To: John Linehan / Paul Hildenbrand 101
MS 623 SS HMRP

LPDR
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Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

WM DOCKET CONTROL CENTER

'87 MAR 25 P2:02

February 26, 1987

Distribution

BWI DIVISION AND QS DIVISION WEEKLY REPORTS

Enclosed for your information are the Basalt Waste Isolation Division and the Quality Systems Division Weekly Reports for the week ending February 26, 1987.

John H. Anttonen, Assistant Manager
for Commercial Nuclear Waste

Enclosures

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BWI DIVISION WEEKLY REPORT
FEBRUARY 26, 1987

I. Critical Items Status

SCP

Although progress on the performance and design issues has been made, finalization of all tables and text remains a problem area and is impacting the schedule for the assembled review. DOE-HQ believes some added work is needed to finalize Performance Issues 1.1 and 1.8, and a meeting will be held the week of March 2, 1987, to accomplish this task. Design issue finalization is also a problem, as this input is needed by some 8.3.1.X authors to properly complete their sections.

Slippage to date and the above continued slippage could result in a three-week delay from the current schedule for producing a complete assembled review version of the SCP.

Hydrology

An NRC meeting has been scheduled for April 8, 1987, to discuss pre-ES hydrology testing and to resolve their comments resulting from the December 1985 hydrology workshop.

Quality Level 1 requirements for DC-24 and 25, in particular design control requirements, may delay restart of drilling until September 1987. This schedule is being evaluated at this time.

Restart

The general restart team is continuing its evaluations of the Rockwell Readiness Restart Report. The team is identifying deficiencies that are being tracked on a Restart Team Status Report. These items are assigned to cognizant Rockwell and DOE-RL review team members for resolution.

II. Significant Accomplishments/Information Items

E&C Branch

- The released document OGR/B-8, which baselines the requirements for defense waste, was received.

- Issue 2.4 tables are nearly complete and the only concern is to determine how to handle the non-site characterization parameters in the document. DOE and Rockwell are involved in ongoing discussions in an effort to resolve this concern.

G&T Branch

- Hydrologist consultants Cartwright and Pettyjohn from HQ visited the site on February 25-26. Discussions held covered the options paper developed by the task group. The consultants will meet with HQ management to present their findings on March 11-12.

- Section 8.3.1.3 has been delivered to HQ for review. A firm review meeting date has not yet been established.

- The geology Work Package Authorization Summaries (WPAS) were completed and a procedures manual for geophysical exploration methods was prepared.

- Internal meetings were held on the Exploratory Shaft grout testing program and the subject of underground mapping.

- During the State of Washington Nuclear Waste Board monthly meeting, the presence of natural resources at Hanford was discussed. The three topics covered were petroleum potential on and surrounding Hanford, geothermal resources of the Columbia Basin, and groundwater and future agricultural activity.

LES Branch

- Section 8.3.1.5 (Climatology) has been sent to DOE-HQ for review and is also being reviewed by RL. Meetings are planned on March 11-12, 1987, as previously scheduled, to discuss the comments on this section.

- Sections 8.3.3 (Seal System Program) and 8.3.5 (Performance Assessment) will be submitted by March 9, 1987, and meetings are scheduled for March 23, 1987, to discuss the reviews.

- The Licensing Assurance Review Team Leaders Meeting took place February 25-26 in Salt Lake City. This meeting was a training session for LAR team leaders. The training session for the full LAR team (35 effects in this technical discipline) will be conducted on March 10-11 in Richland.

- A meeting was held on February 18 with the State of Washington and affected Indian Tribes to discuss the FY-87 work scopes for Environment and Socioeconomics. It was agreed that following resubmittal of the work scopes to address comment program requirements, technical follow-up discussions will be held as necessary to finalize the work scopes.

Other

- A tour of BWIP facilities was provided to six representatives from the GAO on February 23.
- A presentation covering the status of the BWIP was provided to the Amera Mineral Mine staff at Wenatchee, WA, on February 26.

IV. Upcoming Events

See attached pages.

J. J. Keating, Director
Basalt Waste Isolation Division

BWI UPCOMING EVENTS
FEBRUARY 26, 1987

Date	Event	Location	Contact
HQ Meetings			
March 17-18	ACD Review	HQ	Nicoll
TBD	Review of BWIP Systems Integration Activities	Richland	Petrie
Coordinating Group Meetings			
March 10-12	ISCG	Albuquerque	Powell/Whi
April 28-29	Transportation Coordination Group	Salt Lake City	Petrie
State/Indian/Public Interaction			
March 3	Briefing for Umatilla Confederated Tribes	Richland	Turner/Pow
March 4	Matt Taylor - Tri-City reporter	Richland	Olson
March 5	OGC-HQ	Richland	Olson
March 1-5	Waste Management '87	Tucson	Squires
March 10	U. S. Congressman John D. Dingell, State of Michigan, Subcommittee of Over-sight and Investigation	Richland	Anttonen
March 12	DOE Engineering-Construction Symposium	Richland	Squires
April 19-21	Western Regional Energy Conference	Richland	Dahlem
April 21-22	States/Indian Tribes Quarterly Mtg.	Albuquerque	Anttonen/F
Internal Project Meetings			
March 19	BWIP Review with HQ	Richland	Anttonen/S
April 15-16	BWIP Quarterly Update	Richland	Anttonen/S
NRC Interactions			
TBD	Repository Design (workshop)	Richland	Nicoll/Ko

Date	Event	Location	Contact
TBD	NRC meeting to discuss SCP Issues, Hierarchy, Resolution Strategy, Data Needs	HQ	Mecca/Dahle
International			
February 27, 1987	NEA Tour and Briefing	Richland	Squires
March 9	Visitors from FRG (Drs. Heinz, Wurtinger, Bogorinski, Baltes, and Grundler)	Richland	Squires
April 1987	IAEA Natural Analog Meeting	HQ	Dahlem

QS DIVISION WEEKLY REPORT
FEBRUARY 26, 1987

I. Critical Items Status - None at present.

II. Significant Accomplishments/Information Items

Program Development

- An ongoing program effort in the area of training of DOE personnel is in progress. Approximately 70 percent of all required training of DOE personnel has been completed. Because of SCP conflicts, completion is now scheduled for March 1.

- QSD is continuing to update the BWI QA Plan and QA administrative procedures to comply with the latest HQ documents and NQA-1 1986 requirements, and incorporate organizational changes. To date, 13 procedures have been approved and 19 are in the concurrence cycle.

Program Verification

- Preparations for the scheduled audit of KE/PB in April is continuing.

- A number of surveillances have been planned during the month of April. These will be of the ongoing technical tasks of Rockwell, Westinghouse, and DOE.

Program Restart

- DOE reviews of Rockwell QA administrative procedures to support project restart continues. Current status is: 30 received, 22 approved, 4 returned for incorporation of comments, and 4 in DOE's review/comment process.

- Review is ongoing based on the checklist established for partial lifting of the general stop work on Rockwell activities. To date, 37 discrepancies have been identified by the Readiness Review Team. These discrepancies cover the breadth of all management control systems being emplaced by Rockwell.

- In order to provide further assurance that all DOE and Rockwell activities related to restart are being properly executed from a quality management point of view, an Independent Management Readiness Team has been established and is conducting independent evaluations to be provided to the Readiness Review Chairman.

- For the benefit of DOE-HQ, NRC, states and affected Indian tribes, an in progress status briefing describing all stop work and restart activities to date is currently scheduled for March 17, 1987.

III. <u>Upcoming Events</u>

See attached page.

R. P. Saget

R. P. Saget, Director
Quality Systems Division

QSD UPCOMING EVENTS
FEBRUARY 26, 1987

Date	Event	Location	Conta
HQ Meetings			
None scheduled			
State/Indian/Public Interaction			
March 17	Restart Briefing	Richland	Kasch
April 19-21	Presentation of paper at ASQC Conference	Richland	Saget

2/20/87

F.R. Cook
Senior On-Site Licensing Representative
Nuclear Regulatory Commission
Washington D.C. 20555

Dear Mr. Cook,

I have read with interest the pollen section in the report by Raymond and Tillson (1968) on "Evaluation of a thick Basalt sequence in S. Central Washington...", and I thak you for sending me the copy. The fossil pollen work was done by a collegue who has more experience with the Tertiary pollen of Washington state than anyone I know. He was a student of Robert Tschudy (USGS), who was a top authority in Cenozoic palynology.

I am happy to report that the wor' seems to be exceedingly well done, and the conclusions seem faultless as far as we understand the stratigraphic ranges of the forms present. I will give you my own interpretation of the pollen evidence:

The appearance of Larix/Pseudotsuga is of special interest, as with my experience in the USGS, we found the earliest forms at Florissant, Colo., where the basal Oligocene is perhaps best known) by pollen) in the U.S. The form ranges upward to the present, but I have never seen it in pre-Oligocene beds. It appears above 3500' in the Rattlesnake Hills well. Another telling form is Jussiaea (Onagraceae or evening primrose family). This is the same story: no pre-Oligocene occurrences are known to me.

A number of forms are not restricted to the Oligocene, but are typical in Oligocene and younger beds in the Northwest: one of these is Cedrus, which is present in the deepest sample. Most of the angiosperm pollen reported from the lower samples are also typical of Oligocene (though they do range outside of that interval). Grass pollen is in the same category.

In summary, an Oligocene age seems to be the case, based on knowledge from leaf and pollen floras of the Pacific Northwest. Newman's reasoning that the age (including the lower beds) may be late Oligocene makes sense to me. We can expect that the early Oligocene is more tropical is backed up by a variety of reports, including Coos Bay, Oregon, and other sites in Oregon and California. His reasoning that the absence of the Miocene and younger pollen of the Compositae (daisy) family indicates a pre-Miocene age, (I would add at least a pre-late Miocene age) is founded on broad evidence in the western states and Northwest. I would agree that perhaps the upper parts of the well might be as young as Miocene, assuming that in some environments Compositae is somehow not well represented even in Miocene time.

It looks good to me. I am wondering what this means in terms of the Hanford site plans. Guess this awaits a further discussion with you or our Olympia geologists, like Bill Brewer.

Sorry for the delay in this letter and report.

Sincerely,

Estella B. Leopold

Estella B. Leopold
Botany KB-15
University of Washington
Seattle WA 98195

cc. Bill Brewer

P.S. In case someone at NRC wonders on what basis I write this letter, may I state that I spent 21 years working for USGS on Cenozoic pollen, with particular emphasis on Eocene and younger sediments of the western United States. In the Pacific Northwest I have done some work on the Miocene and Pliocene including sediments of the Vantage beds, Ellensberg Fm. and the Wenatchee Fm (Oligocene?), which in many ways the lower part of the Rattlesnake Hills well assemblage resembles. A grad student of mine did her thesis on the Weaverville flora (Oligocene?) of northern California. I am quite familiar with the fossil leaf literature of this region, since I teach a course on that topic.

Bob Cooke - may I submit a bill for this analysis? What's an appropriate fee?

EL

****** FOURTH COLUMBIA RIVER BASALT SYMPOSIUM ******

HILO, HI
MAY 20-22, 1987

MAY 20, 1987 SESSION 1 - PHYSICAL VOLCANOLOGY

SESSION CHAIRPERSONS: S.P. REIDEL AND D.A. SWANSON

TIME	AUTHORS FORM # TITLE
8:00 AM	Introduction
8:10	CROSS, R.W., and FAIRCHILD, K., #136160, LATERAL CONTINUITY OF INTRAFLOW STRUCTURES OF THE COHASSETT FLOW (GRANDE RONDE BASALT) AT SENTINEL GAP, WASHINGTON
8:25	TAYLOR, H.D., CROSS, R.W., LONG, P.E., #136147, GEOSTATISTICAL ESTIMATION OF COHASSETT INTRAFLOW GEOMETRY IN SUPPORT OF NUCLEAR WASTE REPOSITORY DESIGN
8:40	ROSS, M.E., #118037, STRATIGRAPHIC RELATIONSHIPS OF INVASIVE AND SHEET FLOWS OF SADDLE MOUNTAINS BASALTS IN THE TROY BASIN, OREGON
8:55	BYERLY, G.R., SWANSON, D.A., #132363, THE TRANSITION FROM SUBAERIAL TO INVASIVE LAVA FLOWS, GRANDE RONDE BASALT, NW COLUMBIA PLATEAU
9:10	WELLS, R.E., NEIM, A.R., #134338, GEOLOGY OF THE COLUMBIA RIVER BASALT GROUP IN THE ASTORIA BASIN, OREGON AND WASHINGTON: EVIDENCE FOR INVASIVE FLOWS
9:30	PFAFF, V.J., BEESON, M.H., #136146, MIOCENE BASALTS OF COASTAL OREGON AND WASHINGTON: GEOCHEMICAL AND GEOPHYSICAL EVIDENCE FOR COLUMBIA PLATEAU ORIGIN
9:45	MCMILLIAN, K., CROSS, R.W., LONG, P.E., #136162, INTERNAL VESICULAR ZONES OF GRANDE RONDE BASALT, PASCO BASIN, WASHINGTON
10:00	BREAK
10:15	LONG, P.E., #136141, REVIEW OF EVIDENCE FOR QUENCHING ORIGIN OF ENTABLATURE IN COLUMBIA RIVER BASALT FLOWS
10:30	SWANSON, D.A., #132368, REGIONAL VARIATION OF JOINTING STYLE IN GRANDE RONDE BASALT RELATED TO MIOCENE GEOGRAPHY, COLUMBIA PLATEAU

MAY 20, 1987 PHYSICAL VOLCANOLOGY (CONTINUED)

10:45 BEESON, M.H., TOLAN, T.L., REIDEL, S.P., FECHT, K.R., ANDERSON, J.L., HOOPER, P.R., #136158, JOINTING IN COLUMBIA RIVER BASALT FLOWS: ASSOCIATION OF JOINTING STYLES WITH OTHER FACTORS

11:00 DEGRAFF, J.M., AYDIN, A., LONG, P.E., # 128426, FRACTURE GROWTH DIRECTION AND INFERRED THERMAL REGIME DURING SOLIDIFICATION OF BASALTIC LAVA FLOWS

11:15 MEINTS, J.P., #136151, ORIENTATION AND SPACING OF COOLING JOINTS IN TWO COLUMBIA RIVER BASALT FLOWS

11:30 LINDBERG, J.W., #136153, COOLING JOINT WIDTH AND SECONDARY MINERAL INFILLING CHARACTERISTICS IN 4 GRANDE RONDE BASALT FLOWS AT HANFORD WASHINGTON

