Walter Scott Adkins Collection, Center for American History, The University of Texas at Austin. Cuatro Cienegas, Coahuila - Water Resources. COL2/M320 AR89-194. December 1920.

2. AREA EXAMINED

is geological examination primarily referred to the areas comprised n the Ramon Villars property, of which the water rights have been acquired by Messrs. O'Hea and Kennedy, and the land of Jose M. Vilars and a southern strip of the land of Francisco Vilars, of which the options to the water rights are held by Messrs O'Hea and Kennedy. These lands are located about 20 km. south and slightly east of south of Cuatro Cienegas, Coahuila, along the east foot of the Sierra de San Marcos. In addition, a sufficient geological examination was made of the west side of this ridge and of the east side of the valley in which the leased land is located, to determine the trend and the general composition of the faulting in this region. The examinations occupied about ten days in December, 1920.

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3. TOPOGRAPHY AND GEOLOGY OF THE SURROUNDING LANDS

Topographically this territory is a portion of the Cordilleran or Rocky Mountains foothills country, and consists of long, roughly parallel, steeply tilted anticlinal ridges separated by alluvial-covered valleys. This type of topography is common in Trans-Pecos Texas and Western Coahuila, and presents many geological similarities wherever it occurs.

The valley in which the land in question lies is a gently sloping wide valley bounded on the west by the steep Sierra de San Marcos and on the east by the parallel range known as La Purisima. The slope of the valley is to the north and slightly east of north, and the drainage (from springs) is naturally in that direction, and empties from the valley eastward through the Puerta de San Juan, near the station of San Juan. At its northern end the valley is wider and lower, and formerly contained several swamps, of which all but one are now drained leaving a typical "salt flat", with white surface incrustations of various sodium and potassium salts, calcium carbonate (in the form of loose caliche), etc.

The San Marcos Range ends abruptly in the alluvial-covered plain at a point about 10 km. slightly west of south from Cuatro Cienegas, by a change of direction in the dip of its strata, producing doming, whereby the strata which south of this point have been trending nearly north-south now plunge down into the alluvial plain around the whole north end of the San M---

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creates a synclinal valley running roughly east-west, at the north end of the San Marcos range, and in this valley the railroad from Cuatro Cienegas runs west through the Puerta de Jora and thence to Sierra Mojada. Curiously, this synclinal valley is bounded on its north by a tall anticlinal cross range, the Sierra de Anteojo, which thus has a course nearly at right angles to that of the Sierra de San Marcos and other north-south ranges.

Theeeast side of the Sierra de San Marcos consists of visible strata dipping eastward from the crest of the range at low angles (up to 16°), and the north end has variable low dips (up to 12°). The west slope on the other hand, has mainly steep dips, which beginning as gentle dips (12°) at the northwest end increase southward (12°-60°) for several kilometers, and finally in the neighborhood of the wax factory are in part overturned (110°); this feature is directly connected with the major faulting of this locality, as is explained later. The overturned dips are accompanied by a parallel-trending large fault, which gives rise to considerable springs. The Sierra de San Marcos is thus an anticlinal ridge and the slopes of the sides correspond to the dips of the limestone strata; the ridge was produced by a lateral or an upward thrust (probably the former) which elevated the strata in the central part of the ridge several hundred feet above their levels at the two bases of the ridge, and the dislocation and adjustment from this thrustare responsible for the breaking of the strata at the bases of the ridge, which produced the parallel faults and the resultant springs.

The valley to the west of the Sierra de San Marcos is likewise an alluvial valley with a considerable depth of alluvium, but beneath this the underlying strata are gently rising to the west. This rise westward, which is seen already to begin in the small block of strata just west of the main fault on the west foot of the ridge (near the wax factory), is seen to continue to the horizon inn the foothills to the west of this valley.

Turning now to the range--La Purisima--lying just east of the leasdd land, this range is seen to be an eroded anticline with the upper beds of the west limb removed by erosion. On its west slope it has a west dip, as seen at San Pablo, and on its east slope it has a variable east dip. Indeed this is the general type of structure of all the ranges between Cuatro Cienegas and Monclova, a fact which is readily ascertained from the train.

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This ridge at its north end, towards the Puerta de San Juan, decreases in height and becomes more irregular in its trend, turning in a more easterly direction; these changes of direction are partly erosional and partly structural.

