Enclosure 5

LR-287-65

12/08/86

LETTER REPORT

Title: Review and Evaluation of Structures, Textures, and Cooling Histories of Columbia River Basalt Flows, Geol. Soc. Amer. Bull., v. 97, pp. 1144-1155, Sept., 1986, by Philip E. Long and Bernard J. Wood

AUTHOR: J. G. Blencoe
Chemistry Division
Oak Ridge National Laboratory

PROJECT TITLE: Technical Assistance in Geochemistry

PROJECT MANAGER: G. K. Jacobs

ACTIVITY NUMBER: ORNL #41 88 54 92 4 (FIN No. B0287)
NRC #50 19 03 01

OVERVIEW

This article discusses the origin of colonnade and entablature zones in subaerial basalt flows. The evidence weighed in theorizing an origin for these structures includes: (1) the macroscopic characteristics of subaerial basalt flows — and particularly the nature of fracturing (columnar jointing) in these flows; (2) the petrographic characteristics of rock samples from intraflow structures in subaerial basalts; and (3) the results obtained from mathematical modeling of the cooling of a subaerial basalt flow. It is concluded that colonnade zones in subaerial basalt flows form by slow conductive cooling, while entablature zones form by relatively fast, "convective" cooling induced by downward-ingressing meteoric water that enters the flow after its base and top have solidified.

REVIEW

Petrologic and Petrographic Characteristics of Colonnade and Entablature Zones in Subaerial Basalts

In numerous localities worldwide, subaerial basalt flows are characterized by laterally persistent, intraflow structures known as "colonnade" and "entablature." (Hereinafter, these structures will be referred to as "colonnade zones" and "entablature zones.") Colonnade zones commonly occur in the lower and upper third of a subaerial basalt flow, and consist of relatively well-formed ~0.3-2 m basalt columns which are typically oriented perpendicular to the base of the flow. The lower (basal) colonnade zone commonly grades upward into an entablature zone which occupies the interior one-third or upper one-half of the flow. The entablature zone exhibits small (0.2- to 0.5-m-diameter), irregular to hackly columns, which may form radiating patterns, or otherwise deviate from an orientation perpendicular to the base of the flow. Finally, in many subaerial basalt flows, entablature grades upward into an upper colonnade zone, which in turn is overlain by a vesicular flow top.

In most subaerial basalts there is a close relationship between intraflow structures and petrographic textures. Samples of basalt from colonnade zones typically exhibit intersertal to intergranular textures. By contrast, samples from entablature zones are characterized by subhyalophitic textures, dendritic opaque oxide minerals, and an inclusion-charged glassy mesostasis.

Long and Wood stress that the petrographic characteristics of colonnade and entablature basalt can be highly variable. For example, both the quantities and the textures of mesostasis in entablature basalt can vary significantly from one flow to the next. In particular, the quantities and morphologies of opaque oxide grains in the mesostasis are highly variable from one flow to another. In some flows it is observed that opaque oxide phases are virtually absent in the entablature, whereas in other flows the textures of opaque grains differ only slightly across the entablature-colonnade contact(s). Despite these variations, however, two features of colonnade and entablature zones are consistent from one flow to the next: (1) the quantities of mesostasis are always markedly greater in entablature zones than in colonnade zones, and (2) the quantities of inclusions (blebs) in entablature mesostasis are always much greater than the quantities of inclusions in colonnade mesostasis.

Internal Structures and Textures of Grande Ronde Basalt Flows

In attempting to explain the origin of colonnade and entablature zones in subaerial basalts, Long and Wood focus attention on the basalt flows of the Grande Ronde Basalt formation in the Columbia Plateau of Washington state. The authors believe that this formation merits special attention because an unusually high proportion (~60%) of Grande Ronde flows exposed in the central part of the Columbia Plateau exhibit well-defined entablature zones.

According to Long and Wood, Grande Ronde Basalt flows are typically stratified from top to bottom as follows: (1) a ropy to brecciated, vesicular flow top; (2) upper colonnade with relatively large, irregular columns (0.7 to 2.2 m in diameter) — with or without vesicles; (3) entablature, consisting of relatively small, hackly to regular columns (0.2 to 0.9 m in diameter); (4) lower colonnade, consisting of well-formed to wavy, large columns (0.5 to 1.5 m in diameter); and (5) a glassy basal zone that varies greatly in thickness and may be highly fractured, vesicular, or pillowed with hyaloclasite. However, the authors also stress that, in a given flow, these structures may vary greatly in thickness, be entirely absent, or occur repeatedly.

Long (1978) has documented the relationships between the petrologic and petrographic features of Grande Ronde Basalt flows. He classified the flows into three general types: Type I, Type II, and Type III. Long and Wood stress that these flow types should be regarded as hypothetical end members, among which there can be continuous gradation of petrologic and petrographic characteristics.

Type I Flows

Type I flows are composed mainly of highly irregular colonnade basalt. Type I flows are comparitively thin (10-30 m thick), they contain irregular, tapering columns 1-2 m in diameter, they always lack a distinct entablature, and they have a poorly developed vesicular flow top. Also, Type I flows exhibit little variation in petrographic texture throughout the main body of the flow. Specifically, with the exception of the glassy basalt in the upper 5% of the flow (this basalt is believed to be formed by rapid cooling of surficial and near-surface lava shortly after eruption), Type I flows exhibit intersertal to intergranular textures throughout their thicknesses. Moreover, the quantities and textures of mesostasis glass, as well as the morphologies of opaque grains, are similar in all parts of the flow beneath the flow top.

Type II Flows

Type II flows exhibit repeated colonnade and entablature tiers. An upper colonnade zone may or may not be present. Type II flows are comparatively thick flows (45-76 m thick) and exhibit columnar tiers of alternating entablature and colonnade-type columns in the lower half of the flow, which grade upward into a hackly entablature. In the upper one-third of some tiered flows, layers are defined by thin zones of abundant vesicles. In the entablature zones, fanning of columns is sometimes observed. Finally, Type II flows commonly possess a clinkery flow top.

Type II flows also exhibit petrographic characteristics that vary in accordance with macroscopic intraflow structures. Samples of basalt from the lower colonnade typically display intersertal to intergranular textures that are finer grained but otherwise similar to basalt samples from Type I flows. In contrast, basalt samples from entablature zones typically exhibit subhyalophitic textures, dendritic opaque oxide minerals, and an inclusion-charged glassy mesostasis. Another important observation is that glassy mesostasis is much more abundant in entablature zones than in colonnade zones. Colonnade zones typically contain 15 to 25 volume % mesostasis, whereas entablature zones contain from 35 to 65 volume % mesostasis.

Type III Flows

Type III flows are typically thick flows (30-80 m) that possess a distinct lower colonnade zone and a single, well-defined entablature zone. Therefore, unlike Type II flows, the colonnade and entablature sequence is not repeated. A crude upper colonnade caps the entablature of most Type III flows. Basal pillow basalt, while observed in all types of Grande Ronde Basalt flows, is most common in Type III flows. The columns in the colonnade zones frequently exhibit pinch-and-swell structure. The entablature zone is typically a complex pattern of small, radiating columns. The textures of colonnade and entablature basalt samples from Type III flows are similar to those in Type II flows.

In Type III flows, the boundary between colonnade and entablature is marked by an abrupt change in fracture abundance and column size. This single, sharp entablature-colonnade contact commonly occurs approximately one-third of the way up from the base of the flow. Samples ~1 m apart on either side of this contact show the characteristic textures of colonnade and entablature. In the few flows where the entablature-colonnade contact is gradational, the textures of basalt samples are also gradational across the contact. Therefore, in type III flows, petrographic textures consistently reflect macroscopic features.

Origin of Colonnade and Entablature Zones in Grande Ronde Basalt Flows

The petrographic characteristics of colonnade and entablature zones in Grande Ronde Basalt flows – specifically, the quantities and textures of the mesostasis in entablature zones, along with the quantities and morphologies of opaque grains in these zones relative to colonnade zones – suggest strongly that entablature zones formed during periods of comparatively rapid cooling of a flow. Therefore, Long and Wood propose that entablature zones form when comparatively slow rates of cooling (which produce zones of colonnade basalt) are suddenly interrupted or replaced – spatially or temporally – by rates of much faster cooling. This hypothesis accounts for the greater quantities of mesostasis observed in entablature samples. Long and Wood emphasize, however, that rates of cooling during the formation of entablature zones were not so rapid that crystallization was arrested completely. Instead, the accelerated cooling typically gave rise to higher rates of crystal nucleation that produced a higher density of both crystalline and glassy inclusions (rounded blebs) in the mesostasis.

The dendritic morphologies of the opaque oxide grains in samples of entablature basalt are also consistent with a significant degree of undercooling that would result from rapid cooling. In some flows, titaniferous magnetites are completely absent in entablature zones, and this observation suggests that, in these flows, rates of cooling were sufficiently rapid to completely suppress the nucleation and growth of magnetite. These same samples of entablature basalt typically exhibit mesostasis with the finest grain size. This observation, too, is consistent with a high rate of cooling.

Thus, for Type II and Type III basalt flows, it is evident that there were significant differences in the rates of cooling across entablature-colonnade contacts. Significantly, however, the thermal properties of silicate rocks and mathematical models of conductive cooling indicate that abrupt changes in rates of cooling of a basalt flow cannot occur if cooling is attributable entirely to conductive heat loss (Jaeger, 1961; Spry, 1962). In other words, the apparent "quenching" of the center of a subaerial basalt flow cannot occur if the flow cools in an undisturbed conductive manner.

