



Amoco Production Company

Research Department

Visual Description Of Shrinkage Cracks In The Red Silts Of Chase (Wolfcamp) Cores, Kansas

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JANUARY 1976

Visual Description of Chase (Wolfcamp) Cores, Kansas,
Documenting the Lithology and the Occurrence and
Intensity of Shrinkage Cracks Occurring
in the Red Silts

T.S. 6251MM, Job 5596

By

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January 1976

For Amoco Research

1.0 INTRODUCTION AND REFERENCES

This report is the result of a one-month internship with the Amoco Production Company Research Center in Tulsa, Oklahoma as part of an off-campus independent study in geology from Skidmore College.

The core descriptions found within are the product of one month's work at the Research Center of the Amoco Production Company. This work was carried out as a Special Project for the 1976 winter term of Skidmore College. I spent the month of January at the Research Center in Tulsa studying the three cores included in this report. Major emphasis was placed on documenting lithology and sedimentary structure as well as determining the existence and distribution of any fractures in the rocks. The cores were examined visually and with the aid of a binocular microscope.

I am especially grateful to Warren Spaulding and Dan Hartmann for their invaluable help in setting up the project and putting together this report. Special thanks are due John Bradley and his family for making my stay in Tulsa so enjoyable, and to everyone at the Research Center who patiently answered all my questions and helped me to feel right at home. The assistance given me by Jim Ebanks of the Kansas State Geological Survey was also much appreciated.

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2.0 LOCATION AND GEOLOGIC INTERVAL

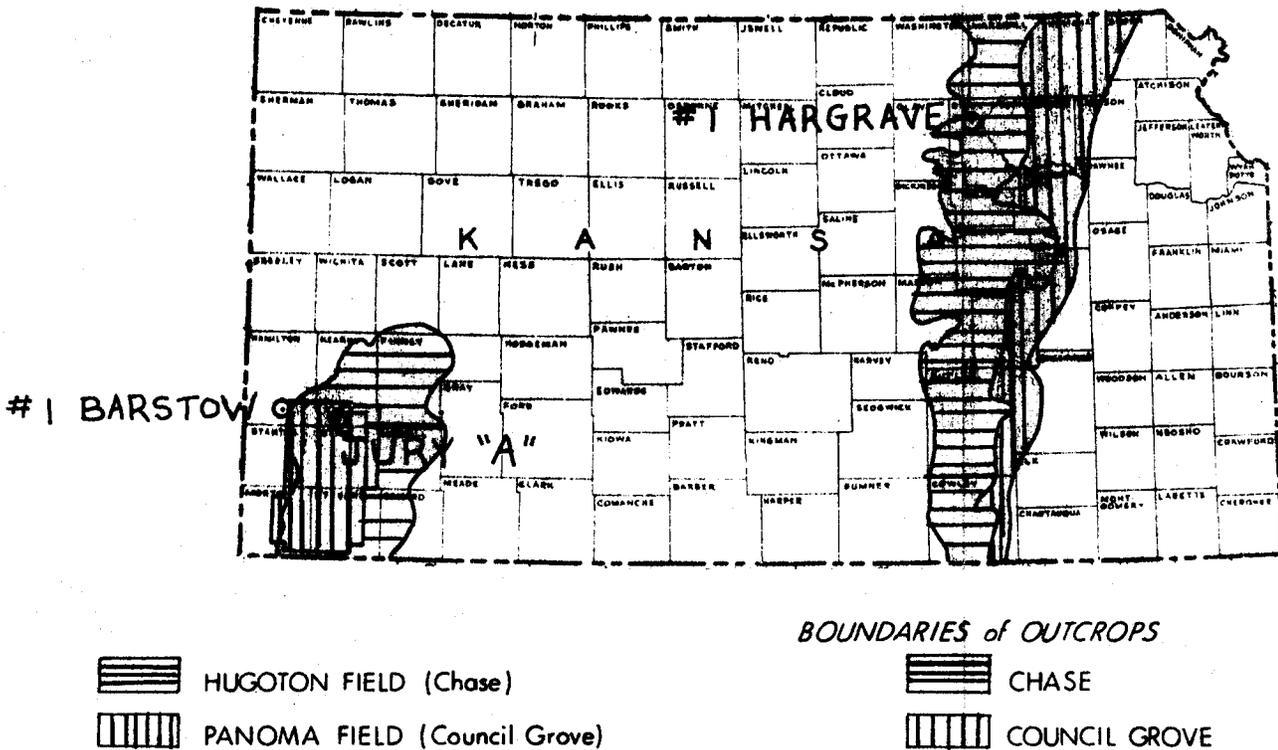
Chase cores from Panama field were compared to a Chase core cut behind the outcrop in eastern Kansas, to related fracture units.