4. SUMMARY OF THE GEOLOGY OF THE AREA

A. The Geological Section:

Two general classes of materials are found in the area under consideration:

(1) Limestones and Conglomerates, Sandstones and other massive rocks:----in the MOUNTAIN RANGES

(2) Caliche, tepetate, piedra tosca, soil, sand, gravel and boulders:----in the VALLEY ALLUVIUM.

The first class is marine sedimentary rocks of Cretaceous age and was deposited horizontally before the occurrence of the earth movements which resulted in the formation of the mountain ranges. The second class is recent or in part doubtfully Pleistocene land and fresh-water deposition, and has been spread over the valleys through being brought down from the weathered and disintegrating mountains; this process is constantly going on, as the large alluvial fans at the mouths of the present-day canyons demonstrate. The first class of rocks is subject to the folding already described, which has produced in it anticlinal structures in the ridges and synclinal structures in the valleys. The second class of materials is only recently deposited, and lies almost horizontal in the valley. This material has one characteristic feature: its assortment. Upon being deposited it was assorted, so that the largest boulders and gravel generally lie close to the ridges and the finer material lies nearest to the center of the valley. This has a bearing on water accumulation.

SECTION OF CRETACEOUS STRATA IN SIERRA DE SAN MARCOS:	Thickness Feet	Age
Massive bedded, indurated, somewhat magnesian cavernous limestones, sparsely fossiliferous, containing locally rudistids, Hippurites, Gryphea, echinoids, Ostrea and other shells......	400	CENOMANIAN
Softer, whiter, thinner bedded limestones, with abundant Chondrodonta.........................	25-	ALBIAN (?)
Massive cavernous limestones, no fossils seen.....	300	APTIAN
Conglomerate and Sandstone........................	550	NEOCOMIAN (?)

In the hill at San Pablo, Limestones, thin bedded and marly and carrying fossils which indicated their probable Cenomanian age were found. The fossils (poorly preserved) are: Hemiaster, Ostrea, Nucula, Tapes, Turritella, etc., species indeterminate.

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B. Geological Structure:

The structure in this region may be summarized in four general groups: Anticlines, Monoclines (Terraces), Synclines and Faults. These are, briefly, from west to east across the region, as follows:

(1) Monoclinal mountains west of Sierra de San Marcos:

The large and scattered group of ridges and hills lying west of the Sierra de San Marcos, and possibly the country west of these have a general monoclinal structure, with eastward dip. The Cretaceous system of rocks, known from localities on the west border of Coahuila and in Durango descends in elevation eastward, throwing its water horizons at a lower level, and plasing the water under increased pressure, as has already been described. Probably this monocline is unbroken by faults and fissures, since the area traversed has no springs. The east end of this monocline is seen as it ends in the synclinal valley just west of the San Marcos Range.

(2) Syncline west of Sierra de San Marcos:

The valley to the west of this range is a syncline covered with caliche and alluvium. Several large pozos lie near the east edge oft the valley, not far removed from the large fault at the west foot of the San Marcos Range. A large laguna collects some of the water and is itself drained by the San Marcos River. Near the wax factory there is a block of strata consisting of a westward-projecting hill of basal conglomerate, which lies between the main fault and a small subsidiary fault. This block next to the subsidiary fault, shows a slight east dip due to drag.

(3) San Marcos ~~West~~ Fault:

This main fault, with an unknown displacement and a downthrow to the west, traverses the west foot of the San Marcos Range on its northwest side, and farther south cuts farther up on the mountain. To the south the strata on the east side of the fault are steeply tilted, as the photographs show.
It is not improbable that there is further secondary faulting besides the small subsidiary fault mentioned. This is made more probable by the fact that some of the more northern large pozos are located to far west of the main disturbance, unless they sh should happen to have long solution channels. Short superficial solution channels for underground water in the caliche deposits have been noted here.

This fault is perfectly visible and its connection with the large amount of water issuing in this valley is obvious.

(4) San Marcos Anticline:

As previously explained, the Sierra de San Marcos is an asymmetrical anticline, with the steeper dips to the west. This anticlinal structure is deep seated, and water migrating down to this region from farther west naturally has to follow the foldings of the strata unless they find solution channels in the rock. This does not mean that the interior of San Marcos contains water; that depends upon the depth at which the water bearing strata occur. The San Marcos ridge contains a vertical thickness of strata equal to its height at the crest of the anticline--roughly say 1200 feet--none of which is exposed in the valley.

