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MEMORANDUM FOR: Ron Ballard, Branch Chief
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FROM: Charlotte Abrams
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SUBJECT: NNWSI FIELD TRIP, FEBRUARY, 1987

On February 22, 1987, staff of the Technical Review Branch, Division of High-Level Waste Management embarked on a site specific and regional field trip of the NNWSI area. The objectives for the field trip (see attachments 1 and 2) were to observe the following:

1) Tectonic features
   a) detachments
   b) north-trending normal faults
   c) northeast-trending strike-slip faults
   d) northwest-trending strike-slip faults
2) Vein deposits associated with faulting
3) Ore deposits associated with faulting
4) Spring deposits

Representatives from the State of Nevada and University of Nevada, Reno joined us. Participation by state representatives greatly added to the success of the trip and enabled NRC representatives to meet and speak with those geoscientists who will be conducting state investigations of the Yucca Mountain High Level Nuclear Waste Repository site.

DOE observers accompanied the field trip, but no DOE representatives were present to provide technical input. The presence of USGS/DOE representatives would have added to technical discussions.

The following is a chronological account of localities visited. Attachment 3 shows approximate locations for all stops.

On Sunday, February 22, 1987, Charlotte Abrams, Keith McConnell, John Trapp, Michael Blackford, Buck Ibrahim, John Bradbury, William Ford, and Paul Prestholt (NRC); Charles Purcell, and Lawrence McKague (LLNL); and DOE observers left Las Vegas, Nevada, for Mercury where the field trip was to begin.

Day 1, Monday, February 23

On day one of the field trip NRC representatives and DOE observers (attachment 4) visited areas north of Mercury and in Yucca Flat. State respesentatives did not join NRC on this day of the trip. McKague (LLNL) lead all stops on this day.

Stop 1: Faulting in the Horse Springs Formation north of Mercury. At this stop the group viewed the Oligocene (29 my) Horse Springs Formation which is the oldest post Mesozoic unit in the area. The Formation is composed of thin to medium bedded, continental limestones, limey shales and conglomerate and rests unconformably on Ordovician Eureka Quartzite. Clasts in this unit are recognized to be primarily from the Precambrian Sterling Quartzite. At this location the Horse Springs Formation is cut by north trending faults which exhibit a small amount of displacement. The contact between the Horse Springs Formation and the Eureka Quartzite has been interpreted as a fault. Another interpretation is that the Horse Springs Formation/Eureka Quartzite contact may be a normal depositional contact where Horse Springs Formation lithologies were deposited on a preexisting surface of dipping Eureka Quartzite. A third interpretation may be that the contact between the two units possibly represents a displacement surface for slump-like movement of the Horse Springs Formation into the area of Frenchman Flat. The slump interpretation could provide a means of explaining the presence of low amplitude folding in the overlying Pavits Springs Formation.

Stop 2: Horse Springs Formation overlying Ordovician Antelope Valley Formation two miles west of Stop 1. Easternmost evidence for detachment. According to Bob Scott of the USGS at this stop the presence of isoclinal folding suggests there is evidence for slump of lower Tertiary Pavit Springs and Horse Springs Formations. We could not identify isoclinal folds at this stop and would have benefited from the presence of USGS representatives.

Stop 3: Mine Mountain, Mine Mountain thrust, and the Mine Mountain fault. Several lead, silver, and mercury prospects occur along Mine Mountain and mercury retorts are located on the slope and top of the mountain. The early Mesozoic Mine Mountain thrust placed Devonian carbonate over argillite of the Mississippian Eleana Formation. The thrust is visible on hillsides and is defined by light grey carbonate overlying red sediments of the Eleana Formation. To the south Mid Valley and the approximate location of the northeast trending Mine Mountain fault trace are visible. To the north and east Yucca Flat is visible. Yucca Flat is dissected by two major faults, the Yucca and Carpetbag faults. The east side of Yucca Flat is made up of lower Paleozoic rocks overlain by Timber Mountain tuffs. Rocks on both sides of the flat dip into the flat.

Stop 4: Carpetbag fault. From the roadside the group viewed faults as splays off the Carpetbag fault interpreted from gravity, seismic reflection, and drill hole data. Data from drill holes (Ellwood and others, 1985) indicates the alluvium dips deeper to the west and shallows to the northeast. This change in dip has been interpreted as evidence for a listric fault.

