U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

NUCLEAR WASTE TECHNICAL REVIEW BOARD

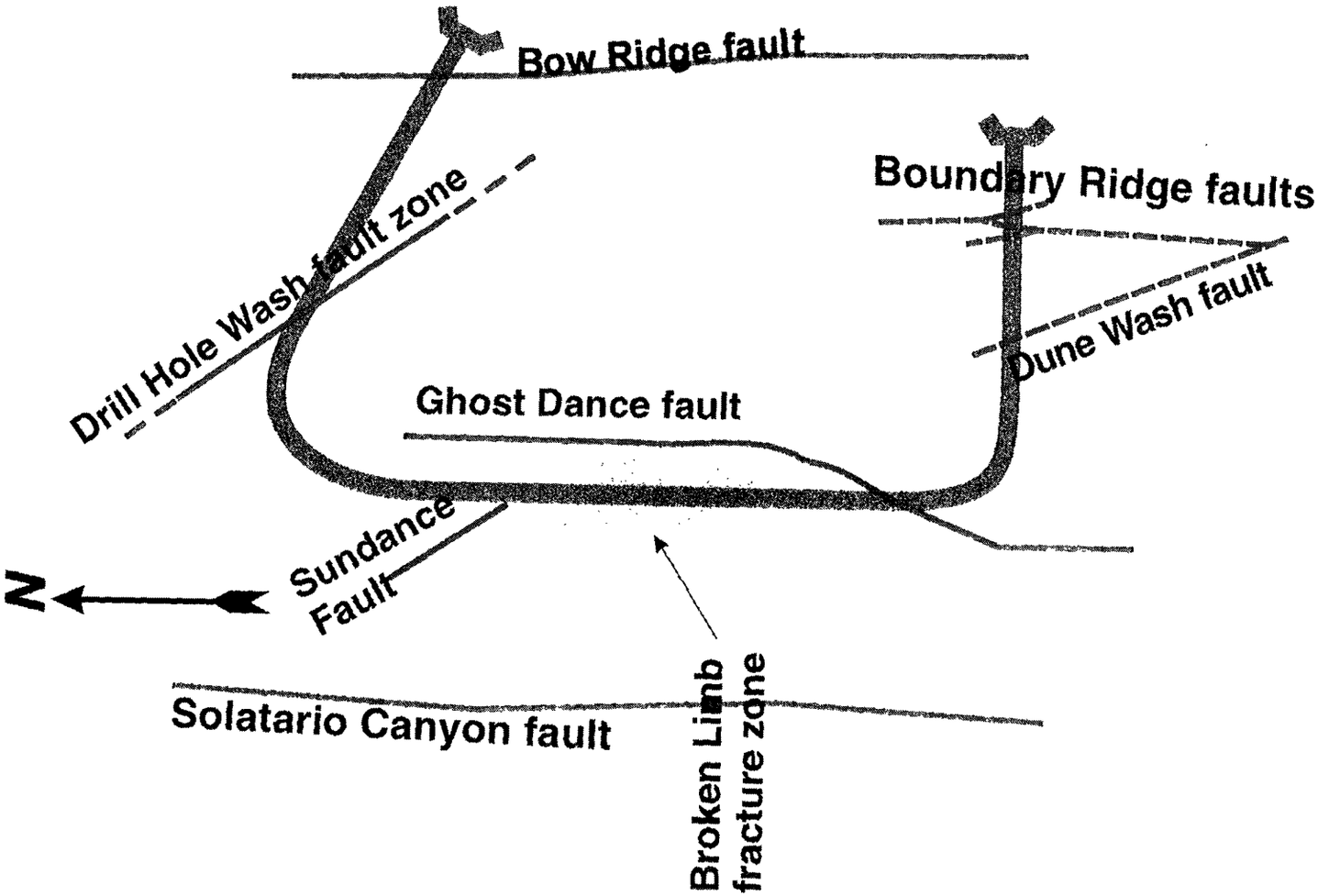
SUBJECT: GEOLOGICAL STRUCTURE AT YUCCA MOUNTAIN

PRESENTER:	**WARREN DAY**	**STEVE BEASON**
PRESENTER'S TITLE AND ORGANIZATION:	**PRINCIPLE INVESTIGATOR U.S. GEOLOGICAL**	**PRINCIPLE INVESTIGATOR U.S. BUREAU OF RECLAMATION**
TELEPHONE NUMBER:	**(303) 236-5050 ext. 269**	**(702) 295-5514**

JULY 9-10, 1996
DENVER, COLORADO

Geological Structure in the ESF

- Characteristics of notable structures in the ESF
- Characteristics of fractures in the ESF main drift
- Fracture densities in the North ramp and main drift
- Broken limb fracture zone characteristics and discussion of origins
- Correlation between surface and subsurface mapping


Bow Ridge fault
Boundary Ridge faults
Drill Hole Wash fault zone
Dune Wash fault
Ghost Dance fault
Sundance Fault
N
Solatario Canyon fault
Broken Limb fracture zone

ESF Notable Structural Features

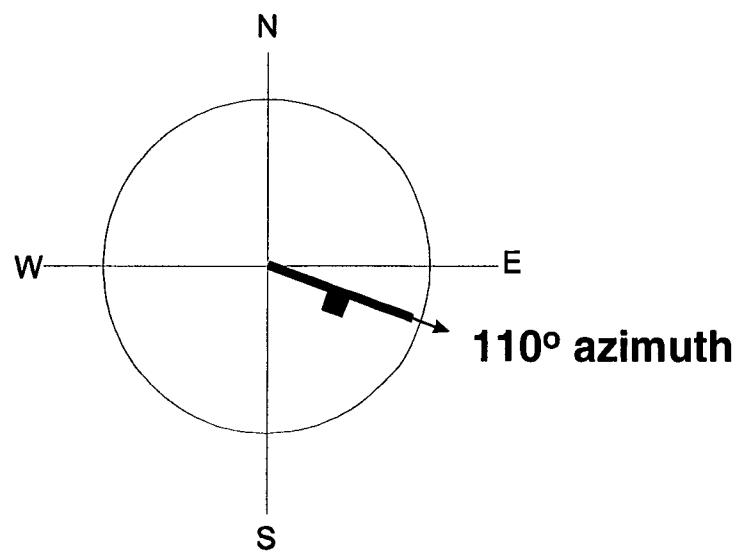
Name	Station	Thickness	Offset	Characteristics
Bow Ridge fault	2+00	2 m	100 m	Uncemented breccia - Wall rock relatively unfractured, no distinct calcite veins visible associated with the zone
"Imbricate" fault zone	4+30-11+70	Multiple zones up to 5m thick	Multiple offsets up to 18m	Numerous individual faults, many with offsets >5m offset, typically uncemented fault rubble with little or no cemented breccia
Drill Hole Wash fault zone	19+00	0.5 m	6 m	Composed of 2 separate faults, horizontal slickensides, no mineraliza -tion along fault trace
Sundance fault	35+94	0. 5m	<1 m	Composed of a series of discontinuous shears and small fault planes, no min-eralization along fault trace
Ghost Dance fault	TBD			

Geologic Structure in the ESF

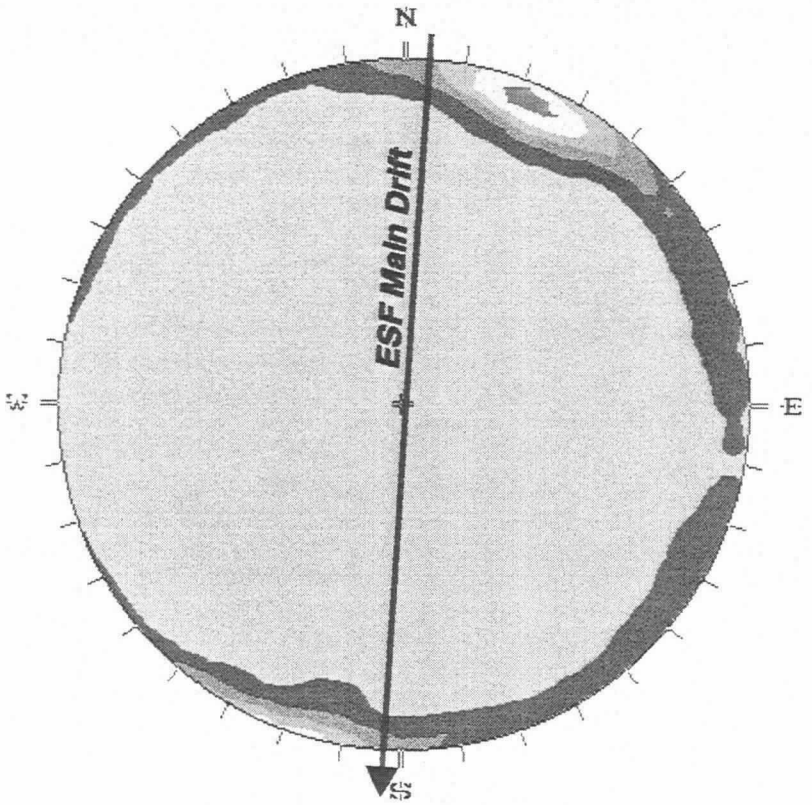
Determining fracture attitudes

- Fracture attitudes expressed in terms of azimuth and dip

- Azimuth = strike expressed in terms of compass direction, such as 125°, using the right-hand rule