11:45 EWART, J.W., #132362, SULFUR IN THE FRENCHMAN SPRINGS MEMBER OF THE WANAPUM BASALT IN WASHINGTON AND OREGON

12:00 LUNCH BREAK

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MAY 20, 1987 SESSION 2 - STRATIGRAPHY, AND STRATIGRAPHY-TECTONICS

SESSION CHAIRPERSONS: R.D. BENTLEY AND P.E. LONG

1:30PM TOLAN, T.L., REIDEL, S.P., BEESON, M.H., ANDERSON, J.L., FECHT, K.R., AND SWANSON, D.A., #136140, REVISIONS TO THE AREAL EXTENT AND VOLUME OF THE COLUMBIA RIVER BASALT GROUP

1:45 BAKSI, A.J., #127423, REEVALUATION OF THE TIMING, DURATION AND MAGNETOSTRATIGRAPHY OF THE IMNAHA, PICTURE GORGE, AND GRANDE RONDE BASALT

2:00 AMERIGIAN, C., TOTH, J., REIDEL, S., #136139, PALEOMAGNETISM OF THE COLUMBIA RIVER BASALT GROUP

2:15 REIDEL, S.P., TOLAN, T.L., ANDERSON, J.L., BEESON, M.H., FECHT, K.R., #136149, REGIONAL STRATIGRAPHY OF THE GRANDE RONDE BASALT AND ITS TECTONIC AND PETROGENETIC IMPLICATIONS

2:30 LANDON, R.D., LONG, P.E., #136161, DETAILED STRATIGRAPHY OF THE UPPER GRANDE RONDE BASALT, COLUMBIA RIVER BASALT GROUP, IN THE CENTRAL COLUMBIA PLATEAU

2:45 BENTLEY, R.D., POWELL, J.E., # 125540, BASALT STRATIGRAPHY OF THE FRENCHMAN SPRINGS MEMBER IN THE TYPE AREA, CENTRAL WASHINGTON

MAY 20, 1987 SESSION 2 - STRATIGRAPHY, AND STRATIGRAPHY-TECTONICS (CONTINUED)

3:00 BREAK

3:15 MARTIN, B.[illegible]., #134740, CHEMICAL STRATIGRAPHY OF THE ROZA MEMBER, COLUMBIA RIVER BASALT GROUP

3:30 BEESON, M.H., TOLAN, T.L., #136150, COLUMBIA RIVER BASALT GROUP IN WESTERN OREGON: FACTORS CONTROLLING FLOW EMPLACEMENT

3:45 BENTLEY, R.D., POWELL, J.E., #125541, EVOLUTION OF THE YAKIMA RIVER CANYON AND TIMING OF DEFORMATION IN CENTRAL WASHINGTON

4:00 FECHT, K.R., BJORNSTAD, B.N., REIDEL, S.P., TOLAN, T.L., ANDERSON, J.L., BEESON, M.H., SMITH, G.A., #136157, RECONSTRUCTION OF NEOGENE DRAINAGE SYSTEMS IN THE AREA COVERED BY COLUMBIA RIVER BASALT GROUP

4:15 SMITH, G.A., FECHT, K.R., BJORNSTAD, B.N., #136152, NEOGENE SYNVOLCANIC AND SYNTECTONIC SEDIMENTATION ON AND ADJACENT TO THE COLUMBIA PLATEAU

4:30 CAMPBELL, N.P., #134653, STRUCTURAL AND STRATIGRAPHIC RELATIONSHIPS BETWEEN THE NORTHWESTERN COLUMBIA RIVER BASALT MARGIN AND RECENT SUBBASALT GAS WELLS

4:45 DAHLEM, D.H., #136154, APPLICATION OF GEOSCIENCE DATA TO THE BASALT WASTE ISOLATION PROJECT

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7:00PM INFORMAL POSTER SESSION AND DISCUSSION OF PHYSICAL VOLCANOLOGY, STRATIGRAPHY, TECTONICS RELATED TO STRATIGRAPHY, AND NUCLEAR WASTE STORAGE IN COLUMBIA RIVER BASALT

MAY 21, 1987 SESSION 3 - STRUCTURAL GEOLOGY, TECTONICS, AND MAGMA SOURCE

SESSION CHAIRPERSONS: J.L. ANDERSON AND R.E. WELLS

8:00AM BERGSTROM, K.A., KUNK, J.R., MITCHELL, T.H., ROHAY, A.C., # 136145, DEEP STRUCTURE OF THE PASCO BASIN, SOUTHCENTRAL WASHINGTON

8:15 HAGOOD, M.C., #134656, STRUCTURE AND DEFORMATION ALONG A PORTION OF THE HORSE HEAVEN HILLS, SOUTHCENTRAL WASHINGTON

8:30 ROHAY, A.C., #136144, EARTHQUAKE FOCAL MECHANISMS, RECURRENCE RATES, AND DEFORMATION IN THE COLUMBIA RIVER BASALTS

8:45 HOOPER, P.R., # 135136, DEFORMATION IN THE EASTERN PART OF THE COLUMBIA PLATEAU

9:05 REIDEL, S.P., CHAMNESS, M.C., FECHT, K.R., HAGOOD, M.C., TOLAN, T.L., # 136148, TECTONIC DEVELOPMENT OF THE CENTRAL COLUMBIA PLATEAU

9:25 ANDERSON, J.L., BEESON, M.H., TOLAN, T.L. #136156, TECTONIC DEVELOPMENT OF THE OF THE SOUTHWEST COLUMBIA PLATEAU

9:45 WELLS, R.E., SIMPSON, R.W., #134252, MORE PALEOMAGNETIC RESULTS FROM THE MIOCENE COLUMBIA RIVER BASALT GROUP, OREGON AND WASHINGTON: STRATIGRAPHIC AND TECTONIC IMPLICATIONS

10:00 BREAK

10:15 CAGGIANO, J.A., # 136155, USE OF COLUMBIA PLATEAU TECTONIC MODELS FOR DEVELOPMENT OF DISRUPTIVE SCENARIOS FOR A NUCLEAR WASTE REPOSITORY

10:30 WATTERS, T.R., #128242, VOLCANIC PLAINS RIDGES ON THE TERRESTRIAL PLANETS: A COMPARISON OF THE COLUMBIA AND THARSES PLATEAU

10:45 ELLIOT, D.H., #121436, JURASSIC THOLEIITES OF ANTARCTICA: TECTONIC SETTING

11:00 HOOPER, P.R., CHAMBERLAIN, V.E., LAMBERT, R., #135138, STRONTIUM ISOTOPIC AND CHEMICAL CONSTRAINTS ON CRUSTAL CONTAMINATION OF THE COLUMBIA RIVER BASALTS

11:15 CHAMBERLAIN, V.E., LAMBERT, R., DUKE, M.J., # 134549, URANIUM, THORIUM, AND LEAD SYSTEMATICS OF THE COLUMBI RIVER BASALTS AND YOUNGER VOLCANICS

SESSION 3 - STRUCTURAL GEOLOGY, TECTONICS, AND MAGMA SOURCE (CONTINUED)

11:30 CARLSON, R.W., HART, W.K., #128726, ON THE CAUSE OF COLUMBIA RIVER BASALT VOLCANISM

11:45 HART, W.K., MOSHER, S.A., CARLSON, R.W., # 121575, PETROGENESIS OF THE PUEBLO MOUNTAINS BASALTS OF SOUTHEASTERN OREGON

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MAY 22, 1987 SESSION 4 - PETROGENESIS

SESSION CHAIRPERSONS: P.R. HOOPER AND T.L. WRIGHT

1:30PM DUNCAN, A.R., ERLAND, A.J., SMITH, H.S., #134652, CRUSTAL CONTAMINATION IN THE PETROGENESIS OF SOME KAROO BASALTS - IMPLICATIONS FOR OTHER CONTINENTAL FLOOD BASALT PROVINCES

1:50 SUBBRATO, K.V., AND OTHERS, PALEOMAGNETIC STRATIGRAPHY OF THE DECCAN BASALTS, WESTERN GHATS, INDIA (NO ABSTRACT AS YET)

2:10 FLEMING, T.H., ELLIOT, D.H., #121433, JURASSIC THOLEIITES OF ANTARCTICA: GEOCHEMISTRY

2:30 HODGES, F.N., MCKINLEY, J.P., LONG, P.E., HORTON, D.G., #136159, MINERAL CHEMISTRY OF COLUMBIA RIVER BASALT FLOWS: PETROGENETIC IMPLICATIONS

2:50 GOLES, G.G., BRANDON, A.D., LAMBERT, R., #117671, TRACE ELEMENT AND ISOTOPIC FEATURES OF LITTLE-KNOWN MIOCENE BASALTS OF CENTRAL AND EASTERN OREGON

3:10 BAILEY, M.M., #135137, VARIATION WITHIN THE PICTURE GORGE BASALT AND THE POSSIBLE INFLUENCES OF RECHARGE VS. ASSIMILATION

3:30 BREAK

3:45 HELZ, R.T., WRIGHT, T.L., #130933, A MODEL FOR THE ORIGIN OF THE YAKIMA BASALT SUBGROUP, NORTHWESTERN USA

4:05 HOOPER, P.R., #135133, COLUMBIA RIVER BASALT GENESIS: NEW GEOCHEMICAL MODELS FOR THE MAIN SERIES

4:25 LAMBERT, R., DUKE, M., CHAMBERLAIN, V.E., # 134550, GEOCHEMISTRY OF INCOMPATIBLE ELEMENTS IN THE COLUMBIA RIVER BASALTS

MAY 21, 1987 SESSION 4 - PETROGENESIS (CONTINUED)

4:45 TAUBENECK, W.H., #125400, CRUSTAL CONTAMINATION IN DIKES OF THE COLUMBIA RIVER BASALT GROUP IN THE WALLOWA BATHOLITH, NORTHEASTERN OREGON

5:25 LAMBERT, R, MARSH, I., CHAMBERLIAN, V.E., # 134553, THE UNIVERSAL OCCURRENCE OF INTERSTITIAL GRANITE GLASS IN THE COLUMBIA RIVER BASALT AND ITS PETROGENETIC IMPLICATIONS

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5:45-? INFORMAL POSTER SESSION AND DISCUSSION ON STRUCTURE, TECTONICS, IGNEOUS PETROLOGY AND PETROGENESIS (STARTS AFTER LAST PAPER OF SESSION 4 TO ALLOW PEOPLE TO ATTEND EVENING EVENTS PLANNED BY GSA; WILL CONTINUE AS LATE AS PARTICIPANTS WISH, AFTER GSA EVENTS)

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MAY 22, 1987 SESSION 5 - OPEN FORUM ON PETROGENESIS OF THE COLUMBIA RIVER BASALT GROUP AND OTHER FLOOD BASALT PROVINCES

8:30AM TO 12:00AM

1987 GSA ABSTRACT FORM

USE THIS FORM FOR ALL 1987 GSA MEETINGS (SECTION & ANNL

YOU MUST COMPLETE ALL SECTIONS BELOW 1 THROUGH 7

[1] TYPE YOUR ABSTRACT IN THE SPACE BELOW using fresh black carbon ribbon. Follow the format shown on the attached instructions. Blue lines below show absolute limits. Do not fold abstract; mail flat with reinforcement to avoid retyping charge.

Nº 136160

LATERAL CONTINUITY OF INTRAFLOW STRUCTURES OF THE COHASSETT FLOW (GRANDE RONDE BASALT) AT SENTINEL GAP, WASHINGTON

CROSS, Randal W., and FAIRCHILD, Kingsley R., Rockwell Hanford Operations, P.O. Box 800, Richland, WA. 99352

Intraflow structures of Columbia River basalt flows are important to both design and performance of a repository because they represent zones of potential hydrologic flow and influence mechanical properties of basalt.

In order to evaluate lateral continuity of intraflow structures, twenty-four stratigraphic sections were measured through the Cohassett flow over a 6 km lateral distance at Sentinel Gap, Washington. The sections consisted of a multilayered sequence of intraflow structures corroborating more widely scattered data elsewhere in and near the Pasco Basin. The sequence of the intraflow structures is nearly the same in each measured section and includes flow top, vesicular zones, and multiple entablatures/colonnades. Correlation of the intraflow structures between sections was achieved by photo mapping and walking contacts along the nearly continuous outcrops.

The results of this study demonstrate that the sequence of intraflow structures is laterally continuous for at least 6 km. Moreover, individual intraflow structures maintain a consistent stratigraphic position within the flow when the flow thickness is normalized to 100 percent. Some intraflow structures such as flow top, the internal vesicular zone, and lower colonnade, maintain a nearly constant proportional thickness relative to total flow thickness, across the study area. These consistencies imply a degree of lateral uniformity in the conditions of origin of primary features of the Cohassett flow.

These observed lateral consistencies may be typical only of ponded flows. However, continued investigation of exposures of comparable length in different areas of the Columbia Plateau should determine if similar consistencies occur in different emplacement environments.

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№ 136147

GEOSTATISTICAL ESTIMATION OF COHASSETT INTRAFLOW GEOMETRY IN SUPPORT OF NUCLEAR WASTE REPOSITORY DESIGN

TAYLOR, Harold D., DASA of Denver, 12096 W. Virginia Place, Lakewood, CO 80228; CROSS, Randal W., and LONG, Philip E., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352

Geostatistical methods have been used to estimate positions and associated uncertainties of key horizons within the Cohassett flow in order to define the probability that repository tunnels for a given design will maintain appropriate vertical distances from either the flow top or the flow bottom. Specific requirements for waste emplacement, haulage, and drainage result in repository tunnels that do not precisely follow the geologic structure. Therefore, structural attitude and thickness of the Cohassett flow interior are key factors in repository placement. The Cohassett structural attitude was estimated by ordinary kriging of top-of-basalt borehole data which provide more elevation control than deeper horizons. The thickness of units from top-of-basalt to an internal vesicular zone in the Cohassett flow (used as a datum at depth) and the thickness of the Cohassett flow from the internal vesicular zone to the flow top and flow bottom zones were combined with the top-of-basalt data to form structure contours of the upper and lower bounds of the Cohassett flow interior.

Estimation standard deviations were calculated to determine the uncertainty of the above estimates. Using these standard deviations and planned repository elevations, an assessment was made as to how well the proposed repository workings would "fit" in the Cohassett flow given a specific confidence criterion (80% confidence). Regions where the repository did not satisfy the criterion were identified and can now be used to locate additional geologic borehole drilling to reduce uncertainties. Evaluation of optional drilling plans revealed that a combination of deep and shallow boreholes would produce greatest reduction in standard deviations (uncertainty) for a given drilling budget. Alternatively, repository design configurations can be adjusted in order to meet uncertainty requirements for future phases of repository design.

