OCCURRENCE OF GYPSUM AT THE WCS SITE

Outcrops of the Dockum Group in the RCRA landfill at the WCS site contain minor amounts of gypsum. Gypsum appears to be confined to a ~20 ft thick horizon roughly 30 ft below the caliche caprock and is absent from this horizon where calcic alteration has penetrated the upper Dockum surface. The gypsum horizon does not occur throughout the RCRA landfill excavation and is limited to the southern-most outcrops. Gypsum is contained within burrowed, mottled red, silty to sandy mudstone displaying blocky fabrics consistent with paleosol formation and pedogenic movement of clays. Slickensides are also common within the mudstone. Dockum Group cores from the site area show little evidence of gypsum to depths of up to 270 ft, indicating that the gypsum occurs only locally. The gypsum displays a variety of morphologies including fibrous antitaxial veins, lenticular gypsum rosettes, and passive pore-filling cements in fractures. In the following, we discuss describe each of these gypsum morphologies and then comment on its origin.

GYPSUM MORPHOLOGIES

Poorly preserved, discontinuous, arcuate to planar, subvertical to subhorizontal, antitaxial gypsum-filled veins occur within the gypsum-bearing interval at the WCS site (Figure 1). Crystals within the veins are blocky and are primarily oriented perpendicular to the edge of the vein, indicating that minimum principle stresses were oriented subvertically when the veins formed (e.g., Durney and Ramsay, 1973; Ramsay, 1980). Gypsum crystals within the veins appear to be partly corroded or fluted and may show local overgrowths or recrystallization (Figure 2), indicating a complex fluid history since the veins first formed. Medial lines,

commonly associated with antitaxial veins, are poorly preserved due to gypsum dissolution, overgrowth, and possible recrystallization.

At the WCS site, lenticular gypsum rosettes occur in elongated zones along some fractures, in cylindrical zones (possible rizoliths) (Figure 3), and as irregular masses (Figure 4). Gypsum crystals range up to ~1 cm and contain inclusions of the mudstone host rock. The morphology of the gypsum crystals provides some information about their origin. Lenticular gypsum crystals form from alkaline fluids (pH >7.5) in the presence of soluble organic materials at relatively high temperatures (greater than ~ 35° C) (e.g., Cody, 1979; Cody and Cody, 1988). Lenticular penetration twins observed at the WCS site also require the presence of high concentrations of terrestrial humic substances in the pore fluids (Cody and Cody, 1988).

Large (several cm), interlocking gypsum crystals occupy some fractures at the WCS site (Figure 5). Some crystals contain small inclusions of mudstone, while the surfaces of other crystals are lenticular. The large crystal size indicates that most of this gypsum grew passively into and filled existing void space associated with fractures. Limited displacive and incorporative growth may have occurred as the crystals began to encroach on the boundary of previously open fractures.

DISCUSSION

Widespread occurrences of antitaxial gypsum veins have been attributed to stresses induced by large-scale processes such as unloading (Holt and Powers, 1990 a, b; El Tabakh et al, 1998) and collapse due to regional-scale dissolution (Gustavson et al., 1994). The limited vertical and areal extent of gypsum at the WCS site, however, eliminates unloading and dissolution as a potential cause of the gypsum veins found at the site. Because the veins are typically small in

length (< 1 m), discontinuous, subvertical, and often arcuate, they likely developed below the water table in response to localized stress conditions within ductile Dockum mudstones. Under these conditions fracturing is not required to produce antitaxial gypsum veins, as the force of crystallization is sufficient to open the space required by the vein, and the orientation of veins and their fibers reflect local stress conditions (e.g., Means and Li, 2001; Elburg et al., 2002; Hilgers and Urai, 2005). Furthermore, it is difficult to maintain open fractures within a water-saturated mudstone. The original fibrous texture of the veins has been altered by recrystallization and overgrowth, and later gypsum undersaturated fluids dissolved and corroded vein fibers. Because other forms of gypsum are also present within the same limited area, it is likely that these veins developed within the same hydrologic environment as the other forms of gypsum present at the site. This does not represent a new concept as syndepositional gypsum veins have been reported elsewhere (e.g., Holt and Powers, 1990 a,b; Aref and Morsy, 2000).

The forms of gypsum present at the WCS site reveal additional information about the hydrologic system in which they formed. Crystal habits suggest that lenticular gypsum rosettes at the WCS site formed displacively in soft sediments containing warm and alkaline groundwater with high amounts of humic substances (e.g., Cody and Cody, 1988), requiring the decomposition of large amounts of plant matter. The lenticular habit of some of the passive pore-filling crystals suggests that they are coeval with the rosettes and also formed in warm, alkaline, humic-rich groundwater.

The limited extent of gypsum and its proximity to the caliche caprock at the WCS site suggest that hydrologic environments that formed gypsum were also of limited vertical and areal extent. Because abundant humic substances are required to form lenticular gypsum rosettes, the gypsum formed in a shallow, phreatic aquifer in a warm climate with abundant vegetation.

These conditions suggest that the gypsum likely developed beneath or at the margins of a small saline lake or wetland.

The source of dissolved gypsum within the groundwater need not be the deep evaporites that occur over 1,500 ft below the gypsum horizon. Low permeability mudstones separate deeper Dockum aquifers from the gypsum horizon, and current groundwater age dating (Darling, 2006) supports hydrologic separation. During the Triassic and throughout most of the Cenozoic, eastward-draining fluvial systems associated with the Dockum Group and Ogallala Formation crossed evaporite-bearing rocks exposed west and northwest of the WCS site. Groundwaters associated with these fluvial systems were likely to be enriched in dissolved gypsum. Sulfate may also have been derived from sulfide minerals within the Dockum group mudstones (e.g., Joeckel et al., 2005), atmospheric sulfer (e.g., Dultz and Kühn, 2005), Cretaceous seawater, or shallow saline groundwaters associated with saline lakes (e.g., Wood and Jones, 1990).

Gypsum at the WCS site could not have formed in the Holocene. The relationship to pedogenic carbonate indicates gypsum formed earlier than the calcretes. The OAG interval at the WCS RCRA landfill currently contains no groundwater. Nearby, the pH of groundwater in two samples from the OAG aquifer is 7.36 and 7.15 (Darling, 2006), too low to generate lenticular crystals (Cody and Cody, 1988). Furthermore, OAG waters are undersaturated with respect to gypsum, and the vegetative cover cannot provide sufficient humic substances to generate gypsum rosettes.

The gypsum horizon predates the development of the caprock caliche. Gypsum is absent where calcic alteration associated with the caliche caprock has penetrated the upper Dockum surface. The caprock developed on a long stable topography. In the vicinity of topographically low areas, downward percolating fluids dissolved gypsum, reducing the areal extent of the

gypsum horizon. The gypsum horizon was preserved in topographically high areas where gypsum was beyond the depth of high amounts of infiltrating precipitation. Some etching and corrosion of gypsum veins likely occurred during the development of the caprock.

