Tape #1

Mel Kuntz - July 10, 1984

First off would be the relationship of the Snake River Plain to the Columbia Plateau or just Northwest Geology in a nutshell. Columbia Plateau is kind of the Western United States. Snake River Plain, divided into two parts, Yellowstone here, Snake River Plain, Great Rift there, and then the Eastern Plain kind of swings up like this and we don't really know what happened to it, the Eastern Plain, as it goes off to the Southwest. Boise is about there and it kind of fingers out, except that here is the Columbia Plateau, which has a configuration like this, with a bunch of mountain ranges stuck around inside of it.

About somewhere between 14 and 16 million years ago, a whole bunch of really long and extensive cracks formed over in this part of the world and huge, huge volumes of basalt came out. These are what are known as plateau basalts and they're unique in the fact that tremendous volumes of stuff came out in only a two million year period of time. We know that the number of individual eruptions were small, that is, the number of feeder fissures for these things, these long, open cracks are fairly small in number, maybe, I really don't know what the number is, but we're not talking about thousands, we're talking maybe in the order of a hundred or possibly even less. So, plateau basalts fit by fissures, which were measured in lengths of maybe a few tens of miles and, thru the Columbia River Plateau, fissures in a few tens of miles.

The thing that is unique about this is that when the eruptions began, tremendous volumes of stuff came out in fairly short periods of time, so that one of these flows, which is maybe on the order of several hundred feet thick and which covers thousands of square miles, the volume of stuff there was probably erupted in a matter of a few weeks. The stuff was coming out of the ground at just a fantastic rate and volume. That happened about, like I said, somewhere between 14 and 16 million years ago.

It looks like the Western Snake River Plain has in it basalt which are Columbia River in age, in its deeper parts and exposed at various points around the edge of it, they are Columbia age basalts. So, this looks like it was an extension of the Columbia River basalt province, back in 14 to 16 million year ago time. In fact, some of the faults that appear in the Western Snake River Plain, which are along here on the edges, look as if they may actually be extensions

of the same kind of system in the deep crust which formed these fissures. The Columbia River Plateau basalts ended 14 million years ago and that was it, there was no more. Once it went through it's thing, it went through it's thing and bingo, that was all, it was all through. The Western Snake River Plain had its Columbia River age basaltic volcanism going on back 14 to 16 million years ago but then it looks as if volcanism continued on up until almost yesterday, although there aren't young things like Craters out there. But it still kept going on and on.

Now nobody really knows exactly why the Western Snake River Plain continued on and things shut off here, except that when it did continue on, after 14 million years ago, it went through a very distinctive kind of history that was separate from this. It was another unique kind of basaltic volcanism. It's possible that the Columbia River Plateau, in fact the area where I'm working now near McCall, has a lot of Columbia River basalt on it, high up on mountain range tops and its possible that the Columbia River Plateau basalt province may have had an original distribution that looks something like this. Since this area has been uplifted, a lot of that basalt has been striped off and we don't see it anymore, except in tiny patches here and there. So, that was possibly the original distribution of the Columbia River basalt. This is where it is really exposed now as real thick flows.

The Western Snake River Plain went through its history up from 14 million years ago on up until yesterday and what happened then in the period from 14 million years ago until just now was that basalt volcanism continued on, but the style of volcanism and the timing of volcanism in the Western Plain was very different from what went on here. There were intermitent eruptions from very short lengths of fissures. Instead of fissures being measured in tens of miles, the length of eruptive fissures in the Western Snake River Plain were only a few kilometers in length.

The style of volcanism was very different. We end up with shield kinds of volcanism, producing the kinds of things that you see on the way into Idaho falls, the big, broad kinds of shields and the volume of an individual shield is miniscual compared to an individual flow erupted during Columbia River time. The ratio might be 1000 to 1 or 10,000 to 1 or something like that. Small blips of stuff coming up along real short fissures. That continues right on up to the present time.

Now, let's go over to the Eastern Snake River Plain.

DAVE: What was the last eruptive period over on the Western Plain?

MEL: We don't have any good dates, but the look of it is, for example if your driving on the highway from Mtn. Home to Boise, some of those things look as if they're on the order of a few million years old, maybe a few in the 500,000 year range, but nothing like tens of thousands of years or things that are older than that.

Dave: Why can't you get good dates on that?

Mel: We could, but I don't think it's ever been done. Why it hasn't been done, I don't know.

O.K., Eastern Snake River Plain. The Eastern Snake River Plain and the Western Snake River Plain have been described together because their similar topographic features, their similar structural features, and their similar petrologic or rock kinds of features. They're both depressions filled with basalt and rhyolitic rocks. My viewing is that they're very, very different in their origin. My viewing is that the Eastern Snake River Plain and the Western Snake River Plain developed very differently from one another. The Western Snake River Plain is, I think, a continuation of the structural trend of the fissure system that fed the Columbia River Plateau area into Southwest Idaho. One of the reasons that I think ... If we were to draw a cross section through here, what we would have is (drawn on diagram). There is the Columbia River Plateau where a whole bunch of basalt flows in and here is the Idaho batholith? and down here is a bunch of magma chambers forming basalt. What's happening down here we really don't know. Let's just say that the

Idaho batholith? has some kind of root to it and these are basalt flows lying on top of presumably what we would call oceanic crust and the Idaho batholith? lies in what we would call continental crust.

The oceanic and continental crust are very different from one another and down here we have the mantle and we have basalt magma chambers forming in the mantle beneath the Idaho batholith? and the oceanic crust. For some reason, it was very, very easy for basalt magma to get out through the oceanic crust and to be deposited up on the surface to form the Columbia River Plateau than it was for it to get through this area. For some reason either these rocks are stiff or the density structure is different or something, but if you assume that these two basalt magma chambers are producing basalt magma at the same rate, this stuff is getting trapped down deep in the crust, this stuff is all escaping to the surface. That may explain the difference in the rates for all the stuff coming out here to the stuff not coming out on the Western Snk. River Plain. The boundary line between continental crust and oceanic crust looks like this.

The Columbia River Plateau was formed on oceanic crust, an area that was originally ocean, and in the idea of the accretion of continental plates this is all material that was brought on to the western part of the North American Plain and just stayed there, but it was oceanic crust, it was not continental crust. It didn't have any of the sedimentary rocks in it, it didn't have old, Precambrian, thick, _____, metamorphic rocks, it was just thin, oceanic crust. Oceanic crust being the kind of material that forms out and floor that consists mostly of oceanic basalt, a little bit of sediment that is very, very thin, not more than a few tens of kilometers thick and then lies directly on that. Whereas, oceanic crust is very thick and contains igneous rocks like we have in the Idaho batholith , like the tetonic rock, metamorphic rock, sedimentary rocks - thick, lightweight, floats on top of the mantle and is very thick. So, for some reason, when basalt begins to be formed in the mantle it's easy for it to get out to the oceanic crust. Nobody really understands the process very well. The possibility is that once magma forms, since the

oceanic crust is very dense and heavy, it literally pushes down on the magma and squeezes it out. Whereas, this crust is lightweight and doesn't have as much pushing power down on it and the stuff that does come up is going to tend to pond and pool in here some way and make drops of congealed basalt.

So, the Western Snake River Plain is an extension of the structures here from beneath the oceanic crust to beneath the continental crust, but since the structures continue on to the Southeast going in to the western Snake River Plain and go underneath the continental crust, the continental crust acts as a barrier someway in getting basalt magma to the surface. So what happens is, small volumes come out and they only come out spiraticly because evidently if the stuff is wedging its way up continuously most of it is being blocked and is congealing down here deep in the continental crust. (175)

O.K., now Eastern Snake River Plain. The idea for the origin of the Snake River Plain is currently involved and currently has the best acceptance is a combination of what is called plume theory and called era theory and their really intimately intertwined with one another. Before I start that, let me tell you that there are a couple of papers coming out in a publication by the Idaho Bureau of Mines and Geology, and they have published a symposium volume called the Cenazoic Geology of Idaho and it is edited by a guy named Bill Bonicks and Roy Breckenridge. These guys are with the Idaho Geologic Survey in Moscow. It is associated with the University. If you write to these guys or if you call them on the phone, tell them you want a copy of this and you should get it. It will have our paper in it about Craters of the Moon and have a lot of other papers in it about all kinds of geology and _____? (196) and just simply as a reference book for your library it would be great. It will have two papers in it that will be of interest to you. One, by Bill Leiman, and that will be on the origin of the Eastern Snake River Plain.

Dave: It is a previously published paper?

Mel: No, it is new, but it incorporates all of..Bill just keeps regenerating his (203)

ideas over and over and here's the latest version. Another paper of interest will be a paper by Grealy, on the Snake River Plain, but basically it's a re-hash of something he's done before. I had to review this thing and I recommended that it not be published because it was exactly the same, the same wording, the same photographs, the same figure sequence and so forth that had been published before in the Eastern Snake River Plain volume, published by NASA and it's the same paper again.

I have not read Leiman's paper, but I think I know what's going to be in it. The idea is that the Eastern Snake River Plain...It was known long ago that the rhyolitic rocks exposed around the margin of the Snake River Plain and all of the rhyolitic rocks in Yellowstone... these were dated long ago, either by direct radiometric methods or by geological relations. The idea was that when the ages of these rhyolitic rocks were known, it turned out that the oldest rhyolitic rocks down here were about approximately 15 million years to about 18 million years old in the vicinity of Twin Falls. Around Pocatello, some dating was done and some of those rhyolitic rocks down there were in the vicinity of about 10 to 12 million years roughly. Around Idaho Falls, in the area up north and east of Arco, the ages are in the vicinity of 6 to 4 million years and the same thing around Idaho Falls. These aren't exact numbers, but they're just rough. Yellowstone National Park, we know that there has been three bursts of rhyolitic volcanism at about 2.0 million years, 1.2 million years and 0.6 million years ago. 600,000 years ago was the last burst. We've also got some dates on the rhyolite domes, Big Southern Butte - 0.3 million years (300,000), East Butte (1.2 Million). When you look at those ages, there's a progression in age from old to young.

Dave: Would the only thing out of sequence be Big Southern Butte?

Mel: Yah, right. Now, that was the simple picture that was apparent to people about 5-6 years ago. Since then the picture has changed. (256)

The idea is that all of these rhyolite sheets that are exposed out on the margins of the plain come from some big caldera and you know what calderas are. What happens is that a great big mass of rhyolitic magma, which is melted continental crust, and we get into why the crust melts in a little bit. A big mass of magma works it's way up to the surface. There are a few volcanic eruptions and then literally the roof of one of these big calderas, which may be this big mass of molten material only a few kilometers deep in the Earth, has worked its way up - still molten - might be ten miles across, maybe 20 miles deep or ten miles deep. Think of it as a sphere. It works its way up to the surface and finally the surface can no longer atain it. For various reasons, either the cap above it drops in or the material inside blows it away.

Dave: Various reasons being??

Mel: The main reason is that for one thing, granitic magma is lightweight, its density is much less than the density of all the surrounding rock, so it's just like holding a ping pong ball down in the bottom of a swimming pool. Gravitationally these things are unstable. They tend to rise. When they do, they keep working their way up and finally they get to the point where there is a tremendous amount of dissolved gas in the magma. The same explaination that goes into describing vesicles in basaltic rock. That gas was dissolved in the rock very deep in the crust under very high pressure and as you bring it up, as you take this mass with dissolved gas in it, and you bring it up and decrease the confining pressure, this stuff starts to bubble out in the rock. It's no longer dissolved in there - it becomes its own separate phase and the gas starts to expand and that's what leads to these violent kinds of eruptions. The magma literally blows itself apart. When the confining pressure is so low on it, the pressure from the internal gas dissolved in the rock or which separates out into its own bubble phases so great that the bubbles want to explode. When they explode, they literally blow the roof off of this thing. Then, here's this stuff with no confining pressure on it and then all hell breaks loose and the stuff out here just....there's only one place for it to go and that is strait up. (303)

Huge volumes of the stuff, tens, hundreds of cubic kilometers worth of the material blows out of this hole and then it's spread around the countryside and it comes out as very hot material - it comes out at about 1000 degrees centigrade, maybe a little less, but not a whole lot less. That stuff is blown through the air, where some of it is cooled, but chances are it moves out laterally and moves out as it's own unique kind of lava flow, not liquid basalt flowing on the ground, but this stuff rides along on a cushion of heated air and flows for long distances and that's basically what happened at Mt. St. Helens for a lot of these.