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№ 118037

STRATIGRAPHIC RELATIONSHIPS OF INVASIVE AND SHEET FLOWS OF SADDLE MOUNTAINS BASALTS IN THE TROY BASIN, OREGON

Ross, Martin E., Dept. of Geology, Northeastern University, Boston, MA 02115

Both the Wenaha flow (Elephant Mountain Member) and the Buford Member are locally invasive into a lower and an upper sedimentary interbed respectively in the Troy Basin (Stoffel, 1984; Ross, unpublished mapping). The Wenaha flow erupted as a sheet flow onto the lower interbed, sweeping much of the sediments away within one km of its dike. The lava invaded the underlying sediments where they markedly thicken 4.5 km northeast of the source dike. The spectacularly jointed, thick entablature of the flow is greatly thinned where it is invasive and sill-like. Locally, the invasive lava encountered small, narrow valleys eroded into the interbed. The flow extruded into these valleys to form intracanyon flows with the same, thick entablatures of the subaerial sheet phase. The upper interbed was deposited on the lower interbed where the latter was invaded by the Wenaha flow, but was deposited on the flow where not invasive. Rather than two distinct but identical flows (with an intervening interbed and Buford Member flow) as proposed by Stoffel (1984), the sheet, invasive, and intracanyon phases resulted from a single eruption of Wenaha lava.

The Buford Member erupted onto the upper interbed and is locally invasive into it. Field evidence indicates only a single Buford flow is present rather than two identical flows interfingering with two Wenaha flows and the upper interbed as proposed by Stoffel (1984). Poor exposures of Buford boulders mixed with interbed occur locally across terraces below in situ outcrops of the flow. Rather than a lower flow, these rubbly exposures represent talus and landslide debris left as remnants on the terrace produced by erosional retreat of cliffs in the Buford Member as it (and the Wenaha flow) was undercut by the meandering, ancestral Grande Ronde River.

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THE TRANSITION FROM SUBAERIAL TO INVASIVE LAVA FLOWS, GRANDE RONDE BASALT, NORTHWESTERN COLUMBIA PLATEAU

№ 132363

EYERLY, Gary R., Department of Geology, Louisiana State Univ., Baton Rouge, LA 70803; and SWANSON, D. A., U. S. Geological Survey, Cascades Volcano Observatory, Vancouver, WA 98661

Low-level oblique aerial photographs of the Columbia River canyon wall between Moses Coulee and Rock Island, WA, show complex northwestward transitions from subaerial basalt flows to pillowed flows and finally to sill-like invasive flows surrounded by sediment. Twelve measured sections document the N_2 and R_2 magnetostratigraphic units and the eight chemical types that constitute the nearly 600 m of Grande Ronde Basalt and interbedded lake and floodplain deposits of the Ellensburg Formation. The magnetostratigraphic units and chemical types correlate with those found in the Pasco Basin as part of the regional stratigraphic sequence. Feeder dikes and vents occur 200-300 km farther southeast.

Foreset-bedded pillows from the upper four chemical types, well exposed in the canyon walls, indicate northwestward flow directions away from the feeder dikes. Farther northwest, near Wenatchee, sandstone separates most flows, which are commonly invasive and characterized by few vesicles and by upper glassy rinds quenched against the sandstone. Dikes of basalt and pods of hyaloclastite or peperite project tens of meters into overlying sandstone from the top of one 120-m-thick invasive flow, but they do not cut higher flows. Within a single sequence, glass compositions of invasive flows, dikes, and hyaloclastites are identical, good evidence that the glass formed quickly during flow emplacement, not later during cooling and injection of fractionated melt. Transitions from subaerial to invasive flows are most likely under the following conditions: (1) lava is relatively fluid and dense, (2) eruption rates or paleoslopes produce sufficient head, and (3) sediments are water saturated and loose or weakly consolidated. These conditions occur in many volcanotectonic environments, so invasive flows may be common; however, their resemblance to intrusions may obscure their origin.

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№ 134238

GEOLOGY OF THE COLUMBIA RIVER BASALT GROUP IN THE ASTORIA BASIN, OREGON AND WASHINGTON: EVIDENCE FOR INVASIVE FLOWS

WELLS, Ray E., U.S. Geological Survey, Menlo Park, CA 94025, and
NIEM, Ale : R., Oregon State University, Corvallis, Oregon

Exposed along the Oregon-Washington coast is an enigmatic Miocene intrusive suite having all of the characteristics of certain units in the Columbia River Basalt Group (CRBG). These rocks intrude marine sedimentary and volcanic units as old as middle Eocene and range in size from small irregular blobs to massive sills and dikes exceeding 500 m in thickness and 40 km in length. Sills of CRBG affinity are also found in several wells at depths up to 2 km and up to 30 km offshore. The origin of these intrusive rocks has long been the subject of debate. The original field investigators were impressed by the scale of the features and the common occurrence of vent complexes composed of central intrusive plugs and associated radial dikes and preferred a local source for the intrusions. Later workers, armed with new geochemical and paleomagnetic data from the Plateau, suggested that the intrusions were the distal remains of CRBG flows that invaded and shouldered aside soft marine sediments as they entered the sea. Our new geologic mapping in concert with detailed geochemical and paleomagnetic comparisons of both plateau-derived CRBG flows and adjacent intrusive rocks along the lower Columbia River convincingly demonstrate a direct correlation between the flows and intrusive rocks. In particular the Pomona Member, the flows of Ginkgo, and a Low-Mg N2 Grande Ronde flow with E. declination all have major intrusive complexes with identical chemistry and paleomagnetic directions downstream from their subaerial terminations. Near Nicolai Mt., OR and at Brookfield, WA, subaerial flows can be traced continuously into sill complexes which intrude the underlying marine sediments and dive down section to the west. The one-to-one spatial correlations of identical far-travelled extrusive and local intrusive types argue strongly for an invasive origin for the coastal intrusions. However, many questions remain as to the actual mechanics of their emplacement.

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№ 136146

MIOCENE BASALTS OF COASTAL OREGON AND WASHINGTON:
GEOCHEMICAL AND GEOPHYSICAL EVIDENCE FOR
COLUMBIA PLATEAU ORIGIN

PFAFF*, Virginia J., and BEESON, Marvin H., Geology Department, Portland State University, Portland, Oregon 97207
(*currently with Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352)

The "coastal basalts" are Miocene tholeiitic basalt flows and intrusions that crop out along the Pacific coast from Seal Rock, OR to Grays Harbor, WA. Based on their extensive mapping of dikes, sills, and lava flows, Snavely and others (1973) proposed that the coastal basalts erupted from local vents. However, based on field associations and petrogenetic considerations, Beeson and others (1979) suggested that the coastal basalts represent the distal ends of plateau-derived flows of the Columbia River Basalt Group (CRBG) that flowed into estuarine and deltaic environments, invading and deforming soft sediment. Evidence supporting the plateau origin for the coastal basalts includes:

1) Stratigraphic correlations and areal distribution. Mapping, geochemical analyses (major oxides/XRF, trace elements/INAA), and magnetic polarity determinations by us and by other workers demonstrate that all the coastal basalt units have CRBG counterparts in the Willamette Valley.

2) Geophysical constraints on depth. Gravity profiles across coastal basalt dikes are consistent with shallow, near-surface basalt masses. All of the intrusions investigated (including the linear dikes at Fishhawk Falls and Denver Point, the arcuate segments of the "ring dike" on the Klaskanine River, the U-shaped dike at Youngs River Falls) can be interpreted as extending less than 300 m below sea level; many continue for only about 100 m below the surface. The gravity data cannot be satisfactorily modeled by deep, vertical dikes.

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No 136162

INTERNAL VESICULAR ZONES OF GRANDE RONDE BASALTS, PASCO BASIN, WASHINGTON

MCMILLAN, Kent, CROSS, Randal W., LONG, Philip E., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352

Thick (>30 m) Grande Ronde basalt flows of the Pasco Basin contain internal vesicular zones within otherwise dense, sparsely vesicular basalt. These zones are continuous over distances ranging from 2 km to 30 km; most are characterized by abrupt transitions from vesicle-rich to vesicle-poor rock above and by gradational lower margins. The zones formed by post-emplacement migration, coalescence and entrapment of aqueous vapor bubbles. Under appropriate physicochemical conditions bubbles nucleate at the lower solidification front and rise buoyantly until retarded by the higher viscosities preceding the upper solidification front. In some cases ponding of bubbles against this ceiling occurs before freezing-in of the vesicles by the downward passage of the upper front. The position of a zone within a flow is determined by the relative rates at which the fronts advance (R_1 upper, R_2 lower) and the rates at which the bubbles migrate (R_3). For a vesicular zone to form, R_3 must be $> R_2$. In all cases R_1 is $> R_2$. R_1 can vary as a function of cooling mode; it is a minimum for cooling by pure conduction and increases sharply when conduction is combined with convective heat transfer. The upper and lower fronts meet at d/l = 0.6 to >0.8 for these cases respectively, where d = depth in flow, and l = flow thickness. If R_1 is $\gg R_3$ the zone will occur relatively low in the flow above the meeting point of the fronts. If R_3 is $\gg R_1$ the zone will occur relatively high in the flow, in the extreme case at the flow top. Vesiculation in four flows was compared. In the Cohassett flow a single zone occurs, continuous over >30 km at d/l = 0.4, suggesting uniform cooling conditions and R_1 approximately = R_3. In the McCoy Canyon and Rocky Coulee flows multiple zones occur, continuous over distances of <5 km at d/l values ranging from 0.5 to <0.1, suggesting variable cooling conditions and $R_3 > R_1$. In the Umtanum flow no vesicular zones occur, also suggesting uniform cooling conditions but $R_1 \gg R_3$.

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No 136141

REVIEW OF EVIDENCE FOR THE QUENCHING ORIGIN OF ENTABLATURES IN COLUMBIA RIVER BASALT FLOWS

LONG, Philip E., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352

Entablature and colonnade are prominent internal subdivisions of basalt flows characterized by differences in fracture abundance and regularity. Entablatures have more abundant and less regular fractures than adjacent colonnades. Quenching of partially crystallized basalt flows by lakes or streams has been proposed as the origin of entablatures. Evidence for quenching includes 1) entablatures exhibit quench textures that contrast sharply with textures indicative of slower cooling found in colonnades (Long and Wood, 1986a, GSA Bulletin, v. 97, p. 1144-1155) and 2) fracture propagation directions show that flows cooled from the top down to the contact between the lowermost entablature and the lower colonnade (DeGraff and others, 1985, EOS, v. 66 p. 1104). Fracture propagation directions are consistent with interpretation of textures and thermal model predictions and indicate that the cooling rate from the top of a flow downward is typically 4 to 12 times greater than from the bottom up.

The relationship between the occurrence of quench textures and flooding-induced acceleration of cooling has been corroborated by petrographic examination of drill core from the 1973 Heimaey flow which was intentionally quenched with seawater (Long and Wood, 1986b, GSA Abs., v. 18, p. 675). Development of entablatures by quenching has been widely accepted in Iceland where Holocene lava flows exhibit entablatures exclusively along drainages. The relationship between drainage and entablature is ordinarily not obvious on the Columbia Plateau. Evidence for quenching cited above suggests that ephemeral lakes and streams inundated parts of the plateau during Columbia River basalt time. Mapping of the occurrence of entablature in individual flows should provide a further test of the quenching hypothesis in that the distribution of entablature should be consistent with geomorphic controls on drainage developed immediately after flow emplacement.

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№ 132368

REGIONAL VARIATION OF JOINTING STYLE IN GRANDE RONDE BASALT RELATED TO MIOCENE GEOGRAPHY, COLUMBIA PLATEAU

SWANSON, Donald A., U. S. Geological Survey, Cascades Volcano Observatory, 5400 MacArthur Blvd., Vancouver, WA 98661

Reconnaissance mapping of most of the area covered by the Grande Ronde Basalt revealed geographic variation in jointing style interpreted to reflect the presence or absence of water ponded on the lava flows as they cooled. The flows lapped against highlands along much of the perimeter of the province. Each flow buried the drainage system developed on the next older flow. Runoff from the highlands ponded and spread across each hot flow, in places as far as 40 km into the province. The water poured into cooling joints that opened in the crust of each flow, progressively quenching the underlying lava by convective heat transfer. The rapid cooling formed thick entablatures whose physical features (hackly joints, glassy texture, and crystals with quenched morphologies) resemble those of subaqueous pillows. Long and Wood (1986) successfully modeled such features as caused by water that accelerated cooling. Heavy rainfall "seeded" by fine ash and aerosols associated with the huge eruptions, which produced tens to hundreds of cubic kilometers of lava, may have speeded the cooling, if not directly (Long and Wood, 1986) then indirectly by increasing runoff from the highlands onto the basalt plain. Invasive basalt flows are also common in marginal areas of the province, where clastic sediment accumulated. In contrast, most flows in the central part of the province, isolated from highland sources of water and clastic sediment, developed no thick entablatures or invasive relations. Prominent exceptions to these generalizations exist, owing to the complex interplay between lava flows, rainfall, and erosion. Thick entablatures found in the central part of the province imply the presence of water and hence either a connection to the highlands via disrupted drainages or possibly local ponds formed by rain.

Long, P.E., and Wood, B.J., 1986, GSA Bull., v. 97, p. 1144-1155.

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JOINTING IN THE COLUMBIA RIVER BASALT (CRB) FLOWS: ASSOCIATION OF JOINTING STYLES WITH OTHER FACTORS

No 136158

BEESON, Marvin H., Geology Dept., Portland State Univ., Portland, OR 97207; TOLAN, Terry L., REIDEL, Stephen P., and FECHT, Karl R., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352; ANDERSON, James Lee, Dept. of Geology, Seaver Lab., Pomona College, Claremont, CA 91711; HOOPER, Peter R., Dept. of Geology, Washington State Univ., Pullman, WA 99164

The jointing patterns in CRB flows can be broadly classified as either entablature-colonnade (E-C) or columnar/blocky (C/B). The origin of E-C jointing has been recently attributed to rapid cooling resulting from water flowing over, or ponded on, the flow (Long and Wood, 1986). However, numerous field observations suggest that other factors are also important in the origin of jointing styles.

Particular jointing styles are commonly associated with individual CRB units and persist over vast areas. In the western half of the CRB distribution, the "low MgO" Grande Ronde flows characteristically display an E-C while N_2 "high MgO" Grande Ronde, Frenchman Springs Member, and Priest Rapids Member flows are characteristically C/B.