Because undisturbed conductive cooling cannot explain "quenching" of the interior of a subaerial basalt flow, Long and Wood suggest that a special event must occur during the cooling history that induces more rapid cooling. They suggest that the most likely means of rapid cooling is for liquid water to invade the solidified top of the cooling lava flow along propagating cooling joints. Water has a high heat capacity and latent heat of vaporization and, therefore, combined with its low viscosity, it provides a viable medium for removal of heat via convective circulation. The ability of water to induce relatively high cooling rates has been amply demonstrated in modern extrusive basalts such as the Haemiey basalt flow (Bjornsson et al., 1982) and Kilauea Iki Lava Lake (Hardee, 1980).

Cooling of Grande Ronde Basalt Flows via Water Ingress

Laterally extensive pillow structures that occur locally at the bases of Grande Ronde Basalt flows (Long and Davidson, 1981) reflect the lacustrine environment into which these lavas were erupted. Paleoclimatic evidence indicates that the environment during the main Grande Ronde eruptive phase (16.5-14.5 m.y. B.P.) was subtropical with a relatively high rainfall (Newman, 1970; McKee et al., 1977). Under such conditions, there would have been considerable runoff of meteoric water and a potential for the development of both long- and short-lived lakes. Accordingly, Long and Wood propose that, as thick Grande Ronde Basalt flows invaded stream valleys and lakes, they caused temporary damming and disruption of local drainage systems. This eruptive phase was followed by a period of subaerial cooling that established a quenched flow top, a glassy basal zone, a basal colonnade zone and, in some cases, an upper colonnade zone in each lava flow. However, in this climatic and physiographic setting, it is also to be expected that, within a brief period of time – perhaps a few months to a year – water would overflow the tops of cooling flows. Influx of water into the solidified tops of flows along columnar joints and cracks would have increased the rates of cooling in the interiors of the flows. Alternatively, widespread flooding might have occurred as subsequent basalt flows rapidly displaced ponded water.

Mathematical Models for the Cooling of Grande Ronde Basalt Flows

To test the idea that flood waters affected the cooling histories of many Grande Ronde Basalt flows, Long and Wood developed a simple one-dimensional thermal model that mimics convective removal of heat by water. Specifically, two simple hypothetical cases of basalt-flow cooling and solidification were investigated mathematically to explore the possibility that water ingress can explain the development of entablature zones in Grande Ronde Basalt flows.

Case 1

In Case 1, water penetrates the solidified top of the flow and cools it to ambient temperature down to a depth "x." The flow above depth "x" remains fixed at ambient temperature ($0^{o}C$). Cooling below depth "x" proceeds by pure conduction.

Case 2

In Case 2, water also penetrates the solidified top of the flow and cools it to ambient temperature down to a depth "x." However, unlike

Case 1, as soon as the solidus is reached at a particular depth, the basalt is instantaneously quenched to 0°C. Therefore, as the lava below depth x cools through the solidus, the cold boundary – representing the depth of water penetration – follows the solidus down through the flow, extending the zone of quenching through the flow interior.

Results for Case 1

Results for Case 1 indicate that a <u>fixed</u> cold boundary within a subaerial basalt flow cannot quench more than a small fraction of the liquid beneath it. Therefore, Case 1 is a poor model for subaerial basalt flows with thick entablatures.

Results for Case 2

Results of calculations for Case 2 indicate that a "front" of downward descending water immediately above the liquid/solid interface can produce a thick entablature zone in the interior of a flow. Also, the calculations indicate that the bottom part of a flow will continue to cool slowly through the solidus, thereby allowing the basal colonnade zone to extend upward. Therefore, the contact between the lower colonnade and the entablature represents the position in a flow where the upper and lower solidification fronts meet and where the last magma crystallizes. The upper solidification front moves downward from the top of the flow at a faster rate than the lower solidification front moves upward from the base of the flow and, therefore, the upper solidification front is responsible for cooling most of the flow. (The relatively slow upward movement of the solid/liquid interface near the bottom of the flow – compared to the downward movement of the solid/liquid interface near the top of the flow – may explain the observation that lower colonnades are generally better developed and exhibit more perfect column shapes than do upper colonnades.) Upper colonnades are explained by the Case 2 model if it is assumed that slow cooling prior to flooding continues long enough to crystallize a significant portion of the upper part of the flow.

Origin of Type I, II, and III Basalt Flows in the Grande Ronde Basalt

Type I Flows

In view of the comparatively simple "typical" petrology and petrography of Type I flows, and particularly the absence of a well-defined entablature zone, Long and Wood conclude that these flows solidified by slow conductive cooling. Type I flows are typically thinner than Type II or Type III flows and, therefore, Type I flows were less likely to pond and disrupt local drainage patterns. Consequently, Type I basalts were less susceptible to "quenching" by flood waters.

In some Type I flows, the thickness of the lower colonnade zone varies markedly, even to the extent of being almost completely absent locally. Where the lower colonnade of Type I flows is thin, Long and Wood surmise that conductive cooling must have been very rapid. Correspondingly, where Type I flows exhibit a thick basal colonnade zone, it is logical to conclude that conductive cooling was comparatively slow.

Type II and III flows

In the Case II mathematical model investigated by Long and Wood, progressive downward movement of a quenched zone induced by water ingress generates a thick, rapidly cooled entablature zone in the interior of the flow. This model accurately predicts the principal macroscopic features of Type III Grande Ronde Basalt flows. However, in Type II flows, colonnade and entablature tiers are repeated from the bottom to the top of the flow. In order to simulate conditions that could produce this pattern of intraflow structures, Long and Wood devised a model based on cyclic flooding. Significantly, this model reproduces the cycle of fast and slow cooling that is required to give the appropriate structural and textural variations in Type II flows. Therefore, mathematical modeling indicates that Type II flows can be formed by multiple flooding events with intervening dry periods.

Conclusions

Evidence and analysis presented by Long and Wood imply the following conclusions regarding the origin of colonnade and entablature zones in Grande Ronde Basalt flows.

1. Colonnade zones in Grande Ronde Basalt flows form by slow conductive cooling, while entablature zones form by relatively fast, "convective" cooling induced by downward-ingressing meteoric water that enters the flow after its base and top have congealed.

2. The water content of primary basaltic lava, evolution of volcanic gases, and kinematics of flow emplacement appear to be irrelevant to to the development of colonnade and entablature zones in Grande Ronde Basalt flows.

REFERENCES

Bjornsson, H., Bjornsson, S., and Sigurgeirsson, Th., 1982, Penetration of water into hot rock boundaries of magma at Grimsvotn: Nature, v. 295, p. 580-581.

Hardee, H. C., 1980, Solidification in Kilauea Iki Lava Lake: Journal of Volcanology and Geothermal Research, v. 7, p. 211-223.

Jaeger, J. C., 1961, The cooling of irregularly shaped igneous bodies: American Journal of Science, v. 259, p. 721-734.

Long, P. E., 1978, Characterization and recognition of intraflow structures, Grande Ronde Basalt: RHO-BWI-LD-10, Rockwell Hanford Operations, Richland, Washington, 74 p.

Long, P. E., and Davidson, N. J., 1981, Lithology of the Grande Ronde Basalt with emphasis on the Umtanum and McCoy Canyon flows, in Myers, C. W., and Price, S. M., eds., Subsurface geology of the Cold Creek syncline: RHO-BWI-ST-14, Rockwell Hanford Operations, Richland, Washington, July, 1981, 240 p.

McKee, E. H., Swanson, D. A., and Wright, T. L., 1977, Duration and volume of Columbia River basalt volcanics, Washington, Oregon and Idaho: Geological Society of America Abstracts with Programs, v. 9, no. 4, p. 463-464.

Newman, K. R., 1970, Palynology of interflow sediments from the Standard Oil Company of California Rattlesnake Hills No. 1 Well, Benton County, Washington, in Gilmour, E. H., and Stradling, D., eds., Second Columbia River Basalt Symposium proceedings: Cheney, Washington, Eastern Washington State College Press, p. 201-208.

Spry, A., 1962, The origin of columnar jointing, particularly in basalt flows: Geological Society of Australia Journal, v. 8, no. 2, p. 191-216.

EVALUATION

This article discusses the origin of colonnade and entablature zones in subaerial basalt flows. The evidence weighed in theorizing an origin for these structures includes: (1) the macroscopic characteristics of subaerial basalt flows — and particularly the nature of fracturing (columnar jointing) in these flows; (2) the petrographic characteristics of rock samples from intraflow structures in subaerial basalts; and (3) the results obtained from mathematical modeling of the cooling of a subaerial basalt flow. It is concluded that colonnade zones in subaerial basalt flows form by slow conductive cooling, while entablature zones form by relatively fast, "convective" cooling induced by downward-ingressing meteoric water that enters the flow after its base and top have solidified.

The authors' explanation for the origin of colonnade and entablature zones in Grande Ronde Basalt flows is fully consistent with the evidence presented. However, it is also true that additional evidence could have been marshalled to further elucidate the origin of these intraflow structures. In particular, it would be very informative to obtain whole-rock oxygen isotope data for samples of basalt taken from colonnade and entablature zones. If the authors' explanation for the origin of entablature zones is correct, then samples of basalt from the layer of rock immediately above each entablature zone should offer evidence of oxygen isotope exchange between basalt and meteoric water. Further, it is distinctly possible that the Fe^{2+}/Fe^{3+} ratio of mesostasis glass in the rocks immediately above entablature zones will provide evidence of intimate contact with hot, oxidizing meteoric waters.

Finally, in text presented near the end of this article, Long and Wood imply that all of the secondary minerals now found in Grande Ronde basalts formed after burial beneath superjacent rocks. However, no evidence is provided to support this conclusion. Therefore, the reader is left wondering whether some of the secondary minerals observed in entablature-bearing flows might have crystallized contemporaneously with entablature basalt via rock-water interaction in the rocks immediately above the part of the flow where entablature basalt was forming.