The following cores were studied:

- Amoco Barstow Gas Unit #1, Hamilton County, Kansas
- Northern Natural #1 Jury "A", Kearny County, Kansas
- Amoco #1 Hargrave, Riley County, Kansas

All three cores are lower Permian in age, belonging to the Chase Group (Fig. 2.0). The overall character of Permian rocks in this area is that of a marine regressive sequence, while those of the Chase Group represent cyclic marine and nonmarine deposition. The complete Jury "A" core shows this quite well with its alternating beds of siltstones, shales and limestones.

The geographic locations of the cores are noted on the map below.



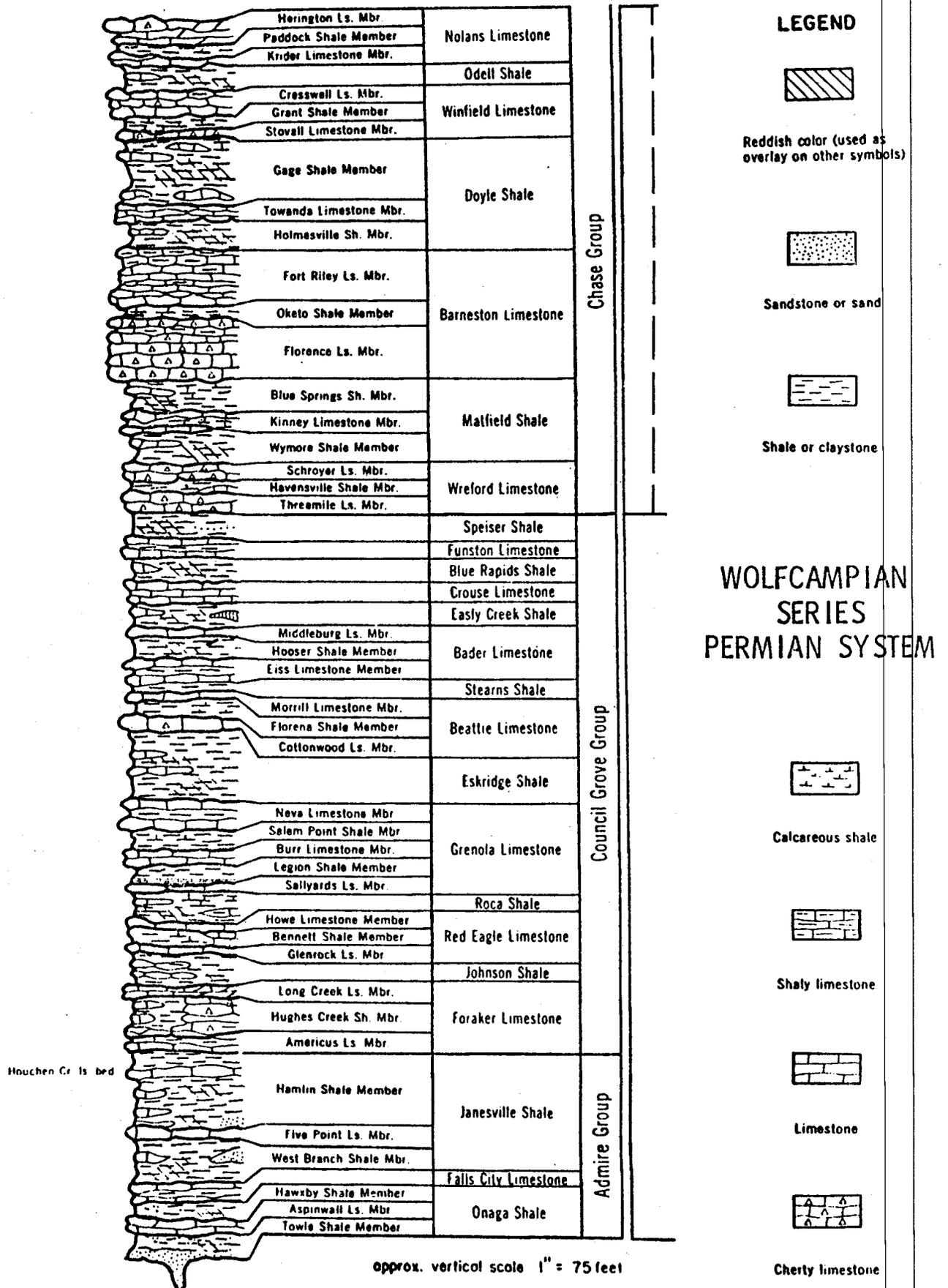


Fig. 2.0 Columnar section of Wolfcamp units. from West et al, 1972a, G.S.A. G.B., South Central Section.