28+00 to 35+00 DLS Fractures



Poles to Planes

Contour Plot

SCHMIDT POLE CONCENTRATIONS % of total per 1.0 % area

< 0	%
< 2	%
< 4	%
< 6	%
< 8	%
< 10	%
< 12	%
< 14	%

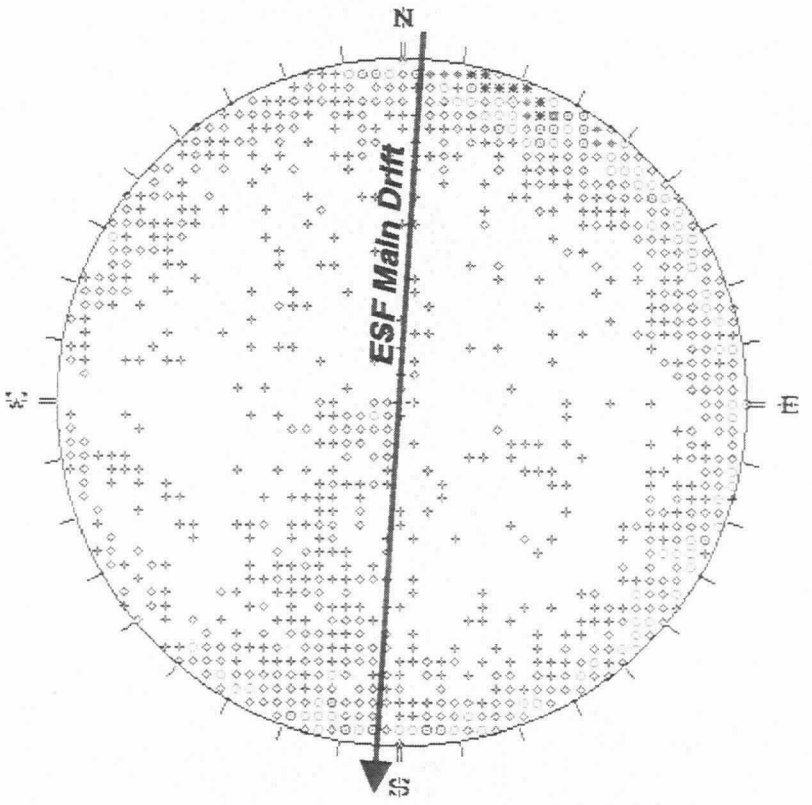
EQUAL AREA

LWR. HEMISPHERE

2563 Poles

NO BIAS CORRECTION

28+00 to 35+00 DLS Fractures



Poles to Planes

Scatter Plot

NUM. OF POLES

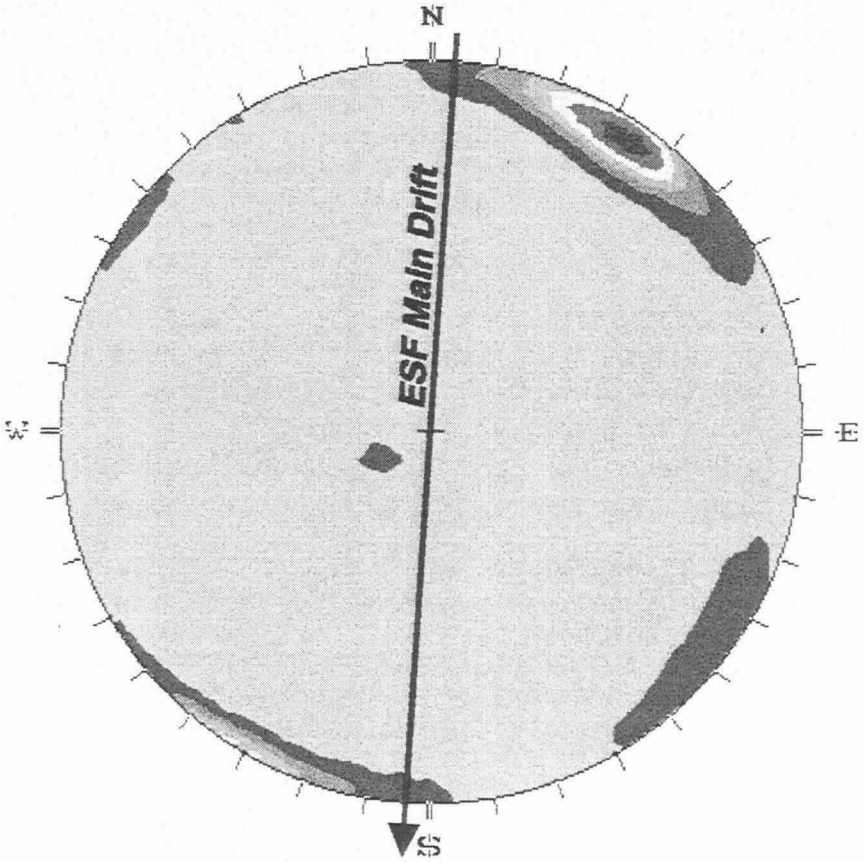
+	1	pole	
◇	4	to	7
○	8	to	11
○	12	to	15
◆	16	to	19
*	20	to	23
◇	24	to	27
○	28	to	31
■	32	to	35

EQUAL AREA

LWR. HEMISPHERE

2563 Poles

35+00 to 42+00 DLS Fractures



Poles to Planes

Contour Plot

SCHMIDT POLE CONCENTRATIONS
% of total per 0.8 % area

< 0	%
< 2	%
< 4	%
< 6	%
< 8	%
< 10	%
< 12	%
< 14	%

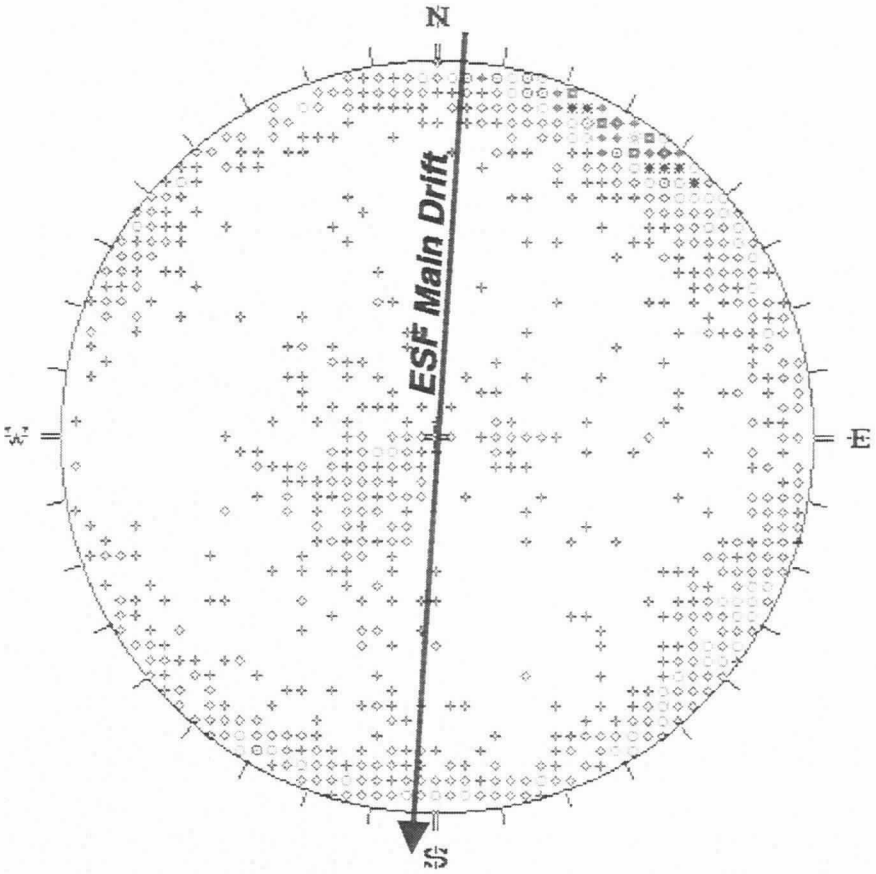
EQUAL AREA

LWR. HEMISPHERE

2208 Poles

NO BIAS CORRECTION

35+00 to 42+00 DLS Fractures



Poles to Planes

Contour Plot

NUM. OF POLES

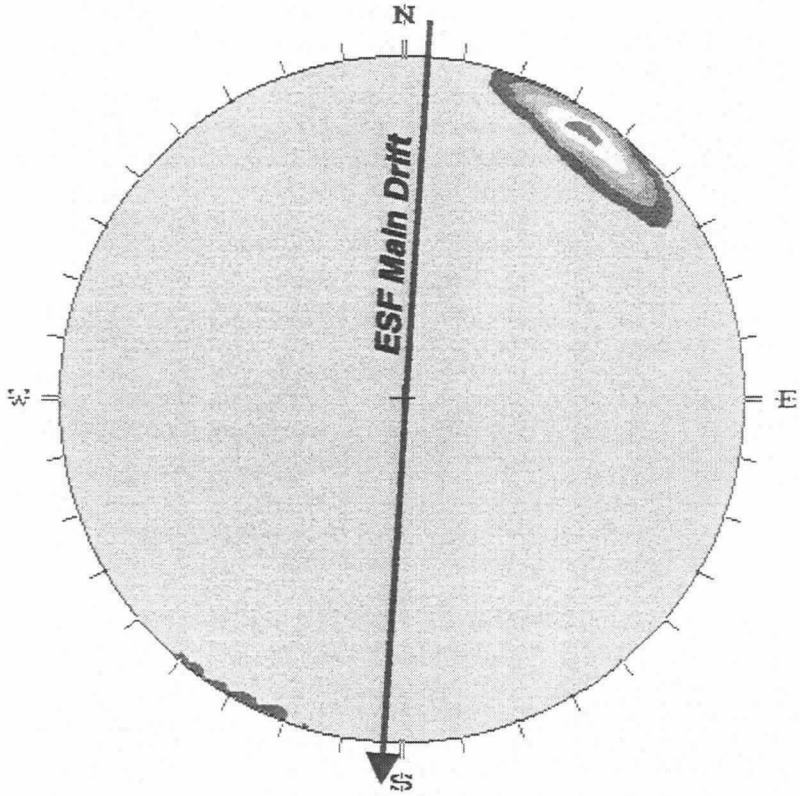
1	pole		
4	to	7	
8	to	11	
12	to	15	
16	to	19	
20	to	23	
24	to	27	
28	to	31	
32	to	35	
36	to	39	

EQUAL AREA

LWR. HEMISPHERE

2208 Poles

42+00 to 49+00 DLS Fractures



Poles to Planes

Contour Plot

SCHMIDT POLE CONCENTRATIONS
% of total per 0.3 % area

< 0	%
< 2	%
< 4	%
< 6	%
< 8	%
< 10	%
< 12	%
< 14	%

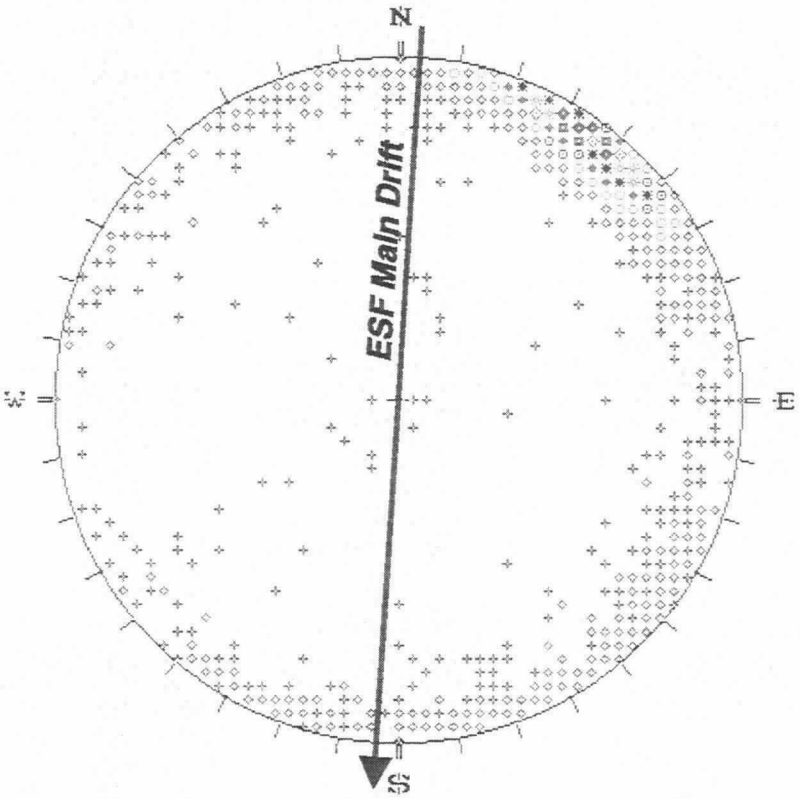
EQUAL AREA

LWR. HEMISPHERE

3159 Poles

NO BIAS CORRECTION

42+00 to 49+00 DLS Fractures



Poles to Planes

Scatter Plot

NUM. OF POLES

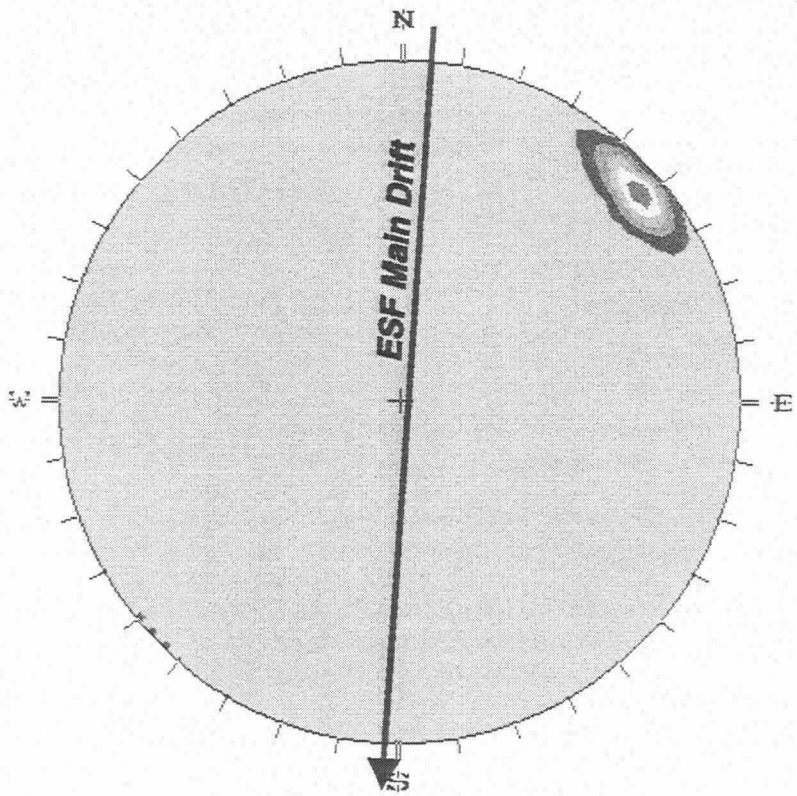
1	pole
10	to 19
20	to 29
30	to 39
40	to 49
50	to 59
60	to 69
70	to 79
80	to 89
90	to 99