Stop 5: Carpetbag fault scarp. Along the Carpetbag fault scarp relative movement was down to the east with approximately 5 feet of displacement at the point which the group viewed the fault. This displacement along the fault developed following a nuclear test. South of this stop is a graben structure related to the Carpetbag fault. The graben is several miles long and approximately 1000 feet wide and may be similar to features developed in other areas of the Basin and Range after major earthquakes. An alternate interpretation for formation of the graben structure other than tectonic development is that the graben formed due to compaction of surface material by shock waves resulting from nuclear tests. At this stop the fault was trenched to expose Quaternary alluvium. Carbonate filling is present in the fault. McKague stated that this carbonate filling was dated by U-Th method to give a minimum age for the last natural fault movement of greater than 35,000 years.

Stop 6: Yucca fault scarp. The Yucca fault scarp trends in a north-south direction and is visible from northern Yucca Flat, where normal fault displacement is up to 50 feet, to central Yucca Flat, where displacement decreases to zero. Aeromagnetic data indicate that right lateral strike-slip movement occurred along the fault with a displacement of approximately 500 meters. McKague stated that vertical displacement on subsurface Paleozoic rocks is approximately 150 meters.

Stop 7: Boundary fault along the eastern edge of the Climax stock. The Boundary fault is a northeast-trending, southeast dipping normal fault and may be the northern extension of the Yucca and/or Carpetbag faults. Trenches through the fault show granite (upthrown side) in fault contact with alluvium (downthrown side). Alluvium pebbles have been rotated and caliche occurs in the fault zone. The granite adjacent to the fault is altered and sheared. In the trenches it appears that the fault is at the boundary between the granite and alluvium, but, according to McKague, granite was encountered in a drill hole on the downthrown side of the fault. The Climax stock is the site of the spent fuel test facilities.

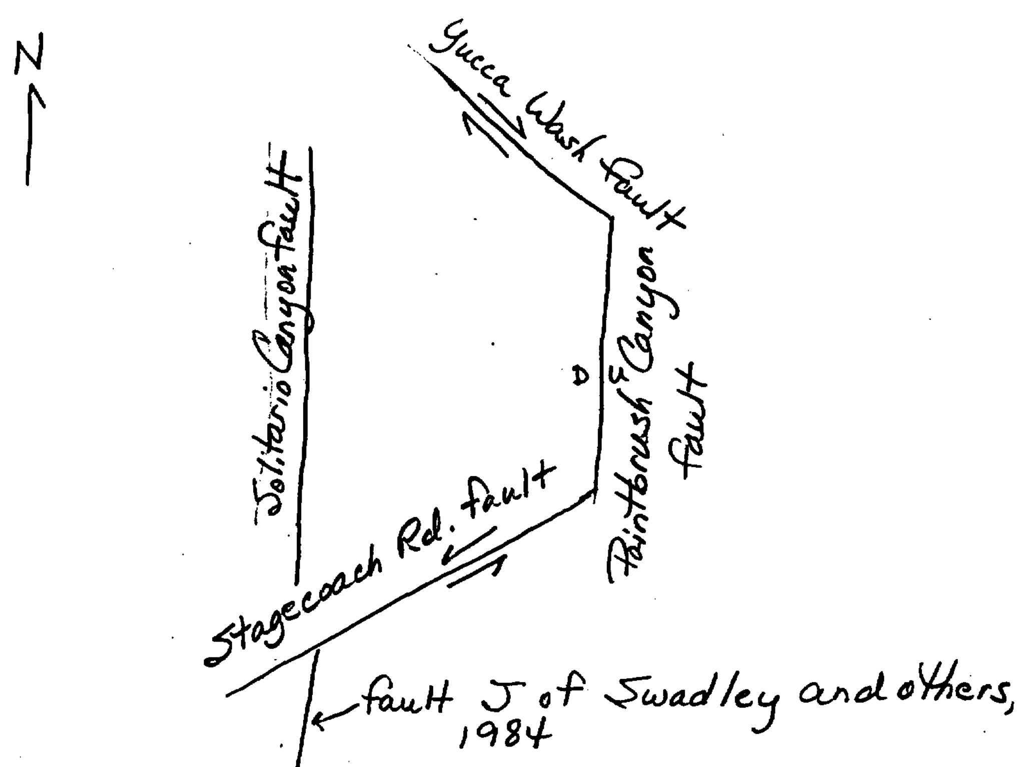
Due to heavy snowfall we were unable to see other stops on the itinerary for day 1. The field trip adjourned to Mercury to see presentations by Purcell and McKague. McKague presented an overview of the geology of the NTS. Purcell presented slides with a discussion on geomorphic characteristics of the area and recognition factors for ages of alluvial surfaces.

