Chapter 12

The Dockum Aquifer in West Texas

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Introduction

The Dockum aquifer, classified as a minor aquifer by the Texas Water Development Board (TWDB), extends over approximately 42,000 mi^2 primarily in the Panhandle region of north Texas (figs. 12-1, 12-2). A portion of the southern tip of the aquifer extends into Crane, Ector, Loving, Pecos, Reeves, Ward and Winkler Counties in West Texas. Although the Dockum aquifer can be an important source of groundwater for irrigation, public supply, oil-field activity, livestock and manufacturing purposes, deep pumping depths, poor water quality, low yields, and declining water levels have generally discouraged its use except locally.

The purpose of this article is to present a summary of the characteristics of the Dockum aquifer in West Texas. Much of the information presented in the article was obtained from previous literature and from TWDB records.

Physiography and Climate

The area overlying the Dockum aquifer in West Texas is generally flat with a gentle slope toward the southeast-flowing Pecos River, which drains much of the region. Drainage north and east of the Pecos River typically is closed, with runoff collecting in swales, sinks and playas (Ashworth, 1990). The climate of the region is semiarid, with hot summers and mild winters (Larkin and Bomar, 1983). Mean annual precipitation in the Pecos River Valley is approximately 10 inches, and lake surface evaporation about 80 inches/yr. (Larkin and Bomar, 1983).

Geologic Setting

The approximately 2,000-ft-thick Triassic sediments of the Dockum Group that form the Dockum aquifer consist of a series of alternating sandstones and shales (Cazeau, 1962). Individual sandstone units are light to dark or greenish-gray, buff, and red, and range in thickness from a few feet to about 50 ft. The red and maroon sandy shale units that separate the sandstones range in thickness from about 50 to 100 ft.

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[1] Texas Water Development Board

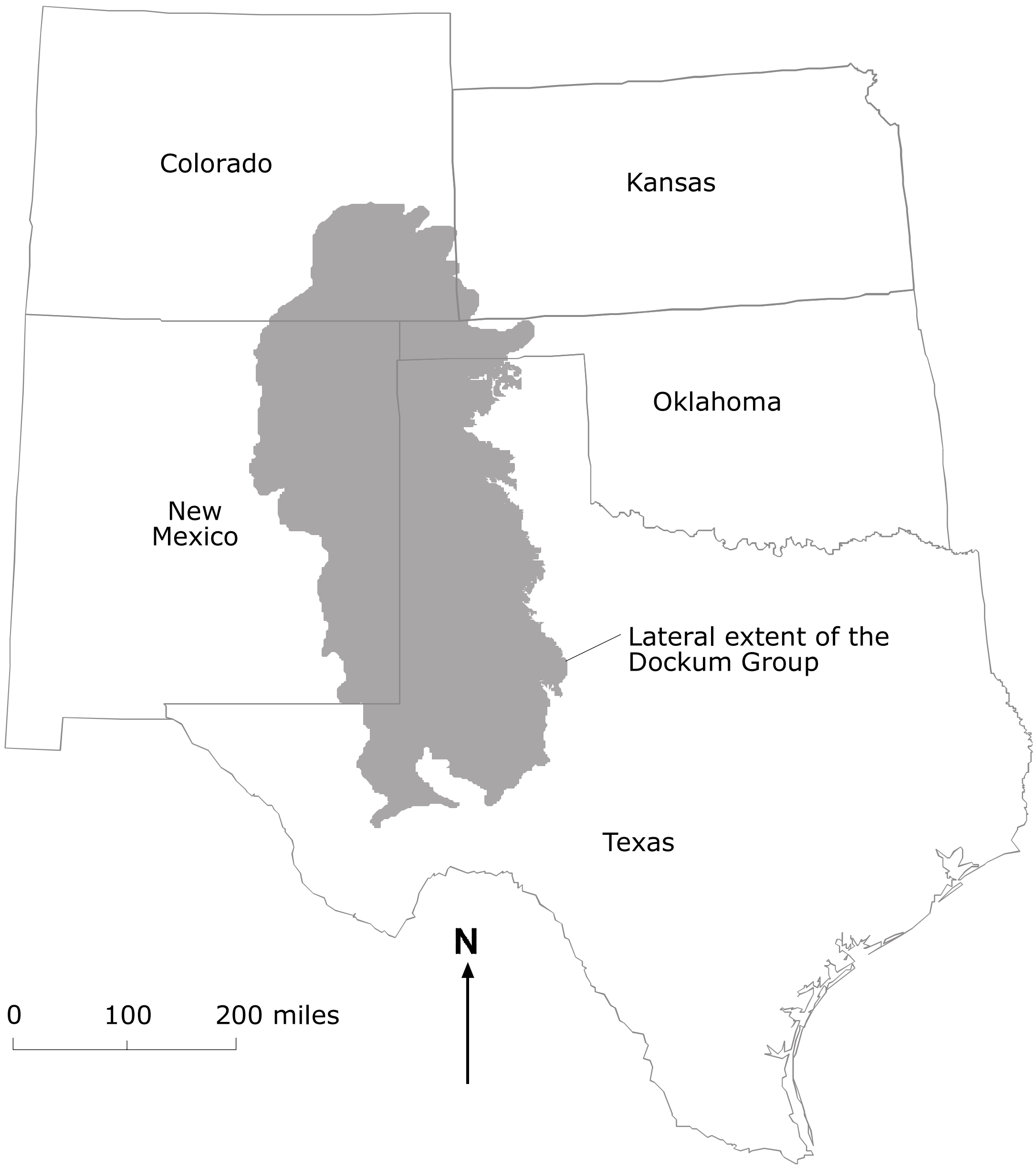

Figure 12-1: Location of the Dockum Group in Texas, New Mexico, Colorado, Kansas, and Oklahoma.

The formations within the Dockum Group (in ascending stratigraphic order) are: Santa Rosa Formation, Tecovas Formation, Trujillo Sandstone, and Cooper Canyon Formation. Locally the term *Santa Rosa* has been applied to the lower sandstone zones in the Dockum Group that may include all units of the Dockum Group except the upper mudstone.

