COMPUTERIZED INVENTORY OF DATA ON TEXAS SALT DOMES

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INTRODUCTION

On the basis of our initial investigations, a computerized spread sheet has been derived that summarizes information relevant to storing chemical wastes in salt domes in Texas. This inventory provides a ready reference source of dome-related data including location, physical dimensions and structure of the domes, surrounding strata, domal resources, and ground water. The data base is especially useful for manipulating data and creating lists and tables to compare individual domes and their potential uses and resources.

DATA BASE

The inventory is stored on System 2000 (S2K). S2K provides the user with a powerful tool for managing the data base. With S2K the user may define new data bases, modify definitions in existing data bases, and retrieve and update values within the data bases. S2K provides archival copies of data bases and records an audit trail to changes in the data base.

The structure of the data base is hierarchical. Basic components of the data base are data elements and repeating groups. Values (either numeric or text) are stored in data elements. Repeating groups are the structure for storing related sets of data elements. Repeating groups link hierarchical levels of the data base. Output in the form of tables and reports is generated with the "Report Writer."

Organization of the Data Base

Single data elements include 55 dome variables listed and defined in table 1. Repeating groups include 16 sets of data elements comprising 63 individual data elements listed and defined in table 2. The organization of the data base is shown in table 3; the entire data base as of May 1, 1984, constitutes appendix 1. The "Report Writer" feature of S2K facilitates preparation of charts and tables of data from the data base. Tables 4, 5, and 6 are examples of

output using the "Report Writer." The code needed to reproduce these tables is included at the bottom of the individual tables.

EXPLANATION OF GEOLOGIC TERMINOLOGY

Information on 84 salt diapirs in Texas is presented in the data base. Some salt pillows (nondiapiric salt structures) may also be included. Data for very deep salt structures is meager. The availability of data for each dome is variable. Structure-contour maps on top of domal material are available for 52 domes (62 percent of the total).

All data elements and repeating groups are listed by program line (pl) and defined in tables 1 and 2. Most geologic terms are self explanatory. The following sections and figures 1, 2, 3, and 4 provide an explanation of the geologic terminology. In the following sections parameters in the data base are keyed to a program line in parentheses. All documentation of the source of data is listed in Documentation Repeating Group (pl-500).

Shape of the Salt Stock

Several parameters describe the shape of the salt stock. Shape parameters are derived from structure-contour maps on top of the stock. Figure 1A illustrates how major-axis length (pl-31), major-axis orientation (pl-32), and minor-axis length (pl-33) were derived. Area of planar crest (pl-40) and planar crest percentage (pl-41) were calculated as shown in figure 1B. Axial ratio is a measure of the ellipticity of a diapir (fig. 1C).

The area (ft^2) enclosed by each domal-structure contour was calculated by planimetry and is in Area Statistics Repeating Group (pl-34).

Salt-structure contour maps also yield data on the three-dimensional shape of the salt stock. Diapirs not having vertical axes are described in terms of axial tilt (pl-55), axial-tilt orientation (pl-56), and axial-tilt distance (pl-57) in figure 2. The presence and position of the salt-stock overhang determine whether the sides of the stock (pl-59) are parallel (no overhang),

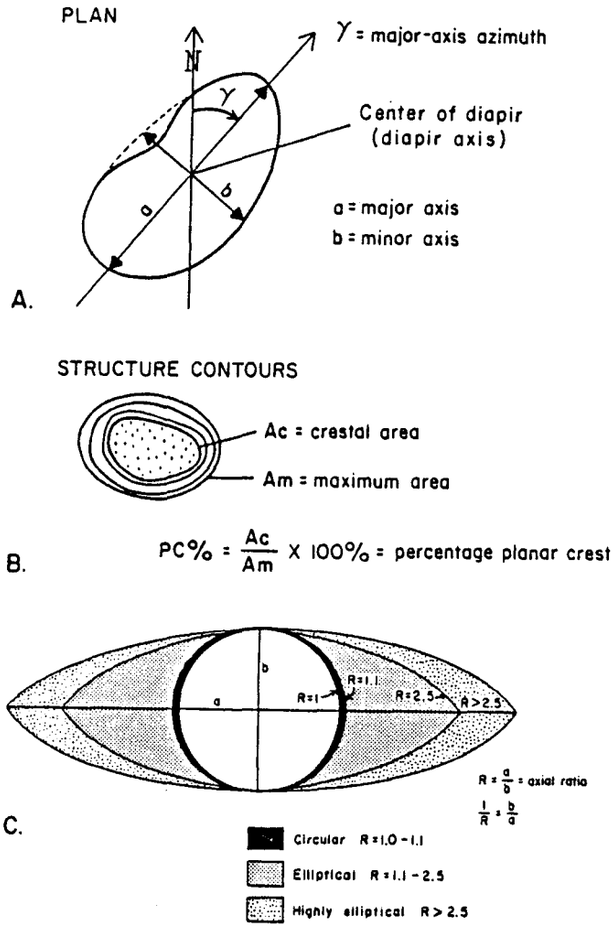

Figure 1. Definition of diapir shape in plan view. (A) Major axis, minor axis, and major-axis azimuth. (B) Crestal area and percentage planar crest. Area is measured by planimetry. (C) Three classes of diapir shape defined by different axial ratios.

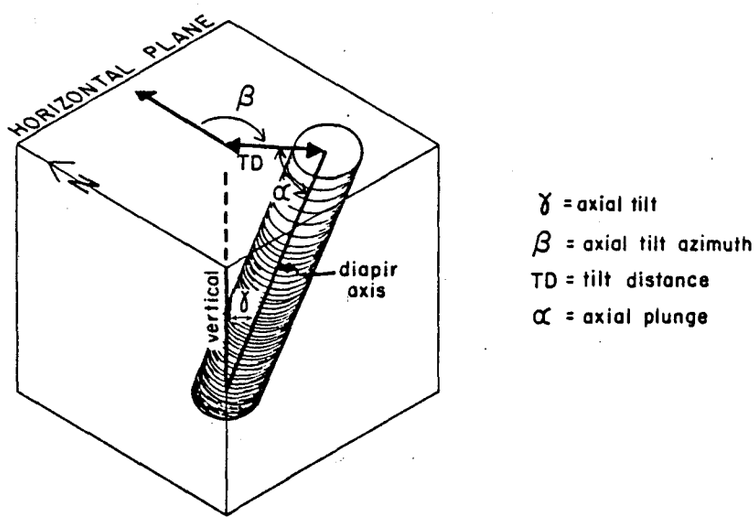

Figure 2. Parameters describing inclined diapirs in three dimensions. These are calculated from structure-contour maps on top of salt.

upward diverging (below overhang), or upward converging (above overhang or no overhang). If an overhang is present, information is provided in Overhang Repeating Group (pl-60). If a partial overhang is present, the overhang arc is bracketed by the azimuth orientation of two lines--overhang orientation 1 (pl-62) and overhang orientation 2 (pl-63) (fig. 3B). Domes completely encircled by an overhang have an overhang orientation of 1 equal to 000° and an overhang orientation of 2 equal to 360°. Overhang azimuth (pl-64), lateral overhang (pl-65), and percentage overhang (pl-66) are illustrated in figure 3B.