3.0 GEOLOGIC CROSS SECTION

The following generalized geologic cross section illustrates the variation in character of the Chase Group across the State of Kansas.

As can be seen from the accompanying lithologic columns, there is a great deal of similarity between the Barstow and Jury "A" cores. Both consist primarily of dirty, fossiliferous limestones overlain by coarse, well sorted red-brown siltstones and thin interbedded units of red and gray shales. In both cores fracturing is limited primarily to the finer silts and shales, many of which are quite fissile. The fracture networks found in these units are quite small, and have a modified rectangular-chicken wire shape. Some larger chicken wire fracturing is found in the siltstones, but this for the most part seems to be related to the fracturing of the finer grained rocks and is not extensive.

Anhydrite is abundant in both cores in several forms. Nodules and thin stringers of crystalline anhydrite are scattered throughout the rocks, and there are occasional beds

of the mineral ranging from one to several feet thick. The siltstones from each are all calcareous, although those in the Jury "A" seem to be a bit more so, reacting more rapidly and vigorously to acid. For the most part the character and appearance of the Barstow and Jury "A" cores is very much alike.

The Hargrave core, however, is quite different. Part of this is due to the fact that the core was taken near the surface, and its upper half was subject to much weathering. Nonetheless, the rocks as a whole are much finer grained, and shales rather than siltstones predominate. Fracturing is much more extensive in the Hargrave core, but this is believed to be a function of the smaller grain size. The fracture networks are fairly small, and in many places the rock is quite fissile.

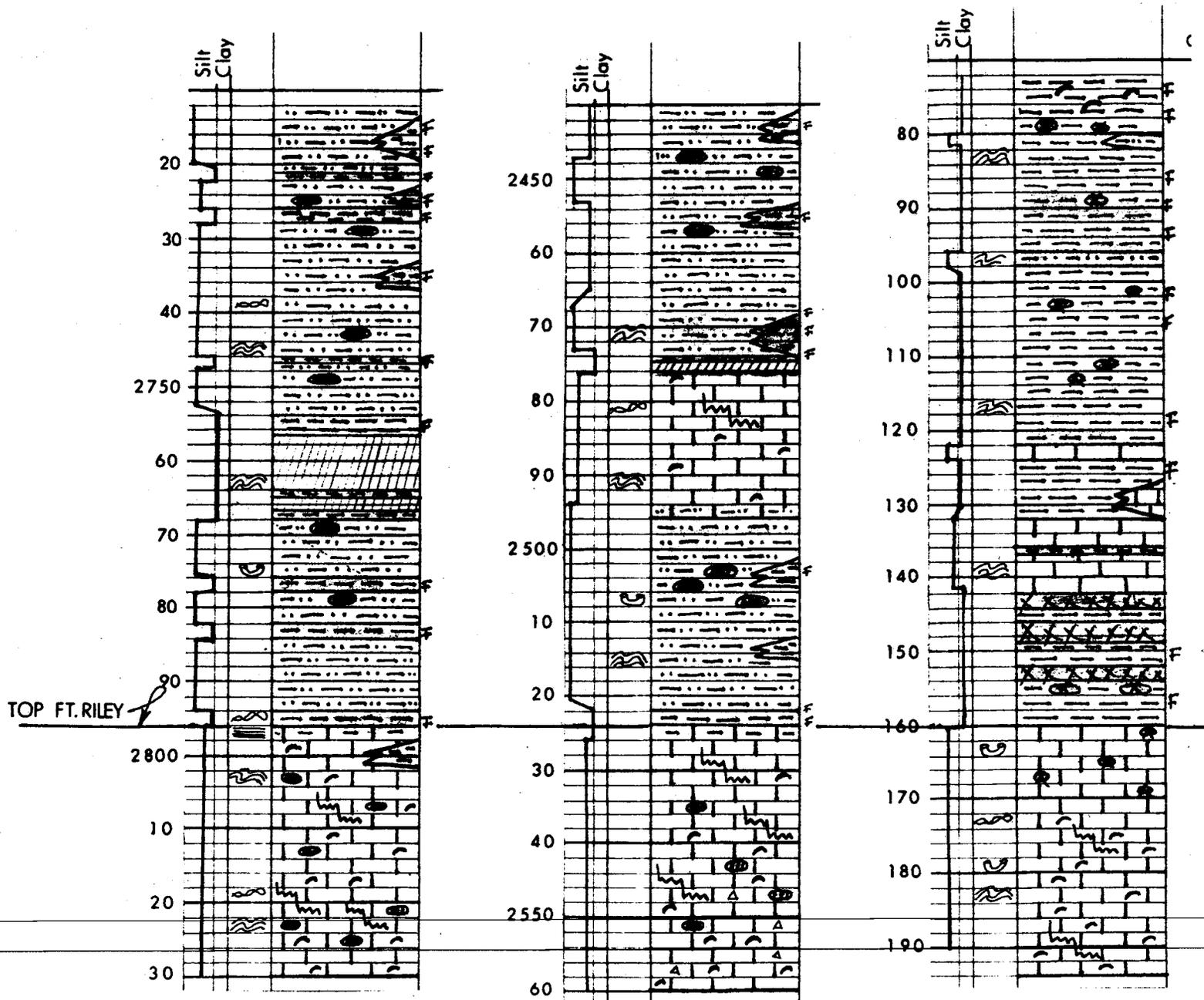
AMOCO-BARSTOW, GAS U.1
Hamilton Co., Kans.
34-25S-40W

