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relief partial melting in the upper mantle would produce a column of basalt magma with a hydrostatic head proportional to the depth of the basin. The deeper the basin, the deeper partial melting penetrates, and the higher the magma buoyancy will raise the top of the magma column. The crater basin filled with magma to become a lava lake which periodically erupted basalts that flooded nearby lowlands in Oregon, northeastern California, western Idaho, and eastern Washington. Each major eruption would unload the top of the magma column, prompting further pressure relief melting at depth.

Such a deep lava lake would melt crustal rocks and differentiate into coexisting felsic and basaltic components. Basalt plateaus typically contain felsic rocks which include granophyric rhyolites. Felsic magmas erupted as superhot rhyolites in southeastern Oregon and nearby areas of Nevada and southwestern Idaho. Their greater viscosity confined them to the region of the lava lake, thus identifying the site of the impact.

Volcanic activity ended at the impact site after about two million years, but volcanism over the hot spot has since generated the giant rhyolite calderas of the Snake River Plain. Hot-spot volcanism continues in the Yellowstone volcano. Basin and Range volcanism continues to generate basalt and rhyolite in large parts of the region.

STRATIGRAPHY, STRUCTURE, AND MINERALIZATION OF THE DEER BUTTE FORMATION, WEST OF LAKE OWYHEE, MALHEUR COUNTY, OREGON, by M. L. Cummings, Department of Geology, Portland State University, Portland, Oregon 97207.

Felsic volcaniclastic sediments and primary air-fall tuffs are interfingered with basalt palagonite tephra deposits, basalt flows, and rhyolitic flow-dome complexes in the Deer Butte Formation of Miocene age. Geologic mapping in The Elbow, Twin Springs, and Hurley Flat Quadrangles showS formation of successive volcanic-sedimentary basins that become smaller and younger to the east. The volcanic and sedimentary deposits in the older basins were faulted, uplifted, and eroded as successively younger basins were formed. Nonporphyritic to weakly porphyritic rhyolite flows and domes are the oldest deposits in the map area. Xenoliths of rhyolite occur in basalt palagonite tephra deposits for at least 8 km east of rhyolite outcrops, suggesting that rhyolite underlies the volcanic-sedimentary basins.

Hydrothermal systems developed concurrently with faulting and sedimentation. Within two stratigraphic sequences of the Deer Butte Formation, lacustrine sediments that were deposited after extensive basalt hydrovolcanism contain sediments that were altered near the time of deposition. These sediments contain anomalous concentrations of Au, Hg, As, Sb, W, and Mo. As the stratigraphy of the Deer Butte Formation evolved, faulting and uplift of older deposits within the Hurley Flat Quadrangle allowed erosion of hydrothermally altered clasts and transport in east-flowing streams into developing sedimentary basins in the east.

The stratigraphy of the Deer Butte Formation contains a record of sedimentation and volcanism within basins controlled by north-trending fault zones, uplift and erosion within areas of the older basins during the formation of younger basins, and concurrent hydrothermal activity.

SIGNIFICANT DISCOVERIES DURING 1989 INVOLVING DIKES OF COLUMBIA RIVER BASALT IN PRE-TERTIARY ROCKS IN EASTERN OREGON AND WESTERN IDAHO, by W.H. Taubeneck, Department of Geosciences, Oregon State University, Corvallis, Oregon 97331-5506.

The study area includes 6,000 mi^2 (15,540 km^2). Much field work remains.

Four major eruptive axes occur south of an east-west zone (canyon of Powder River along Highway 86 is included) of few dikes at about latitude 44°48′ N. From west in Oregon to east in Idaho, each of the four axes extends northward, passing in turn beyond the Amelia stock for 3.7 km, beyond the Pedro Mountain stock for 3.3 km, beyond the Big Lookout Mountain (BLM) stock for 0.3 km, and beyond the Iron Mountain stock in Idaho for 24 km. Dike distribution in relation to the four stocks, as well as elsewhere in Oregon for the Little Lookout Mountain stock, the Wallowa batholith (WB), and the Bald Mountain batholith, suggests that all axes of dike eruptions were appreciably constrained geographically in longitude by the location of stocks and batholiths.

The highest dike densities are along the four aforementioned eruptive axes rather than in WB as is commonly believed. Some areas contain more than 30 dikes per mi^2. Major sources of Grande Ronde Basalt and Imnaha Basalt are south of latitude 44°48′N. Scores and scores of Grande Ronde feeders are more than 13 m thick, whereas two Imnaha feeders are 23 and 24 m thick.

The best examples of partial melted wall rocks are within 4 km of BLM and in the western two-thirds of the WB. Field relations indicate turbulent flow. Crustal xenoliths are more abundant than is commonly believed but nowhere on the scale of those in the WB, where a few dikes contain more than 200,000 xenoliths. Many dikes in WB contain between 25 and 100,000 xenoliths.