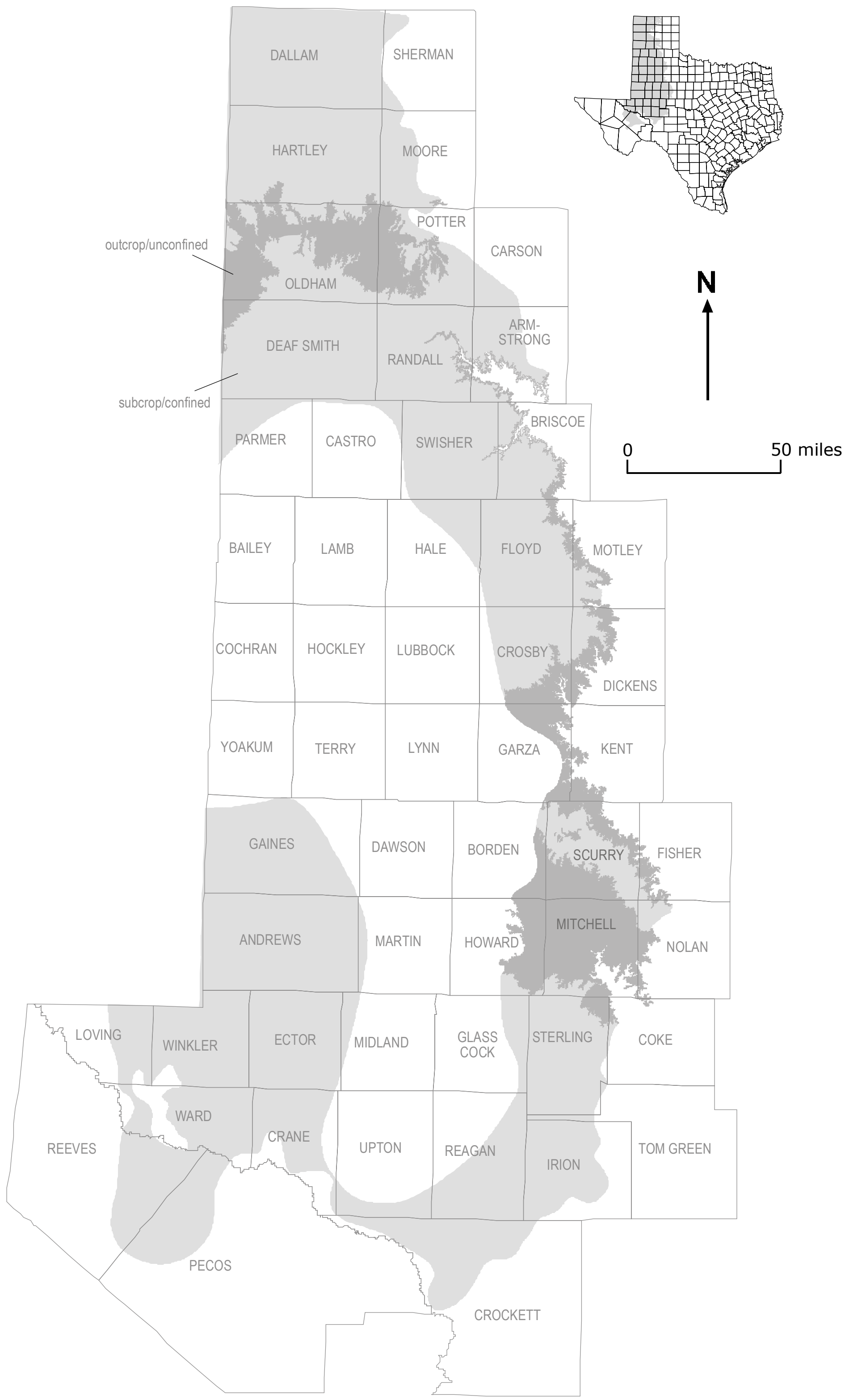

Figure 12-2: Location of the Dockum aquifer in Texas.

The basal unit, called the Santa Rosa Formation, rests unconformably on Upper Permian red beds and can be up to 130 ft thick (Lehman and others, 1992; Lehman, 1994a, b; Riggs and others, 1996). The Santa Rosa Formation is overlain by variegated mudstones and siltstones of the Tecovas Formation (Gould, 1907), which in turn is disconformably overlain by the 250-ft-thick Trujillo Formation composed of massive, crossbedded sandstones and conglomerates (Lehman, 1994a, b). The Cooper Canyon Formation consists of reddish-brown to orange mudstone, with some siltstone, sandstone and conglomerate (Lehman and others, 1992).

The Dockum Group is generally considered to represent sediments deposited in fluvial, deltaic, and lacustrine environments within a closed continental basin (McGowen and others, 1977, 1979; Granata 1981). The basin apparently received sediments from all directions, although in West Texas the source areas were primarily to the south and southwest (Fallin, 1989).

The beds of the Dockum Group are essentially horizontal, with very gentle dips toward the center of the main basin, whose axis trends approximately north-south. The dip varies considerably from location to location but is approximately 30 ft/mi (Rayner, 1963). In West Texas, the primary structural features are the Central Basin Platform in the east and the Delaware Basin in the west (Fallin, 1989).

The top of the Dockum Group is relatively flat and reflects the final filling of the Dockum Basin and the effects of postdepositional erosion. The opening of the Gulf of Mexico in the Cenozoic Period tilted the entire region toward the southeast.

Hydrogeology

Recoverable groundwater in the Dockum aquifer is contained within the many sandstone and conglomerate beds that are present throughout the sedimentary sequence. The coarse-grained deposits form the more porous and permeable water-bearing units, whereas the fine-grained sediments form impermeable aquitards (Fallin, 1989). Consequently, the better groundwater flow zones are developed in the lower and middle sections of the stratigraphic sequence, where the coarse-grained sediments predominate. Locally, any water-bearing sandstone within the Dockum Group is typically referred to as the Santa Rosa aquifer. In the Pecos River Valley, the Dockum aquifer is usually known as the Allurosa aquifer (White, 1971).

In West Texas, the Dockum aquifer overlies Permian-age beds and is overlain by the Cenozoic Pecos Alluvium. The aquifer typically is under confined or partially confined conditions where Dockum Group sandstones are in contact with the Cenozoic Pecos Alluvium.

Water Levels and Groundwater Flow

Potentiometric maps drawn from water levels measured by the TWDB between 1981 and 1996 indicate that groundwater flow in the Dockum aquifer in West Texas is generally to the southeast. Hydrographs of wells located in Crane, Ector, Loving, Reeves, Ward and Winkler Counties show a variety of water-level fluctuations. In Loving, Ector and Reeves Counties, the water table appears to have declined markedly whereas in Ward and Winkler Counties, it has remained relatively stable or has declined only slightly. The most significant water-level decline (almost 85 ft) was recorded in well 28-39-401 in Ector County. The decline presumably was the result of pumping in a nearby municipal water-supply well.

Recharge

The Dockum aquifer is recharged by precipitation over areas where Dockum Group sediments are exposed at the land surface. Groundwater in the confined portions of the Dockum aquifer most likely originated as precipitation that fell on outcrops in eastern New Mexico. This recharge ceased when the Pecos and Canadian River Valleys were incised during the Pleistocene between the present-day Dockum aquifer in Texas and the paleo-recharge areas to the west (Dutton and Simpkins, 1986).

The Dockum aquifer is also recharged by upward leakage from the underlying Permian aquifer (Bassett and others, 1981; Bentley, 1981; Wirojanagud and others, 1984; Orr and others, 1985). Downward leakage into the Dockum aquifer occurs from the overlying Cenozoic Pecos Alluvium as a result of hydraulic-head differences between the aquifers (Dutton and Simpkins, 1986; Nativ and Gutierrez, 1988). Estimated annual recharge for outcrop areas and other areas in contact with overlying aquifers for the entire Dockum aquifer in Texas is approximately 31,000 acre-ft.