NORTHERN NATURAL
NO.1 JURY 'A'
Keamy Co., Kans.
32-26S-37W

AMOCO-HARGRAVE NO.1
Riley Co., Kans.
32-7S-6E

LEGEND

-  Sandstone
-  Siltstone
-  Shale
-  Limestone
-  Dolomite
-  Siltstone with interbedded sh.
-  Slump or flow structures
-  Irregular layers or pods
-  Burrows
-  Stylolites
-  Fossiliferous
-  Chert
-  Fractured
-  Nodules
-  Anhydrite
-  Gypsum



4.0 GEOLOGIC CORE DESCRIPTIONS

4.1 Detailed Description of the Amoco #1 Barstow

A close, careful examination of the Barstow core was carried out with the specific intent of documenting the occurrence and extent of fracturing. In addition to noting the size and shape of all fracture networks, the following description includes comments on both the lithologic character and sedimentary structures of the core.

2712-2716.7 (Depth)

Siltstone - very well sorted, dolomitic. Light gray at the top, becoming mottled light gray and reddish brown and eventually completely red-brown at 2715. Finely laminated in places. Fractured, network fairly large (.25 cm average on a side), not well developed.

2716.7-2717

Shale - gray, with darker gray laminations. Some very fine fractures, but these are hard to see.

2717-2717.8

Siltstone - moderate brown but color can vary from dark brown to tan. Highly fractured along a "chicken wire" pattern, rock breaking into pieces. Some laminations, these tend to be a bit contorted. Dolomitic (very slow reaction to HCl). Anhydrite nodules present.

2717.8-2718.2

Gray, highly fractured and broken shale layer. Dolomitic. Rock is extremely flakey, fracture polygons are small and plate like. Some also breaking off in ball-type structures.

2718.2-2719

Coarse reddish-brown siltstone, mottled in some places with gray. Dolomitic, reaction to HCl is more vigorous along fractures. The fracture pattern in this section is coarse and irregular. Scattered anhydrite nodules are present.

2719-2720.2

Same as above, but very few fractures. Many small anhydrite nodules. Dolomitic (very minor reaction to HCl).

2720.2-2721

Coarse siltstone, dark reddish brown. Fairly regular coarse chicken wire fractures, from about 2.0-5.0 cm along each side. Scattered anhydrite nodules found along fractures. Irregular laminations near 2721. Dolomitic.

2721-2721.5

Gray shale or very fine siltstone, highly fractured and flakey. Mixed with irregular blotches of white dolomitic material. These areas are not fractured as much. Some anhydrite nodules.

2721.5-2722.5

Shale grades back into the red-brown siltstone. Extent of fractures decreases, fracture pattern becoming coarse and not well defined. Outer surface of core slightly pitted near top. Amount of dolomitic material (blotches) gradually decreases to nothing (rock in general, however, is still dolomitic). Anhydrite found in nodules and elongate crystalline inclusions.

2722.5-2724.5

Medium to fine siltstone with visible dolomite concentrated in scattered small nodules. This section is highly fractured, often

4.1 Detailed Description of the Amoco #1 Barstow (Continued)

crumbling into subangular or rounded pieces. The fracture network starts out quite coarse (up to 40 cm along a side) but becomes finer with depth (< 1.0 cm/side) as rock changes from siltstone to shale (at 2724). Rock is dark red-brown. Anhydrite is scattered in nodules and along some of the fractures.

2724.5-2726

Shale sequence continues, color becomes a mottled brown, gray-green, and white (dolomitic or limy reaction of this to HCl is fairly rapid). Outer surface of core somewhat pitted, with the white areas being a bit more resistant. This section of rock, though it is still fractured, tends to be a bit more massive than those immediately above and below it. It is not as crumbly or flakey, the pattern is not well developed. Scattered inclusions of anhydrite are present.