The attitudes of dikes in granitic rocks rather commonly are controlled by joint patterns.

GEOCHEMISTRY OF FERRUGINOUS BAUXITE DEVELOPED FROM COLUMBIA RIVER BASALT, SOUTHWESTERN WASHINGTON, by J.M. Fassio and M.L. Cummings, Department of Geology, Portland State University, Portland, Oregon 97207.

Ferruginous bauxite deposits are developed from flows of the Columbia River Basalt Group in northwestern Oregon and southwestern Washington. The geochemistry of samples of the pisolitic, gibbsite nodular, and fine-grained gibbsite zones from 9 m of drill core from Wahkiakum County in southwestern Washington have been analyzed by instrumental neutron activation. In this core, the upper 1 m is of the pisolitic zone, and the gibbsite nodular zone is 1.2 m thick. The thickness of the pisolitic zone ranges from 0.3 to 4.9 m in different cores from the area.

Within the fine-grained gibbsite zone, ratios of V, TiO_2, Cr, Co, Sc, Ta, and Hf to Fe_2O_3 are similar among samples from over 3 m of core. The Al_2O_3:Fe_2O_3 ratio increases in the same interval. In the gibbsite nodular and into the pisolitic zones, the ratios of Th, Ta, and Hf to Fe_2O_3 increase, and those of Co, Al_2O_3, and Sc to Fe_2O_3 decrease.

La:Lu ratios for basalt and the fine-grained gibbsite zone are consistent with preferential depletion of LREE (basalt = 33; gibbsite zone = 11-16). However, La:Lu ratios increase to 45 from the fine-grained gibbsite into the pisolitic zone. A positive Ce anomaly on chondrite-normalized plots is most pronounced in the gibbsite nodular zone.

Within the pisolitic zone, the order of enrichment of elements in iron-rich pisolites relative to bulk samples is Fe_2O_3 > Cr > Th, Hf > TiO_2, Eu, Ta; the order of depletion is Al_2O_3, La, Ce > Sm > Co, Sc > Lu.

The patterns in trace element abundances and ratios is believed consistent with changing climate conditions from continuously wet during formation of the bauxite profile to alternating wet and dry during formation of the pisolitic zone.

PLUTONISM AND HYDROTHERMAL MINERALIZATION ASSOCIATED WITH THE DETROIT STOCK, WESTERN CASCADES, OREGON, by J.M., Curless, M.W. Vaughan, and C.W. Field, Department of Geosciences, Oregon State University, Corvallis, OR 97331.

The Detroit Stock is a composite pluton (10 m.y.) that consists of at least five stages and intrudes volcanic rocks of early Miocene age in the Western Cascades of Oregon. Cross-cutting relationships exposed near Detroit Dam reveal the relative ages between five intrusive stages. Oldest to youngest, these are: (1) quartz diorite, (2) porphyritic hornblende quartz diorite, (3) porphyritic diorite, (4) porphyritic hornblende granodiorite, and (5) aplitic tonalite.

Intrusive rocks within the adjacent Sardine Creek and Rocky Top areas have mineralogical, textural, and chemical features similar to the nearby Detroit Stock. Early quartz diorites at Sardine Creek and Rocky Top are exposed as dikes with sharp to slightly brecciated contacts that were emplaced along preexisting northwest-trending fractures. Later hornblende granodiorites, with contacts defined by well-developed intrusive breccias, are exposed as irregularly shaped northwest elongate dikes and small stocks. Stratigraphic reconstruction from Sardine Creek to Rocky Top suggests that the later hornblende granodiorites were emplaced at a minimum depth of roughly 1.5 km, with the earlier quartz diorites intruding to shallower levels.

Propylitic alteration is widespread throughout the area and intensifies with proximity to northwest-trending fractures. Potassic alteration is limited to the Detroit Stock where several samples contain incipient veinlets and diffuse replacement zones of hydrothermal biotite. Late-stage quartz-sericite alteration is structurally controlled and overprints earlier propylitic and potassic alteration.

More than 80 rock-chip samples from the Detroit Stock, Sardine Creek, and Rocky Top areas were analyzed for Cu, Pb, Zn, and other trace metals. Threshold values were determined to be 80 ppm Cu, 50 ppm Pb, and 90 ppm Zn. The relative proportions of these metals in mineralized samples depict a progressive change with increasing horizontal and vertical distance from Cu (Zn) at the Detroit Stock, through Zn (Cu) at Sardine Creek, to Pb (Zn) at Rocky Top.

Although plutonism and hydrothermal mineralization associated with the Detroit Stock have many features in common with nearby mining districts of the Western Cascades, the absence of well-developed breccia pipes, through-going veins, and zones of intense pervasive alteration are consistent with the lack of extensive exploration and previous mining activity in this area.