Let's suppose that there are a few mountain ranges out here along the edge of the plain where some of this stuff comes out. The distribution of the stuff blowing out of here is going to be, let's say, it's going to skirt around this mountain range and go up this valley and then it blows down the Snake River Plain and here's the extent of this thing. That forms what we call a welded tough. The material that comes out is so hot that it welds itself together and it's a tough ryholite. It's so hot that as the material is spread out laterally, it welds itself together. I'm trying to think where you can see this things . The best example is, of welded toughs around here, is a real short stretch between Carey and Picabo. Those hills in there are not basalt, but rhyolite is welded tough, but we don't know the age of those things.

It's going to skirt around some mountain ranges, but some of it will be exposed on the flanks of the mountain ranges. Now we're going to look at this area later. Later all of this stuff out here is covered by basalt, so we can't see the caldera and we can't see the welded tough that was spread out on the Snake River Plain. This is going to be covered by basalt. All of the alluvial material coming in from the mountain ranges outside that Plain is going to cover it all up. This stuff is also, the stuff that was flown out into the vallies, is also going to be covered by alluvial material. The only part that is going to be left is right down in here along the edges of the mountain ranges. So, those are the only scraps currently viewable from much more extensive welded tough sheet than had distribution of thousands of square miles. (347)

So that's what we see in these little, tiny hatches around the edges of the plain. We look at these things individually and we realize that they are scraps of much larger sheets. In fact, we can't see any of the calderas out here. They're all buried. None of them are out there, except that, a lot of people think they can see them from geophysical methods. There are a lot of geophysical methods that are used to identify these things. People think they know where they are .

So, we end up with a bunch of these rhyolite sheets scattered at various places around the Plain and they are not very extensive in their distribution because they're only scraps of much larger welded tough sheets.

Dave: All resulting from a series of calderas that goes clear to Yellowstone National Park, each one a little younger than ... the Western ones.

Mel: That's the idea. Remember I told you that that picture, old rhyolite flows to the southwest, young rhyolite flows to the north east, was the simple picture that appeared .. was present about 15 years ago (10 to 15 years ago), maybe even up until 5 years ago. Since then, people have gone in and have studied alot of the well exposed rhyolite sheets in the Idaho Falls and let's say, in the area between Dubois and Arco. A lot of work has been done on the rhyolite sheets in that area, both on the northwestern margin of the plain and on the southeast margin of the Plain, down near Idaho Falls. It turns out that the studies that have been done by a woman, who also has a paper coming out in this symposium volume that you need to read, Lisa, she studied these things for her Master's thesis and she is continuing on for her Ph. D. thesis. She studied a lot of these rhyolite flows around Lidy Hot Springs, in the area of Lidy and Idaho Falls and she found that a lot of these things have very different age relations than were known before. It turns out that the simple age progression - old to young - is a gross simplification. It turns out it is old, old - young, moving back to the southwest - old, old, young, young, young, old, old, young, young etc. The overall pattern is old to the southwest - young to the northeast. But it's not a simple pattern as we once knew. (394)

What's happening? Why do these calderas form? Well, calderas form when large blobs of melted, crustal material form and then rise gravitationally to the surface and they form at the base of the crust where the mantle is so hot for some reason that it begins to melt the crust. There is a fundamental problem there - how did the base of the crust get hot?

Now we get into plume theory. From various pieces of geophysical evidence, people know that the Earth is broken up into plates. You're well aware of the plate theory? One idea is that America is a plate all by itself and that North America is rotating on the surface of the Earth as a sphere. It's rotating as a plate. From various geophysical studies, they known the direction in which it's moving and they know the rate it is moving. It's moving to the southwest at a rate of about 3 cm a year.

Another piece of evidence on this is that the Hawaiian Islands are really part of a chain of volcanic islands that extends off to the northwest toward Japan and Siberia. A long time ago, some guys in the USGS memo park went out and dated all the rocks along the chain called the Hawaiian Emporer Chain of Islands and they found a beautiful age progression from young rocks in Hawaii, old rocks in the northern end of this chain. In fact, when they worked out this age progression, it seemed to be so regular that .. the idea was that the Pacific Plate is over lying a mantle plume. The mantle plume is nothing but a spot which is fixed, does not move, the mantle does not move except for some convection cells, but they stay in the same place. Some of these convection cells bring up hot mantle material to the top of the mantle and at the base of the oceanic crust and begin melting there and pump out basalt magma. So, as the Pacific plate slides across, there are going to be a series of volcanoes that form directly above the mantle plume. Mantle plume is a real simple term. Nobody really knows what a mantle plume is, so we'll back off that. The Hawaiian Emporer Chain represents a series of volcanic lands, which there is definate age progression and this all goes back to the fact that the, in a very strait line, it looks as if the plate , the Pacific plate, was moving the northwest toward Japan. (449)

and going over mantle plume, and the mantle plume was just simply sending out batches of basalt magma,periodically they came out on the surface and they formed Hawaii like islands, as the plate moved across.

Now, let's to back to the Eastern Snake River Plain. We know that the American plate is moving to the southwest at a rate of about 3 cm a year. A man who promoted the plume theory was a professor at Princeton named Jason Morgan. He said there are plumes all over. They're fixed and we can see the traces of mantle plumes by just simply finding out where their tracks are. They're either in the ocean or on continents - continents flow across mantle plumes just like pieces of the ocean crust do. The best place to see one is the Snake River Plain.

By that time, when he developed his mantle plume theory, enough age dates were available from along the margins of the Eastern Snake River Plain so that he could work out something like this. Then he took the ages and the distance divided it through and it turns out that the age progression is that things move along at about 3 cm per year from Twin Falls to Yellowstone National Park. The idea then is that the plume is down here (on diagram) and if this is the direction of movement of the North American plate as it swings across the surface of the flow, you're going to get an age progression from old to young directly beneath the flow. This point down here was beneath the plume 14 million years ago - 15 million years ago near Twin Falls. Yellowstone is directly beneath it now.

That's alright. There's nothing wrong with that theory except it's kind of simple, but it's probably the best explanation we have right now. However, there are variations on the plume theory. One variation is that mantle plume produces heat at base of moving crust which leads to rhyolitic magma - bodies which rise to form calderas and welded tough sheets and that boils down to 3 cm per year - old to the southwest, young to the northeast.

Modifications to the Plume Theory:

One modification is that there is no plume at all. It's not a modification - another theory is that there is no plume at all. No plume, and we'll call this one the Basin Range Extension in frictional heating. Because the North American Plate has slid to the West, it's overridden what's called the East Pacific Rise. (Explains diagram #532 -539). You know that in the oceans there are rises in which the crust is moving away in conveyer belt fashion from these rises. Here are the East Pacific Rise , maybe 80 PR, and the North American plate has ridden over the East Pacific Rise, but the spreading still is taking place. Now that we're out here, look what's happening. The mantle beneath this part of the United States is moving that way and that way. All it's doing is tearing California off into the Pacific. But out here, the movement of the plate is this way, the movement of the mantle is that way. That's causing a tremendous amount of friction at the base of the crust. There's a possibility of heating. It's also the reason for simply, although the actual mechanism is much more difficult, for what's called the extension in the production of basin and range kind of structure in the Western part of the United States. This thing is going on now. It's tending to pull ~~X~~ the Western part of the United States apart producing basin and range structure in the basin and range province.

Dave: This was called the Eastern Pacific ...

Mel: Eastern Pacific Rise. That's the spreading center for the Pacific Ocean in the eastern part of the Pacific Ocean. If you want to put Hawaii in here, there's Hawaii. If the mantle is down below this, and this plate is moving this way, what's going to happen will be the next island will form down here as it goes across the mantle plume and then the next island will be down here, and the next island will be down here. Then you get your chain of Hawaiian Islands. As that part of the Pacific plate moves across the mantle flow.

Let's suppose there is no plume here at all. It turns out that the Eastern Snake River Plain, we look again at the western United States, and here's the East Pacific Rise coming up and spreading this way through the Gulf of California, it goes beneath the (Western) United States and comes out up on the northern California coast. (592)

Here's the extension in the crust beneath and here's the direction in which the plate is moving. I'll put mantle down here because that's what's moving there and here's the Eastern Snake River Plain and here's the Idaho batholith. It turns out that the basin and range province has an extent about like that, it comes down here and comes across something like this and comes up along the sea eras and then extends over this way, so this is basin and range. The Eastern Snake River Plain is located at the boundary between a stable part of the continent and a spreading part of the basin and range. A lot of people think that this boundary here is a boundary between the spreading part of the crust, which is extending, and a stable part of the crust, which is not extending.

(First, I'm bothered between)

So, it becomes then a frictional boundary - extending basin and range crust and stable Idaho batholith crust to the North. This material is, the basin and range mountains are extending this way down here. It turns out that there are some basin and range mountains to the North, but let's ignore those for a minute. The Snake River Plain is located just simply by virtue of the fact that it's between extending basin and range crust and stable crust to the North. It's a frictional boundary and heating is occuring at that particular location just because it happens to be there. We know the basin and range is expanding off to the East more and more and more country to the East is coming into the basin and range kind of extension as the basin and range moves outward and therefore, that may explain the progression of calderas at this frictional boundary between these two parts of the non-extending and extending crust. Why these calderas would move off to the northeast, as the basin and range expands, it includes more and more extending area and the frictional boundary between these two moves off to the Northeast as well.

Dave: Who's done work on this?

Mel: This theory is explained in a paper by Christensen and McKee, Geological Society of America, Special paper, 152 ? I really don't know what the name of it is. (675)

Dave: Your basic mantle plume - Did you say that was Jensen?

Mel: The idea for plume theory was originally explained by Jason Morgan and I don't know where the reference is, but you could get it out of any... and was picked up by and explained by and added to by Armstrong Leiman and Moldy and that's the paper in which all the dates in the Snake River Plain are spelled out. That's a KAR mark on dating paper. That was a rare feature.....

End of side one, tape one

Tape #2

Another idea that is floating around now that has a lot of appeal... I'm separating out all of these things, saying they're really separate from one another, they're really not, they may be all intimately related to one another, let me come back to that. A new slant on things is something called the Flaw Theory. The Flaw Theory says that there is some basic southwest, northeast trending structure in the crust that is being used by magma to get to the surface. Now, this flaw would be seen if we could strip off all of the thin, superficial cover of igneous rocks around here to get down to Precambrian rocks. The kind of rocks that are exposed in southwest Montana and over in the Tetons, down near Pocatello, in various places around here. Where we do see Precambrian rocks, exposed around the area of the Snake River Plain, there is what's called a structural grain to the Precambrian basin of this area. That grain where we can see it, is southwest, northeast generally speaking. A series of faults, bands of rock, all the structures seem to be align southwest, northeast. In other parts of the western U.S., there are trains of volcanoes which are also aligned parallel to the Eastern Snake River Plain. There are lots of people who think that the structural grain of the Precambrian rocks, Precambrian basement, around here is southwest, northeast.