Aquifer Properties

The hydraulic properties of the Dockum aquifer vary considerably from location to location. In West Texas, well yields measured by the TWDB ranged from approximately 23 gallons per minute (gpm) in Crane County to 353 gpm in Reeves County. Similarly, specific capacity ranged from 5.3 (Wink County) to 25 (Reeves County).

An aquifer test conducted on City of Kermit wells (Winkler County) by the TWDB in 1957 yielded an average transmissivity of 4,600 ft^2/day. These wells are completed in the Santa Rosa Sandstone that was described by Garza and Wesselman (1959) as a massive sandstone unit of limited areal extent. The storage coefficient was approximately 2.5×10^{-4}, which suggests that the aquifer in the test area is confined to partially confined.

Groundwater Quality

Groundwater in the Dockum aquifer generally is of poor quality. It is characterized by decreasing quality with depth, mixed types of water, concentrations of total dissolved solids (TDS) and other constituents that exceed secondary drinking water standards over most of the area, and high sodium levels that may be damaging to irrigated land.

The chemical quality of water in the Dockum aquifer in West Texas ranges from fresh (TDS <1,000 milligrams per liter [mg/L]) in outcrop areas to moderately saline (TDS between 3,000 and 10,000 mg/L). Fresh water generally is present only at the edges of the Dockum basin, especially in outcrop areas where the aquifer is recharged. TDS ranges from 473 mg/L (Winkler County) to 4,040 mg/L (Reeves County). Water from the Dockum aquifer is typically hard, with $CaCO_3$ concentrations ranging from 203 mg/L (Ector County) to 1,394 mg/L (Crane County).

Where overlain by the Cenozoic Pecos Alluvium, groundwater in the Dockum aquifer is characterized by Ca-SO_4-mixed-anion-type waters. Groundwater samples collected from Ector County had gross alpha particle concentrations of 6 to 23 picocuries per liter (piC/L). The MCL established by the Texas Natural Resource Conservation Commission for gross alpha particle activity limit is 15 piC/L. Groundwater samples from Crane County had maximum radium-226 and radium-228 concentrations of 6.8 piC/L and 5 piC/L, respectively. The MCL for combined radium-226 and radium-228 is 5 piC/L. The occurrence of uranium in the Dockum Group has been known for years (McGowen and others, 1977) and is the source of the high concentrations of radium-226 and radium-228 detected in the groundwater samples.

Sodium in groundwater is a constituent that has neither an MCL nor a secondary standard but is still a concern where the water is used for irrigation purposes. Sodium adsorption ratios higher than 18 (which typically result in excess sodium in the soils) were detected only in groundwater samples from Ector County. These same samples also had residual sodium carbonate (RSC) values greater than 2.5 meq/L, suggesting that the water was not suitable for irrigation.

Discharge

Discharge of groundwater from the Dockum aquifer occurs at pumping wells, small springs that contribute to stream base flow in the outcrop, evapotranspiration, and cross-formational flow. The greatest amount of discharge occurs from the pumping of wells installed in the aquifer.

Irrigation and public supply use is limited to areas of the Dockum aquifer where the water quality is acceptable, depth to water is shallow, and a sufficient thickness of sandstone exists to make the aquifer productive. Municipal users of Dockum aquifer water include the cities of Barstow, Kermit and Pecos. The Colorado River Municipal Water Authority also uses water from the Dockum aquifer.

Springs occur in areas where the Dockum sediments intersect the water table. Brune (1981) described springs issuing from the Dockum aquifer along the Pecos River Valley. Many of these springs are now dry or have lower flows than they did in the past.

Conclusions

The Dockum aquifer in West Texas occupies a relatively small area and is only locally important where sufficient sandstone thickness and acceptable water quality are present. High TDS concentrations and salinity limit its use for many purposes.

Recharge of the Dockum aquifer only occurs in areas where the sandstone units are exposed at the surface or are in contact with overlying aquifers. However, since much of the Dockum aquifer in West Texas is confined, it receives little recharge so any water withdrawn from it is not immediately replenished.

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Chapter 13

Igneous Aquifers of Far West Texas

Andrew Chastain-Howley[1]

Introduction

The igneous aquifers of far west Texas are currently under review for a study financed by the Texas Water Development Board (TWDB). This study is analyzing the igneous aquifers in the tri-county area of Brewster, Jeff Davis, and Presidio Counties (fig 13-1). The igneous units also extend into southern Culberson County and southern Reeves County, but their extent is small compared with that of the other three counties.

The overall area covered by the igneous aquifers exceeds 5,000 mi^2, and the greatest measured depth of these units is 6,032 ft just north of Valentine. The average thickness of the igneous units is probably over 1,000 ft.

Igneous Aquifers Geology

The Igneous aquifer is not a single aquifer like the Ogallala or Edwards aquifers. The Fort Stockton, Marfa, and Emory Peak-Presidio sheets of the Geologic Atlas of Texas show over 40 named volcanic units (table 13-1), not counting those in Big Bend National Park. Many of the units have been subdivided by more detailed mapping. "Igneous aquifers" would be a better name and should include the entire area where volcanic rocks crop out or are present beneath the alluvial cover—approximately 5,000 mi^2.

These volcanic rocks were formed mainly within the Tertiary Period between 39 and 31 million years ago (Ma). The approximate extent of these volcanic eruptive units and their respective chronology are shown in figure 13-2a through 13-2c. The volcanic rocks consist of a complex layering of vents, flows, and interbedded volcanic-sedimentary units, which were deposited in the many intervals between eruptions. This layering has led to the very complex interrelationships between the rock units. Figures 13-2a through 13-2c show the locations of the volcanic centers, which were most active in each of the main phases of volcanic activity. The most obvious trends are the main-center shifts from the south in the early phase (48 to 39 Ma), to the north in the middle phase (39 to 35 Ma), and back to the south again in the late phase (35 to 27 Ma). The overall geological map showing the surface outcrops related to these volcanic centers is depicted on figure 13-3.