In the vicinity of the WCS site, conditions suitable for the development of warm, alkaline, saline lakes or wetlands bounded by vegetated environments have existed several times prior to the development of the caprock. Dockum mudstone textures observed at the WCS site are consistent with a wetland or a shallow lacustrine environment, and the Dockum environment was sufficiently warm to produce lenticular gypsum. Abundant burrowing attests to significant biological activity, and soil textures suggest subaerial exposure and the presence of plants. During the accumulation of the Dockum, fluvial systems drained evaporite terrains west and northwest of the site (McGowen et al., 1979). Groundwaters associated with these systems were likely sufficiently alkaline and saline to lead to localized gypsum accumulation in the vicinity of wetlands and lakes. These conditions persisted after Dockum deposition. Eastward drainage of evaporite terrains likely continued after Dockum deposition until the accumulation of the Antlers Formation during the Cretaceous. While this period of time is dominated by net erosion, localized wetlands or saline lakes capable of accumulating the WCS gypsum may have developed. During the Cenozoic, eastward drainage over evaporite terrains again resumed, and localized wetlands or saline lakes could have formed.

SUMMARY

There are three major summary points from this examination of gypsum occurrences at the WCS site and a review of literature:

- Because the gypsum is limited in areal extent and occurs within a limited horizon near the upper surface of the Dockum redbeds, the occurrence of gypsum cannot be related to large-scale processes such as unloading or dissolution of underlying evaporites.
- Antitaxial gypsum vein morphologies suggest that the veins developed in response to localized stress conditions.
- Gypsum morphologies indicate formation in shallow, warm, alkaline groundwaters. The most likely setting and time of formation is syndepositional, as sulfate, organic activity, and warm temperatures should have been present at and near the surface; other possible periods of exposure or near-exposure occurred between Dockum deposition and the deposition of the Cretaceous Antlers Formation and in the Cenozoic prior to the accumulation of the caprock.

REFERENCES

Aref, M. A., and M. A. Morsy, 2000, Polygonal shrinkage cracks filled with gypsum in the Upper Eocene, Fayum, Egypt, *Sedimentology of Egypt*, vol. 8, p. 89-103.

Cody, R. D., 1979, Lenticular gypsum: Occurrences in nature, and experimental determinations of effects of soluble green plant material on its formation, *Journal of Sedimentary Petrology*, vol. 49, no. 3, p. 1015-1028.

Cody, R. D., and A. M. Cody, 1988, Gypsum nucleation and crystal morphology in analog saline terrestrial environments, *Journal of Sedimentary Petrology*, vol. 58, no. 2, p. 247-255.

Darling, B. K., 2006, Letter report on findings related to the age-dating of groundwater at a proposed treatment and disposal facility for low-level radioactive waste, Andrews County, Texas, *unpublished report*, LBG-Guyton Associates, Lafayette, LA.

Durney, D. W. and Ramsay, J. G., 1973, Incremental strains measured by sysntectonic crystal growths, in *Gravity and Tectonics*, K.A. de Jong and R. Scholten (eds), John Wiley and Sons, New York, p. 67-96.

Dultz, S. and P. Kühn, 2005, Occurrence, formation, and micromorphology of gypsum in soils from the Central-German Chernozem region, *Geoderma*, vol. 129, p. 230-250.

El Tabakh, M., B. C. Schreiber, and J. K. Warren, Origin of fibrous gypsum in the Newark Rift Basin, Eastern North America, *Journal of Sedimentary Research*, vol. 68, no. 1, p. 88-99.

Elburg, M. A., P. D. Bons, J. Foden, and C. W. Passchier, 2002, in *Deformation mechanisms, rheology and tectionics: Current status and future perspectives*, S. de Meer, M. R. Drury, J. H. P. de Bresser, and G. M. Pennock (eds), Geological Society, London, Special Publications, vol. 2000, p. 103-118.

Gustavson, T. C., S. D. Hovorka, and A. R. Dutton, 1994, Origin of satin spar veins in evaporite basins, *Journal of Sedimentary Research*, vol. 64, no. 1, p. 88-94.

Hilgers, C., and J. L. Urai, 2005, On the arrangement of solid inclusions in fibrous veins and the role of the crack-seal mechanism, *Journal of Structural Geology*, vol. 27, p. 481-494.

Holt, R.M., and D. W. Powers, 1990a, Geotechnical activities in the air intake shaft (AIS): *DOE/WIPP 90 051*, US Department of Energy, Carlsbad, NM.

Holt, R.M., and D. W. Powers, 1990b, The Late Permian Dewey Lake Formation at the Waste Isolation Pilot Plant, in Geological and Hydrological Studies of Evaporites in the Northern Delaware Basin for the Waste Isolation Pilot Plant (WIPP), D.W. Powers, R. M. Holt, R. L. Beauheim, and N. Rempe, (eds) Guidebook 14, Geological Society of America (Dallas Geological Society), p. 45-78.

Joeckel, R. M., B. J. Ang Clement, L. R. VanFleet Bates, 2005, Sulfate-mineral crusts from pyrite weathering and acid rock drainage in the Dakota Formation and Graneros Shale, Jefferson County, Nebraska, *Chemical Geology*, 2005, vol. 215, p. 433-452.

McGowen, J. H., G. E. Granata, and S. J. Seni, 1979, Depositional framework of the lower Dockum Group (Triassic) Texas Panhandle, *Report of Technical Investigations No. 97*, Bureau of Economic Geology, The University of Texas at Austin, 60 p.

Means, W. D., and T. Li, 2001, A laboratory simulation of fibrous veins: Some first observations, *Journal of Structural Geology*, vol. 23, p. 857-863.

Ramsay, J. G., 1980, The crack-seal mechanism of rock deformation, Nature, vol. 284, p. 135-139.

Wood, W. W. and B. F. Jones, 1990, Origin of solutes in saline lakes and springs on the southern High Plains of Texas and New Mexico, in *Geologic framework and regional hydrology; upper Cenozoic Blackwater Draw and Ogallala Formations, Great Plains*, T. C. Gustavson (ed), proceedings of the Symposium on geology and geohydrology of the Tertiary Ogallala Formation (Group) and Quaternary Blackwater Draw Formation, Lubbock, TX, p. 193 – 208.

APPENDIX A FIGURES

Figure 1. Antitaxial gypsum veins found in the WCS RCRA landfill are discontinuous and display planar (P) and arcuate (A) morphologies.

Figure 2. Gypsum crystals within antitaxial veins appear to be partly corroded or fluted and show local overgrowths and possible recrystallization.

Figure 3. Rosettes of gypsum crystals display lenticular crystal habits. This example occurs in a roughly cylindrical zone and could be a rizolith.

Figure 4. Some lenticular gypsum rosettes occur in irregular masses within the host mudstone.

Figure 5. This gypsum fracture filling from the WCS site displays large interlocking crystals with lenticular surfaces. Note that some wall rock mudstone has been incorporated within the crystals, especially along crystal boundaries.