Let me go back to the structural grain again. If we could look at the Western United States a 100 million years from now, we wouldn't see anything (24)

topographically like we see now. We wouldn't see the Rocky Mountain Ranges, the Sierra's, the Cascades. We would probably see something totally different, but we would probably see remnents of all of these mountain ranges. If we looked at the structural grain of the Western United States a 100 million years from now and looked at the remnents of these ranges, we would see a north-south trend. That's the structural grain of what we see now.

Back in Precambrian time, uniform structural trend was imposed on the Precambrian rocks at that time and now with the continent sliding around as they way they have, that particular trend is oriented parellel to the Snake River Plain. What's happening possibly is that whatever process is producing magma seems to be taking advantage of the structural trend and the flaw in the crust, with this trend, is being taken advantage of by magma moving to the surface and it seems to be moving in a direction which is from southwest to northeast, possibly by the fact that as the plate is moving, a some kind of process takes place to form the magma and then once the crust has gone through its melting stage and all of the low temperature melting cracking has been bled off, its been heated up, the materials that can melt at whatever the temperature is do melt and form the magma to go off and what's left behind, the residual rock material, is of a composition that won't melt regardless of how high it was heated. It would if you could heat it up way high, but there are no processes that can heat rock that high. There's no way for that rock to melt anymore. But farther along the flaw, to the northeast, there's still rock that can be melted, so it's getting melted there. Maybe it has to do with the fact that the crust is moving in a southwest direction. It's not over a plume, it's just that the flaw may be the spot that allows the magma to get to the surface. It's a weakness in the crust, through which the magma can get up there.

Dave: So this theory totally disregards the Mantle Plume Theory.

Mel: Yes, it basically disregard the Mantle Plume. It's still o.k. to have a plume, but it's not absolutely necessary. (53)

Now, one of the reasons that the flaw is believed to be there, there is geophysical evidence to say that it is there, there's a paper again in by Maybe and a whole bunch of other people in special paper, I think it's 152, of Geological Society. It says that this trend is really extensive. It goes all down the Eastern Snake River Plain, it goes down into the (north-eastern) part of Nevada and it's so prominent down there that they call it the Humbolt trend because it follows the Humbolt River across. I'll call it the Humbolt Magnetic Trend because this was all devised by analysis of the aeromagnetic data. That's the Flaw Theory. Tomorrow there will be another one, next week there will be another one and there's no one theory. Everybody's going to have a shot at it and there's no one theory and there's no answer to it. There's no way to dig out an absolute answer. All we can do is say here's an idea and is it consistent to what's known about geologic history? Is it consistent with what's known about geophysical properties around this part of the world? If it is, then it seems to be acceptable at the time.

Dave: What you're talking about is whatever theory you go to has to affect an extremely large area, thousands of square miles, comparable to the formation of the Rocky Mountains. So the data that's obtained has to come from a huge number of sources and until that data comes in, one theory may carry a little weight and add a little more information, we may want to go to another theory or that may throw us back clear to an original theory, so were strictly working with theories. Like I say, which ever one is in most favor at that time is the one we would use to explain it if you were doing a general publication it's kind of an obligation, maybe you explain several of the theories and I suppose you would come back and say it may be a combination of a part of each theory. (87)

Mel: These things are so complicated that the only people who can really understand the theories very well are people who are total generalists in geology. They have to be good in a million different areas to apply data from a million different avenues of research to figure out what particular theory jives with everything. It has to jive with geology, it has to jive with geophysics, it has to jive with petrology, historical geology and everything else. You can only really get good at that if you are a generalist. You can't be a specific guy. A geophysicist can say, hey, I think this is what's going on, but it doesn't match the geology and it's no good. A geologist says, hey, this is what I think is going on, but if it doesn't match the geophysics, it's no good. So, in that, to try and take all this complex stuff and try to explain it to the public, people who have no idea what a sliding plate is, have no idea what a mantle plume is, have no idea what a caldera is or rhyolite, or how rocks are dated. The job is impossible. It's impossible to understand, it's even more impossible to explain.

Dave: You're doing an awful good job of it. We've got the calderas established which are rhyolitic, now I guess we need to go on and put the basalts on top of it.

Mel: There's a real neat paper that describes calderas and how they form and what happens in the stages they go through. It was a paper, a fairly general paper - specific in some parts, the neat thing is that it describes the caldera theory in pictures so well that you really ought to have it. It's a paper by Smith and Bailey; Robert L. Smith and Roy H. Bailey. It's in a geological society of America memroir and I don't know the name or number of the memoir, but the title of the paper is Researgent Calderas and if you don't have it, I'll get it for you. It takes calderas through their formation. Basically the way the idea starts is that you have to have some kind of heat source in order to melt the deep crust. That comes from the mantle, probably, there probably aren't any heat sources natural to the crust that are capable of melting the deep crust. You've got to have some heat put into the deep crust from the mantle and nobody really knows how that happens. (129)

You can't sample it, you can't see it. You just simply look at the products that come out in terms of volcanic rock. You can study the earthquakes and so forth. Anyway, let's say there's something in the deep crust that's supplying heat to the base of the crust. Now, when the mantle is hot enough to melt the crust, it also hot enough to partially melt itself. When the mantle melts itself, it produces basalt magma. When basalt magma starts to rise through the mantle, the upper part of the mantle and to the base of the crust, it carries its heat with it . So, the production of basalt magma in the mantle beneath the continental crust is a mechanism for bringing heat to the base of the crust and beginning some melting. You've got to have whole sale production of basalt magma to melt the crust and we really don't know what those processes are in the mantle that are producing basalt magma and _____? (#142). But let's say that it does, for whatever reason, that basalt begins to rise and for various reasons, it going to , let's say, get stuck at the base of the mantle. It's just going to pool there with all of its heat. So, it's taking heat from deep in the mantle and this blob of liqued basalt magma rises through the mantle because it's less dense, gravitationally unstable, and it's going to rise just at the base of the crust and it's going to take its heat with it and it only has to raise the temperature of the crust a few tens of degrees to begin the base of the crust to partially melt and form rhyolitic magma.

Then you've got two kinds of magma - basalt, rhyolite. Two very different kinds of rocks are going to come from those magmas if they get to the surface. The caldera cycle really begins with eruptions of basalt magma, not rhyolitic magma because the basalt magma, which is coming up through the mantle at the base of the crust to begin the melting of the rhyolite magma, some of that basalt is going to escape to the surface. It's going form basalt lava flows on the surface, but most of the stuff is going to stay at the base of the crust, it's not going to come out. It's going to stay down there. It's going to cool very, very slowly and it's going to give off its heat in that rhyolitic magma. It's going to start to form little bits at a time, which begin to rise,coalesce with one another (160)

and form one larger body. Then you go through a rhyolite stage. You have this huge eruption. The blob of rhyolitic magma rises through the crust, a little bit of the basalt is getting out, so you have a stage of basalt volcanism and the formation of the caldera and then there are several stages in the formation of the caldera. The caldera goes through its cycle, basically what happens is you've added heat to the base of the crust, you've produced ryholitic magma and you produce all that's possible to produce because so much heat is added the temperature of the crust reaches a certain stage down where the melting is taking place to produce rhyolitic magma. That forms, it rises out of the way, and what's left is a collection of minerals and rocks which will not melt any more, unless you raise the temperature more. Chances are you're not going to raise it a whole lot more because either the basalt coming from the base of the crust dies out or some other process takes place. It's not a continuing process over long periods of time, it just happens periodically and then it's over with or it shifts to a new spot.

Go through the rhyolitic stage. All that stuff that comes out is blown out as welded toughs and ashes and so forth and that's over. There are a few little blips and dribbles of rhyolitic stuff that keep coming out but once the rhyolitic stage is over, it's over. Let's say the basalt continues on and more basalt comes out , so basalt, rhyolite, basalt. The basalt stage continues after the rhyolite stage and that's why all the rhyolitic rocks are basically covered on the Snake River Plain because the basalt process has continued on after the rhyolite is formed. The end driving the system is the production of basalt magma at that one affect of basalt pooling at the base of the crust with a little bit getting out is to melt the crust and produce a fraction of rhyolite magma, which is going to work its way to the surface and come out and form a caldera.

Dave: From what areas is the covering basalt going to keep the eruptive to the surface? We obviously have a Great Rift here. I think I've heard something about along the margins of the calderas are particularly productive. You go the big theory on the Snake River Plain, I can go back to many, many fissure flows for this type of thing. (197)

Dave: Can you describe a little bit of where all that basalt is coming from. Is it coming from several different type sources?

Mel: O.K., let me give you a real simple answer to start off with. Let's start out with a simple model. The simple model is the Plume Theory. This part of the world has already passed over the plume, the plume is no longer here, but let's say that the mantle is still hot beneath us. The base of the crust is still hot. You can't disipate that amount of heat in a matter of a few thousands or hundreds of thousands or even a few million years. It's going to stay around for a long time. So let's say there is still a source of magma all the way from Twin Falls to Yellowstone. Basalt magma - it's still there. Let's say there's an infinate supply of this stuff. Basically there is an infinate supply of magma. We know at what rate it is being produced in the mantle. We know what rate it's coming out on the surface. It turns out that a lot of it is still being stored in the crust - not much gets to the surface. Much more stuff ends up as congealed stuff way down deep in the crust and never gets to the surface. It's a unique event if it ever breaks out on the surface. O.K., as the crust passes over the plume, the plume is the source of heat which is going to really drive this basalt-rhyolite (-basalt) system and once we go through the basalt-rhyolite-basalt stage, we get to the second basalt stage, then we're on a down-hill side of things, we've gone past, there's more cooling in the deep crust, less chance for more basalt to be formed and less chance for more of this stuff to come up. So, if the rhyolites are older to southwest and younger to the northeast, basalts might also be older to the southwest and younger to the northeast. We don't have a good handle on that because we haven't done enough dating to prove wheather that is true or not. But, basically speaking, the oldest basalts are found down to the southwest. At least older basalts are found in the southwest, younger basalts are found in the northeast.

Let's assume that there's an infinate supply of basalt magma at depth beneath the Snake River Plain and it extends from Yellowstone to Twin Falls. As a friend of mine said one time, "It's there, it's just like blood in your arm. If you want to see it, all you have to do is scratch your skin and you'll see the blood." (237)

All you have to do is break the surface of the Snake River Plain and you're going to see the basalt. Here's one idea I've be toying around with for awhile. We know that the Snake River Plain is oriented southwest and northeast and ... One thing I haven't touch on is the Snake River Plain, what we call a rift as in terms of the African Rift System. It is a big fault bounded valley with faults parallel to the margins of the plain. It's been dropped down and there are many examples in the world of fault vallies like this that are filled with volcanic rocks, some in Africa called the East African Rift System and some in Germany called the Rhine Rapids System, there's some in Norway called the Oscow Graben. They all have shapes like this and they tend to be forming in the extensional tectonic regime, very similar to what's happening in the western United States.