[1] Water Prospecting, LLC

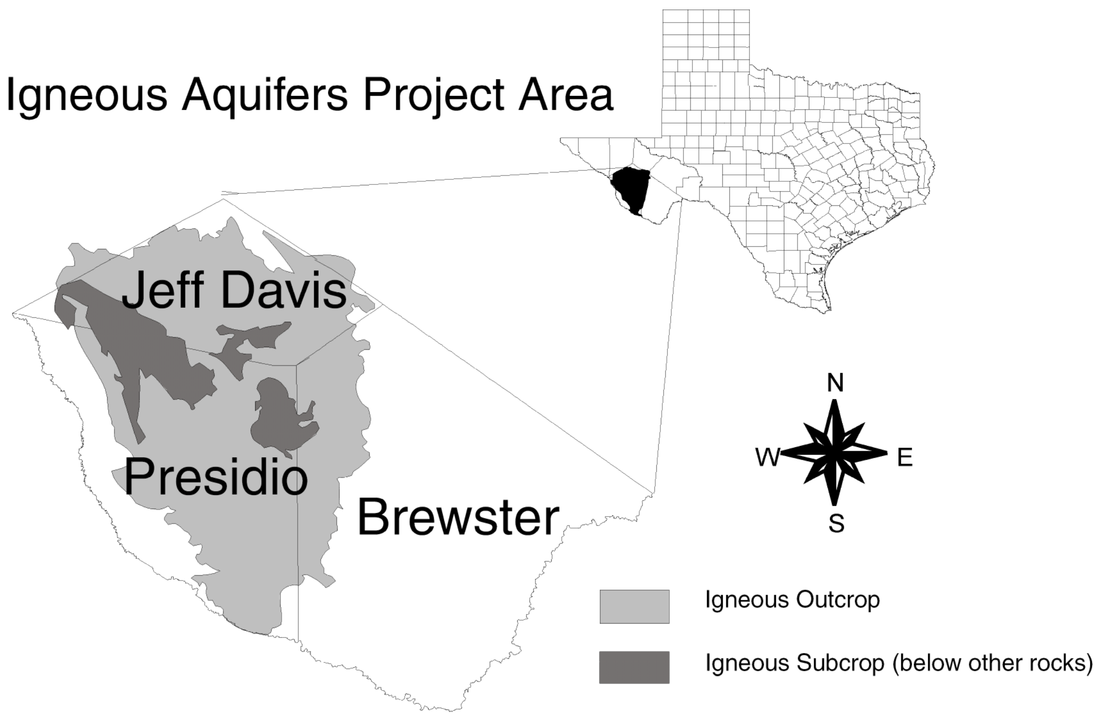

Figure 13-1. Igneous Aquifers Project Area within Brewster, Jeff Davis and Presidio Counties

The aquifers within this study area are found within three distinct geological-type aquifer units:

- **Igneous extrusive aquifers** (basalts, trachytes, rhyolites, tuffs)—generally referred to as volcanic.
- **Igneous sedimentary aquifers** (sandstone and conglomerate)—formed by the erosion of volcanic rocks and may be interbedded with volcanic units (e.g., Tascotal Formation).
- **Structurally controlled aquifers** (fault and fracture zones)—water-bearing capacity of the extrusive aquifers is generally structurally controlled. This unit refers to the improvement of the water-bearing capacity of all other units where faults and fractures occur.

The igneous geology also includes igneous intrusive rocks (these consist of the volcanic plugs and other slow-cooling igneous units). These intrusive rocks are important for

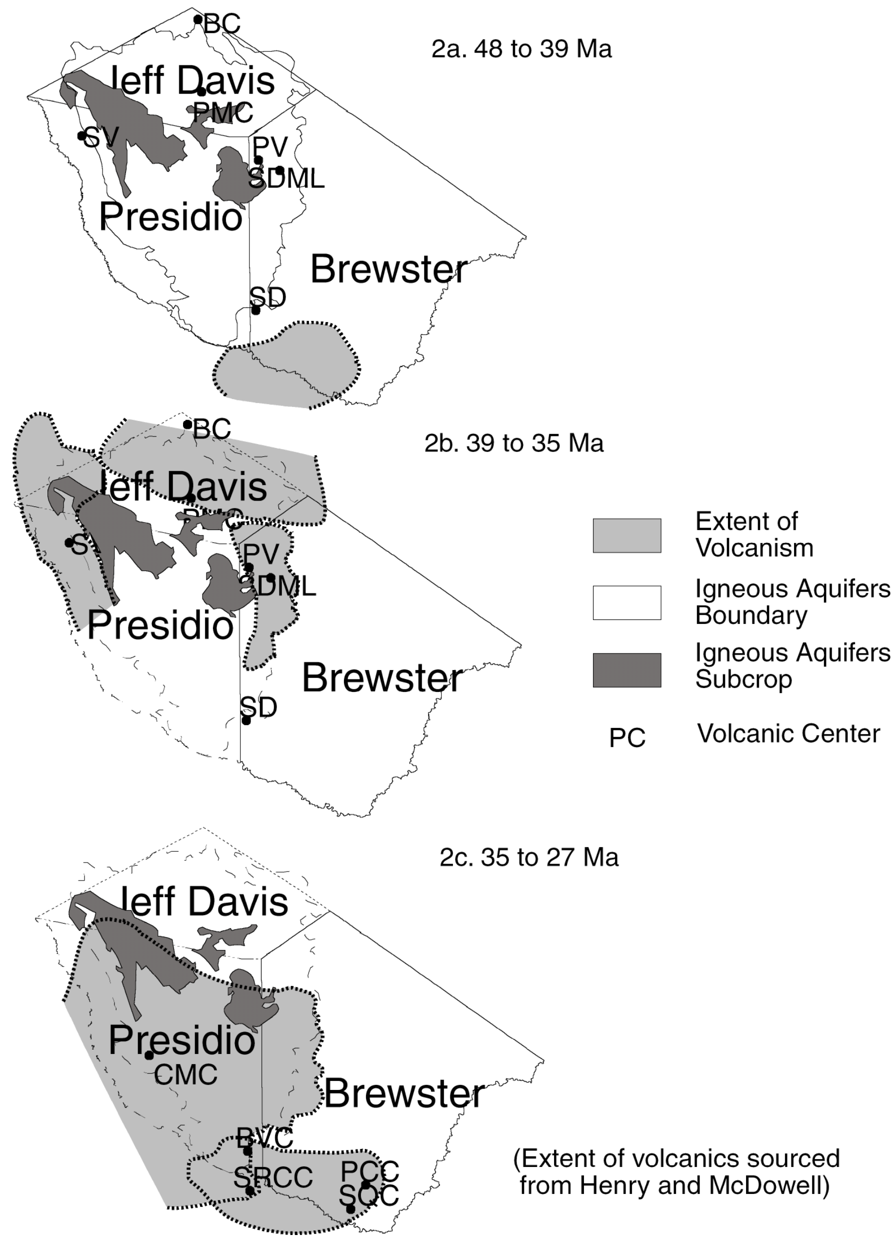

Figure 2a to 2c. Generalized history of the Trans-Pecos volcanic field (stipled pattern) separated into three phases, following Henry and McDowell (1986). 2a). Early phase consisting of Christmas Mountains Intrusions (XM) and the Alamo Creek Basalt (ACB). 2b). Middle phase consisting of Buckhorn Caldera (BC), Paradise Mountain Caldera (PMC), Paisano Volcano (PV), Sierra Vieja (SV), the Southern Davis Mountains Mafic Lavas (SDML), and Solitario Dome (SD). 2c). Late phase and early tensional phase consisting of the Chinati Mountains Caldera (CMC), the Siera Quemada Caldera (SQC), Pine Canyon Caldera (PCC), the Bofecillos Volcanic Complex (BVC), and the Sierra Rica Caldera Complex.