APPENDIX B

BASIC STRATIGRAPHIC DATA FROM OIL AND GAS WELLS AT AND AROUND THE WCS SITE

Stratigraphic Data at WCS Site (Figures 14-19)												
		Depth Data (ft below reference elevation)				Elevation Data (ft amsl)				Thickness Data (ft)		
API Number	Reference Elevation (ft amsl)	Top of Rustler Fm	Base of Rustler Fm	Base of Cowden Anhydrite	Base of Salado Fm	Top of Rustler Fm	Base of Rustler Fm	Base of Cowden Anhydrite.	Base Salado	Rustler Fm	Salado Fm	Base of Cowden to base Salado
25-06572	3417	1272	1472	2264	2565	2145	1945	1153	852	200	1093	301
25-06769	3420	1324	1523	2293	2585	2096	1897	1127	835	199	1062	292
25-07890	3566	1615	1826	2607	2896	1951	1740	959	670	211	1070	289
25-07894	3577	1621	1834	2605	2890	1956	1743	972	687	213	1056	285
25-09969	3380	1120	1342			2260	2038			222		
25-12111	3406	1582	1820	2628	2913	1824	1586	778	493	238	1093	285
25-12112	3399	1565	1804	2590	2882	1834	1595	809	517	239	1078	292
25-12114	3362	1365	1600			1997	1762			235		
25-21104	3377	1330	1555	2390	2684	2047	1822	987	693	225	1129	294
25-21105	3386	1364	1595	2440	2734	2022	1791	946	652	231	1139	294
25-22768	3362	1416	1656	2499	2796	1946	1706	863	566	240	1140	297
25-22796	3483	1560	1786	2553	2837	1922.9	1696.9	929.9	645.9	226	1051	284
25-22883	3458	1557	1786	2584	2878	1901	1672	874	580	229	1092	294
25-22969	3463	1547	1773	2570	2862	1916	1690	893	601	226	1089	292
25-22977	3428	1520	1752	2572	2867	1908	1676	856	561	232	1115	295
25-22980	3363	1338	1558	2418	2711	2024.5	1804.5	944.5	651.5	220	1153	293
25-24841	3339	1175	1400	2237	2535	2164	1939	1102	804	225	1135	298
25-25158	3465	1177	1406	2256	2572	2288	2059	1209	893	229	1166	316
25-25479	3382	1196	1424	2227	2530	2186	1958	1155	852	228	1106	303
25-25644	3368	1186	1410	2220	2517	2182	1958	1148	851	224	1107	297
25-27902	3434	1404	1613	2397	2679	2029.5	1820.5	1036.5	754.5	209	1066	282
25-30005	3572	1631	1840	2615	2888	1941	1732	957	684	209	1048	273
25-33347	3583	1629	1845	2619	2897	1954	1738	964	686	216	1052	278
25-34171	3421	1190	1408	2195	2499	2231	2013	1226	922	218	1091	304
25-36130	3408	1563	1800	2591	2881	1845	1608	817	527	237	1081	290
25-37203	3411	1207	1404	2223	2524	2204	2007	1188	887	197	1120	301
25-37483	3372	1279	1500	2291	2580	2093	1872	1081	792	221	1080	289
3-00975	3422	1668	1903	2725	3000	1754	1519	697	422	235	1097	275
3-01209	3496	1620	1832			1876	1664			212		
3-01811	3441	1567	1798	2596	2877	1874	1643	845	564	231	1079	281
3-01812	3466	1560	1790	2597	2877	1906	1676	869	589	230	1087	280
3-01813	3491	1612	1833	2623	2917	1879	1658	868	574	221	1084	294
3-01814	3465	1616	1830	2613	2905	1849	1635	852	560	214	1075	292
3-02591	3368	1510	1742	2565	2847	1857.5	1625.5	802.5	520.5	232	1105	282
3-03756	3359	1630	1890	2595	2850	1728.5	1468.5	763.5	508.5	260	960	255
3-03757	3340	1600	1800	2551	2810	1740	1540	789	530	200	1010	259
3-04076	3554	1604	1816	2600	2880	1950	1738	954	674	212	1064	280
3-05102	3366	1603	1784	2547	2805	1762.7	1581.7	818.7	560.7	181	1021	258
3-05500	3386	1630	1830	2582	2850	1756	1556	804	536	200	1020	268
3-05906	3380	1545	1770	2568	2852	1835	1610	812	528	225	1082	284
3-06707	3332	1582	1796	2570	2835	1750	1536	762	497	214	1039	265

Stratigraphic Data at WCS Site (Figures 14-19)												
		Depth Data (ft below reference elevation)				Elevation Data (ft amsl)				Thickness Data (ft)		
API Number	Reference Elevation (ft amsl)	Top of Rustler Fm	Base of Rustler Fm	Base of Cowden Anhydrite	Base of Salado Fm	Top of Rustler Fm	Base of Rustler Fm	Base of Cowden Anhydrite.	Base Salado	Rustler Fm	Salado Fm	Base of Cowden to base Salado
3-07838	3345	1587	1793	2560	2815	1758	1552	785	530	206	1022	255
3-10364	3378	1613	1802	2554	2816	1765	1576	824	562	189	1014	262
3-10503	3378	1623	1806	2550	2816	1755	1572	828	562	183	1010	266
3-10806	3480	1601	1807	2587	2860	1879	1673	893	620	206	1053	273
3-11054	3525	1612	1827	2623	2911	1913	1698	902	614	215	1084	288
3-30290	3312	1600	1810	2587	2853	1712	1502	725	459	210	1043	266
3-31132	3557	1610	1825	2626	2898	1947	1732	931	659	215	1073	272
3-31589	3360	1644	1894	2590	2845	1716	1466	770	515	250	951	255
3-32910	3428	1654	1882	2688	2968	1774	1546	740	460	228	1086	280
3-33854	3435	1700	1918	2711	2983	1734.5	1516.5	723.5	451.5	218	1065	272
3-33882	3337	1720	1942	2710	2970	1617	1395	627	367	222	1028	260
3-34548	3540	1604	1814	2590	2867	1936	1726	950	673	210	1053	277
3-36041	3447	1637	1836	2608	2869	1810	1611	839	578	199	1033	261
3-36094	3471	1656	1895	2685	2966	1815	1576	786	505	239	1071	281
3-36289	3456	1724	1942	2703	2974	1732	1514	753	482	218	1032	271
3-36567	3435	1638	1838	2610	2875	1797	1597	825	560	200	1037	265
3-36967	3477	1661	1865	2639	2906	1816	1612	838	571	204	1041	267
3-37072	3468	1627	1810	2588	2856	1840.5	1657.5	879.5	611.5	183	1046	268
3-37214	3446	1654	1842	2621	2887	1792	1604	825	559	188	1045	266
3-37580	3382	1624	1854	2648	2930	1757.5	1527.5	733.5	451.5	230	1076	282
3-37680	3456	1673	1875	2650	2920	1783	1581	806	536	202	1045	270
3-37698	3438	1705	1935	2734	3010	1733	1503	704	428	230	1075	276
3-37734	3364	1620	1809	2540	2795	1744	1555	824	569	189	986	255
3-37880	3402	1636	1878	2700	2975	1766	1524	702	427	242	1097	275
3-38605	3410	1653	1854	2604	2864	1757	1556	806	546	201	1010	260
3-39026	3328	1545	1744	2507	2769	1783	1584	821	559	199	1025	262

