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Spatial Analysis of Cinder Cone Distribution at Newberry Volcano, Oregon: Implications for Structural Control on Eruptive Process

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Newberry Volcano of central Oregon is located in a complex, extensional tectonic setting. Fracture systems converging near the volcanic center include the Brothers (west-northwest trending), Tumalo (north-northwest), and Walker Rim (northeast) fault zones. Newberry covers greater than 1600 sq. km and is associated with over 400 basaltic cinder cones and fissure vents (Holocene-Late Pleistocene). The large number of cinder cones provides a robust data set from which to conduct spatial analyses of vent distribution patterns and quantitatively test for structural controls on magma emplacement.

Newberry cone positions (n=296) were compiled from digital geologic maps and statistically analyzed using GIS. Cone locations were further subdivided into northern (n=149) and southern (n=147) domains to test for mutually independent relations between the three fault zones. Observed cone patterns were tested for randomness and spatial anisotropy using a combination of quadrat analysis (Komogorov-Simirnov test) and comparative-distribution analysis via Monte Carlo simulations. The latter employed the "line-azimuth" and "point-density" techniques of Lutz (1986) and Zhang and Lutz (1989). Statistically significant cone-distribution patterns were subsequently compared to fault trends to assess the degree to which magma emplacement was guided by regional tectonic stress fields.

Results of the K-S tests reject the null hypothesis at the 95% confidence interval, documenting that Newberry cinder cones are not randomly distributed. The Monte Carlo-based analyses identify four significant cone alignments in the southern domain (dominant azimuth directions = 10-15, 30-35, 325-330, 355), and three in the northern (85, 310, 345). Fault segment analysis reveals three dominant azimuthal trends in the region: 310-325 (Brothers fault zone), 330-340 (Tumalo fault zone), and 45-50 (Walker Rim). The above results suggest that the Brothers and Tumalo fault zones had a detectable control on cinder-cone emplacement in both the northern and southern domains, whereas the Walker Rim is poorly correlated to significant cone-alignment patterns. Cinder cone alignments with azimuthal trends of 10-15, 30-35, and 85 suggest additional control by structural conditions other than those represented by mapped surface faults.