Structure Adjacent to the Salt Stock

The dome data base is set to accept data on the structure of strata surrounding the salt stock. As of May 1, 1983, such data were not collected. Jackson and Seni (1984) provide definitions of terms used in the dome data base for terms applicable to strata surrounding the stock.

SURFACE EXPRESSION

The surface expression of strata over the dome is one indication of the relative structural and hydrologic stability of a dome. Subsidence above a dome is usually attributed to subsurface dissolution of salt by ground water or to solution-brining operations. Both natural and man-induced sinkholes and depressions are expressions of such processes (pl-120, 121). Uplift over a dome indicates that rates of upward dome growth exceed rates of dome-crest attrition by dissolution (pl-110).

Anomalous drainage patterns (Drainage Systems Repeating Group [pl-111]) over domes provide a way to assess the evidence for subsidence or uplift. Five ideal types of drainage patterns are recognized over Texas salt domes. Figure 4 shows a classification of four of these drainage types. Toroidal drainage (not included in figure 4) includes a central depression and a peripheral mound. Centrifugal drainage is radial drainage away from a central mound that

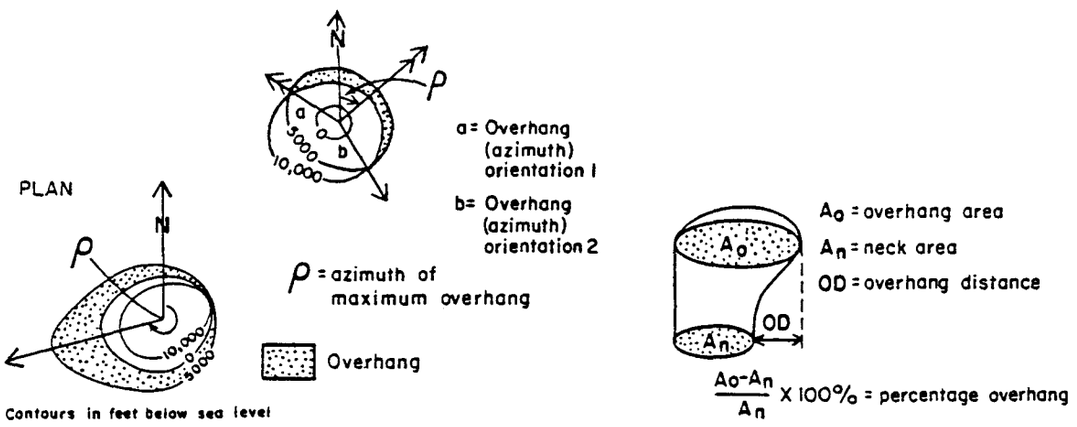

Figure 3. Parameters describing diapir overhang. Plan view (A) defines overhang and azimuth of maximum overhang on a structure-contour map on top of the salt. Plan view (B) defines partial overhang. Contours are elevation below sea level. Oblique view defines overhang area, neck area, overhang distance, and percentage overhang. Area is measured by planimetry.

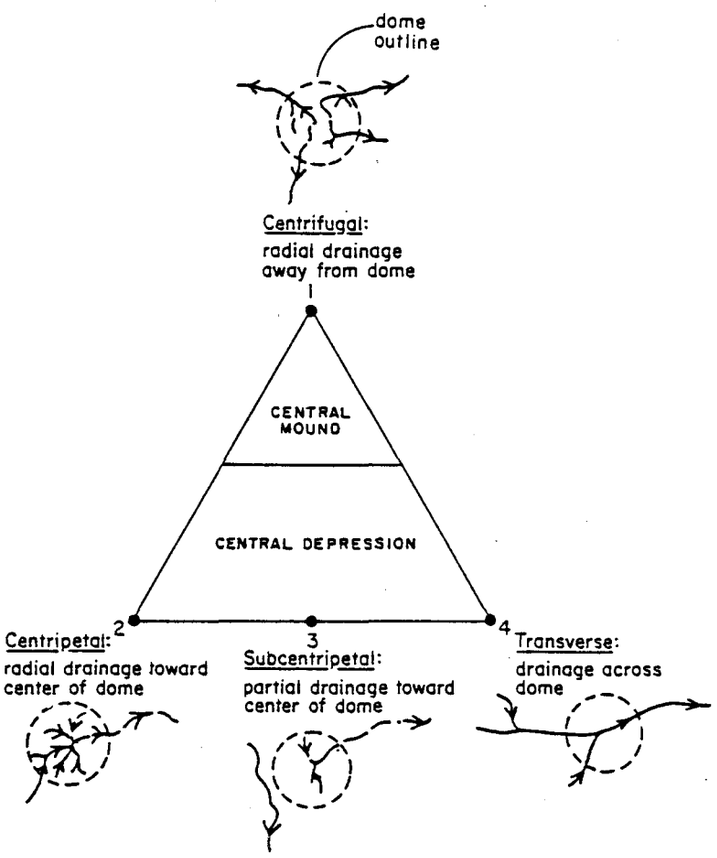

Figure 4. Qualitative classification of drainage systems above domes: four ideal types as a guide to relative movement of the land surface. Toroidal drainage is not shown.

occurs over domes rising faster than the overburden is being eroded or the crest is being dissolved. Centripetal drainage is drainage toward the central area over the salt stock. It provides evidence of collapse over the dome crest. Subcentripetal drainage suggests subsidence but is equivocal evidence. Transverse drainage indicates that any rise or subsidence of the dome is negligible compared with the rate of regional uplift or subsidence and stream incision or aggradation.

RESOURCES

Hydrocarbon production histories from producing salt domes are listed in Hydrocarbon Repeating Group (pl-150). These data are from the 1982 Railroad Commission Oil and Gas Annual Report. Other resources associated with diapirs include rock salt, brine, sulfur, and sulfide minerals. These resources and history of development are listed in Mineral Production Repeating Group (pl-190). Solution-mined storage caverns represent another domal resource. Data domes with a history of hydrocarbon storage, company, number of caverns, capacities, and products stored are listed in Hydrocarbon Storage Caverns Repeating Group (pl-225).

Ground-water resources around domes are listed in Aquifer Water Chemistry Repeating Group (pl-400). Water chemistry data are from Texas Department of Water Resources water chemistry wells. In addition to water chemistry, the following ground-water parameters are listed; regional depth of slightly saline ground water (pl-420), depth of slightly saline ground water near the dome (pl-421), ground-water irrigation near the dome (pl-435), municipalities using ground water near the dome (Repeating Group pl-425), and industries using ground water near the dome (Repeating Group pl-430).

DOCUMENTATION

Each dome includes a Documentation Repeating Group indicating the source of data. The information on each dome can be divided into three major classes of related data--dome

geometry, dome resources, and ground-water chemistry. Most of the data in these classes were derived from outside sources. All other data were generated at the Bureau of Economic Geology for this report.