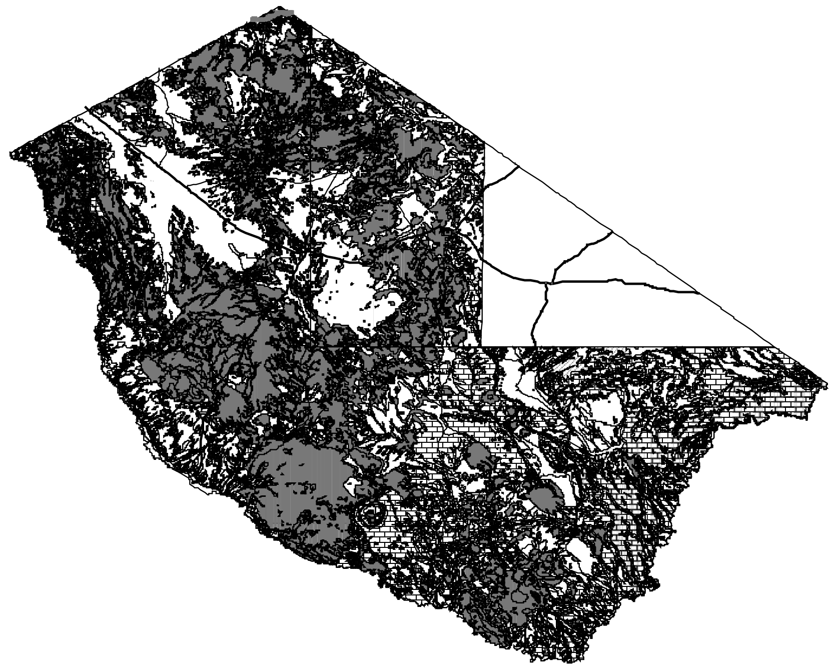

Figure 13-3: Surface geology of study area.

spring flow in certain areas but are not classed as an aquifer type because they do not have extensive storage.

The groundwater resources of the Igneous aquifers have been only cursorily studied but have tremendous potential. The entire municipal supplies of Alpine, Marfa, and Fort Davis and the supplies of the three commercial farms in the vicinity of those towns are

produced from an area of about 5 mi^2 and from at least five different volcanic aquifers. Recent studies by Brown and Caldwell (2001) suggest that much of the water in the Ryan Flat Bolson is also coming from the Igneous aquifers. Therefore, the six main groundwater supply fields are without exception pumping large volumes of water from comparatively small areas within the Igneous aquifers. This fact alone should show that there is great potential for withdrawal from these aquifers.

Igneous Extrusive Aquifers

Igneous extrusive aquifers are mainly located in interflow zones. These often include vesicular zones near the tops of flows and rubble at the base of the overlying flows. Water is also found in the cooling fractures, such as those seen in many of the outcrops in the Davis Mountains. Because the porous zones are generally separated by dense flow rocks (mainly basalt and trachyte in this area), the aquifers are usually poorly connected except in the vicinity of faults or fracture zones. The effect is similar to sand layers separated by shale layers. Even within a single formation there may be multiple interflow zones/aquifers.

Examples of this phenomenon are available from studies around the world. A British Geological Survey study from the Deccan Plateau in India evaluated the hydrogeological capacity of basalt flow layers using down-hole geophysics and pumping-test interpretation. This same methodology could be used in future studies to outline the possibilities and complexity of these Igneous aquifer systems. Studies in the Snake River Plain in Idaho also show the complexity of these systems that are from a similar time period as the Far West Texas Igneous units.

The Igneous extrusive rocks in the tri-county area are varied in content and extent (fig. 13-4). There are extrusive rocks that include lava flows, ash-flow tuffs, and detrital rocks, which include erosional rubble. Studies conducted by Woodward (1954) and Wightman (1953) outline the complexity of the igneous rocks around Valentine. Woodward recorded over 40 different lava flow or tuff units within the 6,032 ft of volcanics from the Killam oil test well.

Igneous Sedimentary Aquifers

These aquifers include both the Tertiary and Quaternary sedimentary units that have formed from erosion of local volcanic rocks. The Perdiz and Tascotal are the main aquifers that were deposited at around the time of volcanism. Quaternary bolson deposits in the Valentine area (Ryan Flats, Lobo Flats) are also made up of volcanic sediments and are therefore included in this unit as shown in figure 13-5.

Review of oil-well logs and recent studies (Brown and Caldwell, 2001) suggests that the bolson and underlying Igneous extrusive aquifers may be interconnected. Additional

work is needed, but sufficient data may be available to begin evaluating these aquifers. If, however, the bolsons are being recharged from the underlying volcanic aquifers, recharge rates may be more complicated than has been assumed. The extent and hydrologic attributes of the volcanic aquifers are likely to be the controlling mechanism. Other Quaternary alluvial deposits in general have too much clay to make good aquifers. There are reports of strong water flows from the alluvium (Sunny Glen area and southern Jeff Davis County near Point-of-Rocks) being possibly related to stream-channel deposits. However, these are generally of small areal extent.

Structurally Controlled Aquifers

The structure of the Igneous units is very complicated. The basin-and-range faulting that created the Rio Grande valley has created a number of northwest-southeast-trending structures that are highlighted in the bolson valleys and in the McCutcheon Fault Zone on the northern edge of the Davis Mountains. figure 13-6 shows the regional trends of the fault and fracture systems within the Igneous aquifers area. There are a number of springs

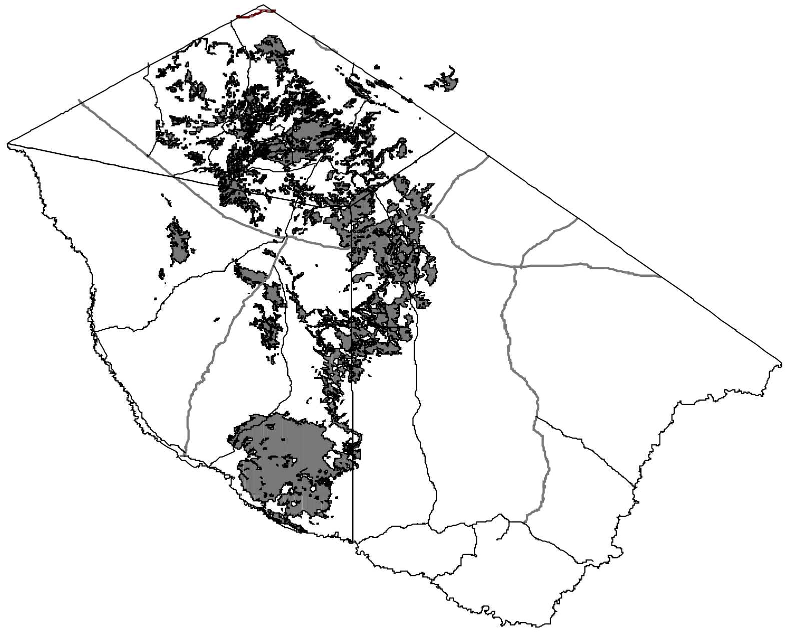

Figure 13-4 Igneous extrusive aquifer units---surface utcrop withing main study area.

