APPENDIX 11

Fracture Characterization – John Lorenz, Sandia National Laboratories

GRI 99/0068

Consortium for Emerging Gas Resources in the Greater Green River Basin

"Integrating Geoscience and Engineering Data To Characterize and Exploit Tight Gas Sand Sweet Spots"

Monday, April 26, 1999
Marriott City Center
Denver, Colorado

Sponsored by

Gas Research Institute

U.S. Department of Energy

Petroleum Technology Transfer Council

Independent Petroleum Association of Mountain States

Consortium Meeting for the Emerging Gas Resources in the Greater Green River Basin

"Integrating Geoscience and Engineering Data to Characterize and Exploit Tight Gas Sand Sweet Spots"

Proceedings Table of Contents

Emerging Resources in the Greater Green River Basin Consortium Meeting Agenda

"Integrating Geoscience and Engineering Data to Characterize and Exploit Tight Gas Sand Sweet Spots"

Monday, April 26, 1999

7 30 - 8 30	REGISTRATION AND CONTINENTAL BREAKFAST	
8:30 - 8:40	INTRODUCTION/OPENING REMARKS	Chuck Brandenburg Gas Research Institute
8 40 – 9 10	GGRB Production Improvement Project, Rock Island Unit #4-H, Table Rock Field, Frontier Formation	Lee Krystinik Frank Lim Union Pacific Resources Company
9 10 - 9:35	Natural Fracturing in Horizontal Core Near a Fault Zone: The Rock Island Unit #4-H Well, Green River Basin, WY	John Lorenz Sandia National Labs Tom Mroz Department Of Energy
9:35 – 10 10	Siberia Ridge Reservoir Characterization Project: Sweet Spot Identification	Stephen Sturm Schlumberger-Holditch Reservoir Technologies Randal Billingsley BP Amoco
10:10 - 10:30	**BREAK** (Core Poster Session)	
10 30 – 11:00	3-D Seismic Aspects of Siberia Ridge Field, Sweetwater County, Wyoming	Charles Hinson Schlumberger-Holditch Reservoir Technologies
11 00 – 11:30	Natural Fracture Characterization for Borehole Data	Lesley Evans Schlumberger-Holditch Reservoir Technologies
11 30 – 12:00	Improved Permeability Prediction From NMR Logs Using Core Calibration	George Hirasaki Rice University Leif Colson Schlumberger-GeoQuest
12:00 - 1:00	**LUNCH (Provided)**	
1 00 - 1:30	Siberia Ridge Almond Formation, What Well Logs Can and Can't Tell You	Donald Burch The Discovery Group
1 30 - 2 00	Gas Isotope Study, Siberia Ridge Field	Martin Schoell Chevron Petroleum Technology
2:00 - 2:35	Reservoir Characterization of the Almond Formation in Siberia Ridge Field, GGRB	William Clark Schlumberger-Holditch Reservoir Technologies
2 35 - 3:05	Anomalously Pressured Gas Accumulations in Cretaceous Rocks in Laramide Basins of Wyoming A New Class of Hydrocarbon Accumulation	Ronald Surdam Institute for Energy Research
3:05 - 3:20	**BREAK** (Core Poster Session)	
3:20 - 3:50	Two Processes Leading to Overpressurization: Examples from Rocky Mountain Laramide and Gulf Coast Basins	Henry Heasler Institute for Energy Research
3 50 - 4 20	Restimulation Results in the Frontier Formation, LaBarge Platform	Connie Jump Enron Oil and Gas Scott Reeves ARI
4 20 - 4 50	An Update on Air Quality Issues in Southwest Wyoming	Curtis Rueter Radian International

Natural Fracturing in Horizontal Core Near a Fault Zone: The Rock Island Unit #4-H Well, Green River Basin, WY

John C. Lorenz, Sandia National Laboratories, Albuquerque, NM, and Thomas H. Mroz, Federal Energy Technology Ctr., Morgantown, WV

ABSTRACT

Approximately 76 natural fractures are present in 78.2 ft of near-horizontal, 2 5/8"core taken from the Rock Island Unit #4-H well. Fracture spacings vary significantly along the length of the cores· the maximum length of unfractured core is 3 8 ft in core #3, compared to a maximum of 16 9 ft of unfractured core in the contiguous cores #1 and 2. Minimum fracture spacing in all cores is less than an inch

Two sets of fractures are present:

3. The oldest fractures are the numerically dominant set, and strike generally east-west, with strikes ranging between 50-120 degrees but strongly concentrated between 80-110 degrees.
4 A less numerous, younger set of extension fractures strikes approximately north-south, between 0 and 10 degrees

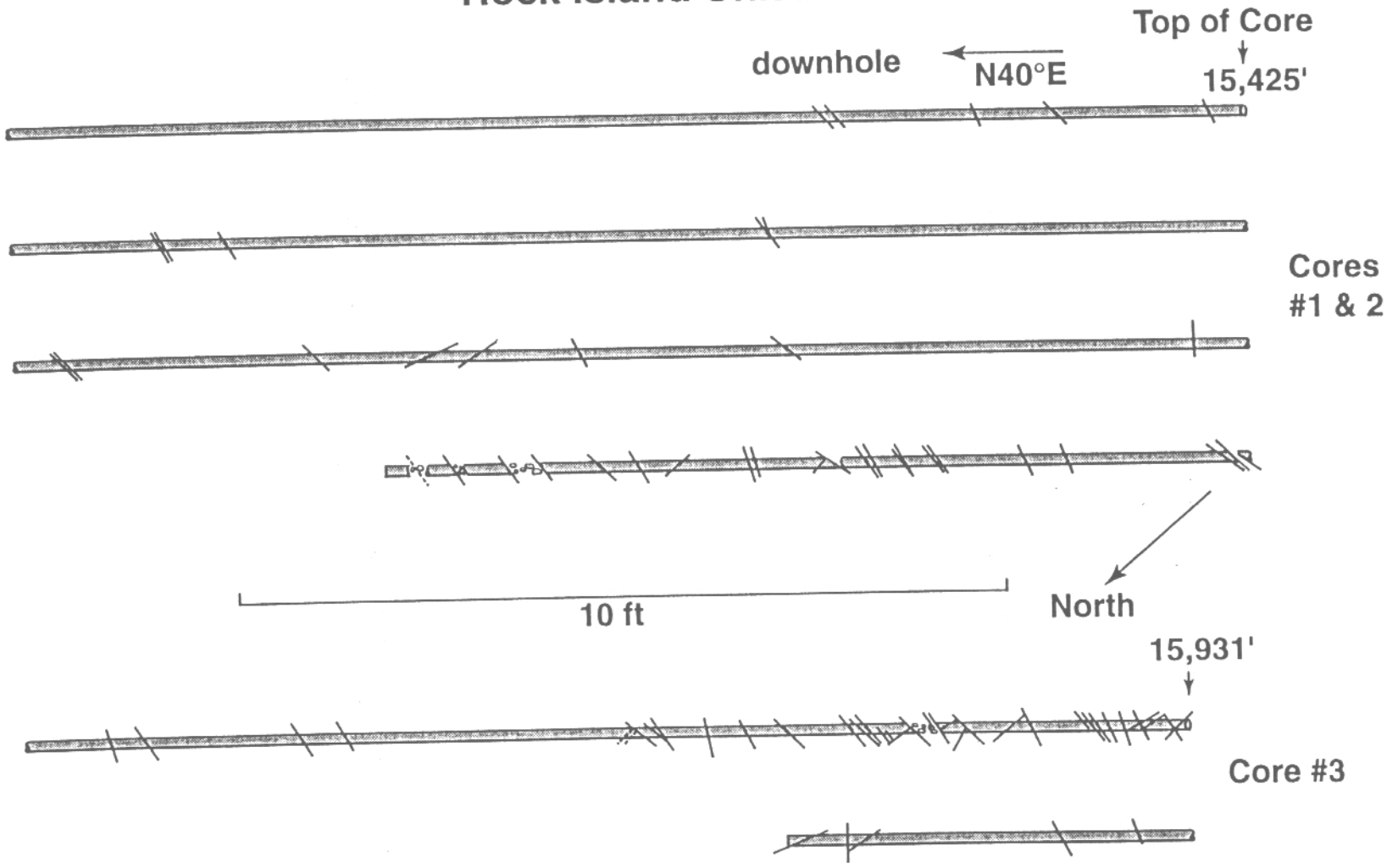
The east-west fracture set is typically mineralized with a quartz druze, a black, bituminous lining, and a late, patchy to thick, white to tan kaolinite layer The younger, north-south fractures are mineralized with quartz druze having a larger and clearer crystal habit than that found on the east-west fractures, and local patches of late calcite

About a third of the fractures of the east-west set have been reactivated by right-lateral to oblique shear (primary shear would be found on all of the fractures of this set) The shear typically indicates that rock on the southern side of the fracture has moved westward, and possibly down relative to rock north of the fracture

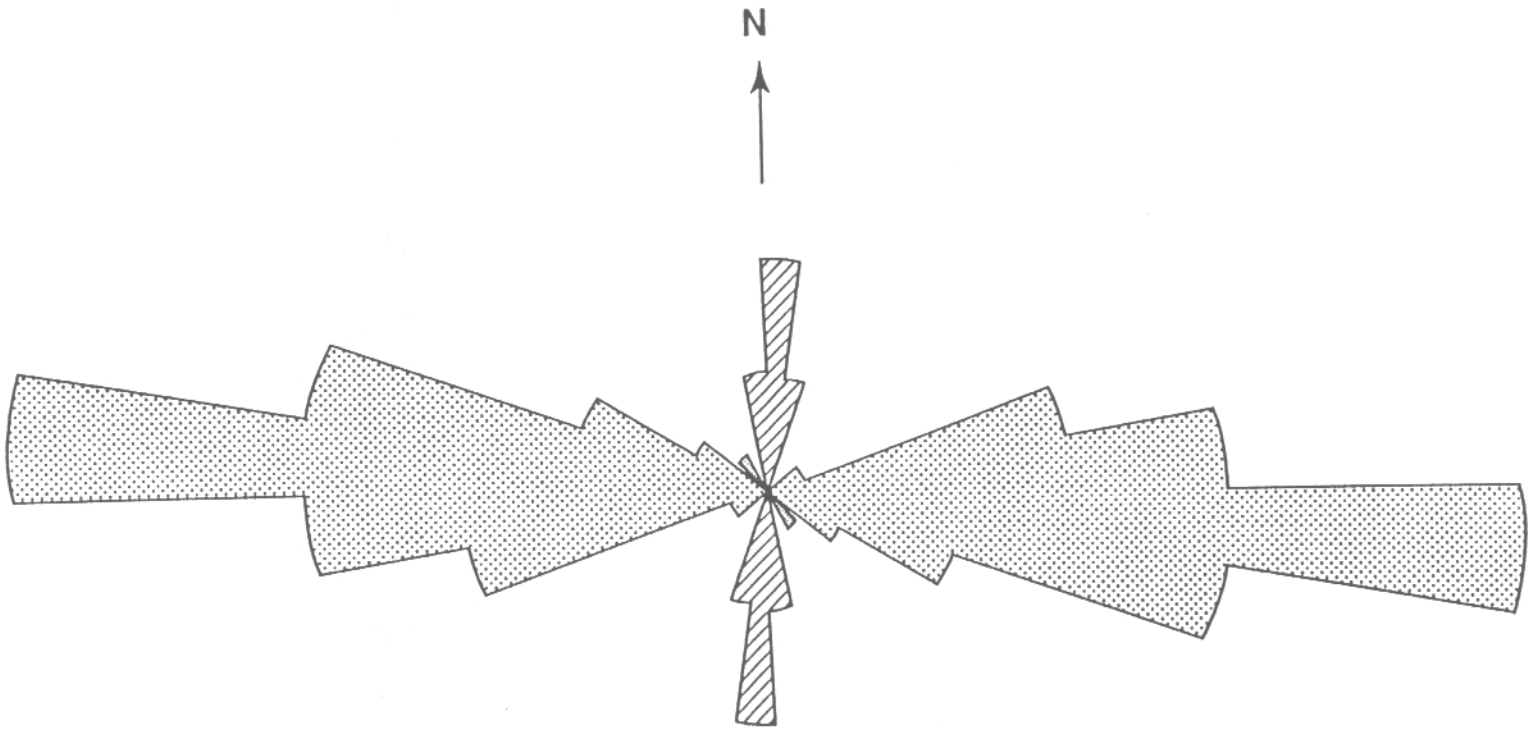
The preliminary interpretation is that the east-west fractures formed first, in response to overpressured conditions, and were reactivated later during local thrust faulting. The north-south extension fractures may be contemporaneous with reactivation of the first set, related to extension over the crest of the thrust-related flexure.

About half of the fractures of both sets have obvious remnant open aperture despite mineralization and should be good permeability pathways at virgin reservoir conditions. No coring-induced fractures have been found in these horizontal cores, thus the in situ stress orientations and magnitudes, which should have important effects on the conductivity of the fractures, are unknown. One-inch plugs taken along and across the fractures suggest that system permeability is enhanced by a factor of about 2 parallel to the east-west fractures, but that the north-south fractures do not significantly affect the reservoir permeability The plugs also suggest that permeability is not degraded from matrix values in the directions across either fracture set.