Data on dome location and geometry were derived from salt-structure contour maps. Major sources of these contour maps are the Railroad Commission of Texas Hearing Files, Jackson and Seni (1984), Halbouty (1979), Geomap, and numerous articles on individual domes. Resource data include oil and gas, sulfur, sulfides, salt, brine, and storage. All oil and gas data are from the Railroad Commission of Texas 1982 Oil and Gas Annual Report. Most data on sulfur, salt, and brine are from Hawkins and Jirik (1966) and Jirik and Weaver (1976). Data on sulfide minerals are from Smith (1970a, b) and Price and others (1983). Data on storage in salt domes are from the Railroad Commission of Texas Hearing Files and Gas Processors Association (1983). The Texas Department of Water Resources provided data on ground-water chemistry and uses of ground water.

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TABLE 1. List of computer program line number, data element, definition, and example.

PROGRAM LINE NUMBER	DATA ELEMENT	DEFINITION	EXAMPLE
1	DOME NAME	Name of dome	Barbers Hill
2	DOME CODE	Two letter/two number code for documentation	BB-28
3	LATITUDE	Latitude of center point of salt dome--degrees, minutes, and seconds north of equator	29D50M56S
4	LONGITUDE	Longitude of center point of salt dome--degrees, minutes, and seconds west of central meridian	94D54M37S
5	GRID LATITUDE-NORTH	Latitude located 2.5 mi north of deepest salt contour	29D54M19S
6	GRID LATITUDE-SOUTH	Latitude located 2.5 mi south of deepest salt contour	29D47M35S
7	GRID LONGITUDE-WEST	Longitude located 2.5 mi west of deepest salt contour	94D57M20S
8	GRID LONGITUDE-EAST	Longitude located 2.5 mi east of deepest salt contour	94D49M55S
21	SHALLOWEST CAP-ROCK DEPTH (in feet)	Minimum depth (feet) of cap rock below surface	320
22	SHALLOWEST SALT DEPTH (in feet)	Minimum depth (feet) of salt below surface	1300
23	DEEPEST CONTROL ON SALT (in feet)	Deepest depth (feet) of salt below surface penetrated by drill or seismic	6500

TABLE 1 (cont.)

PROGRAM LINE NUMBER	DATA ELEMENT	DEFINITION	EXAMPLE
31	MAJOR-AXIS LENGTH (in feet)	Length (feet) of major axis of salt dome, from structure-contour map; measured between shoulders of dome (see figure 1A)	11600
32	MAJOR-AXIS ORIENTATION (in degrees)	Azimuth orientation (range 0 to 180 degrees) of major axis (see figure 1A)	163
33	MINOR-AXIS LENGTH (in feet)	Length (feet) of minor axis of salt dome, from structure-contour map; measured between shoulders of dome perpendicular to major axis (see figure 1A)	9000
40	AREA OF PLANAR CREST	Area (feet^2) enclosed within highest structure contour of salt stock as measured by planimeter (see figure 1B)	41714286
41	PLANAR CREST PERCENTAGE	Percentage planar crest equals area of planar crest divided by maximum area of salt stock times 100 (see figure 1B)	56%
50	GENERAL SHAPE	Text description of salt stock	Piercement diapir
51	AXIAL RATIO	Major axis divided by minor axis (see figure 1C)	1.29
52	PLAN SHAPE	Text description of ellipticity salt stock (see figure 1C)	Circular

TABLE 1 (cont.)

PROGRAM LINE NUMBER	DATA ELEMENT	DEFINITION	EXAMPLE
53	DOME SYMMETRY	Text description of three-dimensional symmetry of dome	Orthorhombic
54	AXIS	Text description of straight "line of best fit" joining centers of salt dome at individual structure-contour horizons	Inclined
55	AXIAL TILT ANGLE (in degrees)	Inclination angle (degrees) of diapir with respect to vertical (see figure 2)	13
56	AXIAL TILT ORIENTATION (in degrees)	Azimuth angle (degrees) in horizontal plane of line connecting diapir axis and center of dome at deepest structure-contour horizon (see figure 2)	226
57	AXIAL TILT DISTANCE (in feet)	Length (feet) of line connecting diapir axis and center of dome at deepest structure-contour horizon (see figure 2)	300
58	CREST	Text description of shape of crest of dome	Planar
59	SIDES	Text description of shape of flanks of dome	Upward converging above -3000 ft
70	MAXIMUM TRUE THICKNESS OF CAP ROCK (in feet)	Maximum true (isopach) thickness (feet) of cap rock	750
71	MINIMUM TRUE THICKNESS OF CAP ROCK (in feet)	Minimum true (isopach) thickness (feet) of cap rock	50

TABLE 1 (cont.)

PROGRAM LINE NUMBER	DATA ELEMENT	DEFINITION	EXAMPLE
72	CAP-ROCK MINERALOGY	Text description of mineralogy of cap rock	Calcite and anhydrite
73	CAP-ROCK LOST-CIRCULATION ZONES PA	Present/absent key of lost-circulation zones in cap rock	Present
74	CAP-ROCK LOST-CIRCULATION ZONES INFO	Text description of lost-circulation zones in cap rock	Lost-circulation zone at cap-rock-salt-stock interface
75	SULFIDE MINERALS	Present/absent key of sulfide occurrences in cap rock	Absent
76	GENERAL DOME INFORMATION	Text description suitable as storage buffer for any dome information	Drill rig collapsed while drilling through cap rock
81	LATERAL EXTENT OF RIM SYNCLINE (in feet)	Lateral distance (feet) between crest points of rim syncline	13000
82	LATERAL EXTENT OF DRAG ZONE (in feet)	Lateral distance (feet) between trough points (axial trace of rim syncline) around dome	2000
83	MAXDIPVERTVARI (in degrees feet)	Maximum dip (degrees) of strata that dip away from dome; depth (feet)	+70°, 2000
84	MAXDIPVERTVARZ (in degrees feet)	Minimum dip (degrees) of strata that dip toward dome; depth (feet)	0°, 4000
85	MAXDIPVERTVAR3 (in degrees feet)	Maximum dip (degrees) of strata that dip toward the dome; depth	20°, 8000

TABLE 1 (cont.)

PROGRAM LINE NUMBER	DATA ELEMENT	DEFINITION	EXAMPLE
102	YOUNGEST FAULTED STRATA	Formation and age of youngest faulted strata over dome	Lissie, Pleistocene
103	OLDEST STRATA ON SURFACE	Formation and age of strata exposed over dome	Austin Chalk, Cretaceous
110	RELIEF OVER DOME	See Repeating Group III	
120	SINKHOLES	Present/absent key of occurrence of sinkholes over dome	Present
121	SINKHOLE INFO	Text description of sinkhole	300 ft diameter sinkhole; water depth 30 ft; formed 1984 over old brine well
122	SURFACE SALINES	Present/absent key of occurrence of surface salines around dome	Absent
123	CONFIGURATION OF OVERBURDEN	Descriptive text of attitude of overburden	Homothetic faults in uplifted Pleistocene strata
220	PRODUCT STORAGE STATUS	Status key for storage operations in domes--active, abandoned, under construction	Active
221	STORAGE METHOD	Method key for construction method of cavern--cavern or mine	Cavern

TABLE 1 (cont.)