2726-2727

Once again, the rock is highly fractured and broken into pieces. Fracture density is fairly high - polygons are 1.0 cm or smaller along a side. The rock is fairly flakey, and fracture planes tend to be somewhat rounded. Dolomitic.

2727-2730

The grain size increases to that of a coarse siltstone. Much anhydrite is present in nodules of varying size. The appearance of the rock continues to be a mottled brown, and green with blotches of white. All portions of the rock are calcareous, though the white and green areas tend to react faster to HCl than do the brown. The fracture pattern is fairly dense, but fractures are fine and hard to see.

Fractures become less frequent starting at 2729.

2730-2731.5

Dark red-brown coarse siltstone, dolomitic, some mottling of light green. Many short hairline fractures (~ 5 cm long)...a more definite fracture pattern develops with depth. At 2731.2, there is an abrupt color change to gray-green for 0.3 ft. Then back to red-brown. Found in this thin gray layer are wavy laminations which seem to serve as breakage planes. Associated with this and all above other gray-green sections are tiny dark flecks which seem to represent some sort of dark mineralization.

2731.5-2733

Brown medium-grained siltstone mottled with the above-mentioned white dolomitic material. "Chicken wire" fracturing is present. The pattern is fairly fine; polygons range from .5 to 1.5 cm on a side, and are for the most part relatively equidimensional (i.e., not flakey). Inclusions of anhydrite are scattered throughout the rock.

2733-2733.8

Color change to gray, grain size the same - coarse silt. Contorted laminations and disturbed bedding - section looks quite churned up. Irregular pods and lenses of varying tones of gray. Dolomitic.

2733.8-2735

Abrupt color change back to brown, churned up appearance persists for a while, then disappears. Minor anhydrite inclusions scattered throughout. A thin layer (about 1") of fissile brown shale is found within this section - otherwise rock is

4.1 Detailed Description of the Amoco #1 Barstow (Continued)

fractured and broken into pieces. Fracture pattern is somewhat rectangular, horizontal fractures being longer than vertical ones. The rock is dolomitic.

2735-2736.7

Red-brown coarse dolomitic siltstone, no fractures. Scattered anhydrite inclusions, some faint laminations. Fracture pattern begins to develop at 2736.3, a fairly large open network at first - rectangular...up to 40 cm horiz., 1.0-2.0 cm vert. Pattern becomes finer quickly as grain size decreases. Anhydrite found filling in some fractures.

2736.7-2737

Fine dolomitic siltstone, red-brown. Extensively fractured, rock crumbly and flakey, breaking into pieces. Fracture network 0.5-1.0 cm horiz., 0.2-.5 cm vert. This is followed by a thin layer of gray shale, not quite as extensively fractured as the above red-brown layer, but still very crumbly... breaking off into larger pieces. Anhydrite present.

2737-2746

Red-brown dolomitic siltstone, mottled tan-brown in some places (especially around 2745). Some laminations, these are wavy with minor contortions. Scattered small anhydrite inclusions are present. The only fractures in this section are those associated with a thin shale bed from 2739.5-39.9. The character of fractures here is the same as those of previously described shale units.

2746-2747.2

Fractured shale layer, dark brown mottled with light gray-green, thick

band of green at the top. Breaking into pieces easily. Fractures about 3.5-4.0 cm long, 1.5 cm high, 1.0 cm deep. Slightly dolomitic.

2747.2-2752

Red-brown siltstone with thin layers and irregular pods of light green. Dolomitic. Green areas react to HCl slightly quicker than the red-brown areas. Bedding planes a bit contorted. Scattered thin anhydrite inclusions. 2747.2-47.7 - completely green section, with a few thin wavy laminations.

2752-2757.9

Section of rapid changes. Rock grades from siltstone to a fractured and broken section of red-brown shale or very fine siltstone with thin interbeds and laminations of green shale. Laminations are a bit contorted, flow and slump structures are seen within them. A moderate-size fracture pattern develops with greater lateral than vertical dimensions (2.0-3.0 cm long, 1.0 cm high, 0.5-1.0 cm deep). Some pieces more fissile than others. Both siltstone and shale are slightly dolomitic. Some large anhydrite nodules present.

2757-2764.8

Massive section of anhydrite with some minor inclusions and thin bands of shale (this slightly dolomitic in parts). Appearance of this section is such that it looks like anhydrite nodules that grew so large they came to dominate the shale section.

2764.8-2765.5

Shale, very prominent but irregular laminations, slightly contorted. Slightly dolomitic. Color varies from medium to dark gray.

2765.5-2768

Anhydrite section, same as above.