Day 2, Tuesday, February 24

On this day NRC representatives joined with state representatives to visit the area adjacent to the south and east sides of Yucca Mountain (see attendence list, attachment 5).

Stop 1: Stagecoach Road fault. Representatives of the State of Nevada visited this stop in November with the USGS on a field trip on which NRC staff were not present; therefore, State of Nevada personnel (John Bell) lead the trip at this stop.

The Stagecoach Road fault is located at the southern end of Yucca Mountain and joins with north-northeast trending fault "J" of Swadley and others (1984). Along fault "J" the north trending scarp is defined by vertical calcareous material within the fault zone. John Whitney (USGS) cites offset in intersecting washes as evidence for left lateral offset along the Stagecoach Road fault. In the interpretation of Scott and Whitney (USGS) the northeast trending, left lateral strike-slip Stagecoach Road fault would intersect and stop at the north trending Paintbrush Canyon fault. The northwest trending, right lateral strike-slip Yucca Wash fault to the north would intersect the Paintbrush Canyon fault in a similar fashion (see diagram below).



Bob Scott (USGS) interprets the Stagecoach Road/Paintbrush Canyon/Yucca Wash fault system part of the proposed detachment system that extends under Yucca Mountain. If the detachment is shallow as proposed, seismic risk may be limited. A problem with the Scott and Whitney interpretation for the Stagecoach Road/Paintbrush Canyon/Yucca Wash fault system is that no no recent strike-slip movement has been observed on the Yucca Wash fault. The necessity for recent movement along the Yucca Wash fault is eliminated by Scott's interpretation that this fault system may be rotational. Alternatives mentioned at this stop to the Scott and Whitney interpretation are: that the Stagecoach Road fault may be the northern boundary of the Mine Mountain - Rock Valley fault system or fault "J" may bend northward to connect with the Solitario Canyon fault instead of trending to the northeast to connect with the Stagecoach Road fault.

Stop 2: Trenches 14 and 14a. Trenches 14 and 14a span the Bow Ridge fault east of Yucca Mountain and west of Exile Hill. The fault zone in trench 14 contains vein deposits of calcite and silica. The interpretation of these deposits is important to the proposed site (Abrams, memo of 6/86) and four possible interpretations have been proposed for the origin of these deposits. These are: 1) pedogenic, emplacement by descending waters; 2) spring, emplacement by ascending waters; 3) hydrothermal, ascending higher temperature waters; and 4) a combination of any of the first three proposed origins. Representatives of the NRC and State of Nevada viewed these calcite-silica deposits in trench 14. Deposits are poorly developed in trench 14a. In two other shallower trenches located nearby no vein deposits are visible. Fred Peterson State of Nevada, examined the vein deposits and alluvium in trench 14 at the downslope end of the trench and interpreted the wide calcareous deposits as probably pedogenic deposits similar to duripan. Based on the placement of markers in the trench Fred Peterson said that he agreed with the mapping and break-out of soil horizons. The USGS has obtained uranium trend ages for the Q2s soil layer of greater than 400,000 to 500,000 years and a uranium series age of greater than 55,000 to 90,000 for Q2a soil. A discussion ensued on B horizon carbonate suitability for age dating. Peterson stated that carbonate from this horizon may be ripped up older material which would give a much older age. For this reason the USGS ages of approximately 50,000 and 500,000 were questioned.

Hal Bonham and others on the field trip saw signs of hydrothermal alteration in the breccia zone and supported a multiple origin interpretation. Bonham (State of NV) believes trace element geochemistry is important to the resolution of the origin of the trench 14 deposits. Bonham stated that opal CT which is a constituent of the vein deposits is commonly found in hydrothermal or hot spring systems. No agreement or consensus could be reached among field trip participants on the origin of the well-defined calcite-silica veins located between the breccia zone and thick carbonate zone in the trench.