PROGRAM LINE NUMBER	DATA ELEMENT	DEFINITION	EXAMPLE
222	NUMBER OF CAVERNS	See Repeating Group 225	
223	TOTAL STORAGE CAPACITY (in barrels)	Reported product storage capacity (bbls) in 1983	2500000
420	REGIONAL DEPTH OF BASE OF SLIGHTLY SALINE GROUND WATER IN FEED	Average regional depth (feet) to base of slightly saline ground water defined as $\leq$3000 mg/l total dissolved solids in area not affected by dome growth	500
421	DEPTH OF BASE OF SLIGHTLY SALINE GROUND WATER OVER DOME	Depth (feet) to base of saline ground water defined as $\leq$3000 mg/l total dissolved solids over dome	200
422	SALINE ANOMALIES IN GROUND WATER	Present/absent/insufficient data key on occurrence of saline anomalies in ground water	Present
435	GROUND-WATER IRRIGATION NEAR DOME (in acres)	Present/absent/none indicated key on occurrence of irrigation and coverage (in acres)	Present 500
445	SURVEY NAME FOR CENTER OF DOME	Survey name where center of dome coordinates are located	J. Miller A-232
446	SALT BASIN	Salt basin in which diapir is located	Houston salt basin

TABLE 2. List of computer program line number, repeating group, definition, and example.

PROGRAM LINE NUMBER	REPEATING GROUP	DEFINITION	EXAMPLE
10	COUNTIES	Repeating Group for county or counties where dome is located	-
10 - 11	COUNTY NAME	County name	Harris
34	AREA STATISTICS	Repeating Group for area and depth of dome from structure-contour map	-
34 - 35	DEPTH OF AREA CALCULATION (in feet)	Depth (feet) of salt dome for which subsequent area is calculated in program line (pl) -36	1000
34 - 36	AREA IN SQUARE FEET FOR DEPTH OF 35	Area (ft^2) at depth listed in pl-35	55809524
60	OVERHANG	Repeating Group for data on overhang	-
60 - 61	OVERHANG INFO	Text description of general characteristics of overhang	Overhang on NW corner of dome
60 - 62	OVERHANG ORIENTATION I (in degrees)	Azimuth orientation (degrees) of line from center of dome at overhang depth to margin of dome where overhang is initiated (see figure 3B)	300°

TABLE 2 (cont.)

PROGRAM LINE NUMBER	REPEATING GROUP	DEFINITION	EXAMPLE
60 - 63	OVERHANG ORIENTATION II (in degrees)	Azimuth orientation (degrees) of line from center of dome at overhang depth to margin of dome where overhang is terminated; overhang orientation II is the line that brackets overhang and is clockwise from overhang orientation I; for those domes with complete overhang--overhang orientation I = 0 degrees overhang orientation II = 360 degrees (see figure 3B)	52
60 - 64	OVERHANG AZIMUTH (in degrees)	Azimuth orientation from center of dome to maximum overhang (see figure 3B)	356
60 - 65	LATERAL OVERHANG (in feet)	Lateral extent (feet) overhang projects over dome flanks (see figure 3A)	400
60 - 66	PERCENTAGE OVERHANG	Percentage of overhang area over neck area (see figure 3A)	50
90	ANGLE BETWEEN SALT STOCK-STRATA	Repeating Group for angles and depths formed at contact between salt stock and strata	-
90 - 91	ANGLE (in degrees)	Angle between salt stock and strata	20
90 - 91	DEPTH (in feet)	Depth for angle measured in pl-91	2000

TABLE 2 (cont.)

PROGRAM LINE NUMBER	REPEATING GROUP	DEFINITION	EXAMPLE
100	ADJACENT STRATA FAULTING	Repeating Group for describing style of faulting and units faulted around salt domes	-
100 - 101	FAULT DESCRIPTOR	Text description of fault type-- homothetic and antithetic, dip of fault plane, strata faulted, and depth	Homothetic, toward dome, Frio, 2000
111	DRAINAGE SYSTEMS	Repeating Group for drainage system over crest of dome	-
111 - 112	DRAINAGE TYPE	Drainage systems are Centrifugal - Type 1 Centripetal - Type 2 Subcentripetal - Type 3 Transverse - Type 4 Toroidal - Type 5	Centrifugal - Type 1
150	HYDROCARBON RESOURCES	Repeating Group for maintaining current and cumulative production statistics on hydrocarbons from salt domes as reported by Railroad Commission of Texas	-
150 - 151	FIELD NAME PRODUCING HORIZON	Name of field and producing horizon	Sour Lake - 6700 Sand
150 - 152	RRC DISTRICT	Railroad Commission of Texas District where field is located	3

TABLE 2 (cont.)

PROGRAM LINE NUMBER	REPEATING GROUP	DEFINITION	EXAMPLE
150 - 153	COUNTY RESIDENCE	Texas county where field is located	
150 - 154	DISCOVERY DATE	Date of operator's request for field rules on new field discovery	1949
150 - 155	FIELD DEPTH (in feet)	Field depth (feet)	5200
150 - 156	GRAV API	API gravity of crude oil	
150 - 157	ENVIRONMENTAL CODE	Text description for environmental aspects	
150 - 158	ENV COMM 1	Text description for comments	
150 - 159	ENV COMM 2	Text description for comments	
150 - 160	ENV COMM 3	Text description for comments	
150 - 161	ENV COMM 4	Text description for comments	
150 - 165	CUMULATIVE CRUDE OIL PRODUCTION IN BARRELS	Cumulative crude oil (bbls) production through 1982	150000

TABLE 2 (cont.)

PROGRAM LINE NUMBER	DATA ELEMENT	DEFINITION	EXAMPLE
170	FIELD PRODUCTIONS	Repeating Group for annual additions to production data	-
170 - 171	YEAR	Latest year of production data	1982
170 - 172	GAS GROSS (in thousands of cubic feet)	Gas (MCF) produced in latest year of production	18000
170 - 173	CONDENSATE (in barrels)	Condensate (bbls) produced in latest year of production	5050
170 - 174	CASINGHEAD GAS (in thousands of cubic feet)	Casinghead gas (MCF) produced in latest year of production	200
170 - 175	CRUDE OIL (in barrels)	Crude oil (bbls) produced in latest year of production	24500

TABLE 2 (cont.)

PROGRAM LINE NUMBER	DATA ELEMENT	DEFINITION	EXAMPLE
190	MINERAL PRODUCTION	Repeating Group for data on minerals produced from salt domes and cap rocks	-
190 - 199	MINERAL NAME	Mineral name	Sulfur
190 - 200	PROD STATUS	Production status for each mineral	Abandoned
190 - 201	METHOD	Mining method; for minerals without production literature reference is cited	Frasch
190 - 202	COMPANY	Mining company	Hooker Chemical
190 - 203	HISTORY	Chronology of mining	1945-1965
190 - 204	ENV CODE	Text description for environmental aspects	
190 - 205	ENV COMM 1	Text description for comments	
190 - 206	ENV COMM 2	Text description for comments	

TABLE 2 (cont.)