Enclosure 7

pc

RES/NATIONAL LABORATORIES MEETING

Crowne Plaza Holiday Inn
1750 Rockville Pike
Rockville, Maryland

9-10 APRIL, 1987

AGENDA

April 9, 1987

8:30 a.m.	Introductory Remarks
9:00 a.m.	Aging
10:30 a.m.	Break
10:45 a.m.	Thermal Hydraulics
12:15 p.m.	Lunch
1:30 p.m.	Severe Accidents
3:00 p.m.	Break
3:15 p.m.	Risk and Reliability
4:45 p.m.	Seismic
5:45 p.m.	End of First Day

April 10, 1987

8:30 a.m.	Nuclear Waste Disposal
9:30 a.m.	Human Factors
10:30 a.m.	Break
10:45 a.m.	Equipment Qualification
11:45 a.m.	Lunch
1:00 p.m.	Radiation Protection
2:00 p.m.	Peer Review and Quality Control
3:30 p.m.	Utilizing University Expertise
5:00 p.m.	End Meeting

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

APR 1 7 1987

TO: ATTENDEES OF THE RES/NATIONAL LABORATORIES MEETING, HELD 9-10 APRIL, 1987

The attached is a summary of the meeting. Please provide me with any additions or corrections you may have.

David Bessette
David E. Bessette
Office of Nuclear Regulatory Research

Summary of RES/National Laboratories Meeting

Held on 9-10 April, 1987 in Rockville, Md.

1. Introductory Remarks

Mr. Beckjord opened the meeting. The meeting is intended to assist in the research planning process by providing a mechanism for the national laboratories to furnish input for future research needs. The current meeting is to discuss research needs and priorities for FY 1989 and beyond. The intent is to continue these types of gatherings, meeting briefly in the Fall during the Water Reactor Safety Information Meeting to discuss management issues and again in the Spring for a more extended duration of about two days. Such meetings address one recommendation from the recent NAS report of Revitalizing Safety Research, that of improving the research planning process.

A number of other activities are underway to respond to the NAS report. A statement of research philosophy is being developed to be part of the Agency's strategic plan. A draft research philosophy statement is currently being circulated for comment. The statement considers the question of what information is needed and how this information should be obtained through research. A general guideline is that about 15% of the research budget should be reserved for long term research not directly associated with particular current issues.

The NUREG-1150 report highlights again the uncertainties associated with containment performance in the event of vessel melt-through. The forthcoming BNL study on uncertainties in severe accident phenomena is expected to support the same conclusions. Given the consequences of breach of containment in a severe accident, priority should be given to measures to maintain adequate core cooling and to prevent full core melt. Emphasis should, therefore, be given to component, systems, and human reliability to prevent accidents, and to development of procedures for accident management to terminate accident sequences and recover the plant prior to vessel melt-through or containment breach. It would appear that accident management to limit core damage, restore core cooling, and recover the plant has the potential to yield significant, near term, cost-effective improvements to safety.

Mr. Malinauskas reviewed the process by which the laboratories prepared their presentations. Nine decision units were defined. Each of the nine laboratories assumed responsibility for a decision unit. Each laboratory consulted with other laboratories in attempting to represent the views of the different laboratories for a given decision unit. This was done using telephone and mail rather than face-to-face meetings. The presentations should, therefore, be representative of all the laboratories but may not necessarily represent a complete consensus. Priorities may not be completely formulated or agreed upon.

[Rather than repeating the information found in the handouts, the following summarizes some of the main points of discussion.]

2. Aging

Mr. Freshley presented the Aging decision unit. The plans for aging research were concluded to be sound, properly focused, and integrated. The program is being coordinated with industry and DOE. Foreign cooperation is being carried out and may be expanded. The future research trend may be away from metal components as this work is completed, and towards, for example, electrical systems. While much work is underway, more would be desirable if funding were available.

Life extension can be considered as part of the aging issue. A point to be considered is how the Commission and industry will approach life extension, i.e. whether the licensee will be renewed for 10 years, 20 years, or indefinitely. Industry is approaching the aging question on the basis that replaceable components should be treated as part of plant maintenance. Given that the NRC already has a set of criteria that a plant must meet, a case could be made that a plant may continue to operate for as long as it meets the criteria. The research program on aging should consider whether current criteria are sufficient and complete. Reliability trends and inspection and test requirements need to be evaluated.

3. Thermal-Hydraulics

Mr. Charlton summarized this decision unit. The subject of technical integration of thermal hydraulic research results is receiving increased attention. A trial B&W study is underway that considers human factors, reliability analysis, and thermal-hydraulic code modeling. Future experimental programs will focus on B&W experiments. There is also a need for large scale experiments for determination of flow regime and constitutive relations. The flow regime map is currently based on fully developed flow in small pipes and the codes may need to be revised to account for scale effects. The Japanese TPTF results are currently being evaluated in this regard. The need for a new integral facility should be weighted against the alternative of separate effects experiments. A question that is not resolved is how good do the codes need to be for use in the regulatory process.

The codes could also be applied to provide improved fidelity for plant simulators. Such application would warrant its own consideration of required accuracy. Whether advanced LWR designs will require thermal-hydraulic safety research will need to be evaluated.

University work in the area of thermal-hydraulics is strongly issue oriented. This is in juxtaposition to what the universities would like to perform, which is basic, phenomenological research.

4. Severe Accidents

Mr. Walker provided information on this decision unit. A survey of the laboratories indicated that the principal products of severe accident research should be associated with accident management and improved hardware and procedures. The next level of importance was ascribed to emergency planning and models and data for PRA applications.

The laboratories were also surveyed for their views on the state of understanding and modeling of various severe accident phenomena. For the most part, there was general agreement among the laboratories, however, for some of the issues the opposite was the case. An example of the latter was high pressure melt ejection. In relatively few instances (about 15%) was the state of knowledge and modeling generally agreed to be good. In contrast, for about 1/4 of the phenomena the understanding was judged to be poor. Research is underway to address some but not all of the phenomena for which understanding is deficient. The general conclusion is that the technical basis for understanding severe accident phenomena is currently inadequate and that significantly more work is needed. More emphasis is also required relative to BWR phenomena.

5. <u>Risk and Reliability</u>

Mr. Hall reviewed this decision unit. The highest research priorities were identified with: common cause failure due to human error and extreme external events; equipment failure rate information including aging effects; applications of PRA to regulatory decision-making, inspection, and plant operations; and assessing plant safety relative to a safety goal. Human factors was felt to be the dominant influence on plant safety.

6. <u>Seismic</u>

Mr. Anderson presented his survey of this decision unit, which is directed at assessing seismic hazard, seismic risk, and seismic margins. The survey performed included national laboratory programs only and did not include other domestic and international cooperative activities. Therefore, it included about 1/2 of the total NRC program. A number of areas were noted for continued seismic research.

7. <u>Waste Management</u>

Mr. Jacobs discussed the laboratory survey of this decision unit. Mill tailings were not included since the subject was considered resolved for the purpose of research. The research being carried out is associated with high and low level waste disposal. It includes materials behavior of waste packaging, hydrology, geochemistry, and modeling. In the low level waste area, most of the work is being performed at national laboratories whereas the opposite is true for high level waste, where most of the work is at universities. It is generally agreed that the work should concentrate on general model development and validation rather that site-specific characterization. The current work appears to have the appropriate balance with the most critical issues being addressed. There was concern that the level of effort was below what is required. In this regard, any postponement of the high level waste repository was viewed as providing more opportunity to perform the needed research rather than allowing research to be deferred.

Improved interchange with NMSS and DOE should be sought to ensure that the research continues to have the proper focus. This is particularly true in view of the uncertainty in timing and the size of the DOE high level waste program, which is two orders of magnitude greater than the NRC research effort. More emphasis should be given to integration and synthesis of research results. The need to explore alternatives to shallow land burial for low level waste continues to exist since the States are pressing for such alternatives.

8. Human Factors

Mr. Ehret summarized this decision unit. The various laboratories were surveyed for their views. In a number of instances, it was difficult to separate out specific views on human factors since some people couple the subject inextricably with probabilistic risk assessment research. A lot of human factors research has been performed by other agencies. The NRC does not necessarily need to perform a large amount of human factors research as much as it needs to take account of what already exists from other sources.

A structured human factors research program should be circulated and agreed upon. It should specify the research objectives in terms of utilization of the information in the regulatory process. An example of poor human factors procedures currently in use by the industry is the use of extended working hours and shift rotation among over half the operating plants, the effect of which on human performance are well known. Fitness for duty is another important area the NRC should consider. The conclusion from the NAS report regarding human factors was cited, wherein it states that the NRC should establish a regulatory climate that encourages technological advances in the area of human factors rather that one that is merely neutral.

9. Equipment Qualification

Mr. Saffell provided information on this decision unit which includes environmental and dynamic qualification of electrical and mechanical equipment. Fire protection was also included. Fires occur in plants at a not uncommon rate. PRAs have indicated that fires may be a significant contributor to core melt. Installed fire protection systems can also have adverse systems interaction in terms of shorting electrical equipment and control room habitability. Commission and NRR support for equipment qualification research has been intermittent in recent years. A number of information needs were identified. More technical integration of past work and planning is needed in formulating a future research effort.

10. Health Effects

Mr. Straume discussed this decision unit. A number of issues could be considered as candidates for research. The NRC research effort should be properly coordinated and integrated with other programs being performed by other agencies.

11. Peer Review and Publications

Mr. Malinauskas summarized issues regarding peer review and publication of research results. The distinction between peer review and quality assurance was noted. It was commonly agreed that publication of research results in refereed scientific journals should receive greatly increased attention.