Stop 3: Trench 17. Trench 17 is located near drill hole UE25 P-1. Depending upon which geologic map of the area is used (Scott and Bonk, 1984 or Lipman and McKay, 1965) the trench either cuts the Midway Valley fault or the Paintbrush Canyon fault. The trench was cited in a DOE report as having calcite-silica-sepiolite veining like that seen in trench 14. A very small, predominantly silica, vein was present in bedrock exposed in the trench floor. No veining was apparent on the shallow walls.

Stop 4: West side of Busted Butte. At Busted Butte, located east of Yucca Mountain, units of the Paintbrush Tuff are exposed. Evidence for faulting exists in sand ramps which border the Butte on all sides and faults zones are generally filled with carbonate. At this stop, lead by John Bell (State of NV), caliche layers were visibly offset by faulting (approximately 8 meters). Flower structure, a possible indication of strike-slip faulting, was apparent in the fault zone. A breccia zone similar to the breccia zone seen in trench 14 occurs at one point along the fault trace. The breccia zone contains calcite and silica and rims of rock fragments appear to be altered. The calcrete zone topping the sand ramp at our stop is well-developed and contains calcified roots. The calcrete zones have been dated by the USGS with the youngest zone being younger than 100,000 yrs. It is assumed that the underlying layer of calcrete must be younger than 700,000 years due to the presence of underlying Bishop Tuff. At the top of Busted Butte was evidence of fracture mapping with fractures numbered. Textural features in rocks on the west face of the Butte included collapsed pumice lapilli tuff, ash falls, and columnar jointing in the basal tuffs.

Stop 5: Rock Valley fault. The Rock Valley fault is part of a major northeast trending, seismically active, fault zone. Trench RV-2 crosses the fault exposing mainly Q2 alluvium. The fault zone contains caliche veining and flower structure. Flower structure may indicate strike-slip movement. At the site of the trench the fault scarp is approximately 1 meter with the north side of the fault downthrown. The upper zone of the Q2 horizon has been dated (Uranium trend) as approximately 35,000 years. Two faulting events are recognized in the trench, the older being approximately 1 my and the younger being constrained by the Q2 date or a minimum age of 35,000 years.

<u>Day 3, Wednesday, February 25</u>

On day three of the field trip representatives of the NRC and State of Nevada with DOE observers (attendance list, attachment 5) left the NTS and continued the trip on the west side of Yucca Mountain in the Crater Flat area. Weather on this day was poor with continuous snowfall and limited visibility.

Stop 1: Lathrop Wells basaltic cone. The Lathrop Wells cone was viewed from Highway 95 as mining of the cone by a private concern has limited access. L. McKague (LLNL) gave an overview of work done by Crowe and a handout listing K-Ar dates of basalt samples dated by Sandia (see attachment 6, note variability in ages). The Lathrop Wells cone has been identified as the youngest basaltic cone in the area of Yucca Mountain with a reported age of 270,000. Recent work may indicate this age is now in question and the cone may be 20,000 years or younger. The Lathrop Wells cone actually consists of a main cone and satellite cones arranged in a northwesterly alignment. The Lathrop Wells main cone and smaller cones are interpreted as being different in age, but McKague suggests that a alternate interpretation may be that the secondary smaller cone may not represent another eruption, but may occur due to rafting of cinder cone material by associated lava flows.

Stop 2: Crater Flat trenches CF2 and CF3. Trenches CF2 and CF3 are located across a portion of the north trending Windy Wash fault. The Windy Wash fault has been studied in detail by John Whitney and other members of the USGS (Whitney and others, 1986). Representatives of the State of Nevada visited the trenches crossing the Windy Wash fault with Whitney in November of 1986 and therefore John Bell (State of NV) was able to relate the most up-to-date interpretations. Both trench CF2 and CF3 contain offset alluvial deposits with younger alluvium present in trench CF3. Flower structures are present in the fault zone and may indicate strike-slip movement. Seven to nine periods of fault movement are recognized within the two trenches, but neither trench contains a complete record of all nine fault events. Movement has been both vertical and strike-slip in nature. Based on results of thermoluminescence age determinations USGS workers have suggested that the most recent movement along the Windy Wash fault occurred 3,000 to 6,000 years ago (Whitney and others, 1986).