PROGRAM LINE NUMBER	DATA ELEMENT	DEFINITION	EXAMPLE
225	HYDROCARBON STORAGE CAVERNS	Repeating Group for data on hydrocarbon storage operations	-
225 - 226	COMPANY	Current operator for storage operation	Texaco
225 - 227	ORIGINAL APPLICANT	Original applicant for storage operation	Texas Co.
225 - 228	TOTAL NUMBER OF CAVERNS	Total number of caverns created by operator; may include brine caverns	20
225 - 229	TOTAL CAVERN STORAGE CAPACITY IN BARRELS	Sum of storage capacity (bbls) used in 1983	2000000
225 - 230	RRC SPECIAL ORDER NUMBER	Railroad Commission authorization number for cavern creation and use	03-29667
235	STORED PRODUCT	Repeating Group for various products stored by operator	-
235 - 236	PRODUCT STORED	Name or type of hydrocarbon stored	Natural gas

TABLE 2 (cont.)

PROGRAM LINE NUMBER	DATA ELEMENT	DEFINITION	EXAMPLE
400	AQUIFER WATER CHEMISTRY	Repeating Group for aquifer data; all data compiled by Texas Department of Water Resources	-
400 - 401	AQUIFER	Name of aquifer for which data applies; area of interest is within grid boundaries in program lines 5, 6, 7, and 8	Sparta
400 - 402	TOTAL NUMBER OF WELLS SURVEYED	Number of wells with water chemistry available	8
400 - 403	LOWER NA IONS	Lowest value of Na (mg/L) reported for wells surveyed	20
400 - 404	HIGHER NA IONS	Highest value of Na^+ (mg/L) reported for wells surveyed	50
400 - 405	LOWER SO_4 IONS	Lowest value of SO_4 (mg/L) reported for wells surveyed	10
400 - 406	HIGHER SO_4 IONS	Highest value of SO_4 (mg/L) reported for wells surveyed	30
400 - 407	LOWER CL IONS	Lowest value of Cl (mg/L) reported for wells surveyed	10
400 - 408	HIGHER CL IONS	Highest value of Cl (mg/L) reported for wells surveyed	80
400 - 409	LOWER TDS	Lowest value of TDS (mg/L) reported for wells surveyed	2000
400 - 410	HIGHER TDS	Highest value of TDs (mg/L) reported for wells surveyed	35000

TABLE 2 (cont.)

PROGRAM LINE NUMBER	DATA ELEMENT	DEFINITION	EXAMPLE
425	MUNICIPALITIES PUBLIC GROUND-WATER USE NEAR DOME	Repeating Group listing all municipalities using ground water near dome	-
425 - 426	USER	Name of municipality using ground water	Mount Belvieu
430	INDUSTRIES USING GROUND WATER NEAR DOME	Repeating Group listing all industries using ground water near dome	-
430 - 431	INDUSTRIAL USER	Name of industrial user	Exxon
440	POPULATION CENTERS NEAR DOME	Repeating Group listing all population centers near dome with grid defined in program lines 5, 6, 7, and 8	
440 - 441	TOWN NAME	Name of population center	Port Neches
440 - 442	DISTANCE FROM DOME CENTER	Distance (feet) from center of population center to center of dome	8500
500	SALT-DOME DATA BASE DOCUMENTATION	Repeating Group with documentation of data base	-
500 - 501	DOCUMENTATION	Source of data	RRC
500 - 502	REPORTING YEAR	Date of referenced documentation	1984

Table 3. Data base organization.

```
:
DESCRIBE:
 SYSTEM RELEASE NUMBER       2.60F
 DATA BASE NAME IS DOMES
 DEFINITION NUMBER     13
 DATA BASE CYCLE      598
    1*  DOME NAME (TEXT X(20))
    2*  DOME CODE (NAME X(6) WITH SOME FUTURE ADDITIONS)
    3*  LATITUDE (NAME X(15))
    4*  LONGITUDE (NAME X(15))
    5*  GRID LATITUDE-NORTH (NAME X(15))
    6*  GRID LATITUDE-SOUTH (NAME X(15))
    7*  GRID LONGITUDE-WEST (NAME X(15))
    8*  GRID LONGITUDE-EAST (NAME X(15))
   21*  SHALLOWEST CAP ROCK DEPTH-IN FEET (INTEGER NUMBER 9(5))
   22*  SHALLOWEST SALT DEPTH-IN FEET (INTEGER NUMBER 9(5))
   23*  DEEPEST DEPTH CONTROL ON SALT-IN FEET (INTEGER NUMBER 9(5))
   31*  MAJOR AXIS LENGTH-IN FEET (INTEGER NUMBER 9(9))
   32*  MAJOR AXIS ORIENTATION-IN DEGREES (INTEGER NUMBER 999)
   33*  MINOR AXIS LENGTH-IN FEET (INTEGER NUMBER 9(9))
   40*  AREA OF PLANAR CREST-IN SQUARE FEET (DECIMAL NUMBER 9(9).9)
   41*  PLANAR CREST PERCENTAGE (DECIMAL NUMBER 99.9)
   50*  GENERAL SHAPE (TEXT X(80))
   51*  AXIAL RATIO (DECIMAL NUMBER 99.999)
   52*  PLAN SHAPE (TEXT X(80))
   53*  DOME SYMMETRY (TEXT X(12))
   54*  AXIS (TEXT X(80))
   55*  AXIAL TILT ANGLE-IN DEGREES (INTEGER NUMBER 99)
   56*  AXIAL TILT ORIENTATION-IN DEGREES (INTEGER NUMBER 999)
   57*  AXIAL TILT DISTANCE-IN FEET (INTEGER NUMBER 9(5))
   58*  CREST (TEXT X(80))
   59*  SIDES (NON-KEY TEXT X(200))
   70*  MAXIMUM TRUE THICKNESS OF CAP ROCK-IN FEET (INTEGER NUMBER 9999
        )
   71*  MINIMUM TRUE THICKNESS OF CAP ROCK-IN FEET (INTEGER NUMBER 9999
        )
   72*  CAP ROCK MINERALOGY (NON-KEY TEXT X(100))
   73*  CAP ROCK LOST-CIRCULATION ZONES PA (TEXT X(7))
   74*  CAP ROCK LOST-CIRCULATION ZONES INFO (NON-KEY TEXT X(100))
   75*  SULFIDE MINERALS (TEXT X(7))
   76*  GENERAL DOME INFORMATION (NON-KEY TEXT X(100))
   81*  LATERAL EXTENT OF RIM SYNCLINE-IN FEET (TEXT X(10))
   82*  LATERAL EXTENT OF DRAG ZONE-IN FEET (TEXT X(10))
   83*  MAXDIPVERTVAR1-IN DEGREES FEET (TEXT X(10))
   84*  MINDIPVERTVAR2-IN DEGREES FEET (TEXT X(10))
   85*  MAXDIPVERTVAR3-IN DEGREES FEET (TEXT X(10))
  102*  YOUNGEST FAULTED STRATA (TEXT X(30))
  103*  OLDEST STRATA ON SURFACE (NON-KEY TEXT X(100))
  110*  RELIEF OVER DOME (NON-KEY TEXT X(50))
  120*  SINKHOLES (TEXT X(7))
  121*  SINKHOLE INFO (NON-KEY TEXT X(100))
  122*  SURFACE SALINES (TEXT X(10))
  123*  CONFIGURATION OF OVERBURDEN (NON-KEY TEXT X(100))
  220*  PRODUCT STORAGE STATUS (NAME X(10) WITH MANY FUTURE ADDITIONS)
  221*  STORAGE METHOD (NAME X(10) WITH MANY FUTURE ADDITIONS)
  222*  NUMBER OF CAVERNS (INTEGER NUMBER 99)
  223*  TOTAL STORAGE CAPACITY-IN BARRELS (INTEGER NUMBER 9(9))
  420*  REGIONAL DEPTH OF BASE OF SLIGHTLY SALINE GROUNDWATER -IN FEET
        (INTEGER NUMBER 9(5))
  421*  DEPTH OF BASE OF SLIGHTLY SALINE GROUNDWATER OVER DOME-IN FEET
        (INTEGER NUMBER 9(5))
  422*  SALINE ANOMALIES IN GROUNDWATER (TEXT X(20))
  435*  GROUNDWATER IRRIGATION NEAR DOME-IN ACRES (TEXT X(50))
  445*  SURVEY NAME FOR CENTER OF DOME (TEXT X(100))
  446*  SALT BASIN (TEXT X(20))
```