The problem is that if you look at the mountain ranges along the margins of the plain, they're all bounded by faults, which look like this and they're called basin and range mountains and they have a range front fault that separates one mountain range from the next and sometimes the patterns look like that. You've got a valley in the middle, with a stream which comes out. Here's the Lost River Range , here's the Pioneer and the next one over is the Lemhi Range, with it's fault - this is the Howe fault. This is the Lost River fault and we know they're active and it turns out that many of the volcanoes in the Snake River Plain are found in linear chains, like the Great Rift. Some of these linear chains are situated on the Snake River Plain so that if you follow them along their extremities, they end up as being rough extensions of these boundary faults out onto the Plain. In some places that's not true; in some places they sit right out here in the wrong place. But whenever you see one of these things, there is a structural orientation to the gap in the surface of the Earth through which the basalt migrates. That gap is always oriented in a position, not always, but 99% of the time it is oriented like that. The fissures are, these basalts are fissure basalts, they come up through a fissure, they don't come up through a pipe in the ground that feeds some kind of central volcanic cone. (281)

There's reason to believe that almost all volcanism throughout the world is produced along extensional cracks in the Earth's crust and is a fissure. For example, Mt. St. Helens probably lies over a fissure. The studies of Mt. St. Helens show that all the earthquakes are aligned in a northwest-southeast trend. That is believed to be the fissure and it narrows down into, it would be like caving a funnel, in squeezing two sides of a funnel, so that you have something that's shaped like this - here's the bottom of it and the funnel comes up and there's the pipe leading out to it. But in cross section, if you were looking at the bottom of it, this thing would look like this. Not round, you're just taking the sides of a funnel and squeezing them in. Probably these fissures out here look a lot like it. They start out as an open crack at the surface, but then they start to spout lava only from a few points along the original eruptive fissure. You know the sequence of a _____(#297) that we think takes place in Craters of the Moon or any kind of eruption out here. First of all you start out with a whole fissure erupting curtain-firery eruptions, then it centers down to a few spots, then maybe only one and if future eruptions were to take place on that one fissure, chances are it would continually come up that one particular pipe.

Dave: What are the mechanics that cause that all along the eruption and narrowing down ?

Mel: There's been a beautiful paper written on this...Why does that happen? (I can give you a reference) It's all mathematical and very technical, but it's really elegant. Basically what happens is these things freeze themselves shut. There's so much heat lost to the walls of the crack as the magma comes up that the magma flowing in it must congeal. There's no way that it can keep flowing as a curtain-firery eruption for a long period of time. The cracks are not very wide - there's a lot of stuff that wants to come up, so most of the crack freezes shut. The very widest parts of the crack may be in an intersection with another crack or something like that. (314)

Those things tend to erode themselves. So it freezes in some places, erodes in others. Where it erodes, it tends to enlarge the pipe; it tends to erode in a single spot- in a wide part of the crack system and freeze in others. So that's why everything centers down to eruptions along surface spots on the crack. Maybe there's three spots erupting; two of those will freeze up and there will only be one ready to keep going. If there's magma capable of supplying it and not everything is frozen shut, it will continue to flow out and if it has to erode a pipe-like ____(324) to come up, it'll do it in order to get out. Physics say that it has to.

Dave: O.K., we're at a point here where your saying that most of the fissures run across the plain. Is this disproving this massive fissure?

Mel: What I think is that if you look at the basin and range structure southest of the plain and a little bit northeast of the plain-Lost River Range, Beaverhead Range and so forth - they all show that the crust is being spread apart this way. So the basic movement in the crust is this way. Things are being extended from northeast to southwest. That's why the mountain ranges occur perpindicular to that. The extension is from northeast to southwest. Ranges run northwest to southeast. That extension is taking place in the crust north of the plains, south of the plain and here too, beneath the plain. If the extension is taking place that way, how can you have a fault oriented parallel to the direction of the extension. Geometrically, it's impossible. If these faults occur, it implies extension this way. But all of the contempory sizemisity and techtonics and mountain forming tells us that extensions take place this way. So, it's no wonder that the cracks are forming this way too. The surface of the plain is nothing more than a brittle calf that's responding to the extensions taking place in the crust below it.

Dave: So, this vast amount of basaltic lava is a result of numerous fissures extending across the plain that are more or less extensions of these basin and range fissures and we now know where some of them are located, such as the Great Rift, right here at Craters of the Moon, but tremendous amount of lava as we (358)

may not know the full extent of these rifts and fissure systems that existed at one time.

Mel: The formation of the Snake River Plain, if you wanted to take a time-lapsed movie scene of the formation of the plain - how would it look? You're up in a satellite and you could view fifteen million years worth. It would be like taking a narrow part of your parking lot out there and sitting there with a whole bunch of pancakes. You flick them out, because that's basically what a lava flow is like, it's a pancake - it's a little bit thicker in the middle, but basically it's pretty thin. You just start flicking out pancakes and that's how the Snake River Plain formed. It's a series of pancakes stacked on top of one another. Some of the pancakes are long, if the flows happen to be long in one direction. Basically most of them are circular in alpine.

Dave: The source for these pancakes is the series of fissures.

Mel: Right.

Dave: We don't really have an explanation for the ones that seem to be out of alignment with the mountain?

Mel: Yah, I think there's an explanation for them. It is that the brittle surface of the plain, the thin volcanic layer at the surface, is under tension because the deep crust beneath the plain is being extended in this direction parallel to the open arrows. So all parts of the plain are being extended or under extensional forces. Some of those forces are going to be concentrated in areas where you have some kind of pertorvation of extensional regime. The pertovation comes from the projection of these boundary faults for the mountain ranges outside the plain onto the plain. There's some reason to believe that if this part of the crust is broken here, it's probably broken out into the plain beneath this brittle cover as well. We know that, even though the crust is extending this way, it produces a vertical movement in the blocks horizontal extension, but the blocks still have to respond by moving up and down and that's what happened up in Mackay. The Borah peak side of the range went up, the Chili Buttes or Big Lost River side of the range went down. (398)

Relatively speaking. And presumably, that movement may not have been very great down near Arco, maybe it was only a half a millimeter or so - most of the movement was up there where it was an average of 4 millimeters worth, but there was a little bit of movement in Arco. Let's say that the next time an earthquake occurs in Moore or the northern suburbs of Arco or in that vicinity, it will still have its effect out on the plain and the viewing is that, my feeling is that, those processes that are taking place outside the plain have their effect on the crust beneath the brittle cover of the plain (in terms of basalts) and the structures that we see as fissure systems are simply extensions of major structures that lie outside the plain, not in all cases, but in most cases.

Dave: Two questions to extend on that. Let's move the epicenter from Chili out onto the plain, another earthquake of that magnitude, would this comparable to when you used the analogy of breaking the surface of the skin to bleed; you break the surface of the Snake River Plain if we had an earthquake of that type. Could you expect renewed activity because of that or is it much more complicated?

Mel: It's probably a little more complicated, but not a whole lot. First of all, if you were to look at a map of Idaho and look at the location of the epicenters of all the earthquakes in Idaho, you'd find that the Snake River Plain is basically blank. Sizemigraphs do not record earthquakes beneath the Snake River Plain and an earthquake in nothing more than - rocks move as blocks either because they are being pulled apart or sqeezed together and that's how the rocks respond to the stresses put on them by breaking and when they break, sizemic energy is released. Sizemic energy will be released if rocks are fairly cool and brittle; if rocks are hot and plastic, they will tend to flow rather than to break.

Dave: When you said no sizemic activity has been recorded, you mean it could be recorded, but it has not happened?

Mel: Yah, that's a possibility, except that we've got what 30 years worth of historic records, probably more than that, maybe 50 years worth of historic records and we've got jillions of earthquakes all around the plain, but we don't have any under the plain. There's got to be some reason for that. (448)

The best explanation at present is that the reason we don't have earthquakes beneath the plain is that the crust is still very hot. The rocks in the crust are not responding in a brittle way. They are more plastic.

Dave: That kind of leads into the next question I had. It was my understanding of the basin and range fault is that it was basically a give in a brittle crust mainly with enough down relative movement;and the rift here is mainly a spreading and relaxation type of thing. Is that true? Does the rift act differently than these basin and range faults?

Mel: Yah, probably. There is the possibility that the relation between cracking at the surface and eruptions. Generally speaking, the cracks don't form until the eruption is just ready to begin and that's probably due to the fact that there is a stress system in the crust that's there due to the extension of the crust that's being driven by processes in the mantle, which is driving the basin and range extension. Those stresses are there in the crust and if magma is going to come up, there's a simple map that can be done - simple mathematical analysis that tells you that the magma will come to the surface in a sheet rather than in a little blob or something else. It will come to the surface in a sheet, the sheet will be oriented vertically and perpindicular to the direction of extension. Some simple mathematical rules go to say that. Maybe it's the magma coming to the surface that forms the crack, maybe the magma is working its way up for no particular reason. It works it's way up, pushes the crack ahead of it and then forms. It may not be the fact that the crack forms first, extends down and taps a body of magma to death. We don't know that. It may be due to the fact that the forces that tend to be built up to form these faults are also being formed, or being built up out here. When the stress is relieved here, it may be relieved here in some way which triggers the delivery of magma to the surface. That was one of the reasons why I called you on the phone after the earthquake and said start looking for smoke. It's possible that there may be some kind of relationship between the two. Maybe just simply shaking of the ground that allows the magma to come to the surface. (513)

Dave: Again, like all geological processes, it may have had a great effect on the rift, except that a vast reaction may be 10 - 20 years down the road.

Mel: Except, Dave, we know that when magma starts to move up, it moves up fast it would be a matter of a few hours, days or a week at the most. Magma will rise from 40-60 kilometers down to get to the surface.

Dave: So, we don't really know enough at this point to know what to expect. Am I wrong in..basin and range faults, which run at the base of the mountain extend on out into the plain. You don't know that. We're calling this a rift, we're not calling it a basin and range fault that runs into Craters of the Moon, we're calling it a rift. I guess what I'm trying to do is differentiate between these basin and range faults at the base of the mountains vs. these faults, or rift systems, that extend into the plain. Are they one in the same? What is the coalation between them? Are they acting the same?

Mel: First of all, let me tell you what people mean by the term rift. If you were to ask most geologists what they mean by the term "rift" most of them would say "a fault bounded valley filled by volcanic rock." Many people have said the Snake River Plain Rift and they mean this whole thing. What I have tried to do in the past is - this was called the Great Rift and what he meant by rift there, Sterns, was "a crack in the ground, it is a great crack." That is what he meant by rift. Geologic meaning is "a large fault bounded valley, distances measured in hundreds of kilometers, widths in tens of kilometers and filled by volcanic rocks." Other term rift is "a large crack in the ground." Thats how Sterns used it. He used the second definition. This is how most geologist use the term "rift." What I have tried to do is I've tried to combine them both. I have called the Great Rift a "volcanic rift zone" and that is a second geologic meaning to the term "rift." This is a rift valley. A volcanic rift zone is a zone of cracks through which volcanic rocks have come up. It's simply talking about a fissure or a delivery system. Now, let me talk to you about what is the relationship between a range-front fault and its extension onto the plain as a volcanic rift zone. There is no obvious fault on the ground that we can see that cuts rocks or forms a topographic feature northwest of the Monument ~~on~~ along the Great Rift except that

Dry Creek is very striat as an extension to the Great Rift. However, the geologists that work in that part of the world say that there doesn't seem to be any fundamental structure in rocks near the surface that is an extension northward of the Great Rift. Nobody really knows the reason for that. However, the Arco volcanic rift zone is an extension of the Lost River Range front fault out onto the plain. Let me tell you what we see along the Arco Rift Zone and we'll use that as kind of the model which to interpret this thing. Arco itself sits in a little valley - you wouldn't realize that it's a valley, but it is - it's a structural valley. You start to rise as you go just out of Butte City and up to the turn off to Howe. As you leave town going out past the airport you rise up out of the valley. It turns out that from Arco southeast to Big Southern Butte there is a system of structures, faults, cracks, fissures and volcanic features,aligned fissures, aligned vents and so forth that all go out to Big Southern Butte and pretty much stop at Big Southern Butte. Big Southern Butte is the end of the Arco Rift Zone. Near Arco, actually south near Box Canyon - that is in a small rift belt, it's a fault bounded block and the reason that the river is intrenched there is a couple of flows have gone across and the river had to cut through. But what we find is that there is faults out there - I can take you and show you beautiful faults scarps? that are spectacular - 15-20 feet high-and if you follow those faults out and those little scarps out towards Big Southern Butte, the scarps become less and less prominent until you get out about ten miles northwest of Big Southern Butte and you can't find any faults any more. There are open cracks in the ground parallel to some of the faults and it looks there as if you can trace those fissures out for aways and the fissures go for awhile, then they give out as you get toward Big Southern Butte. So the amount of faulting, the displacement on the faults, the number of fissures and the width of the fissures all seem to decrease in number and displacement as you go out towards Big Southern Butte. My feeling is that what's happening is that the Arco Rift Zone - volcanic rift zone - is an extension on to the plain of the structure which is the boundary fault outside the plain northwest. What we see is a series of structures which is a reflection of the fault zone. We actually see faulted basalt rock in the vicinity of Arco. (647)

The faults become less and less and less in their displacement as you go toward Big Southern Butte and out there it looks as if all of the displacement is taking place in simply pulling apart and not so much ~~X~~ pulling apart and dropping down. Why that takes place, I don't know. I can't tell you that. There's a tremendous amount of displacement as you go away from the plain; less displacement as you go toward the plain. It looks as if the range front faults are more active away from the margins of the plain, that is there are more earthquakes away from the plain and they occur ~~X~~ in larger numbers and with greater magnitudes and greater displacements the farther away from the plain you get, so if you look at the fault history of the Arco fault at Arco, at Moore, and at Mackay - at Mackay you would see maximum displacement, maximum number of earthquakes and faulting events. At Arco, you would see much less and at Moore it would be some intermediate volume. And out on the plain, you would probably see even less. The forces are still working away. Why does it decrease ~~X~~ number, I don't know. That really hasn't been explained.

