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MEMORANDUM FOR: Philip S. Justus, Acting Chief
Geotechnical Branch
Division of Waste Management

FROM: Julia Corrado
Geology/Geophysics Section
Geotechnical Branch
Division of Waste Management

SUBJECT: TRIP REPORT FOR THE GSA FIELD TRIP AND ANNUAL MEETING, SAN ANTONIO, TX, NOVEMBER 7-13, 1986

DATE: 87/02/ FEB 04 1987

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Enclosed is the Trip Report for the Geological Society of America (GSA) Field Trip "Geology and Geomorphology of the Rolling Plains, Texas Panhandle," November 7-9, 1986 and the GSA Annual Meeting, San Antonio, Texas, November 10-13, 1986.

This Trip Report constitutes "Enclosure A" of the December 11, 1986 memorandum from J. Corrado, J. Forstrom, W. Kelly, and K. McConnell to Philip S. Justus.

Julia Corrado
Geology/Geophysics Section
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Enclosure:
As Stated

ENCLOSURE A - TRIP REPORT

Julia A. Corrado
Geology/Geophysics Section, WMGT

On November 7, 1986, I travelled to Lubbock, TX to take part in the field trip "Quaternary Geology and Geomorphology of the Rolling Plains, Texas Panhandle" sponsored by the Geological Society of America (GSA) and the Texas Bureau of Economic Geology (TBEG), a part of the University of Texas at Austin. On November 9, 1986, I travelled from Lubbock, TX to San Antonio, TX to attend the annual meeting of the GSA. A summary of these two activities and their significance to the NRC high-level waste management program follows:

I. Quaternary Geology and Geomorphology of the Rolling Plains, Texas Panhandle

Friday, November 7

During the landing approach into Amarillo, TX numerous playa lakes were visible from the air. This sight was unusual in that normally dry playas were filled due to rainfall during 1986 that has greatly exceeded the average for the Southern High Plains. (Average yearly rainfall is twenty inches at the Caprock Escarpment. As of November 1, 1986 the High Plains had received more than thirty-six inches.)

Playa formation is poorly understood. The possibility that playas are related to salt dissolution is an issue in siting a HLW repository in Deaf Smith County. Alternate hypotheses have been proposed. One such hypothesis is that playas are not really round but are actually trigonal in

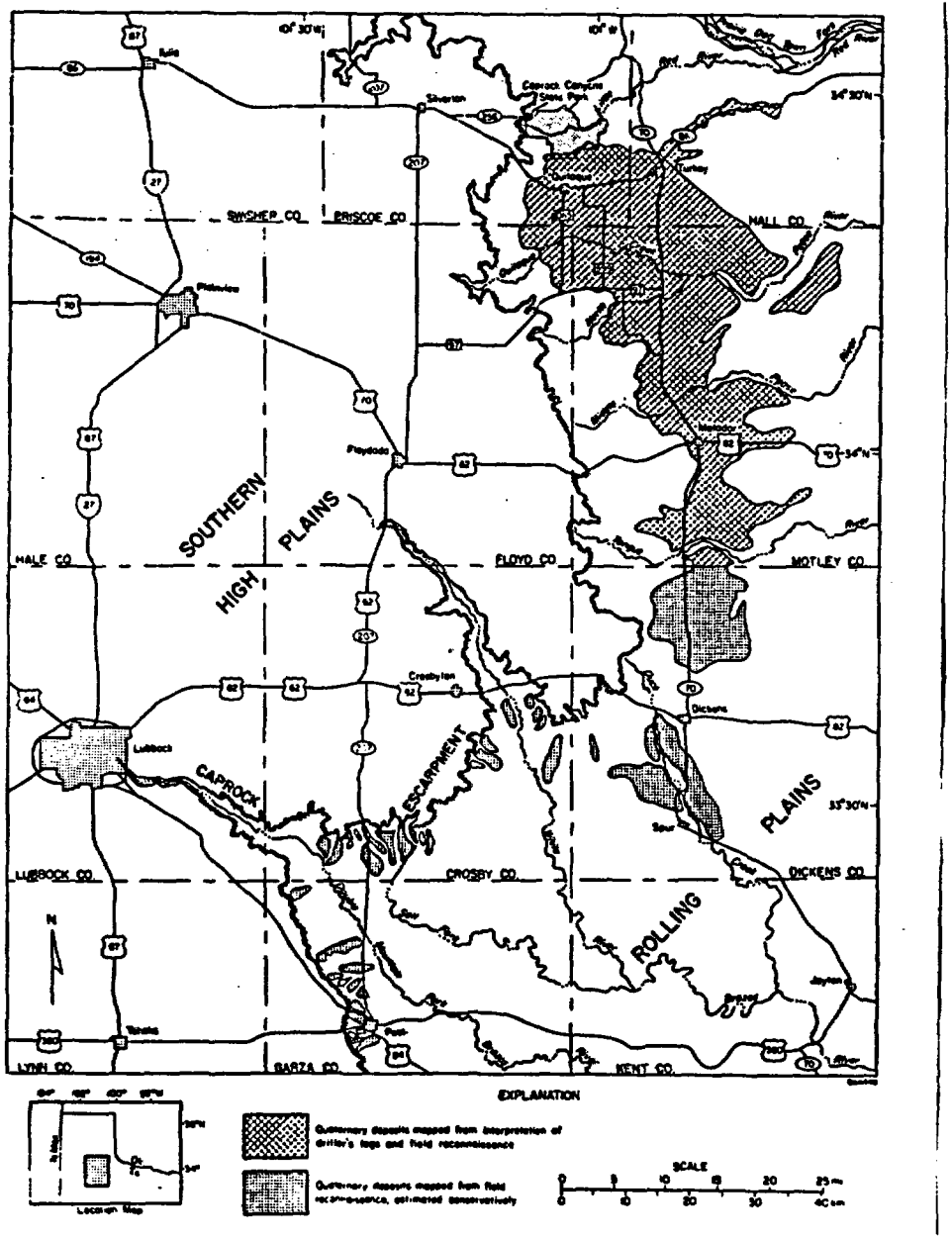
shape and result from aeolian deflation. (Active aeolian deflation in the High Plains is so severe that the Highway Dept. has to maintain plows to move silt and fine sands from paved roads.)