Plan-View Schematic of Fractures in Horizontal Cores, Rock Island Unit #4-H



All Natural Fractures in Core, Rock Island Unit #4-H



n = 74

Sequence of Fracture Formation in the Frontier Sandstone, Rock Island Unit #4-H

1. Deep burial, overpressuring, and east-west fracturing

2. Overmaturation of hydrocarbon to bitumen

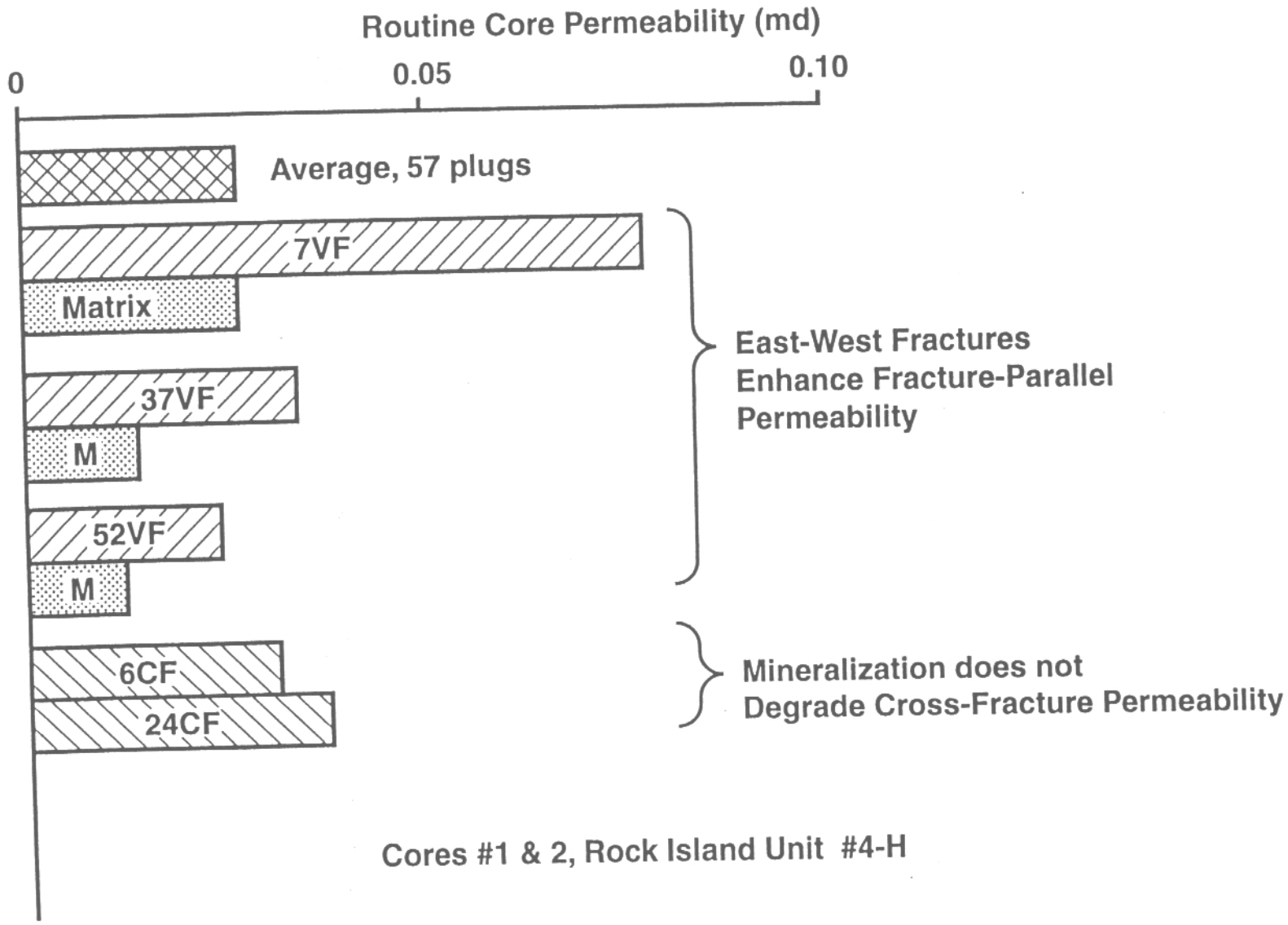
3. Mineralization of fractures with quartz druze

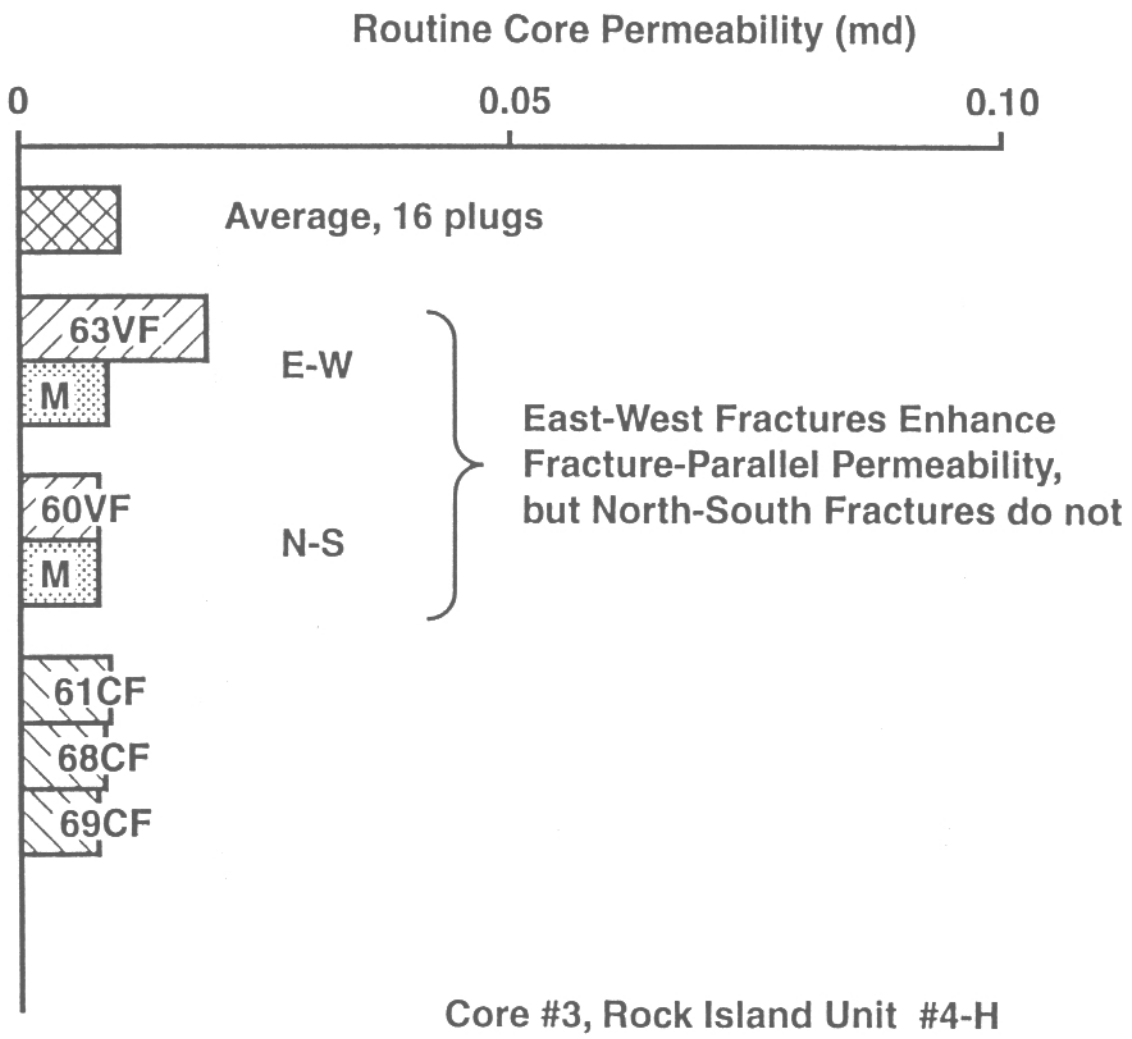
4. Mineralization of fractures with kaolinite

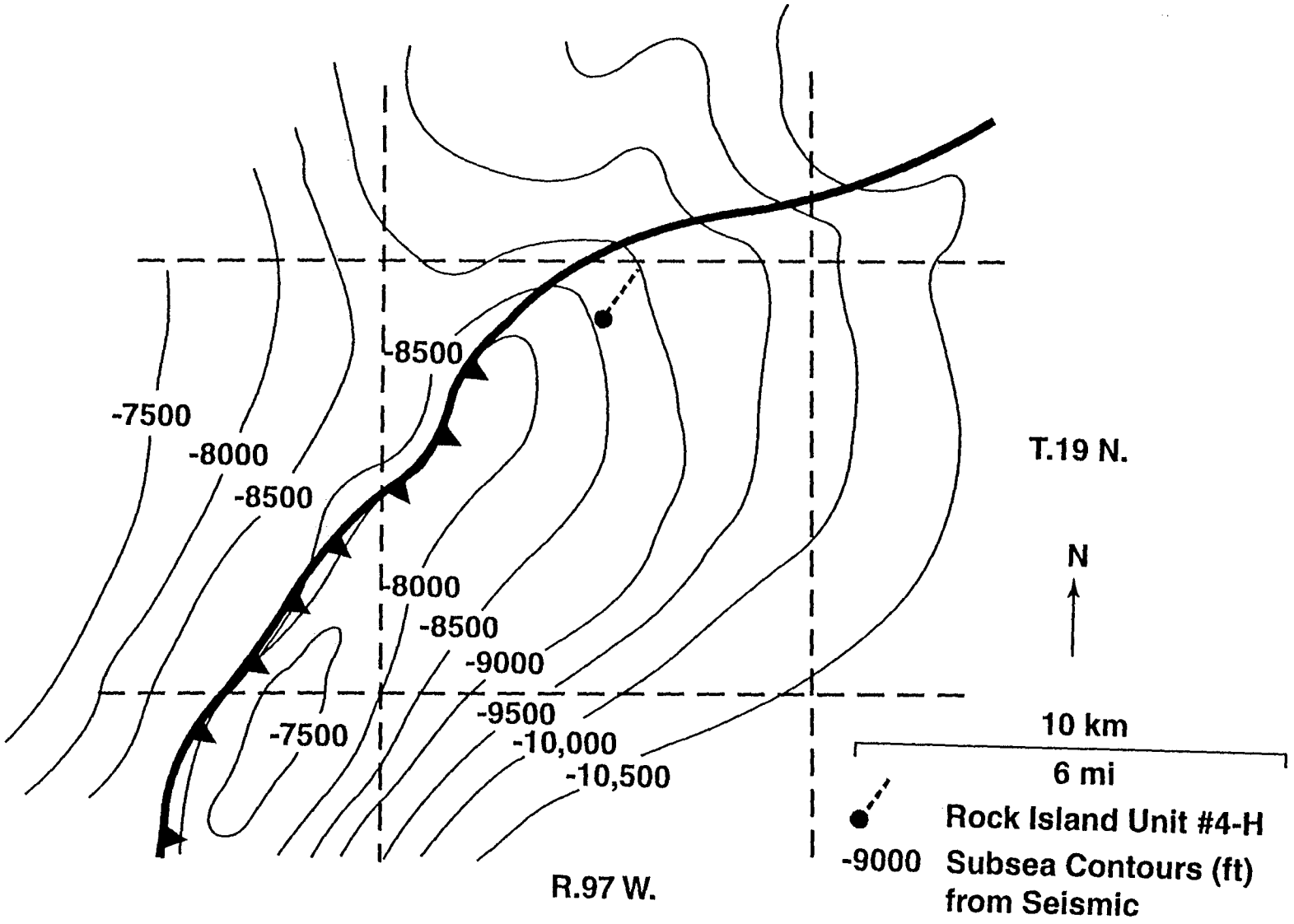
5. Thrust faulting and associated reactivation of east-west fractures in strike-slip or oblique-slip shear

6. Formation of north-south fractures

7. Mineralization of north-south fractures with quartz druze and later calcite


Routine Core Permeability (md)
0
0.05
0.10
Average, 57 plugs
7VF
Matrix
37VF
M
52VF
M
6CF
24CF
East-West Fractures
Enhance Fracture-Parallel
Permeability
Mineralization does not
Degrade Cross-Fracture Permeability
Cores #1 & 2, Rock Island Unit #4-H

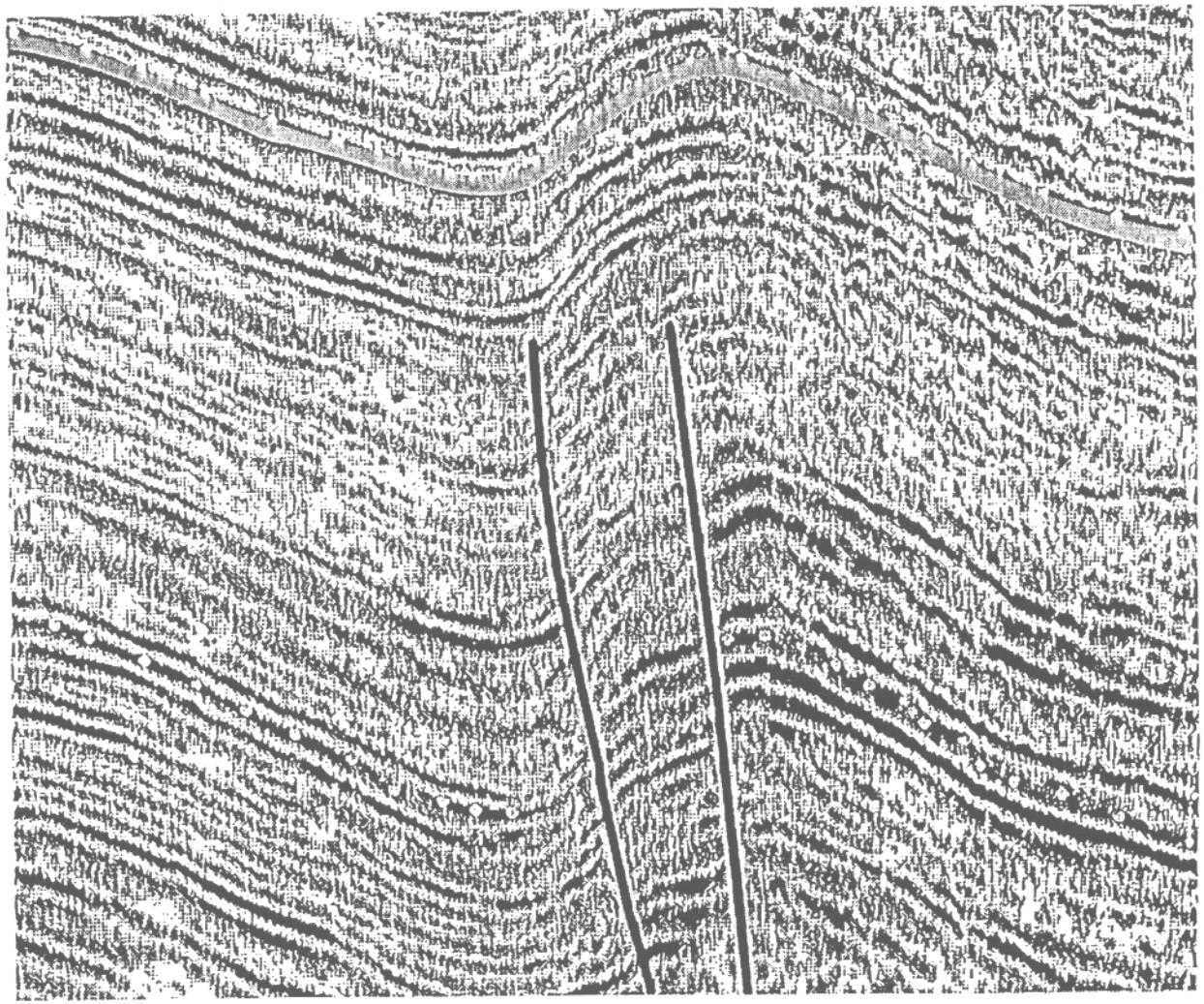

Routine Core Permeability (md)
0
0.05
0.10
Average, 16 plugs
63VF
M
60VF
M
61CF
68CF
69CF
E-W
N-S
East-West Fractures Enhance
Fracture-Parallel Permeability,
but North-South Fractures do not
Core #3, Rock Island Unit #4-H


-8500
-7500
-8000
-8500
-8000
-8500
-9000
-9500
-7500
-10,000
-10,500
T.19 N.
N
10 km
6 mi
Rock Island Unit #4-H
-9000 Subsea Contours (ft)
from Seismic
R.97 W.