NUREGs were decried as often being too thick and prone to containing extraneous information such as boilerplate, facility descriptions, and data listings. Being voluminous makes them difficult or impossible to peer review prior to publication. Since they also come out in large numbers, it is impossible for most people to read them. The suggestion was made that the reports should contain a much higher information density. Other reports such as facility description documents should be referenced rather than repeating information found elsewhere. The alternative view was also expressed, that is, past experience has driven NUREGs to be all things to all people.

Data listings in reports were viewed as being particularly useless since such information should be transmitted via data tape. If not documented, the data should, however, be archived in a data bank.

12. <u>Utilization of University Expertise</u>

Mr. Malinauskas described proposals for utilizing university expertise. The laboratories commonly agreed on the value of utilizing universities. Universities are primarily interested in projects through which graduate students can be supported. This calls for a certain amount of long term stability and long term rather than short term expectations of results. Experience has generally shown that universities can deliver useful products according to a set schedule.

Grants are limited to 1% of the RES budget. Other university work can be funded as part of a national laboratory program or directly by RES through a sole source or competitive bid. It was suggested that an RES staff member be assigned responsibility for tracking the level of university utilization. It was noted that NRC does not have the responsibility or resources to assure that the nation's nuclear engineering university programs receive a level of support sufficient to assure an adequate supply of nuclear engineers. This properly falls within the responsibility of DOE and NAS.

13. <u>General Observations Provided During the Meeting</u>

The laboratories generally commented on the value of the exercise that went into preparing presentations for the meeting. Cooperation among the labs was good, and the consultation process should be continued. For several of the decision units, the feeling was that the level of technical integration and syntheses of results needed improvement. The responsibility to assure technical integration lies with the RES staff, but the laboratories could provide assistance as required. In some cases, adequate technical integration might exist, but this was not obvious to the laboratories. This points to a need to bring together different laboratories working on different aspects of a decision unit to exchange information and to clarify how the different elements of research are contributing to ultimate resolution of given issues.

DISTRIBUTION:

Battelle Pacific Northwest Laboratory

I. S. Levy
Max Freshley
Robert Sorenson

Battelle Columbus Laboratory

B. F. Saffell
Rich Denning

Oak Ridge National Laboratory

Gary Jacobs
A. P. Malinauskas

Idaho National Engineering Laboratory

Walt Pasedag
Paul North
Tom Charlton

Brookhaven National Laboratory

Robert E. Hall
Walter Y. Kato
Robert A. Bari
U. S. Rohatgi
J. G. Guppy

Argonne National Laboratory

Richard A. Valentin
Charles F. Ehret

Los Alamos National Laboratory

Dick Bohl
Charles Anderson
Tom Hirons

Lawrence Livermore National Laboratory

Garth Cummings

Sandia National Laboratory

Dave McCloskey
Jack Walker

NRC/RES

David Bessette
C. Z. Serpan, Jr.
Charles N. Kelber
Guy A. Arlotto
Bill Morris
Denwood F. Ross, Jr.
Eric S. Beckjord
D. Sullivan
M. Silberberg
J. Murphy
A. Murphy
H. Peterson
Louis Shotkin
Richard Grill

<ITEMNO> 2932 <DATE> 1983, August
<AUTHOR> Allen, C.C. Strope, M.B.
<TITLE> Microcharacterization of Basalt--Considerations for a Nuclear Waste Repository
<PUBNO> RHO-BW-SA-294P
<SITE> HAN <PROJECT> BWIP
<COMMENT> Presented at Electron Microscopy Society of America Meeting, Phoenix, AZ, August 8-12, 1983.
<KEYWORD> GEOCHTA BASALT NO KEYWORDS
#EXP #MIN/PET EVAL3
<ABSTRACT>The National Waste Terminal Storage Program of the U.S. Department of Energy is assessing a number of rock types to determine their suitability for the disposal of nuclear waste. As a part of this effort, the Basalt Waste Isolation Project (BWIP) is investigating the Pasco Basin in southeastern Washington State as the possible site of a nuclear waste repository in basalt (NWRB). The microcharacterization work described in this paper results in a detailed identification of the minerals and other phase assemblages that provide the basis for a determination of the environment that acts to control geochemical conditions in an NWRB. Interactions between the basalt, groundwater, and proposed waste packages are being studied to ensure that the final repository and waste package designs meet all requirements for safety and isolation. The rock at the proposed repository location is a fine-grained tholeite, containing crystals of plagioclase, pyroxene, and titaniferous magnetite plus a glass-rich mesostasis. Partial reaction of this mesostasis with groundwater is thought to be the predominant source of most elements in the groundwater. The composition of the mesostasis and its reaction thus should affect the chemical environment of the waste packages. For this reason, microcharacterization of the mesostasis, particularly the glass phase, has been conducted by the BWIP in support of hydrothermal laboratory studies that provide data to geochemical and performance models.
<EVAL>
<EDATE> 06-14-85 <CDATE> <ADSEPNO> 2977

<ITEMNO> 4364 <DATE> 1983, November
<AUTHOR> Allen, C.C. Lane, D.L. Palmer, R.A.
Johnston, R.G.
<TITLE> Experimental Studies of Packing of Material Stability
<PUBNO> RHO-BW-SA-313/P
<SITE> <PROJECT> BWIP
<COMMENT> Published in the Proceedings of the Materials Research Society Symposium, Scientific Basis for Nuclear Waste Management, Boston, Massachusetts, November 14-17, 1983
<KEYWORD> GEOCHTA NO KEYWORDS #PACKAGE
#EXP #MIN/PET #COND/REAC
EVAL3
<ABSTRACT>The Basalt Waste Isolation Project is conducting experiments to assess the stability of bentonite (sodium montmorillonite) and crushed basalt as waste package packing materials in a nuclear waste repository in basalt. The experiments are designed to identify changes in physical, chemical, and mineralogical properties that these materials could undergo in the repository environment. A series of bentonite dehydration experiments showed that after 1 year at 370 deg C the clay's structural and swelling properties were preserved and only reversible dehydration occurred. At 440 deg C, however, irreversible dehydration, collapse of the clay structure, and loss of swelling ability took place. Hydrothermal tests using bentonite, or an equal mixture of bentonite and basalt, along with synthetic groundwater, were also conducted. A bentonite + water experiment showed negligible structural alteration at 200 deg C, although some iron enrichment of the clay occurred. At 300 deg C, partial conversion of the montmorillonite to an iron- and postassium-rich smectite occurred, along with the formation of secondary quartz and albite. An experiment in the basalt + bentonite + water system at 150 deg C resulted in partial etching of the basalt grains, but no detectable change in rock or clay mineralogy. At 300 deg C, the basalt was strongly etched. Furthermore, iorn- and potassium-rich smectite apparently replaced montmorillonite as the dominate clay, and secondary silica, zeolites, and minor feldspar were formed. These mineral assemblages are thought to be metastable at 300 deg C, based on natural analogs. The kinetics and reaction paths of further transformations of packing materials are important areas for continued study.
<EVAL>
<EDATE> 07-31-86 <CDATE> <ADSEPNO>

<ITEMNO> 1477 <DATE> 1980, September
<AUTHOR> Ames, L.L.
<TITLE> Hanford Basalt Flow Mineralogy
<PUBNO> PNL-2847
<SITE> HAN <PROJECT> BWIP
<COMMENT>
<KEYWORD> GEOCHTA BASALT CALCITE
CHEMICAL ANALYSIS CLAYS DRILL CORES
ELECTRON MICROPROBE ANALYSIS EXPERIMENTAL DATA FELDSPARS
GEOLOGIC DEPOSITS HANFORD RESERVATION ILMENITE
MAGNETITE METALS MINERALOGY
OXIDES PYROXENES QUARTZ
WELLS ZEOLITES #MIN/PET
#EXP EVAL3

<ABSTRACT>Mineralogy of the core samples from five core wells was examined in some detail. The primary mineralogy study included an optical examination of polished mounts, photomicrographs, chemical analyses of feldspars, pyroxenes, metallic oxides and microcrystalline groundmasses and determination from the chemical anlayses of the varieties of feldspars, pyroxenes and metallic oxides. From the primary mineralogy data, a firm understanding of the average Hanford basalt flow primary mineralogy emerged. The average primary feldspar was a laboradorite, the average pyroxene was an augite and the average metallic oxide was a solid solution of ilmenite and magnetite. Secondary mineralization consisted of vug filling and joint coating, chiefly with a nontronite-beidellite clay, several zeolites, quartz, calcite, and opal. Specific flow units also were examined to determine the possibility of using the mineralogy to trace flows between core wells. These included units of the Pomona, the Umatilla and a high chromium flow just below the Huntzinger. In the Umatilla, or high barium flow, the compositional variation of the feldspars was unique in range. The pyroxenes in the Pomona were relatively highly zoned and accumulated chromium. The high chromium flow contained chromium spinels that graded in chromium content into simple magnetites very low in chromium content. A study of the statistical relationships of flow unit chemical constituents showed that flow unit constituents could be roughly correlated between wells. The probable cause of the correlation was on-going physical-chemical changes in the source magma.