The axis of this anticline is roughly northwest--southeast, and is parallel to the major folding as seen in the vast majority of the ridges in Coahuila. (Sierra de Anteojo and a few other ridges are local exceptions to this type of folding.) See Geographical Map of Coahuila (photograph).

(5) San Marcos Terrace and Subsidiary Structures:

A terrace is a small shelf or even a hump (or anticline) on evenly sloping surface (monocline). If it is a hump it is said to have closure, as indicated by an elevation contour.

On the east slope of the ridge is a structure which begins at the northeast end of the ridge as a very slight monoclinal flexure, but on going south increases in intensity, until finally opposite the leased land it has closure of about 1 or 2 meters. South of this point the new anticline formed increases its amount of closure so that to the south the ridge becomes structurally split into two, with a synclinal valley between them. This valley is plainly visible, high up on the ridge, from the settlement of O'Hea and Kennedy. Naturally therefore this anticline is separated from the main body of the ridge farther west, by a distinct syncline, which towards the north is gradually obliterated.

(6) San Marcos East Fault:

This fault was not seen at any place, but is indicated by the large springs which appear near the east foot of San Marcos, in a relatively straight line, and particularly by the hot springs, which distinctly indicate faulting. This straight line is not parallel with the east foot of the range but diverges from it on going south.

(7) Synclinal Valley east of the San Marcos Range:

This valley is covered with alluvium, which obscures the geological structure. It is therefore impossible to say, without well logs, at what point the strata which are dipping east straighten out and start rising east, like the rocks seen on the east side of this valley.

(8) San Pablo Monocline and Fault:

This structure, lying along the west foot of La Purisima, at the village of San Pablo, has been described. The monocline passes southwards into a fault, from which springs issue.

(9) Purisima Anticline:

From the valley near the leased land, La Purisima has the appearance of a truncated anticline. The upper strata have eroded into a tall cliff face, but the lower strata show that the dip at San Pablo is west, towards the valley. The axis of this range is northwest-southeast, and parallel to the general Coahuila folding.

(10) Sierra de Anteojo and Sierra de Menchaca:

These ridges, lying north, northwest and northeast of Cuatré Cienegas are folded transversely to the other ridges. They are anticlinal at least in part. This region was not investigated. They are separated from the northwest-southeast trending ridges by synclinal valleys, and probably are faulted at their bases.

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5. PRINCIPLES OF WATER ACCUMULATION

The geological features of water supply can be briefly defined as follows:

The Sierra de San Marcos is a nearly straight anticlinal ridge with its axis trending west of north and east of south. This means that instead of its rock beds (strata) lying horizontally as they were originally deposited in the sea bottom, the strata were uplifted along the central axis or crest of the range, and from this high point each individual stratum dips toward the valley on each side of the range and finally plunges beneath these valleys. The dip is relatively slight (12°-17°) on the east flank of the ridge, and is steep (20°-110°) on the west flank.

This group of rocks which composes the Sierra de San Marcos dips eastward under the valley on which the land in question is located and at some concealed and undetermined point beneath the valley begins to rise again so that as it continued into the Sierra de la Purisima it is dipping gently (12°) to the east. These rocks therefore form a synclinal trough (or syncline) in the valley between the two ranges.

(The photographs will show clearly the dip of these rocks).

A fault is a vertical break in a sheet of rock, produced by unequal stresses (of weight, pressure, etc) on either side of the break, by which the portion on one side sinks or the portion on the other side rises. The portions are called fault blocks.

Faulting is generally (almost universally) associated with disturbances such as have given rise to the folding into anticlines and synclines seen in this regions. The amount of vertical displacement is called the throw of the fault. For purposes of water migrationsalong faults, the amount of throw is immaterial, so long as a definite fissure is produced by faulting; the throw may be only a few feet, but it has nevertheless produced a sharp break through which artesian water under pressure may ascend.

Underground water occurs in sheets or in streams. It occurs in streams only very rarely and under special conditions, as for instance, in a cavernous limestone, in which solution channels have been formed by water under artesian pressure. These solution channels are formed when water in "sheets" (i.e., in pervious strata - sand, etc - inclosed

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between impervious strata) encounters a region of greater solubility and dissolves gradually an irregular and usually short channel. This phenomenon is frequent in caves and along fault lines. The limestones underlying the Sierra de San Marcos are of this character as shown by their cavernous and jointed condition at the surface. (See photographs of caverns).