Other hypotheses for playa formation include structural (fracture) controlled dissolution and collapse. Although many playas appear to line up in straight rows, according to T. Gustavson of the Texas Bureau of Economic Geology (TBEG), no fractures have been observed in the Tertiary Ogallala and Quaternary Blackwater Draw Formations. This confounds the theory that fractures control the alignment of playas.

The field trip commenced at 5:00 p.m. in the Lubbock, TX airport where participants were met by Tom Gustavson, Christopher Caran, Robert Baumgardner, and Ed Collins of the TBEG who were leading the trip. Tom Gustavson and Ed Collins later gave presentations on regional geology and on gypsum-filled extension fractures in the Upper Permian strata of the Western Rolling Plains.

Geology of the Western Rolling Plains, Texas Panhandle

The field trip was focused on geomorphic features and outcrops in Brisco and Hall Counties, within approximately ten miles of the Eastern Caprock Escarpment of the Southern High Plains (Fig. 1). In this part of the Rolling Plains, the Upper Permian Whitehorse Group and Quartermaster Formation are surficial equivalents of the Salado/Tansill and Dewey Lake Formations and are overlain by thin quaternary sedimentary sequences, where not removed by headwater erosion of Little Red and North Pease Rivers (Fig. 2).


SWISHER CO
BRISCOE CO
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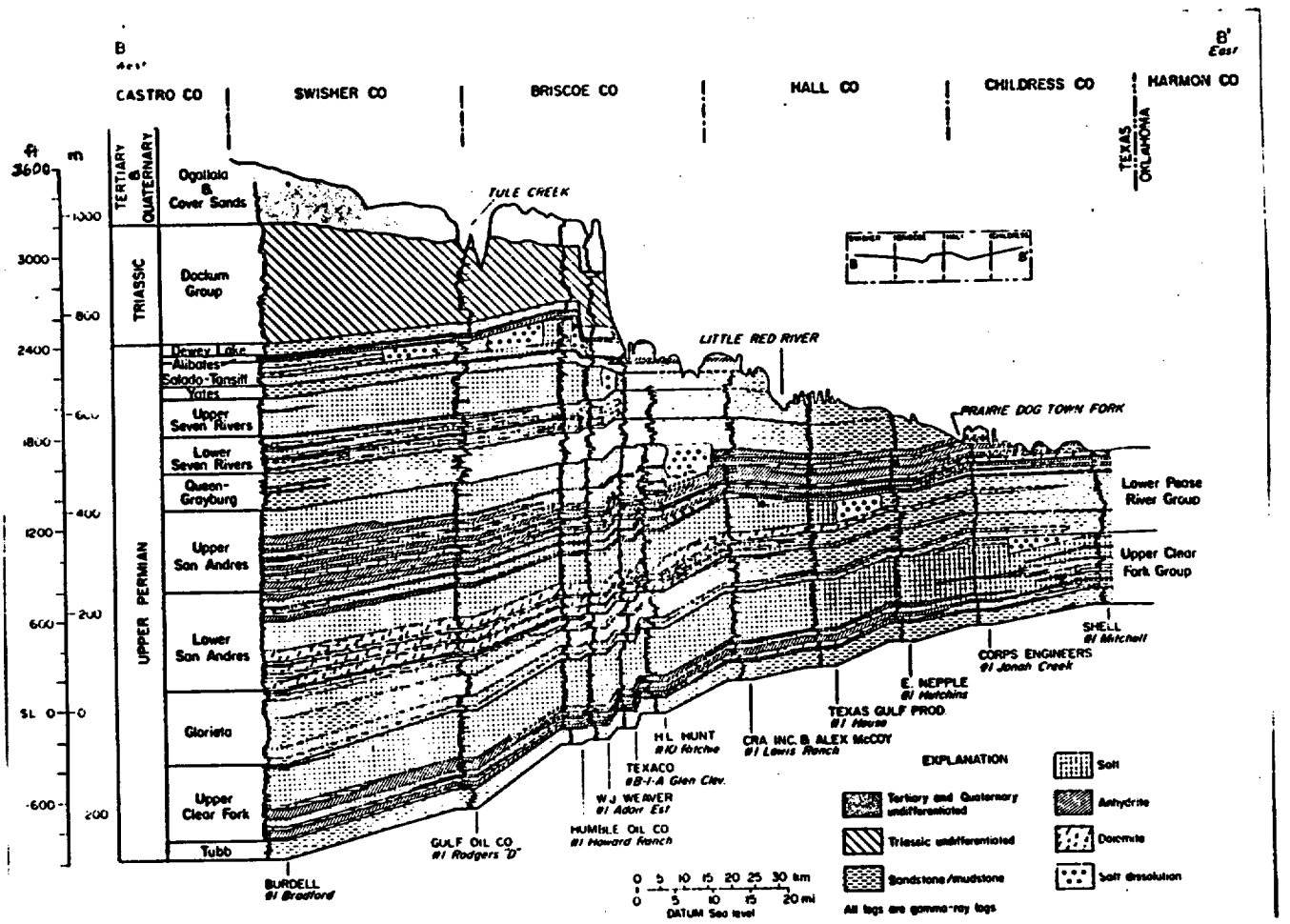
HALE CO
FLOYD CO
MOTLEY CO
LUBBOCK CO
CROSBY CO
DICKENS CO
LYNN CO
GARZA CO
KENT CO
SOUTHERN HIGH PLAINS
CAPROCK ESCARPMENT
ROLLING PLAINS
Plainview
Floydada