Uncertain contacts or uninterpretable log intervals show as blank values

APPENDIX C

BASIC STRATIGRAPHIC DATA FROM OIL AND GAS WELLS ACROSS A SECTION OF THE MESCALERO RIDGE, NM

Basic Drillhole Data from Mescalero Ridge for Figures 25-27

API (30-025-#)	Township (S)	Range (E)	Section	Feet from north (n) or south (s) line	Feet from east (e) or west (w) line	UTMX (m)	UTMY (m)	Reference Point Elevation (ft. amsl)	Depth (ft) to top of Rustler Fm	Depth (ft) to top of Salado Fm	Thickness (ft) of Rustler Fm	Elevation (ft. amsl) of top of Rustler	Elevation (ft. amsl) of top of Salado
26706	18	34	23	330S	660E	638315	3621782	3995	1843	2103	260	2152	1892
02370	18	34	28	1980S	660E	635107	3620611	4028	1824	2085	261	2204	1943
02376	18	34	32	660N	1980W	632692	3619768	3927	1673	1950	277	2254	1977
26532	18	34	36	330N	1980W	638640	3619464	3986	1914	2183	269	2072	1803
26698	18	34	36	660N	660W	638740	3619867	3992	1907	2176	269	2085	1816
26817	18	34	36	380N	660E	639940	3619980	3969	1929	2200	271	2040	1769
03146	18	35	29	1980N	660W	641875	3621128	3948	1853	2112	259	2095	1836
27333	18	35	29	660s	660e	643255	3620304	3927	1792	2052	260	2135	1875
27392	18	35	30	990S	330W	640235	3620407	3971	1929	2198	269	2042	1773
26287	18	35	30	1980S	1980E	641106	3620710	3959	1905	2178	273	2054	1781
03149	18	35	31	660S	660E	641576	3618679	3921	1834	2101	267	2087	1820
26661	18	35	31	330N	330W	640241	3620000	3963	1923	2207	284	2040	1756
27618	18	35	31	660S	1980W	640762	3618694	3960	1910	2183	273	2050	1777
25839	18	35	32	1980N	660W	641933	3619885	3945	1860	2125	265	2085	1820
29121	18	35	32	660S	660E	643183	3618697	3935	1854	2126	272	2081	1809
29336	18	35	32	2280N	660E	643155	3619403	3931	1824	2090	266	2107	1841
26590	19	34	1	1980N	660E	639954	3617894	3962	1883	2165	282	2079	1797
22365	19	34	1	660S	660W	638736	3616930	3977	1863	2150	287	2114	1827
27827	19	34	2	1980N	1650E	638048	3617855	4020	1920	2209	289	2100	1811
32435	19	34	2	550S	1980E	637932	3616902	3989	1861	2150	289	2128	1839
36680	19	34	3	1650S	1650E	636407	3617293	4021	1872	2156	284	2149	1865
27181	19	34	3	1980N	660E	636735	3617784	3999	1871	2158	287	2128	1841
21156	19	34	3	718N	660E	636736	3618213	4003	1862	2142	280	2141	1861
36391	19	34	3	760N	660W	635534	3618183	4002	1830	2108	278	2172	1894
32963	19	34	4	2355S	400W	633847	3617410	3892	1644	1923	279	2248	1969
26348	19	34	11	1980N	660E	638333	3616221	3977	1848	2130	282	2129	1847
26783	19	34	11	1980S	660W	637138	3615794	3992	1857	2145	288	2135	1847
26473	19	34	11	660S	660E	638345	3615415	3970	1838	2130	292	2132	1840
27096	19	34	11	660S	660W	637146	3615393	3992	1871	2160	289	2121	1832
26707	19	34	11	990N	990E	638226	3616521	3981	1850	2134	284	2131	1847
36902	19	34	11	1830N	1980W	637572	3616222	3993	1862	2149	287	2131	1844
02384	19	34	12	660N	660W	638730	3616631	3974	1855	2150	295	2119	1824
22719	19	34	12	1980S	1980W	639147	3615833	3969	1845	2130	285	2124	1839
22984	19	34	12	1980S	660E	639945	3615847	3956	1867	2155	288	2089	1801
23634	19	34	12	520N	520E	639976	3616696	3932	1845	2126	281	2087	1806
22519	19	34	13	2310S	330W	638730	3614307	3965	1860	2162	302	2105	1803
22671	19	34	13	1980N	660W	638760	3614618	3954	1846	2142	296	2108	1812
28207	19	34	13	460N	990E	639854	3615102	3954	1856	2143	287	2098	1811
22181	19	34	13	660N	660W	638755	3615020	3968	1850	2145	295	2118	1823
22717	19	34	13	660S	660W	638771	3613814	3878	1793	2098	305	2085	1780
22069	19	34	14	1320N	660E	638353	3614812	3973	1857	2160	303	2116	1813
25493	19	34	14	1980N	1680E	638044	3614604	3967	1865	2165	300	2102	1802
23029	19	34	14	2080S	1980E	637957	3614233	3896	1800	2103	303	2096	1793
25506	19	34	14	660N	1980E	637946	3615004	3977	1852	2143	291	2125	1834
02386	19	34	15	330S	330W	635456	3613656	3777	1740	2048	308	2037	1729
26087	19	34	15	1980S	660W	635550	3614160	3780	1753	2057	304	2027	1723
21286	19	34	15	660N	660E	636748	3614982	3928	1810	2112	302	2118	1816
20812	19	34	15	660S	660W	635555	3613759	3801	1742	2050	308	2059	1751
23356	19	34	20	2310S	1650W	632656	3612605	3714	1650	1973	323	2064	1741
27556	19	34	23	1980N	1980E	637974	3612996	3827	1810	2120	310	2017	1707