4.1 Detailed Description of the Amoco #1 Barstow (Continued)

2768-2769.6

Light gray shale grading downward into fine-grained siltstone and eventually coarse red-brown siltstone. Shale shows some minor slumping or flowing. Within the siltstones are a few large pods and lenses of light green clay. Also numerous small stringers of clay material within the fine siltstone. Dolomitic.

2769.6-2777

Red-brown siltstone continues, marked by some laminations and irregular small pods of lighter brown. Dolomitic. Scattered anhydrite in long thin stringers.

2777-2778

Fracture network begins to develop, becomes finer as siltstone grades into brown shale at 2777.2. The shale is highly fractured and broken up into small pieces, and is slightly dolomitic.

2778-2782.5

Many tiny inclusions of light green clay material near 2778 - these are thin stringers, some lens-shaped, most concordant but a few discordant with bedding planes. They decrease in number with depth, but are still present. Most likely, these are burrows of some sort. Area high in bioturbation. Rock becomes increasingly silty, color varies from dark red-brown to light brown. Laminations - most contorted, broken into irregular pods and lenses. Anhydrite present in both nodules and thin stringers. The entire rock is dolomitic, with the burrows being slightly more so.

2782.5-2784

Another fine silt or clay layer, highly fractured and broken into

pieces. Dark red-brown. Fracture polygons fairly large, slightly rectangular, ave - 2.0 x 1.5 x 1.0 cm, but size varies. Anhydrite present. Dolomitic.

2784-2785

Red-brown siltstone mottled with light green, the green occurring mostly in bands with downdropping lobes. Perhaps an indication of presence of plant material (roots) at one time. Bioturbation very evident in the form of burrows, some filled with clay-like material as mentioned above.

2785-2789

Green mottling for the most part disappears, rock is a red-brown dolomitic siltstone. Scattered inclusion of anhydrite continuous throughout.

2789-2794

Rock once again takes on a mottled appearance, this time tan and brown. Rock remains dolomitic. Laminations are contorted and broken into irregular layers and pods. Incidence of scattered anhydrite inclusion decreased starting at 2789. No fractures.

2794-2799

Highly transitional area.

2794-2795

Some chicken wire fracturing begins to develop. Grain size decreases to clay, rock becomes a mottled red and green shale with a tight network of fractures and breaks off into small pieces.

2795-2798

Shale, somewhat fissile and breaking into pieces. Very fine laminations (varves, almost) of red and

4.1 Detailed Description of the Amoco #1 Barstow (Continued)

green, slightly contorted. Grades downward rapidly into gray and green varves and eventually dark gray and black. By 2795.5, varves are very straight, no contortion at all. Varves become farther apart and eventually dissipate, rock grades into a tan limestone with occasional dark laminations. Several large anhydrite nodules are present, as are scattered fossil fragments. Also, burrows (much larger than those above), filled with a larger grained, more clastic material. This section of rock quite churned up and highly variable, especially at ~ 2796-97. Laminations broken up into irregular pods and lenses.

2798-2799.3

Laminations once again become very fine and varve-like, colors dark gray and tan. These laminations decrease in thickness with depth, also become more calcareous (i.e., lower ones react much faster to HCl). Some are broken up into lens-shaped pods, but most are very straight and regular. Rock is very fine grained - shale. Scattered anhydrite inclusions, some in nodules, others in stringers following the bedding plane.

2799.3-2803.3

Tan limestone, fairly clean near top but becoming murkier-looking with depth. Medium to coarse silt-size grains. Scattered fossil fragments and a few minor stylolites. Quite a bit of anhydrite in both nodules and thin stringers.

2803-2816.5

Very churned up section.

2803.3-2809

Gray, dirty, churned up limestone. Separated from overlying tan limestone by a stylolite. Scattered

fossil fragments and anhydrite nodules, numerous fine stylolites. Some small, irregular lenses of tan limestone. Minor slumping and flowing evident. Rock contains an abundance of small dark circular coated grains. (Thin section reveals that these are microfossils...some fusulinids, some algae-coated shell fragments known as Osagia.)

2809-2809.5

Greater concentration of fossil fragments. Rock very dark and dirty looking. Stylolites present. Osagia abundant, but not evenly distributed.

2809.5-2811.5

Much fewer Osagia, found only in scattered groups. Beds broken into irregular lenses and pods, also irregular laminations. Minor slumping and flowing. Anhydrite nodules, fossil fragments scattered throughout.

2811.5-2816.5

Many irregular lenses and pods of lighter colored rock. Slump and flow structures present. Scattered fossil fragments. Some anhydrite nodules and stylolites present.

2816.5-2818.5

This section not as churned up, but still very dirty looking. A few large anhydrite nodules.

2818.5-2819

Appears to be an area of slumping or minor faulting...huge stylolite with a 0.3-ft vertical drop. Several smaller stylolites in same section. Anhydrite found in nodules and along vertical portion of stylolite. Also associated with this feature - irregular pods and slump structures.