EQUAL AREA

LWR. HEMISPHERE

3159 Poles

49+00 to 56+31 DLS Fractures



Poles to Planes

Contour Plot

SCHMIDT POLE CONCENTRATIONS % of total per 0.3 % area

< 0	%
< 2.5	%
< 5	%
< 7.5	%
< 10	%
< 12.5	%
< 15	%
< 17.5	%

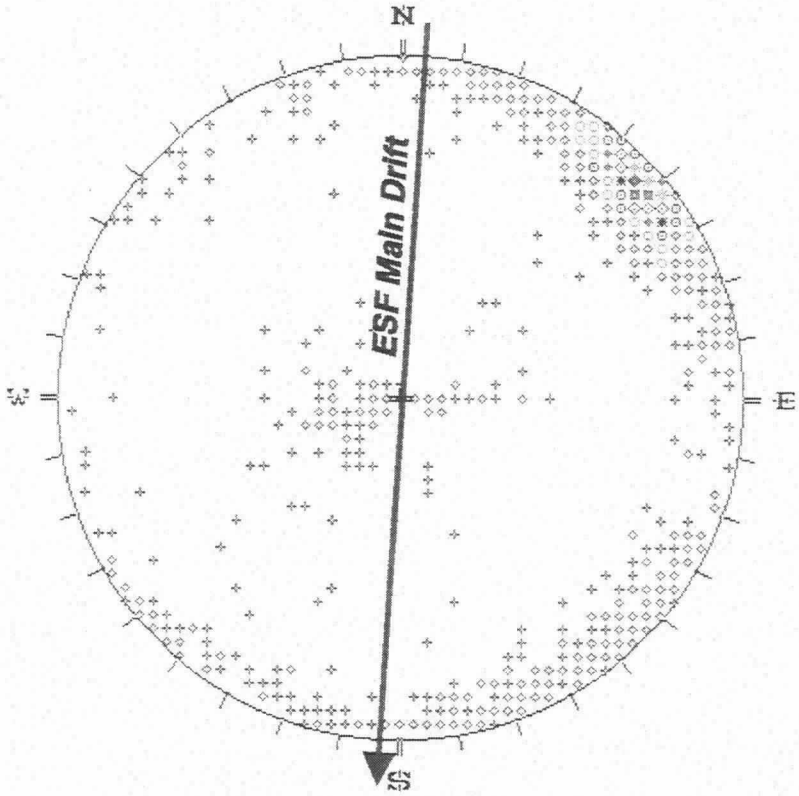
EQUAL AREA

LWR. HEMISPHERE

2208 Poles

NO BIAS CORRECTION

49+00 to 56+31 DLS Fractures



Poles to Planes

Scatter Plot

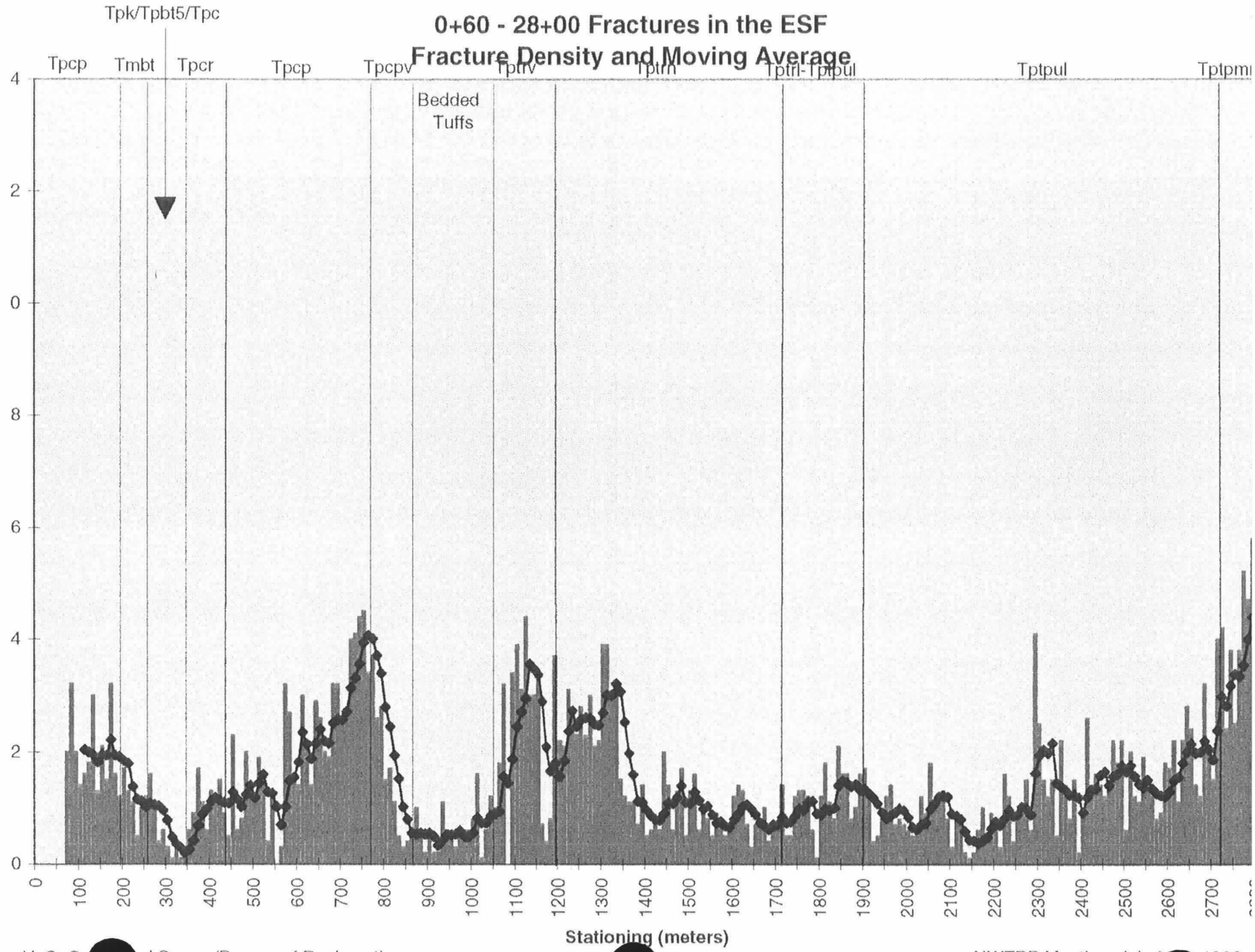
NUM. OF POLES

1	pole		
9	to	17	
18	to	26	
27	to	35	
36	to	44	
45	to	53	
54	to	62	
63	to	71	
72	to	80	
81	to	89	

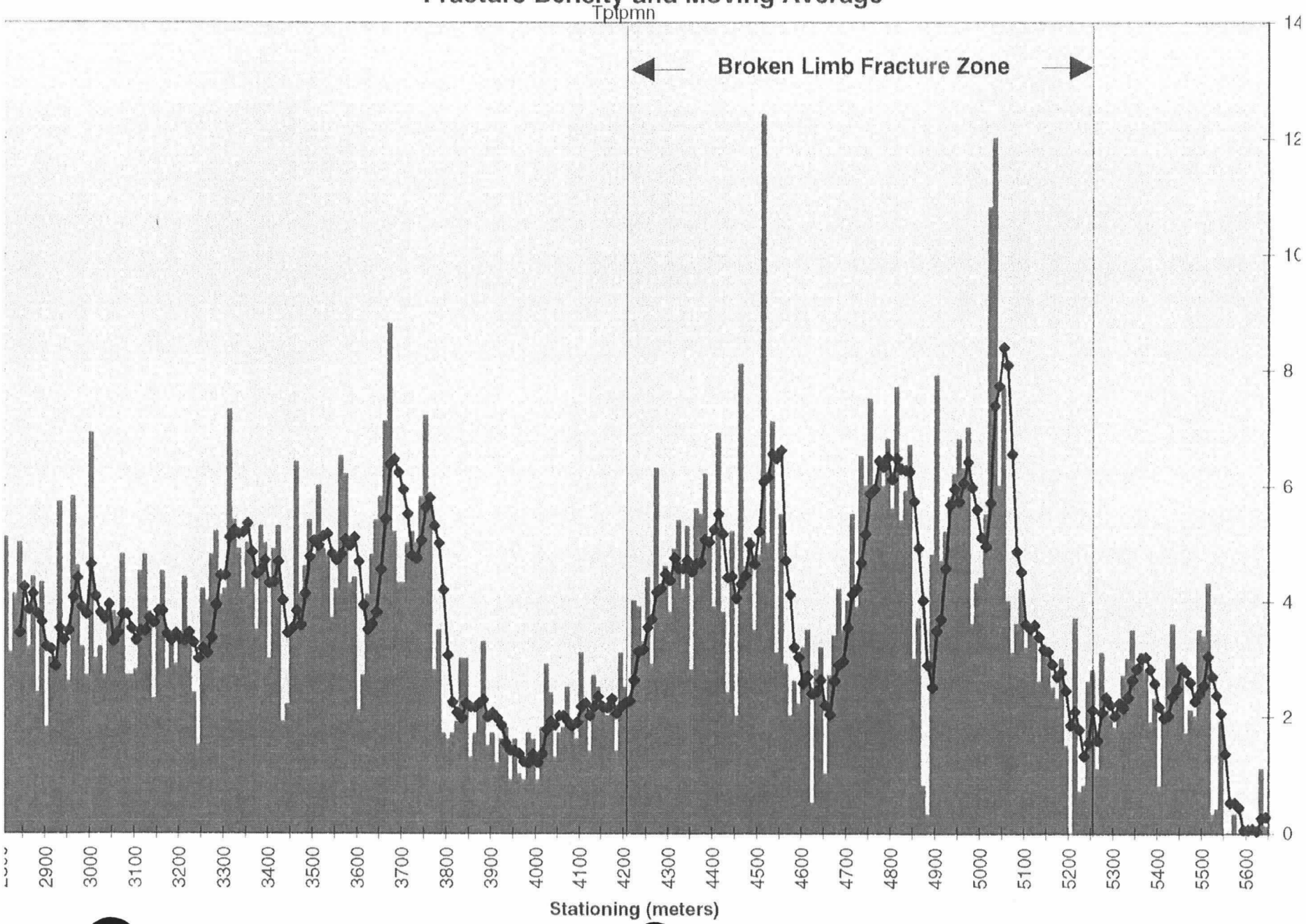
EQUAL AREA

LWR. HEMISPHERE

2208 Poles


0+60 - 28+00 Fractures in the ESF
Fracture Density and Moving Average
Tpk/Tpbt5/Tpc
Tpcp
Tmbt
Tpcr
Tpcp
Tpcpv
Bedded Tuffs
Tptrv
Tptrn
Tptrl-Tptpul
Tptpul
Tptpm
4
2
0
8
6
4
2
0
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
Stationing (meters)

28+00 - 56+30 Fractures in the ESF
Fracture Density and Moving Average



Broken Limb Fracture Zone

Characteristics

- Extends from Station 42+05 to Approximately 52+50
  - From 42+05 to 46+00 — oriented 105-125°, dipping 80-85°
  - From 46+00 to 52+50 — oriented 130-145°, dipping 80-85°
- Not observed at surface
- Fracture densities locally greater than 12 fractures/meter
- Fractures are generally long (2-4 m), smooth (>R5), and planar
- Fractures typically coated with Mn oxides and /or vapor-phase minerals, less frequently with crystalline calcite, opal, and occasionally fluorite
- Numerous fractures exhibit vapor-phase alteration of the fracture walls
- Video log of borehole SD-12 indicates the fractures do not extend into the overlying and underlying lithophysal zones