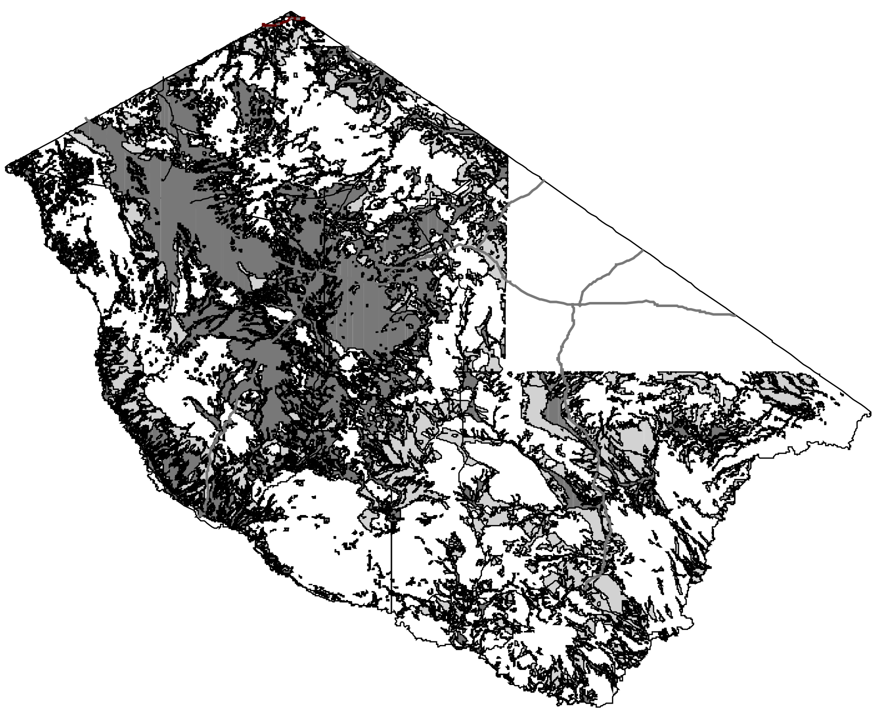

Figure 13-5 Igneous sedimentary aquifers units---surface outcrop within main study area.

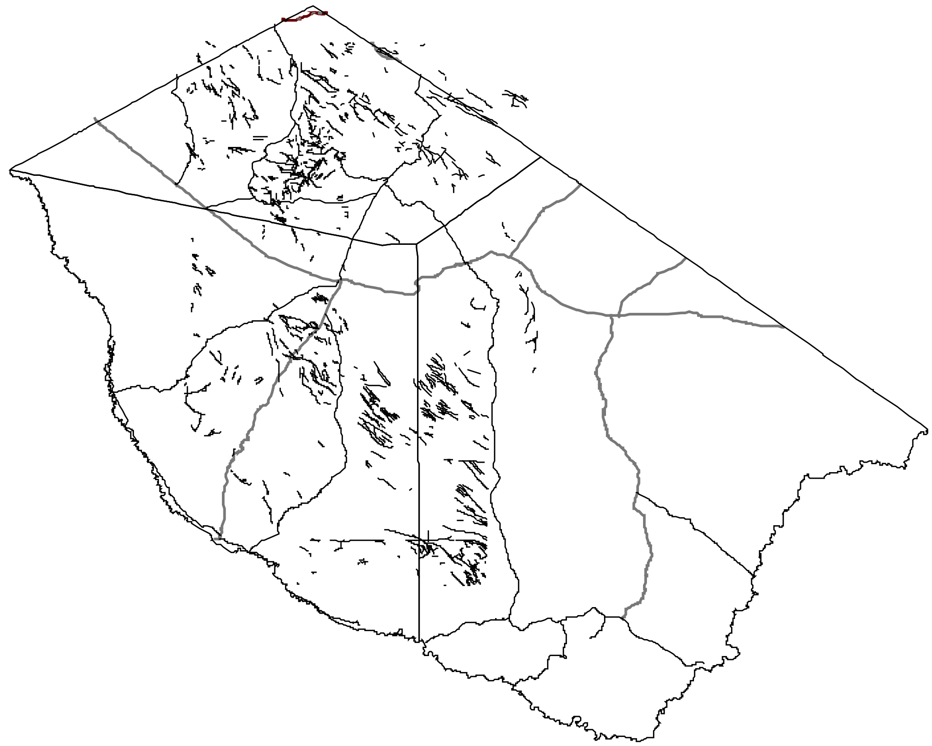

Figure 13-6: Structural features (faults) within main study area.

associated with faults and fractures, suggesting that there is hydraulic connection between units through faults.

Even today there is basin-and range-movement within the area. The area is seismically active and has produced numerous small earthquakes. The overall structural deformation sequence is well described in Henry (1998) and is not discussed in detail here. However, the main structural trends in this region are northwest to southeast, which includes the basin-and-range faulting in the Ryan Flat area and along the Rio Grande.

Subsurface Stratigraphy

The most complex geological details are those found underground. A small number of oil-well tests have been drilled through the Igneous rocks in this area, and these wells give the basic interpretation of the thickness of Igneous rocks in the study area (fig. 13-7). However, because of the large amount of faulting in this area and the scarcity of drill holes, this data should be used carefully. The outside contour line equates to a 2,000-ft thickness. Most of these oil-well tests were drilled in valleys and close to the edge of

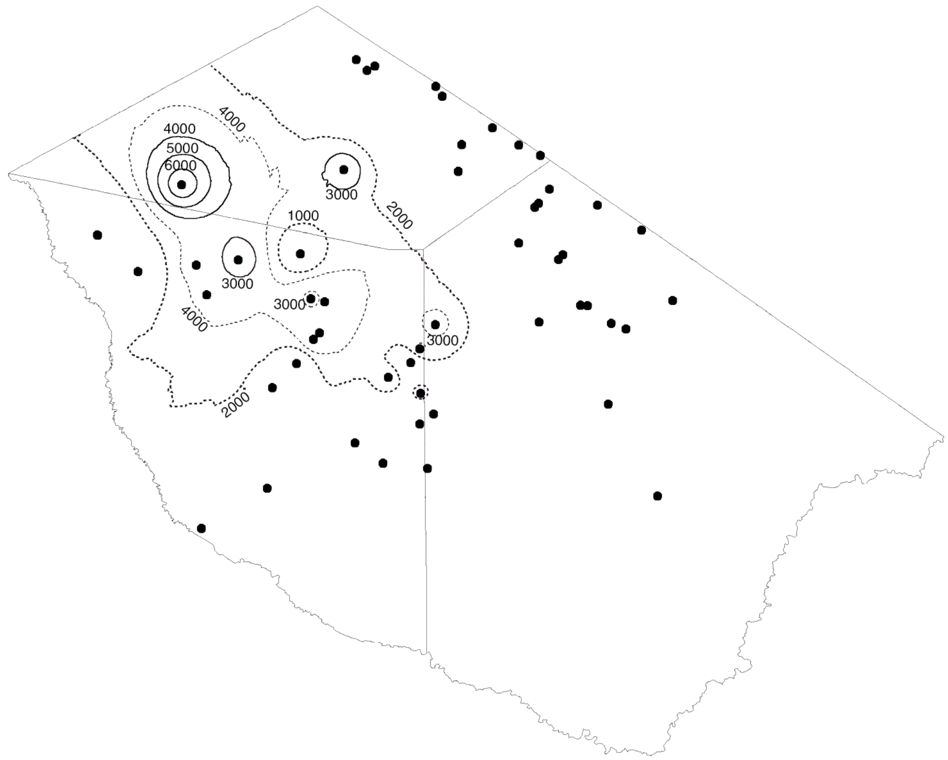

Figure 13-7: Approximate extent and depth of Igneous rocks derived from oil-well logs.

volcanic outcrops. Therefore, they will probably mask the true thickness of the igneous units (the depth is likely to be greater than that shown in figure 13-7).