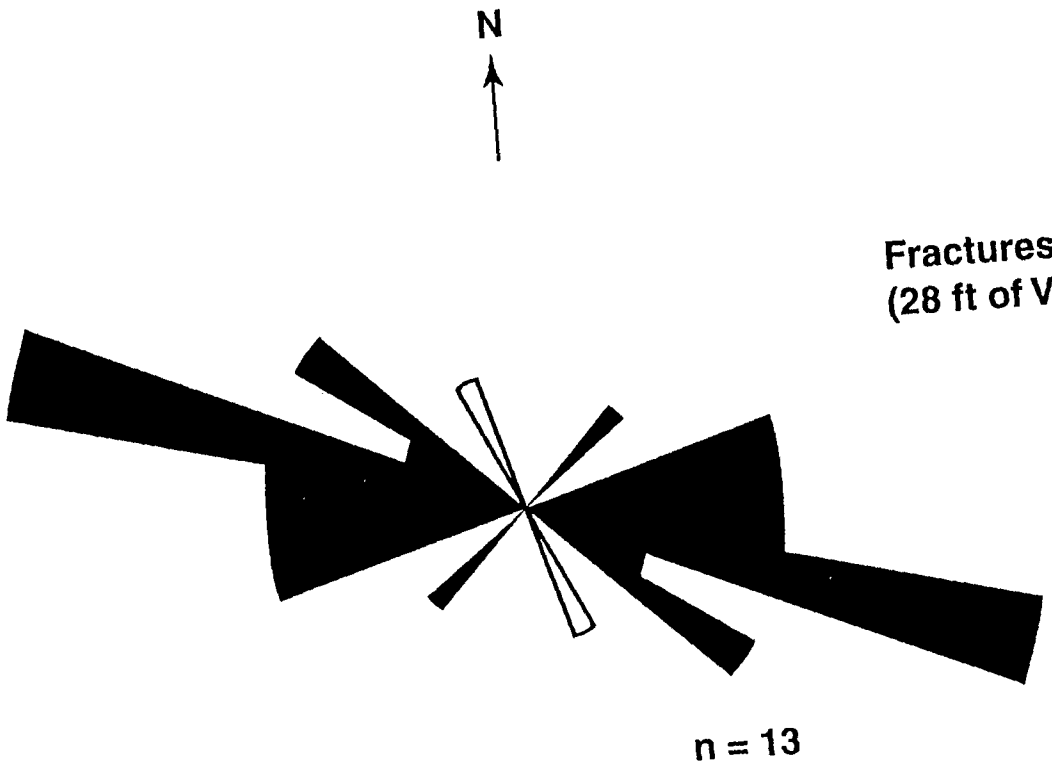
Seismic Section Across Table Rock Structure

West

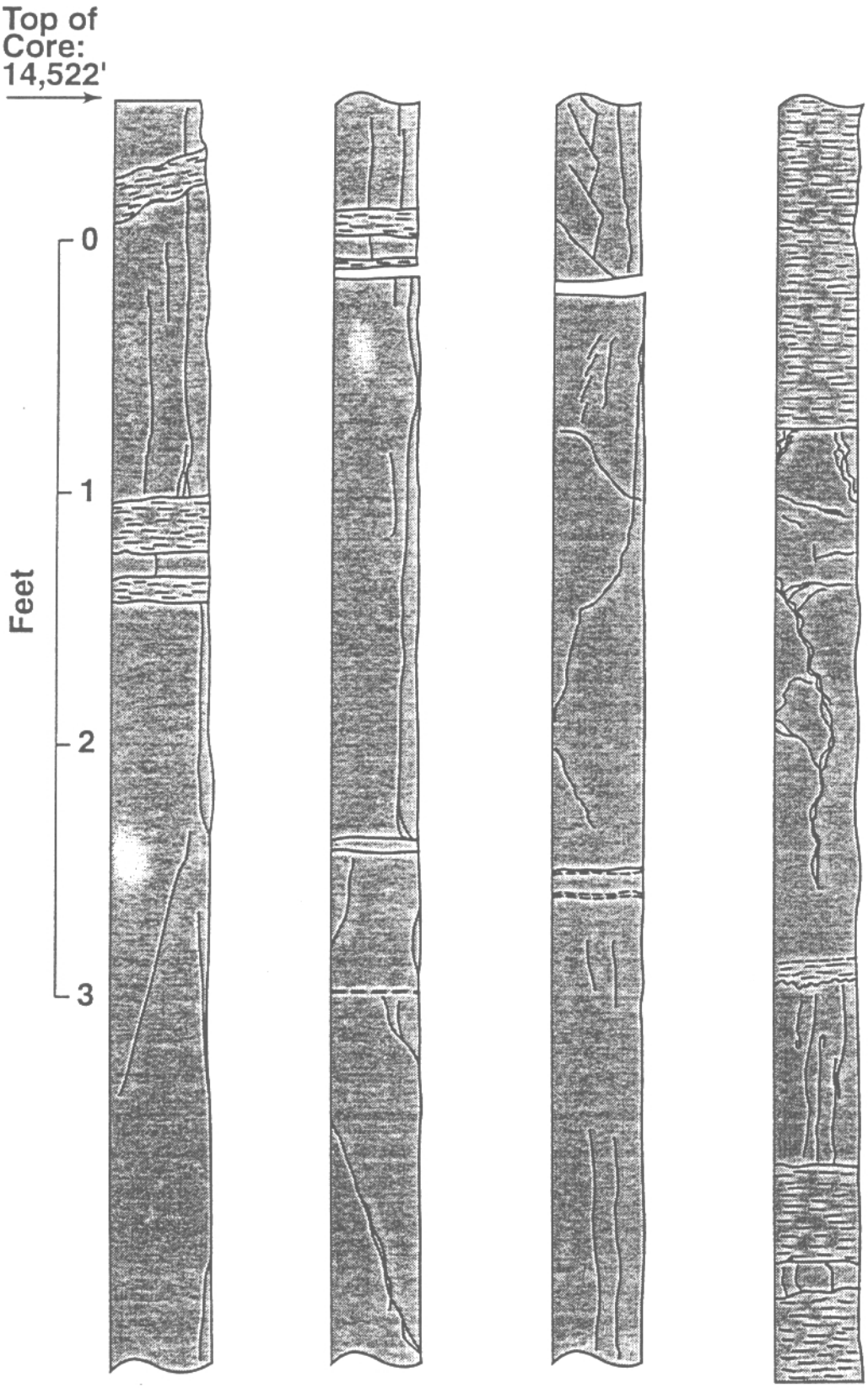
East



Frontier

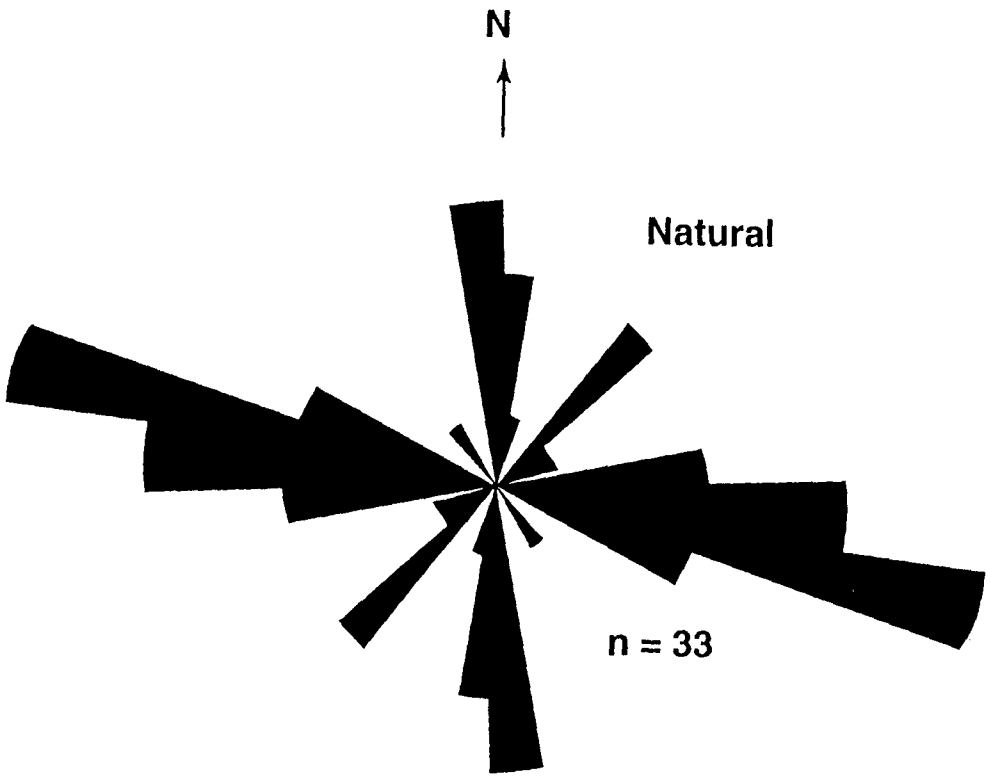

N
Fractures in Table Rock #104
(28 ft of Vertical Frontier Core)
n = 13

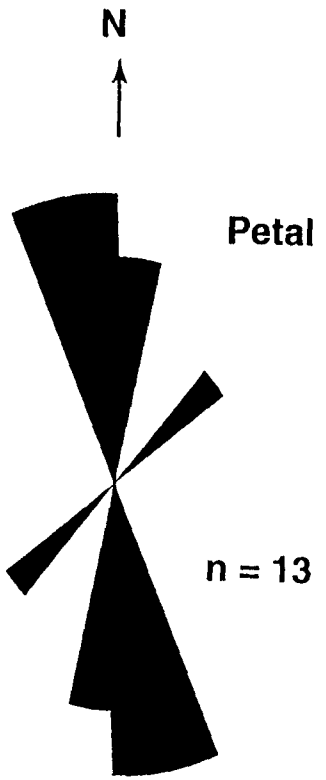
Fractures in the Government Union #4 Core



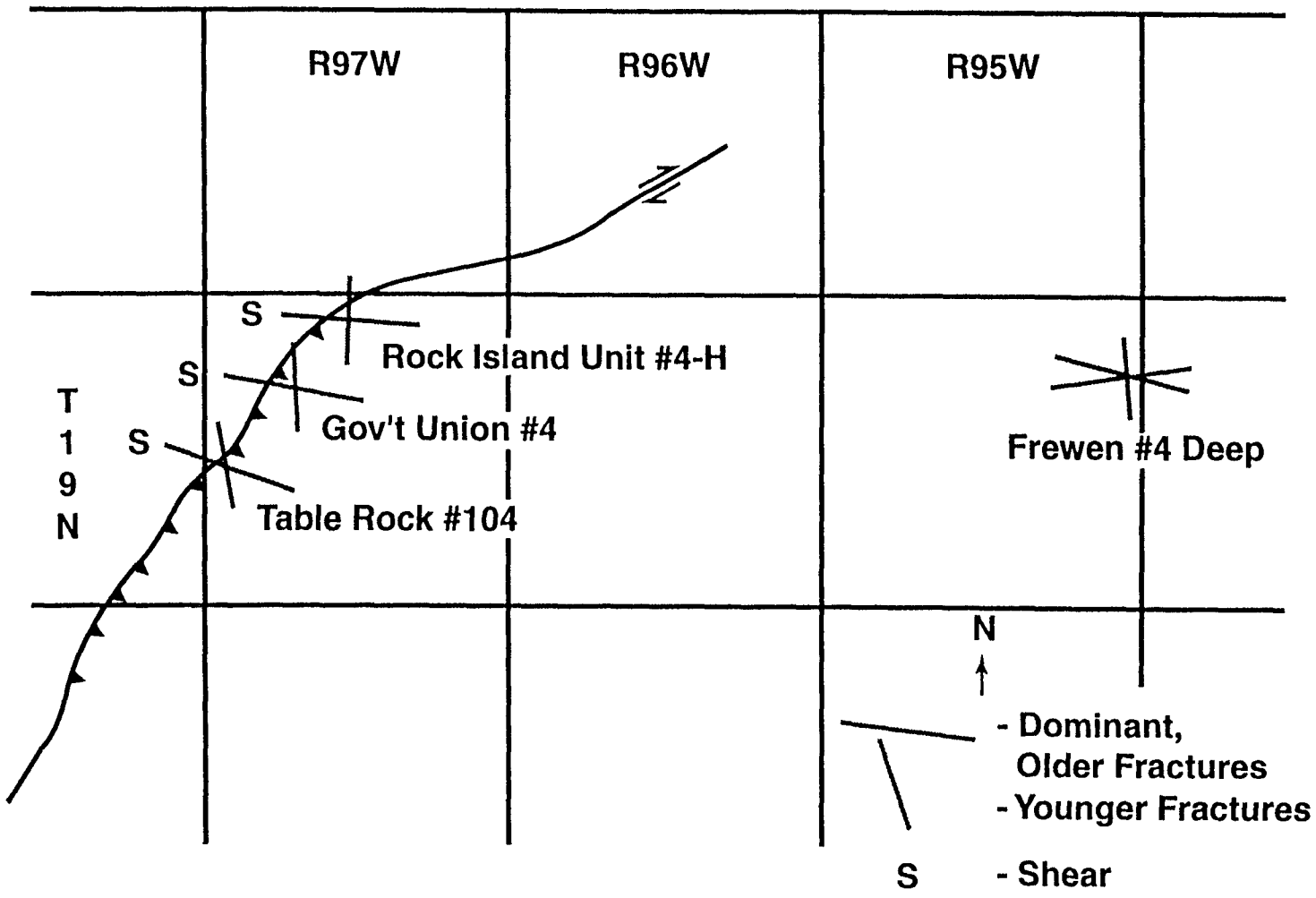
Fractures in Vertical Core, Gov't Union #4