Broken Limb Fracture Zone

(Continued)

Origin Theories

- Related to a previously unrecognized cooling surface on the Topopah Spring, middle non-lithophysal zone
- Related to the excavation by tunnel boring machine
- Related to the area of maximum offset along the Ghost Dance fault*
- Formed by the Topopah draping over some pre-existing topographic feature
- Related to syn-eruptive tectonics*
- Cooling joints
- Some Combination of the above

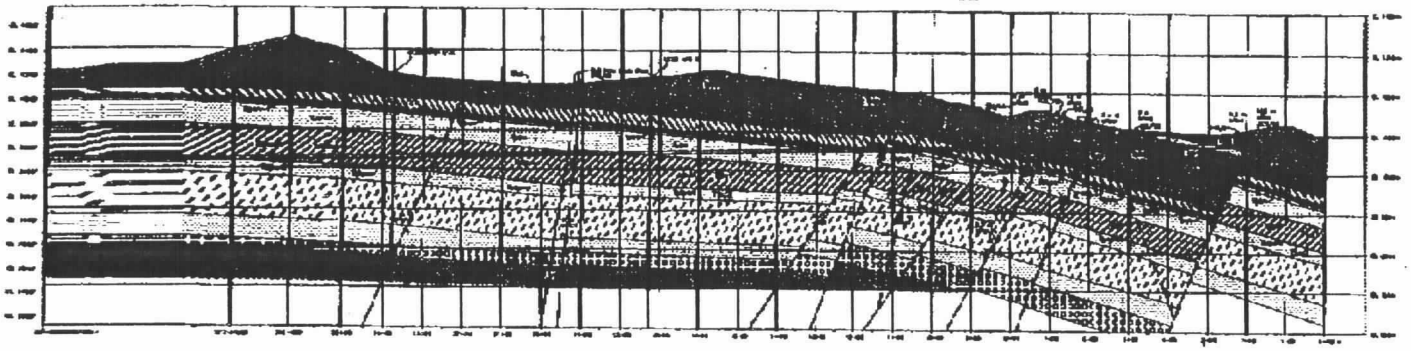
*Preferred Concepts

BEST AVAILABLE COPY

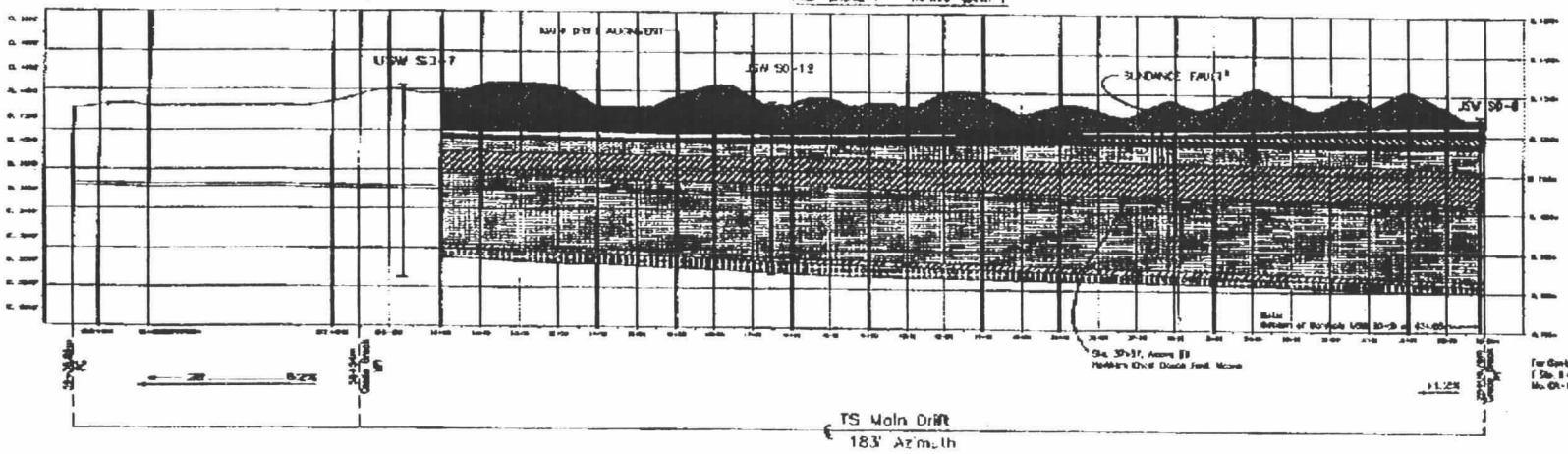
U.S. GEOLOGICAL SURVEY/USGR

GEOLOGIC CROSS-SECTION OF THE ESF NORTH RAMP AND MAIN DRIFT

AS-BUILT SECTION - NORTH RAMP



AS-BUILT - MAIN DRIFT



SecO-Sta.dwg AutoCad

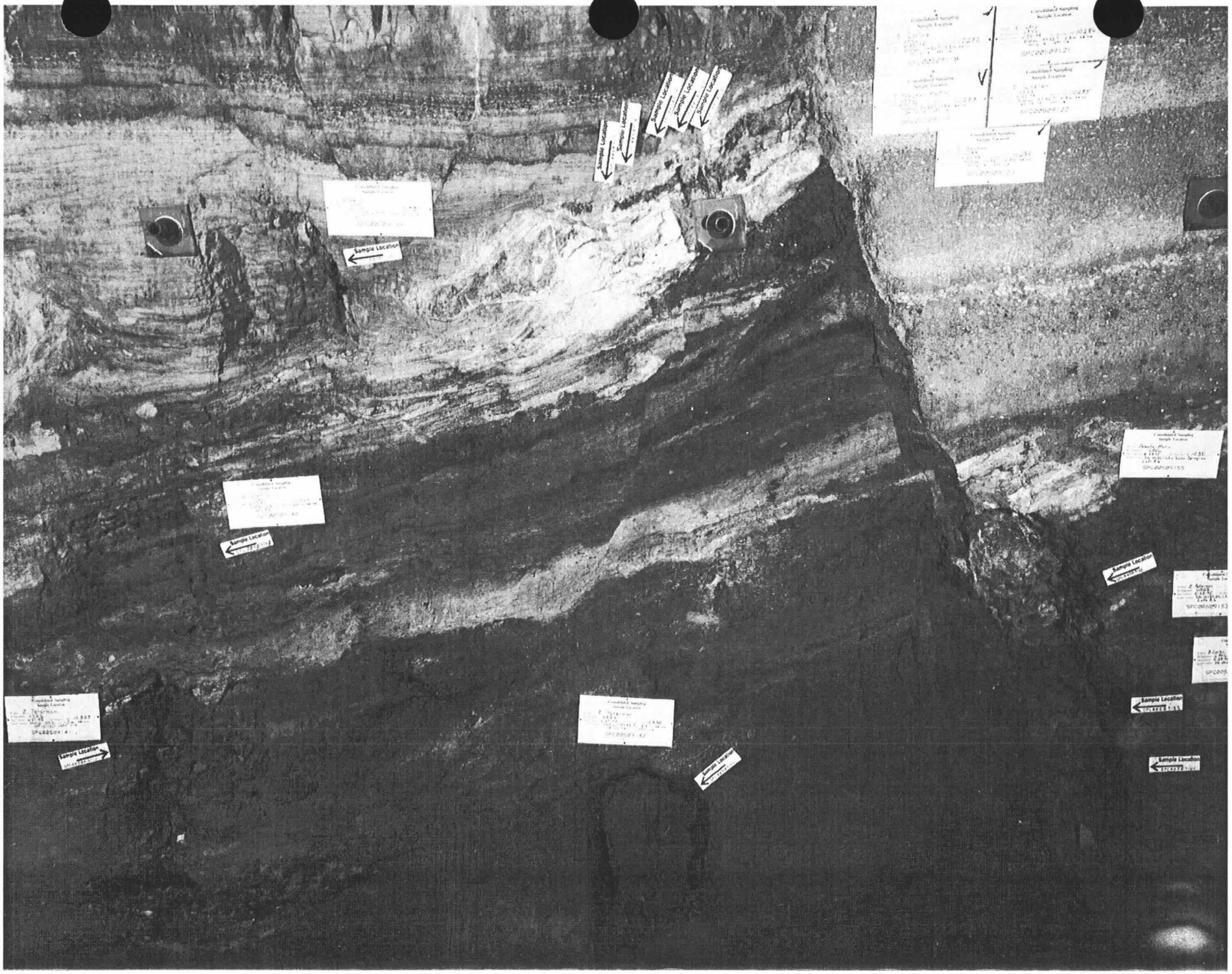
Correlation Between Surface and ESF Mapping

- Imbricate fault zone
  - Surface mapping helped define faults obscured by support in the ESF at station 5+50
  - Underground mapping showed several faults not easily visible at the surface
- Drill Hole Wash faults
  - Surface and underground mapping agreed on location of the main faults
  - Underground mapping defined the limited size of the faults
- Northern extent of the Ghost Dance Fault
  - Both surface and underground mapping confirm that the fault does not extend as far north as the ESF

Correlation Between Surface and ESF Mapping

(Continued)

- **Sundance Fault**
  - Surface and underground mapping confirmed the minor and discontinuous nature of the fault zone
  - The difference in fault location between the surface and underground suggests a vertically discontinuous nature for the fault
- **Broken Limb fracture zone**
  - Surface Mapping confirms that the zone is apparently stratabound (not visible at surface)
- **South Ramp Surface Mapping**
  - Detailed mapping and cross-section provide the basis for design
  - Help underground team correctly identify fault zones with know surface features