Geophysical techniques are being used in this area to create a more detailed model of the subsurface. Gravity, magnetics, and remote-sensing data are currently being evaluated. In addition, all available downhole sample logs and geophysical logs are being studied to determine any gross changes in stratigraphy.

Previously published gravity data (Mraz and Keller, 1980) give an indication of the basic structural models these data can provide (fig. 13-8).

Hydrogeology

The hydrogeology of the Igneous aquifers is very complex. There are many discrete and interconnected aquifers. The faulting and fracturing prevalent in the rocks of this region also increase the chances of connection between units. Even within aquifers that are commonly thought to be comparatively homogeneous (e.g., Ryan Flat Bolson), we have determined that the flow is very complex and consists of many different flow units (over 40 different units reported by Woodward [1954]).

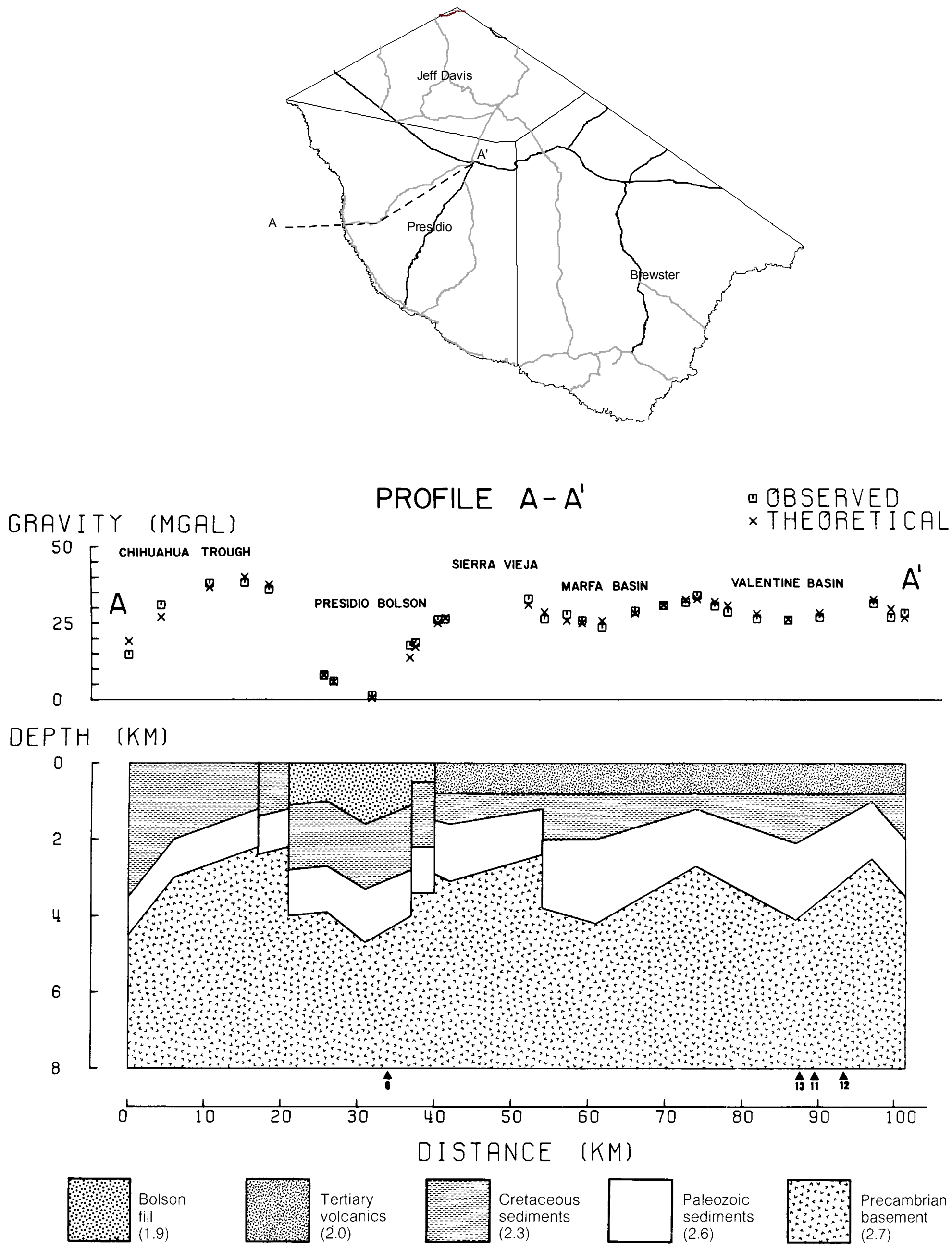

Figure 13-8: Gross estimate of the geological structure to a depth of 8 km (26,000 ft) (from Mraz and Keller, 1980).Groundwater Flow Paths

Table 13-2: Subbasin watershed areas for Brewster, Jeff Davis, and Presidio Counties.

County Basin	Subbasin	Area (mi^2)
Brewster	Alpine	273
Jeff Davis (Hart 1992)	Toyahvale	299
	Limpia	351
	Marfa	153
	Valentine/Ryan Flat	227
	Michigan Flat	206
	Kent	287
Presidio	Alamito Creek	To be determined
	Valentine/Ryan Flat	To be determined

The groundwater basin areas within Jeff Davis County were delineated by Hart (1992). The groundwater basin areas for Brewster and Presidio Counties were being analyzed at the time of publication. Current data is outlined in Table 13-2. These basins will be reevaluated after all the new water-level data are collated and organized.

All the streams in this area are losing streams and provide a recharge mechanism for the aquifers at certain locations. Many of the local landowners have reported that there are recharge zones on their properties. However, no organized delineation of these sites has yet been conducted.

Springs

There are many springs in the area, and these have been mapped approximately to determine which formations provide most of the spring flow in the region. Hart (1994) examined the springs in Jeff Davis County. An initial review by the author of the known springs as determined by the U.S. Geological Survey (from within the Igneous aquifers) in Presidio County suggests that the units listed in Table 13-3 are the most likely to produce spring flow.

Some of the discharge rates have been estimated in the area around the Davis Mountains. The rates of flow vary from 0.5 gallons per minute (gpm) to 200 gpm. The total discharge from springs around the Davis Mountains is estimated to be 1.1 million gallons per day (Hart, 1992).

Table13-3. Summary of Spring data from study area in Jeff Davis, Brewster and Presidio Counties.