Dave: Now you could move to the fault system here and explain why it isn't exactly the same.

Mel: If we look at the basin and range distribution around here...(End of tape #2) ...the plain and skematically a bunch of mountain ranges north and south. Here's the Great Rift right here. If you project the Great Rift north, you basically get into an area that's underlain by the Idaho batholith. The Idaho batholith is a big area which consists mainly of what we call plutonic igneous rocks their basically called. They're alike things that probably broke to the surface and what we see now are the roots of a big caldera system. We see the rock that actually congealed to death - it wasn't blown out on the surface. It's deeply eroded - we're seeing the roots of a very complex caldera system. If we could stack back everything that's been eroded off, we'd probably find lots of the volcanic rocks. In fact, there are places in the Idaho batholith where erosion isn't so deep that you can actually find the volcanic cover for all of the deep plutonic rocks.

Dave: What kind of age are we looking at for formation?

Mel: Let's say 60 to 100 million years.

Dave: The oldest thing we've looked at so far in correlation to this.

Mel: Yah, exactly. Here are all the basin and range mountains and extension we know is going this way in this part of the world. For some reason it looks as if the area underlain by the Idaho batholith is probably being extended in the same way. The crust beneath it is extending or...let me just expand on this for a minute. There's the U.S., there's the Idaho batholith that looks like this and here's the basin and range province. This is the area basin and range mountains and basin and range style extension with extension taking place like this down here, like this up here and probably like that up in that part of the world. There's the Idaho batholith sitting right along this part of it. We don't really know why, but the extension beneath the Idaho batholith seems to either be less in amount or if it's the same in amount, the Idaho batholith is not responding in the same way that areas outside the plain are. It doesn't tend to break up into basin and range kinds of mountain systems. There are plenty of faults running through here - we can see them all over in this part of Idaho (where I'm working). We don't tend to have basin and range kinds of mountains form and I really don't know the basic reason for that but there is some reason or explaination for that but I'm not sure what it is. So, maybe that's the reason that we don't find a great big range front fault going up into the northwest of the Great Rift northwest of the Monument. There may be something there, but for some reason it isn't responding that way. One thing we know, another interesting thing is that basin and range mountains all kind of have a fairly uniform distance between crests of ranges or between range fronts or the centers of vallies and it tends to be a regular distribution of these things. One valley is isn't a hundred miles wide, the next one only ten miles wide. They all seem to be about 5 miles wide, maybe 20 miles from crest to crest -maybe more than that. There's a regular progression. If you look at the Howe fault, the Lost River fault, the next one in secession is the Great Rift, then there's a gap and the next one over is the fault valley that goes up through Ketchum and Sun Valley. (50)

Dave: So you would normally project there being a fault in this area from that.

Mel: Yah, right.

Dave: What would have caused this rift in this area? The same reason as these were formed?

Mel: I don't know. I think I can see structures that do project north of here. One of the things I want to do this afternoon is as least go up and see if the bed rock is faulted up there.

Dave: With this basin and range stretching in this whole area is basically what's called a series of faults. What your saying is ~~XXXX~~ although we may not have it extending into the mountain ranges like the rest of these faults-that the stretching still had an effect here and it may expand into that batholith, but the reason for it being here is basically the same.

Mel: Exactly. But the Idaho batholith is having it's effect on the topography produced. We don't end up with basin and range topography in areas underlain by the Idaho batholith.

Dave: Right, so this just makes it a little different circumstance. So the rift is basically spreading?

Mel: You mean the Great Rift?

Dave: Right.

Mel: Not necessarily. It may simply be a passive response. Yah, there's spreading going on. When you take a plate - a brittle plate - like we have in the thin cover of volcanic rocks on the plain and you stretch it from below it has to crack, and where it cracks is going to be filled with volcanic rocks. By dikes, by feeters that are going to fill this thing. It's a chicken and egg argument- does the crack form and the basalt come up to fill it-or because the rocks are under tension, and basalt wants to get to the surface, the basalt comes up and forms the crack. It really doesn't make any difference one way or the other. In any case, the amount of crust is going to continue to increase in length and volume and the spaces created are going to be filled with basalt dikes. (78)

Dave: Why was Williams here then? I took and I don't really fully understand his research, but by putting out those sites and taking lasar measurements that basically he would be measuring movement. Was it movement?

Mel: Dave was not measuring movement. All he was doing was trying to get very accurate distance control. Since there were no obvious topographic points on a map where he could say he was setting out his gravity meter, he was simply using a lasar to locate the distance away from a certain site where a gravity station was established and where gravity was being measured. He was not measuring expansion of the crust in the vicinity of the Great Rift, although studies like that have been proposed many times.

Dave: I guess at this point I'm getting a little bit confused. We have an eruptive period about every two thousand years here.

Mel: Why?

Dave: Apparently and since you're saying it's not that each area has to erupt every two thousand years - erupting along a section that's much older usually ten thousand years or so. Why?

Mel: Why has volcanism been concentrated on the Eastern Snake River Plain here at Craters of the Moon in the last 15 thousand years. We know that there have been other eruptions around here. There was an eruptions down at Shoshone Ice Caves, there's been Hell's Half Acre, there's been a few flows out by Big Southern Butte. They've all occured within the lifetime of the Craters of the Moon lava field, but there haven't been repeated eruptions there. They're one-shot affairs and then they're over. Why we have repeated eruptions at Craters of the Moon - I don't have any good explanation for that and I don't think there is one. I'll give you a couple of possibilities. One might be that we just have a super abundant volume of magma here and it's concentrated beneath the Great Rift and for whatever reason - it's there and if it's there - it's got to get out or it wants to get out and we're just going to sit here and wait for it to come out. That persumes that there's a large amount of magma and the magma wants to get out so the magma is going to be the Great Rift producing system. (110)

Another possibility is that if this particular part of the plain is under more extensional strain than any other part of the plain - why would that be - well, there's a possible explanation to that. But if it is under more extensional strain than any other part of the plain, then that strain is going to tend to be releived here more than anywhere else on the plain. That's the idea that basalt there is sitting there in a pool and once you scratch the surface and once you form the crack, the stuff will simply bleed into the crack and come out on the ground.

Let me get a little more complex. Suppose at depth you have a supply of magma and this magma is going to come up from the...You know about the paper we've written describing Craters of the Moon and the age dating and the progression?

Dave: I've seen a couple of papers.

Mel: There's been a couple of versions of that, it's been reorganized a couple of times. I've written a second part to that - why is Craters of the Moon formed...

Dave: I don't think we have that.

Mel: Suppose the magma is coming up from the mantle and it's going to pool at the base of the crust for some reason and it's just going to sit there. It's probably going to sit there in some kind of a magma chamber. The magma chamber is probably going to be nothing more than a whole series of dikes. It's probably not a spherical blob or .. it's probably a whole series of dikes down there. Those dikes are maybe going to be real close together, nobody knows how high they are, how wide they are, wheather it's a big system, one dike or whatever. But anyway there's something hot down there and it's probably a dike similar to the orientation of the Great Rift and it's just sitting there waiting to come up. As that crack is being fed and magma is leaking up into the base of the crust from in the mantle, that crack system is going to create it's own pressure. It's going to be surrounded by somewhat brittle rock. Probably mostly plastic, but somewhat brittle rock. There's going to be an internal pressure created by this long dike system being filled with stuff coming up that's either going to want to go up or out or both. It's going to create it's own internal pressure. (145)

There's a confining pressure tending to hold the stuff down there. That's the weight of all the overlying rocks. What I was playing around with was the stress system that's created down there. It looks as if it takes about 2,000 years for enough magma to accumulate at depth in some kind of reservoir system - the dike system - before the magmatic pressure, the pressure created by the magma filtering into the system, exceeds the strength of the rocks surrounding it. Just like blowing up a balloon - you keep putting air into it and putting air into it and putting air into it until you would see the strength of the rubber, of the latex or the plastic or whatever the balloon is made of. The balloon can no longer hold the air inside and it breaks. It would be like filling up a dry cleaning bag with water from your hose - you keep pumping water in there until the bag can't hold it anymore and it's going to crack and the water will come out. The same thing as probably happens here. It takes about 2,000 years for the amount of excess pressure necessary to crack the walls of the feter system and then the magma starts to move up. Once it does, it's going to come up in a sheet-like form, the sheet oriented vertically and perpindicular to the direction of stretching in the overlying rocks. The overlying rocks are just providing a median through which the stuff has to come out.

Dave: When you say sheet-like eruption, you mean a long fissure, it's going to come up all along that crack and then go through the mechanics of sealing itself off again to a central point. Why does it erupt along that crack? Why does it erupt at the oldest part or section? It's been so long since it erupted. Why does it erupt at that particular place instead of just anywhere along this-if it is one big dike?

Mel: It looks as if rocks have some kind of memory effect. They're being stretched; they're being pulled apart. That part of the rock - that part of the area around here that had it's stress build up relieved most recently must wait a longer period of time for more stress build up and have it relieved than the part that has had stress build up for a very long period of time. Maybe that didn't make sense.

The magma is going to come up where the stress can be releived most easily. If it's going to form a crack it has to break the rock. It's going to break the rock most easily that's under the most stress -pulling apart stress. If I had a piece of gum, take it out of my mouth and pull it just a little bit, it's not going to stretch very much, but if I pull it a lot, it's going to stretch out and become much thinner. The more stress you build up, the easier it is to project that crack up to the surface because you tend to pull the rock apart rather than squeeze it together. If the rock is just sitting there without any tension on it, you'd have to produce a tremendous blow to send a crack through it. If the rock is under tension, something is tending to pull it apart, it doesn't take very much of a bang with a hammer or any other kind of pressure to drive a crack through it. So the greater build-up of stress, the more the rock is being pulled apart, the more it is under stress, the easier it is to relieve that stress by driving a crack through it.

Dave: O.K., so there's really two powerful forces acting on the rift. There's the whole Snake River Plain movement going in opposite directions and then you have this magma, which is exerting it's own forces and it's a combination of the two that will result in an eventual eruption.