<EVAL>
<EDATE> 06-14-85 <CDATE> <ADSEPNO> 1482

<ITEMNO> 1601 <DATE> 1978, June 30
<AUTHOR> Barnes, M.
<TITLE> Hanford and Columbia River Basin Basalts: X-ray Characterization before and after Hydrothermal Treatment
<PUBNO> RHO-BWI-C-17
<SITE> HAN <PROJECT> BWIP
<COMMENT>
<KEYWORD> GEOCHTA BASALT COLUMBIA RIVER BASIN
EVALUATION HANFORD RESERVATION HIGH TEMPERATURE
HYDROTHERMAL ALTERATION OXIDATION RADIOACTIVE WASTE STORAGE
UNDERGROUND STORAGE X-RAY DIFFRACTION #EXP
#MIN/PET #COND/REAC EVAL3

<ABSTRACT>Results are presented of a project to obtain quantitative data to assist in the evaluation of basalts as a nuclear repository host rock, in particular those basalts underlying the Hanford reservation. The two basalts studied are the U.S. Geological Survey's standard Basalt Columbia River-1 (BCR-1) and a section of core from Hanford Drill Hole DDH-3 (A2120/3320). It was found that the principal minerals of Basalts BCR-1 and DDH-3 are still present after hydrothermal treatment up to 400 degrees C. No new phases have been observed, with the exception of one in the longest run, 300 degrees C for 56 days. There is not enough of this phase present to give positive identification in the bulk powder diffractogram. The spinel magnetite-ulvoespinel was observed to change oxidation state under some conditions. Because uranium and plutonium are both far more soluble in the +6 state than in the +4 state, the oxidation state of the system basalt + waste + water is important. The basalt is in enormous excess and contains both ferrous and ferric iron in its spinels and in augite. Together they should be the principal influence on the oxidation state of the system. Several further X-ray measurements would be useful: first, examination of spinels in runs already made with 2 percent water and with 10x by weight water; second, examination of runs made in an all-stainless system; third examination of the Umtanum Basalt from Umtanum Ridge; fourth, search for ilmenite

8706160293-02

after further magnetic separation; and, fifth, look for possible changes in both spinels in order to follow the oxidation state in basalt + waste + water.

<EVAL>
<EDATE> 06-14-85 <CDATE> <ADSEPNO> 1616

<ITEMNO> 1930 <DATE> 1977
<AUTHOR> Barney, G.S. Grutzeck, M.W.
<TITLE> Kinetics and Reversibility of Radionuclide Sorption Reactions with Rocks
<PUBNO> PNL-SA-6957
CONF-7709157, pp. 433-477
<SITE> <PROJECT> BWIP
<COMMENT> In Proc. Waste Isolation Safety Assessment Program. Task 4; Contractor Information Meeting Proc., Seattle, WA , September 20, 1977
<KEYWORD> GEOCHTA ADSORPTION AMERICIUM 241
BASALT CESIUM 137 CHEMICAL COMPOSITION
EQUILIBRIUM GRANITES GROUND WATER
LEACHING MINERALOGY PLUTONIUM
ROCKS RUTHENIUM 106 SORPTIVE PROPERTIES
STRONTIUM 90 SURFACE AREA WEATHERING
#SORPTION #EXP EVAL3
<ABSTRACT>The work completed emphasized a thorough characterization of the rocks chosen for study, determination of the precision of K(d) measurements using the batch equilibration method, and accelerated "weathering" experiments by leaching the rocks. Four rock types were selected: basalt, quartz monzonite porphyry ("granite"), argillite, and rocksalt. The radionuclides used were Cs-137, Sr-90, Ru-106, Pu, and Am-241. Chemical composition, minerals, and surface areas of the rocks were determined. Equilibrium K(d)'s for the five nuclides were measured under conditions simulating natural groundwater in contact with the rocks.
<EVAL>
<EDATE> 06-14-85 <CDATE> <ADSEPNO> 1955

<ITEMNO> 1606 <DATE> 1978, November 15
<AUTHOR> Benson, L.V.
<TITLE> Secondary Minerals, Oxidation Potentials, Pressure and Temperature Gradients in the Pasco Basin of Washington State
<PUBNO> RHO-BWI-C-34
<SITE> HAN <PROJECT> BWIP
<COMMENT>
<KEYWORD> GEOCHTA GEOCHEMISTRY GROUND WATER
MINERALS OXIDATION PRESSURE GRADIENTS
RADIOACTIVE WASTE DISPOSAL RADIONUCLIDE MIGRATION SORPTIVE PROPERTIES
TEMPERATURE GRADIENTS UNDERGROUND DISPOSAL WASHINGTON
#COND/REAC #MIN/PET #SORPTION
EVAL3
<ABSTRACT>Three subjects are addressed: pressure and temperature variations with depth in the Pasco Basin; problems associated with the measurement and interpretation of oxidation potentials; and a review of the secondary mineral phases present at depth in the Pasco Basin. It was found that clinoptilolite, smectite, and silica are the most common secondary minerals in basalts of the Pasco Basin. These materials will act as sorptive substrates for positively charged nuclear species when and if radionuclides enter the groundwater flow system. Any studies involving retention of radionuclides by sorption on geologic materials should, therefore, include the minerals clinoptilolite and smectite. Pressure and temperature profiles for the Pasco Basin show that the environment surrounding the Umtanum unit is characterized by a temperature near 60 degrees C and a lithostatic pressure near 0.10 kb. The measurement and interpretation of the oxidation potential of Pasco Basin waters may be difficult if not impossible.
<EVAL>
<EDATE> 06-14-85 <CDATE> <ADSEPNO> 1621

8706160293-03

<ITEMNO> 2416 <DATE> 1979, September
<AUTHOR> Benson, L.V. Teague, L.S.
<TITLE> Study of Rock-Water-Nuclear Waste Interactions in the Pasco Basin Washington. Part 1. Distribution and Composition of Secondary and Primary Mineral Phases in Basalts of the Pasco Basin, Washington
<PUBNO> LBL-9677
<SITE> HAN <PROJECT> BWIP
<COMMENT>
<KEYWORD> GEOCHTA BASALT CRYSTALLIZATION
MINERALOGY CHEMICAL COMPOSITIONS DISSOLUTION
DRILL CORES ELECTRON MICROSCOPY MASS TRANSFER
MINERALIZATION MINERALS RADIOACTIVE WASTE DISPOSAL
UNDERGROUND DISPOSAL WASHINGTON X-RAY DIFFRACTION
#MIN/PET #COND/REAC EVAL4
<ABSTRACT>In Part I of this report the results of Task III are presented and discussed. The subject of Task III is the study and identification of secondary and primary mineral assemblages in basalts of the Pasco Basin of southeastern Washington. In particular, we have determined the relative amounts, crystallization sequence, and compositions of secondary minerals found lining vesicle and fracture surfaces. This information, together with data on the chemical composition of primary minerals and the extent to which they have undergone dissolution, has been used in theoretical simulations of mass transfer which is the subject of Part II (Task IV) of this report.
<EVAL> This report was used during preparation of the ORNL review and analysis of BWIPradionuclide sorption information, NUREG/CR-3763, issued in 1984. Part I of this report is a detailed description of the distribution and composition of secondary and primary mineral phases in basalts of the Pasco Basin. Part II presents results of calculated interactions of water and basalt. This report is the primary reference (as of July 1984) identifying secondary minerals present at the BWIP site. No radionuclide sorption information is included in this report. (AD Kelmers, July 1984)
<EDATE> 06-14-85 <CDATE> <ADSEPNC> 2455

<ITEMNO> 3284 <DATE> 1984, May
<AUTHOR> Brookins, D.G. Murphy, M.T. Wollenberg, H.A.
Flexser, S.
<TITLE> Geochemical and Strontium Isotopic Studies of Columbia River Basalts
<PUBNO> NUREG/CP-0052, pp. 454-463
CONF-8308126
<SITE> HAN <PROJECT> BWIP
<COMMENT> In: NRC Nuclear Waste Geochemistry 1983, Proc. NRC Research Annual Review Meeting of Nuclear Waste Management Research on Geochemistry of HLW Disposal, Alexander, D.H. and Birchard, G.F., (Editors), Reston, VA, August 3 0-31, 1983, pp. 454-463.
<KEYWORD> GEOCHTA BASALT GEOCHEMISTRY
CHEMICAL COMPOSITION COLUMBIA RIVER BASIN GROUND WATER
HIGH-LEVEL RADIOACTIVE WASTES INTRUSION ISOTOPE RATIO
RADIONUCLIDE MIGRATION #MIN/PET #GEOLOGY
#ANALOG EVAL3
<ABSTRACT>A rhyodacite intrudes the Wanapum basalt and is exposed in a quarry along the Hood River, Oregon. Since the rhyodacite is different geochemically from the basalt, and was intruded at a high temperature, then this site can be used to evaluate the effects of the intrusion on the basalt. The intrusive rock is a high temperature heat engine, and cooling may be by convection, conduction, or both. Contact effects of the intrusion are not pronounced in the basalt, and are restricted to minor recrystallization within one meter of the contact, and to possibly some minor fracture filling. Traverses were made from the rhyodacite into the basalt, and samples at closely spaced intervals were analyzed for K, U, Th by field and laboratory gamma spectrometry and by neutron activation analysis for some 35 elements. The Sr isotopic studies indicate that the rhyodacite possesses Sr(87/86) = 0.70407 +/- 0.00008 while the intruded basalts possess Sr(87/86) = 0.7052 +/- 0.0002. Even in samples of the contact, with intermingled rhyodacite and basalt, each rock preserves its own characteristic Sr(87/86) signature, thus again attesting to the closed system conditions. The authors conclude for this natural experiment that the Wanapum Basalt is not readily penetrated by elements from a high temperature, molten source. Measurements confirm the Sr(87/86) ratios for the Grande Ronde Basalt, with an average of 0.7055. Analyses of fracture filling minerals, which consist of clinoptilolite, chabazite, other zeolites, minor Ca-plagioclase, and calcite, range from 0.7052 to 0.7063 and average 0.7057. These

data confirm that the Sr in the fracture filling minerals has been derived from the Grande Ronde Basalt, and that there is no evidence for mixing of meteoric-derived Sr with basalt Sr.