Lubbock
Crosbyton
Dickens
Spur
Post
Tahoka
N
EXPLANATION
SCALE

Figure 1


B
West
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CASTRO CO
SWISHER CO
BRISCOE CO
HALL CO
CHILDRESS CO
HARMON CO
TEXAS
OKLAHOMA
ft
m
3600
3000
2400
1800
1200
600
SL 0
-600
1000
800
600
400
200
0
200
TERTIARY & QUATERNARY
TRIASSIC
UPPER PERMIAN
Ogallala & Cover Sands
Dockum Group
Dewey Lake
Alibates
Salado-Tansill
Yates
Upper Seven Rivers
Lower Seven Rivers
Queen-Grayburg
Upper San Andres
Lower San Andres
Glorieta
Upper Clear Fork
Tubb
TULE CREEK
LITTLE RED RIVER
PRAIRIE DOG TOWN FORK
Lower Pease River Group
Upper Clear Fork Group
BURDELL
#1 Bradford
GULF OIL CO
#1 Rodgers "D"
HUMBLE OIL CO
#1 Howard Ranch
W J WEAVER
#1 Adair Est
TEXACO
#B-1-A Glen Clev.
H L HUNT
#10 Fritche
CRA INC. & ALEX McCOY
#1 Lewis Ranch
TEXAS GULF PROD
#1 Abuse
E. NEPPLE
#1 Hutchins
CORPS ENGINEERS
#1 Jonah Creek
SHELL
#1 Mitchell
EXPLANATION
Tertiary and Quaternary undifferentiated
Triassic undifferentiated
Sandstone/mudstone
Salt
Anhydrite
Dolomite
Salt dissolution
All logs are gamma-ray logs
0 5 10 15 20 25 30 km
0 5 10 15 20 mi
DATUM Sea level

Figure 2

Geomorphology and deformation of Quaternary deposits in the Western Rolling Plains has been controlled largely by dissolution of Permian bedded salt. Collapse of units overlying dissolution zones has been active during the Quaternary and possibly as recently as the Holocene. Present day salt dissolution is evidenced by mean annual solute loads in the Prairie Dog Town Fork, Little Red River, in excess of 1 million metric tons of dissolved solids per year of which chloride makes up 387,000 tons.