2819-2821

Several quite irregular stylolites, core breaking along the larger ones.

4.1 Detailed Description of the Amoco #1 Barstow (Continued)

2821-2822

Osagia quite prevalent.

2822-2830

Gray limestone, dirty. Relatively fine silt-size grains. Occasional stylolites, flow and slump structures. Variety of fossil fragments scattered throughout.

Anhydrite scattered in large white nodules and smaller dark gray crystalline inclusions. Irregular contact between this crystalline anhydrite-bearing limestone and limestone without such anhydrite at 2824...looks like slumping of some kind. Osagia not found below 2827.

4.0 GEOLOGIC CORE DESCRIPTIONS (Continued)

4.2 *Detailed Description of the Jury "A"*

In order to present a more extensive view of the Chase Group the entire stratigraphic section of the Northern Natural #1 Jury "A" core has been included. It spans the

entire Chase Group, and extends into the upper part of the Council Grove. For a detailed description of this core see Figure 3.

WELL NAME _____

Northern Natural #1 Jury "A"

STATE OR PROVINCE Kansas

COUNTY Kearny

SEC. 32 TWP. 26 S RGE 37 E FIELD

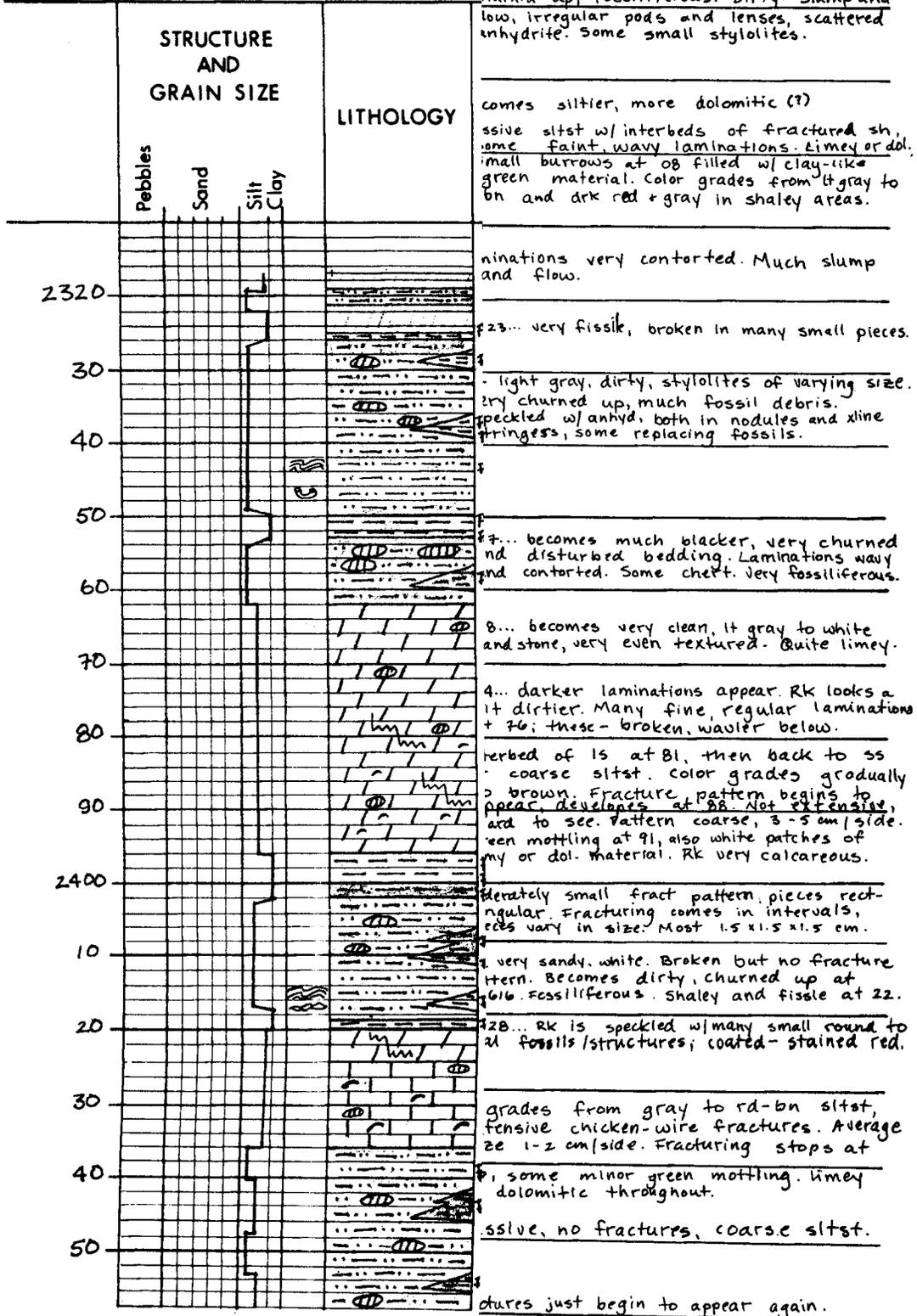
LSD _____ BLK. _____ SURV. _____

bn massive coarse siltst w/ interbedded
arker fine silts and shales... these fractured
may or dolomitic, becoming more so w/ depth.