Basic Drillhole Data from Mescalero Ridge for Figures 25-27													
API (30-025-#)	Township (S)	Range (E)	Section	Feet from north (n) or south (s) line	Feet from east (e) or west (w) line	UTMX (m)	UTMY (m)	Reference Point Elevation (ft amsl)	Depth (ft) to top of Rustler Fm	Depth (ft) to top of Salado Fm	Thickness (ft) of Rustler Fm	Elevation (ft amsl) of top of Rustler	Elevation (ft amsl) of top of Salado
29406	19	34	23	1980N	1980W	637580	3612988	3817	1794	2101	307	2023	1716
29299	19	34	23	1980N	660E	638378	3613002	3832	1804	2110	306	2028	1722
30839	19	34	24	1650S	2310W	639295	3612516	3812	1805	2105	300	2007	1707
24413	19	34	24	1980N	760E	639955	3613031	3840	1803	2100	297	2037	1740
24390	19	34	24	330S	1700E	639681	3612121	3794	1799	2108	309	1995	1686
2393	19	34	24	660N	660E	639980	3613434	3862	1802	2100	298	2060	1762
23502	19	34	24	660S	660W	638794	3612205	3794	1804	2110	306	1990	1684
28571	19	34	24	760S	2080E	639563	3612249	3814	1815	2123	308	1999	1691
21369	19	34	25	1980S	660W	638812	3610999	3753	1814	2120	306	1939	1633
25101	19	34	25	1670N	2310E	639504	3611508	3775	1795	2110	315	1980	1665
20889	19	34	25	1780N	1980W	639210	3611469	3771	1806	2117	311	1965	1654
25123	19	34	25	1800N	990E	639908	3611476	3772	1804	2113	309	1968	1659
22967	19	34	25	1980S	660E	640016	3611020	3762	1803	2120	317	1959	1642
21098	19	34	25	2130N	760W	638837	3611356	3775	1808	2122	314	1967	1653
24868	19	34	25	330N	1650W	639102	3611909	3788	1807	2113	306	1981	1675
23708	19	34	25	610S	1880W	639191	3610588	3745	1815	2132	317	1930	1613
27896	19	34	25	660N	1980W	639204	3611811	3798	1815	2120	305	1983	1678
02394	19	34	25	660N	660W	638800	3611803	3779	1800	2110	310	1979	1669
02396	19	34	25	660S	1980W	639222	3610604	3743	1813	2126	313	1930	1617
02395	19	34	25	660S	660E	640022	3610618	3746	1808	2128	320	1938	1618
24069	19	34	25	760N	760E	639973	3611794	3786	1802	2108	306	1984	1678
24867	19	34	25	990N	1980E	639601	3611718	3781	1801	2110	309	1980	1671
21745	19	34	25	990S	1650W	639119	3610703	3737	1807	2123	316	1930	1614
21370	19	34	25	990S	400W	638736	3610696	3741	1817	2130	313	1924	1611
22081	19	34	26	1650S	1980W	637609	3610878	3751	1805	2122	317	1946	1629
36196	19	34	28	1980S	660W	633984	3610919	3714	1695	2032	337	2019	1682
32003	19	34	32	2310N	1980E	633195	3609597	3680	1512	1840	328	2168	1840
32783	19	34	34	1980S	1980E	636418	3609349	3696	1677	2020	343	2019	1676
20096	19	34	36	660S	330E	640147	3609010	3702	1830	2153	323	1872	1549
20144	19	35	6	1980S	660E	641585	3617492	3898	1830	2106	276	2068	1792
20322	19	35	6	1980S	1980E	639806	3617492	3900	1822	2096	274	2078	1804
20590	19	35	6	860N	660E	641557	3618217	3924	1840	2110	270	2084	1814
21171	19	35	6	560S	1880E	641213	3617059	3921	1850	2134	284	2071	1787
39842	19	35	6	660S	660W	640393	3617038	3950	1859	2140	281	2091	1810
29945	19	35	18	1780S	660E	641623	3614203	3919	1870	2159	289	2049	1760
29041	19	35	18	660N	1980W	640813	3615023	3949	1869	2159	290	2080	1790
03169	19	35	19	990S	660W	640400	3612349	3829	1808	2111	303	2021	1718
03168	19	35	19	660S	660E	643242	3613873	3802	1808	2110	302	1994	1692
33762	19	35	30	990S	700E	641678	3610736	3758	1808	2122	314	1950	1636
24034	19	35	30	2090S	760E	641659	3611071	3778	1810	2120	310	1968	1658
23987	19	35	30	1980S	1980W	640881	3611010	3752	1810	2122	312	1942	1630
03259	19	35	30	2310N	330E	641757	3611332	3768	1800	2105	305	1968	1663
03260	19	35	30	660S	1980E	641288	3610635	3752	1812	2124	312	1940	1628
03256	19	35	30	330S	990W	640579	3610507	3738	1796	2115	319	1942	1623
03258	19	35	30	1980S	660E	641690	3611038	3757	1803	2115	312	1954	1642

UTM (NAD27) coordinates were calculated from the nearest section corner.

APPENDIX D

BASIC STRATIGRAPHIC DATA FROM OIL AND GAS WELLS ACROSS A SECTION OF MONUMENT DRAW, NM (T21S, R37E)