Mel: Right, and one of reasons we think is that the Great Rift is kind of like a loaded gun. It's ready to go off almost any time and there's a balance of forces that's tending to prevent eruptions. Once that balance is upset, either the rock is really stressed so that a crack can form _____?(208) by magma or the pressure in the magma depth becomes so great that it is going to just force it's way to the surface. When either one of those systems, either one of those unbalancing things occur, then there's a chance of an eruption. There's another possibility and that is that the system is almost always poised for an eruption. There may be diking events going on all the time- every ten years, every twenty years, every hundred years - but only a few them ever make it to the surface. Maybe dikes that are coming up to within a mile of the surface never make it. That's a possibility. There are a lot of open cracks around here. The open-crack system southwest, between here and King's Bowl lava field seems like it should of had some lava come out of it, but it didn't. (221)

Dave: O.K., I think we've pretty well covered my first three questions. As far as our relationship to Yellowstone, it is just the relationship of the whole Snake River Plain, which is not totally been worked out yet. Part of the massive caldera thing, part of the spreading, there's rhyolite there, there's rhyolite close to here. If we have a mantle plume, it may be at Yellowstone now and may have been here earlier but - yes, there's probably a connection, but we're working through the theories yet to really establish it.

Mel: The Snake River Plain has evolved in the caldera cycle as a series of calderas that become younger and younger and younger with time, as Yellowstone, then Yellowstone represents the earliest part of that series. The idea is that millions of years down the road Yellowstone will have gone through its rhyolite caldera cycle. After an area goes through the caldera cycle, there is cooling and contraction of the rocks, literally sinking of the crust and then you go through the second basalt stage when all the rhyolites become covered with basalt. It turns out that a lot of the relief, a lot of the heights and vallies in Yellowstone, are created by _____??(246), which has just been superimposed on it. You see all the ___(247) up there. There isn't really that much in the way of relief. It's a high plateau but may tend to sink now in the next few hundred, few hundred of thousands of years or millions of years. We may end up with a valley, an extending valley to the northeast just like we have now and five million years from now it will look just like it does from here to Arco.

Dave: One question has come up. I think I asked Dick this and he didn't have an answer. Why are the cones concentrated in the north end of the Rift here?

Mel: O.K., two answers. One is that there have been more eruptions on this end of the Rift than there has been in the middle part or the southern part. Another is due to the fact of the composition of the lavas. We've gone through this elaborate process of trying to determine what the compositions of the lavas are. It turns out that there are a few lavas here that are very silica rich and that makes the lava more pasty, more viscous, and as soon as it becomes more viscous and more pasty, it tends to build up in vulbous?? flows and the _____??(266). The big cinder cone, Big Cinder Butte, is composed of lava that is very high in silica. (268)

Lava at North Crater is, Silent Cone is, Grassy is somewhat, Sunset is somewhat. The low cones here I would call, even though Inferno doesn't look like a low cone - it is. The cones tend to be built up from lavas which are fairly high in silica and it doesn't take a very big change in the SiO_2 content of the lavas to make it basically pretty viscous.

Dave: O.K., the more silica, the more explosive eruption, the more likely a cinder cone will be formed under those situations.

Mel: Right.

Dave: That leads us to the next one is the significance and reason for higher silica levels.

Mel: We don't know. The one possibility is that as the basalt collects in a pocket at depth, it also builds up enough heat to begin melting rock at depth.

Dave: Is the silica level being controlled by ...

Mel: No, then if you have the production of, a couple of processes are going on and this is something we're working on right now - we don't have the answer for it yet. As basalt pools in some kind of reservoir at depth, it begins giving off its heat [illegible] down there to surrounding rocks. Those rocks begin to melt so its possible that you have mixed magma there. Magmas that are a mixture of basalt and rhyolite that give intermediate compositions or the basalt is just preferentially soaking up materials, either crystals or certain elements or something like that - like silica and some other elements - soaking them up, melting-the crystals might get incorporated into - they get melted into the magma into the exchange of the flow constitution??

Dave: O.K., I think your report states that silica level has been increasing with more recent eruptions. Why?

Mel: Whatever the process is that's going on to change the composition of the basalt magma has become more pronounced with time.

Dave: O.K. have we gone past the silica level that produces the typical Hawaiian eruption or will we go past that?

(306)

Mel: One of things I can say is that with time, we will get the whole sweet of magmas. Some magmas have become more silica rich with time; however, in each eruptive episode, along with the very silica rich magma there's also the low silica magmas, not quite as low as what we had before - but there's still low enough. In any one eruptive period you might have eruption of both the really high silica stuff and the low silica stuff. Maybe simultaniously, but maybe in that order too. The silica rich stuff gently coming out first, being followed by the other stuff.

Dave: In predicting a future eruption, you would not see anything more significant than the typical eruptions that have already occurred?

Mel: Yah, that's what I think. The eruptions that occur in the future will be very similar to what's happened in the past.

Dave: This is similar to what is happening in Hawaii today. It's not wrong for us to make a lot of our comparisons with Hawaii?

Mel: Right. I think the style of eruptions will be fairly similar, but there will be some differences.

Dave: Greeley said when he was talking about basaltic plains that basically this area was characteristical - say it was flood basalts combined with Hawaiian type or shield volcano formation. Why not getting away with what we intially started with, which I heard parts of these in both of them. He was making some big differntiations between basaltic plains and the Columbia Plateau, but our comparisons to Hawaii...

Mel: He doesn't understand why there's a difference. He's an observer. He can observe something and described what things are different, he doesn't know why they are different. That's what bothers me about him.

Dave: I would say that was true.

Mel: He's very descriptive, he's good at describing things, but he doesn't understand why.

Dave: We pretty well understand how you age the flows and etc., but you have lumped in some ages for cinder cones, etc. Talking with Dick, he said that right now there really was no way to age a cone unless you traced a flow directly to it. To side step this a little bit, he also said that he felt most of the cones here were formed

from a single volcanic episode (353)

from a single volcanic episode (353)

Dave: He has talked with the person who did our vegetation study and there's been a little bit of question concerning the person who did the vegetation study did some soil profiles. Not only did he find the soil layer on the top of some of the cones, but on several of them he found a soil layer at about the 3 foot level. So he questions that they were single episodes cause certainly it took hundreds of years for that soil layer to build up. I can't tell you specifically now on what cones those are. I, myself, find it a little difficult that just because you can age a flow to a cone insures that that cone is that age.

Mel: First of all, I'd like to know how the guy is using the term "soil". For example, there's a turn out on the road to the Tree Molds parking lot, just on the north end of Broken Top. Those are not soils in any sense of the word. A soil is some kind of accumulation of broken rock & vegetated? material that builds up over a long period of time in the weathering processes. Soils are not going to build up on cinder cones. There's no way a soil can build up on a cinder cone unless you're in the middle of a constant dust storm - constant over hundreds of years.

Dave: I have seen these soil layers that he talks about and certainly I know that if you go on one of these old cones that's 2,000+ years old, you go through a very loose layer of cinders, immediately under that you begin to hit the soil horizon and there is plants growing in it. What you're saying is that you tend to go along with the single episode for the formation ...

Mel: Not necessarily. Nobody has seen an eruption. All we can do is go back to well documented Hawaiian eruptions and Islandic eruptions. What happens is is that a cinder cone can form over an extremely short period of time, in a matter of a few hours or a few days from a fire fountain that just keeps going and going. My feeling is that an eruption like the one that formed Big Cinder Butte probably took a good, long time to form and it may not have occured in just one eruption, it may have occured in several, but my feeling is that they were probably fairly closely spaced in time. Now, eruptions can be discreet events. A discreet event. A bunch of processes are going on, but they only last a few days, hours, weeks - not years and then they are over with (404)

Cinder cones can form in very short, short, short periods of time without a doubt. Any cinder cone here could have formed in a matter of a few days or a few weeks. However, these things are set along the Great Rift and chances are that if a fissure is going to form, it's going to form on the Great Rift so it's going to be by close some pre-existing cinder cone and presumably cinder cones form because the stuff is coming up a pipe-like c_____? (414) after the fire-type? eruptions. When that happens, the c____?(415) is there and chances are the c___? probably doesn't fill up with congealed lava as the eruption plain. It drains back down the hole, so we assume the possibility of the next eruption will come right back up piping in. The only cinder cone that I know of, actually I know of two in the monument, that look as if they've had a multiple history, that is that maybe they've been involved in a couple different eruptive periods separated by hundreds of thousands of years. It would be the Watchman and down here, the Sheeptrail.

Dave: O.K., I don't think those were involved. He is going down three feet and finding something that he believes to be the soil level. There's no way he's going to find a natural soil level unless hundreds of years have passed after that cone was initally formed,hundreds of years passed before any other material was deposited. So soil could indeed form. in that case What you're saying is that you don't believe that was the sequence of events that occurred here. Then what is he finding at that level?

Mel: Let me bring out a couple of possibilities. One would be that _____?(442) is accumulating on the cones. Wind-blown dust is accumulating on the cones and it accumulates in such a thickness that it actually forms what I think of as a soil. The oldest flows in the Craters of the Moon lava field has some ___(448) on them but only very near the edges of the field. You've got to be close to a supply of ___(450) to have an area covered by it. There's no close by source. Everything is covered by young lava. So you'd have to have an extremely old cinder cone to have dust being lofted through the air over long distances from the edge of the lava field to get covered. Cinder cones do not weather very well. The cinders and the stuff from the cinder cone oxidize - most of the oxidation takes place right at the time that the cinders are deposited, not later on. (459)

They oxidize and they can break down. That doesn't happen very fast either. The water tends to go through the cinder cone like nothing. There's not going to be a whole lot of weathering going on to form a soil. My feeling is that what he is doing is he's simply going down through layers of different kinds of stuff, deposited in the same eruption that look different. He probably going through course black stuff then he comes to a layer of fine, redish stuff then he might go into a layer of course redish stuff and he might call the layer a fine ash. He might call that a soil. It's no different than any other cinder in there, except it's finer grain and different color. When these fountains are playing around, the fountains are going through all different kinds of activity. They're putting out big clouds of stuff sometimes, they're putting out fine ash sometimes. Generally when these fountains are running and going full boar there are different kinds of materials that are being spread all around the cinder cone from the fountain that's forming them. Big blocks of cinder near real fine ash there and then the thing switches around and you get all different kinds of accumulations of different material is in cinder cone form. Lava flows, congealed blocks of lava, just.. if you could stand there in an asbestes suit for a week and just watch the stuff accumulate, you'd be surprised at how different the stuff is that is accumulating at your feet every ten minutes. So, a cinder cone is an accumulation of a whole different, tremendous array of stuff as it forms in any one spot. (right all these things are going on)

Dave: I am certain that he would be interested in this. He would be interested that you came back with proof that ....so we will pass this on to him. As I understand it, a cone erupts and is formed and usually a lot of gas is given out initially and that must take North Crater for example. Lava continues to come up the conduet?? and usually becomes thicker and turns into lava flow. The cones are not very strong structures, so often times, like North Crater the wall is _____?(501) etc. You trace that flow to the cone and you feel the cones are basically one formation and the cone forms if resulting lava flows come from the same conduet?. It's going to occur at one time. You're not going to have a cone form and later up the conduet - hundreds of years later - comes a lava flow. (507)

Mel: No, that is possible. If our understanding of the history of North Crater is right that's exactly what happened. The cone formed during the time of implacement or of the formation of the highway?, the serate? & the Devil's Orchard flow and later, right up the conduet came the North Crater flow. We don't know what the difference in kind is because we haven't been able to date those. We haven't even been able to date the North Crater flow.

Dave: Why not?

Mel: The idea of dragging a back-how. HA! HA!

Dave: It's not the kind, a pahoehoe flow can be done with thinial? magnetic dating; aa flow has no real ...