Jointing style can also be associated with emplacement environment. Intracanyon flows and flow-margins often are E-C, even if the flow is C/B elsewhere. For example, the Rosalia flow (Priest Rapids Member) is E-C in intracanyon occurrences, but is C/B where it overflowed the canyon rim; a similar pattern occurs in basalt of Ginkgo and Elephant Mtn. Member flows.

Field evidence fails to support the hypothesis that either standing or flowing water was the sole agent responsible for producing the jointing patterns seen in the above cases. We alternatively suggest that a combination of intrinsic lava flow properties (e.g., composition, viscosity) and several external factors (e.g., environment, flow stresses) play a primary role in determining the jointing style.

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№ 128426

FRACTURE GROWTH DIRECTIONS AND INFERRED THERMAL REGIME DURING SOLIDIFICATION OF BASALTIC LAVA FLOWS

DEGRAFF, James M., AYDIN, Atilla, Dept. of Earth & Atmos. Sciences, Purdue Univ., West Lafayette, IN 47907; LONG, Philip E., Basalt Waste Isolation Project, Rockwell International, Richland, WA 99352

Cooling fractures in a basaltic lava flow form in the upper and lower solidifying crusts and grow toward the flow interior as the crusts thicken. By determining fracture growth directions, we can identify the level in the flow where the two crusts met. Conductive cooling would cause the upper and lower crusts to meet just below a flow's middle. However, the crusts of some flows apparently met well below the middle, implying very rapid heat loss through the flow top by a mechanism other than conduction. Examples are two-tiered flows, having a thin lower unit of widely spaced columnar joints (colonnade) under a thick upper unit of closely spaced joints (entablature), and multi-tiered flows with a basal colonnade under alternating tiers of entablature and colonnade.

Fracture growth directions are obtained by determining the formation order of cracks that comprise a single columnar joint. Field data show that: (1) a new crack's origin is on the leading edge of an old crack; (2) new cracks overlap the leading edges of old cracks, leaving blind tips that point toward younger cracks; (3) a crack's plumose structure is largest on the side of the plume axis toward younger cracks. Application of these criteria to basalt flows of the western U.S.A. reveals that joints of basal colonnades grow upward, whereas joints of overlying entablatures and colonnades grow downward. The two main joint sets of two-tiered and multi-tiered flows meet well below a flow's middle because the upper crust cooled and thickened much faster than the lower crust. Using the final ratio of upper to lower crustal thickness, we infer that heat loss at the tops of these flows is up to 12 times greater than that at the bases. This result is consistent with observations that entablatures have quench textures and high glass content indicative of rapid cooling. Faster cooling of a flow's upper part probably results from water convection in fractures, an idea supported by thermal modelling

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№ 136151

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ORIENTATION AND SPACING OF COOLING JOINTS IN TWO COLUMBIA RIVER BASALT FLOWS*

MEINTS, Joyce P., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352

Fracture mapping was conducted in eighteen field sites in the Museum (M) and Rocky Coulee (RC) flows near Vantage, Washington, and in the Saddle Mountains south of Vantage. Fracture data were also collected from vertical drill core which was oriented via paleomagnetic declinations. Fracture orientation and spacing were analyzed using classical statistical methods. A chi-squared test, involving contingency table analysis based on fracture pole frequencies was used to compare Schmidt plots of the following intraflow structures: colonnade (COL), columnar entablature (COL-ENT) and entablature (ENT). Within-flow, between-flow, and surface and core comparisons were analyzed to determine if fracture orientation varied spatially with areal location or depth.

Fracture spacing was analyzed by dividing the Schmidt plots into ten orientation sets. Spacing in high angle sets was shown to be lognormal. The Student -t test was used to compare spacing populations between individual orientation sets. Results of the "t-tests" and a binomial distribution were used to determine if spacings showed regional similarity.

Fracture orientation results indicate that each of the three intraflow structure types has a characteristic pole plot. However, there may be variation within one intraflow structure. For example, the COL-ENT at Vantage changes from more colonnade-like to more entablature-like in character laterally across the area studied. Attempts to compare surface to core orientations were not successful because of the blind zone of vertical boreholes.

In general, fracture spacings were similar between the M and RC COL's at Vantage. Spacings in the M COL's at both Vantage and Saddle Mountains locations were similar to the RC COL-ENT at Vantage. * Funded by Northwest College and University Association for Science (NORCUS).

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No 136153

COOLING JOINT WIDTH AND SECONDARY MINERAL INFILLING CHARACTERISTICS IN FOUR GRANDE RONDE BASALT (GRB) FLOWS AT HANFORD, WASHINGTON

LINDBERG, Jonathan W., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352

Cooling joint width and secondary mineral infilling are important geomechanical and hydrologic parameters for the design of a deeply buried nuclear waste repository at Hanford and the assessment of its performance. To characterize width and infilling, approximately 3,200 randomly selected joints were examined in drill core. The core samples were from the Cohassett flow, the flow being studied for the proposed nuclear waste repository, and three other GRB flows. Measured joint widths were characterized by calculating sample statistics, constructing and comparing cumulative frequency plots, and comparing joint width between flows, intraflow structures, and core holes with an analysis of variance. Percentages of secondary minerals filling the joints were estimated visually and the number of joints with various predominating infilling types (including voids) among basalt flows, intraflow structures, and joint width groups were compared.

Results indicate that joint width does not vary significantly within basalt flows or even between flows. The joints may be characterized as belonging to one width population with a lognormal distribution, an arithmetic mean of 0.23mm, and a standard deviation of 0.49mm.

Clay is the predominant infilling type with lesser amounts of silica and zeolite. For example, 89% of the selected joints from the Cohassett flow are filled predominantly with clay, 6.5% with zeolite, and 4.0% with silica. Only 0.6% of the joints measured have observable void space. Different intraflow structures do not exhibit different infilling types except for the entablature of the deepest flow studied which has joints that contain 33% zeolite. Wider joints are more likely to contain more silica and zeolite than narrower joints.

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№ 132362

SULFUR IN THE FRENCHMAN SPRINGS MEMBER OF THE WANAPUM BASALT IN WASHINGTON AND OREGON

EWERT, John W., U.S. Geological Survey, 5400 MacArthur Blvd., Vancouver WA, 98661

Fresh glass from dike selvages and pillow rinds was analyzed for total sulfur content by XRF in order to determine loss of sulfur during flowage from vent areas. Glass collected on the Columbia Plateau is remarkably fresh in both pillows and selvages, grading from sideromelane at the outer quench margin to tachylite and finally into microcrystalline groundmass in a space of 0.5-2 cm. Skeletal opaque spinel is present within the sideromelane near the transition to tachylite.

Sulfur content of the dike selvages averages 950 ppm and ranges from 750 to 1200 ppm; pillow rinds average 820 ppm and range from 720 to 950 ppm. The 135 ppm (14%) average loss of sulfur found between dikes and pillows most likely reflects degassing during flowage. The sulfur content of the basalt is slightly higher than that of oceanic basalts reported by Moore and Fabbi (1971) and probably reflects the higher iron content of the Frenchman Springs Member. Sulfur contents of the dike selvages agree well with experimentally derived sulfur-saturation limits determined by Haughton and others (1974) for mafic melts at 1200 degrees C and 1 atmosphere total pressure with iron content similar to that of the Frenchman Springs Basalt. There is no consistent difference in sulfur content in pillow samples collected at progressively greater distances from the vent area, including samples from the Columbia Plateau, the Cascade Range, the Willamette Valley, and the Coast Range of Oregon. Instead, sulfur is apparently lost during and soon after eruption, and thereafter remains at stable concentration in the basalt.

Haughton, D.R., Roeder, P.L., and Skinner, B.J., 1974, Solubility of sulfur in mafic magmas: Economic Geology, v.69, p. 451-467.

Moore, J.G. and Fabbi, B.F., 1971, An estimate of the juvenile sulfur content of basalt: Contributions to Minerology and Petrology, v.33, p.118-127.

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No 136140

REVISIONS TO THE AREAL EXTENT AND VOLUME OF THE COLUMBIA RIVER BASALT GROUP (CRBG)

TOLAN, Terry L., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352; REIDEL, Stephen P., Rockwell Hanford Operations, Richland, WA 99352; BEESON, Marvin H., Geology Dept., Portland State Univ., P.O. Box 751, Portland OR 97207; ANDERSON, James Lee, Dept. of Geology, Pomona College, Seaver Lab., Claremont, CA 91711; FECHT, Karl R., Rockwell Hanford Operations, Richland, WA 99352; SWANSON, Donald A., U.S. Geological Survey, 5400 MacArthur Blvd., Vancouver, WA, 98661

Recent reevaluations of CRBG geologic maps show that accepted estimates for the areal extent (200,000 km^2) and volume (200,000-382,000 km^3) were in error. New estimates have been calculated from 33 digitized CRBG isopach maps and are summarized below.

Formation	Area (km^2)	Vol. (km^3)	Vol.%	No. Flows	Ave. Vol/Flow
Saddle Mtns.	30,573	2,393	1.40	19	126 km^3
Wanapum	95,948	10,673	6.25	33	32 km^3
Grande Ronde	150,922	149,244	87.46	131*	1,139 km^3
Picture Gorge	10,677	2,391	1.40	42	60 km^3
Imnaha	34,390	5,773	3.38	26	222 km^3
Total CRBG**	163,721	170,649	100.00	292	-

* Reidel, Tolan, Anderson, Beeson, and Fecht (1987, this volume)

** Includes informal units in the Clearwater/Weiser Embayments.

This study also reveals that the new average volume/flow estimates are markedly greater than the previously accepted average of 10 to 30 km^3 per flow. We have also estimated the distance that some individual Wanapum and Saddle Mtns. flows traveled. The distances traveled vary from <40 km to >750 km. These estimates do not include the submarine extension of some of these flows onto the Oregon and Washington continental shelf. The interplay of three primary factors - volume, vent location, and paleotopography, controlled the distance flows traveled.

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№ 127423

REEVALUATION OF THE TIMING, DURATION AND MAGNETOSTRATIGRAPHY OF THE IMNAHA, PICTURE GORGE AND GRANDE RONDE BASALTS.

BAKSI, Ajoy K., Dept. of Geology, Louisiana State University, Baton Rouge, LA. 70803-4101.

The geochronological data available for various sections of the Columbia River Basalts (CRB) was reevaluated along with pertinent paleomagnetic data. Since few 40Ar-39Ar incremental heating results are available, published whole-rock K-Ar ages were reexamined for their reliability, in light of their atmospheric argon contents. It will be demonstrated that the least altered whole-rock samples from the flood basalt province in India yield the most reliable ages and contain low amounts of 36Ar. Herein, we limit our comments to the sections of the CRB studied by Watkins and Baksi [Am. Jour. Sci. 274 (1974), 148-189]; we list below the best estimates of their ages and tentatively identify the geomagnetic reversals seen in these sections in terms of the magnetostratigraphic units defined by Swanson et al. [U.S.G.S. Bull., 1457-G (1979), 1-59].

Snake River Canyon (Whitman Co., WA.): T > 14.9 Ma, R_2-N_2-R_3
Grande Ronde River (Asotin Co., WA.): T = 15.6 Ma, N_1-R_2-N_2
Lapwai Creek (NezPerce & Lewis Co., ID.): T ≈ 15.6 Ma, R_2-N_2
Imnaha (Wallowa Co., OR.): T ≈ 17.2 Ma, N_0-R_1
Butler Canyon (Wasco Co., Oregon): T ≈ 16.9 Ma, R_1-N_1
Cow Canyon (Wasco Co., OR.): T ≈ 15.8 Ma, N_1-R_2
Picture Gorge (Grant Co., OR.): T ≈ 16.2 Ma, N_1-R_2.

These results show good agreement with the reversal time scale of Harland et al. [Cambridge Univ. Press (1982)]. We suggest the Imnaha, Picture Gorge and Grande Ronde Basalts were formed by the Columbia Volcanic Episode between ~17.5 and ~15.0 Ma.

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№ 136139

PALEOMAGNETISM OF THE COLUMBIA RIVER BASALT GROUP

AMERIGIAN, Craig and TOTH, John, Analytical Services Co., 127 Liverpool Drive, Cardiff, CA 92007; REIDEL, Stephen, Rockwell International, P.O. Box 800, Richland, WA 99352

Paleomagnetism has played a major role in the development of a stratigraphy for the Columbia River basalt. The first significant developments in the stratigraphic subdivision of the sequence occurred in the 1960's and were based on improvements in geochemical techniques and polarity stratigraphy. Further refinements in the geochemical characterization of individual flows, aided by additional paleomagnetic studies, led to revisions and further subdivision of the sequence. These techniques can now routinely be used to unambiguously identify many of the flows across wide areas. Furthermore, these developments have provided the opportunity to utilize the paleomagnetic method as a far more powerful tool than simple stratigraphic correlation; namely as a means to investigate local and regional tectonic history.

We will summarize paleomagnetic results for the Imnaha, Grande Ronde, Wanapum, and Saddle Mountains Basalts. The directions for flows in each formation will be discussed in the context of the corresponding site locations and the effect of local deformation on flow directions at many localities. Previously published interpretations for results from the region, which are based on directional data for individual flows over a large area, will be discussed in the context of the larger data base now available and in light of the ambiguities introduced by local tectonic disturbance.

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№ 136149

REGIONAL STRATIGRAPHY OF THE GRANDE RONDE BASALT (GRB) AND ITS TECTONIC AND PETROGENETIC IMPLICATIONS

REIDEL, S. P., TOLAN, T. L., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352; ANDERSON, J. L., Pomona College, Claremont, CA 91711; BEESON, M. H., Portland State University, Portland, OR 97207; FECHT, K. R., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352

A new regional GRB stratigraphy is proposed wherein the GRB is subdivided into 48 subunits; these subunits differ from those defined by Mangan and others (1986) but are similar to, and add to those defined by Reidel (1983). Our proposed stratigraphy is based upon compositions, paleomagnetic properties, lithology, and stratigraphic position of flows from 134 surface stratigraphic sections, and 34 boreholes (14 that penetrate the entire GRB section) from throughout the region.

Based on our work, we estimate that the total volume of the GRB is 149,244 km^3 (~87 vol.% of the Columbia River basalt) with the volumes of individual magnetostratigraphic units being - R_1: 36,242 km^3, N_1: 31,437 km^3, R_2: 53,362 km^3, and N_2: 28,203 km^3. We estimate that ~131 flows have regional extent and the average volume/flow is >1,100 km^3. Some flows exceed 2,000 km^3.