Maximum Horizontal Stress is Normal to the Dominant Fracture Set





Generalized Fracture Trends



COMPARISON OF FRACTURE HISTORY IN THREE WELLS

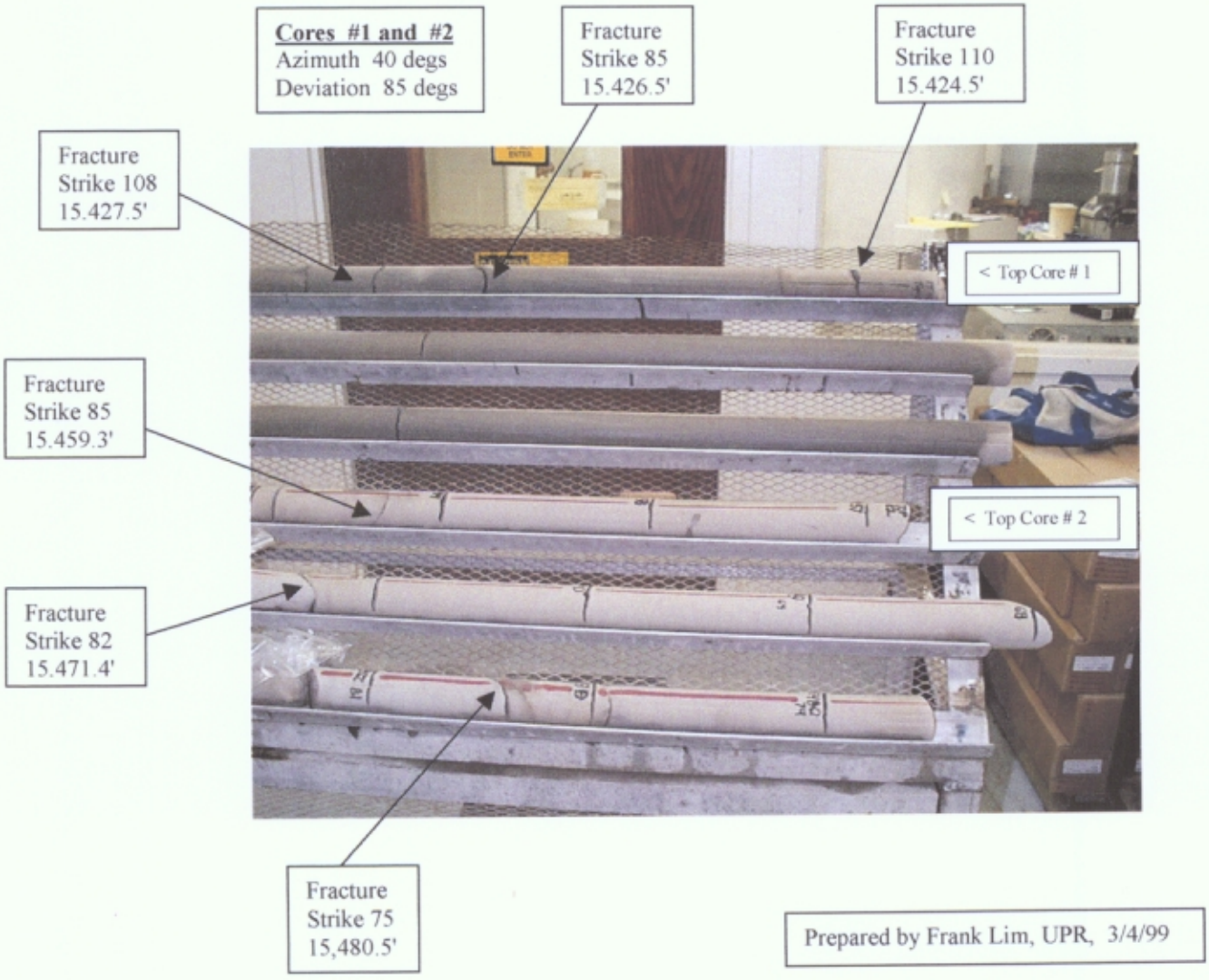
	Rock Island #4-H	Government Union #4	Frewen #4 Deep
1. Deep burial, overpressuring, and east-west fracturing	X	X	X[1]
2. Overmaturation of hydrocarbon to bitumen	X	X	X
3. Mineralization of fractures with quartz druze	X	X	X
4. Mineralization of fractures with kaolinite	X	X	-
5. Thrust faulting and associated reactivation of east-west fractures in strike-slip or oblique-slip shear	X	X	-
6. Formation of north-south fractures	X	X	X
7. Mineralization of north-south fractures with quartz druze and later calcite	X	X	X

[1]Frontier sandstones in the Frewen area underwent second east-west fracture event, separated from first by vertical pressure solution

ROCK ISLAND 4H, HORIZONTAL CORE, NATURAL FRACTURE DESCRIPTIONS

PERFORMED BY JOHN LORENZ (SANDIA NATIONAL LAB)

ATTACHED REPORTS: CORE #1 & #2 (JANUARY 21, 1999) and CORE #3 (JANUARY 25, 1999)



January 21, 1999

To Tom Mroz, USDOE
Frank Lim, UPRC

From John Lorenz, SNL

Subject Fractures in cores 1 & 2, Rock Island #4-H, Sweetwater Co , WY

Fifty-eight feet of horizontal core from the Rock Island #4-H well were examined at the TerraTek laboratory on January 18-19 Approximately forty natural fractures are present in this core, the exact number of fractures varying with whether the individual fractures of a closely spaced swarm are counted or not and on how the fracture indications within rubble zones are counted Fractures are concentrated most heavily within the second core Changes in fracture frequency and in the fracture characteristics suggest that the core approaches a structure, perhaps a fault

Two sets of fractures are present The dominant fracture set strikes east-west, with strikes ranging between 50-120 degrees but strongly concentrated between 80-110 degrees Fractures of the dominant set appear to be mineralized with an early phase of fine quartz druze and a late phase of kaolinite Characteristically there is also an intermediate phase consisting of an unidentified black substance that coats the fracture surfaces If analogy with the previously studied Frewen well core is appropriate, this black substance may be organic carbon derived from over-mature oil The black material is absent from some of the fractures lower in the core

About half of the fractures of the dominant set show horizontal to sub-horizontal lineations indicative of strike-slip to oblique-slip shear, always right-lateral where shear sense can be determined

The core has split along the fracture planes in most instances making fracture aperture impossible to measure, although 0 25-0 5 mm would be in the ballpark estimate most fracture planes are very rough, limiting the effective apertures even where mineralization is incomplete Multiple mineralization phases suggest that drilling and stimulation fluids should be chosen carefully

A minor, secondary set of fractures consists of four or five calcite-mineralized fractures that strike approximately north-south, between 0 and 10 degrees At least three of these fractures are healed completely, with no remnant aperture

1/18/99

Rock Island Unit #4-11, Sweetwater County, WYO

1/6

Azimuth 43° Deviation 88°

40' az.

29 28 27 26 25 — 15,424' MD

27.5
strike 108°
dip 80° to N (grnd)
Black surf w/ thick kaolinite
faint horiz slicks -
irreg surface suggests
minimal offset

26.55
strike 85°
dip 78° to N
Black surface w/patches kaolinite
2+ strands max ½" apart
horiz slickenlines

15424.5'
Strike 310°
dip 70° to NE
RL slicks,
sub horiz.
Black surf
mm-scale rock
inclusions

top of core
tri-cone dimples

34 33 32 31 30 — 15429

Intact Rock across F ?

29.4
est ¼mm aperture
Strike 90°
black-lined
(others probably
also but
not open)
mirror slkys
each side
of main F

29.25
Strike 92°
dip 72° N
black surf
Rough - no
slicks.
small patches of K

Continuous fm
top core to 55.5
Rubble 55.5 - 56.0
Core catcher hits 56.0 to base of core @ 56.8