Mel: O.K. we have some relative ages. The relative ages we have tell us that highway,serate, Devil's Orchard, North Crater are all fairly young and part of the 2,000 year old sequence of events, but North Crater is obviously the youngest of those four.

Dave: So but, almost geologically you can say, even though it came back up the conduet later, the sequence was very close knit there. It wasn't thousands of years spread.

Mel: No, maybe a hundred.

Dave: O.K., you have referred to the ages of cones. If I understand it, you can't go in and age cones and rely on the flows leading up to that. Mel: Yah, exactly.

Dave: So you're fairly comfortable in saying that you trace this flow to that cone therefore, that cone is such-and-such age. There are some exeptions where you can't do that and so you really haven't established an age.

Mel: Right, right.

Dave: Dick mentioned and it's been dropped ever since and I was hoping that if he was coming back it was for that study, but I'm not so sure. By looking at what we call the irredecent lava, which he said was only found right around the throats of the cones for the most part, or at least always in his approximity of that. There were some people working on some research who thought they might be able to get an age based on that material. I don't know any more about that. (547)

Mel: I don't know about that, Dave, it's all kind of brief and I have no idea what they've referred to.

Dave: However, talking about North Crater, you have two theories on what occured at North Crater and Hiway Fault?, etc. I have a feeling that one of you had one theory; others of you had another theory. Which theory do you, yourself, support?

Mel: I like the idea of the highway flow flowing south to north?

Dave: Coming between some certain ____? (565)

Mel: Dwane thinks that the highway flow was erupted right up at the north end.

Dave: O.K., right, that's his second theory. You're theory is that it came out of North Crater, went up, and then the fault exploded and flowed back. When we say flowed back - down south and it went through the vent up there.

Mel: There's a good possibility that the Serate flow and the Hiway Flow are the same thing.

Dave: Now the monoliths, or things we call monoliths, the crater fragments that came out of North Crater are obvious there on the North Crater parking lot. Are the fragments that are out in the serate flow clear down at Devil's Orchard - are those crater fragments from North Crater?

Mel: We think so. There's no way to prove that, Dave. Somebody could do that if they really did it in a very serious study with a lot of chemical analysis. First of all, if you went in and sampled North Crater to find out what the variation is, you're finding unique rock in there and then go out and look at the monoliths and see if you can find the same rock distinct in .....and then you could prove it. The only thing we can say is that you can see a train of them. You know the Serate flow went from here in that direction. North Crater doesn't have a north side - it's gone.

Dave: Right. So, you know they were floated down there on AA; pahoehoe's covered a major portion of the northern section of that flow. Down around Devil's Orchard cinders have covered a large part of that flow from subsequent eruptions - Big Craters or whatever.

(603)

Mel: Big Craters flow is down in there - what else? The Serate flow covers the Devil's Orchard flow we think.

Dave: Big Craters with at least eleven identified craters is the simple complex cone. The figure eight that you have more or less in the main vent there would indicate that one very cylindrial cone had probably formed and subsequently the second portion began to form and probably blew out the center section or ....

Mel: Big Craters has eloggated along the Rift and chances are nothing probably records really well how an eruption finally centers down to erupting from one pipe-like conduet. It was probably an eruptive fissure that went all the way from the southern most spatter cone right up to the northwest corner of North Crater. That thing was going like crazy, then it stopped down here at the Spatter Cones and started along a short section of the length of the rift that's incompassed by Big Craters and then all the sudden a fire fountain would come up at the North end of Big Craters and then it would die down. One would come up in the middle and die down; switch back to the north and die down or maybe it would keep going and another one would come up at the south end. Each pulse of a fountain ends up with kind of a circular accumulation of stuff around it. A new one comes up and it's real violent, it tends to blow out some stuff that accumulated before from a previous fountain. You can kind of imagine these things going on and off and switching back and forth. This is what you end up with, an accumulation of a whole bunch of (different) fountains going off, maybe similtaniously, sometimes just separated from one another.

Dave: That's sometimes a hard idea to get across to the visitor when they ask "why does this look like this?" It's hard to get across to them (that) it's because there's a whole lot of things that can be happening and they can be happening in any order so you don't always have a specific answer for every question. How deep are the lava flows? Right here? And how deep do they get down by the Snake River? What is the maximum depth that has been recorded?

Mel: O.K., good question. Can't give you an answer here cause we don't know what's underneath this right here. My guess is probably that when you get away from the bed rock up here in the north the flows are half a kilometer deep. (674)

before you get into something else which would be rhyolite. Only one hole in the Snake River Plain has been drilled through basalt and that was the exploratory well over at the INEL and that went down in the rhyolite and as I remember there was something like a little over a kilometer thick section of basalt and then it went through almost two kilometers of rhyolite. Elsewhere, studies across the plain, show that the basalt is anywhere from a half of a kilometer to about a kilometer and a half deep.

Dave: My other question centered around this area, which is right at the base of the Pioneers. Somewhere we picked up the figure of probably 300 feet right in this area. It's hard to say. You say half a kilometer -you're really talking when you get established out in the plain aways .....What exactly happens when pahoehoe turns to aa?

Mel: A lot of things cause that to happen. If the lava becomes educated? in some way; for example, it falls over a cliff or flows down a steep slope, that tends to be a process which liberates a lot of disolved gas from the flowing lava. When pahoehoe comes out, it tends to form, because it is contact with the air, it forms a cool skin. End of Tape #3!!

...The lava in some way break up that skin, break up that cool surface and let more gas out. When you let it out it tends to, the disolved gases tend to make the lava very fluid. When you take it out, it tends to make the lava more viscous, less fluid and it tends to break up in those plates. Other things that are just simply cooling the lava become stiffer and it breaks up into those pieces.

Dave: And that's what you usually refer to as slab pahoehoe. It's a transition state really?

Mel: Slab pahoehoe is simply pahoehoe that's made up of broken upper surface plates of pahoehoe flow. The upper surface congeals and the interior of the lava keeps moving, it breaks the surface up into plates. The best example of a slab pahoehoe kind of, what we used to call semi-hoe, the transition between pahoehoe and aa, is the Big Craters flow just north between the overlook on the south side of Grassy Cone and the northwest corner of Big Craters or the northeast corner of Silent Cone. (15)

True aa occurs when big viscous flows are moving along very slowly and the top surface cools down to a depth of a couple meters. The interior of the flow keeps moving and as the flow moves along, it's like the track on a catapillar tractor. The upper surface is a big jumble of blocks and as the flow extends forward, those blocks roll off the front and the interior of the flow rolls right over them. That flow is made up of very stiff viscous lava. It's still incandescent and moving and you see in any movie of an aa flow, you can still see the red lava inside it. It's really stiff stuff. It's not running. The top surface is breaking up, the sides are breaking up, As the interior rolls over that,big cracks form in it and that cools off the lava inside it even more and it stiffens up and forms these blocks. That's basically the difference. Cooling...Why does pahoehoe turn into aa? You cool pahoehoe down until can't be runny any more. The viscousity increases because it's cooling down and loosing gases, which tend to make it fluid. Also, if it flows over a steep imbankment, if pahoehoe runs too fast, it gets very thin with more exposure to the air and less heat capacity in that thing, it will break up. Probably the most important factor is composition of the lava. A high silica lava is very stiff and tends to be erupted at a little bit lower temperature and it tends to have a little bit less basalt gas.

Dave: We talked before that pahoehoe turns into aa. You said there was one exeption where the aa didn't turn into pahoehoe, but if you had an aa flow slowed, it's possible for a pahoehoe type flow to come out of that flow. That makes sense to me because even a solid aa flow has various temperatures within it. Some may be high enough to heat lava close to what would be a pahoehoe type lava. The question that I go to now is can an aa flow come directly out of the conduet? Temperature is very important in whatever form of lava you have. Most books you read say that it comes out at about 2000° F, which is your basic pahoehoe temperature. If I understand correctly, it doesn't take a huge drop in temperature before you can go into aa, maybe 300°.

Mel: Certainly.

Mel: Maybe not even that.

Dave: So, that's what I read. It usually comes out a 2000°F. How are we going to get an aa flow out and why is it an aa flow? Because of the silica level?

Mel: O.K. There are some flows in the field that are only aa over their entire length - from beginning to end. The flows that I can think of are the ones that are down just to the west of Big Cinder Butte. The Sawtooth flow is a fine example. We have other flows that we have named and identified that appear on these maps that are almost entirely aa flows. The little Laidlaw Park flow, Caryc?abooka flow and the Little Park flow. These are all aa flows. The flows that are completly aa are very unique in terms of their field characteristics and in terms of their composition. Almost all of these things that are entirely aa flows have silica compositions about 51-52% or higher. The pahoehoe flows have silica contents that are 52% or lower. These aa flows...their compositions are unique. That's the most distinctive thing about it. They're erupted as aa, it comes out as very viscous stuff and it's viscous along it's entire life. Some pahoehoe flows change into aa if they're _____(66) just because by the time the flow gets down there, it's cooled down so much and become so stiff that the only thing it can do is break up into aa.

Dave: So in a case of an aa flow being erupted directly onto the surface, temperature isn't probably the big difference. It's probably a very hot lava right where it's coming out of the vent, but it has such a high silica level that that over comes the temperture.

Mel: Yes, but they may be a few tens, maybe a hundred degrees cooler than pahoehoe lava too, but there the composition is the most distinctive.

Dave: Going a step further then, blocky lava is not very prevalent around here. Could you tell me a little about the formation of that and why it's not very prevalent around here?

Mel: Block lava is a variety of aa. Instead of having the spiny kinds of projections and blocks that are very irregular in shape, the block lavas tend to set up very quickly because they are so stiff. The very highest silica lavas around here are the ones that form the block lava. That's the highway flow. The highest silica content we know of is 64, 65, or 66%. (83)

That stuff was so stiff when it came out that it basically set up right away and when it sets up right away, the only thing it can do is basically break up into _____ shaped blocks. Those blocks don't move once the thing is set up and become non-moving. And then it just stops and that's it. If the stuff is very fluid and keeps moving, then you're going to have these things with the spiny projections on them and all kinds of blocks in many different sizes intermixed with one another. The blocks tend to keep moving and the grind themselves up and that's why you have aa flows with all of these different ranges and sizes.

Dave: We call some material here, it's all basalt, why do we call some of it thenirdite?

Mel: Thenirdite is a mineral, I not real up on thenirdite, but it's a mineral that's deposited I believe on the walls of the lava tubes.

Dave: O.K. I'm mistaken on that then. That's morabolite-thenirdite. That's not what I'm thinking of. This very solid basaltic rock. I would say it's block lava. No vesicles in it, just solid. They refer to it as something. Maybe it's not thenirdite, but it's close to it.

Mel: What we did in describing the lava flows for the large map, we had to come up with a description of what these flows were based on their mineralology and their chemistry. Mineralology for minerals you can see in thin sections and chemistry you can make chemical analysis. We used a classification system that gave a specific name to the flows based on their chemistry. What we tried to do was we gave an illustration of chemical composition of the flows on a graph in which the names were blocked out in different parts of the graph and then the little dots were shown for the position of the chemical analysis on this Rift system, it showed all the names. Wherever the dot fell we used that name in describing the flows. So the names that came up were basalt, andisite, latite, Hawaiite and one or two other names. We simply took a very well know and well used classification system to apply names to these rocks. The names are really a break down of a much larger group of rocks which are the basaltic rocks, which have a broad range in chemical composition. They all tend to be fairly dark colored and fairly runny. They form pahoehoe and occasionally aa. (119)

Dave: For our purposes, we would be more correctly in this basaltic rock with no vesicles, obviously very thick, and that would be the block lava.

Mel: Right, it's called block lava and it's basically basatic rock in the broad terms of how basalt is used to describe rocks of a given mineralology and a given composition.