T. Gustavson does not consider dissolution in the Southern High Plains to be as catastrophic as in the Rolling Plains where salt dissolution is evident from structural deformation, i.e., fracturing in Permian clastic sedimentary units, breccia pipes, and Quaternary filled (closed) basins and depressions. The zone of catastrophic dissolution is parallel to the Caprock Escarpment at the western edge of the Rolling Plains and is characterized by re-entrants which are joint-controlled. Rates of escarpment retreat calculated from stream solute analysis range from 110 to 180 m/1,000-year, but this estimate assumes uniform retreat. Recent evidence suggests that mass movements (i.e., landslides, rock falls) after heavy rains may have a strong effect on escarpment retreat. Joint-controlled re-entrants and localized jointing in Southern High Plains may result in localized dissolution of Permian salt. However, it was suggested by T. Gustavson that the most active dissolution occurs where horizontal bedded salt turns upward along the flanks of the basin.

Gypsum-Filled Extension Fractures

Dissolution of Permian salt and subsequent vertical displacement and collapse of overlying strata resulted in fracture deformation of thinly bedded Upper Permian shale, siltstone, and sandstone of the Whitehorse Group. The relatively massive sandstones and shales of the overlying Quartermaster Formation are largely undeformed (Fig. 3). In addition to extension fractures, small scale (less than 0.5m displacement) nontectonic normal and reverse faults are also present. Fibrous gypsum appears to

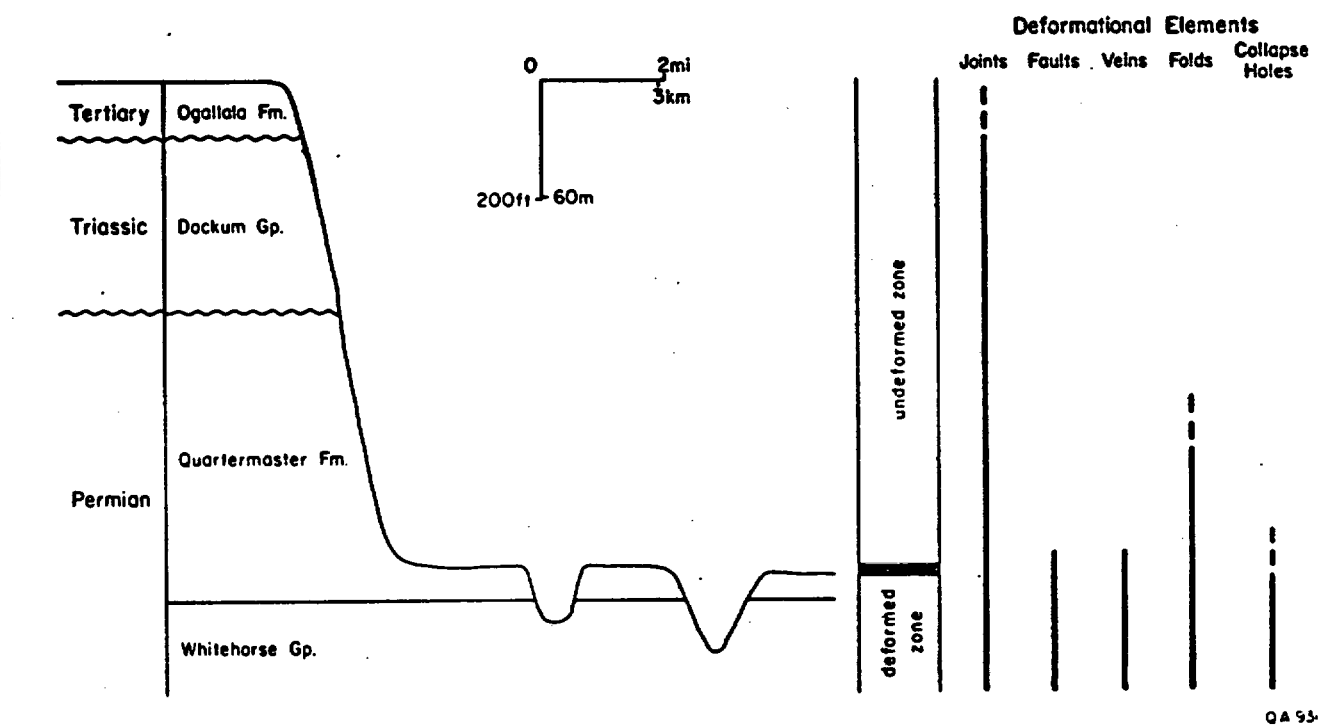
Deformational Elements
Joints
Faults
Veins
Folds
Collapse Holes
0
2mi
3km
200ft
60m
Tertiary
Ogallala Fm.
Triassic
Dockum Gp.
Permian
Quartermaster Fm.
Whitehorse Gp.
undeformed zone
deformed zone
QA 93

Figure 3

have grown outward from the direction of separation or extension, for example fibers are horizontal within vertical fractures. It is thought that the gypsum-filled fractures and faults fill joints that existed prior to salt dissolution and collapse and that these joints may have provided ground water conduits which enhanced salt dissolution.