<EVAL>
<EDATE> 06-14-85 <CDATE> <ADSEPNC> 3332

<ITEMNO> 4948 <DATE> 1986, June
<AUTHOR> BWIP
<TITLE> Basalt Waste Isolation Project Drilling and Testing Quarterly Report, January 1, 1986 through March 31, 1986
<PUBNO> RHO-BW-SR-86-1 1QP
<SITE> HAN <PROJECT> BWIP
<COMMENT>
<KEYWORD> #MIN/PET #HYDROLOGY #SUMMARY
BOREHOLE GEOCHTA
<ABSTRACT>The Drilling and Testing Group at Rockwell Hanford Operations is responsible for all borehold drilling and testing conducted in support of the Basalt Waste Isolation Project. Geologic and hydrologic characterization data obtained by the group are an integral part of the studies required to assess the feasibility of using the deep basalts beneath the Hanford Site for the terminal disposal of nuclear waste. This document is a summary of drilling and testing results during the first calendar quarter (January through March 1986). The principal work during this period included the core drilling of boreholes RRL-17, DC-18, and DH-33; rotary drilling of borehole DC-23GR; site preparation and entry holes for boreholes DC-25, DH-30, DH-31, DH-32, DH-34, and DH-35, and hydraulic head monitoring at 36 locations around the Hanford Site. Borehole RRL-17 was drilled to a total depth of 3,337 ft (1,017.1 m) in the interior of the Birkett flow. This borehole will aid in the characterization of thickness and structure of the Cohassett flow. Borehole DC-18 was drilled to a depth of 760 ft (231.6 m) in the Rosalia flow top. This borehole will aid in characterization of the groundwater flow regime and stratigraphic and tectonic framework of the Gable Gap area. Boreholes DC-23GR and DC-25 were drilled to 2,215 ft (675.1 m) in the Ginkgo flow and 64 ft (19.5 m) in the surficial sediments, respectively. These boreholes will aid in hydrologic testing and piezometer completion of the Grande Ronde Basalt. Boreholes DH-30, DH-31, DH-32, and DH-33 were drilled as entry holes and will be deepened to determine the depth and thickness of the Elephant Mountain and Pomona flows. These boreholes will be used as access holes for future geophysical testing. Boreholes DH-34 and DH-35 were drilled as entry holes and will be deepened to determine the depth and thickness of the Pomona flow and definition of the Yakima Barricade geophysical anomaly. These boreholes will be used as access holes for future geophysical testing. Hydrologic testing of the Rosalia and Sentinel Gap flow tops was conducted at borehole DC-23GR. Tests conducted included air-lift pumping, slug injection, and submersible pumping. Geophysical logs were run for boreholes RRL-2B, RRL-2C, RRL-14, RRL-17, DC-2, DC-18, DC-22C, DC-23GR, 399-5-2, and the O'Brian well. These logs help determine stratigraphic relationships, selection of potential zones of high and low porosity and permeability, and heat-flow relationships. Hydraulic head was monitored to characterize the dynamics of the groundwater flow system in and around the reference repository location. In addition, changes were noted in water level and pressure at monitoring sites (DC-23GR, DC-18, and RRL-17) in response to borehole construction and hydrologic testing activities. Field testing of the multilevel packer system continued, following removal of a failed pressure probe from the Rocky Coulee monitoring port.

<EVAL>
<EDATE> 03-19-87 <CDATE> <ADSEPNC>

<ITEMNO> 1824 <DATE> 1982, September
<AUTHOR> Carnahan, C.L. DeLany, J.M. Long, J.C.S.
Silva, R.J., et al
<TITLE> Selected Hydrologic and Geochemical Issues in Site Characterization for Nuclear Waste Disposal: Flood Basalts at the Hanford Reservation
<PUBNO> LBL-15029
NUREG/CR-2983
<SITE> HAN <PROJECT> BWIP
<COMMENT>
<KEYWORD> GEOCHTA BASALT GEOCHEMISTRY
GEOLOGIC DEPOSITS GEOLOGY GROUND WATER
HANFORD RESERVATION HIGH-LEVEL RADIOACTIVE WASTES
HYDROLOGY PHASE TRANSFORMATIONS RADIOACTIVE WASTE DISPOSAL
#MIN/PET RADIONUCLIDE MIGRATION SILICATE MINERALS

SITE #GEOLOGY SURVEYS
SMECTITE STRATIGRAPHY UNDERGROUND DISPOSAL
WASHINGTON ZEOLITES #HYDROLOGY
#SOLUBILITY EVAL3

<ABSTRACT>Four issues are considered that must be addressed by a site characterization program designed to evaluate the suitability of the flood basalts of the Pasco Basin in Central Washington as a site for the construction of a repository for the disposal of high-level nuclear waste. The four issues are (1) identification of hydrostratigraphic units within a sequence of flood basalts, (2) mechanisms and points of groundwater recharge and discharge, (3) solubility of radionuclides, and (4) phase transformation of fracture filling materials. Each issue is discussed in terms of its significance to waste isolation. Available approaches for resolving the issues are presented and their limitations identified. Where appropriate, research programs for overcoming these limitations are indicated.

<EVAL>
<EDATE> 06-14-85 <CDATE> <ADSEPNO> 1844

<ITEMNO> 1623 <DATE> 1978, September
<AUTHOR> Deju, R.A. Ledgerwood, R.K. Long, P.E.
<TITLE> Reference Waste Form, Basalts, and Ground Water Systems for Waste Interaction Studies
<PUBNO> RHO-BWI-LD-11
<SITE> HAN <PROJECT> BWIP
<COMMENT>
<KEYWORD> GEOCHTA BASALT CHEMICAL COMPOSITION
GLASS GROUND WATER MECHANICAL PROPERTIES
MINERALOGY RADIOACTIVE WASTES SPENT FUELS
#SUMMARY EVAL3

<ABSTRACT>This report summarizes the type of waste form, basalt, and ground water compositions to be used in theoretical and experimental models of the geochemical environment to be simulated in studying a typical basalt repository. Waste forms to be used in the experiments include, and are limited to, glass, supercalcine, and spent unreprocessed fuel. Reference basalts selected for study include the Pomona member and the Umtanum Unit, Shwana Member, of the Columbia River Basalt Group. In addition, a sample of the Basalt International Geochemical Standard (BCR-1) will be used for cross-comparison purposes. The representative water to be used is of a sodium bicarbonate composition as determined from results of analyses of deep ground waters underlying the Hanford Site. 12 figures, 13 tables.

<EVAL>
<EDATE> 06-14-85 <CDATE> <ADSEPNO> 1641

<ITEMNO> 4924 <DATE> 1982, March
<AUTHOR> Guzowski, R.V. Nimick, F.B. Muller, A.B.
<TITLE> Repository Site Definition in Basalt: Pasco Basin, Washington
<PUBNO> NUREG/CR-2352
<SITE> HAN <PROJECT> BWIP
<COMMENT>
<KEYWORD> #CALC #MIN/PET HYDROLOGY
BASALT GROUND WATER GEOCHTA
NO KEYWORDS GEOCHEMISTRY HANFORD

<ABSTRACT>Pasco Basin is a structural and topographic basin of approximately 2000 mi(2) (5180 km(2)) located within the Yakima Fold Belt Subprovince of the Columbia Plateau. The stratigraphic sequence within the basin consists of an undetermined thickness of lower Miocene and younger flood basalts with interbedded and overlying sedimentary units. This sequence rests upon a basement of probably diverse rock types that may range in age from Precambrian through early Tertiary. The basin is bounded on the north, south and west by east-west-trending Yakima folds which, along with related folds within the basin, plunge to the east. Subsurface structures may be related to the intersection of both east-west-trending and northwest-trending structural features. Faults have been proposed to explain structural relationships at Wallula Gap and along the northeastern flank of Rattlesnake Hills. Two faults are present at Gable Mountain. Although a large amount of information is available on the hydrology of the unconfined aquifer system, ground-water flow within the basin is, in general, poorly understood. Recharge areas for the Mabton interbed and the Saddle Mountains Formation are the highlands surrounding the basin with the flow for these units toward Gable Butte - Gable Mountain and Lake Wallula. Gable Butte - Gable Mountain probably is a ground-water sink, although

TI APERTURE CARD

Also Available On Aperture Card

8706160293-06

the vertical flow direction in this zone is uncertain. The amount of upward vertical leakage from the Saddle Mountains Formation into the overlying sediments or to the Columbia River is unknown. Units underlying the Mabton interbed may have a flow scheme similar to those higher units or a flow scheme dominated by interbasin flow. Upward vertical leakage either throughout the basin, dominantly to the Columbia River, or dominantly to Lake Wallula has been proposed for the discharge of the lower units. None of these proposals is verified. The lateral and vertical distribution of major and minor ions is solution, Eh and pH, and ion exchange between basalt and ground-water are not well defined for the basin. Changes in the redox potential from the level of the subsurface facility to the higher stratigraphic levels along with the numerous other factors influencing Kd, result in a poor understanding of the retardation process. Experimental determinations of mechanical properties of Columbia River basalts are not available in sufficient quantity or quality to adequately define the properties as a function of pressure, temperature, mineralogy, and porosity. The data set for thermal properties is more complete.