A digression at this point is relevant. It may be asked, Why do these limestones not have such water from solution channels appearing at the surface at numerous places? The answer is; Only the solution channels which are connected with pervious water-bearing layers can release water. Not all caverns in these limestones are present day solution channels; some are due to expansion and contraction from heat, cold, frost and rain; some are enlargements by cleavage of joint cracks produced originally by earth movements; some are ancient solution channels whose source is now removed by erosion. In general only those solution channels in close proximity to faults are water-bearing. The Edwards and Glenrose limestones in Central Texas expose large cavernous bluffs from which no water emerges; yet in other locations the same strata underground are water-bearing.

Underground water occurs principally in sheets, or in water-bearing strata of sufficient porosity to allow the water to pass.

This water is collected by the same stratum at its outcrop on the surface, and follows the stratum underground through the pressure of the water behind it from the same source. It follows therefore that if this water is not to be diffused in all directions the porous stratum must be confined by impervious strata above and below. Under these conditions the water collects under greatest pressure in the structurally lowest spots, i.e., in synclines. (Oil and gas through hydrostatic pressure from below, collect in the structurally highest spots, anticlines, and domes, since they float on the water. If the water is absent they collect in synclines by gravity, like water).

Underground artesian water is therefore under water pressue, and while it is not in actual motion within its reservoir, it will be forced upward by hydrostatic pressure, where it finds any opening in the strata, as a fault, solution channel, well boring, etc.

Under these conditions it may be asked: Why does not water emerge over the whole length of a fault instead of at one spot? The answer is various. The fault may be mechanically or chemically

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(by re-solution) seal d at most places. The fault at most places may have an amount of displacement such as seals the pervious stratum internally by faulting an impervious stratum against it. Solution channels may be favorably developed only locally. Finally, a fault may show seepage or moist areas over a considerable distance, but give rise to springs only locally. (In case of a caliche cover this would be invisible).

It is evident then, that in an artesian water area, fault springs are to be investigated for their water output and if this is not suitable for any reason, they are to be used as indicators of faulting and as information ~~fax~~ leading to the location of the best sites for drilling.

The rainfall of this region is negligible, and is inadequate for our purposes.

The available water possibilities of this region are three in number:

(1) Springs of various classes, and the streams flowing from them;
(2) Seepage water, such as is found in shallow canals;
(3) Artesian water, as encountered in drilling or tunnelling.

(1) Springs.

An examination of the region was made to determine the geological reasons for the existence of springs where they are located. The springs at both bases of the Sierra de San Marcos, at the west base of La Purisima, and in the intervening valley, are of two main classes.
(a) There are springs rising directly from fissures in the underlying rocks, which are known as fissure springs or fault springs. With these are classed certain springs at which the fault or fissure was not directly observed, but which there is good reason to believe lie on or very near such faults.
(b) The greater number of springs are springs situated below these fault lines, and deriving their supply from water which has seeped through the caliche sand and gravel of the valley floor and come to the surface in scattered springs, mainly at lower lvels. These may be called seep springs.

This classification is not very strict, due to the concealment of faulting by caliche, soil, etc., in the valley; but the springs are all undoubtedly of these two classes, though in a few cases it is difficult to say to which class a given spring belongs.

SAN PABLO SPRINGS

The clearest instance of springs arising from a visible fault is the group of three main springs located just south of the village of San Pablo, at the west foot of La Purisima. Immediately east of the main north-south street of the village is a small hill, which is a structural outlier of the main mountain. The strata of this hill show at the crestof the hill a sharp monoclinal flexure with a steep west dip (50°) and a gentle east dip (12°). This flexure is followed 300 meters south is seen to change into a fault of small displacement, and from the limestone along this fault, springs of considerable volume arise. The fault is parallel to the axis of folding of both mountain ranges and to the faults at their bases, and is produced by the same lateral thrust which folded themountains into anticlines.

A short distance northwest of these springs and at about the same elevation there are two small groups of springs which appear to rise out of the caliche mantle at the edge of the valley, but which in all probability are connected by short solution channels to the fault which produces the water in the main springs. Favoring this idea is the fact that there is a steep downdip to the west on the west flank of the monoclinal flexure mentioned in the hill at San Pablo. The monocline would tend to concentrate under underground pressure the artesian water which had arisen through the fault. This water would then escape down the dip to the base of the hill and pass out through any channel or fissure making its exit upwards at the first break in the strata. (It boils up from the bottom of the holes, and has the appearance of an ordinary fissure spring.) This water may all be considered as of the same geological origin.