* NF depths based on position @ top of core

1/18/99
Rock Island Unit #4-11, WYO
Sweetwater County,

Azimuth 40° Deviation 88°

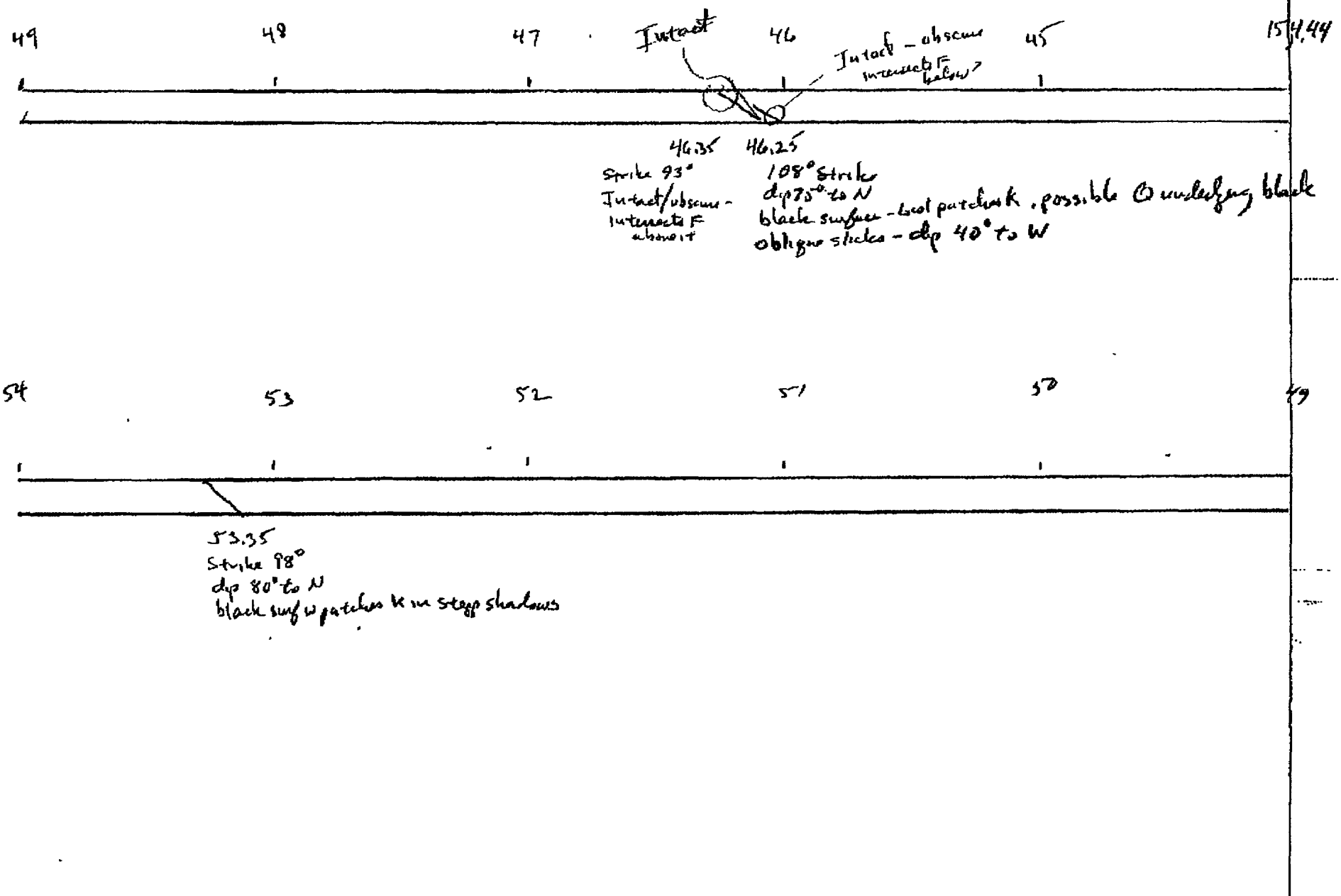
39 38 37 36 35 34

44 43 42 41 40 39

1/18/99

Rock Island Unit #4-11, W/O — Sweetwater County, WY

Azimuth 40° Deviation 88°

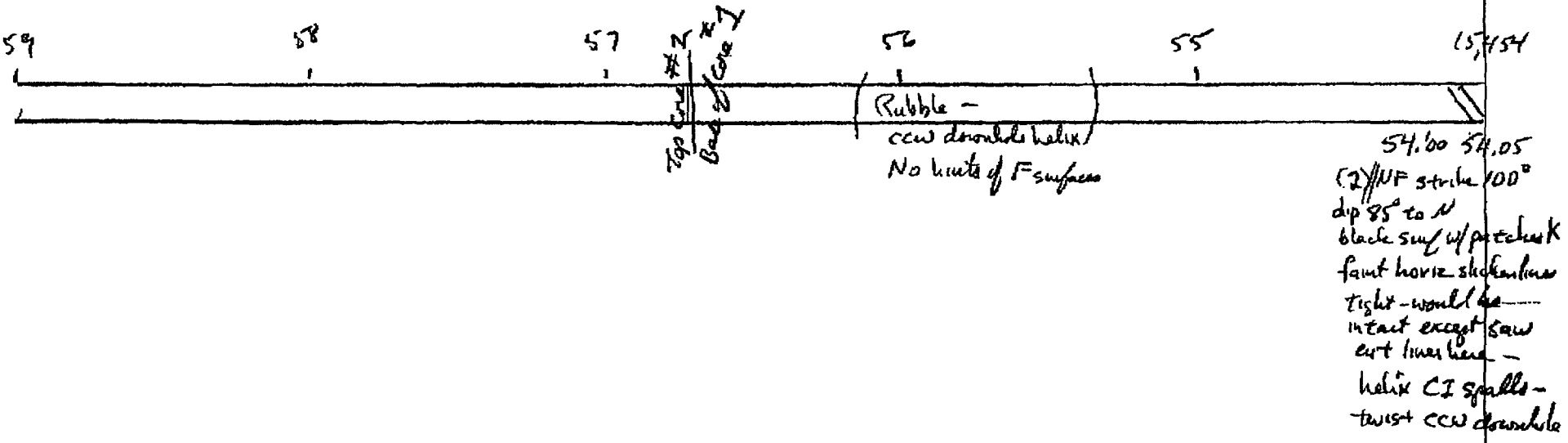


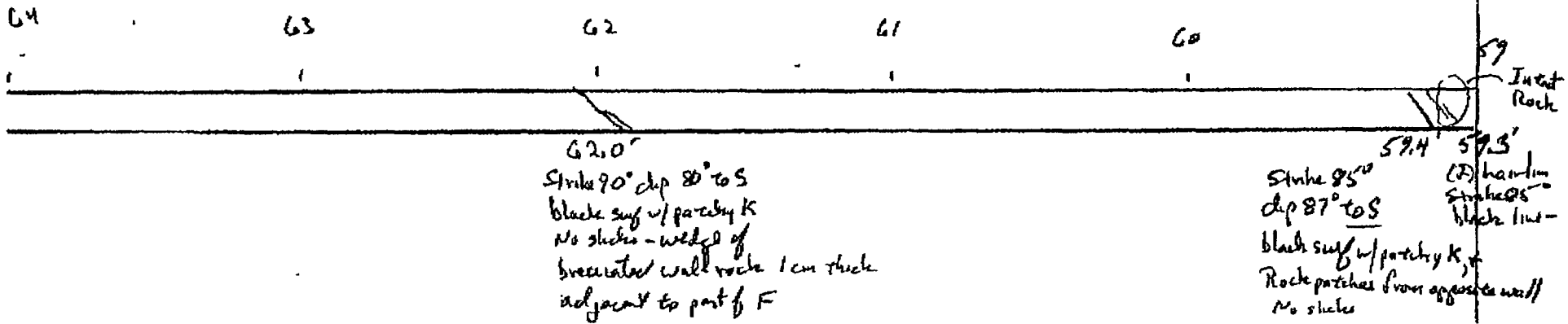
1/18/99

Rock Island Unit #4-11, WY

Sweetwater County,

Azimuth 40° Deviation 88°

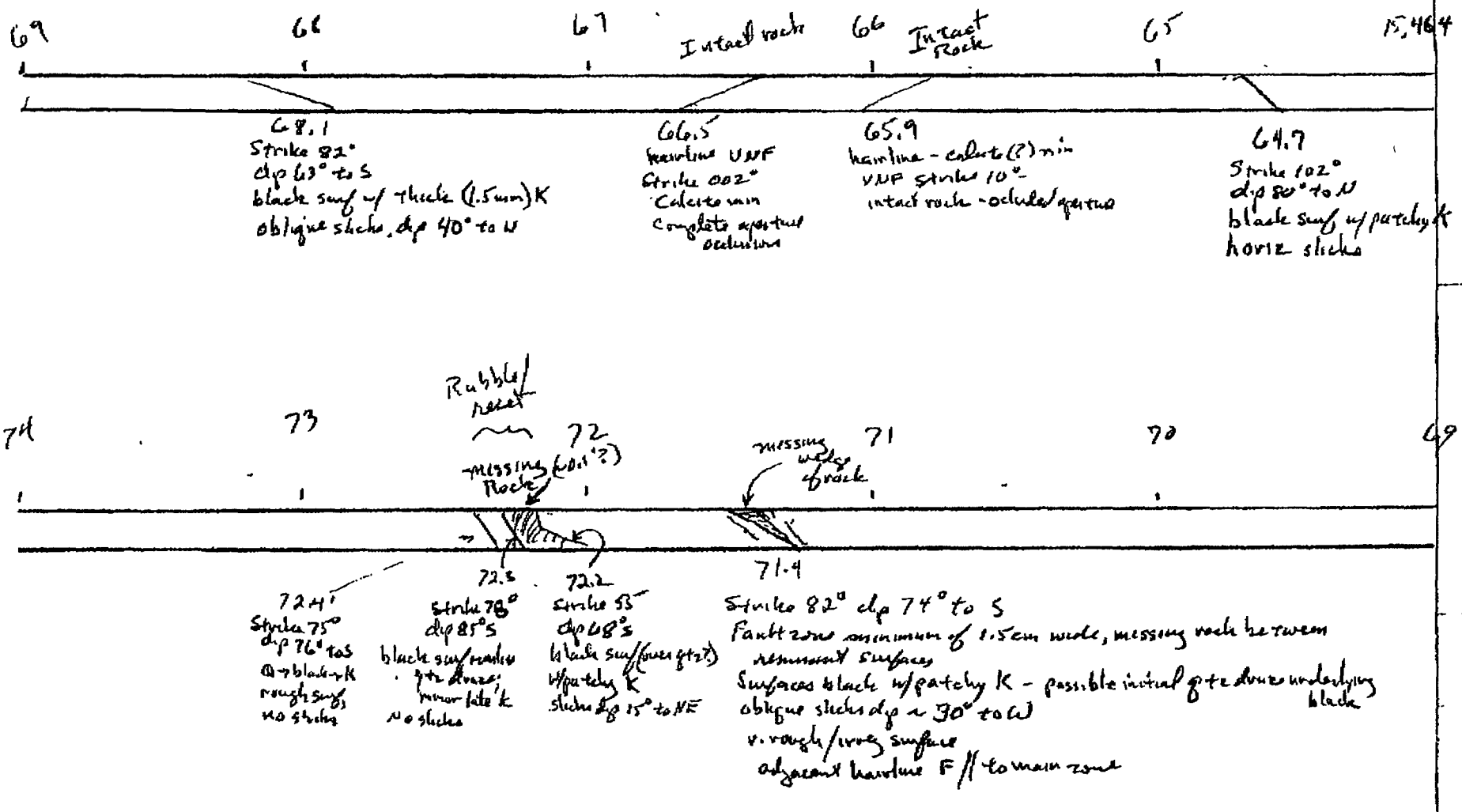




Post coring
wellbore survey
deviation 84.9°
azimuth 39.8° to
40.1°

1/18/99
Rock Island Unit #4-11, W/O
Sweetwater County, WY

Azimuth 40° Deviation 88°

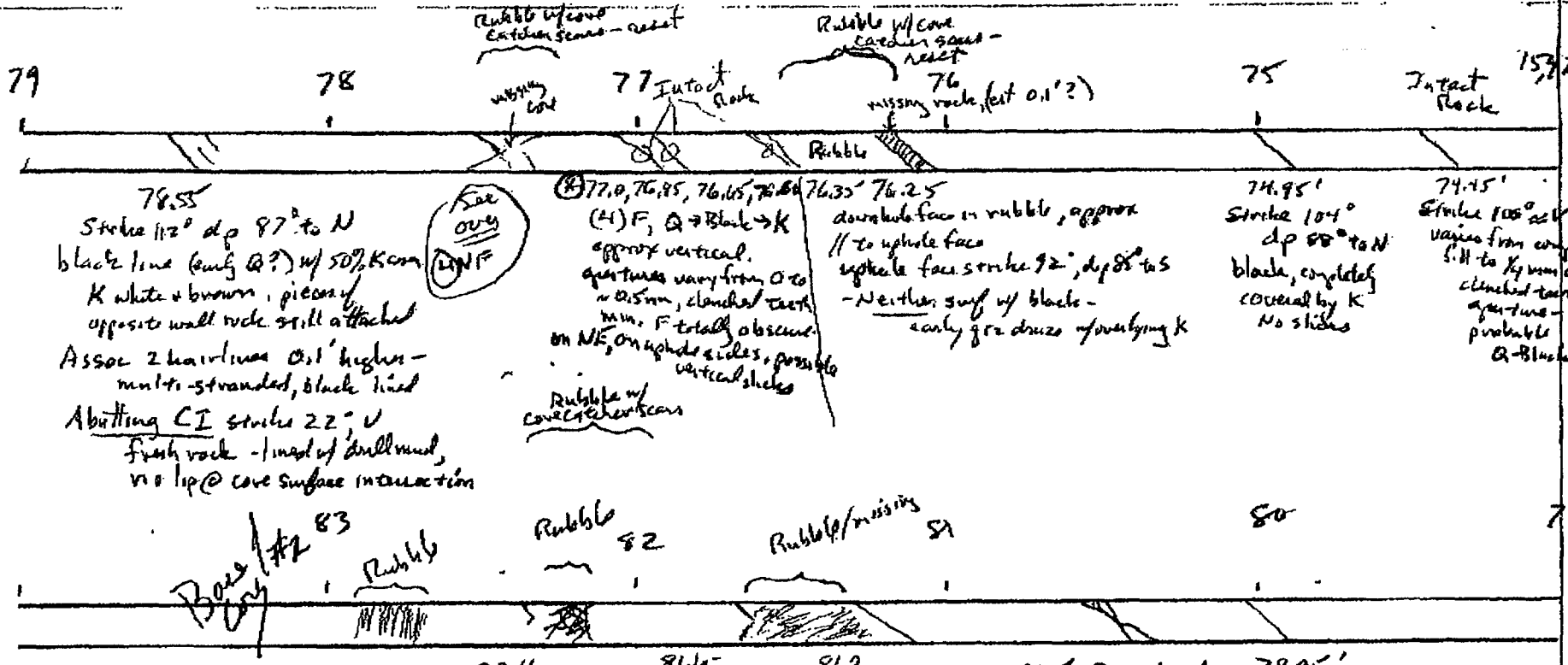


1/18/99

Rock Island Unit #4-11, W/o

Sweetwater County, Wyo

Azimuth 40° Deviation 88°



78.55
Strike 112° dip 87° to N
black line (surf Q?) w/ 50% Kcoat
K white + brown, piece of opposite wall rock still attached
Assoc 2 hairlines 0.1' higher - multi-stranded, black lined
Abutting CI strike 22° V
fresh rock - lined w/ drill mud, no lip @ core surface intersection

Rubble w/ core catcher scars

77.0, 76.85, 76.65, 76.60 (H) F, Q → Black → K
approx vertical.
apertures vary from 0 to ~0.5mm, clenched teeth
mm. F totally obscured on NE, on uphole sides, possible vertical slicks

76.35' 76.25
downhole face in rubble, approx // to uphole face
uphole face strike 92°, dip 85° to S
- Neither surf w/ black - early Qtz druze w/ overlying K

74.95'
Strike 104°
dip 88° to N
black, completely covered by K
No slicks

74.75'
Strike 100° ± K
varies from complete fill to K w/ open, clenched teeth aperture - probable Q-Black-K

Fair core (DNF)

82.4
F strike 95°
dip 82° to S
No slicks
No Black
Qtz druze
V. small patches K

81.6 - Fracture surface on butt of core - incomplete: probably // to F at similar to F @ 81.3

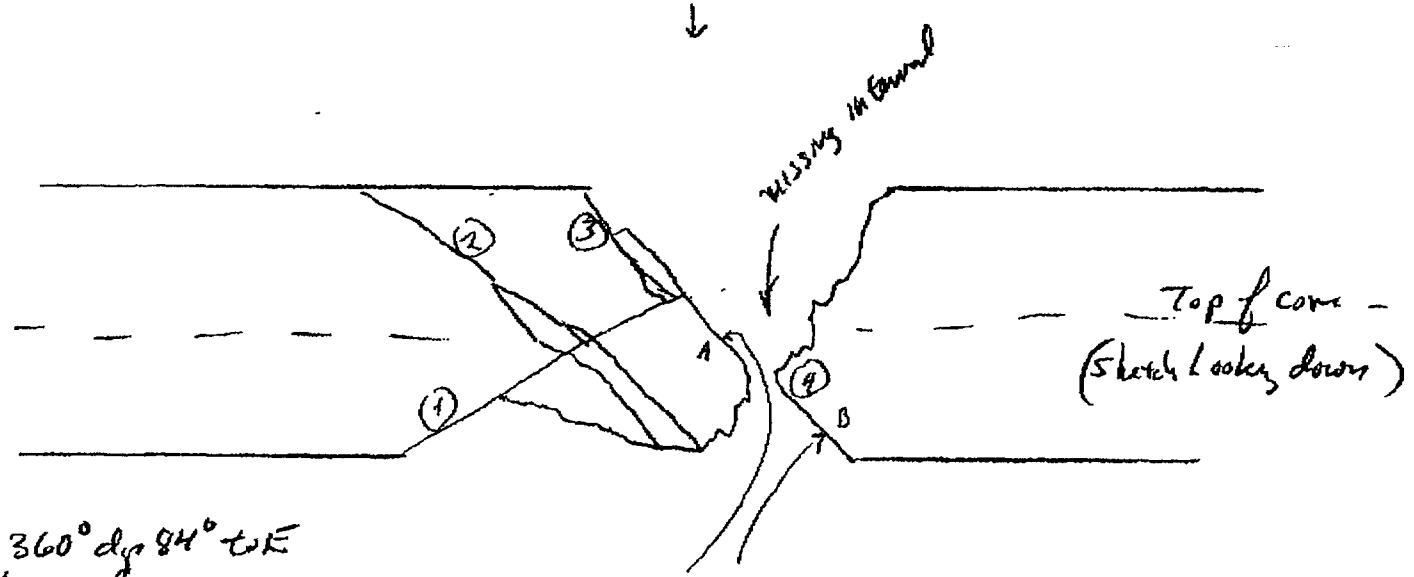
81.3
Strike 95° dip 88° to S
Rough, no slicks
early Qtz, black - spotty K cover

80.5' - F complex of 2-3 V NF, strikes 70-80° dip 90° - Rough surface w/o slicks - No Black; early large Qtz-XL (0.5mm) druze w/ possibly small patches K

79.95'
Strike 98° dip 88° to S
Rough surf / No Slicks
No Black
early Qtz druze w/ Patchy K

Fracture orientations from 15,476' to 77.5' and from 81.5' core if core are approximate, based only on alignment of hole - Bedding V. obscure this interval & Rubble zone breaks Scribe-line continuity

15,477.5'



NF(1) Strike 360° dip 84° to E
No black – only minor Qtz drags
w/ small K patches – no slicks

NF(2) - multi-stranded hairline F in intact rock, Strike 65°, approx vertical, black lining, minor K

NF(3) Black-lined F, multiple sub// surfaces showing inclined slicks (dip 45° to W)
Strike 70° dip 68° to S, probable Qtz drags, overlain by black, w/ local patches K

NF(4) Strike 85° dip Vertical
black-lined Rough surface, possible early Qtz drags, patches late K

Surface A shows oblique slicks, dip down to W ~30°
Whereas Surface B shows no slicks, therefore these are probably Not the same F, just pieces of 2// F

Age relationships not apparent – both F sets cross-cutting

fCf

TABLE 1: FRACTURES IN THE ROCK ISLAND UNIT #4-H CORE

	Depth* (ft MD)	Strike	Dip**	Mineralization***	Shear
1	15424 5	110	75N	B	horiz , RL
	mm-scale host-rock inclusions along fracture plane				
2	15426 55	85	83N	B, K	horiz
	Fracture consists of two or more sub-parallel strands				
3	15427 5	108	85N	B, thick (1mm) K	faint horiz
4	15429 25	92	77	B, small patches K	none
5	15429 4	90	V	B, probably other	unknown
	Rock is intact across fracture dip, shear, and mineralization components unknown Minor splays on either side of the fracture				
	---No fractures are present in the 16+ft interval between 15429 4 and 15446 25---				
6	15446 25	108	80N	B, K patches	Oblique slicks, dip 40 deg to W
7	15446 35	93	V	B	unknown
	Rock is intact across this fracture Intersects fracture #6				
8	15453 35	98	85	B, K	none
9	15454 1	100	90	B, patches K	faint horizontal
	Two parallel fractures 0 05 ft apart, with anastamosed fracture planes between the two bounding fractures Rock across this fracture would be intact except for the sawcut from breaking core barrel				
10	15459 3	85	V	B	unknown
	Two faint hairline fractures marked by black material on the surface of intact rock				
11	15459 4	85	82S	B, patchy K	none
	Fracture tightly mineralized such that patches of wall rock from opposite face adhere to the fracture				
12	15462 0	90	85S	B, patchy K	none
	Wedge of brecciuated wall rock 1-cm thck adjacent to part of the fracture				
13	15464 7	102	85	B, patchy K	horiz
14	15465 9^{+}	10	V	C	unknown
	hairline fracture in intact rock, aperture occluded by calcite				