Sample Location
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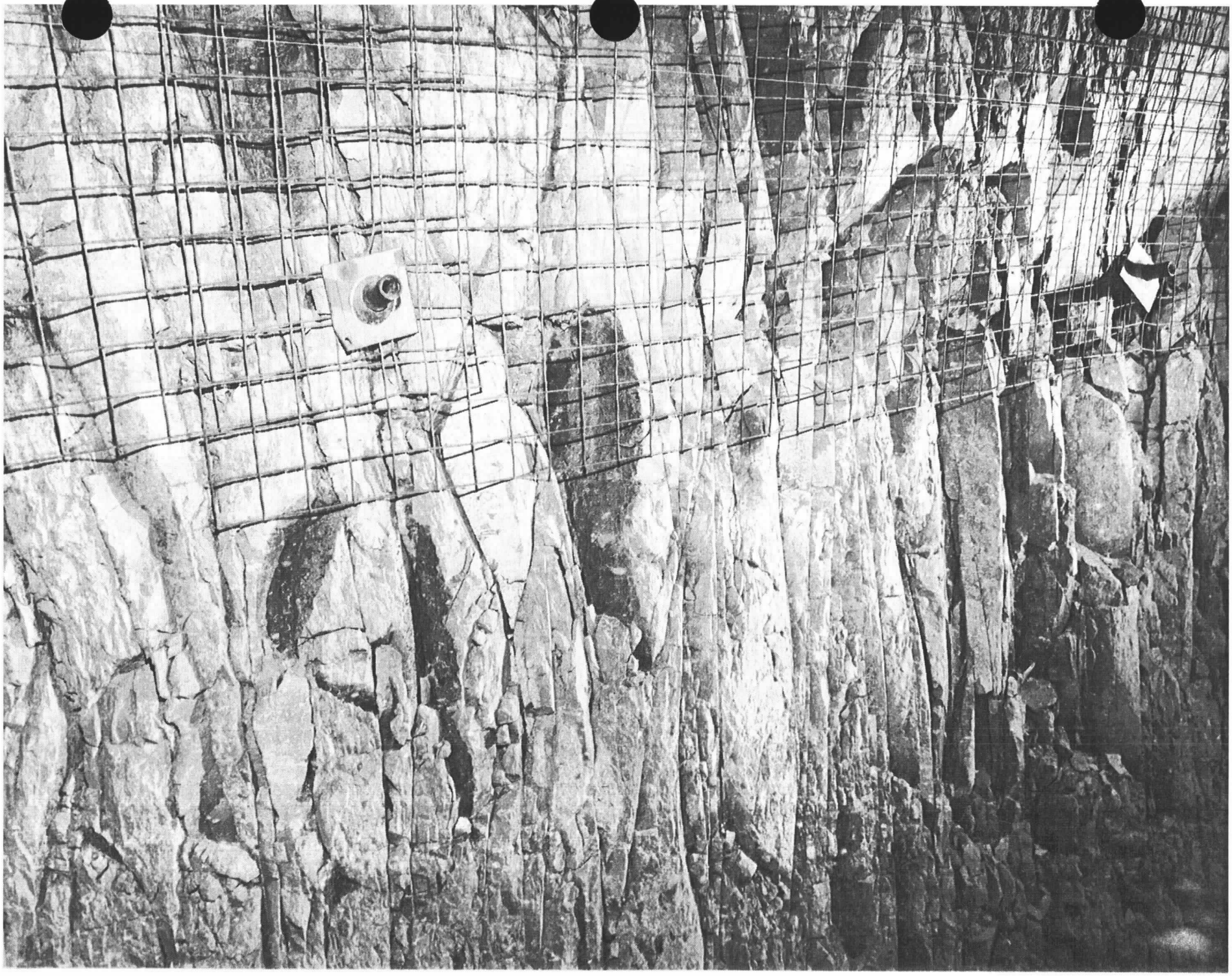
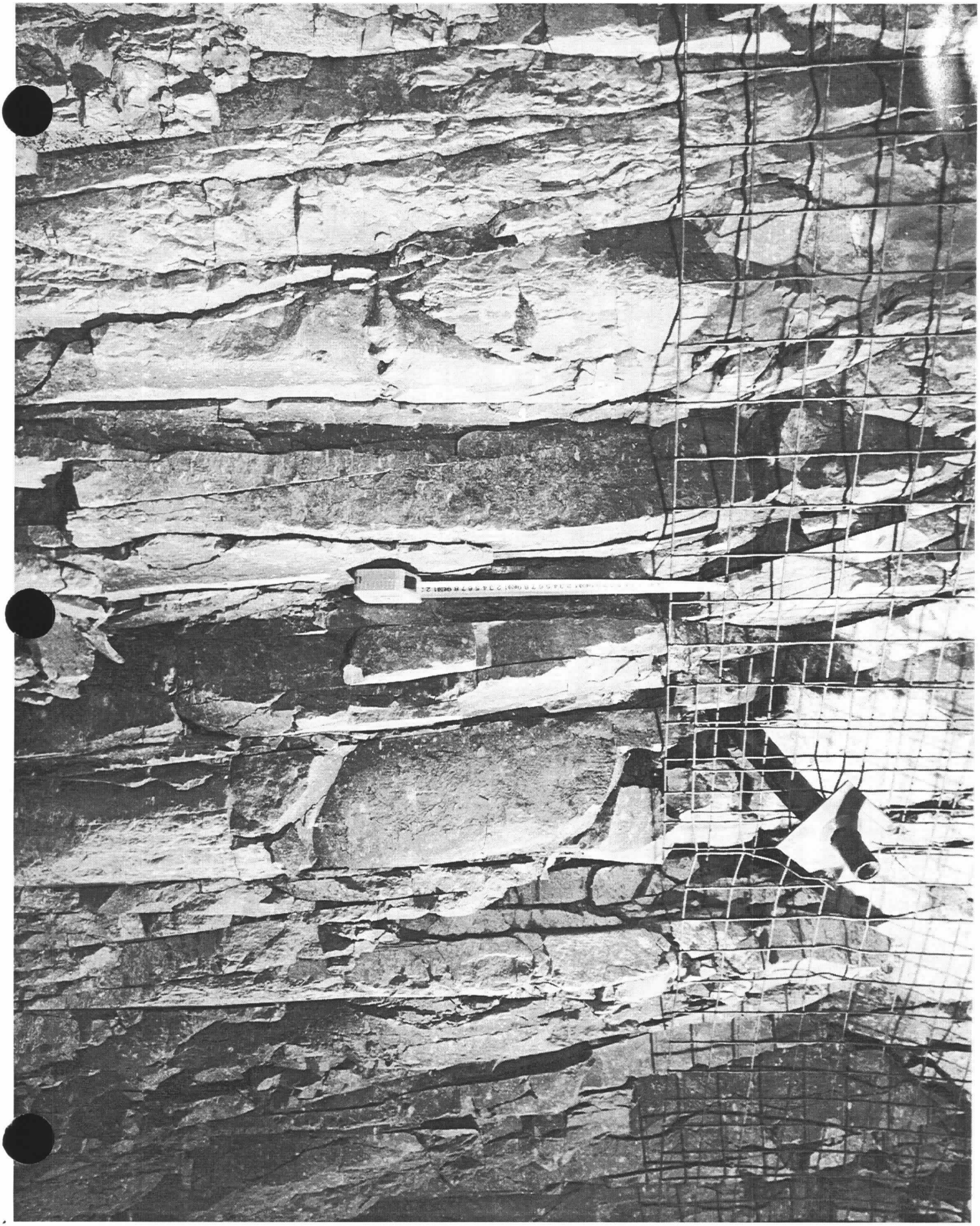




GEOLOGIC STRUCTURE AT YUCCA MOUNTAIN

Topics for Today's Tag Team Presentations

→ NEW 1:6,000-SCALE SURFACE GEOLOGIC MAP

Presenter: Warren Day, USGS, PI

- Differences from Previous Map

→ GEOLOGIC STRUCTURE IN THE ESF

Presenter: Steven Beason, Bureau of Reclamation, PI

- Geologic Structure in the ESF

→ CORRELATION BETWEEN SURFACE AND ESF MAPPING

- Example: North Ramp Cross Section

Presenter: Beason

Day

OBJECTIVES OF TODAY'S TALK

- ➔ SOME HIGHLIGHTS OF NEW MAPPING
- ➔ COMPARISON WITH EARLIER MAP (1:12,000-SCALE)
- ➔ IMPLICATIONS OF CURRENT MAPPING FOR:
  - Seismotectonic Hazards Assessment
  - Design
  - Constrains possible expansion areas
  - Hydrology: infiltration studies, pneumatic, etc.
  - Process Models
  - ESF Studies: Provides a context for Bureau of Rec Team Members

WHY DID WE BOTHER WITH A NEW MAP?

- ➔ Purpose of Scott and Bonk (1984) was to help locate the outline of the potential repository
  - detailed reconnaissance map
- ➔ It was never intended to be used to the level of detail as is employed today
- ➔ Last Spring we determined that several areas on the map needed revision

REVIEW OF TOOLS AVAILABLE: Context

- ➔ SCOTT AND BONK (1984): Field work 1980-1983
  - GQ Maps (1:24,000-scale) by Lipman and McKay (1965) and Christiansen and Lipman (1965)
    - Defined the major faults
    - Established stratigraphy (formation level) and recognized regional continuity of lithophysal zones within the Paintbrush Group
  - Topographic base map 1:24,000 enlarged to 1:12,000

REVIEW OF TOOLS AVAILABLE: Context (con't)

→ Day and others (1996): all of the above, plus:

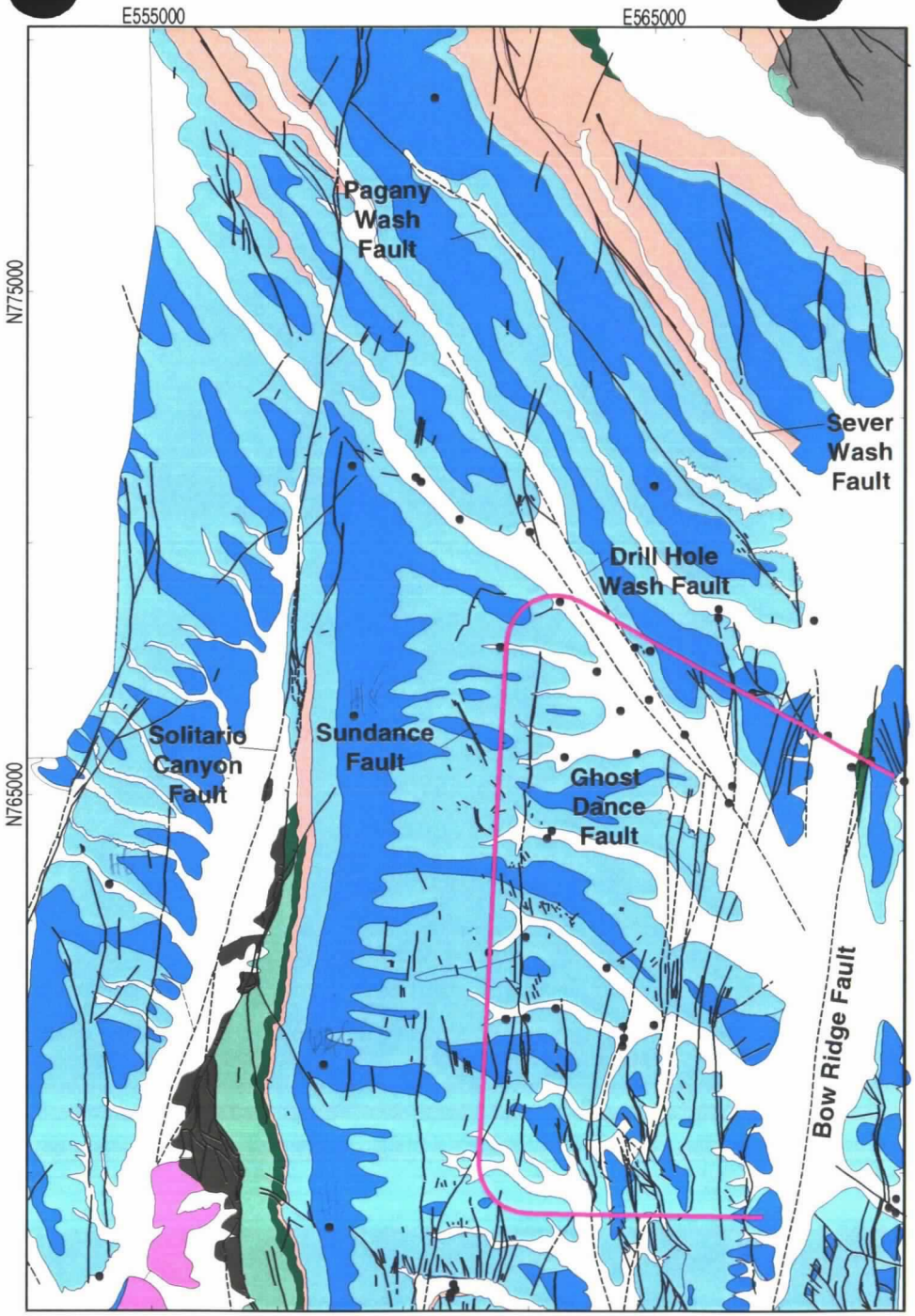
- Greater corporate knowledge on the geology at Yucca Mountain
  - *We're standing on some very tall shoulders*
- More geophysics, borehole data
- ESF under our feet
- Buesch and others (1996) revised stratigraphy
- EG&G topographic and orthophoto basemaps

RESULTS OF SCOTT AND BONK (1984)

- ➔ A Fine Map for the Scale and Original Intent
- ➔ Established Location of Block-Bounding Faults
- ➔ Listric Model for Geometry of Block-Bounding faults
  - Out of vogue now
- ➔ "Imbricate Fault" Zone
  - Bad name
- ➔ Did NOT Recognize Members (crystal-rich/-poor) of Tiva and Topopah
  - VERY POWERFUL TOOL FOR DELINEATING FAULTS
- ➔ Naturally, there is some breakdown due to differences in scale