Basic Drillhole Data from T21S, R37E for Figures 29-31													
API (30-025-#)	Township (S)	Range (E)	Section	Feet from north (n) or south (s) line	Feet from east (e) or west (w) line	UTMX (m)	UTMY (m)	Reference Point Elevation (ft amsl)	Depth (ft) to top of Rustler Fm	Depth (ft) to top of Salado Fm	Thickness (ft) of Rustler Fm	Elevation (ft amsl) of top of Rustler	Elevation (ft amsl) of top of Salado
34937	21	37	1	990s	2430w	676917	3597578	3527	1538	1744	206	1989	1783
34411	21	37	2	3800s	1200w	674926	3598426	3498	1389	1590	201	2109	1908
06373	21	37	2	660s	1980w	675164	3597469	3473	1349	1554	205	2124	1919
37725	21	37	3	330s	330w	673048	3597335	3476	1282	1489	207	2194	1987
35734	21	37	3	1300s	1980e	673956	3597664	3477	1305	1513	208	2172	1964
37727	21	37	3	1940s	1760w	673483	3597825	3437	1257	1460	203	2180	1977
06388	21	37	3	1980s	660w	673148	3597838	3450	1275	1495	220	2175	1955
35354	21	37	3	3448n	1576w	673389	3598560	3469	1299	1522	223	2170	1947
35225	21	37	3	3240s	1839w	673508	3598222	3458	1283	1490	207	2175	1968
35352	21	37	3	2310n	990w	673211	3598907	3488	1310	1520	210	2178	1968
06386	21	37	3	1582n	330w	673010	3599129	3490	1320	1527	207	2170	1963
35224	21	37	4	3196s	426e	672817	3598208	3450	1280	1490	210	2170	1960
35768	21	37	4	330s	1980e	672343	3597335	3477	1276	1493	217	2201	1984
37983	21	37	4	2630s	2310e	672243	3598036	3483	1303	1517	214	2180	1966
37463	21	37	4	2310s	350e	672840	3597938	3481	1293	1503	210	2188	1978
36314	21	37	4	130s	1270e	672560	3597274	3479	1273	1496	223	2206	1983
36141	21	37	4	2460s	990e	672645	3597984	3479	1299	1511	212	2180	1968
35341	21	37	4	3630n	810e	672662	3598505	3428	1265	1480	215	2163	1948
35557	21	37	4	1050n	150e	672863	3599291	3483	1330	1542	212	2153	1941
34737	21	37	4	2620n	116e	672874	3598812	3483	1306	1516	210	2177	1967
06400	21	37	4	1582n	990e	672607	3599129	3486	1320	1529	209	2166	1957
35493	21	37	4	3168s	1650e	672444	3598200	3473	1304	1520	216	2169	1953
34738	21	37	4	3810s	200e	672886	3598395	3445	1257	1470	213	2188	1975
35351	21	37	4	2310n	810e	672662	3598907	3463	1304	1515	211	2159	1948
06397	21	37	4	1980s	660e	672746	3597838	3483	1295	1506	211	2188	1977
36811	21	37	4	3480s	1650e	672444	3598295	3480	1296	1514	218	2184	1966
06399	21	37	4	4620s	660e	672746	3598642	3465	1282	1494	212	2183	1971
35895	21	37	4	330s	2050w	671968	3597302	3478	1295	1512	217	2183	1966
06389	21	37	4	660s	660w	671544	3597402	3498	1304	1524	220	2194	1974
35875	21	37	4	330s	760w	671575	3597302	3501	1303	1523	220	2198	1978
12759	21	37	4	1980s	1980w	671947	3597805	3487	1293	1513	220	2194	1974
37236	21	37	5	3630n	330e	671192	3598481	3488	1326	1549	223	2162	1939
27954	21	37	7	330n	660e	669540	3597073	3538	1347	1577	230	2191	1961
21621	21	37	8	1980n	1980e	670739	3596597	3548	1330	1552	222	2218	1996
35350	21	37	9	1980s	330e	672882	3596220	3487	1292	1502	210	2195	1985
06445	21	37	9	660n	585e	672769	3597033	3480	1274	1484	210	2206	1996
37028	21	37	10	2375s	505e	674440	3596376	3446	1265	1471	206	2181	1975
37026	21	37	10	330n	330e	674459	3597167	3457	1296	1502	206	2161	1955
35905	21	37	10	550n	740e	674334	3597100	3449	1285	1486	201	2164	1963
35637	21	37	10	704n	2208e	673887	3597053	3431	1277	1475	198	2154	1956
35545	21	37	10	1470n	1350e	674149	3596820	3426	1250	1450	200	2176	1976
34367	21	37	10	42n	2334e	673849	3597255	3427		1455			1972
37876	21	37	10	2360n	1650e	674057	3596549	3447	1260	1460	200	2187	1987
06553	21	37	12	660s	2310e	677097	3595907	3463	1460	1670	210	2003	1793
23953	21	37	18	660s	330e	669686	3594159	3509	1230	1443	213	2279	2066
21035	21	37	19	990n	884w	668478	3593627	3533	1257	1472	215	2276	2061
23494	21	37	30	1650s	660w	668461	3591214	3527	1199	1424	225	2328	2103
24084	21	37	30	660s	1820w	668815	3590912	3518	1200	1424	224	2318	2094
24120	21	37	31	330n	330w	668361	3590610	3523	1184	1405	221	2339	2118

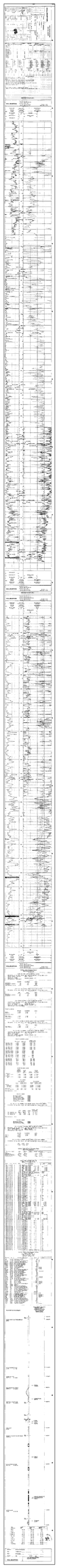
Value in red indicates a ground-level elevation obtained from a topographic map. UTM (NAD27) coordinates were calculated from the map values of the nearest section corner.

APPENDIX E

ELECTRONIC FILES OF GEOPHYSICAL LOGS OF DRILLHOLES AT AND NEAR THE WCS SITE

A CD-ROM is attached to the report with electronic files of geophysical logs from drillholes in the vicinity of the WCS site. These files are in TIFF format and are best viewed with software such as Quick View Plus® because of the length of each log. There are no markings of stratigraphic contacts on these logs from this study.

The files from the CD-ROM have been converted to PDFs and follow this page.



Ministry of Finance	
Revenue Canada	
Taxation	
Revenue Canada	
Taxation	
Revenue Canada	
Taxation

Operator	Chesapeake Appalachia, L.L.C.
Operator Address	14000 Quail Springs Parkway, Suite 600 Oklahoma City, OK 73134-2646
Surface Owner	Gerald Lee Bowman
Surface Owner Address	1000 Bowman Lane Sistersville, WV 26175
Mineral Owner	Gerald Lee Bowman, et al
Mineral Owner Address	1000 Bowman Lane Sistersville, WV 26175
Latitude	39.3125
Longitude	-80.8125
Elevation	1,000'
Proposed Depth	7,500'
Formation	Marcellus Shale
Drilling Method	Rotary
Casing Program	13 3/8" 54.5# J-55 BTC @ 500' 9 5/8" 40# J-55 BTC @ 2,500' 5 1/2" 20# P-110 BTC @ 7,500'
Cement Program	13 3/8" Cement to surface 9 5/8" Cement to surface 5 1/2" Cement to 2,000'
Completion Method	Plug & Perf
Stimulation Method	Slickwater
Stimulation Rate	80 bbl/min
Stimulation Pressure	8,000 psi
Stimulation Volume	4,000,000 gal
Proppant Type	100 Mesh, 40/70
Proppant Volume	4,000,000 lbs
Water Source	Fresh Water
Water Volume	4,000,000 gal
Water Quality Test	Yes
Water Quality Test Date	2/1/2011
Water Quality Test Results	Attached
Water Quality Test Location	Gerald Lee Bowman
Water Quality Test Author	Chesapeake Appalachia, L.L.C.
Water Quality Test Author Address	14000 Quail Springs Parkway, Suite 600 Oklahoma City, OK 73134-2646
Water Quality Test Author Phone	405-848-8000
Water Quality Test Author Email	
Water Quality Test Author Fax	
Water Quality Test Author Contact	
Water Quality Test Author Contact Phone	
Water Quality Test Author Contact Email	
Water Quality Test Author Contact Fax	
Water Quality Test Author Contact Address	
Water Quality Test Author Contact Author	
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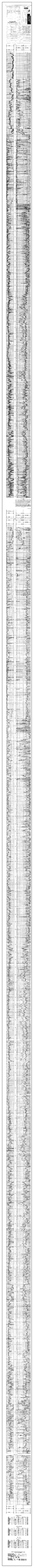

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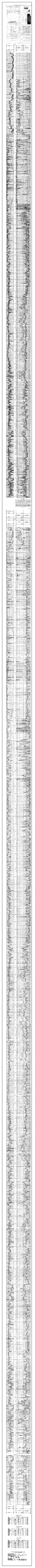
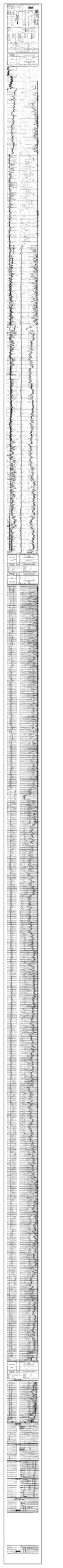