15 15466 5+ 2 V C unknown
hairline fracture in intact rock, aperture occluded by calcite

16 15468 1 82 60S B, thick (1 5mm) K oblique, dip 40 to W, RL

17 15471 4 82 69S Q, B, patchy K oblique, dip 30 to W
Two non-congruent fracture surfaces at this depth suggest that rock is missing between two fracture faces (estimate minimum 1 5 cm missing) This is the first good indication of quartz underlying the black material Several black-highlighted hairline fractures parallel the main fracture zone in the adjacent intact rock

18 15472 2 55 63S Q(?), B, K slicks dip 15 to NE, RL

19 15472 3 78 80S Q, B, K none

20 15472 4 75 71S Q, B, K none

21 15474,45 105 V Q, B, K unknown
Fracture is in intact rock, irregular remnant aperture of about 0 25 mm is present within the mineralization

22 15474 95 104 87S B, K none

23 15476 25 92 80S Q, K none
First fracture of the dominant set that is NOT covered with black material

24 15476 35 92 80S Q, K none
This fracture evident on mineralized pieces of rubble immediately below fracture number 23 similar mineralization and proximity suggest parallel orientation

25 15476 6 100 75S Q, B, K faint, possibly vertical

26 15476 65 90 V Q, B, K unknown

27 15476 85 100 V Q, B, K unknown

28 15477 0 95 V Q, B, K unknown
Fractures number 26, 27, 28 occur in intact rock Fractures are only apparent on the underside of the core, where they have obvious mineralization with 0 25-0 5 mm remnant irregular aperture

29 15477 5 85 V Q, B, patchy K none
Remnant of fracture face, poorly defined

30 15477 6 70 63S Q, B, patchy K oblique, dip 45 to W
Composite fracture of multiple, sub-parallel surfaces

31 15477 6[+] 360 84E Q, small patches K none
This fracture intersects two fractures of the dominant set, but both sets are crosscutting without evidence of interference as between younger-older sets

32 15477 65 65 V B, K unknown
Fracture in intact rock

33 15478 55 112 87S Q(?), B, K none
Pieces of opposing wall rock still attached across fracture plane Associated, parallel, black-lined hairline fractures occur in the intact rock immediately uphole

34 15479 35[+] 360 V unknown unknown
Hairline fracture in intact rock

35 15479 95 98 83S Q, K none
Rough surface without slicks and without black lining

36 15480 5 70-80 90 Q, small K none
Fracture complex of 2-3 strands, with large (0 5mm) quartz crystals but no black lining

37 15481 3 95 83S Q, B, K none

38 15481 6 95? V Q, B, K unknown
Small fracture surface on butt end of core, incomplete Probably similar to #37

39 15482 4 95 77S Q, K none

40 15483 0[(+)] ? ? C, K unknown
Mineralized fracture face in rubble Calcite suggests it may be part of the secondary fracture set

*fracture depth measured from its intersection with the top of core

**dip listed as "V" for near-vertical where not measurable exactly

***1 B = unidentified black substance, Q = quartz, K = kaolinite, C = calcite,
2 Listed in order of superposition, from fracture face out
3 Fine quartz druze may underlie most of the fractures of the dominant set, but is obscured by the black material

[+]Denotes fractures of the subordinate set

Subject:
Date: Thu, 21 Jan 1999 14 27 01 -0700
From: "Lorenz, John C" <jcloren@sandia gov>
To: "'(F H Lim)'" <f _h _lim@upr com>, "'(J G DeJarnett)'" <j _g _dejarnett@upr com>,
"'(L F Krystinik)'" <l _f _krystinik@upr com>,
"'THOMAS MROZ'" <THOMAS MROZ@fetc doe gov>,
"'Walck, Marianne'" <IMCEAMS-MAILHUB_MAILHUB_mcwalck@sandia gov>

Rock Island Core descrip.doc	**Name:** Rock Island Core descrip doc **Type:** Winword File (application/msword) **Encoding:** base64

January 25, 1999

To: Tom Mroz, USDOE
Frank Lim, UPRC

From: John Lorenz, SNL

Subject: Fractures in core # 3, Rock Island #4-H, Sweetwater Co., WY

SUMMARY

Almost as many natural fractures (36) occur in the 20.2 ft of core #3 as are present (40) in the 60 ft of cores #1 and 2, thus the fracture intensity in core #3 is nearly three times that found in the shallower cores. Although exciting in a scientific sense, this increase in fracture intensity occasions much grumbling on the part of the hardworking fracture analyst. Maximum length of unfractured core is 3.8 ft (compared to 16.9 ft in core #1), but minimum fracture spacing in all cores is less than an inch.

Fractures in core #3 are the same types (extension and reactivated/sheared extension), and have the same orientations (north-south and east-west respectively), as found in the earlier two cores. Better examples of the intersections of the two fracture sets in this core suggest that the north-south fractures are in fact the younger fracture set, as hypothesized earlier from less definitive data. The fractures have somewhat more variability in mineralization than noted in cores #1 and 2, although the basic sequence is the same. The east-west fracture set is typically mineralized with an early-formed, dark quartz druze, a black lining (tentatively identified by Tad Taylor at UP as black kaolinite), and a late, patchy to thick white to tan kaolinite layer. The younger, north-south fractures are mineralized with quartz druze having a larger and clearer crystal habit than that found on the east-west fractures, and locally with younger patches of calcite.

About a third of the fractures of the east-west set have been reactivated by right-lateral to oblique shear (primary shear would be found on all of the fractures of this set). The shear typically indicates that rock on the southern side of the fracture has moved westward and down relative to rock north of the fracture.

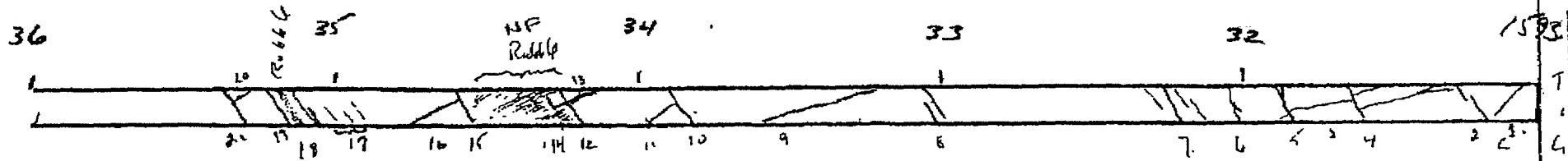
The preliminary interpretation is that the east-west fractures formed first, in response to overpressured conditions, and were reactivated later during local thrust faulting. The north-south extension fractures may be contemporaneous with reactivation of the first set, related to extension over the crest of the thrust-related flexure.

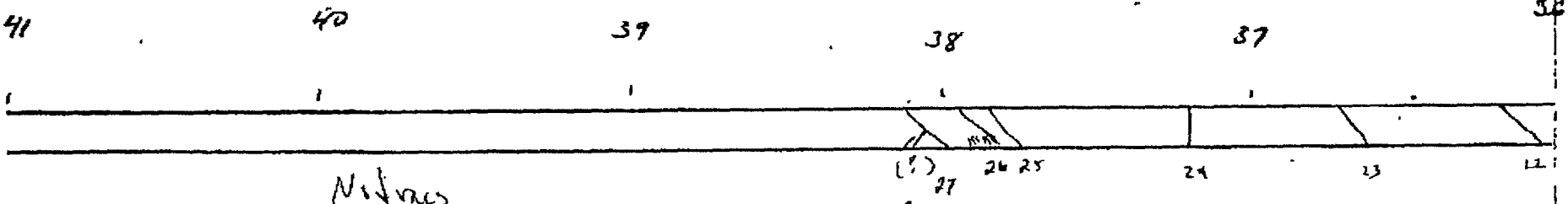
About half of the fractures of both sets have obvious remnant open aperture despite mineralization and should be good permeability pathways at virgin reservoir conditions No coring-induced fractures have been found in these horizontal cores, thus the in situ stress orientations and magnitudes, which should have important effects on the conductivity of the fractures, are unknown. Plugs are being taken, as with the earlier cores, to assess the permeability along and across the faces of the different fracture sets.

1/24/99
Rock Island Unit #4-H, Sweetwater County, WYO

Sketches looking down on top of core

Azimuth 35° Deviation 85°

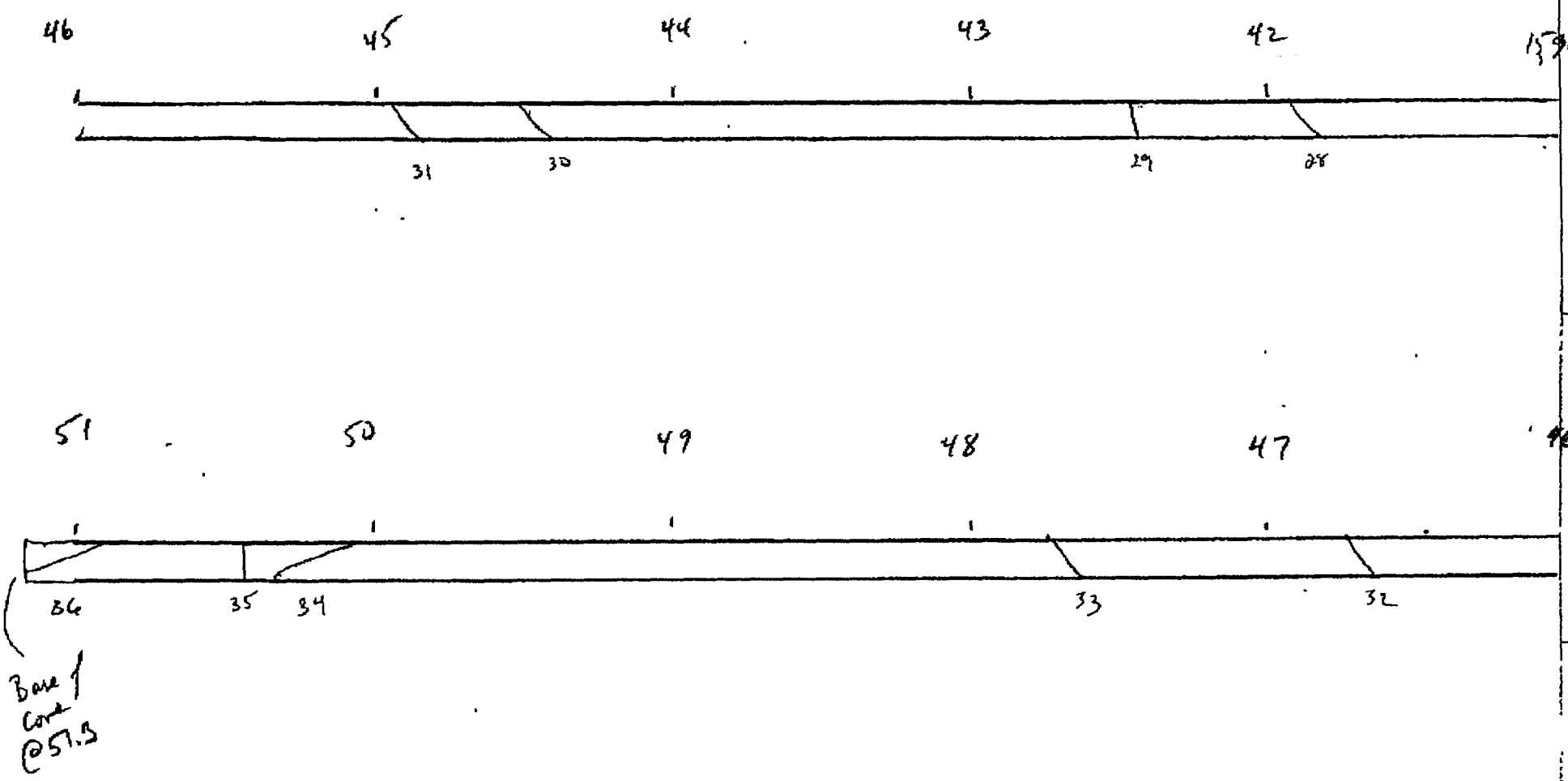




depth
strike
dip
slide
mm
n/f

Core Run #3 1/24/99 Rock Island Unit #4-H Sweetwater County, WYO

Azimuth 35 Deviation 85°



Base of core @ 57.5

depth
strike
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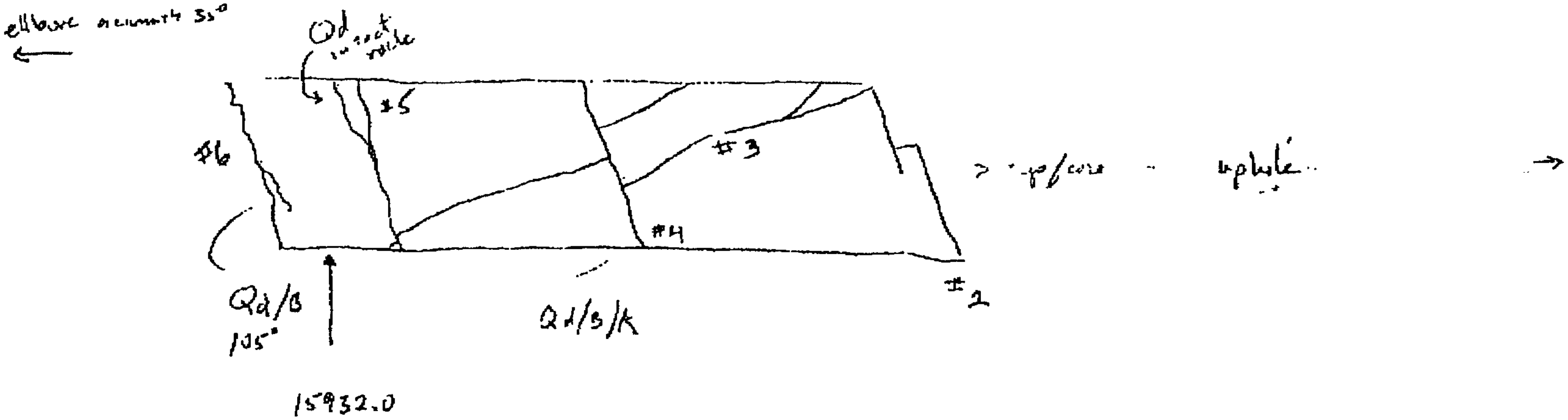
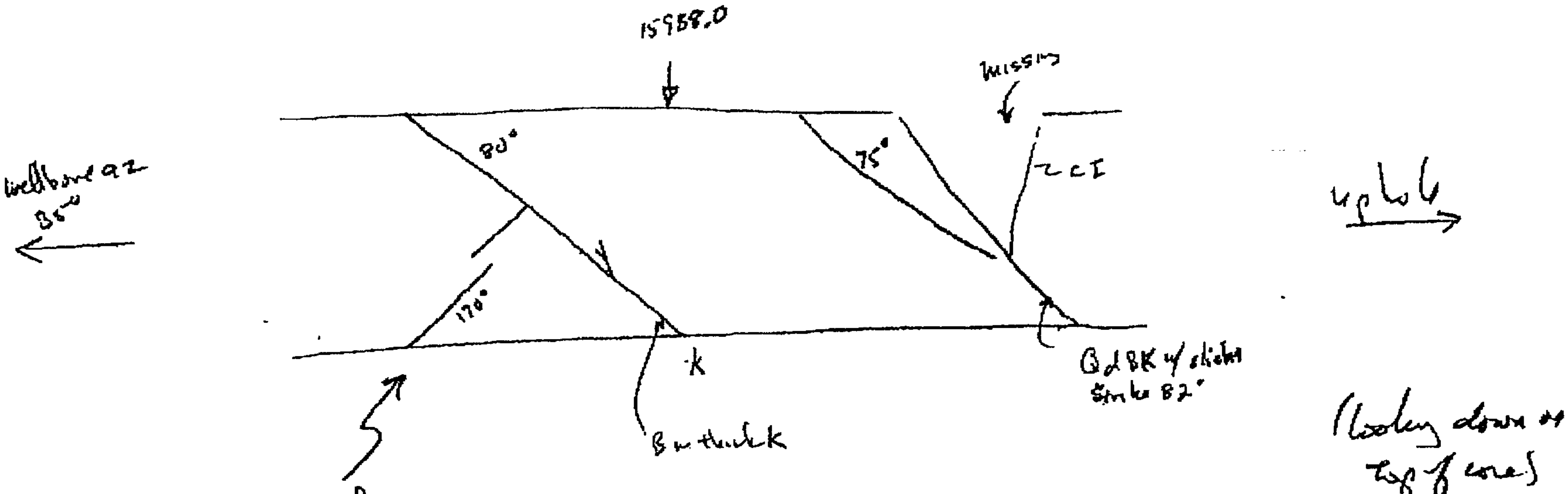
R/L