Stop 3: Solitario Canyon fault along road to drill hole WT-11. The Solitario Canyon fault is a north-trending, westward dipping normal fault which forms the western boundary of the proposed repository. In the summer of 1986 John Bell (State of Nevada) and Charles Purcell (LLNL/NRC) worked in the area of southern Crater Flat. As part of that work they noted shear zones which align with the Solitario Canyon fault which would extend that fault to the south. The group visited this possible extension of the Solitario Canyon where a fault scarp is present in calcrete cemented alluvium. Carbonate veining fills the fault zone. Based on the evidence for a fault at this stop the USGS may place a trench at this location.

Stop 4: Bare Mountain fault zone. The Bare Mountain fault bounds the east side of Bare Mountain and the west side of Crater Flat. The Bare Mountain fault has been interpreted differently by Reheis and Scott (USGS). Reheis, based on evidence from prospect pits along the east side of Bare Mountain, has suggested late-stage, normal faulting occurred along the Bare Mountain fault. Scott originally suggested that the Bare Mountain fault is an expression of a detachment fault located at the Tertiary-Paleozoic contact and extends that detachment beneath Yucca Mountain. Scott now does not extend the detachment the entire distance across Crater Flat. The Bare Mountain fault at this stop, lead by John Bell, was observed in a prospect pit where Paleozoic carbonate rock (limestone) is in fault contact with alluvium. The limestone in the pit is broken up and altered and slickensides define the fault. Bare Mountain is the site of one active gold mine (Sterling Mine) and several gold and fluorspar prospects. Prospects are located along the fault zone and gold mineralization is suggested to be hydrothermally emplaced along a fault zone. A transmitter located adjacent to the prospect pit is part of the local seismic monitoring network.

Stop 5: Near Steve's Pass on the road leaving Crater Flat the group stopped briefly for McKague to point out a hill of Paleozoic carbonate which Will Carr (USGS retired) interprets as a gravity slide off Bare Mountain. Carr interprets the gravity slide to have moved in response to the rise of Bare Mountain placing Paleozoic carbonate over Tertiary volcanics.

Stop 6: Trenches across the Beatty fault lead by John Bell (State of NV). The Beatty escarpment may represent an erosional scarp due to side-cutting by the Amargosa River or a fault. The scarp has been trenched at two points. The trenches have been located in fluvial deposits offset from the scarp front due to the assumption that scarp retreat has occurred. No good evidence was noted for a fault interpretation, but due to the set back of the trench from the scarp front, evidence could be termed inconclusive. Representatives of the State of Nevada called the NRC staff's attention to a new publication by Taylor and others of the USGS which discusses the Beatty trenches and concludes that the Beatty scarp is an erosional feature.

<u>Day 4, Thursday, February 26</u>
(See attachment 5 for attendence)

Stop 1: Evidence for detachment in the Bullfrog Hills. The Bullfrog Hills area and the town of Rhyolite are noted as a famous gold mining area. Gold mineralization in this area is associated with fault zones. At this stop field trip participants observed a fault exposed in an open cut at the Bullfrog Mine. The fault at this site may represent the westwardmost exposure of the detachment exposed on Bare Mountain as proposed by Scott (1986)*. The low angle fault at the Bullfrog Mine has placed Tertiary tuff over Paleozoic rocks. Slickensides may indicate an apparent east-west direction of movement for the low angle fault. Mine adits in the area follow the fault zone, indicating the fault relationship of ore zones.

A short distance from the Bullfrog Mine (in a southwest direction) Burt Slemmons (State of NV) lead field trip participants to an outcrop of metamorphic core complex where exposures of schist, gneiss, and pegmetite were observed.

* Recent conversations with the USGS suggest that Scott has changed this interpretation.

Stop 2: Evidence for the detachment in Fluorspar Canyon. At this stop field trip participants observed another fault zone which Scott (1986) suggests is part of the proposed detachment system. Paleozoic carbonate is in fault contact with overlying Tertiary volcanic rocks. State of Nevada participants observed that at this stop the fault zone appears to be at a steeper angle than that observed at stop 1 on this day in the Bullfrog Hills. Slickensides in the carbonate were oriented at an oblique angle to the dip of the fault surface. Abandoned fluorspar mine workings and prospects are located in close proximity to the fault zone.