GEOCHEMISTRY OF UPPER EOCENE BASALTS FROM THE OREGON COAST RANGE, by M.A. Barnes and C.G. Barnes, Department of Geosciences, Texas Tech University, Lubbock, Texas 79409.

The Yachats Basalt at Cascade Head is one of three volcanic centers in the Oregon Coast Range from which alkalic basalt was erupted in late Eocene time. At Cascade Head, the volcanic rocks are interbedded with thin-bedded, tuffaceous, brackish-water to marine siltstones of the Nestucca Formation. The volcanic sequence is 300 m to 600 m thick and marks the transition from submarine to subaerial eruption. Rhyolitic ash deposits are locally present.

The volcanic pile is dominated by mildly alkaline basaltic rocks with lesser hornblende trachyandesite. The suite is characterized by enrichments in high field strength elements (HFSE) and by steeply negative rare earth element (REE) patterns ($[La/Lu]_n$ = 15-20). Transition metal contents are low (Ni, 7-53 ppm; Cr, 5-86 ppm; Sc, 1-22 ppm), indicating that all of the lavas are differentiated. Spidergrams are typical of continental alkalic basalt in that they show K depletion and Nb and Ta enrichment. Most spidergrams also indicate the relative depletion of Sr and Ti. Spidergrams of interbedded rhyolitic ash are distinct from the basalt, are depleted in Nb, Ta, and Ti, and indicate an arc source. The mass-balance calculations and incompatible element ratios are consistent with differentiation from basalt to trachyandesite by fractional crystallization of olivine + clinopyroxene + plagioclase ± oxides ± apatite. The geologic and geochemical evidence is consistent with a forearc tectonic setting that was undergoing extension. □

And the winner is . . .

The response to our contest in the July issue of *Oregon Geology* was a pleasant surprise in many ways. We regret that we cannot answer each individual letter and postcard or print all the interesting extra comments. However, we thank all contestants most deeply for their participation.

Yes, the landmark on the July cover was indeed Sheep Rock—never mind that the name officially applies to 12 "summits" or "pillars" in Oregon! It is, of course, the relationship of this particular Sheep Rock with the John Day Fossil Beds National Monument that gives it a special place in the geology of Oregon—well, at least the paleontology of Oregon. And even if not all contestants could get the name quite right or determine that the view was "probably N. 5° E." or recognize the "sheep atop that funny spire," most of the participants in our contest in the July issue did identify the view correctly. In fact, among 45 valid entries there was only one that had to be disqualified as wrong.

And the winner of the free one-year subscription is—Larry Chitwood of Bend. Congratulations! Since Larry is already a faithful subscriber to *Oregon Geology*, his expiration date will be moved back one year.

Since quite a number of contestants said that they would like to see more such contests, we feel confirmed in our plan to continue the practice—at irregular intervals. We wish all our readers many opportunities to enjoy the visual pleasures that are such an essential part of Oregon's geology! □

NWMA announces convention

The Northwest Mining Association (NWMA) will hold its 96th Annual Convention, Short Course, and Trade Show on December 2-7, 1990, in Spokane, Washington, at the Sheraton-Spokane Hotel, Cavanaugh's Inn at the Park, Spokane Convention Center, and Agricultural/Trade Center.

The theme for this year's convention is "The 90's—Strength Through Balance." The program will consist of 22 technical and practical sessions and present more than 100 speakers on the most important topics of the mining industry. Special sessions and social events will offer additional opportunities to exchange ideas.

This year's short course is entitled "Drilling for Minerals—Management, Techniques, and Systems." The course will take place the first three days prior to the convention, December 2, 3, and 4. The cost of the course is $425.

For more information, contact Northwest Mining Association, 414 Peyton Building, Spokane, WA 99201, phone (509) 624-1158.

—*NWMA news release*

(***Oil and Gas,*** continued from page 122)

8) **Volcanic magnetic susceptibility and wet bulk density analyses of strata from the Texaco Federal no. 1 well, Crook County, and the Standard Oil Kirkpatrick no. 1 well, Gilliam County.** The study by Terra Exploration concludes that there is sufficient contrast between the volcanic rocks and underlying Cretaceous and older rocks to warrant the use of gravity data for mapping basement structures in the study area. However, the lack of contrast in the magnetic susceptibility of these rocks rules out the use of aeromagnetic data to map such structures.

Additional analyses are being done at this time and will be made available in the future. Other studies already completed are listed in DOGAMI's 1987 publication OGI-16, *Available Well Records and Samples of Onshore and Offshore Oil and Gas Exploration Wells in Oregon*, available at the DOGAMI Portland office (address on page 122 of this issue). Contact Dennis Olmstead or Dan Wermiel at DOGAMI if you are interested in reviewing any of these studies. □