SOME HIGHLIGHTS OF THE NEW MAP

- ➔ Defined branching of faults (vertical & horizontal)
  - Ghost Dance Fault
  - Abandoned Wash (on cross section)
- ➔ Connectivity of Faults
  - Ghost Dance with the Abandoned Wash but not Dune Wash
  - Dune Wash and "imbricate fault" zone
  - Northward continuation of a splay of the Abandoned Wash fault
- ➔ NW-striking fault connecting C-hole complex with Bow Ridge fault



Bedrock Geologic Map of the Central Block Area, Yucca Mountain, Nevada

by
W.C. Day, C.J. Potter, D.S. Sweetkind, and R.P. Dickerson

Explanation

Quaternary

- Alluvium & Colluvium

Tertiary

- Rainier Mesa Tuff
- Comb Peak Rhyolite
- Tiva Canyon & Topopah Spring Tuff

Tiva Canyon Tuff

- Crystal - rich member
- Crystal - poor member

- **Pah Canyon, Yucca Mountain Tuffs - undivided**

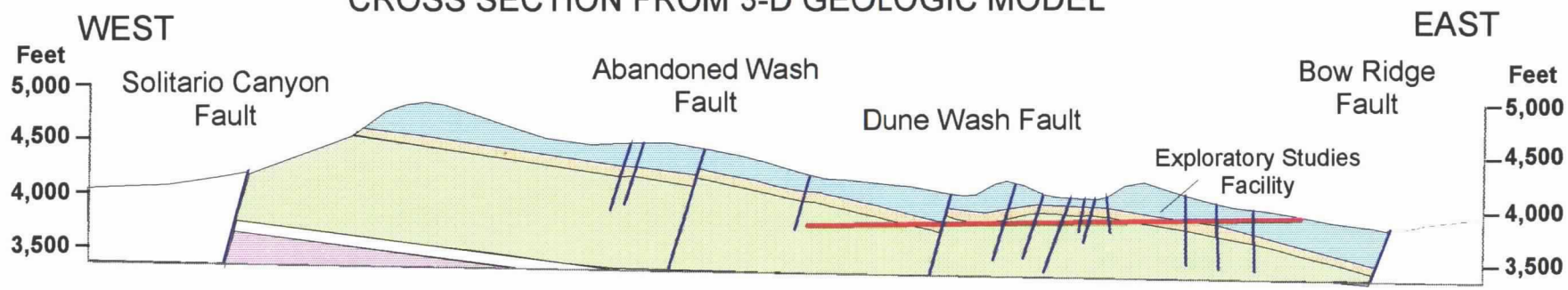
Topopah Spring Tuff

- Crystal - rich member
- Crystal - poor member

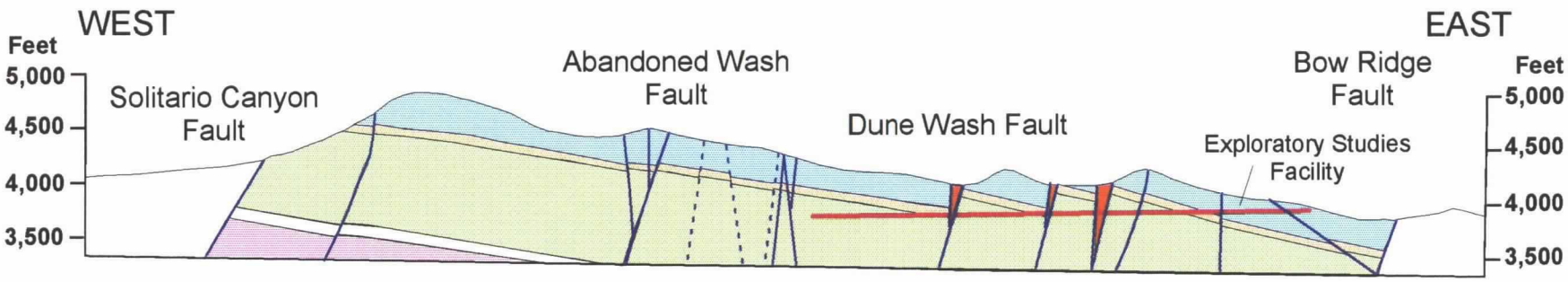
0 2,500 Feet

Preliminary Data for Information Only
USGS
July, 1996

CROSS SECTION FROM 3-D GEOLOGIC MODEL



CROSS SECTION FROM NEW BEDROCK GEOLOGIC MAP



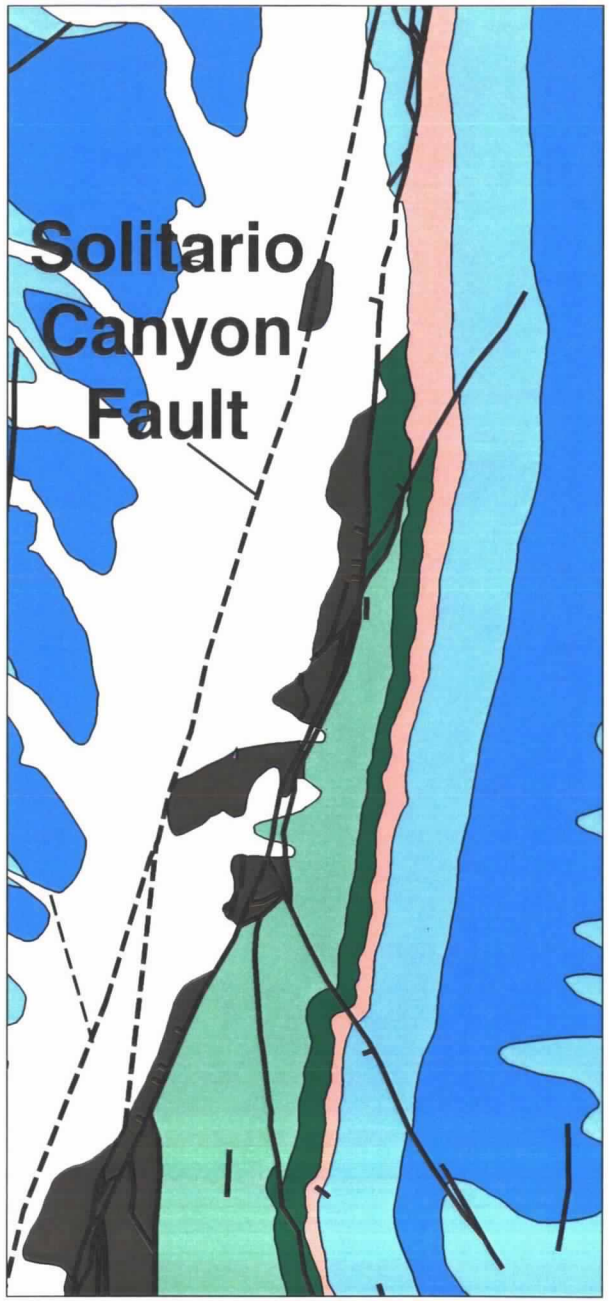
Explanation

- Breccia Zone
- Tiva Canyon Tuff
- PTn
- Topopah Spring Tuff
- Calico Hills
- Prow Pass

PRELIMINARY DATA
USGS (JULY, 1996)

SOME HIGHLIGHTS (con't)

- ➔ Solitario Canyon growth fault splays
  - Offsetting of Topopah>PTn>Tiva
  - Apparent thickness increase of the PTn
  - Implication: evidence for post-Topopah Spring pre-Tiva deformation, extent of which is obscured b ovelying blanket of Tiva Canyon Tuff



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- **Pah Canyon, Yucca Mountain Tuffs - undivided**

Topopah Spring Tuff

- Crystal - rich member
- Crystal - poor member

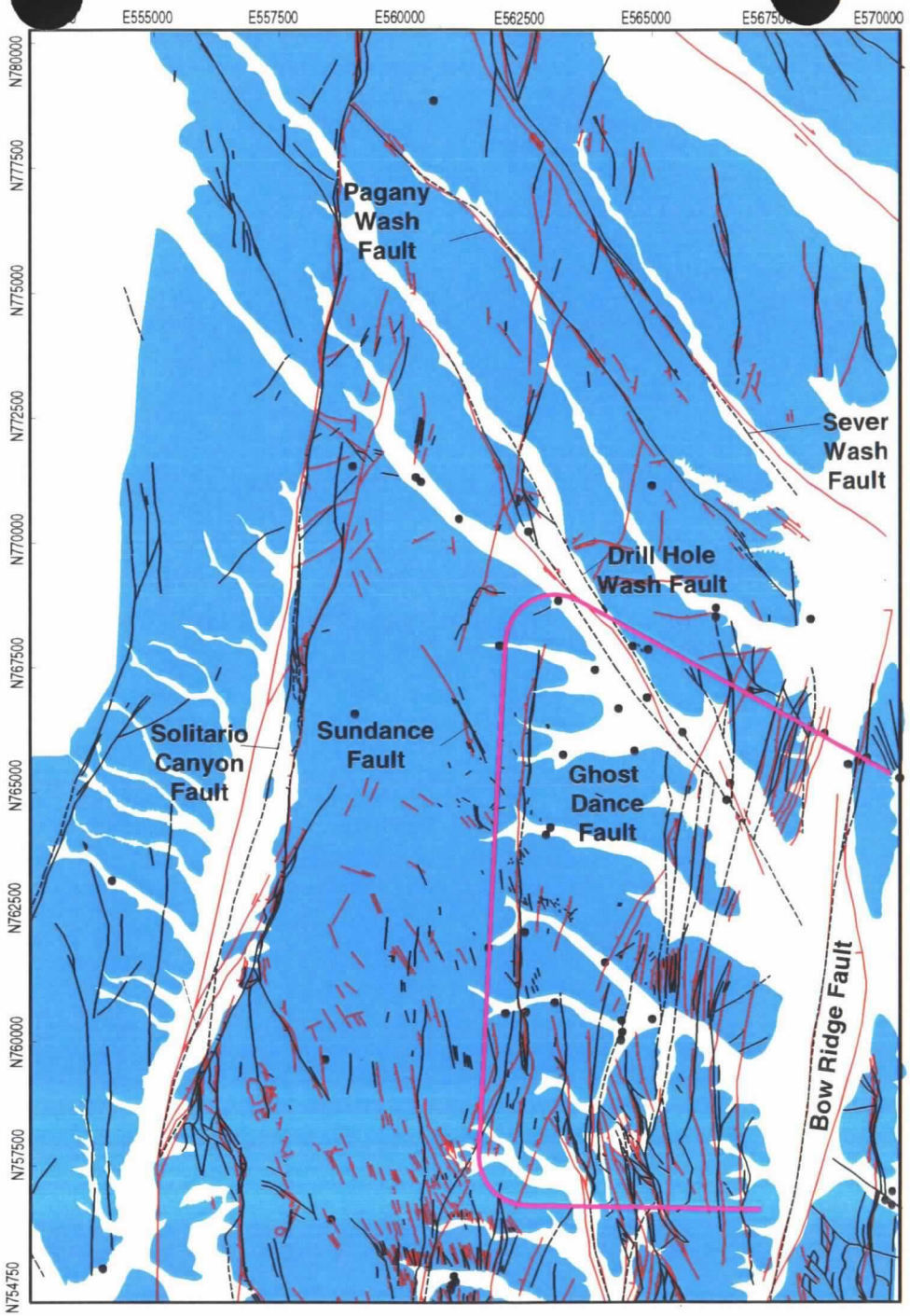
0 2,500 Feet

Preliminary Data for Information Only • USGS • July, 1996

COMPARISONS WITH PREVIOUS STUDIES

Examples of Block-Bounding Faults

- Solitario Canyon Fault: hanging wall deformation delineated
- Bow Ridge Fault: Trace essentially the same because it is buried, but some important differences with hanging wall faults
- Sever, Pagany, and Drill Hole Wash locations, displacements, and associated faults refined



Faults in the Central Block Area

Faults - known and inferred (Day and others)

Faults - known and inferred (Scott and Bonk, 1984)