Although all GRB vent sources are apparently east of 119° longitude, the thickest GRB section (>14,000 feet) occurs near the Pasco Basin where subsidence kept pace with eruptions. Thickening of the GRB begins abruptly west of the Palouse slope indicating the greatest subsidence was concentrated in the Yakima Fold Belt. Regional stratigraphic relationships show that the most complete GRB sections are in the Pasco Basin area with flows pinching out toward the margins.

In complete GRB sections, the flow compositions show a progressive, gradational change through time. This suggests that most flows are genetically related, thus eliminating the need for eruptions from different magma chambers during GRB time.

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DETAILED STRATIGRAPHY OF THE UPPER GRANDE RONDE BASALT, COLUMBIA RIVER BASALT GROUP, CENTRAL COLUMBIA PLATEAU

No 136161

LANDON, R. D.; LONG, P. E., Rockwell Hanford Operations, P.O. Box 800, Richland, Wa. 99352

A flow by flow stratigraphy has been developed for the upper two-thirds of the N_2 polarity unit of the Grande Ronde Basalt (GRB) within the Pasco Basin of south-central Washington. The stratigraphy was developed by the multivariate statistical technique of discriminate analysis using major, minor, and trace element chemistry, paleomagnetic direction, and stratigraphic position relative to the top of the GRB as the discriminating variables. Using a stepwise selection it was possible to determine the variables most important to correlating flows over the stratigraphic interval of interest. The ten most useful variables are: relative stratigraphic position, Cr, CaO, TiO_2 P_2O_5, MgO, K_2O, FeO, Th, and Eu. Tests of the classification system show that flows are correlated within ± one flow in approximately 95% of the cases. Correlations differ from those presented in Mangan and others (1986) for both individual flows and groups of flows. Our analysis indicates two relatively thick flows, the Rocky Coulee and Umtanum, belong in different flow groups than proposed by Mangan and others (1986).

Results show that within the Pasco Basin the upper two-thirds of the N_2 contains seventeen individual flows of which only nine to fifteen flows may be present at any one location. Seven of these flows are present throughout the basin. More flows occur in the southeast portion of the basin, yet in the west and northwest, where there are fewer flows, a thicker section occurs.

Data from these correlations permits analysis of the tectonics during the time of the emplacement of the upper GRB. Analysis of individual flows and groups of flows shows that subsidence was greater in the western portion of the basin and the growth of the Yakima ridges appears to have begun by at least late GRB time. This is consistent with previous studies.

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BASALT STRATIGRAPHY OF THE FRENCHMAN SPRINGS MEMBER IN THE TYPE AREA, CENTRAL WASHINGTON

№ 125540

BENTLEY, Robert D., and POWELL, John E., Geology Department, Central Washington University, Ellensburg, WA 98926

Although the Frenchman Springs Member (FS) is one of the most extensive units of the Columbia River basalt, its stratigraphy is still poorly understood. Beeson and others (1985), adopting names of Mackin (1961), have divided the FS into several chemical units on a basis of major oxide chemistry. Through careful flow by flow mapping (scale 1:12,000) of the Frenchman Hills to Yakima River Canyon area, where Mackin (1961) named 3 flows, we have found 8 or 9 mappable units. Within the type area 6 informally named flows end with a complex flow distribution pattern; from oldest to youngest, the generalized section is two Ginkgo flows, one to two Sand Hollow flows, one Rye-Kelley Hollow flow, one to two Sentinel Gap flows, and the Babcock Bench flow. The distribution and thinning of Frenchman Springs flows in the area of study does not reflect the uplift and deformation of the Yakima structures. The north-south trending Hog Ranch anticline is crossed by FS flows with very little if any change in flow thicknesses or distribution. The FS units are unchanged across the west and north-west trending Umtanum, Hanson Creek, Saddle Mountains, and Frenchman Hills-Whiskey Dick anticlinal ridges. A local thickening of units occurs in the vicinity of the Hanson Creek-Manastash Ridge structure and in the Sagebrush syncline. Local thinning may occur near Sentinel Gap, Rye Grass and at Priest Rapids Dam but this is probably a random thinning not necessarily related to deformation during FS time. The local thickness variations (10m) are as great in the synclinal areas as near the anticlines.

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CHEMICAL STRATIGRAPHY OF THE ROZA MEMBER, COLUMBIA RIVER BASALT GROUP

No 134740

MARTIN, Barton S., Dept. Geology/Geography, U.Massachusetts, Amherst, MA 01003

The Roza Member of the Columbia River Basalt Group is one of the most distinctive lithologies on the Columbia Plateau. Consisting of from one to four flow units in the field; detailed trace element analyses from 33 controlled sections have delineated four chemical subtypes corresponding to individual flow units and vents. These subtypes are: I--Cr<25 ppm,"high" incompatibles; II--Cr 27 to 33 ppm; III--Cr 34 to 43 ppm; and IV--Cr>43 ppm,"high" Ni. In addition, incompatible element (Ba,La,Zr, Nb,TiO2) abundances decrease with increasing Cr in subtypes I,II, and III. Plagioclase phenocryst abundances behave inversely from incompatible patterns, although Sr is approximately constant throughout the Roza. Subtype IV is anomalous in that it is characterized by higher incompatibles and lower phenocrysts than III.

Stratigraphic relationships between the four subtypes are complex. In general, subtype I forms the base of the Roza in the eastern and north-central parts of the plateau; II is the basal unit in the NW and Columbia Gorge and has the widest distribution; III is at the base of the Roza along its southern and far western margin, and IV is the only flow type present in the NE. Although there may be multiple flows of a subtype in a measured section, each succeeding flow tends to have higher Cr and lower incompatibles.

Field and chemical relationships suggest that each subtype is the product of separate magma batches and do not represent eruptions from a periodically tapped, continuously fractionating reservoir.

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№ 136150

COLUMBIA RIVER BASALT GROUP (CRBG) IN WESTERN OREGON: FACTORS CONTROLLING FLOW EMPLACEMENT

BEESON, Marvin H., Geology Department, Portland State University, Portland, OR 97207; TOLAN, Terry L., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352

Topography and ground conditions were important factors in controlling the distribution of individual CRBG flows west of the Cascades. The SW extension of the Yakima folds along with local volcanism created topography that largely controlled the distribution of CRBG flows across the Miocene Cascades. The first flows to cross the Miocene Cascades encroached on a low relief topography consisting of eroded Tertiary marine sedimentary rocks, volcanic highs, and estuaries. Water-saturated sedimentary rocks rapidly extracted heat from the lava, producing narrow but abnormally thick lobes extending along topographic lows.

Paleodrainage courses developed during intervals between CRBG flows. The position of these drainage pathways were influenced by the position of CRBG flow margins and/or topographic lows. A longer hiatus between flows (>100,000 yrs) enabled streams to develop major canyons, by headward erosion, which served to channelize subsequent CRBG flows.

The NW-trending Clackamas River-Portland Hills (CR-PH) structural zone produced a topographic barrier before and during the incursion of the CRBG flows. The CRBG thins across this zone from 600 m to 150 m. This zone diverted the earliest flows (N_1 Grande Ronde) through the Portland basin. Some succeeding R_2-N_2 Grande Ronde flows crossed the CR-PH zone and followed a structural trough extending from Lake Oswego southwestward through Sherwood, Oregon, to the coast. The total thickness of the CRBG along the Lake Oswego-Sherwood trough (and in the northern Tualatin Valley) is greater (>210 m) than most sections in the Willamette Valley, west of the CR-PH zone (<150 m).

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№ 136157

RECONSTRUCTION OF NEOGENE DRAINAGE SYSTEMS IN THE AREA COVERED BY COLUMBIA RIVER BASALT GROUP (CRBG)

FECHT, K. R., BJORNSTAD, B. N., REIDEL, S. P., and TOLAN, T. L., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352; ANDERSON, J. L., Dept. of Geology, Pomona College, Claremont, CA 91711; BEESON, M. H., Geology Dept., Portland State University, Portland, OR 97207; SMITH, G. A., Dept. of Geosciences, University of Arizona, Tucson, AZ 85721

Relative positions of Neogene streams in the area covered by CRBG are delineated by using the distribution, texture, and composition of sedimentary sequences and intracanyon/valley-filling lava flows, hyaloclastites and pillow lavas, as well as erosional features. Geologic features that controlled the position of these streams included regional paleoslopes, synclinal basins and anticlinal ridges and constructional topography built by lava flow emplacement and the aggradation of volcanism-induced sedimentary sequences.

Results of our studies indicate that east of the ancestral Cascades, in the early and middle Miocene, major streams were generally located near the margins of the Columbia Plateau (CP) and streams were primarily controlled by the west-dipping Palouse slope, the highlands bounding the CP, and the emplacement rates and volume of CRBG flows. Drainage courses through the Cascades and across western Oregon to the Pacific were controlled by a combination of constructional topography created by lava flows and developing structural lows.

In the late Miocene and early Pliocene, with waning and finally cessation of CRBG volcanism, major streams flowed across much of the CP in a centripetal pattern. Streams were primarily controlled by CP subsidence and intra-CP tectonism. In and adjacent to the Cascades, streams were localized within structural valleys and were locally displaced by lava flows and/or volcanism-induced sedimentary sequences that frequently engulfed these valleys. In western Oregon and Washington streams were mainly controlled by emerging structures.

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NEOGENE SYNVOLCANIC AND SYNTECTONIC SEDIMENTATION ON AND ADJACENT TO THE COLUMBIA PLATEAU

№ 136152

SMITH, G.A., Dept. of Geosciences, Univ. of Arizona, Tucson, AZ 85721; FECHT, K.R., and BJORNSTAD, B.N., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352

Neogene sedimentation on and adjacent to the Columbia Plateau in Oregon, Washington and western Idaho was induced by volcanism and tectonism. During emplacement of the largest volume of middle Miocene flood basalts (Grande Ronde and Wanapum basalts) local drainage disruption and gradient diminishment caused deposition in lakes and by sluggish mixed-load streams at or near the flow margins (e.g., Latah, lower Ellensburg, and Simtustus Formations). The Mascall and Payette Formations (and equivalents) were deposited in subsiding basins along the south and southeast plateau margins. Basalt isopachs record the Pasco Basin as the principle subsiding feature at this time but, because of its central position on the basalt plateau, only minor detrital and organic-rich sediments accumulated locally.

As the eruptive frequency and volume of basalt diminished (Saddle Mountains Basalt), deposition continued primarily in response to intrabasin tectonism and Cascade volcanism. A well-integrated, through-flowing river system transported detritus from the surrounding highlands across the plateau (e.g., Ellensburg Formation, North Lewiston Gravel). Fluvial and lacustrine deposition occurred in response to basin subsidence (e.g., Ringold and Idaho Formations) or influx of coarse clastics into shallow basins (e.g., Alkali Canyon and McKay Formations, Thorp Gravel, Clearwater Gravels, and Clarkston Gravel). Episodic introduction of fragmental volcanic debris is represented by the Ellensburg, Dalles (sensu stricto), and Deschutes Formations along the western part of the plateau. Sedimentation in most basins ended temporarily with regional late-Pliocene incision. Aggradation mechanisms related to tectonism and volcanism produced distinctive depositional sequences that aid in the interpretation of Neogene tectonics on and near the Columbia Plateau.

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№ 134653

STRUCTURAL AND STRATIGRAPHIC RELATIONSHIPS BETWEEN THE NORTHWESTERN COLUMBIA RIVER BASALT MARGIN AND RECENT SUB-BASALT GAS WELLS

CAMPBELL, Newell P., Department of Geology
Yakima Valley College, Yakima, WA 98907

Recent mapping of pre-basalt rocks along the northwestern Columbia River basalt margin and well logs from Shell Oil Company gas wells provide new information about the rocks and structure underlying the Yakima fold belt. Pre-basalt rocks along the margin range in age from Jurassic to early Miocene. Early Tertiary fluvial-deltaic and volcaniclastic sediments are concentrated in four graben-like basins separated by upthrown blocks and bounded by high-angle faults. Two major structures, the Leavenworth-Hog Ranch structure and the White River-Naches River fault zone, control the distribution of sedimentary rock types. With one exception, pre-basalt rocks cut by the Shell Oil Company wells (Yakima Minerals, Bissa, and Saddle Mountains) can be correlated with rocks found along the margin. Early Tertiary sediments thicken under the Yakima fold belt relative to the eastern Columbia basin. Columbia River basalt encountered in the wells varied in thickness from 1390 to 3500 m. The basalt thins across the Leavenworth-Hog Ranch structure indicating that this feature was active during Miocene. Few pre-basalt faults extend into Columbia River basalt along the northwestern margin. The intense folding occurring in the interior of the Yakima fold belt is missing; most folds either die out before reaching the margin or become broad, gentle flexures. Older folds mimic folds in the Columbia River basalt only within the Olympia Wallowa Lineament (OWL). Recent work along the margin suggests that structures formerly attributed to the OWL may be related to southeastward trending splays of the Straight Creek fault system.

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GEOSCIENCE APPLICATIONS IN THE BASALT WASTE ISOLATION PROGRAM

№ 136154

DAHLEM, David H., Ph.D., U.S. Dept. of Energy, Richland Operations Office, BWIP, PO Box 550, Richland, WA 99352; KNEPP, Anthony J., U.S. Dept. of Energy, Richland Operations Office, BWIP, PO Box 550, Richland, WA 99352

The Basalt Waste Isolation Project, located in Hanford, Washington, is conducting an intensive site characterization program leading to the evaluation of the potential for the flood basalts at Hanford to become the nation's first permanent geologic repository for high level nuclear waste. The need to demonstrate the capability of the site to isolate potential radionuclide releases from the repository over a period of 10,000 years, as per federal regulation, places the collection and use of data in the geosciences in a unique position as compared to most large engineered construction programs, such as the more familiar dams, flood protection projects, and mine construction. By comparison, most engineered projects have design lives of 10-50 years and require markedly less precise geoscience data.

Establishing rates of many common processes, such as reactivity of rock and groundwater systems, long term structural stability of underground openings, gradual changes in the tectonic and geohydrologic environment, usually occupies a minor role in most engineered projects. Standard practice is to include safety margins in the design based on other similar experience, and limited field data to minimize uncertainties in the physical nature of the site and its geologic environment, i.e., the site is "designed for." This approach is basically not feasible in the selection of a repository as the program is currently envisioned.

In this paper the utility of geoscience data in resolving the major project issues is examined. These issues include feasibility of construction and operation, possible retrieval of waste, permanent closure, and the demonstration of isolation potential.