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 10*  COUNTIES (RG)
   11*  COUNTYNAME (NAME X(20) IN 10 WITH SOME FUTURE ADDITIONS)
 34*  AREA STATISTICS (RG)
   35*  DEPTH OF AREA CALCULATION-IN FEET (INTEGER NUMBER 9(9) IN 34)

   36*  AREA IN SQUARE FEET FOR DEPTH OF 35 (DECIMAL NUMBER 9(9).9 IN
        34)
 60*  OVERHANG (RG)
   61*  OVERHANG INFO (NON-KEY TEXT X(200) IN 60)
   62*  OVERHANG ORIENTATION 1-IN DEGREES (INTEGER NUMBER 999 IN 60)
   63*  OVERHANG ORIENTATION 2-IN DEGREES (INTEGER NUMBER 999 IN 60)
   64*  OVERHANG AZIMUTH-IN DEGREES (INTEGER NUMBER 999 IN 60)
   65*  LATERAL OVERHANG-IN FEET (INTEGER NUMBER 9999 IN 60)
   66*  PERCENTAGE OVERHANG (DECIMAL NUMBER 9999.9 IN 60)
 90*  ANGLE BETWEEN SALT STOCK-STRATA (RG)
   91*  ANGLE-IN DEGREES (INTEGER NUMBER 999 IN 90)
   92*  DEPTH-IN FEET (INTEGER NUMBER 9(5) IN 90)
100*  ADJACENT STRATA FAULTING (RG)
  101*  FAULT DESCRIPTION (TEXT X(50) IN 100 WITH MANY FUTURE ADDITIO
        NS)
111*  DRAINAGE SYSTEMS (RG)
  112*  DRAINAGE TYPE (TEXT X(100) IN 111 WITH MANY FUTURE ADDITIONS)

150*  HYDROCARBON RESOURCES (RG)
  151*  FIELD NAME PRODUCING HORIZON (TEXT X(100) IN 150)
  152*  RRC DISTRICT (NAME X IN 150 WITH SOME FUTURE ADDITIONS)
  153*  COUNTY (NAME X(20) IN 150)
  154*  DISCOVERY DATE (NAME XXXX IN 150 WITH MANY FUTURE ADDITIONS)
  155*  FIELD DEPTH-IN FEET (INTEGER NUMBER 9(5) IN 150 WITH SOME FUT
        URE ADDITIONS)
  156*  API GRAVITY (NAME XXXX IN 150 WITH SOME FUTURE ADDITIONS)
  157*  ENVIRONMENTAL CODE (NAME X(5) IN 150 WITH MANY FUTURE ADDITIO
        NS)
  158*  ENV COMM 1 (NON-KEY TEXT X(250) IN 150)
  159*  ENV COMM 2 (NON-KEY TEXT X(250) IN 150)
  160*  ENV COMM 3 (NON-KEY TEXT X(250) IN 150)
  161*  ENV COMM 4 (NON-KEY TEXT X(250) IN 150)
  165*  CUMULATIVE CRUDE OIL PRODUCTION-IN BARRELS (INTEGER NUMBER 9(
        11) IN 150)
  170*  FIELD PRODUCTION (RG IN 150)
    171*  YEAR (NAME XXXX IN 170 WITH MANY FUTURE ADDITIONS)
    172*  GAS GROSS-IN THOUSANDS OF CUBIC FEET (INTEGER NUMBER 9(10)
          IN 170)
    173*  CONDENSATE-IN BARRELS (INTEGER NUMBER 9(10) IN 170)
    174*  CASINGHEAD GAS-IN THOUSANDS OF CUBIC FEET (INTEGER NUMBER 9
          (10) IN 170)
    175*  CRUDE OIL-IN BARRELS (INTEGER NUMBER 9(10) IN 170)
190*  MINERAL PRODUCTION (RG)
  199*  MINERAL NAME (NAME X(10) IN 190 WITH MANY FUTURE ADDITIONS)
  200*  PROD STATUS (NAME X(20) IN 190 WITH MANY FUTURE ADDITIONS)
  201*  METHOD (NAME X(50) IN 190 WITH MANY FUTURE ADDITIONS)
  202*  COMPANY (NAME X(50) IN 190 WITH SOME FUTURE ADDITIONS)
  203*  HISTORY (NON-KEY TEXT X(100) IN 190)
  204*  ENV CODE (NAME X(10) IN 190 WITH MANY FUTURE ADDITIONS)
  205*  ENV COMM1 (NON-KEY TEXT X(250) IN 190)
  206*  ENV COMM2 (NON-KEY TEXT X(250) IN 190)
225*  HYDROCARBON STORAGE CAVERNS (RG)
  226*  COMPANY NAME (TEXT X(150) IN 225 WITH MANY FUTURE ADDITIONS)
  227*  ORIGINAL APPLICANT (TEXT X(150) IN 225)
  228*  TOTAL NUMBER OF CAVERNS (INTEGER NUMBER 9(5) IN 225)
  229*  TOTAL CAVERN STORAGE CAPACITY-IN BARRELS (INTEGER NUMBER 9(9)
        IN 225)
  230*  RRC SPECIAL ORDER NUMBER (NON-KEY TEXT X(150) IN 225)
  235*  STORED PRODUCT (RG IN 225)
    236*  PRODUCT STORED (TEXT X(30) IN 235 WITH SOME FUTURE ADDITION
          S)
400*  AQUIFER WATER CHEMISTRY (RG)
  401*  AQUIFER (TEXT X(40) IN 400 WITH MANY FUTURE ADDITIONS)
  402*  TOTAL NUMBER OF WELLS SURVEYED (INTEGER NUMBER 9(5) IN 400)
```