A point of interest for the project at hand is that if this water arising far to the west of the Sierra de San Marcos, traverses the synclinal valley near San Pablo and emerges at San Pablo with the force and volume observed, it must have a considerable artesian pressure beneath the valley, and drilling should without difficulty produce flowing wells.

It is stated by Mr. Kennedy that still farther east, on the east slope and higher valleys of La Purisima there are flowing springs of fair volume. The argument just stated applies with greater force to these, on account of their greater elevation.

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SPRINGS WEST OF SIERRA DE SAN MARCOS

Near the west foot of the Sierra de San Marcos there emerge several springs of considerable volume These drain around the north point of the mountain into the Rio San Marcos which atv a poing southwest of Cuatro Cienegas is largely diverted into an eastward flowing canal. The floor of the valley is stratified rock and the larger springs empty into an extensive laguna from which the river flows.

There is abundant evidence that a long straight fault of considerable displacement skirts the west foot of the Sierra de San Marcos and gives rise to the line of springs near the mountain. At a point opposite Quinteros, the divergence of dip between the east and west fault blocks is sufficiently striking to make the fault perfectly visible. The strata of this last block are overturned, having a dip of as much as 110°. The overturning is gradual, and the dip increases from north to south along the west foot of the mountain. The dip of the west block is very slight (10° west). These strata upon passing westward become horizontal, and in the mountain farther west there is an east dip of ten degrees or less, so that the valley just west of the San Marcos Range is also a gentle syncline.

It is thought that the loss of water pressure due to the escape of water through this fault is not great enough to interfere with an artesian flow in the leased land, if a well were drilled. This idea is strengthened by the great flow observed at the San Pablo Springs; if there were serious loss of pressure, we would not have such strong springs at this place.

SPRINGS AT THE EAST FOOT OF THE SIERRA DE SAN MARCOS

Such faulting as exists along the east foot of this ridge is invisible, due to the caliche and soil mantle which extends over the whole valley and up to the foot of the ridge and into the mouths of the canyons. The valley alluvium consists of soil, degraded rock, gravel and boulders brought down by weathering from the canyons of the ridge and deposited on the plain. Large alluvial fans of such material, graded as to size, are seen at the mouths of the canyons. The caliche and mineral coating of this valley soil has been produced by subsoil water carrying calcium carbonate, chlorides, sulphates and other salts to the surface by capillarity, and upon evaporation leaving these salts as a whitish deposit more or less mixed with soil. This alluvial mantle has never

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been penetrated in the valley, but it is unquestionably underlain, at an increasing depth toward the center of the valley by the mountain limestones and conglomerates, part of which must be penetrated by the drill if wells are located in the valley. These valley strata are only in part the same strata as the mountain strata, being mainly the lower strata. The alluvial mantle is saturated with water at a shallow depth (5 meters or less) and at a less depth its water content decreases rapidly.

The presence of a fault along the east foot of the Sierra de San Marcos, which is asdefinite in its effect upon water production as the San Pablo Fault, is proved by the Hot Springs which occur on the leased land (and the one near the northeast end of the range). Although this fault is not visible, due to the mantle of valley alluvium and caliche, a narrow zone can be delimited, within which it must run. This is indicated on the map. The main springs which indicate the existence of this fault arise in close proximity to it on the down-dip (valley) side. These are: Tio Candido, the Hot Springs, Quinteros, and the Santa Tecla springs. Their nearly straight alignment indicates a fault of considerable displacement. The Blue Pozos (pozas) may be due to solution channels. Most of the other springs in the area are seepage springs. No springs arise on the up-dip side of the fault, a fact which helps greatly in limiting its zone on the side next to the ridge. This fault may be a continuation of a plunging anticline seen in the south face of the Sierra de Anteojo (See photograph), but this is doubtful.

It may be asked: If this is a fault of the character described and there issartesian water under pressure, why do we not have springs of large flow, like those of San Pablo and the west side of the San Marcos range? Most of the springs on the east side of San Marcos are overlain with caliche through which an irregular drainage channel has been cut by the spring; towards the north end of the area there is a compact gravel, infiltrated with caliche and intermingled with finer wash material from the range. This cap in the valley disperses the water pressure and much of the flow is used up in saturating the alluvial material with water. At Santa Tecla the water underlies a piedra tosca, a cavernous, indurated caliche (calcium carbonate) ledge. This is true also at the Quinteros spring and elsewhere. The fault at San Pablo is entirely, and the fault west of San Marcos relatively, free from this

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caliche overbedding.