Saturday, November 8

We began the day by driving from Plainview, TX northeast across the Southern High Plains, down the Caprock Escarpment onto the Rolling Plains. At the Caprock Escarpment, it was possible to see the Quaternary through Upper Permian units in outcrop. The Quaternary Blackwater Draw forms a relatively thin layer above Caprock Caliche of the Ogallala Fm. The Blackwater Draw is made up of sand, loam and clay loam and fines eastward from its source area in Pecos River Valley to west. Basically, the Blackwater Draw is a series of at least 7 aeolian soil horizons, of which at least one cycle of aeolian sedimentation and soil formation preceded the 1.4 my Gauje Ash. The upper limit on the age of the youngest soil horizon is based on a 40,000-50,000 years B.P. thermoluminescence date on a dune which buries it.

Beneath the Blackwater Draw, a resistant Caprock Caliche marks the top of the Ogallala Formation. The Miocene-Pliocene Ogallala varies in thickness from 200-400'. Lower portions are fluvial and lacustrine whereas upper portions are aeolian. The Ogallala aquifer is considered to be the most valuable natural resource in the region.

A resistant unit marks the base of the Ogallala, and contrasts with the thick (up to 800') Triassic Dockum Formation which consists of mostly fluvial and overbank deposits, consolidated sandstone, siltstone and conglomerates.

The contact between the Dockum and the massive red sandstones of the Upper Permian Dewey Lake (Quartermaster) Formation is difficult to identify.

The Quartermaster contains a marker bed, a light pink volcanic ash which has been dated at 256 ± 9 my establishing this part of the section as uppermost Permian.

In the Rolling Plains, the Upper Permian Quartermaster Formation is overlain by Quaternary sediments of the soon to be formally named "Lingos" Formation. The Lingos Formation is a coarse gravel at the base which fines upward and includes clayey lacustrine sediments. Lingos deposits have undergone subsidence-related collapse as recently as uppermost Pleistocene/Early Holocene. The Lingos abuts the Caprock Escarpment and thins out to the east. Its thickest section is 245' thick and occurs in a closed depression. Underlying the Quartermaster Formation, the Whitehorse Group is marked by gypsum-filled extension fractures. This marks the lowest part of the Permian section we were able to observe in the Caprock Escarpment and Rolling Plains. (Note: salt does not exist in outcrop; in situ salt must be observed in core.)

Stop 1 - As an illustration of the dynamic nature of landscape evolution in the Rolling Plains, T. Gustavson noted that between 1950 and 1970, 36 new sinkholes and 2 new depressions have been identified in a 100 mi^2 area of the Western Rolling Plains. At this stop, we observed evidence of an extensive continuous open earth fracture on the surface in the Upper Whitehorse Group (≈ Salado Fm). This feature opens and closes following heavy rains. It is thought that the rains flush out and fill these fractures from above, in a "clastic dike" type of mechanism.

Stop 2 - At this locality, dissolution-induced collapse/subsidence of Permian units is believed to have deformed overlying Quaternary deposits (Units 2 and 3, Fig. 4) whose age is uncertain. Frye and Leonard (1963) believed that the Uppermost Unit 1 was Illinoian, however, a radiocarbon age of 1235 ± 100 year BP was obtained on a sample from this unit collected 10m from the measured section. Ages on calcrete range from 18K

