magma was stored for thousands of years before ascent to the surface. This distinction may relate to the presence of a light continental crust above Grande Ronde sources and an oceanic crust over Kilauea sources.

The eruption and emplacement of more than $1,000 \text{ km}^3$ of $1100\text{-}^{\circ}\text{C}$ basaltic lava on the surface within several days doubtless had at least local meteorologic effects. Whether the effects were broader can at present only be hypothesized. Contemporary plant life flourished in highlands adjacent to the plateau, diatoms

were abundant in shallow lakes on the plateau, and vertebrates were trapped and killed by rapidly advancing flows. The province, then, was far from barren despite the huge eruptions and episodic fresh lava surface.

Grande Ronde Basalt and Picture Gorge Basalts contain moderately common but thin sedimentary interbeds between flows, whereas earlier and later formations contain numerous, locally thick sediment accumulations. I am not aware of any work on these interbeds concerning shocked quartz, high Ir, or other characteristics thought to be relevant to the extinction controversy; it would seem natural to conduct such work if one is interested in evaluating the flood-basalt role in mass extinctions. Why look in the far field when interbeds exist within the province?

Volcaniclastic debris derived from extra-plateau sources commonly occurs in the interbeds. Two important observations concerning this debris are (1) that Cascade calc-alkaline eruptive activity continued during the time of flood-basalt volcanism but (2) did not upsurge at the onset of the basaltic volcanism or during its peak during Grande Ronde time. One might expect that, if the flood-basalt volcanism had been triggered by a large impact, activity in the nearby Cascades would also have responded in a positive way; it did not. Apparently the initiation and culmination of Columbia River basalt volcanism was independent of volcanic activity in the Cascades.

REFERENCES

- Dzurisin, Daniel, Koyanagi, R. Y., and English, T. T., Magma supply and storage at Kilauea Volcano, Hawaii, 1956-1983: *Jour. Volcanol. Geothermal Res.*, v. 21, p. 177-206.
- Long, P. E., and Duncan, R. A., 1983, ⁴⁰Ar/³⁹Ar ages of Columbia River basalt from deep boreholes in south-central Washington: *EOS*, v. 62, p. 61.
- Long, P. E., and Wood, B. J., 1986, Structures, textures, and cooling histories of Columbia River basalt flows: *Geol. Soc. America Bull.*, v. 97, p. 1144-1155.
- McKee, E. H., Hooper, P. R., and Kleck, W. D., 1981, Age of the Imnaha Basalt--oldest flows of the Columbia River Basalt Group, northwest United States: *Isochron West*, v. 31, p. 31-33.
- McKee, E. H., Swanson, D. A., and Wright, T. L., 1977, Duration and volume of Columbia River basalt volcanism, Washington, Oregon, and Idaho: *Geol. Soc. America Absts. with Programs*, v. 9, no. 4, p. 463-464.
- Shaw, H. R., and Swanson, D. A., 1970, Eruption and flow rates of flood basalts, in Gilmour, E. H. and Stradling, D., eds., *Proc. Second Columbia River Basalt Symposium*: Cheney, Wash., p. 271-299.
- Swanson, D. A., 1972, Magma supply rate at Kilauea Volcano, 1952-1971: *Science*, v. 175, p. 169-170.
- Swanson, D. A., Wright, T. L., Hooper, P. R., and Bentley, R. D., 1979, Revisions in stratigraphic nomenclature of the Columbia River Basalt Group: *U. S. Geological Survey Bull.* 1457-G, 59 p.
- Tolan, T. L., Reidel, S. P., Beeson, M. H., Anderson, J. L., Fecht, K. R., and Swanson, D. A., in press, Revisions to the estimates of the areal extent and volume of the Columbia River Basalt Group: *Geol. Soc. America, Volume on Columbia River Basalt Group*.