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№ 136145

DEEP STRUCTURE OF THE PASCO BASIN, SOUTH-CENTRAL WASHINGTON

BERGSTROM, K. A., KUNK, J. R., MITCHELL, T. H., and ROHAY, A. C., Rockwell Hanford Operations, P. O. Box 800, Richland, WA 99352

Fifty-six magnetotelluric (MT) sites provided the principal data for the construction of a map of the thickness of the flood basalts in the Pasco Basin, south-central Washington State. The data quality from thirty-two MT sites collected in 1982 are relatively poor, but the twenty-four MT sites collected in 1985 data are of high quality. Gravity models were used to constrain the interpretation of the MT data which was based primarily on the results from continuous and layered inversions. Numerous two-dimensional MT models were also computed to evaluate anisotropy in the MT data and to aid static corrections.

The resulting maps show that the basalt thickness varies from 3000 to 5000 meters. The thickest section appears to be to the southwest of the Pasco Basin. Low frequency anisotropy was used as an indicator of large basement features. There is notable low-frequency anisotropy at the easternmost sites. This suggests the presence of a substantial feature to the east of the survey area which may correlate with a basement high identified with the refraction data. The MT data does not extend far enough to the east to locate and evaluate the feature causing the anisotropy. Basement structure determined from seismic refraction data are used to constrain the regional MT interpretations. The rest of the survey area is relatively one-dimensional at the lower frequencies.

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No 134656

STRUCTURE AND DEFORMATION ALONG A PORTION OF THE HORSE HEAVEN HILLS, SOUTH-CENTRAL WASHINGTON

HAGOOD, Michael C., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352

The Horse Heaven Hills (HHH) in south-central Washington consists of two distinct anticlinal segments which join in the lower Yakima Valley: one trending northwest and one trending northeast. The northwest-trending segment lies within the Cle Elum-Wallula deformed zone. The northeast-trending segment parallels the Columbia Hills.

Both segments of the HHH are composed of en echelon or aligned secondary folds whose axes are generally oriented in the direction of the trend. Fold and fault geometries are similar within and between both segments. Anticlines are asymmetric, with northeast and northwest vergences, and are usually double-hinged. Reverse faults lie in the tightly folded hinge zones and strike parallel to the fold axes. Tear faults along the northern limbs mark changes in the fold wavelength or trend. Layer-parallel faults locally occur along stratigraphic contacts or zones of preferred weakness in basalt intraflow structures or sedimentary interbeds.

Uplift occurred simultaneously along both segments during at least Wanapum and Saddle Mountains time. Relief developed at an average rate of less than ~70 m/m.y., decreasing with time.

Similar fold and fault geometries, timing of growth, and rates of growth are found in other Yakima folds within the central portion of the Columbia Plateau.

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Nº 136144

EARTHQUAKE FOCAL MECHANISMS, RECURRENCE RATES, AND DEFORMATION IN THE COLUMBIA RIVER BASALTS

ROHAY, ALAN C., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352

Compilation and systematic reanalysis of 46 eastern Washington earthquake focal mechanism plots, derived from data collected from the University of Washington seismic networks, were undertaken to determine the maximum and minimum stress directions (P- and T-axes). New focal mechanism plots for the 10/25/71 M=3.8 and 12/20/73 M=4.4 earthquakes, and the average of 14 shallow and 7 deep earthquakes in the south-central Columbia Plateau determine the P- and T-axes (azimuth, plunge) shown below.

10/25/71	P = (340,03)	T = (200,84)
12/20/73	P = (185,08)	T = (298,70)
shallow:	P = (347,03) (a_{95}=21)	T = (308,83) (a_{95}=12)
deep:	P = (175,08) (a_{95}=19)	T = (327,82) (a_{95}=13)

Thrust or reverse faulting on east-west planes is consistent with deformation along the anticlinal ridges of the Yakima Fold Belt. However, strike-slip focal mechanism solutions (east-west T-axes) are often found for earthquakes on the western margin of the Columbia Plateau. East-west P-axes (instead of north-south) are found near the Blue Mountains.

Recurrence curves were constructed for shallow earthquakes (within the Columbia River basalts) in the south-central Columbia Plateau. Seismic moment release rates were calculated using an assumed relationship between magnitude and seismic moment; this results in an estimated 30-60 meters/m.y. uplift rate (or north-south shortening). This rate is comparable to the growth rate of the Saddle Mountains anticline, along which most of the earthquakes occur. Other anticlinal ridges in this region should also have similar deformation rates, but appear to be relatively aseismic.

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№ 135136

DEFORMATION IN THE EASTERN PART OF THE COLUMBIA PLATEAU

HOOPER, P.R., Dept. of Geology, Washington State University, Pullman, WA 99164-2812

The eastern part of the Columbia Plateau can be divided into a northern part which overlies thick crust of the North American craton and is undeformed bar mild east to west tilting, and a complexly deformed southern part overlying ocean derived accreted terranes (Blue Mountains Province).

Structures in the south are of three types: 1, those associated with SE-NW or E-W tilting; 2, regional NNW compression/WSW extension; and 3, WNW basin and range extension. All three types were active before, during and after the CRB eruption, all employ older structures where possible, and all are interdependent to some degree. Tilting is a result of the rise of granitic blocks in the east and sinking of the Pasco Basin in the west. The regional stress regime consists of σ_a = horizontal NNW-SSE, σ_b = horizontal ENE-WSW, and σ_c = vertical. $\sigma_a > \sigma_b \cdot \sigma_c$ increases with depth. Near the surface $\sigma_c < \sigma_b$ permitting the E-W Yakima and Lewiston folds associated with steep reverse faults. At intermediate levels within the crust $\sigma_a > \sigma_c > \sigma_b$ which permits formation of the NW-SE (dextral) and NE-SW (sinistral) strike slip faults. Near the base of the crust σ_c has increased so that $\sigma_a = \sigma_c > \sigma_b$, a tensional regime exploited by the CRB magma to form feeder dikes to the surface.

The basin and range component is manifest along the southern margin of the Plateau where greater extension south of the Olympic Wallowa Lineament than to the north makes OWL a broad zone of dextral transform motion anchored at the Idaho Batholith, displacing earlier dikes, rotating crustal blocks, and causing crustal thinning and a change in the character of the volcanic activity on its southern side. Basin and range extension creates the stress regime in the more competent block to the north and provides a rationale for the location of the CRB eruption.

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№ 136148

TECTONIC DEVELOPMENT OF THE CENTRAL COLUMBIA PLATEAU

REIDEL, S. P., CHAMNESS, M. A., FECHT, K. R., HAGOOD, M. C., TOLAN, T. L., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352

Tectonic development and evolution of the central Columbia Plateau (CCP) is a product of the dynamic interplay among: the subsidence of the Yakima Fold Belt (YFB) subprovince relative to the Palouse subprovince, the growth of the Yakima folds, and the influence of two regional structures that trend into the YFB: the Hog Ranch-Naneum Ridge anticline (HRNA) and the Cle Elum-Wallula disturbed zone (CLEW).

Subsidence of the YFB subprovince began prior to the eruption of the CRB and has continued through the Miocene to the present. The rate of subsidence kept pace with basalt eruptions, decreasing as eruption rates waned. Simultaneously, anticlinal fold growth within the YFB occurred under N-S compression, and decreased as the rate of subsidence and eruptions of lava declined. Paleomagnetic data indicate fold growth was accompanied by clockwise rotation. Rotation was on a local scale and occurred only in anticlines.

Two regional structural features, the CLEW and the HRNA, extend into and cross cut the YFB/CCP; some Yakima folds terminate against the CLEW. Both structures, which are apparently controlled by subbasalt structures, began growing before the Miocene and continued into the present.

The structural rotation and N-S compression, and thus fold growth, are interpreted to be a result of oblique subduction along a converging plate margin. The coincidence of timing and rates of fold growth and subsidence with basalt production suggests the CRB results from plate margin tectonics rather than hot spot activity.

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№ 136156

TECTONIC EVOLUTION OF THE SOUTHWEST COLUMBIA PLATEAU

ANDERSON, James Lee, Dept. of Geology, Pomona College, 609 N. College Ave., Claremont, CA 91711; BEESON, Marvin H., Geology Dept., Portland State University, Portland, OR 97207; TOLAN, Terry L., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352

The spacing of uplifts in the Yakima Fold Belt (YFB) of the SW Columbia Plateau and adjacent Cascade Range (averaging approx. 28 km) was established during the emplacement of the Grande Ronde Basalt (GRB) as the result of multilayer viscoelastic buckling of the Columbia River basalt (CRB) above heterogeneous mechanically weaker underlying rocks. The initial fold spacing was perpetuated by thickening of basalt in lows and thinning at highs during continued basalt emplacement. The present segmented folds and thrust faults are comparatively narrow (2 to 5 km-wide) zones at or near the crest of the original broad fold deflections where the probability of failure was enhanced by the thinner and hence weaker character of the basalt slab.

Strike-slip faults (some pre-existing) with preferred NW orientations also affected the SW Columbia Plateau during the emplacement of GRB, but after the spacing of the YFB uplifts was already firmly established. Strike-slip faulting (predominately dextral) and contemporaneous fold/thrust faulting at ridge uplifts resulted in segmentation of the uplifts, folding of strike-slip faults in some areas, and displacement of uplifts by strike-slip faults in others. Strike-slip faults, in general, increase in number from east to west across the SW Columbia Plateau.

YFB uplifts extend at least as far as west-central Cascade Range and appear to terminate at a broad zone of NW-striking dextral transcurrent faults bounded on the west by the Portland Hills-Clackamas River Fault Zone. The southern edge of the YFB contains folds that are more closely spaced, have shorter lengths, and are less regular in trend because the effects of pre-basalt basement are more pronounced due to progressive thinning of the CRB against the Blue Mtns. uplift.

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No 134252

MORE PALEOMAGNETIC RESULTS FROM THE MIOCENE COLUMBIA RIVER BASALT GROUP, OREGON AND WASHINGTON: STRATIGRAPHIC AND TECTONIC IMPLICATIONS

WELLS, Ray E. and SIMPSON, Robert W.
U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California

Over the past decade, we have, in collaboration with a number of colleagues, collected over 200 paleomagnetic sites in the Columbia River Basalt Group in Washington and Oregon. Our goals have been, first, to aid in the establishment of a detailed flow stratigraphy from the plateau westward to the Pacific Ocean, and second, to use paleomagnetic directions from uniquely defined flows to evaluate the timing, regional extent, and mechanisms of tectonic rotation in the Pacific Northwest. Earlier investigations by ourselves and others have already shown that the Pomona Member of the Saddle Mountains Basalt, the flows of Ginkgo, and some Grande Ronde lavas flowed all the way to the ocean and have rotated clockwise 15° to 30° in western exposures. Using new paleomagnetic, chemical, and field data we have expanded and refined our regional correlations, in particular in the Grande Ronde Basalt. We can now correlate a minimum of 14 flows westward from the Sentinel Gap area on the Plateau into the Coast Range, including, among others, a Low-Mg R2 Grande Ronde flow with vertical inclination, Low-Mg N2 Grande Ronde* flows with steep, easterly directions, Low-Mg N2 Grande Ronde flows with shallow, northwest directions ("Umtanum-Winterwater"), and High-Mg N2 Grande Ronde flows with steep northwest directions. The secular variation in coastal Grande Ronde flow sequences generally follows the trend described for Sentinel Gap, although clockwise rotated. Our detailed stratigraphy provides several useful strain markers for structural analyses and valuable constraints on the origin and emplacement of a related suite of Miocene coastal intrusives.

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Nº 136155

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USE OF COLUMBIA PLATEAU TECTONIC MODELS FOR DEVELOPMENT OF DISRUPTIVE SCENARIOS FOR A NUCLEAR WASTE REPOSITORY

CAGGIANO, Joseph A., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352

Tectonic and volcanic processes which have shaped the central Columbia Plateau in Neogene and Quaternary time must be extrapolated to determine: 1) their effect on groundwater travel paths and travel times, and 2) whether a repository in Columbia River basalt can isolate high-level nuclear waste for the required 10,000 years.

Tectonic models which satisfactorily explain the petrogenesis of Columbia River basalt and the penecontemporaneous chronologic and mechanical development of Yakima folds can provide the probability, location, characteristics, frequency, and magnitude of initiating tectonic and volcanic events in the Pasco Basin and Columbia Plateau. The type, location, slip history and amount of displacement on various order faults, their geometry, and the extent and character of fault-filling materials can be used to estimate the magnitude and location of future slip events and their potential effects on travel paths and travel times for groundwater. The location, probability, frequency, duration and geologic consequences of future Columbia River basalt and Cascade volcanism allows assessment of the potential direct or indirect effects (e.g., damming the Columbia River) of igneous activity on travel paths and travel times of soluble radionuclides and, thus, waste isolation. Fault/event trees will be developed from tectonic model(s) using expert opinion and will allow assignment of probabilities for initiating events and likely geologic consequences. These can be input to groundwater flow and repository system models to determine effects of tectonic/volcanic processes on the repository system.

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№ 128242

VOLCANIC-PLAINS RIDGES ON THE TERRESTRIAL PLANETS: A COMPARISON OF THE COLUMBIA AND THARSIS PLATEAUS

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Volcanic-plains ridges (VPR's) are a unique structural form observed on all the terrestrial planets. These features are characterized by 1) a common occurrence on volcanic plains; 2) strong similarity in overall morphology; and 3) strong similarity in dimensions. The ridges of the Columbia Plateau and the Tharsis Plateau on Mars both occur on extensive flood basalts, but the extent of VPR-style deformation is much greater on Tharsis. Many of the VPR's on the Columbia and Tharsis Plateaus are co-parallel trending and regularly spaced. In the Yakima Fold Belt the spacing of the VPR's range from 8 km to approximately 30 km. Most of the VPR's on the Tharsis Plateau have spacings of between 30 to 60 km. Strain estimates for the VPR's of Tharsis indicate about 1 km of shortening per structure. Estimates for VPR's on the Columbia Plateau range from about 1 to 3 km of shortening per fold, but this represents cumulative shortening from folding and displacement on associated thrust faults. If thrust faults are associated with the VPR's on the Tharsis Plateau, then the total shortening may be more comparable to the ridges of the Columbia Plateau. The 1 to 2 km thick basalts of the ridged plains of the Tharsis Plateau were emplaced on a mega-regolith, presumed to be poorly consolidated. Thus, a considerable strength contrast exists between the basalts and substrate. This strength contrast and the regular spacing of the VPR's suggests that the deformational mechanism may involve a layer instability with buckling in response to a horizontal load. On the Columbia Plateau, folds are restricted to the Yakima Fold Belt which overlies several thousand meters of sediments. In the Palouse subprovince to the east, where folds are not present, the basalt overlies crystalline basement. Thus, the VPR's of the Columbia and Tharsis Plateaus may also share a common deformational mechanism.