Stop 3: Redtop/Columbia Mountain mining district in Goldfield, NV. Hal Bonham of the Nevada Bureau of Mines and Geology lead this stop. The Goldfield mining district has produced precious metals (4.2 millon oz. Au, 1.5 million oz. Ag) and copper. In the Goldfield area field trip participants observed hydrothermally altered Miocene volcanic rocks which overlie Paleozoic sedimentary rocks and Mesozoic granite. Ores are associated with alteration zones controlled by a fracture and fault system which has been interpreted as the possible rim of a caldera. Alunite is a principal alteration zone mineral.

<u>Day 5, Friday, February 27</u>
(See attachment 7 for attendence)

Stop 1: Mizpah Mine at Tonopah, Nevada. Due to his experience in this area of Nevada, Hal Bonham lead this stop. The Tonopah district has produced in excess of 1.8 millon oz. gold and 174 million oz. silver from hydrothermal veins. Host rock for the veins is volcanic rock of dacite to rhyolite composition. Bonham suggested that the type of mineralization observed in the Tonopah area would be more likely to occur in the Yucca Mountain area than the type observed at Goldfield (Thursday, Stop 3). The main ore zone in the Tonopah district is fault (pre-ore) controlled and faults range from high to low angle. Ore mineralization is early Miocene (18-19 my, Bonham and Garside, 1979). Bonham stated that another, later stage of mineralization in the Tonopah area occurs in hydrothermal zones in rhyolite and tuff.

Stop 2: Cedar Mountain fault zone in Monte Cristo Valley, Nevada. John Bell, Nevada Bureau of Mines and Geology, lead this stop on the field trip. The most recent activity along the Cedar Mountain fault zone occurred in December, 1932. As observed in the valley the surface expression of the Cedar Mountain fault is composed of a series of low amplitude scarp segments. Most recent activity along the Cedar Mountain zone resulted in a magnitude 7.2 earthquake (Diane Dozier, University of Texas, thinks the magnitude may have been less). The State of Nevada has trenched the fault zone and can show evidence for the recent offset in the upper alluvium. The fault zone contains caliche filling which has slickenside striations oriented in a nearly horizontal direction. The horizontally oriented striations coupled with the presence of flower structure indicate a strike-slip component to the fault movement.

Stop 3: Fish Lake Valley faulting. After visiting the Cedar mountain fault zone many of the state representatives separated from the field trip and traveled northward to Reno. NRC staff, state representatives, and DOE observers proceeded south through Fish Lake Valley where participants observed the northern extension of the Death Valley fault. The fault scarp observed in Fish Lake Valley is defined by faceted spurs which occur at the juncture of the range and Fish Lake Valley.

Day 6, Saturday, February 28

On this day the field trip passed through Death Valley to observe tectonic features and veining. In attendance were NRC staff and contractors, DOE observers, and state of Nevada representatives Elwood, Shettel, Chamberlain, Greene, Ramelli, Sawyer, and Donovan. L. McKague (LLNL) lead stops.

Stop 1: Veins at Furnace Creek Wash. Calcite veins at Furnace Creek Wash occur in a poorly sorted sedimentary unit (fanglomerate). Winograd and others (Science, Feb. 1985, v 227) interpret the veins as spring deposits of Pleistocene to Pliocene age. The veins occur along fractures and extend approximately 500 m above the present day groundwater level in Death Valley. The calcite veins are composed of dense calcite that is vertically laminated nearly parallel to fracture walls. Widths vary from approximately 10 mm to several meters. In areas where veining has intersected the ground surface, or what appears to have been a horizontal discontinuity, the vein material has moved in a lateral direction. Veins branch and cross-cut one another indicating the possibility of several generations.

Stop 2: Artists Drive fault in southern Death Valley. The Artists Drive fault is considered the youngest (1000-2000 yrs) fault in Death Valley. The fault scarp trends in a north-northwest direction and is approximately one meter in height with the west side downthrown.

Stop 3: Badwater, Death Valley, California. The group stopped at Badwater to observe a turtleback surface visible from the road. The feature is so named because of its shape which resembles the back of a turtle. As many as five interpretations have been suggested for the formation of the turtlebacks present in Death Valley. They are generally accepted to be extensional features formed by gravity sliding or normal faulting.

Stop 4: Mormon Point faults. At Mormon Point McKague lead field trip participants into a canyon to observe a low angle detachment fault with Quaternary material overlying Precambrian carbonate rock. The overlying Quaternary unit was a diamictite containing small to large cobbles to boulders of various metamorphic rocks. The Quaternary unit was cut by several normal listric faults that soled into the detachment. The underlying Precambrian carbonate was striated along the fault (detachment) surface.