```
  403*  LOWER NA IONS-IN MILLIGRAMS PER LITER (INTEGER NUMBER 9(5) IN
         400)
  404*  HIGHER NA IONS-IN MILLIGRAMS PER LITER (INTEGER NUMBER 9(5) I
        N 400)
  405*  LOWER SO4 IONS-IN MILLIGRAMS PER LITER (INTEGER NUMBER 9(5) I
        N 400)
  406*  HIGHER SO4 IONS-IN MILLIGRAMS PER LITER (INTEGER NUMBER 9(5)
        IN 400)
  407*  LOWER CL IONS-IN MILLIGRAMS PER LITER (INTEGER NUMBER 9(5) IN
         400)
  408*  HIGHER CL IONS-IN MILLIGRAMS PER LITER (INTEGER NUMBER 9(5) I
        N 400)
  409*  LOWER TDS-IN MILLIGRAMS PER LITER (INTEGER NUMBER 9(5) IN 400
        )
  410*  HIGHER TDS-IN MILLIGRAMS PER LITER (INTEGER NUMBER 9(5) IN 40
        0)
425*  MUNICIPALITIES USING GROUND WATER NEAR DOME (RG)
  426*  USER (NON-KEY TEXT X(100) IN 425)
430*  INDUSTRIES USING GROUND WATER NEAR DOME (RG)
  431*  INDUSTRIAL USERS (NON-KEY TEXT X(100) IN 430)
440*  POPULATION CENTERS NEAR DOME (RG)
  441*  TOWN NAME (TEXT X(50) IN 440 WITH MANY FUTURE ADDITIONS)
  442*  DISTANCE FROM DOME CENTER (INTEGER NUMBER 9(5) IN 440 WITH MA
        NY FUTURE ADDITIONS)
500*  SALT DOME DATA BASE DOCUMENTATION (RG)
  501*  DOCUMENTATION (NAME X(50) IN 500)
  502*  REPORTED YEAR (TEXT X(10) IN 500)
```

Table 4. Information on storage operations in Texas domes. Computer code to produce table shown at bottom.

NAME OF SALT DOME	CURRENT OPERATOR OF STORAGE FACILITIES	ORIGINAL APPLICANT	NUMBER OF CAVERNS	STORAGE CAPACITY IN BARRELS	PRODUCT STORED
* BARBERS HILL	TEXAS EASTERN	TEXAS NATURAL GASOLINE	27	30978000	LIGHT HYDROCARBONS
* BARBERS HILL	DIAMOND SHAMROCK	DIAMOND SHAMROCK	10	34700000	LIGHT HYDROCARBONS
* BARBERS HILL	WARREN	WARREN	29	45032000	LIGHT HYDROCARBONS
* BARBERS HILL	X-RAL	X-RAL	16	22065000	LIGHT HYDROCARBONS
* BARBERS HILL	TENNECO	TENNESSEE GAS TRANSMISSION	18	9823000	LIGHT HYDROCARBONS
* BARBERS HILL	EXXON	HUMBLE OIL AND REFINING	7	5710000	LIGHT HYDROCARBONS
* BARBERS HILL	ENTERPRISE	ENTERPRISE	13	13300000	LIGHT HYDROCARBONS
* BARBERS HILL	CONOCO	CONOCO	3	1200000	LIGHT HYDROCARBONS
* BARBERS HILL	ARCO	TEXAS BUTADIENE AND CHEMICAL CORP.	14	4914000	LIGHT HYDROCARBONS
* BETHEL DOME	BI-STONE FUEL	BI-STONE FUEL	3	9000000	NATURAL GAS
* BIG HILL	UNION	PURE OIL CO.	2	640000	LIGHT HYDROCARBONS
* BIG HILL	DEPARTMENT OF ENERGY	DEPARTMENT OF ENERGY	14	0	CRUDE OIL
* BLUE RIDGE	ABANDONED	TULOMA-AMOCO	3	0	LIGHT HYDROCARBONS
* BOLING	VALERO	LO-VACA GATERING CO.	4	10000000	NATURAL GAS
* BRENHAM	SEMINOLE PIPELINE CO.	SEMINOLE PIPELINE CO.	1	48000	LIGHT HYDROCARBONS
* BRYAN MOUND	DEPARTMENT OF ENERGY	DOW CHEMICAL	4	56800000	CRUDE OIL
* BRYAN MOUND	DEPARTMENT OF ENERGY	DEPARTMENT OF ENERGY	12	0	CRUDE OIL
* BUTLER DOME	U.P.G.	FREESTONE UNDERGROUND STOR.	3	490000	LIGHT HYDROCARBONS
* CLEMENS	PHILLIPS PETROLEUM	PHILLIPS PETROLEUM	17	5360000	LIGHT HYDROCARBONS
* DAY	ABANDONED	PURE OIL	1	0	LIGHT HYDROCARBONS
* EAST TYLER	TEXAS EASTMAN	WARREN PETROLEUM	10	4900000	LIGHT HYDROCARBONS
* FANNETT	WARREN PETROLEUM	GULF OIL	5	2428000	LIGHT HYDROCARBONS
* HAINESVILLE	BUTANE SUPPLIES	ENTERPRISE PETROLEUM GAS CORP.	3	1742000	LIGHT HYDROCARBONS
* HULL	MOBIL	MAGNOLIA PETROLEUM CORP.	11	8680000	LIGHT HYDROCARBONS
* MARKHAM	TEXAS BRINE	TEXAS BRINE	9	1800000	LIGHT HYDROCARBONS
* MARKHAM	SEADRIFT PIPELINE	SEADRIFT PIPELINE	6	7455000	LIGHT HYDROCARBONS
* MOSS BLUFF	MOSS BLUFF STORAGE VENTURE	MOSS BLUFF STORAGE VENTURE	5	0	LIGHT HYDROCARBONS
* NORTH DAYTON	ENERGY STORAGE TERMINAL INC.	ENERGY STORAGE TERMINAL INC.	2	0	LIGHT HYDROCARBONS
* PIERCE JUNCTION	ENTERPRISE	WANDA PETROLEUM AND ELLIS TRANSPORT	10	4060000	LIGHT HYDROCARBONS
* PIERCE JUNCTION	COASTAL STATES CRUDE GATHERING	COASTAL STATES CRUDE GATHERING	7	12734000	LIGHT HYDROCARBONS
* SOUR LAKE	TEXACO	THE TEXAS CO.	8	1196000	LIGHT HYDROCARBONS
* STRATTON RIDGE	SEMINOLE PIPELINE	SEMINOLE PIPELINE	4	152000	LIGHT HYDROCARBONS
* STRATTON RIDGE	AMOCO	FENIX AND SCISSON	7	5257000	LIGHT HYDROCARBONS
* STRATTON RIDGE	DOW	DOW	22	7000000	LIGHT HYDROCARBONS