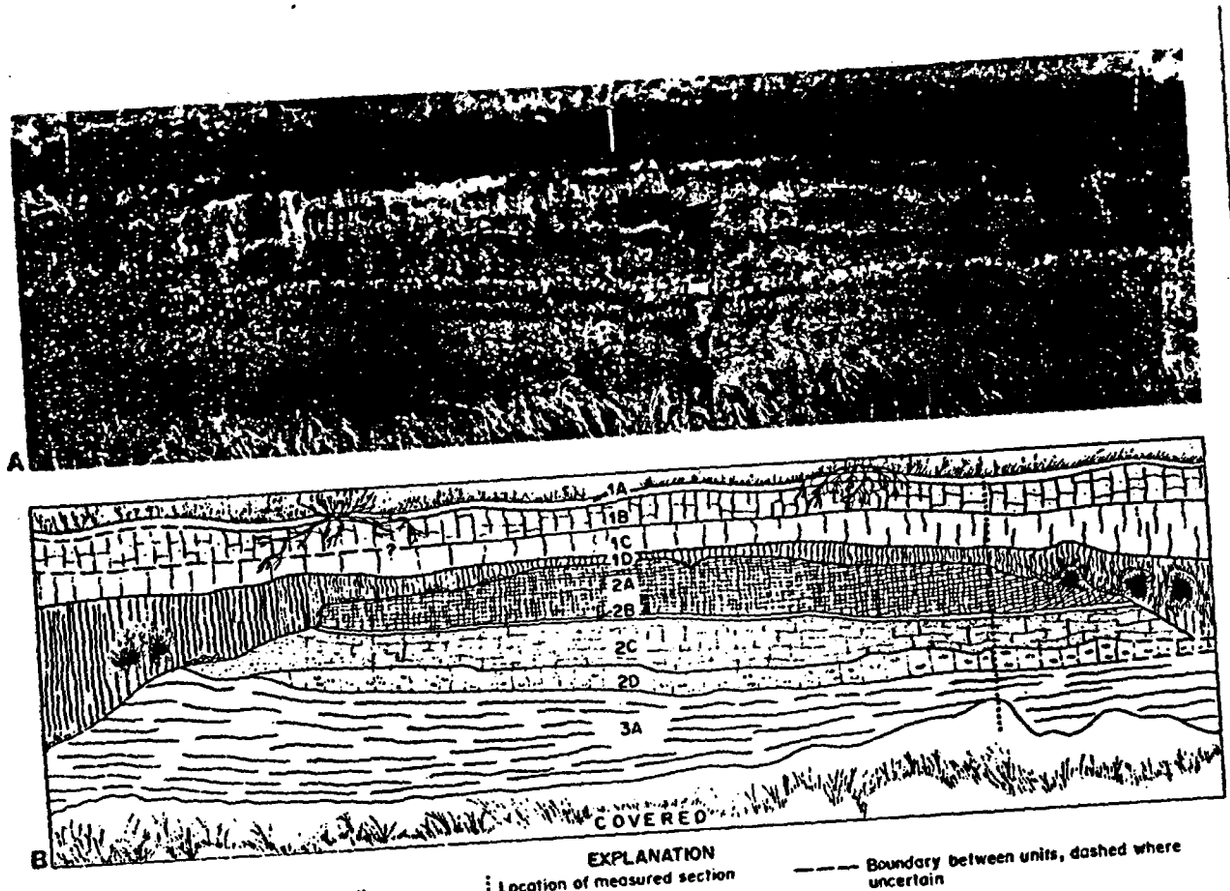
A
B
1A
1B
1C
1D
2A
2B
2C
2D
3A
COVERED
EXPLANATION
1A Unit described in measured section
Location of measured section
Boundary between units, dashed where uncertain

Figure 4

to 1K BP. C. Caran of TBEG believes that these deposits are much younger than Frye and Leonard assumed, and that landscape evolution is very rapid here, enhanced by active dissolution.

Stop 3 - These exposures occur 600' below the surface of the High Plains. In Caprock Canyons State Park (Fig. 1), evidence of regional salt dissolution can be seen in clastic sediments of the Upper Permian Whitehorse Group and Quartermaster Formation. Gypsum-filled extension fractures are common in relatively thinly bedded shales, silt stones and sandstones of the Whitehorse Group as opposed to the thicker, more massive sandstones of the Quartermaster Formation. In the Whitehorse, gypsum veining in response to salt dissolution and extension increases lower in the section, closer to the zone of dissolution. Veining is oriented non-uniformly, but in all veins, a medial scar is present and marks the line of parting. Gypsum fibers grow in the direction of parting. Sigmoidal fibers indicate displacement during vein filling. Filled fractures include small scale normal and reverse faults. TBEG believes that the mechanism for salt dissolution and collapse which caused deformation in Upper Permian sediments was fluid migration along preexisting joints. (TBEG indicated that there may be acoustics log data from intervals above the dissolution zone showing fracture porosity probably due to dissolution in at least one of the DOE cores in the Southern High Plains.)

Sunday, November 9

Stop 1 - In a drainage gully near Quitaque, TX, a 21-meter thick section of Quaternary deposits overlies tilted, jointed (but not veined) Upper Permian Quartermaster Formation siltstone. The Quaternary sediments consisted of a fractured/faulted basal gravel overlain by laterally continuous, jointed lacustrine sediments that filled a basin approximately 0.2 mi in diameter. The age of the lacustrine sediments ranges from 23,255 ± 2,335 years for the next-to-oldest layer to 15,110 ± 500 years for the third to youngest layer. Both the gravels and lacustrine sediments are tilted, the older gravels more so. That the lacustrine

sediments were deposited horizontally is attested by the presence of root casts perpendicular to bedding.