Exploratory Studies Facility

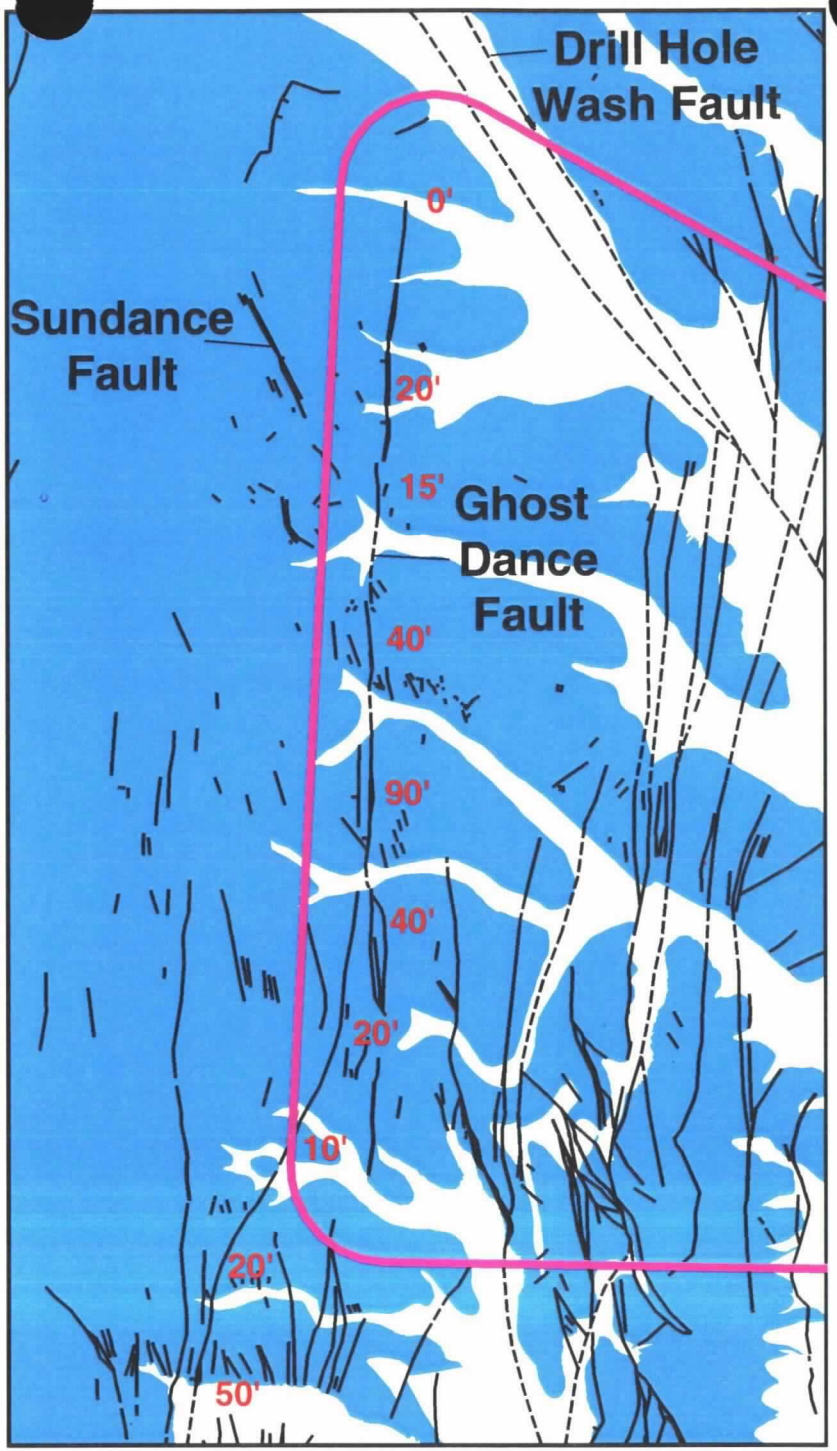
0 2,500 Feet

Preliminary Data for Information Only
USGS
July, 1996

COMPARISON WITH PREVIOUS STUDIES (con't)

Examples of Intrablock Faults

- Ghost Dance Fault (splays, width, and displacement variations)
- Sundance Fault (not delineated by Scott and Bonk, 1984)
- Orientation of minor faults (Scott and Bonk had unrealistically uniform NW-strikes)
- Numerous minor faults incorrectly mapped



Faults in the Central Block Area

Miocene Volcanic Rocks

Faults - known and inferred (Day and others)

Exploratory Studies Facility

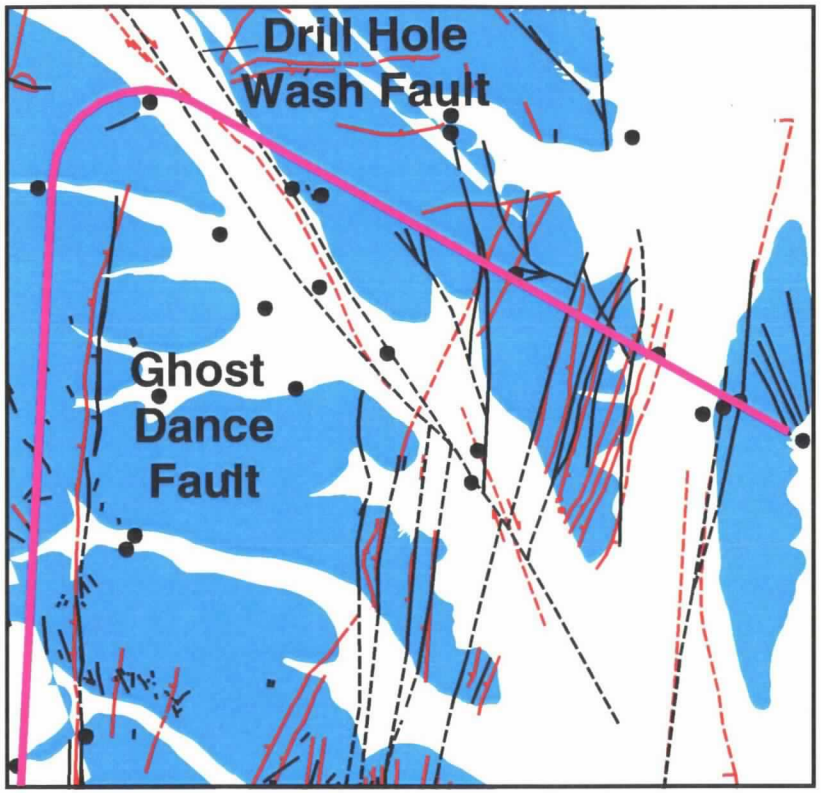
20' Displacement (Feet)

0 2,500 Feet

COMPARISON WITH PREVIOUS STUDIES (con't)

New Mapping Results of the "Imbricate Fault" Zone

- ➔ Several disconnects in the Azreal Ridge Area
  - NW-striking faults connecting the ESF with boreholes UZ#4 & #5
- ➔ Scott and Bonk verified between Live Yucca and Antler Ridges
- ➔ Major busts at Boundary Ridge
  - Implications for South Ramp Cross Section



Faults in the Central Block Area

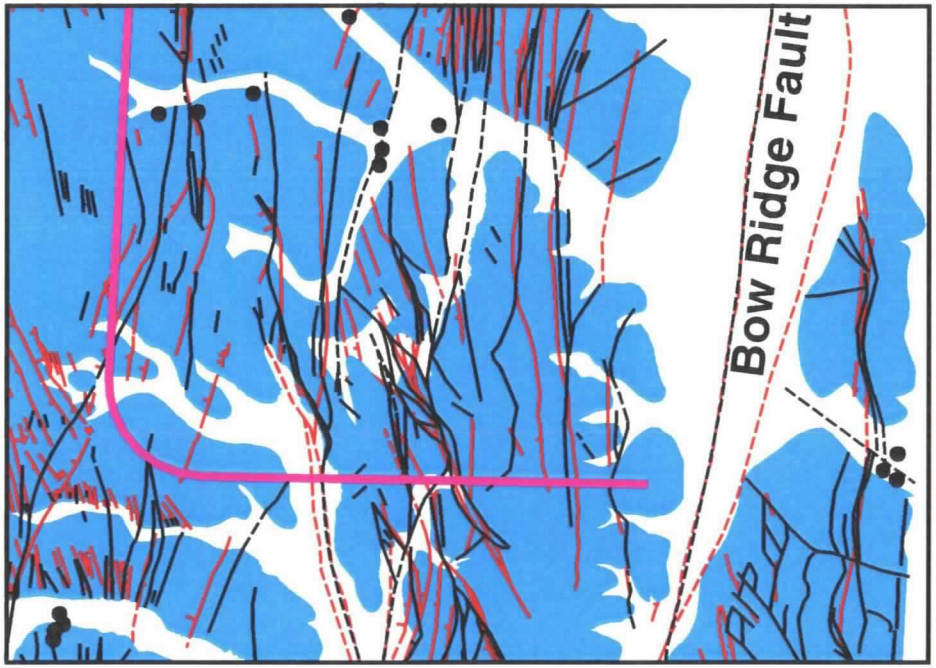
Miocene Volcanic Rocks

Faults - known and inferred (Day and others)

Faults - known and inferred (Scott and Bonk, 1984)

Exploratory Studies Facility

0 2,500 Feet



Faults in the Central Block Area

Miocene Volcanic Rocks

Faults - known and inferred (Day and others)

Faults - known and inferred (Scott and Bonk, 1984)

Exploratory Studies Facility

0 2,500 Feet

SOME IMPLICATIONS (so what?)

- ➔ Central part of the 3-d model needs revision
  - Currently working with modeling team for update of 3-d geologic model
- ➔ Seismotectonic Hazards Assessment
  - Location, orientation, width of faults refined
  - Connectivity of faults in the vicinity of the repository area
- ➔ Design:
  - South ramp cross section
  - Provides detailed information for possible expansion areas
- ➔ Hydrology:
  - infiltration studies
  - pneumatic pathways,
  - infiltration studies, etc.
- ➔ Framework for Process Models
- ➔ Context for ESF Studies

Warren Day's NWTRB Talk July 9, 2:30 pm Red Lion

Slide 1 Title Slide

Good afternoon. I'm Warren Day and I work with the US Geological Survey. This morning Steve Beason, who is with the Bureau of Reclamation, and I would like to present some of the new information gained from both underground and surface-based geologic mapping studies ongoing at Yucca Mountain. I will try to point out some of the differences between our work and that of the previous generation of bedrock mappers and will present just a few of the highlights of the new geologic map. The new bedrock geologic map will be delivered at the end of August.

Steve will discuss some of the outcomes of his group in their underground mapping of the Exploratory Studies Facilities.

The significance of geologic maps and the basic research they support is routinely overlooked. They become part of the background environment—they are like water or air: they just exist to most people. But in fact, the lives of everyone of you in this room this afternoon have been touched by at least two geologic maps. The mere fact that Pete Lipman, Bob Christiansen, and Gordon McKay were interested in ash-flow tuffs and mapped Yucca Mountain is one of the critical reasons Yucca Mountain was chosen for further study in the first place. If that series of quality maps did not exist, people would not have focused on Yucca Mountain and many of <u>your</u> jobs would not exist. Bob Scott was hired away from Texas A&M to provide a detailed reconnaissance map to help site the repository. Again, think of the ramifications if Bob had not done that map. So it is with this understanding of history which is commonly ignored, that we have undertaken the daunting task of providing a bedrock geologic map of the central block area of Yucca Mount, which includes the potential repository area. None of us in this room can begin to guess on how this new map will figure into future directions of this Project.

Slide 2 Objectives Slide

The Objectives of my talk are to:

1) Give you some of the highlights of the new bedrock map
2) Compare it with the structural features on Scott and Bonk's map
3) Touch upon some of the implications for the geologic map I can foresee.

Slide 3 Why Bother?

One question by the non-scientific community that we must always be prepared to answer is: Why Bother? Don't you guys already know everything about that Mountain by now?

The purpose of Scott and Bonk was to provide a detailed reconnaissance of the area and was never intended to be used at the level of detail as is employed now. Last Spring we produced a map of dominant faults in the potential repository area and concluded that while pretty good, Scott's mapping needed improvement in key areas.

Slide 4 Review of Tools Available, context

It is important to know the context of each generation of study.