```
LIST/TITLE L(18)NAME OF SALT DOME,B(1),R(30)CURRENT OPERATOR OF          +
 LIST/TITLE L(18)NAME OF SALT DOME,B(1),R(30)CURRENT OPERATOR OF          +
 ——
STORAGE FACILITIES          ,B(1),R(36)ORIGINAL APPLICANT          ,B(1),
 STORAGE FACILITIES          ,B(1),R(36)ORIGINAL APPLICANT          ,B(1),
 ——
R(7)NUMBER +OF  +CAVERNS,B(1),R(10)STORAGE  +CAPACITY +IN BARRELS,B(3),
 R(7)NUMBER +OF  +CAVERNS,B(1),R(10)STORAGE  +CAPACITY +IN BARRELS,B(3),
 ——
R(18)PRODUCT STORED   /C1,C226,C227,C228,C229,C236,OB LOW C1 WH C226 EXISTS:
 R(18)PRODUCT STORED   /C1,C226,C227,C228,C229,C236,OB LOW C1 WH C226 EXISTS:
```

Table 5. Information on rock salt and brine mining in Texas domes. Computer code to produce table shown at bottom.

NAME OF SALT DOME	MINERAL	STATUS OF PRODUCTION	REPORTING ORGANAZATION OR MINING METHOD	NAME OF COMPANY	MINING HISTORY
* BARBERS HILL	BRINE	ACTIVE	BRINE WELLS	DIAMOND SHAMROCK	
* BLUE RIDGE	BRINE	ACTIVE	BRINE WELLS	UNITED SALT	
* BLUE RIDGE	ROCK SALT	ABANDONED	SALT MINE	UNITED SALT	
* BROOKS DOME	BRINE	ABANDONED	L.S.U.-1976	UNKNOWN	1865
* BRYAN MOUND	BRINE	ABANDONED	BRINE WELLS	DOW CHEMICAL	
* GRAND SALINE DOME	ROCK SALT	ACTIVE	SALT MINE	MORTON SALT	
* GRAND SALINE DOME	BRINE	ABANDONED	BRINE WELLS	MORTON SALT	1845
* HOCKLEY	ROCK SALT	ACTIVE	SALT MINE	UNITED SALT	1929-PRESENT
* MARKHAM	BRINE	ACTIVE	BRINE WELLS	TEXAS BRINE CORP.	
* PALANGANA DOME	BRINE	ACTIVE	BRINE WELLS	P.P.G.IND.INC.	
* PALESTINE DOME	BRINE	ABANDONED	L.S.U.-1976	UNKNOWN	1865
* PIERCE JUNCTION	BRINE	ACTIVE	BRINE WELLS	TEXAS BRINE CORP.	
* SPINDLETOP	BRINE	ACTIVE	BRINE WELLS	TEXAS BRINE CORP.	
* STEEN DOME	BRINE	ABANDONED	L.S.U.-1976	UNKNOWN	1865
* STRATTON RIDGE	BRINE	ACTIVE	BRINE WELLS	DOW CHEMICAL	
* WHITEHOUSE DOME	BRINE	ABANDONED	L.S.U.-1976	UNKNOWN	

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LIST/TITLE L(18)NAME OF SALT DOME,B(4),R(9)MINERAL  ,B(4),R(10)
 LIST/TITLE L(18)NAME OF SALT DOME,B(4),R(9)MINERAL  ,B(4),R(10)
 —
STATUS OF  +PRODUCTION,B(4),R(22)REPORTING ORGANAZATION+
 STATUS OF  +PRODUCTION,B(4),R(22)REPORTING ORGANAZATION+
 —
OR MINING METHOD    ,B(4),R(18)NAME OF COMPANY   ,B(4),R(14)MINING HISTORY/
 OR MINING METHOD    ,B(4),R(18)NAME OF COMPANY   ,B(4),R(14)MINING HISTORY/
 —
C1,C199,C200,C201,C202,C203,OB LOW C1 WH C199 EQ ROCK SALT OR C199 EQ BRINE:
 C1,C199,C200,C201,C202,C203,OB LOW C1 WH C199 EQ ROCK SALT OR C199 EQ BRINE:
```

Table 6. Information on sulfur mining in Texas domes. Computer code to produce table shown at bottom.

NAME OF SALT DOME	MINERAL	STATUS OF PRODUCTION	MINING HISTORY	NAME OF COMPANY
***				
* BIG CREEK	SULFUR	ABANDONED	1925-1926	UNION SULPHUR
* BOLING	SULFUR	ACTIVE	1929-PRESENT	TEXASGULF, INC
* BOLING	SULFUR	ABANDONED	1928-1929	UNION SULPHUR
* BOLING	SULFUR	ABANDONED	1935-1935	BAKER-WILLIAMS
* BOLING	SULFUR	ABANDONED	1935-1940	DUVAL SULPHUR AND POTASH
* BRYAN MOUND	SULFUR	ABANDONED	1967-1968	HOOKER CHEMICAL
* BRYAN MOUND	SULFUR	ABANDONED	1912-1935	FREEPORT SULPHUR
* CLEMENS	SULFUR	ABANDONED	1937-1960	JEFFERSON LAKE SULPHUR
* DAMON MOUND	SULFUR	ABANDONED	1953-1957	STANDARD SULPHUR
* FANNETT	SULFUR	ABANDONED	1958-1977	TEXASGULF
* GULF	SULFUR	ABANDONED	1910-1936	TEXAS GULF SULPHUR
* GULF	SULFUR	ABANDONED	1965-1970	TEXAS GULF SULPHUR
* HIGH ISLAND	SULFUR	ABANDONED	1968-1971	PAN AMERICAN PETROLEUM CO.
* HIGH ISLAND	SULFUR	ABANDONED	1960-1962	UNITED STATES SULPHUR
* HOSKINS MOUND	SULFUR	ABANDONED	1923-1955	FREEPORT SULPHUR
* LONG POINT	SULFUR	ABANDONED	1946-1982	JEFFERSON LAKE SULPHUR
* LONG POINT	SULFUR	ABANDONED	1930-1938	TEXAS GULF SULPHUR
* MOSS BLUFF	SULFUR	ABANDONED	1948-1982	TEXASGULF
* NASH	SULFUR	ABANDONED	1966-1969	PHELAN SULPHUR
* NASH	SULFUR	ABANDONED	1954-1956	FREEPORT SULPHUR
* ORCHARD	SULFUR	ABANDONED	1938-1970	DUVAL SALES
* PALANGANA DOME	SULFUR	ABANDONED	1929-1935	DUVAL SALES
* SPINDLETOP	SULFUR	ABANDONED	1952-1976	TEXASGULF

```
LIST/TITLE L(18)NAME OF SALT DOME,B(4),R(7)MINERAL,B(4),R(10)STATUS OF +
 LIST/TITLE L(18)NAME OF SALT DOME,B(4),R(7)MINERAL,B(4),R(10)STATUS OF +
 ——
PRODUCTION,B(4),R(15)MINING HISTORY,B(4),R(30)NAME OF COMPANY          /
 PRODUCTION,B(4),R(15)MINING HISTORY,B(4),R(30)NAME OF COMPANY          /
 ——
C1,C199,C200,C203,C202,OB LOW C1 WH C199 EQ SULFUR:
 C1,C199,C200,C203,C202,OB LOW C1 WH C199 EQ SULFUR:
```

FIGURE CAPTIONS

1. Definition of diapir shape in plan view. (A) Major axis, minor axis, and major-axis azimuth. (B) Crestal area and percentage planar Area is measured by planimetry. (C) Three classes of diapir shape defined by different axial ratios.
2. Parameters describing inclined diapirs in three dimensions. These are calculated from structure-contour maps on salt.
3. Parameters describing diapir overhang. Plan view (A) defines overhang and azimuth of maximum overhang on a structure-contour map of the salt. Plan view (B) defines partial overhang. Contours are elevation below sea level. Oblique view defines overhang area, neck ara, overhang distance, and percentage overhang. Areas are measured by planimeter.
4. Qualitative classification of drainage systems above domes into five deal types as a guide to relative movement of the land surface above.