The gravel is believed to have been shed as alluvial fan deposits from the retreating Caprock Escarpment. Lithoclasts from the Ogallala caliche have been found in the saprolite underlying the gravel. The age of the saprolite and the rate of retreat of the escarpment are difficult to determine directly but can be approximated as follows:

- In the gully near Quitaque (≈ 5 kilometers or less from escarpment), an Ogallala clast was identified in the basal saprolite of the Lingos Formation, which must have post-dated local retreat of the Caprock Escarpment.

- A gravel unconformably overlying the basal saprolite has been dated at 300,000 years B.P. or younger on basis of Rancho La Brea fauna in a correlative deposit.

- 65 miles east of the Escarpment, Ogallala clasts were found in a volcanic ash deposit dated at approximately 600,000 years B.P. This sets a maximum average rate of retreat for the Caprock Escarpment at approximately 1 mi/10,000 years, or 1.6 km/10,000 years.

- TBEG estimates a maximum age of 100,000 - 200,000 years B.P. for the base of the Lingos Formation in this locality. This estimate seems reasonable in light of the average rate of escarpment retreat calculated above, and the age of the gravel overlying the saprolite. Retreat probably has been occurring episodically in "fits and starts."

Stop 2

The final stop was to observe catastrophic erosion of an existing gully over a two-week period by surface runoff channelled over approximately 1

mile on a very low grade. The length of the 50 ft wide and deep gully increased by approximately 100 ft. through infiltration along joints and undercutting. A portion of a barbed wire fence stretched across part of the gully, in mid-air, over an area where walls had been washed out.

II. GSA Annual Meeting - San Antonio, TX

A summary of presentations with relevance to the NRC's high-level waste program for review of the Deaf Smith site follows:

Monday, November 10

- "Geologic Controls on Hydrogeology and Hydrochemistry of the Ogallala Aquifer, Texas Panhandle" by R. Nativ and A. Smith.

The significance of this presentation was the statement that there is upward flow of groundwater in aquifers below the Ogallala into the Ogallala. This statement is inconsistent with DOE's position as presented in the Final Environmental Assessment that "The regional vertical hydraulic gradient between HSU A (upper aquifer systems) and HSU C (lower aquifer systems) across HSU B is downward" (p. 6-246). The authors presented the following evidence for upward flow into the Ogallala:

- Chemical and isotopic data
- Water level-head data

The areas of upward flow occur in regions between the major depositional axes of the Ogallala where the aquifer is thinner and less permeable, and where contacts between the Ogallala and underlying formations are relatively permeable.

Because the Ogallala aquifer is considered to be one of the most valuable natural resources in the Palo Duro Basin, the possibility that it could be contaminated as a result of disposal of HLW in the Permian Lower San Andres Unit 4 must be evaluated in view of these authors' findings.

- "Depositional History and Stratigraphic Significance of Sheet Sandstones of the Permian Basin" by S. Mazzullo, J. Mazzullo, and P. M. Harris.

This presentation described an aeolian model for the origin and deposition of the Upper Permian sand formations (Queen/Grayburg, Tansill) in the Permian Basin. These sands are characteristically unfossiliferous and essentially "featureless" - i.e., dunes are identified only rarely in seismic profiles. The sands tend to overlie subtidal facies and are believed to represent periods of low sea level stands and little deposition/sedimentation.

Tuesday, November 11

- "Geological Issues in the Siting and Construction of a Nuclear Waste Repository" by L. Chaturvedi and J. Chapman.

The subject nuclear waste repository of this presentation was the Waste Isolation Pilot Plant (WIPP) in Southeastern New Mexico. Geological siting issues at WIPP are relevant to issues at Deaf Smith because both sites are in Upper Permian bedded salt formations in distinct sub-basins of the Permian Basin. The authors addressed the following issues:

- Human intrusion to exploit potash, oil, and gas deposits
- Salt dissolution
- Potential impact of a pressurized brine reservoir beneath the repository
- Geohydrology of Rustler Formation overlying repository
- Rate of closure
- Effect of gas pockets and brine
- Stress relief fractures

L. Chaturvedi discussed geomorphic evidence of dissolution within several kilometers of the site, the numerous solution cavities that have been

found in drilling, and that the only remaining component of exposed evaporite units consists of dissolution residue. Dr. Chaturvedi also mentioned 4" wide open fractures in marker beds in the Salado (host) Formation. He further stated that tests have shown the rate of closure of excavated rooms is 3X greater than the expected rate, and will result in total closure of a typical room in less than 20 years.