these fracs are
very planar, were only obvious
after core was hit with hammer 0.7' below to
break core. Rock was intact before hammer blow, but
frac planes show no interaction w/ core surface. However, rock
on on frac surface is unmineralized and appears identical to
fresh broken rock surfaces other than planarity

TABLE 1: FRACTURES IN CORE #3 FROM THE ROCK ISLAND UNIT #4-H

	Depth* (ft MD)	Strike	Dip**	Mineralization	***	Shear
1.	15931.2(+)	175	86E	Q, patchy C		none
	Fracture is 0.2 ft below top of core: core piece above frac broke off, was turned on twice					
2.	15931 3 100	88S		Q, B		none
	Irregular fracture plane composed of 2-3 sub-parallel fractures up to 1 mm wide each					
3.	15931 8(+)	10	77W	Q		none
	Irregular rough fracture plane that terminates/offsets at fracture #4 showing that #3 is younger					
4.	15931.8 103	88S		B, patchy K		none
5	15931.9 112	V		Q		unknown
	Fracture with obvious remnant porosity within mineralization, in intact rock					
6	15932.05 105	82N		Q (no B)		none
7.	15932.35	88	88N	Q, B		none
	Several sub-parallel black hairline fractures in adjacent rock					
8.	15933.1 100	86S		Q, B, K		none
9	15933.45(+)	178	V	C		unknown
	Fracture in intact rock					
10.	15933.9 85	88E		B, K		none
11.	15933.9(+)	148	67N	Q		none
12.	15934.2 96	87S		B		unknown
	Hairline, black-highlighted fracture in intact rock					
13	15934.3(+)	12	V	Q		none
14.	15934.35	E-W	V	Q, B		dip 40 deg to W
	Multiple fracture surfaces with multiple orientations in rubble zone. Remnant fracture faces have large (o.5 mm) quartz druze crystals in fracture-face hollows, slicks on asperities.					

(Table 1, continued)

	Depth* (ft MD)	Strike	Dip**	Mineralization	***	Shear
15	15934.4	80	70N	Q, B		none
	Smokey quartz druze crystals in fracture-face hollows					
16	15934.7(+)	2	82W	Q		none
17.	15934.95	90-95	V	Q		unknown
	-35.1	Irregular fracture surfaces in intact rock (associated with #18?)				
18.	15935.2	82	74W	Q, B, K		dip 70 deg to E
	1-cm wide shear zone with 3-4 fractures: quartz in pockets (no breccia). Thin rubble zone apparently separates the disconnected face of the last fracture from the open fracture face of #19. Poor fit, associated rubble, and different trends in fracture-face slicks suggest that #18 and #19 are not the same fracture although they are sub-parallel.					
19.	15935.3	75	85W	Q, B, K		dip 50 deg to W
20.	15935.5(+)	175	60E	Q, B		none
21.	15935.5	88	70S	Q, B, K		faint, possibly vertical
22.	15936 15	79	77S	B, K		none
23.	15936.7	95	V	B		unknown
	Irregular remnant aperture within fracture-face mineralization in intact rock					
24.	15937.25	115	88S	Q, K (no B?)		none
25.	15937.8	87	83S	Q, B, K, C		dip 20 deg to W
26.	15937.9	75	V	Q, B, K		unknown
	Fractures # 26 &27 are hairline fractures in intact rock, assumed to be similar to #25					
27.	15938.1	75	V	Q, B, K		unknown
	Several parallel planar features, striking 170 deg., developed at this depth when the core was hit with a hammer a foot away (the rock appeared to be intact before the hammer strike). These planes show no mineralization, suggesting induced, but also show no tendency to change direction or "lip" at the core surface as do most induced fractures.					
28.	15941.9	92	82S	Q, B, K		faint, dip 50 deg to W
	Several associated black, nearby hairline fractures in the adjacent rock					

(Table 1, continued)

	Depth* (ft MD)	Strike	Dip**	Mineralization	***	Shear
29.	15942.45	95	V	B		unknown
	Irregular/complex mare's tails along a black-highlighted, hairline fracture					
30.	15944.55	92	70N	Q, B, patchy K		dip 50 deg to W, RL
31.	15944.9	102	62N	Q, B, K		faint (obsc'd by thick K), dip 50 W
	Associated parallel faint, black, hairline fractures within core 0.2 ft below					
32.	15946.7	104	82N	(prob. Q), B, thick K		none
33.	15947.7	92	88N	(prob Q), B, thick K		faint horiz, RL
34.	15950.25(+)	5	V	C		unknown
	0.5 mm wide calcite-filled aperture with local remnant porosity in intact rock					
35.	15950.4	125	86NE	Q, B, K		dip 40 deg to W
36	15951.1(+)	18	84W	Q with scattered ½ cm patches late C		none

*fracture depth measured from its intersection with the top of core

**dip listed as "V" for near-vertical where not measurable exactly (as in intact core)

***1. B = unidentified black substance; Q = quartz, K = kaolinite, C = calcite;
2 Listed in order of superposition, from fracture face out
3. Fine quartz druze may underlie most of the fractures of the dominant set, but is obscured by the black material

+Denotes fractures of the subordinate set

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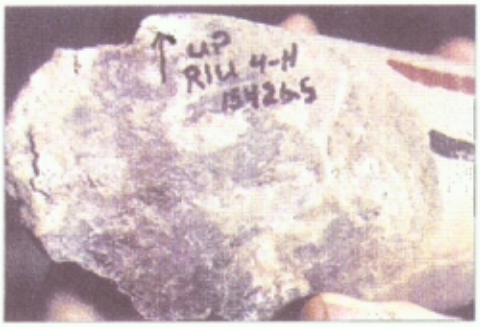

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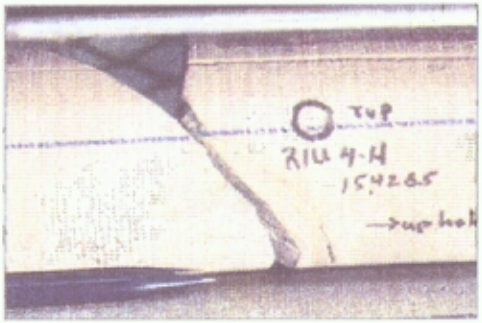

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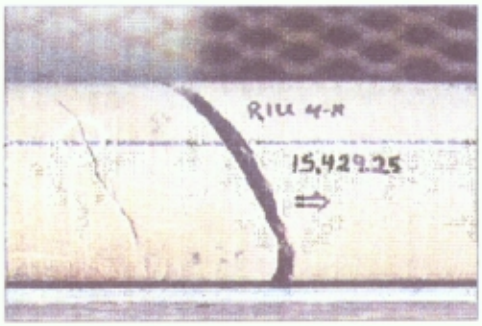

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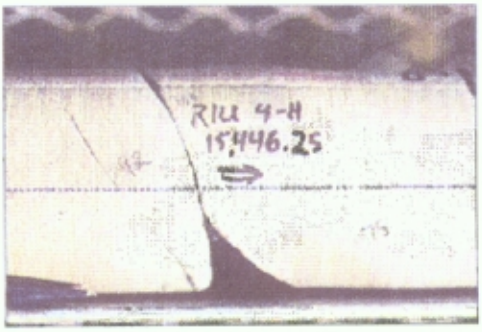

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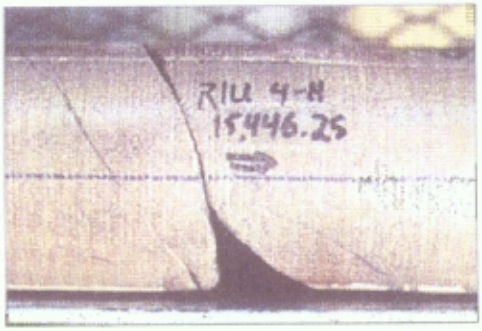

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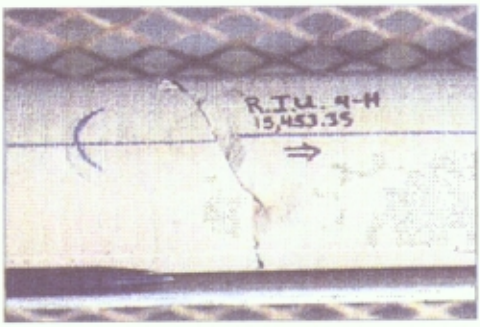

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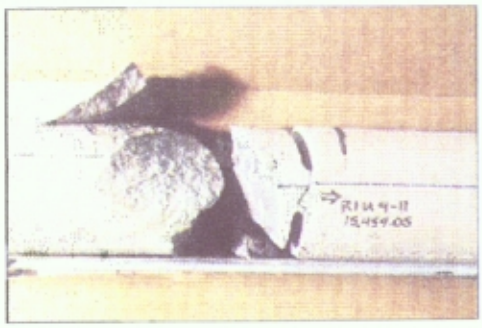

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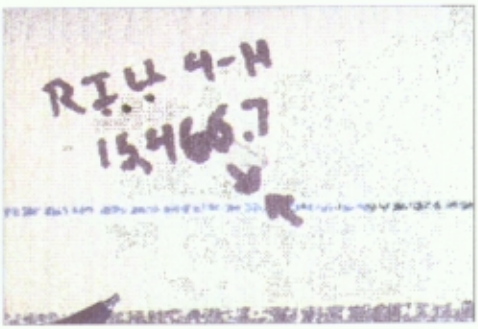

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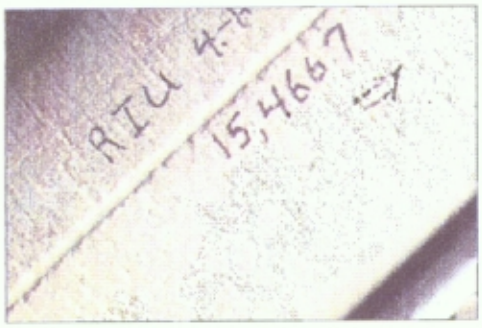

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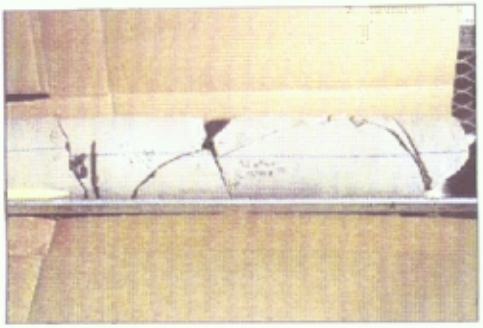

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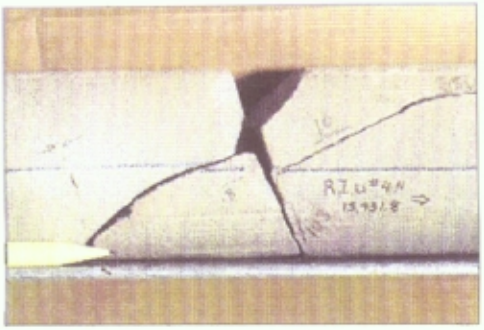

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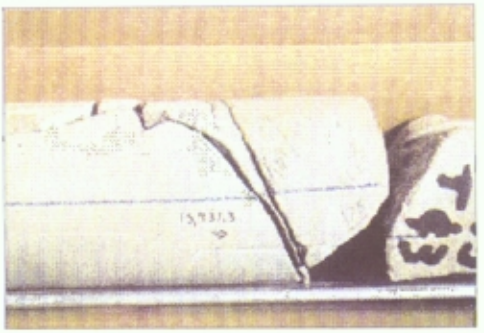

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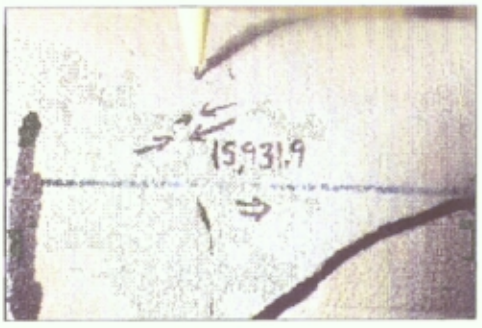

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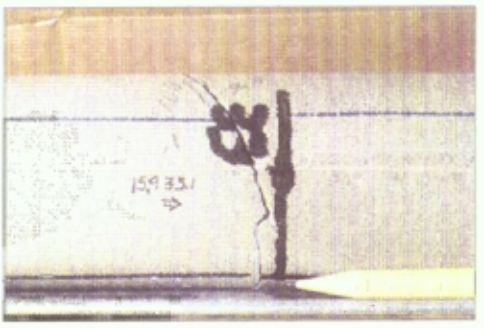