And still ins spite of the caliche, the Santa Tecla spring is one of the largest in the region.

The water-logged caliche and the run-off from the larger springs supply the smaller pozos at lower elevations in the flat east of Quinteros.

<u>HOT</u> <u>SPRINGS</u>: Hot springs in this locality indicate the close proximity of strong faulting. Hot water does not run in strata. Some of the Coahuila mountains have volcanic rocks at places on their surface, where they have outcropped from below. The nearness of these volcanics indicates the source of the heat for the hot water. Hot springs are known from nearly similar localities in Brewster and Presidio Counties, Texas. The larger of the hot springs on the leased land had a flow in December 1920 of 5 liters per second, approximately; cleaning and excavation did not materially increase this flow.

The main interest of the hot springs is theifr use as <u>indicators of faulting</u>.

<u>BLUE POZOS</u>: The examination did not clearly show the nature of the blue pozos, except that their water seems to be of deep-seated origin. These pozos generally have a nearly conical form, with or without a surrounding shelf of caliche or piedra tosca at the edge. The pozos are rather deep, and the water usually clear. It seems undoubted that each of these pozos has a large solution channel reaching to the saturated areas farther up-dip (towards the San Marcos Range). It could not be determined that the pozos aligned so as to indicate any separate line of faulting. Tio Candido is a large pozo something of the same type.

2 SEEPAGE WATER

The method by which the soil and subsoil in this valley have become waterlogged has already been explained.

There is an insignificant rainfall, and the total utilizable water supply is underground. Water carried in subterranean porous strata froma a distance arises through faults in the strata and meets a compact but porous cap of gravel, boulders, caliche and soil. The water is diffused through this cap and migrates downward by gravity. There is however, a sufficient supply to keep the valley soil saturated to within about 3 meters of the surface with local variations

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There is little need to discuss the production of water in quantity by digging long canals to drain off the diffuse sub-surface water. It is found that on digging a hole the water is drained into the hole along radii from all directions and the local water saturation is thus decreased if this water is removed by a canal or other means. In other words any canal lowers the "water table" or the level of water saturation in the soil, so that after first drainage the canal yields disproportionately little water. Since all this water in the valley soil comes from below (in the stratified rocks) it is simpler to try to get the water at its original pressure and amount, before these have been diffused. The wuestion of canals for obtaining water has had considerable trial by experience, and therefore nothing more will be said here.

3 ARTESIAN WATER

(a) Source of the Artesian Water:

On account of the sparse rainfall in this region the source of all underground water must be sought at considerable distance from the locality in question.The Considerable amount of water which comes to the surface in these various springs indicates strong artesian reservoirs. In the absence of more exact information it may be conjectured that since these springs are as strong as most springs which escape along the Balcones Fault Zone in Central Texas from San Antonio northwards, there exists an underground reservoir comparable to the great Trinity reservoir in Texas and like it, capable of producing flowing wells. Naturally this depends upon the massiveness and porosity of the underlying rocks. In Texas, the escape of water from the springs does not materially influende the flow of wells.

It is astonishing that these artesian possibilities have not already been more adequately tested by drilling. Some wells near Ocampo, about 50 km. northwest of Cuatro Cienegas (elevation unknown, probably higher than Cuatro Cienegas) have produced water that rose in the well to within a short distance of the surface. At lower elevations this water might flow from the well under its own pressure.

It has been supposed that the source of some of this water is the Nazas River. Various persons have stated that the yearly rise in the Nazas is followed by an increased flow in the springs at San Pablo. The Nazas River is peculiar in being the largest river in Mexico that has no outlet to the sea. It rises eastb of the Continental Divide

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in the mountains of Chihuahua and Durango, and during the season of greatest flow carries an immense body of water northeastward to the Laguna region near Torreon and San Pedro de las Colonias, where the water gradually is absorbed into the ground and disappears.

Now there are good geological reasons for supposing that the eastward dip of the Cretaceous strata seen in the valley just west of the San Marcos Range continues very far to the west, and that on going west these Cretaceous strata are constantly rising in altitude, because at Sierra Mojada and near Torreon the Cretaceous is still present at a much higher elevation, while at San Pedro del Gallo, Durango, the underlying Jurassic is present at a higher elevation.