1. The GQ maps of Lipman and McKay and Christiansen and Lipman defined most of the obvious block-bounding faults.
2. They also recognized the lateral continuity of lithophysal zones within the Paintbrush Group and defined the initial stratigraphy.
3. Their base maps were the USGS 1:24k topo map.
4. Bob Scott had their initial work to build upon.

Slide 5 Tools Available con't (Day and others)

Day and others entered the Project in February 1995 at a time when there was an enormous corporate knowledge on the geology of Yucca Mountain, the likes of which Scott and the early workers could only dream about.

1. More geophysical data, more borehole data
2. ESF was in progress

3. A new stratigraphic nomenclature was established that correlated surface observations with those gained in the underground and borehole studies.
4. Any we have fantastic 1:6k basemaps.

SLIDE 6 Results Of Scott And Bonk (1984)

1. It was a fine map for its intended purposes.
2. They established the locations of the block-bounding faults and the many of the intrablock faults.
3. One of the main scientific conclusions Bob Scott arrived at was the listric fault model for the area. The listric fault model took the geologic sciences by storm in the mid-1980's and is commonly used today.

However, we know have deep seismic profiles which do not support a shallow detachment fault under the repository area.

4. Scott also introduced the concept of the imbriate fault zone. It was a bad choice in that the faults in the areas he was referring to are not co-planar, do not have uniform offset, nor are they associated with thrust faulting, which is what the term implies.
5. Bob did not recognize the crystal-rich/crystal-poor nature of the Tiva and Topopah, which is a very powerful mapping tool.

Slide 7 Some Highlights

I would like to present just a few of the highlights from the new map.

1. We were able to define the vertical and horizontal branching nature of the faults and relate smaller splays to larger intrablock and block-bounding faults. For instance, the Ghostdance horse-tails vertically along its central part, creating a wide zone of brecciation and faulting that narrows with depth. It also bifurcates laterally joining with the Abandoned Wash fault to the southwest.
2. We were able to verify the interconnectivity of faults and their kinematically related splays.

a. For instance, the so-called imbricate fault zone connects with the Dune Wash fault to the south.

3. The northwest-striking fault through the c-hole complex helps explain some of the hydrologic observations there.

Slide 8 Bedrock Geologic Map

To give you a brief overview: (work map counterclockwise)

Point out color scheme

1. The new map extends south from about Yucca Wash and drill hole G-2 to Abandoned Wash, and from about midway across Jet Ridge east to the northern tip of Bow Ridge. This area encompasses the Sever Wash, Pagany Wash, Drill Hole wash faults as well as the Solitario Canyon and Bow Ridge block-bounding faults.
2. We've been able to unravel some of the hanging wall deformation associated with the Solitario Canyon fault
3. Intrablock faults—Point Out:
   a. Ghost Dance and its splays to the south
   The Ghost Dance fault terminates before intersecting the ESF on the north and bifurcates southwestward, joining the Abandoned Wash fault.
   b. Delineation of the Sundance fault zone.
   c. Connection of Dune Wash to Imbricate Fault zone It does not join the Dune Wash fault to the southeast.
3. The new map has provided input of siting of the Ghostdance alcoves as well as provided predicative information for the south ramp.

I'll go over just a few of the details of the map next.

Point out South Ramp Cross Section Line.

Slide 10 South Ramp Cross Section

On the top of this slide is the old cross section taken from the 3-d geologic framework model. The new cross section is shown at the bottom.

1. Incongruous mapping by Scott lead the initial builders of the 3-d model to punt at Boundary Ridge, and they built a anticline for the Boundary Ridge area.

2. The new mapping resolves some of those problems and shows that in the ESF we will be going through a series of east-dipping blocks, drifting through the top of the Topopah Spring Tuff as well as intersecting several graben structures and breccia zones.

3. To the west, the splays of the Abandoned Wash fault mapped at the surface project downward to give a branching or "horse-tailing" geometry at depth. It is the eastern most splay of this fault that strikes northeastward to connect with the Ghostdance fault.

Slide 11 Some Highlights (Con't)

Fault splays of the Solitario Canyon fault show interesting changes in offset vertically. There are numerous examples where the displacement decreases up section. We have one example of a growth fault across which the stratigraphic thickness increases for the Ptn.

The implications of this is that there was pre-Tiva motion on the Solitario Canyon fault, but the extent is obscured by the blanket of overlying Tiva itself.

Slide 12 Geologic Map of Growth fault

Point out splays, along which displacement dies out upsection and the growth fault with apparent stratigraphic thickening.

Slide 13 Comparisons with Previous Studies

Examples from Block Bounding Faults

Solitario Canyon fault

We have tried to unravel the complex tectonism that affected the hanging wall zone of the Solitario Canyon fault.

Bow Ridge

Because the vast majority of the Bow Ridge fault is covered we did not "move" it from earlier depiction's.

Sever Wash Fault

The Sever Wash fault has numerous fault splays previously unrecognized

Pagany Wash Fault

Our new mapping has clearly delineated the cross-cutting relation between the northwest-trending Pagany Wash fault and its termination by a north-trending fault associated with hanging wall deformation on the Bow Ridge fault.

Slide 14 Fault map: point out above items

Slide 15 Comparisons continued

Examples of Intrablock faults

Ghost Dance

We've already covered some of the differences for the Ghost Dance.

The new map shows that the Sundance fault is a discrete 750 m long zone of discontinuous faults and shears.

The orientation of faults within the potential repository area is more varied than as Scott depicted them.

Numerous minor faults were just incorrectly mapped.

Slide 16 Fault Map: Point out above points.

Slide 17 Ghost Dance Offset Map

Looking at the Ghost Dance fault, the new mapping has shown that the offset on the fault varies considerably along its trace.

a. In the north it is relatively simple with about 20' of displacement downthrown to the west.

b. In the central part the displacement increases to about 90' and is a wider zone (about 100m wide). This maximum displacement segment is over the area of

intense fracturing observed in the Topopah middle nonlithophysal zone which Steve is going to talk about next.

c. To the south, the Ghost Dance merges with the Abandoned Wash fault (you can choose whichever name you want). Where the trace of the ESF intersects the Ghostdance at the surface, there is only about 5 feet of offset, which corresponds very well with what Steve sees in the ESF.

Slide 18 Comparisons (con't)

The new mapping in the Azreal Ridge area is an example where the detailed mapping improves dramatically our understanding of the geology of the north ramp area, which is the focus of Ed Kwicklis's talk.

We can trace a fault north and west from Drill Hole wash into Pagany Wash. This fault strikes into drill holes UZ#4 and #5 with the ESF, explaining the interconnected pneumatic pathway detected by the hydrologists.

Several of the faults associated with the so-called imbricate fault zone were incorrectly mapped.

Scott did not recognize the series of northwest-striking faults on the northern part of Exhile Hill. Had he done so, maybe the north portal would have been located about 100 yards to the south, thus possibly avoiding many of the complications encountered there.

Slide 19 Fault map.

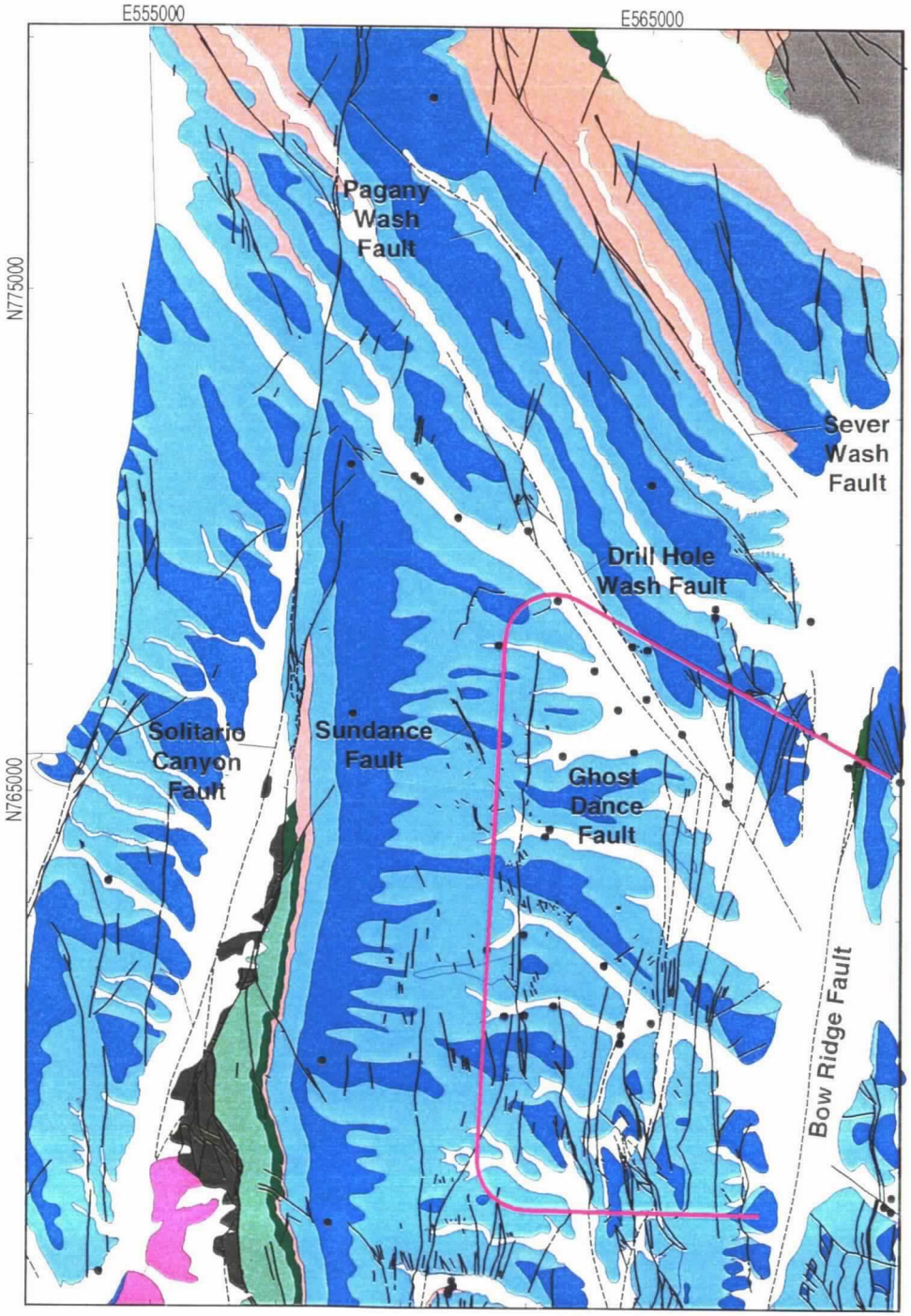
Slide 20 Implications:

The implications of this work will ring throughout the project for years to come. Ones that I can think of off the top of my head include:

1. The 3-d model needs to be revised to include the new map. We are currently working with the team to do so.

2. Seismic Hazards assessment studies will need to know the trace and interconnections between the different faults.
3. We have provided the design team with a preliminary cross section for the south ramp area. Talk about laying it on the line.
4. We are cooperating with the hydrologic investigators to provide the framework geology for infiltration, pneumatic pathways, and process models
5. And we work closely with the Bureau of Reclamation team in the ESF to help provide a heads up for them to give them the structural framework for features they encounter.

Thank you very much for your attention.



Bedrock Geologic Map of the Central Block Area, Yucca Mountain, Nevada

by

W.C. Day, C.J. Potter, D.S. Sweetkind, and R.P. Dickerson

Explanation

Quaternary

- Alluvium & Colluvium

Tertiary

- Rainier Mesa Tuff
- Comb Peak Rhyolite
- Tiva Canyon & Topopah Spring Tuff

Tiva Canyon Tuff

- Crystal - rich member
- Crystal - poor member

Pah Canyon, Yucca Mountain Tuffs - undivided

Topopah Spring Tuff

- Crystal - rich member
- Crystal - poor member

0 2,500 Feet

Preliminary Data for Information Only

USGS

July, 1996

FIGURE 1