Dave: Indians used some of that block lava, the very thickest, to form arrowheads etc., but no known obsidian that I know of in this area - two things that are references that the Indians came into this area to quarry obsidian, which I think are probably false. Also I'd like to know why down on the Wood River there's just all over bits & pieces of obsidian?? Way to many (for Indians) to have carried down, chipped and left there. They have been deposited because they are everywhere just bits and pieces. Is there obsidian in this area?

Mel: Oh, absolutely. The area that the Indians went to quarry obsidian on the plain itself, (without) going very far off, was on Big Southern Butte and there are other places where obsidian can be found just off the margins of the plain in some of the rhyolite flows we were talking about this morning. So obsidian is a great commodity around here. One of things I always found when I was wondering around the plain and stopping at the tops of the volcanic vents, all over the plain, not just here at Craters, was the obsidian everywhere. There are chips everywhere. These guys must have been making....There must have been thousands of guys out here twenty-four hours a day making points. The only thing I can think of is that they are carrying them with them making points as they go. They would take loose material and make points as they went. It's everywhere. I've got an incredible collection of arrowpoints that I collected when I was out on the plain. It really is everywhere. As for the Wood River, the Wood River drains and some parts of the northern margins of the plain...it may have some of these welded tuffs, which have a lot of obsidian in them. I'm always amazed at the amount of material that's out in the plain that came directly from point making.

Dave: Well, like I say, there's so much around the Wood River that I can't see that being the technique the dispersed it, but you say the running river itself over flowing and who knows what it did in historic times, etc. The obsidian cooled .. my understanding of obsidian is that it has to be cooled quite quickly...

Mel: Most obsidian used for arrowpoints is from rhyolitic volcanic rock rather than basaltic volcanic rock. Obsidian is volcanic _____?. It cools very, very quickly and it has a specific chemical composition, generally much greater than 70% silica- like 75, 76, 77% silica.

Dave: Why does it cool quickly ?

Mel: Because that stuff is so incredibly viscous that it really can't flow. It's erupted as a very thick paste and it congeals almost immediately. It is not a liquid median that allows crystals to grow in it. It's a quenched glass.

Dave: I've read where the quick cooling was due to being erupted into snow field or glacier. I guess that would be possible too, but what your saying is that you don't need that for it to form. The blue dragon lavas and the green dragon lavas ... First of all is the blue dragon lava unique to Craters of the Moon or does this occur in Hawaii, etc.?

Mel: I don't really know the answer to that. Most basalts that I've seen in Hawaii are black. A lot of them have a sheen to them, but it's not the irredescent blue that we see here and I really don't know whether this is absolutely unique to Craters, but there's no doubt about the fact that Craters has got a lot of this stuff and it's not very common elsewhere, if at all. I really don't know how to answer it.

Dave: Could you explain the reason for blue dragon being there in five words or less?

Mel: No, I'll leave that to Lebvre. He thinks he has the answer. He's explained to me and I don't understand it.

Dave: The fact that when you go out and look at the lavas, whether they are black or blue or whatever, if the sun disappears and they are relatively undisturbed it has the color of black or blue, but anywhere that it has been disturbed, that very coating on the top, it's red underneath. I take it that that is oxidation. (194)

Dave: The reason we've been giving is that the surface is different than the interior in the fact that it is cooling faster than the interior, subsequently crystal formation is going to be different. It is not weathered the same way the interior is weathered, it does not have the tendancy to oxidize, etc. Do you find that to be true?

Mel: Let me go back a step here. As I remember, Lebvre says that the reason for the blue color has to do with a kind of a unique chemical composition of these lavas and it has something to do with the ratio between faris and theric iron and also has something to do with Titanium as well. It's much more complicated than that and that's a real simple answer. It's a chemical reason. When you look at blue dragon lava and if you were to take a big sledge hammer and break through a piece of blue dragon lava, you'll see that the blue occurs in the outer crust on the flow in the crust that's not more than a couple of millimeters thick, maybe a centimeter thick, and then you get down into the normal color of the rock. The deeper you go, the tendancy is for the color to become a little bit darker. So, evidentally, this color is imparted to the rock as it very quickly cools right on the surface of the flow as the flow is forming. That must have something to do with, as I said, the feris iron ratio. As you get down deeper in the rock, which cools a little more slowly, just because it is insulated from the outer cooling air by this glassy rine that's formed, evidentally the ratio between the feris and feric iron and maybe the oxidation states also change as it cools more slowly, possibly in the presence of more oxygen that's trapped inside the flow as it cools by the outer rine. Red inside of rock is oxidation that takes place on cooling, not necessarily by weathering in some time after the flow is cooled way down.

Dave: You said that on cinder cones too. That the red cinders form usually probably in association with steamed vents, etc. Why would that be, they don't oxidize very rapidly after that at all? Why would steam be such a catalyst?

Mel: O.K., the chemical alteration of cinders is taking place as they cool down and become solid. Let's say that the clot of lava that's going to finally oxidize and become red is erupted at, I'll use a 1000° C, it comes out of the throat of the volcano, was thrown up a couple hundred meters in the air.

Mel: By the time it gets to the ground, it's cooled down to, let's say 900°, but in the time it is cooled down 100°C as it's going up into the air and falling down, it has gone through the temperature at which it is finally congealed. It's no longer a paste any more, it comes down as a hard block, but it's still 900°. It sits on the ground for awhile for ten minutes, but after ten minutes, it finds that it is surrounded by other blocks of cinder which are also at 900° because other things have fallen on top of it. So it's going to go down to 800°, it's going to fall the next hundred degrees in a matter of days or weeks because it is surrounded by all kinds of other hot material and it's also pretty well insulated from the atmosphere. So it cools down the first hundred degrees in a matter of maybe a few seconds as it's being emited and finally dropping back down. It cools the next hundred degrees in a matter of a few weeks, probably doesn't reach room temperature until years after the eruption has ceased. So, it comes down to the point where it's congealed as a solid but then cools very slowly after that. It's during that time where it's very close to the point at which it's liquid that the alteration takes place. Steam is obviously loaded with hydrogen and oxygen. The reactions in oxidizing iron take place in the presence of oxygen. The steam is going to provide the oxygen. The heat is still left in the cinders as it's just sitting there in the cinder pile it's going to aid in the oxidation of what's left in there at the elevated temperature. The oxidation is going to take place in a matter of days, weeks, maybe hours or seconds after the thing comes down, but it's still very hot.

Dave: Columnar volcin? - is that what we have when you see the jagged edges that obviously have a certain pattern to them on some of the flows and so on? Columnar faulting?

Mel: Probably jointing is the best term to use. I haven't seen a whole lot of good examples of columnar jointing out here. Those tend to occur in flows which accumulate to a fairly great depth in a lava pond or a lava lake or something like that and there aren't to many of those around here.

Dave: But it is possible that they're in some of the flows?

Mel: Yah, some of them. You can see an air photograph of some of the flows around here and you get an idea that there's some kind of regular paliginal pattern in terms of a map ? (280)

Mel: Those would tend to form columnar joints. The best example I can think of is on a very large scale, but it's down in the lava lake that formed between the north side of Big Cinder Butte and kind of that narrow neck in the blue dragon flow between Broken Top and some un-named cinder cones that are just north of the Tree Molds trail. There's a lava lake in there that came from the Broken Top flow and there are paliginal blocks that have broken out in that lava.

Dave: Down in the lava tube area you do have areas where it's just like a cylindrical hollow. It looks like a bubble or a blister on the lava. Is that more or less the same type of formation that is a lava tube - a swelling?

Mel: It's a gas blister. Not the same as a lava tube.

Dave: Why does the gas accumulate to that degree?

Mel: Once a flow is flowing on the surface the upper rine of the flow is going to congeal and it's going to become very, very stiff. It doesn't become solid, but it becomes stiff, almost solid. It's going to be just like a balloon. You can stretch it, you can expand it all you want and it probably won't break. It will still remain solid and keep the gas inside trapped. You've got to remember that as the gas is coming out of the flowing lava, its volume is expanding tremendously because it is under such high pressure as it's disolved in the lava. When it comes out, it's volume expands to a hundred, a thousand, maybe a million times more than what it was when it was disolved in the lava. It's easy to see how gas can build up to form one of these blisters. People who have watched flows form in Hawaii are just amazed how resiliant this crust is on a moving lava flow underneath. They're just like balloons. You can blow them way up before these blisters pop or the surface becomes congealed enough so that it finally cracks instead of stretching. Billowy flows are just flows that are inflated with the gas that's coming from the lava inside and being trapped by this cooling,but still stretchable, outer skin.

Dave: The Tree Molds are rather easy to understand. You look at them and understand them. You go out through the lava trees, say out there in the Trench Mortar. Apparently instead of falling into a flow or being surrounded by a flow, these are trees where spatter or whatever was thrown onto the trees. (330)

Dave: That particular area while there's a trench behind it. You have these pillars that come up and they have nothing but cinder surrounding them, rather fragile features, so they haven't been there forever. I just don't see,unless it was that one little trench there was throwing out a few blobs onto the trees, there's nothing to identify what could have thrown that lava onto the trees.

Mel: There are plenty of eye-witness accounts of how these things form in Hawaii. There's a place in Hawaii where you can walk around and see these tree molds extending six, eight, ten feet above the level of the lava flow which surrounds them. When these flows come out, they are said to be inflated. They're so billowy and puffed up from the disolved gas inside that when they finally cool the surface of the flow drops way down. The uniform height when you look around this whole pre-existing forest that now just exists as a bunch of gun barrels that are pointed up to the sky shows you the level of the lava flow when it originally came out and flowed through this forest and then the surface literally drops as it cools down, as the gas escapes, and as lava flows out from the interior. It's mostly due to escape of gas and the deflating of the flow as it cools down, then due to the fact that the flow just simply flows away from an area where it once was.

Dave: Is that what you feel happened down there?

Mel: That may have been the case down there. There may have been lava which was erupted from a crack farther to the south or maybe farther to the north that swept through the area, swept through the trees and then just moved away or deflated and then was later covered by a whole bunch of cinders. There may be a very decent lava flow in the area of Trench Mortar Flat, but now covered by cinders.

Dave: Another possibility is the spatter type?

Mel: And another possibility is that spatter builds up around this thing and the spatter just congealed and became just as hard as a regular lava flow.

Dave: O.K., last question. What future research do you see planned or needed at Craters? I know there's a volcanic hazards report that will come out in the future. What's planned? (377)

Mel: I have a project going back in Denver now, in which a guy is doing a lot of very detailed chemistry on these lavas, so that he gets the chemical composition of the individual crystals in the lava flows. From this I want to use the information to work out the complex history of the chemical diversity of these lava flows. How the diversity formed, what the reasons for it are, what the future trends might be and so forth. This will result in a paper fairly technical in some geological journal. It will come out as a discussion of the origin of the lava flows and their chemistry. Another paper I'm working on is this kind of mechanical probe - the forces involved in the accumulation of the lava and what forces are necessary to trigger eruptions. Dwayne is working on a volcanic hazards paper. He's got all the data in hand to finish it off if he wants to. All he has to do is find the time to write it. We've got the four maps coming out. Lefebvre is supposed to write the popular publication. Presumably, somewhere down the line and I don't know when this will be, a detailed geologic paper, strictly for the geological community, ought to come out in which everything is summed up - everything is tied together - and that would be what we would call a professional paper. Dwayne is not going to write it; Lefebvre couldn't write it, so I don't know when I'm going to do it. Sometime I'll just ask for a year off to do it. It'll take a year to write it.

Dave: It will mainly lean to the technical aspect of everything, where this Leiman's geologic story is semi-technical. (407)

THE END!!