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№ 121436

JURASSIC THOLEIITES OF ANTARCTICA. TECTONIC SETTING

ELLIOT, David H., Inst. of Polar Studies and Dept. of Geology & Mineralogy, Ohio State University, Columbus, OH 43210

Tholeiitic rocks of Jurassic age crop out in a 4,000-km-long linear belt across Antarctica. They include sills, dikes, layered intrusions, lavas and volcaniclastic beds. The age of emplacement is only moderately well constrained at 180 ± 5 my with a possible younger episode at 165 my. Dike swarms are not known; sills are the most common expression and are largely confined to Permian and Triassic strata. Pyroclastic deposits locally form the initial eruptive products; lava sequences are up to 900 m thick. Preserved volume of tholeiite is estimated to be 0.5×10^6 km^3, of which 0.4×10^6 km^3 is a single layered intrusion.

The tholeiites form two distinct geochemical provinces; that in Queen Maud Land (QML) has characteristics quite similar to Karoo tholeiites whereas the province extending from the Dufek Massif to Horn Bluff, the Ferrar Group, is distinguished by high initial strontium isotope ratios (0.7115 ± 0.0012) and other element ratios and abundances.

QML lavas overlie basement or Permian sedimentary sequences. Ferrar lavas and pyroclastics overlie Triassic sequences which in two regions contain abundant contemporaneous silicic volcanic debris; the pyroclastics locally overlie an unconformity with 500 m of relief, suggesting major uplift prior to tholeiitic volcanism.

Ferrar rocks were emplaced into a Late Paleozoic-Early Mesozoic foreland basin associated with an active plate margin in the Pacific sector. The subduction history is poorly constrained; there may have been a hiatus in the early Jurassic prior to renewed calc-alkaline magmatism in middle to late Jurassic time. Jurassic silicic rocks in the foreland region may be anorogenic anatectic melts associated with early stages of tholeiitic magmatism. Most tholeiitic flood basalt provinces are associated with continental rifting and subsequent seafloor spreading. Ferrar rocks are neither temporally nor spatially associated with seafloor spreading. In this respect, and others, they are similar to the Columbia River Basalt which was erupted in a back-arc setting.

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STRONTIUM ISOTOPE AND CHEMICAL CONSTRAINTS ON CRUSTAL CONTAMINATION OF THE COLUMBIA RIVER BASALTS

№ 135138

HOOPER, P.R., Dept. of Geology, Washington State Univ., Pullman, WA 99164; CHAMBERLAIN, V., Dept. of Geology, Univ. of Idaho, Moscow, ID 83843; LAMBERT, R.St.J., Dept. of Geology, Univ. of Alberta, Edmonton, AB, Canada T6G 2E3

$^{87}Sr/^{86}Sr$, chemical and paleomagnetic data on feeder dikes, xenolith-bearing dikes, and flows of restricted extent are reported and permi* preliminary conclusions on the degree and timing of crustal contamination.

(1) Despite remarkably similar chemical compositions of the Pomona and Weippe flows, a 20° difference in paleomagnetic orientation and $^{87}Sr/^{86}Sr$ values of 0.705 and 0.710 respectively imply that the two represent separate eruptions.

(2) The high $^{87}Sr/^{86}Sr$ Weippe value may reflect the dike's position within the radiogenic craton. The Wilbur Creek flow has a similar Sr-isotope ratio and is also suspected of having a feeder dike within the craton. This provides circumstantial evidence of crustal contamination.

(3) Data from the Roza dike/vent system, which crosses the cratonic margin, and from other main Wanapum Basalt flows, show little variation in either chemical or isotopic features. We conclude that all had their reservoirs beneath the accreted terranes, that significant lateral flow occurred along the dikes, and that crustal assimilation, if it occurred, did so in the reservoir and not during transport from reservoir to surface.

(4) Xenolith-bearing dikes in the Wallowa batholith result in small areas of contaminated basalt with intermediate chemical and isotopic values. Inclusions appear to have been leached leaving only silica undigested. We conclude that within the accreted terranes chemical composition is more sensitive than strontium isotopes to crustal contamination, and that contamination of the Grande Ronde Basalts is of only local significance.

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№ 134549

URANIUM, THORIUM AND LEAD SYSTEMATICS OF THE COLUMBIA RIVER BASALTS AND NEARBY YOUNGER VOLCANICS

CHAMBERLAIN, V.E., Dept. of Geology, Univ. of Idaho, Moscow, ID, 83843; LAMBERT, R. StJ., DUKE, M.J.M., Dept. of Geology, Univ. of Alberta, Edmonton, AB, Canada, T6G 2E3

A detailed study of $^{208}Pb/^{204}Pb$ and $^{206}Pb/^{204}Pb$ shows that the number of isotopic reservoirs from CRB, excluding Saddle Mountain flows, must be increased to 5 from the currently accepted 4. The fifth reservoir provides one of the 3 end members for Picture Gorge flows, but is not evident in Imnaha, Grande Ronde and Wanapum. The 4 principal reservoirs have the following Pb isotopic ratios:

Reservoir	206/204	207/204	208/204
1A	18.6	15.57	38.43
1	18.9	15.57	38.53
2	19.1	15.68	38.62
3	18.7	15.68	39.00

Measured μ and k values for CRB show that all observed μ and k are much lower than is required to support the radiogenic Pb: not only was μ greater at sometime in the past but so also was k. It is not possible to devise a contemporaneous fractionation process which would yield the necessary μ and k values during eruption from the mantle. Fractionation must have occurred at earlier stages in the evolution of the parent material.

Comparison of CRB with Saddle Mountain (SM) and Snake River Plain (SRP) Pb isotopes suggests that there are no common isotopic reservoirs. Although SM and SRP may both have had an equally ancient source region, it must have been very heterogeneous with respect to U, Th and Pb. This heterogenity may exist in small pockets in the mantle under NW USA. Further, we suggest that the SM flows no longer be classified as CRB, at least from a tectonic standpoint.

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ON THE CAUSE OF COLUMBIA RIVER BASALT VOLCANISM

№ 128726

CARLSON, Richard W., DTM, 5241 Broad Branch Rd., N.W. Washington, DC 20015; HART, William K., Department of Geology, Miami University, Oxford, OH 45056

Dominating the volumetric output of basalt in the western U.S., Columbia River Basalt Group (CRBG) volcanism has been linked to both "mantle-plume" and "marginal basin" origins. Elemental ratios used to discriminate between convergent margin and intraplate settings (e.g. Ba/La, Ta/Yb) place most CRBG and Oregon Plateau basalts into the fields of convergent margin volcanism. Only the Imnaha, Ice Harbor, and Snake River Plain (SRP) basalts plot in intraplate basalt fields. However, both the Ice Harbor and SRP basalts have isotopic compositions outside the range observed for intraplate basalts from the Northern Hemisphere, as do the main volume of the CRBG (Grande Ronde, Wanapum, Saddle Mtns.). In the case of the CRBG, these elemental and isotopic discriminants need not uniquely define the tectonic situation of basalt genesis. "Convergent margin" signatures indicate the presence of a crustal component introduced either into the basalt sources through plate subduction, or by contamination of magmas during passage through the crust. "Intraplate" signatures could reflect sources not altered by this crustal component, but the evolved isotopic compositions of the Ice Harbor and SRP basalts suggest this source could be a normal component of the subcontinental lithosphere.

More constraining information on the cause of CRBG volcanism can be derived from consideration of other volcanic and tectonic events occurring in the Pacific Northwest during CRBG eruption. During the height of CRBG activity, voluminous basalt eruptions were occurring from the Grande Ronde dikes in the north to Steens Mountain in the south along a line paralleling the edge of the Wyoming Craton. We believe that the chemical characteristics, timing and location of eruption, and the volumetric output of the various basalt groups strongly support the idea that the volcanic activity in this area resulted from the initiation of "back-arc" spreading along the western border of Archean North America.

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PETROGENESIS OF THE PUEBLO MOUNTAINS BASALTS OF SOUTHEASTERN OREGON

Nº 121575

HART, W.K., MOSHER, S.A., Geology Dept., Miami Univ., Oxford, OH 45056; and CARLSON, R.W., Carnegie Institution, DTM, 5241 Broad Branch Rd., NW, Washing' .)C 20015

The Pueblo Mtns. (PM) form the southern end of the Steens-Pueblo fault scarp which, in places, rises to over one km above the surrounding Oregon Plateau. In the PM, Cretaceous crystalline rocks are unconformably overlain by a nearly one km thick sequence of predominantly basaltic lava flows. These tholeiitic to transitional basalts range from 17 to 15 Ma in age and were erupted from numerous widely-scattered fissures.

Detailed field and petrographic data from individual stratigraphic sequences allow for construction of a composite PM basalt stratigraphic section. Over 40 major and trace element and 15 Sr isotope analyses from representative flows and dikes within this section suggest a general decrease in Mg# and Ni concentration coupled with an increase in highly incompatible element concentrations and $^{87}Sr/^{86}Sr$ (0.7035-0.7039) from the base to the top. These general trends are complicated by numerous "reversals" indicative of open system evolution. We suggest that the PM basalt geochemical variations result from complex magma chamber processes including continuous fractionation of olivine+plagioclase±cpx and magnetite, continuous assimilation of crustal rocks and/or melts compositionally similar to the exposed crystalline rocks ($^{87}Sr/^{86}Sr$ at 16 Ma = 0.7041-0.7046), and periodic replenishment by heterogeneous mantle-derived melts.

The similar field, petrographic, chronologic, and geochemical characteristics of the PM and Steens basalts indicate a common evolutionary and eruptive history for the large volume Miocene flood basalts of the Oregon Plateau.

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No 134652

CRUSTAL CONTAMINATION IN THE PETROGENESIS OF SOME KAROO BASALTS - IMPLICATIONS FOR OTHER CONTINENTAL FLOOD BASALT PROVINCES

DUNCAN, A. R., ERLAND, A. J., SMITH, H. S., Geochemistry Department, University of Cape Town, Rondebosch 7700, South Africa; and MARSH, J. S., Geology Department, Rhodes University, Grahamstown 6140, South Africa.

Karoo basalts from the Etendeka area of Namibia show positive correlations between initial Sr isotope ratios, SiO_2, and incompatible elements such as Rb, Ba, Zr and Nb. Erlank et al. (1984) have shown that these relationships cannot be the result of magma mixing between the basalts and the voluminous acid volcanics with which they are interbedded, nor can they be explained by assimilation or AFC models where the contaminant is of intermediate or acidic composition. However, O isotope data which is now available shows a strong positive correlation with initial Sr isotope ratios. It is possible to model major and trace element data together with Sr, O and Nd isotope data by an AFC process with a basic contaminant such as Taylor and McLennan's (1985) "average lower crust" provided that it has an isotopic composition similar to the Etendeka acid volcanics. Such an isotopic composition implies that the contaminant was a restite after partial melting and extraction of an S-type granitoid or acid volcanic.

Studies of possible crustal contributions in the petrogenesis of continental flood basalts almost always consider the crustal contaminant to be relatively acidic. This would obviously be the most likely situation on thermal grounds, but if flood basalts are typically derived from large magma chambers close to the base of the crust (e.g. Hooper, 1984) then bulk assimilation of relatively basic lower crustal materials may be possible. AFC models with basic crustal contaminants my explain some of the more puzzling isotopic and compositional features of continental flood basalts.

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№ 121433

JURASSIC THOLEIITES OF ANTARCTICA: GEOCHEMISTRY

FLEMING, T. H., and ELLIOT, D. H., Inst. Polar Studies and Dept. Geol. Mineral., Ohio State Univ., Columbus, OH 43210

Jurassic tholeiites of the Ferrar Group, extending from Horn Bluff to the Dufek Massif, form a distinct geochemical province, which also includes the Tasmanian Dolerites. These rocks are distinguished from other Gondwana tholeiites by high $(^{87}Sr/^{86}Sr)_o$ (>0.709) and unique geochemical characteristics. In north Victoria Land (NVL) the Ferrar can be divided into two chemical groups, designated the high-Ti and low-Ti units. A similar division can be made in other Ferrar lava sequences.

Lavas and sills of the low-Ti unit make up >90% by volume of the Ferrar in NVL. Compared to other continental tholeiites, low-Ti lavas are: enriched in SiO_2 (52.5-57.5%); depleted in K_2O (0.2-0.9%) and TiO_2 (0.5-0.8%); and strongly LREE enriched. (La/Yb_n = 2.7-3.8, La_n = 29-70). Chilled margins of some sills are more evolved. Most sills have differentiated *in situ*. Mineral phases are Pig, Opx, Aug, Plag and Opq. Plag is unusually calcic (An90) and Pig unusually magnesian (En78). Pyroxene thermometry suggests eruption temperatures as high as 1250°C. Low-Ti lavas in the Beardmore area show evolution to higher SiO_2 contents.

High-Ti rocks cap the lava sequence in NVL. These lavas are higher in SiO_2 (56.7%), FeOT (15.5%), P_2O_5 (0.27%) and TiO_2 (1.9%) and lower in CaO (6.8%) and MgO (2.3%) than the low-Ti rocks. Trace element abundances are also markedly different, though incompatible element ratios change little. Chemical homogeneity in the low-Ti unit approaches analytical precision. Pig, Aug and Plag are chemically more evolved in the high-Ti rocks. Pyroxene thermometry yields eruption temperatures of 1150°C. $(^{87}Sr/^{86}Sr)_o$ of high-Ti lavas is lower than that of low-Ti lavas. Chemical and isotopic data suggest that high-Ti lavas are not derived by fractionation and/or contamination of the low-Ti magmas.

The Ferrar is similar to the Grande Ronde Basalt (GRB) of the Columbia River in its evolved chemical character. Although the Ferrar has distinctly higher $(^{87}Sr/^{86}Sr)_o$ ratios, chondrite normalized patterns and some element ratios (e.g., Th/Ta, La/Ta) exhibit similarities to the GRB.