Nevertheless, the authors consider most of these issues to be "resolved". Because of the difficulty in pursuing the question of issue resolution with the authors during this meeting, we strongly recommend that the authors be asked to meet with the Deaf Smith site review team to discuss it further. We also recommend that NRC consider accepting Dr. Chaturvedi's (often repeated) offer to conduct a field trip for NRC staff and others in the WIPP vicinity to study evidence for salt dissolution and brine seepage.

This presentation and subsequent conversations between the authors and NRC staff have the potential to impact ongoing NRC activities in reviewing the Deaf Smith site, preparing a technical position on dissolution, and conducting the Preliminary Review of Offsite Salt Programs (PROSPER) assignment requested by WMRP.

- "Role of Structure in the Distribution of Sandstone in the Dockum Group, Texas Panhandle" by D. A. Johns.

This presentation discussed material described in the draft TBEG report "Sandstone Distribution and Lithofacies of the Triassic Dockum Group, Palo Duro Basin, Texas" by D. Johns. The author's point basically is that Dockum sands thicken over basement structural lows (e.g., Castro Trough) and thin over basement highs (e.g., Arney Block). The significance of this finding to NRC is the potential for basement structure to carry through at least through the Triassic and possibly into younger sediments. This could include joints, fractures, and/or fault trends which would need to be factored into an assessment of the potential for structural

discontinuties to enhance salt dissolution in the vicinity of the Deaf Smith site.

Wednesday, November 12

- "Nuclear Waste Repository Siting in Deeply Buried Salt Beds - Possible Surficial Evidence of Host Rock Dissolution" by C. C. Reeves, Jr.

The purpose of this discussion was to link some of the numerous geomorphic depressions within the Southern High Plains to point source dissolution of Permian evaporites. The author makes a distinction between large (alkaline) lake basins, playas, and deflation features and whether they could be point sources of dissolution. Reeves also supplies evidence for basin formation antecedent to dissolution. The author concludes that of the "17,000 natural lake basins" in West Texas - New Mexico portion of the Permian Basin, some have resulted in infiltration of surface water through units overlying the evaporites and caused salt dissolution.

This presentation provided information on the various types of geomorphic depressions in the Southern High Plains and how one might evaluate whether they are related to evaporite dissolution. This information will be incorporated into the technical position on dissolution.

PHOTO LOG

Photo 1A - Exposure of Upper Permian through Quaternary units at edge of Eastern Caprock Escarpment. Surface unit is Quaternary Blackwater Draw Formation. Upper two resistant units mark top and base of Tertiary Ogallala Formation. Underlying Ogallala are Triassic Dockum Formation and Permian Dewey Lake. Contact between Triassic and Permian difficult to pinpoint; Dockum is very thick in this exposure.

Photo 4A - Quaternary "Lingos" Formation abutting Caprock Escarpment to west. Lingos 40-80' thick surface unit where photo was taken.

Photo 5A - (Caprock Canyons State Park Archaeological/Paleontological Museum) Contact between Lingos Formation and Permian where light grey meets dark red sand and silt. Caprock Escarpment in background.

Photo 6A - Triassic Dockum with remnants of Ogallala in Caprock Escarpment overlying Western Rolling Plains' Upper Permian Quartermaster Formation and Whitehorse Group.

Photo 8A - (Terrace deposits along Little Red River, Caprock Canyons State Park). Quaternary (Holocene?) sediments fill former stream channel delineated by Permian gypsum.

Photos 9A, 10A, 11A - (South Prong of Little Red River). Gypsum-filled extension fractures in Upper Permian Quartermaster Formation and Whitehorse Group.

Photo 13A - (Smith's Gully, Quitaque, TX). Drainage gully in which deformed Quaternary sediments unconformably overlie Permian. Gully formed during last 10 years. Land washed out beneath barbed wire fence stretched across gully.

Photo 14A - (Smith's Gully, Quitaque, TX). Quaternary basal saprolite, alluvial gravels, and lacustrine sediments.

Photo 15A - (Smith Farm, Quitaque, TX). Outwash gully. This entire gully was gouged out by heavy rains channed along the road at the upper right of the photo over a two week period in late October-early November, 1986.

Photo 17A-- (Smith Farm, Quataque, TX). West wall of gully in photo 15A. Soil washed out beneath fence which is stretched out in mid-air.

Photo 18A - Playa lake crossing road in High Plains.

Photo 20A - Aerial view of hundreds of playas on High Plains.

NOTES: All photos taken November 8-9, 1986 by Julia Corrado.
Photos numbered according to negative numbers.

Negatives on file with original concurrence package in DCC. Prints available from J. Corrado.