Jeff Davis County (Hart 1992)		Presidio and Brewster County (Chastain-Howley 2001)	
Geological Unit	No. of Springs	Geological Unit	No. of Springs
Intrusives	7	Intrusives	19
Merrill	1	Merrill	20
Wild Cherry	3	Petan	19
Mount Locke	4	Tascotal	12
Barrel Springs	18	Perdiz	10
Sheep Pasture	3	Chinati	24
Sleeping Lion	2	Rawls	44
Frazier Canyon	13	Alluvium	29
Adobe Canyon	7	Cottonwood Springs	33
Limpia		Potato Hill	13
Gomez	7	Sheep Canyon	16
Star Mountain	25	Duff	6
Huelster	47	Crossen Trachyte	4
Alluvium	4		

The Presidio and Brewster County springs appear to be more evenly distributed across the different igneous extrusive geological units compared with springs within Jeff Davis County, where the Huelster, Star Mountain, and Barrel Springs account for the majority of flow. However, the majority of springs do appear to originate within the igneous intrusive and extrusive units rather than the alluvials.

Igneous Aquifer Water-Well Locations

The groundwater systems in this area are poorly understood. Records from wells drilled are sparse, and water-level records are not common. Basic well data include location and depths of wells and are recorded in the TWDB Water Well Database. The extent of this database after additions from the ongoing Igneous aquifers project are shown in figure 13-9. These data will be used as a baseline for further analysis of the flow and near-surface storage in future years. Further data will be available after completion of this project in October 2001.

Current known water use / Historical water use

The Far West Texas Regional Water Planning Group (which was set up in response to the requirements presented by Senate Bill 1 from the 1997 Texas Legislature) created a basic analysis of the current and projected use of each of the major water-user groups within the three counties. The data from that study is shown in table 13-4.

Table 13-4: Water use by county estimated for 2000 and 2050 (all values in acre-ft/yr).

County	Location	1996	2000	2050
Brewster	Alpine	1,147	1,524	2,461
	County Other	2,427	2,895	3,611
Jeff Davis	Fort Davis	216	236	225
	County Other	870	3,928	3,611
Presidio	Marfa	722	977	1,189
	Presidio	646	768	1,652
	County Other*	23,924	26,451	24,102
Total		**29,952**	**36,779**	**36,851**

[Note * Presidio "County Other" includes up to 17,000 acre-ft/yr from Rio Grande surface-water allocations.]

The majority of the increase in projected water use is in Presidio and Alpine. Therefore, these are the locations within the counties that will probably need to be looked at in the greatest amount of detail.

Recharge

Rainfall in the area varies from an average of 18.5 inches at Mount Locke to 11 inches at Kent. Most of the precipitation comes in the form of thunderstorms, which have their greatest frequencies between June and September. Most of the actual recharge will probably occur by direct infiltration through fractures within the rocks. This is also the case at the locations where the streams lose water to the aquifers. The amount of recharge is still a matter of great discussion. Recharge estimates range from a few thousand acre-feet per year to over 200,000 acre-ft/yr. The recharge is most likely to be somewhere between 50,000 and 100,000 acre-ft/yr over the Igneous aquifers area. However, further research is needed to verify these estimates.

Storage

Calculations by LBG-Guyton for the Far West Texas Regional Water Plan (2001) suggest that there were a total of 9 million acre-ft of recoverable water in the tri-county area from the Igneous aquifers. Of this, 3.1 million acre-ft of recoverable groundwater was estimated to be in Brewster County, 1.3 million acre-ft is estimated to be in Jeff Davis County, and 4.6 million is estimated to be in Presidio County. This has to be a large underestimate because it was calculated from data from the Texas Water Development Board, which suggest that the extent of the igneous aquifers is only 785 mi^2. The boundaries as defined by this study suggest an area of approximately 5,000 mi^2.

The storage calculation determined for the Regional Water Plan used gross assumptions for the aquifer characteristics, and further study is urgently needed to better define the systems within this area. The scarcity of data makes the assumption of storage defined here highly uncertain.

The Igneous aquifers appear to be highly compartmentalized, and the units are often not laterally continuous. Therefore, this storage would only be available over a very large area, and major withdrawals would probably be cost-prohibitive.

Water Quality

The overall quality of the water within the Igneous aquifers is excellent. The range of total dissolved solids (TDS) concentrations varies between 200 and 700 mg/L. These are all under the maximum concentration level for drinking water of 1,000 mg/L.

Availability

Current supply is able to meet demand quite easily in this region of Far West Texas (FWTRWPG, 2001). Recharge is probably greater than the overall withdrawals, so the existing system appears to be sustainable on a regional scale, as well as through the 2050 planning period.

There is a large amount of water in storage in this area, and this is the subject of great discussion regarding export of this water to population centers in need, such as El Paso. The exportation of large amounts of water will probably mean that the overall aquifer units are locally being mined. However, the complexities of the Igneous aquifers may provide areas where recharge will be concentrated enough to allow larger sustainable withdrawals and where pumping will not significantly affect streamflow. However, further study would be necessary to determine the validity of this statement.

Modeling

Conceptual and numerical modeling of the Igneous aquifers is very complicated and can currently only realistically be conducted on a gross, regional-conceptual scale. Numerical models of the Igneous aquifers have not yet been completed. Current water-level and pumping data within the area are very poor, and therefore it will be very difficult to build meaningful models with existing records. The only areas with enough data to consider modeling at this time would be the Ryan Flat area and possibly the Sunny Glen well field that feeds the City of Alpine.

The conceptual (geological and stratigraphical) models need to be created first before any regional modeling should be attempted. The models can be run, but the data are so sparse that any results may be difficult to prove.

Ongoing research will act as the first stepping stone to creating a usable database with which to determine groundwater availability through numerical modeling.

Further Study and Ongoing Research

Test wells need to penetrate the entire volcanic sequence to adequately evaluate the potential of the full igneous sequence.

As we have seen in Sunny Glen, given the right stress regime (Morin and Savage, in prep.), production can get markedly better from deeper zones within igneous aquifers. Deepening the Roberts No. 3 and the Gardner wells within the Sunny Glen well field (which had been contributing almost nothing to Alpine's supply) resulted in the wells reportedly becoming the principal sources of water in Sunny Glen. The Lewis well found a small flow in the main trachyte aquifer but was deepened into the underlying basalt where a strong (350–500 gpm) flow was encountered. This well is currently not connected to the city supply because of the improved production from the other wells. Most water wells stop at the first water sufficient for the user's purpose (municipal wells may go past weak flows; private wells usually do not). Further exploration in this area would enhance the conceptual and stratigraphic knowledge to aid with studies in other igneous aquifer units in this region.

Initial analysis of well cuttings from the Killam oil-test well suggests that examination of the cuttings from the deep oil tests may be valuable in determining the stratigraphic and hydrogeological variations in the Igneous aquifers.

The University of Texas at El Paso (UTEP) in conjunction with WPR Consulting is currently conducting research of the area using geophysical methods to help determine the structure and extent of the Igneous aquifers. Data of satellite imagery and gravity and magnetics profiles should be available for interpretation and discussion in fall 2001.

There are many other areas of study that could be addressed in this section. The Igneous aquifers are the least-studied aquifers in this region and even just the collection of basic hydrogeological data such as water-level and production data will be valuable. In my opinion, these aquifers have the most potential to gain from more in-depth studies than any of the other aquifers in Far West Texas.

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