The pervious and impervious Cretaceous strata thus dip east towards the Gulf, forming ideal artesian conditions, in most respects very similar to those seen in Texas. Furthermore there is good reason to think that the water pressure thus produced is not expended before the water reached the Sierra de San Marcos region, because the intervening region is an arid desert devoid of flowing springs. This points to an absence of faulting on a large scale in the strata of the intervening region, and the consequent retention of the underground water pressure. Whatever the source of the water, it reaches the region in question under considerable artesian pressure, as seen from the strongly flowing springs.

(b) Conditions for drilling in this region:

The conditions for drilling are briefly:

Drill atv as low a level as is convenient above the canal level; drill on the up-dip side of a fault; locate the site in any synclinal area present, in order to accumulate a greater flow of water; keep frequent and liberal samples of the cuttings, each accurately labeled with its depth. Such a site for a preliminary drilling has already been recommended, about 150 meters northwest of the larger hot spring on the leased land, and keeping within the area of the present (original) leased land. Examination of these cuttings will throw light on the artesian water conditions of the area.

(c) Will drilled wells flow in this area?

Unfortunately it cannot be stated positively that drilled wells in this area will flow, but because the volume of water issuing from springs in

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this valley is so great, a high artesian pressure is indicated. The recommended location is the most favorable one on the original leased land for producing the greatest flow from the well.

(d) Depth to Water:

The depth required to reach water at the recommended drilling site cannot be stated. It will prábably be necessary to penetrate the conglomerate at the base of the San Marcos range, if ascending waters along the fault lines or their solution channels are not struck.

An original estimate of 100 meters or roughly 300 feet was made, based on the observed thicknesses of rock in the Sierra de San Marcos. It was expected, in drilling through this distance on the up-side of a fault, to reach water-bearing strata or to cut solution channels in the limestone near the fault. The reported depths from the Ocampo wells support this estimate. In case a light well drilling machine is used it would be wise to invest the relatively small extra amount necessary to drill to 600 feet or to the limit of the machine, if water is not obtained within the depth stated. After drilling is stabted, an examination of the cuttings will throw much light on the depth necessary to go to strike water.

(e) Amount of water expected:

If artesian water is obtained there is very good reasán to expect it under considerabls pressure. Judging from the wells in the artesian belt in Texas, a flow of more than 200 liters per second may be expected from a single well drilled with a 6-inch casing. For statistics on flow of Texas wells, see Appendix to this report.

(f) Note by Mexican Geological Survey on Water Conditions in Coahuila

A report from this survey by J. D. Villarello: ' Apuntes acerca de la hidrologia subterranea del Estado de Coahuila' divides Coahuila into eight water-bearing zones. Of these roughly divided zones, the Sierra de San Marcos is assigned to zone VIII with the information:

VIII, De circulacion localizada en grietas o cavidades que brota en parte por manantiales y otra parte es captable con exito solo en sondones.

The valley in which the leased land is located and the valley just west of the Sierra de San Marcos are assigned to :

Zone III, Freaticas poco profundas y mucho mas abajosascendentes pero no brotantes. (This refers primarily to the shallow subsurface wate of course the artesian water underlies mountains and valleys)

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ZONE 3: distinction from other zones of map; applies to VALLEY land.

"Cuando en las condiciones superficiales de la zona numero 1 los estratos profondos esten inclinados, pero muy distantes de las serranias en que estos se apoyan, y en las cuales se encuentre el nivel hidrostatico mas alto que la superficie del terreno en la zona que se estudia, puede decirse que se encontraran en ella aguas freaticas poco profundas y, mucho mas abajo, ascendentes pero no brotantes, es decir, que ascenderan del nivel en que se las corte, pero no llegaran hasta la boca del pozo, sino que permaneceran dentre de el, a profundidades variables entre 30 y 150 metros. Esta profundidad dependera de la diferencia de nivel entre la boca del pozo y el nivel hidrostatico en la serrania en que se infiltre esa agua, y tambien de la menor o mayor distancia entre la boca del pozo y esa serrania en la que se halla la superficie de alimentacion del receptaculo acuifero cortado por la perforacion.
Esta zona la llamo numero 3". (page 203)

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Zone 8: Explanations and definition; Middle Cretaceous Limestones of the Mountain Ranges:

"En las serranias constituidas por bancos gruesos de calizas cenomanianas (i. e., Cenomanian = Middle Cretaceous) o formadas por rocas ágneas , ya sean dioritas, rhyolitas o basaltos, es decir, en todas las serranias del Estado de Coahuila, la circulacion subterranea de las aguas esta localizada y se realiza solo por zonas de contacto entre calizas y diobitas, par fallas, diaclasas, grietas o cavidades mas o menos irregulares. En esta zona numero 8, las corrientes subterraneas solo pueden localizarse aproximadamente, despues de conocer con exactitud la tectonica en cada localidad, estudio que indicare en mi informe posterior; pero si puedo decir, desde luego, que en esta zona , no deben perforarse pozos, sino abrir socavones, pues de los primeros, en la inmensa mayoria de los casos, puede asegurarse el fracaso; el agua no brotaria en estos sino por casualidad, tan dificil de realizarse como dificil seria indicar el fundamento cientifico de la localizacion de un pozo en estas rocas calizas, en las cuales el agua desciende, como he dicho, por cavernas, tubos, y en general, cavidades de seccion y trayecto muy regulares y variables."

(page 204)

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"En la zona numero 8 no deben hacerse perforaciones verticales, sino abrir socavones. La localizacion de estos solo debe hacerse en los lugares en que se indica es abundante la cantidad de agua subterranea que circula en los macizos montanosos; porque estos socavones son obras sumamente costosas y que no deben emprenderse sino despues de un estudio muy detallado en cada caso particular, pues de otro modo el fracaso comercial es casi seguro."

(page 207)

On the other hand one assuredly cannot get artesian water unless he does drill for it. However it is not necessary here to enlarge upon the financial risks of the project, since these are well understood.

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I have stated frankly that these recommendations are experimental, and that nothing can be guaranteed as to their outcome. If there were any data from neighboring wells, the situation would be very different.

A location has already been orally recommended to Mr. Kennedy for a first drilling. This is near the north border line of the original tract of land of which the water rights were acquired, and 100 meters or more from the larger hot spring towards the ridge.

I would appreciate it if a complete set of samples is kept in cloth bags, correctly labeled as to depth, and forwarded to me at this office for examination.

It has occurred to me that another trial might be made at damming up such springs as Quinteros to bring them above the level of the canal. This might diminish the flow of the spring, but would still furnish an appreciable amount of water.

Signed:
W S Adkins

W. S. Adkins

Bureau of Economic Geology
Austin, Texas

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7 Bibliography

Abbott, T. S.: Carta general del Estado de Coahuila de Zaragosa. Secretario del Estado de Coahuila, Saltillo, 1905. 1:500,000.

Aguilera, J. G.: Les gisements carboniferes de Coahuila. Livret Guide des excursions, X me Congres geol. int., No. 27.

Böse, E.: Neue Beiträge zur Kenntnis der mexicanischen Kreide. Neues Jahrbüch f. Min., Centralblatt, pp. 652-662, 1910.

Böse, E.: Nuevos datos para la estratigraphia del Cretaceo en Mexico. Par. Inst. Geol. Mex., III, no. 5, pp. 257-280, 1910.

Böse, E.: Sobre algunas faunas del Cretacico de Coahuila. Inst. Geol. Mexico., Bol. 30.

Burckhardt, Carl: Neue Untersuchungen über Jura und Kreide in Mexiko. Neues Jahrbuch f. Min., Centralblatt, pp. 662-667, 1910.

Burckhardt, C.: Nuevos datos sobre el jurasico y el cretacico en Mexico. Par. Inst. Geol. Mex., III, no. 5, pp. 281-301, 1910.

Dumble, E. T.: Cretaceous of Western Texas and Coahuila, Mexico. Bull. Geol. Soc. America, 6, 375-388, 1895.

Haarmann, E.: Geologische Streifzüge in Coahuila. Zeits. deutsch. Geol. Gess.,

Hill, R. T.: The Cretaceous formations of Mexico and their relations to North American Geographic Development. Am. Jour. Sci., III ser., vol. XLV, 307-324, 1893.

Ludlow, E.: Les Gisements Carboniferes de Coahuila. Livret Guide des Excursions, X me Congres Geol. Int., No. 29.

Villarello, Juan D.: Apuntes acerca de la hidrologia subterranea del Estado de Coahuila. Par. Inst. Geol. Mex., V, no. 5, 295-208, pl. 1, 1913. (The plate is a zinc reproduction of Abbott's map of Coahuila with an overlain sheet to show water conditions.)

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