Stop 5: Shoreline of Lake Manley and cinder cone. From the highway Shoreline Butte of Lake Manley and a 600,000 year old cinder cone cut by a fault were observed. Shoreline Butte contains well-preserved shoreline terraces of former Lake Manley. A seismic reflection survey (deVoogd and others, 1986) indicated magma at depth beneath the area of the cinder cone. The cone/magma/fault relationship may be analogous to relationships at the Lathrop Wells cone.

Stop 6: Tecopa Lake Beds (attachment 8). South of Shoshone, California, the group briefly observed the lake beds of Pleistocene Lake Tecopa. McKague pointed out that lake deposits grade from fresh glass near the source of fresh water at the lake's northern end and near the eastern and western shores to a potassium feldspar-rich zone at the lake's southern end and deeper portion. Intermediate between the glass and feldspar zones is a zeolitized zone. It was in this zeolite zone that the stop occurred.

Stop 7: Tecopa Springs. Lead by Paul Prestholt (NRC, OR). Tufa mounds similar to Nevares Spring mound in Death Valley have been formed by hot spring deposits at Tecopa Springs. These mounds are located in what was the deepest part of Lake Tecopa.

<u>Day 7, Sunday, March 1</u>

On this day Keith McConnell (NRC), Charlotte Abrams (NRC) and Larry McKague (LLNL) visited an area in the McCullough Mountains south of Las Vegas. The area visited is the field area of Casey Schmidt, a student at the University of Nevada, Las Vegas, and our guide. The group visited a mini-caldera analogous to the larger calderas found in the vicinity of Yucca Mountain. In this area the group observed Tertiary volcanic rocks (basalt flows and bedded tuffs) overlying Precambrian metamorphic rocks. A detachment surface separates the

Tertiary units from the Precambrian metamorphic rocks. Within the caldera we observed small rhyolite domes and associated dikes.

After visiting the caldera McConnell and Abrams returned to the OR's office to review portions of the draft SCP.

Day 8, Monday, March 2

On this day Charlotte Abrams, Keith McConnell, William Ford, and Larry McKague visited "P" tunnel at the NTS with NRC rock mechanics engineers Dinesh Gupta and John Peshel and their contractors, Loren Lorig (ITASCA), David Conover (USBM), and Kanaan Hanna (USBM). Before reaching the tunnel the group visited a fault north of Mercury (Day 1, Stop 1), the Carpetbag fault (Day 1, Stop 4), and the Yucca fault (Day 1, Stop 6) to familarize the engineers with fault related features in the area.

"P" tunnel is located at Ranier Mesa in bedded tuff that is 80% saturated. The tunnel is currently being prepared for atomic tests, but none had taken place prior to the group's visit. The tuff is fractured, but we observed no groundwater flow through the fractures. Fractures generally were closed with some slickensides visible on the plane of movement. no breccia zones were observed. The walls of the tunnel in some areas were wet, but no water flowed from them. The guide explained that in tunnels "T" and "N", also located at Ranier Mesa, fracture flow was evident and in some cases necessitated pumping. Both "N" and "T" tunnels were "dry" prior to testing. Both "N" and "T" tunnels were not open to visitors during the time period our group was at the NTS. At some later date a visit to either "N" or "T" tunnel would be recommended to varify groundwater conditions.

After leaving "P" tunnel the group visited the exploratory shaft site and trench 14 on the Bow Ridge fault.

Day 9, Tuesday, March 3

The itinerary for March 3 included a visit to the Sterling Mine (attachment 3b, west side of Crater Flat) by Keith McConnell, Charlotte Abrams, and Larry McKague. Our guide at the mine was the mine manager, Dwight Crossland. The Sterling gold mine is located along the eastern front of Bare Mountain. Gold in this area is located within faulted and altered Paleozoic rock. The host rock is carbonate and gold is primarily associated with steep to low angle faults, breccia zones, and alteration zones. Current mining is by open pit predominantly, but older underground workings also exist. While on our tour Mr. Crossland commented that he believes the Bare Mountain fault lies further east than present interpretations would place the range front fault.

Day 10, Wednesday, March 4 was spent in the OR's office reviewing draft chapters of the SCP.

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SIGNATURE DATE

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