<EVAL>
<EDATE> 03-19-87 <CDATE> <ADSEPNC>

<ITEMNO> 2438 <DATE> 1983, August
<AUTHOR> Long, P.E. Strope, M.B.
<TITLE> Composition of Augite and Pigeonite in Basalt Flows That are Candidates for a Nuclear Waste Repository
<PUBNO> CONF-830815--12
RHO-BW-SA295P
<SITE> HAN <PROJECT> BWIP
<COMMENT> Presented at the Microbeam Analysis Society Meeting, Phoenix, AZ, August 8-12, 1983
<KEYWORD> GEOCHTA NO KEYWORDS BASALT
AUGITE PIGEONITE HIGH-LEVEL RADIOACTIVE WASTE
WASHINGTON #MIN/PET #GEOLOGY
<ABSTRACT>The abundance and composition of pigeonite are variable within single flows of basalt in spite of uniform bulk composition. These variations are spatially related to the occurrence of entablature and colonnade, which in turn apparently reflect the cooling history of the flow. Differences from one flow to another in the occurrence of pigeonite may be explained by the extent to which early-formed microphenocrysts of pigeonite react out during crystallization of the flow and the extent to which late-stage pigeonite rims are developed. The preservation of pigeonite in the entablature of flows such as the Umtanum tends to corroborate the proposed origin of entablatures and their attendant fracture patterns by relatively rapid cooling of the interior of these flows.
<EVAL>
<EDATE> 06-14-85 <CDATE> <ADSEPNC> 2478

<ITEMNO> 1636 <DATE> 1980
<AUTHOR> Noonan, A.F. Fredriksson, K. Nelen, J.
<TITLE> Phase Chemistry of the Umtanum Basalt, a Reference Repository Host in the Columbia Plateau
<PUBNO> RHO-BWI-SA-77
CONF-801124-51
<SITE> HAN <PROJECT> BWIP
<COMMENT> Presented at the 3rd Annual Meeting of the Materials Research Society, Boston, MA, November 17, 1980
<KEYWORD> GEOCHTA BASALT CERTIFICATION
CHEMICAL COMPOSITION DRILL CORES GEOLOGIC DEPOSITS
MINERALOGY PHASE STUDIES RADIOACTIVE WASTE DISPOSAL
STANDARDIZATION STANDARDS TESTING
TEXTURE UNDERGROUND DISPOSAL MIN/PET
#SORPTION #SOLUBILITY
<ABSTRACT>Kilogram quantities of reference Umtanum basalt collected from a surface exposure are compared with Umtanum basalt DC-2 core samples extracted from the central Pasco Basin. The two materials are similar in texture and phase composition, suggesting that sorption, waste/rock/water interaction experiments, and radiation effects studies using reference basalt will successfully simulate the proposed Umtanum repository environment. Textural studies of DC-2 core samples also show that dissolution of mesostasis is restricted to flow top breccia with precipitation of secondary minerals in flow top, entablature, and colonnade sealing fissures and vesicles.
<EVAL>
<EDATE> 06-14-85 <CDATE> <ADSEPNC> 1655

<ITEMNO> 1926 <DATE> 1982, June
<AUTHOR> Palmer, R.A. Aden, G.D. Johnston, R.G.
<TITLE> Characterization of Reference Materials for the Barrier Materials Test Program
<PUBNO> RHO-BW-ST-27P
<SITE> HAN <PROJECT> BWIP
<COMMENT>
<KEYWORD> GEOCHTA BASALT PACKAGING
GROUND WATER TUFF CONTAINERS
WASTE MANAGEMENT PETROLOGY GEOCHEMISTRY
#MIN/PET #PACKAGE #EXP
EVAL2

<ABSTRACT>In order to choose a geologic formation for nuclear waste disposal and design a repository system, the physical and chemical characteristics of the natural and man-made components in the system must be known. Initial characterization of the geologic and engineered barrier materials for a nuclear waste repository in basalt has been completed. Data have also been obtained on the characteristics of the reference waste forms which are being studied for eventual disposal in such a repository. The data included in this document reflect the work completed through May of 1982. Future reports are expected to reflect further characterization of the materials discussed herein and to include other materials as deemed necessary by the Basalt Waste Isolation Project. Characterization of Sentinel Bluffs and McCoy Canyon formations as alternative repository horizons is currently in progress. Reference basalt entablature, colonnade, and flow top specimens have been selected from the Umtanum flow, which is the primary basalt flow under consideration for repository siting. Material from the Mabton Interbed Stratum, Pomana Flow basalt, smectite clay from the Pomona Flow, a potassium clinoptilolite, Beverly sandstone and tuff, and Grande Ronde groundwater are also included in the suite of reference geologic materials. Reference engineered barrier materials include sodium bentonite and canister metals such as carbon steel, cupronickel, Hastelloy and Inconel alloys. Spent fuel, borosilicate glass, and supercalcine ceramic comprise the reference waste forms. Characterization of these materials has ranged from simple macroscopic examination of the bulk material to sophisticated analyses with analytical electron microscopes. Chemical compositions of the materials were determined by X-ray flourescence spectroscopy, electron microprobe, and energy dispersive X-ray spectrometry in combination with scanning and analytical scanning transmission electron microscopy (SEM, ANSTEM). Particle morphologies were determined yb optical microscopy, SEM, and ANSTEM. Petrographic analyses of thin sections, X-ray powder diffractometry, and electron diffraction in the ANSTEM were all utilized to identify the crystalline phases present in these materials. Analyses of the elemental and phase chemistries for most of the reference materials have been completed on typical samples. Determinations of material homogeneity are currently being performed. These analyses provide the basis for the interpretation of later experiments designed to define the behavior of host rock components, engineered barriers, and the waste form under conditions expected in a repository in basalt.

<EVAL>
<EDATE> 06-14-85 <CDATE> <ADSEPNO> 1951

<ITEMNO> 1634 <DATE> 1980, November
<AUTHOR> Reidel, S.P. Long, P.E.
<TITLE> Discriminant Analysis as a Method of Flow Identification and Correlation in Layered Basalt Provinces
<PUBNO> RHO-BWI-SA-69
<SITE> HAN <PROJECT> BWIP
<COMMENT> to be presented at the Geological Society of America, Atlanta, GA, November 1980
<KEYWORD> GEOCHTA BASALT CHEMICAL COMPOSITION
COLUMBIA RIVER BASIN CORRELATIONS DEPTH
GEOLOGY STATISTICS STRATIGRAPHY
#GEOLOGY #MIN/PET

<ABSTRACT>Discriminant analysis was applied to over 50 flows of the Columbia River Basalt Group which range from widely differing compositions (Saddle Mountains Basalt) to only slight chemical differences (Grande Ronde Basalt). Well-defined, correlated stratigraphic sections were tested for the probability of correctly identifying individual flows or groups of flows. Probability of properly identifying samples from flows of the Saddle Mountains Basalt approaches 1.0. The Grande Ronde Basalt constitutes approximately 85% of the Columbia River basalt and consists of >35 flows, yet it has previously been divided into only three chemical groups. Using 21 variables for each sample and 28 groups, approx. 67% of the samples were correctly identified with probabilities ranging from 0.3 to 0.9. Elements that were particularly important in discriminating Grande

TI
APERTURE
CARD

Also Available On
Aperture Card

8706160293-08

Ronde Basalt flows were MgO (3.0 to 6.0 wt %), TiO$sub 2$ (1.6 to 2.6 wt %), Zr (160 to 250 ppM), Ba (300 to 1050 ppM), and P$sub 2$O$sub 5$ (0.2 to 0.5 wt %).

<EVAL>
<EDATE> 06-14-85 <CDATE> <ADSEPNO> 1652

<ITEMNO> 1984 <DATE> 1983, April
<AUTHOR> Reidel, S.P.
<TITLE> Stratigraphy and Petrogenesis of the Grande Ronde Basalt from the Deep Canyon Country of Washington, Oregon, and Idaho
<PUBNO> RHO/U-7
GSA Bull., v. 94, pp. 519-542
<SITE> HAN <PROJECT> BWIP
<COMMENT>
<KEYWORD> GEOCHTA BASALT STRATIGRAPHY
PETROLOGY #GEOLOGY #MIN/PET
<ABSTRACT>Deep canyons cut by the Snake, Salmon, Grande Ronde, and Imnaha Rivers near the point where Washington, Oregon, and Idaho join expose >800 m of Grande Ronde Basalt flows. The Grande Ronde Basalt, erupted 16.5 to 14.5 m.y. B.P., makes up 85 vol % of the Columbia River Basalt Group. An area enclosing approximately 1,000 km2 of the deep canyon country dominated by this basalt was mapped, and samples from 16 measured sections in the Grande Rhonde Basalt were analyzed for major, minor, and trace elements. Three magnetostratigraphic units, R1, N1, and R2, were helpful in mapping the area. Using physically distinct flows, the magnetostratigraphic units, and certain chemical variations, a detailed flow-by-flow stratigraphy was developed, and the lateral extent of many individual flows was traced. The number of flows and thickness of each stratigraphic unit decrease from west to east. These tholeiitic flows are fine-grained and aphyric. Clinopyroxene and plagioclase are the predominant minerals, but olivine, orthopyroxene, pigeonite, and accessory minerals are minor but important phases. The flows are primarily of the low-Mg chemical type, with lesser amounts of the high-Mg chemical type. A cyclical trend in the over-all major- and trace-element chemistry through the stratigraphic section is dominated by a Ca-rich clinopyroxene chemistry. Rare-earth elements show significant light-over-heavy enrichment, but overall patterns remain similar from flow to flow. A small negative Eu anomaly is present in many flows. Three models employing fractional crystallization schemes and one combining fractional crystallization and partial melting were tested using least-squares modeling. A petrogenetic model is proposed wherein partial melting of a heterogeneous, clinopyroxene-dominated mantle supplied magma that ascended to the crust, was temporarily stored, and recurrently erupted. During storage, new basaltic melt with slightly different isotopic and trace-element abundances was added and mixed into the liquid that remained after previous eruptions. Orthopyroxene, plagioclase, and, to a lesser extent, olivine fractionated from these temporarily stored liquids. Upon eruption, clinopyroxene and plagioclase with accessory minerals crystallized at the surface.
<EVAL>
<EDATE> 06-14-85 <CDATE> <ADSEPNO> 2010