Dresser Atlas

Company/Well/Field/County/State/Other Services

Densilog Neutron

COMPANY: MERIDIAN OIL CORPORATION
WELL: GUTMAN NO. 2
FIELD: WANTZ (DENAVITE MAINS)
COUNTY: LEA STATE: NEW MEXICO

Other Services: BHC AL, FI, MLL

Permanent Datum: GROUND LEVEL — Elev.: 3209
Log Measured From: KB — 12.0 Above Permanent Datum
Drilling Measured From: KB

Date	6-6-75	
Run Number	ONE	
Depth-Driller	12147	
Depth-Logger	12147	
Bottom Logged Interval	12147	
Top Log Interval	11900	
Casing-Driller	9 5/8 @ 1783	@ @
Casing-Logger	1783	
Bit Size	7 7/8	
Type Fluid in Hole	BRINE	
Density	10.0	
Viscosity	50	
Ph	10.0	
Fluid Loss	10	
Source of Sample	CIRCULATED	
Rm @ Meas. Temp.	.0628 @ 75	@ @
Rmf @ Meas. Temp.	.0628 @ 75	@ @
Rmc @ Meas. Temp.	.0628 @ 75	@ @
Source of Rmf & Rmc	MEAS.	
Rm @ BHT	.0628 @ 174	
Time Since Circ.	8 HOURS	
Max. Rec. Temp. Deg. F	174	
Equip. No. and Location	2-411 MIDLAND	
Recorded By	M.STANLEY	
Witnessed By	MR. KIRKWOOD	

COMPLETION RECORD

SPUD DATE

P. COMP DATE

TOT RECORD

FPL NO. EW-NM-NMB

CASING RECORD

PERFORATING RECORD

PERIODATING RECORD

ACID FRAC SHOT

I.P.

GOR GR

I.P. I.P.

REMARKS

Remarks: CALIPER TOOL IS ABOUT THIS AS LARGE AS LIGHT BULB.

Equipment Data			
Recorded	12127	6414	1100
Recorded	12127	1783	1100
Recorded	12127	1783	1100
Recorded	12127	12127	1100
Recorded	12127	12127	1100
Recorded	12127	12127	1100
Recorded	12127	12127	1100
Recorded	12127	12127	1100

Equipment Data			
Tool Number	1-411	Tool Number	1-411
Tool Number	1-411	Tool Number	1-411
Tool Number	1-411	Tool Number	1-411

Operator	Chesapeake Operating, Inc.	Lease Name	Hoover
Well No.	1-29	Field	Wildcat
County	Ellis	State	Kansas
Date	12-29-2010	Time	0:00
Elevation	2200	Location	1980 FSL 1980 FEL
Sec.	29	Twp.	14 S
Rge.	19 W		

Project	Proposed Residential Development
Location	Ballycorkane, Ballinrobe, Co. Mayo
Client	Ballinrobe Development Company Ltd.
Contractor	Ballinrobe Development Company Ltd.
Operator	Ballinrobe Development Company Ltd.
Hole Type	Trial Pit
Ground Level (mOD)	50.00
Easting	519
Northing	280
Date Started	12/12/2024
Date Completed	12/12/2024
Logged By	Ryan Mc Donnell
Checked By	Ryan Mc Donnell
Weather	Cold, Dry

Depth (m)	Description
0.00	Topsoil
0.30	Brown Sandy Gravelly Clay with occasional Cobbles and Boulders
1.00	Brown Sandy Gravelly Clay with occasional Cobbles and Boulders
1.50	Brown Sandy Gravelly Clay with occasional Cobbles and Boulders
2.00	Brown Sandy Gravelly Clay with occasional Cobbles and Boulders

PAGE 1.0

SCHLUMBERGER WELL SURVEYING CORPORATION

COMPANY: [illegible]

WELL: [illegible]

FIELD: [illegible]

COUNTY: [illegible]

STATE: [illegible]

Other Services: [illegible]

Permanent Datum: [illegible]

Log Measured From: [illegible]

Drilling Measured From: [illegible]

Elev.: [illegible]

Date	[illegible]		
Run No.	[illegible]		
Depth-Driller	[illegible]		
Depth-Logger	[illegible]		
Bottom Log Interval	[illegible]		
Top Log Interval	[illegible]		
Casing-Driller	[illegible]		
Casing-Logger	[illegible]		
Bit Size	[illegible]		
Type Fluid in Hole	[illegible]		
Density	[illegible]		
Viscosity	[illegible]		
Fluid Loss	[illegible]		
Source of Sample	[illegible]		
Rm at Meas. Temp.	[illegible]		
Rmf at Meas. Temp.	[illegible]		
Rmc at Meas. Temp.	[illegible]		
Source Rmf / Rmc	[illegible]		
Rm at BHT	[illegible]		
Max. Rec. Temp.	[illegible]		
Equipment Location	[illegible]		
Recorded By	[illegible]		
Witnessed By	[illegible]		

Run No. [illegible]

Bit No.	Type	Size	From	To
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Casing Record

Size	Wgt.	Grade	From	To
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Tubing Record

Size	Wgt.	Grade	From	To
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Perforations

Type	Size	Number	From	To
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Remarks: [illegible]

Equipment Location: [illegible]

Recorded By: [illegible]

Witnessed By: [illegible]

Run No. [illegible]

Bit No.	Type	Size	From	To
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Casing Record

Size	Wgt.	Grade	From	To
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Tubing Record

Size	Wgt.	Grade	From	To
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Perforations

Type	Size	Number	From	To
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Remarks: [illegible]

Equipment Location: [illegible]

Recorded By: [illegible]

Witnessed By: [illegible]

Run No. [illegible]

Bit No.	Type	Size	From	To
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Casing Record

Size	Wgt.	Grade	From	To
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Tubing Record

Size	Wgt.	Grade	From	To
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Perforations

Type	Size	Number	From	To
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

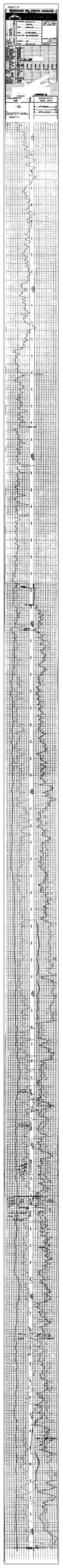
Remarks: [illegible]

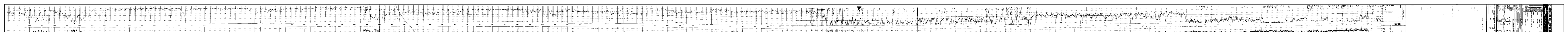
Equipment Location: [illegible]

Recorded By: [illegible]

Witnessed By: [illegible]