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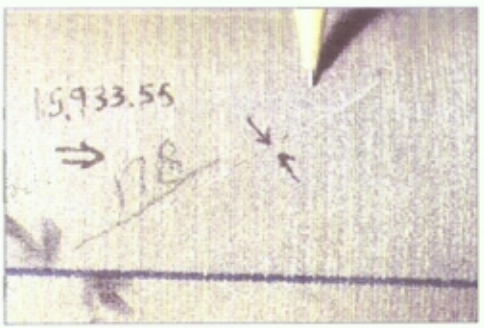

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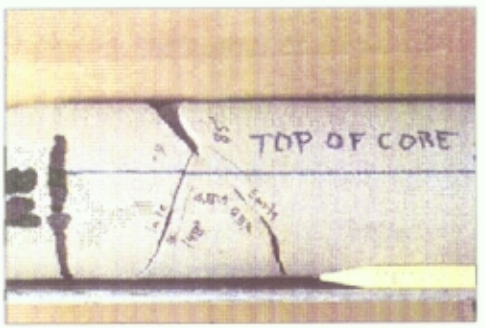

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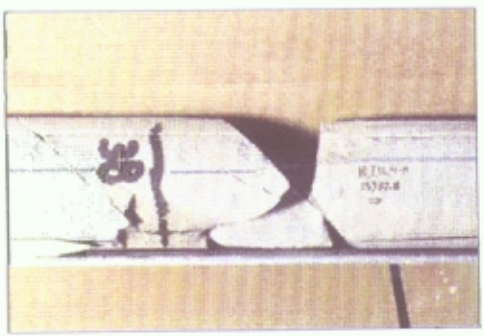

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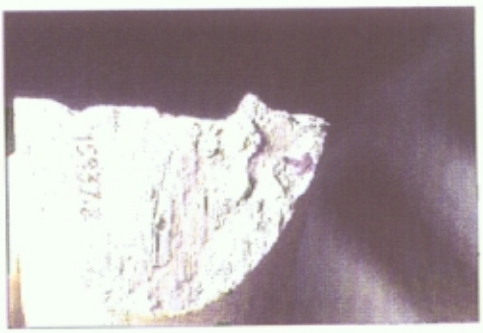

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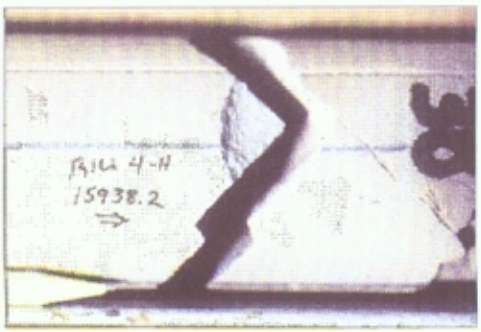

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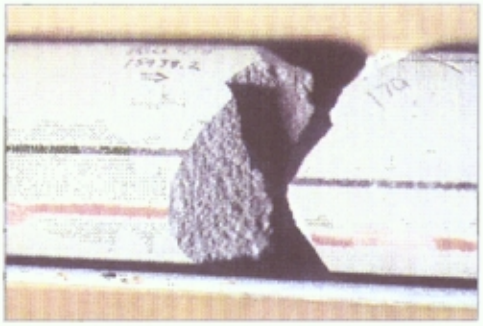

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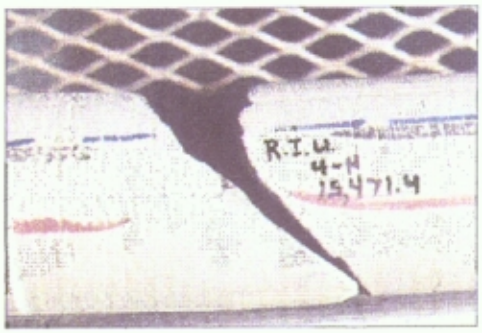

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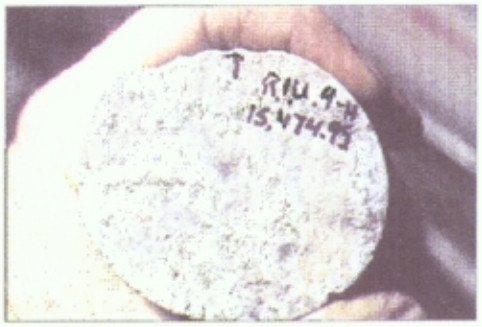

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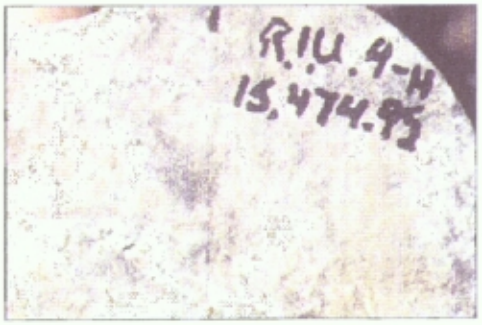

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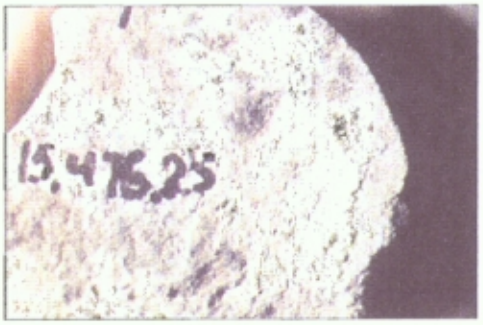

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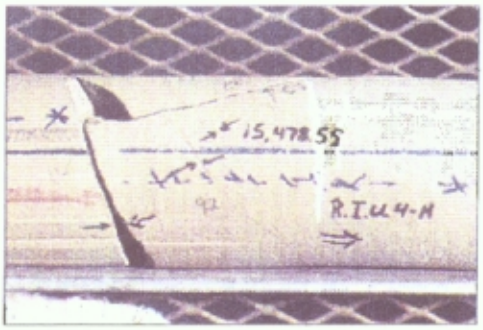

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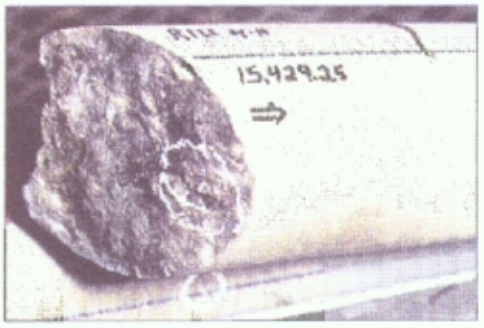

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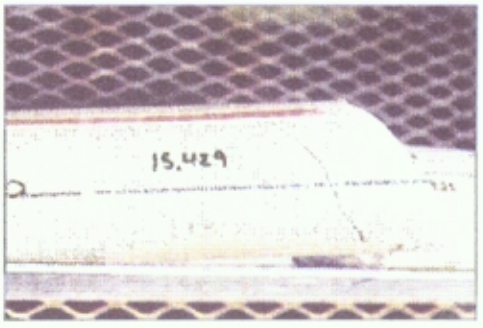

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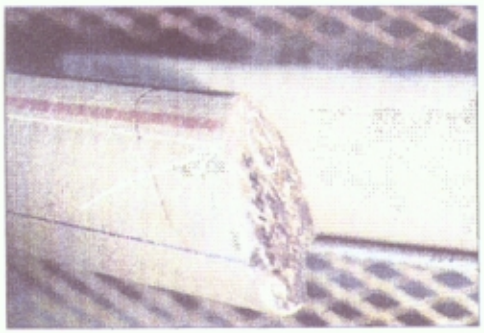

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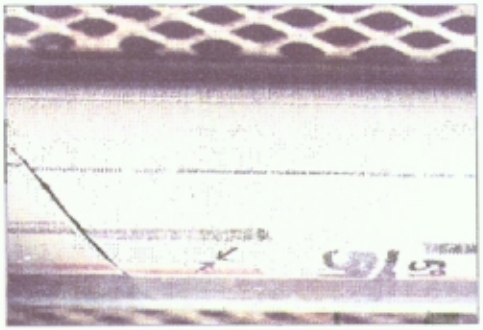

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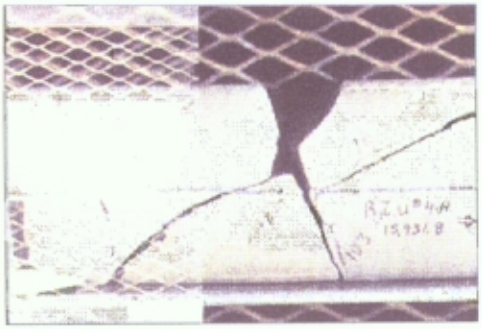

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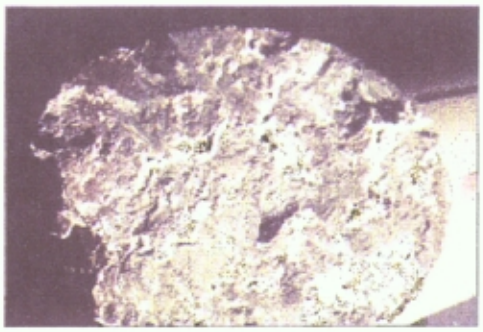

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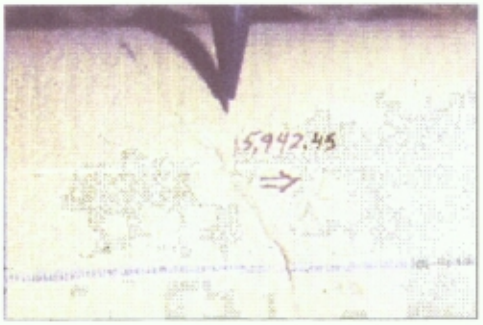
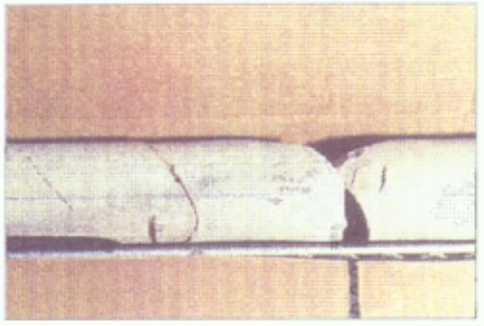
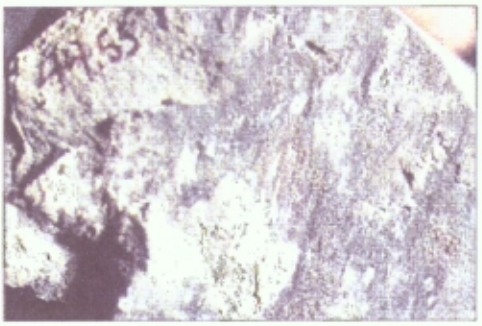


5: 49686_05.sfw



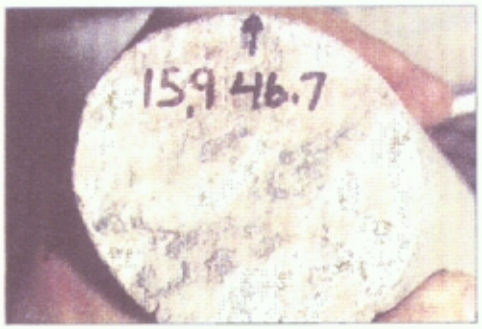
6: 49686_06.sfw

7: 49686_07.sfw



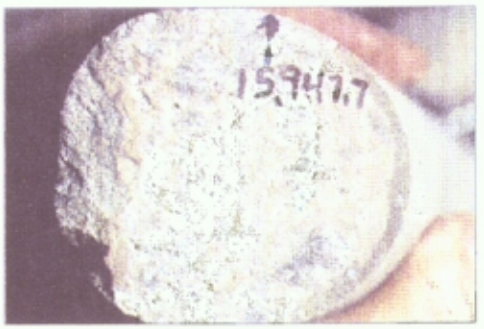
8: 49686_08.sfw

9: 49686_09.sfw



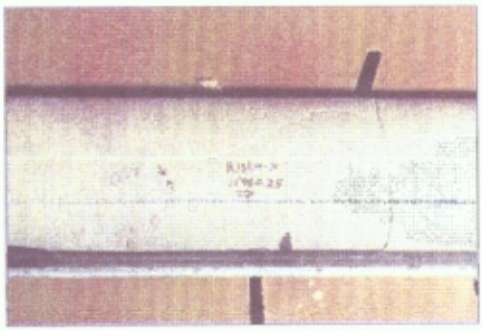
10: 49686_10.sfw

11: 49686_11.sfw

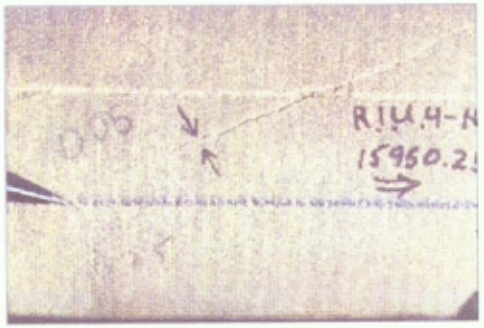


12: 49686_12.sfw

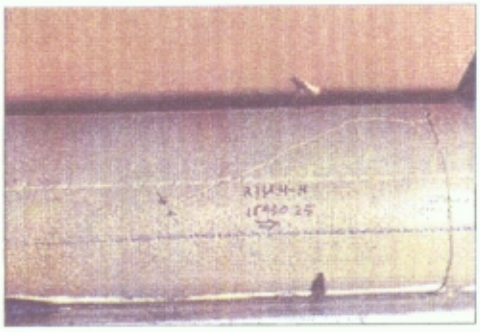
13: 49686_13.sfw



14: 49686_14.sfw



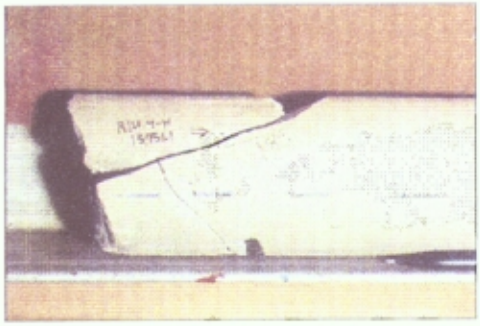
15: 49686_15.sfw



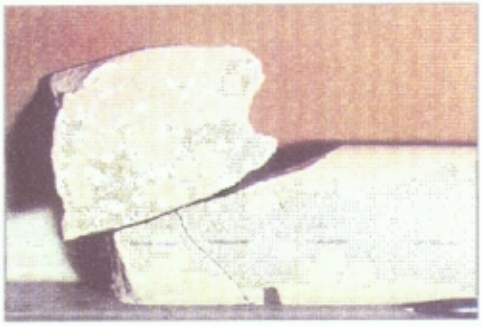
16: 49686_16.sfw

17: 49686_17.sfw

18: 49686_18.sfw



19: 49686_19.sfw



20: 49686_20.sfw

21: 49686_21.sfw