<ITEMNO> 1838 <DATE> 1981, April
<AUTHOR> Salter, P.F. Ames, L.L. McGarrah, J.E.
<TITLE> Sorption of Selected Radionuclides on Secondary Minerals Associated with the Columbia River Basalts
<PUBNO> RHO-BWI-LD-43
<SITE> HAN <PROJECT> BWIP
<COMMENT>
<KEYWORD> GEOCHTA BASALT AMERICIUM 241
CESIUM 137 DISTRIBUTION FUNCTIONS EXPERIMENTAL DATA
GROUND WATER IODINE 125 NEPTUNIUM 237
PLUTONIUM 241 #SORPTION RADIOACTIVE WASTE DISPOSAL
RADIOISOTOPES #MIN/PET RADIONUCLIDE MIGRATION
RADIUM 226 SELENIUM 75 #EXP
SMECTITE SORPTION STRONTIUM 85
TECHNETIUM 99 URANIUM 233 #SOLUBILITY
<ABSTRACT>The sorption behavior of selected radionuclides on the secondary minerals which fill and/or line the vesicles, vugs, and fractures in the Columbia River basalts has been investigated. Radionuclide distribution coefficients (Kd), using a batch equilibrium technique, have been determined for selenium, strontium, technetium, iodine, cesium, neptunium, americium, plutonium, uranium, and radium under oxidizing conditions

TI
APERTURE
CARD

Also Available On
Aperture Card

8706160293-09

at both 23 degrees and 60 degrees C. Groundwater compositions simulating those found in the water-bearing zones of the Columbia River basalts were used in the Kd determinations. In addition, sorption isotherms, describing the dependence of radionuclide sorption on radionuclide concentration, were determined for uranium, cesium, and strontium. Based on these sorption data, it appears that the secondary minerals are capable of retarding the migration of cesium, strontium, radium, plutonium, americium, and uranium from a repository in basalt. Under oxidizing conditions, however, the secondary minerals do not adequately retard the migration of selenium, technetium, neptunium, and iodine. Additional information is needed on the sorption behavior of selenium, technetium, neptunium, and iodine under the highly reducing conditions expected for a sealed repository in basalt before further evaluation can be made of the retardation capability of the secondary minerals for these isotopes. A review of the available sorption data for cesium, strontium, plutonium, americium, neptunium, radium, and zirconium on Hanford Site sediments also is presented.

<EVAL> This report was used during preparation of the ORNL review and analysis of BWIP radionuclide sorption information, NUREG/CR-3763, issued in 1984. This is the key report describing radionuclide sorption onto BWIP secondary minerals (as of July 1984). The report also includes a review of sorption onto Hanford Reservation soils; that review has been superseded by RHO-ST-35. The secondary minerals used were from fractures, vugs, and vesicles of Pomona basalt; they were estimated to be at least 98% smectites. Synthetic groundwaters were used in batch contact tests at 23 and 60 C. Tables of distribution coefficients are given for Se-79, Sr-85, Tc-99, I-125, Cs-137, Ra-226, U-233, Np-237, Am-241, and Pu-241. Dubinin-Radushkevich isotherms are given for uranium only. An important report conclusion is " ... secondary minerals are capable of retarding migration of Cs, Sr, Ra, Pu, Am, and U ... do not adequately retard Se and Tc ... " (ADK, July 1984)

<EDATE> 06-14-85 <CDATE> <ADSEPNO> 1858

<ITEMNO> 3775 <DATE> 1980, January
<AUTHOR> Teague, L.S.
<TITLE> Secondary Minerals Found in Cores DC2 A1 and DC2 A2 Taken From the Grande Ronde Basalt Formation, Pasco Basin, Washington
<PUBNO> LBL-10387
<SITE> HAN <PROJECT> BWIP
<COMMENT>
<KEYWORD>

GEOCHTA	BASALT	MINERALIZATION
DRILL CORES	SCANNING ELECTRON MICROSCOPY	X-RAY DIFFRACTION
COLUMBIA RIVER BASIN	CRYSTALLIZATION	DEPTH
EXPERIMENTAL DATA	FLUID FLOW	FRACTURES
LITHOLOGY	PETROGRAPHY	RADIOACTIVE WASTE DISPOSAL
TABLES	UNDERGROUND DISPOSAL	WASHINGTON
MINERALS	#EXP	#MINIPET

<ABSTRACT>The results obtained for Task I are presented and discussed in this report. The subject of Task I is the study and identification of secondary mineral assemblances in two slant cores drilled off core DC2. The data were obtained from scanning electron microscopic (SEM/EDAX), x-ray diffraction (XRD), and thin section petrographic studies. In addition, an attempt was made to determine the lateral continuity of the secondary mineralization and the extent to which the fissures in this potential repository horizon were interconnected. Differences between the slant cores and DC2 may be due to variations in the vertical distribution of the samples and the fewer slant core samples studied. As a result, firm conclusions cannot be drawn regarding the depth dependence and relationship of mordenite precipitation to clinoptilolite dissolution. The limited data obtained in this and previous reports supports the preliminary conclusion that secondary mineralization is laterally continuous. Secondary mineral assemblages and morphologies in all cores are similar and no significant horizontal changes are observed.

<EVAL>
<EDATE> 08-02-85 <CDATE> <ADSEPNO>

<ITEMNO> 2866 <DATE> 1981, March
<AUTHOR> Van Groos, A.F.K.
<TITLE> Determination of Dehydration Temperatures of a Secondary Vug-Filling Mineral (Smectite Clay) Using a Differential Thermal Analysis at Various Pressures
<PUBNO> RHO-BWI-C-102
<SITE> <PROJECT> BWIP
<COMMENT>
<KEYWORD> GEOCHTA BASALT CLAYS
NO KEYWORDS SMECTITE #MIN/PET
#EXP #PACKAGE
<ABSTRACT>An investigation of the dehydration of smectite clay as a function of pressure and temperature was completed for the Basalt Waste Isolation Project (BWIP) as part of the Waste Package Development Program. The clay sample was obtained from fracture mineralization that occurs in Hanford basalt. This work was completed to assess the chemical stability of smectite clays in the backfill component of a waste package which would be emplaced in a deep underground repository (approximately 1,000 m) located in Hanford basalt. The range of experimental temperatures and pressure was chosen to represent those that would be imposed on the waste package in the repository. The dehydration of smectite is affected strongly by pressure. Interlayer water is lost at approximately 130 deg C at 1 atm pressure and at 430 deg C at 300 bars water pressure and total pressure. At 300 bars and with low water activity, interlayer water appears to be lost fairly gradually. Collapse of the smectite structure to a mica structure appears to be enhanced with increased pressure at low water activity, but delayed at high water activity. The smectite investigated is somewhat unusual because of its high iron and magnesium content. Nevertheless, the conclusions are probably valid for all smectites. The results of this study show that pressure strongly affects the dehydration of clay minerals. Therefore, further study of dehydration of clay minerals is high recommended.
<EVAL>
<EDATE> 06-14-85 <CDATE> <ADSEPNO> 2910

<ITEMNO> 3285 <DATE> 1984, May
<AUTHOR> Wollenberg, H.A. Brookins, D.G. Cohen, L.H.
Flexser, S. Abashian, M. Murphy, M.
Williams, A.E.
<TITLE> Uranium, Thorium, and Trace Elements in Geologic Occurrences as Analogues of Nuclear Waste Repository Conditions
<PUBNO> NUREG/CP-0052, pp. 464-491
<SITE> HAN <PROJECT> GRANITE BWIP
NTS NNWSI
<COMMENT> In: NRC Nuclear Waste Geochemistry 1983, Proc. NRC Research Annual Review Meeting of Nuclear Waste Management Research on Geochemistry of HLW Disposal, Alexander, D.H. and Birchard, G.F., (Editors), Reston, VA, August 3 0-31, 1983, pp. 464-491.
<KEYWORD> GEOCHTA BASALT RADIONUCLIDE MIGRATION
GRANITES SALT DEPOSITS TUFF
GEOCHEMISTRY HIGH-LEVEL RADIOACTIVE WASTES HYDROTHERMAL SYSTEMS
INTRUSION THORIUM URANIUM
#ANALOG #MIN/PET #GEOLOGY
<ABSTRACT>Contact zones between intrusive rocks and tuff, basalt, salt and granitic rock were investigated as possible analogues of nuclear waste repository conditions. Results of detailed studies of contacts between quartz monzonite of Laramide age, intrusive into Precambrian gneiss, and a Tertiary monzonite-tuff contact zone indicate that uranium, thorium and other trace elements have not migrated significantly from the more radioactive instrusives into the country rock. Similar observations resulted from preliminary investigations of a rhyodacite dike cutting basalt of the Columbia River plateau and a kimberlitic dike cutting bedded salt of the Salina basin. This lack of radionuclide migration occurred in hydrologic and thermal conditions comparable to, or more severe than those expected in nuclear waste repository environments and over time periods of the order of concern for waste repositories. Our attention is now directed to investigation of active hydrothermal systems in candidate repository rock types, and in this regard a preliminary set of samples has been obtained from a core hole intersecting basalt underlying the Newberry caldera, Oregon, where temperatures presently range from 100 to 265 degrees C. Results of mineralogical and geochemical investigations of this core should indicate the alteration mineralogy and behavior of radioelements in conditions analogous to those in the near field of a repository in basalt.

TI APERTURE CARD

Also Available On Aperture Card

8706160293-11

<EVAL>
<EDATE> 06-14-85 <CDATE> <ADSEPNO> 3333

431-01-0583
Box 6