PAGE 1.1





SCHLUMBERGER WELL SURVEYING CORPORATION

Gamma Ray Neutron

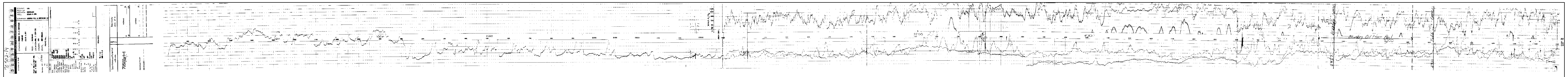
COMPANY PETROLEUM PRODUCTS
WELL LOCKHART # 1
FIELD WILDCAT
COUNTY LEA
STATE NEW MEXICO
LOCATION 1980' FSL & 1980' FEL
SEC. 2 T-16-S R-35-E
ELEV. K.B. 4192
D.F. 4191
G.L. 4179
Date 8-4-55
Run No. ONE
Depth-Driller 9112
Depth-Logger 9116
Bottom Log Interval 9114
Top Log Interval 8800
Casing-Driller 13 3/8 @ 1500
Casing-Logger 1500
Bit Size 12 1/4
Type Fluid in Hole SALT WATER
Dens. 10.0
Visc. 50
pH 10.0
Fluid Loss 10.0
Source of Sample CIRCULATED
Rm @ Meas. Temp. .75 @ 80°F
Rmf @ Meas. Temp. .60 @ 80°F
Rmc @ Meas. Temp. .90 @ 80°F
Rm @ BHT .50 @ 180°F
Time Since Circ. 14 HRS
Max. Rec. Temp. 180°F
Equipment No. 5792
Location HOBBS
Recorded by R. CRAGG
Witnessed by H. E. WILLIAMS

REMARKS: CASING COLLAR LOCATOR RUN
RECORDED FROM 8800 TO 9114
PRESENT TEMP. 180 FROM 8800 TO 9114
PRESENT TEMP. 180 FROM 8800 TO 9114

SCALE 2" = 100'
SCALE 2" = 100'
SCALE 2" = 100'

GAMMA RAY
MICROROENTGEN PER HOUR
0 10 20 30 40 50 60 70 80 90 100

NEUTRON
STANDARD COUNTS PER SECOND
Neutron Counting Rate
Counting Rate Meter Sensitivity 100 KCPMS 40 Mar
Scale Factor Base 10 MICROSEC in Mode Mar
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700

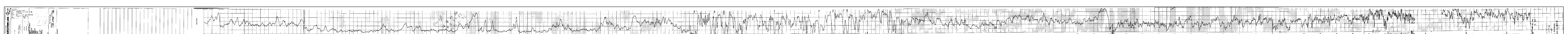

Mudlogging Unit Depth
5500
5550
5600
5650
5700
5750
5800
5850
5900
5950
6000
6050
6100
6150
6200
6250
6300
6350
6400
6450
6500
6550
6600
6650
6700
6750
6800
6850
6900
6950
7000
7050
7100
7150
7200
7250
7300
7350
7400
7450

PERFORATING DIVS ATLAS CORP.

SULTANEOUS RADIATION LOG

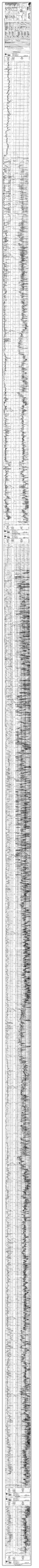
COMPANY	L. E. ELLIOTT
WELL	PARKELL #4
FIELD	LITTMAN
COUNTY	LEA
STATE	NEW MEXICO
LOCATION	2310 FSL 2310 FEL TWP 21S RGE 36E
ELEVATION	3677
DATE	10-21-58
TOTAL DEPTH	4320
DRILLING METHOD	ROTARY
TYPE OF FLUID	BRINE
MAX. REC. TEMP.	104
RUN NO.	ONE
CASING RECORD	SURFACE TO 4306
DRILL PIPE RECORD	4" TO 4306

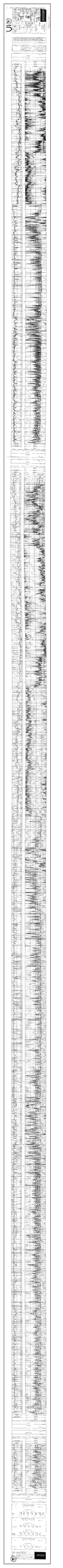
REMARKS AND OTHER DATA



Date	1/1/1
Time	1:1:1
Operator	
Well	
Field	
Company	
Comments	

Depth	1.1
Speed	1.1
Tension	1.1
Gamma Ray	1.1
Density	1.1
Neutron	1.1
Caliper	1.1
Resistivity	1.1





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[redacted]

[redacted]

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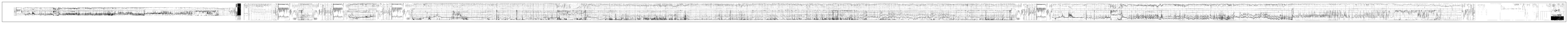


ANDREWS

Sw

Operator	Andrews
Lease	Sw
Well	
Field	
County	
State	
Date	
Elevation	
Total Depth	
Comments	

| | | |

ANDREWS

1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9
10	10	10	10

[illegible]

| | | |

[illegible]

[illegible]

[illegible]

[illegible]

大阪証券取引所

銘柄	市場	業種
[illegible]	[illegible]	[illegible]

取引	信用	貸株	売買
[illegible]	[illegible]	[illegible]	[illegible]

日付	曜日	前日	始値	高値	安値	終値	出来高	売買代金
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Ministerio de Minas y Energía

Instituto Colombiano de Geología y Minas

Sondeo Eléctrico Vertical

Ciudad: Cali

Fecha: 1 Mayo 1 1 1

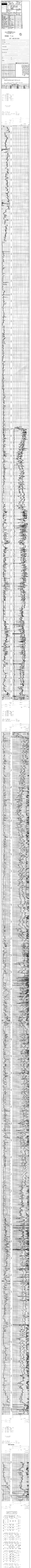
Schlumberger

Dresser Atlas

Well Site Chart

Company	
Well	
Field	
County	
State	
Date	
Run No.	
Depth Driller	
Depth Logger	
Bottom Log Interval	
Top Log Interval	
Casing Driller	
Casing Logger	
Bit Size	
Type Fluid in Hole	
Density	
Viscosity	
pH	
Fluid Loss	
Source of Sample	
Rm @ Meas. Temp.	
Rmf @ Meas. Temp.	
Rmc @ Meas. Temp.	
Rm @ BHT	
Time Since Circ.	
Max. Rec. Temp.	
Equip. Location	
Recorded By	
Witnessed By	

Run No.	Bit Size	From	To

Type	Size	Wt.	Depth

Company	Petroleum Development Oman
Well	Fahud-1
Field	Fahud
Country	Oman
Date	1-Jan-1970
Time	00:00
Depth Unit	Meters
Log Type	Dipmeter
Log Date	1-Jan-1970
Log Run	1
Max Depth	3000.0
Min Depth	0.0
Tool	Dipmeter
Comments