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MINERAL CHEMISTRY OF COLUMBIA RIVER BASALT FLOWS: PETROGENETIC IMPLICATIONS

№ 136159

HODGES, Floyd N., Battelle Pacific Northwest Laboratories, Richland, WA 99352; MCKINLEY, James P., LONG, Philip E., and HORTON, Duane G., Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352

Electron microprobe analyses of primary minerals from numerous Columbia River basalt flows have been obtained as part of the evaluation of the geochemical characteristics of a potential nuclear waste repository site at Hanford. Bulk chemistry, crystal nucleation and growth kinetics, and pre-eruptive magmatic conditions all appear to have influenced mineral compositions.

Intratelluric phases plagioclase, orth. pyroxene and olivine reflect both the relatively uniform melt compositions and, to a lesser extent, magma mixing. Plagioclase phenocrysts exhibit slight normal zoning with minor oscillations and Na enrichment at rims of grains. These characteristics suggest relatively uniform pre-eruptive melt compositions; mixing events, if they occurred, either did not affect Na-Ca ratios of the melt or evidence of mixing events has been erased by diffusion or crystal-melt re-equilibration. Olivine compositions in the Roza flow and other flows (Fo_{17} to Fo_{62}) are apparently out of equilibrium with the whole-rock Fe-Mg. Olivine composition may be inherited from a more Mg-rich melt, indicating that the bulk chemistry of the flows may result from thorough mixing of magmas with different Mg-Fe ratios. Alternatively, Kd values for Fe-rich melts, such as the Roza, may differ significantly from values derived from more Mg-rich melts.

Clinopyroxene and Fe-Ti oxide compositions show the effect of the Mg-Fe ratio of the bulk liquid as well as a strong imprint of cooling rate of the magma. Development of a mosaic zoning pattern in clinopyroxenes as well as the occurrence and compositional range of pigeonite are correlated with cooling rate. Rapidly cooled samples exhibit dendritic Fe-Ti oxides morphologies or, in cases of very high cooling rates, Fe-Ti oxides are absent or occur as tiny equant blebs.

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№ 117671

TRACE ELEMENT AND ISOTOPIC FEATURES OF LITTLE-KNOWN MIOCENE BASALTS OF CENTRAL AND EASTERN OREGON: PETROGENETIC AND TECTONIC IMPLICATIONS

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Miocene basalts of central and eastern Oregon are derived from several mantle source regions and have experienced contrasting petrogenetic processes. We consider (from west to east) the Bear Creek, Slide Creek, and Owyhee basalts.

These basalts all have a calc-alkaline character, although they were contemporaneous with and erupted hundreds of kilometers east of andesitic rocks of the Western Cascades. Bear Creek magmas formed largely by partial melting of quartz eclogite, whose protoliths presumably were part of a subducted slab. They were only slightly modified by fractionation during ascent. Slide Creek magmas may well have had a similar origin; Sr isotopic ratios show that at least two distinct mantle components contributed to Slide Creek magmas. Owyhee basalts erupted from an episodically replenished, tapped, fractionating ("RTF") magma chamber, and subducted oceanic sediment was a major source component for these basalts.

In contrast, data from basalts associated with the border zone between the Blue Mtns. and the Basin and Range Provinces show that during Miocene and Pliocene times contributions from a subducted slab and RTF magama chambers occurred early and attenuated with time. This is consistent with an eastward migration of a slab-window and crustal underthinning that did not occur to the northwest where the Bear Creek basalts were erupted.

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VARIATION WITHIN THE PICTURE GORGE BASALT (PGB) AND THE POSSIBLE INFLUENCES OF RECHARGE VERSUS ASSIMILATION

No 135137

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A plausible parental magma for the PGB is represented by two high Mg dikes in the Monument dike swarm. Characteristics of this magma are similar to "anomalous" MORB (BVSP): Mg'=68, high Al_2O_3 (17.5 wt.%), low incompatibles (e.g., TiO_2=0.75 wt.%), REE at roughly 9X chondritic values, and La_n/Yb_n=1. Total phenocryst abundance is low (up to 5%) but variable. Microprobe data indicate that most of the phenocrysts are primitive (Ol=Fo_{87}, Pl=An_{88}), although sparse reversely zoned (Fo_{79-87}, An_{69-79}) phenocrysts are found. The observed primitive olivine phenocrysts would not be in equilibrium with typical mantle melts. Furthermore, the evolved set of phenocrysts imply a mixing event, either with an evolved liquid or through plucking of phenocrysts from a magma chamber or conduit wall. The evolved component (as represented by PGB flows in equilibrium with the evolved phenocrysts) could account for no more than 15% of the high Mg dike composition, as trace and minor elements rapidly approach zero concentration in simple mixing scenarios. Of critical importance is the conclusion that the high Mg dike has a spider diagram signature only slightly modified from that of the primary magma. This suggests that characteristics of MORB-normalized spidergrams that have sometimes been attributed to crustal assimilation (spikes at Rb and Ba and a trough at Nb) are in fact inherited from the mantle source. It is possible that this reflects a subducted slab component in the mantle. If crustal assimilation can be regarded as an unlikely factor, then another explanation is required to account for the variable degrees of enrichment in incompatible elements. Enrichment factors are not related to decoupling of LIL from HFS elements. Elements such as Y, Yb, Eu, Ti and Zr show enrichment factors of 2-3, while P, Rb, Ba, La, K, and Nb (in increasing order of enrichment) are enriched by factors of 3.7-9. Such extreme decoupling of trace elements (absent any assimilation) can be modelled by crystal fractionation with recharge.

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№ 130933

A MODEL FOR THE ORIGIN OF THE YAKIMA BASALT SUBGROUP, NW USA

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The Yakima Basalt Subgroup of the Miocene Columbia River Basalt Group consists of, from oldest to youngest, the Grande Ronde Basalt, the Wanapum Basalt, and the Saddle Mountains Basalt. All typically occur as large, homogeneous, fissure-fed flows, many of regional extent. They are chemically diverse, with most having compositions far removed from those expected to be produced by partial melting of spinel or garnet lherzolite. However, the uniformity of the flows, their large volume and low phenocryst contents, the scarcity of crustal xenoliths, and the absence of volcanic edifices (shields, calderas) and of more differentiated rock compositions, suggest that extensive storage of basalt magma at crustal levels did not occur.

We propose a model of progressive hybridization, with repeated melting and two stages of metasomatism, of a mixed peridotite-oceanic crust source, to obtain the Yakima lavas' evolved chemistry. We hypothesize that the source volume of the Yakima lavas originally contained much underthrust/accreted material, chiefly oceanic crust and associated sediments. The oceanic slab component hybridized with the overlying peridotite during the early stages of heating and melting. As melting continued, the Grande Ronde magmas were produced from the hybridized regions. The residue, depleted especially in the sedimentary component of the slab, continued to be heated, eventually producing the more MORB-like early flows of the Wanapum Basalt. After eruption of these early flows, the Wanapum lavas changed abruptly to basalts enriched in Ti and lower in Si, which make up the regional flows of the rest of the Wanapum Basalt. We infer this change to result from invasion of the old, partially depleted Grande Ronde source volume by a metasomatic melt of high-Ti pyroxenitic composition, like that documented in xenoliths from kimberlites. The Saddle Mountains Basalt was produced as the heat source shifted eastward, to involve new source volumes similar to those tapped earlier further west, including some regions unaffected by the high-Ti metasomatic event. All Saddle Mountains chemical types show generally higher levels of the incompatible trace elements and higher $^{87}Sr/^{86}Sr$ ratios than the older Yakima lavas, even where major-element chemistry is identical. This suggests that the onset of Saddle Mountains volcanism was triggered by arrival of a second wave of metasomatic fluid, of highly evolved geochemical character, which overprinted all Saddle Mountains source volumes.

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COLUMBIA RIVER BASALT GENESIS: NEW GEOCHEMICAL MODELS FOR THE MAIN SERIES

№ 135133

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It is apparent both from isotope schematics and variable incompatible trace element ratios that the basalts of the Main Series (Imnaha, Grande Ronde, and Wanapum) have multiple sources. But stratigraphically coherent flow subgroups retain similar isotope and incompatible element ratios while displaying geochemical evidence of extensive crystal fractionation. Crystal fractionation supplemented by recharge (RFC) adequately explains apparent discrepancies between degrees of fractionation required by compatible and incompatible elements. Low Mg'; Cr and Ni and the close negative correlation between Mg' and incompatible element concentrations imply that partial melting processes are not important within each subgroup. Also, because the variation in the enrichment of each incompatible element is more closely associated with D_{bulk} than to element mobility, assimilation with fractionation (AFC) is probably not significant. However, the mafic non-radiogenic nature of the potential assimilant would make crustal assimilation difficult to detect. Absence of primary melts representing equilibration with normal peridotite mantle suggests ol+pyx fractionation prior to eruption of the most primitive flows. Sharp changes in isotope and incompatible element ratios between subgroups suggest source changes. Spider diagrams show similarity to Karoo flood basalts with an overall similarity to ocean island tholeiites in their enrichment in all incompatible elements, but with a significant addition of material rich in the mobile (Sr, K, Rb, Ba) elements. A calc-alkaline signature (Nb depletion) is absent. The total geochemical signature is more easily associated with a plume rather than a back-arc spreading origin. The additional mobile-element-rich component may be derived either from a mantle source contaminated by a subducted slab, or from a variably enriched subcontinental mantle.

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№ 134550

GEOCHEMISTRY OF INCOMPATIBLE ELEMENTS IN THE COLUMBIA RIVER BASALTS

LAMBERT, R. StJ., DUKE, M.J.M., Dept. of Geology, Univ. of Alberta, Edmonton, AB, Canada, T6G 2E3; CHAMBERLAIN, V.E., Dept. of Geology, Univ. of Idaho, Moscow, ID, 83843.

The incompatible elements in CRB are enriched over chondritic values in some very peculiar, flow systematic, ways. The following related sets of elements are enriched in the following order (most enriched first, least enriched last): K, Rb, Cs; Ba, Pb, Sr, Eu; La through Lu with Y close to Gd; U, Th; Ta, Nb, Zr, Hf, Ti. It can also be shown that U is enriched over K (K/U = 8000-9000) and Th over La; that Ba is very highly enriched and Ti very highly depleted relative to their geochemical neighbors. K/Cs is in the range 13 to 20 $\times 10^3$, comparable to island arc basalts rather than O.I.B. K/Ba is close to 22, K/Rb close to 300 and K/Zr varies from 40 to 80, picture Gorge being the most primitive and Grande Ronde the least primitive.

The similar behavior of Ba, Pb, Sr and Eu, together with the absence of Eu anomalies in the various CRB formations, is difficult to explain by any fractional crystallization model: Sr and Eu should be incorporated in plagioclase, whereas Ba and Pb should stay in the liquid. Thus fractional crystallization, or more likely, partial melting of the sources, took place at too great a depth for plagioclase to be a liquidus phase of any significance. There is a case for considering the partial melting of phlogopite and/or amphibole-bearing eclogite as one of the principal sources of CRB magma. The REE, Fe/Mg, high incompatible element content, low transition metal content and Pb isotopic data are consistent with eclogite being one of the parental reservoir rocks.

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№ 125400

CRUSTAL CONTAMINATION IN DIKES OF THE COLUMBIA RIVER BASALT GROUP IN THE WALLOWA BATHOLITH, NORTHEAST OREGON

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Paralleling zones (positive relief common) of partly melted wallrock up to 2 m wide occur along some dikes. Embayed xenocrysts of quartz and plagioclase within the basalt verify wallrock contamination.

Dikes commonly contain a small number of granitic xenoliths. Many more xenoliths as well as hundreds to tens of thousands of metasedimentary inclusions from beneath the batholith have been found in either part or all of 14 dikes with widths of 5 to 13 m and lengths up to 3 km. Some dikes apparently were major feeders as suggested by width of partly melted wallrocks and general absence of chilled borders.

Metasedimentary xenoliths show conspicuous size reduction from narrow fingers of basalt that extend along and across bedding planes. About 95 percent of the xenoliths are less than 19 cm long; many are less than 3 cm. Most are elongated with ratios between 3 and 10. Highly contaminated basalt contains numerous microscopic slivers and lenses of metasediments (commonly siliceous) which show reaction with the magma.

Vugs lined with zeolites characterize nearly all contaminated dikes and are attributed to dehydration reactions associated with the conversion of unstable hydrous minerals of xenoliths into stable anhydrous phases. For example, biotite in granitic rocks is transformed into hundreds of very small cubes of magnetite whereas hornblende is converted into hypersthene and spongy clinopyroxene.

Some granitic xenoliths are on the verge of losing their identity. Complete disintegration apparently occurs because xenocrysts are common in highly contaminated dikes.

Two conclusions are (1) melting and size reduction of xenoliths suggest that comparatively few will survive in flows and (2) additional contaminated dikes must occur in the batholith because many concentrations of xenoliths surely were not seen during routine mapping in which dikes commonly were not walked from end to end.

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Nº 134553

THE UNIVERSAL OCCURRENCE OF INTERSTITIAL GRANITE GLASS IN THE COLUMBIA RIVER BASALTS AND ITS PETROGENETIC IMPLICATIONS

LAMBERT, R. StJ., MARSH, I.D., Dept. of Geology, Univ. of Alberta, Edmonton, AB, Canada, T6G 2E3; CHAMBERLAIN, V.E., Dept. of Geology, Univ. of Idaho, Moscow, ID, 83843.

Almost all CRB flows contain a residium which consists of 2 phases, the one chlorophaeite rich, the other a granite glass. The chlorophaeite includes types which vary from irregular aggregates to polycrystalline spherules and to drop-shaped inclusions which occur totally within the unaltered granite glass. The granite glass is usually isotropic but may be crytocrystalline. The average analysis for our samples from Wanapum and Grande Ronde flows is SiO_2, 76.1%; Al_2O_3, 12.5%; FeO(T), 1.7%; MgO, 0.6%; CaO, 0.4%; Na_2O, 2%; K_2O, 6% and TiO_2, 0.7%. The modal abundance by volume varies from a trace in Picture Gorge and 1% in some Imnaha flows to 10% in Grande Ronde and up to 24% in Wanapum. This yields a potential potassic granite batholith of about 25,000 cu.km, comparable in size to the Idaho Batholith to ~1 km depth. This glass is compositionally very similar to some of the Tertiary Granites of Skye and to Tertiary rhyolites from E. Iceland. The current petrogenetic theory for these latter occurrences is by derivation from ferrobasalt by fractional crystallization. The CRB glasses fit this model, except that in this case the rapid eruption of CRB has precluded the physical separation of the rhyolite component. Our present theory of direct derivation of CRB from the mantle without significant crustal contamination thus has the corollary that it is also possible to derive large volumes of granite from that same source given a suitable fractionation process.

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