75... very fractured.

SED. PET. 10-72

ansition into med to lt. gray ls; very disturbed
nurnrd up, fossiliferous. Dirty. Slump and
low, irregular pods and lenses, scattered
anhydrite. Some small stylolites.



4.0 GEOLOGIC CORE DESCRIPTIONS (Continued)

4.3 Detailed Description of the Amoco #1 Hargrave

The examination of the Hargrave core was somewhat less detailed than that of the Barstow. Emphasis was placed on noting the distribution of fractures within the core and on describing the general character of the rocks.

72.3-79.0

Tan - very fine-grained...shale. Limy - highly calcareous. Abundant fossil fragments. Fractured breaking into pieces - fracture pattern very small, modified rectangular - chicken wire. Rock becomes very muddy when wet. Looks weathered, slightly pitted in places. Conglomeratic in places, especially at 78.6-79.

79-80

Same, but not quite as fractured or broken into pieces. Thin, tiny stringers of some sort of black mineralization. Rock a bit coarser grained - medium to fine silt. Color a little yellower. Fault-like fracture at 80. Faint irregular laminations can be seen, very limy.

80-80.5

Light tan-white, very fine silt, scattered gypsum nodules (very small). Rock is very limy.

80.5-83

Very fine grained, highly fractured. Like dried mud. Fracture pattern very irregular, fine. Looks like drying cracks. Core surface pitted, looks dissolved. Very broken up. Color grades from tan-gray to almost white then back to tan-gray. Very chalk-like in places. Very limy.

83-91.5

Rock still very fine grained, but not as broken up. Light gray-green with patches of red. Bedding planes

appear to be very churned up near top. Becoming predominantly red at 86. Very limy, mud-like. 90.3 - nodules of some sort, probably gypsum. Changes to gray-green at 90-91, back to red-brown. Quite fractured - what looks like another fault-fracture at ~90.3 (diagonal like the above one). Rock on bottom side of fault is more churned looking and pitted.

91.5-96

Red-brown, very broken into large pieces. Occasional small mottles of gray-green. Very fine grained, clay-like, limy.

96-97.8

Fine-silt. Highly laminated. Some a bit broken into irregular lenses. Some minor slump and flow. Tends to break along bedding planes. No fracturing, limy. Color - dark and light red-brown, with some gray-green starting at ~96.5. Very broken from 97.5-97.8.

97.8-98.2

Very fine grained shale, limy. Light gray-tan, crumbly, no lamination.

98.2-116.5

Same, not crumbly. Extensive, fine fracture pattern. Very fine grained shale, mudstone, light gray. Patches of red in places. Scattered nodules of gypsum. Surface of core very porous and rough at 99. Bedding planes highly contorted, very granular. Looks like could be

4.3 Detailed Description of the Amoco #1 Hargrave (Continued)

an algal mat of some sort. This area about .3 ft thick, similar band at 100. Beds laminated light gray and yellow from 101.5-102. Surface of core quite pitted, looks dissolved in places, looks churned up or a bit conglomerated at ~116.5 (not conglomerate, no pebbles. Only looks that way due to color differences).

116.5-117.3

Some laminations, broken into irregular lenses. Slump and flow structures.

117.3-119

Very fine grained - shale. Mottled light-medium gray. Mostly broken into pieces. Surface of core a bit porous.

119-122

Light, medium, dark gray bands and laminations. Many yellow-gold tiny nodules and inclusions concordant with bedding. Rock has many pin-size holes in it, also some larger ones that look like they were produced by solution of another material. Depositional setting was very quiet, undisturbed. Rock becomes more vuggy with depth. Very broken and crumbly at 122.

122-123

Limestone - very porous-scorriaceous texture. Medium gray, a bit churned up and dirty. Some broken in pieces.

123-127

Very fine grained - shale - medium light gray with medium to dark laminations scattered throughout. No fractures. Vuggy, pinholes, also several large solution holes, up to 3 cm wide, very homogeneous texture

and appearance. Laminations for the most part very straight, some a bit wavy and irregular.

127-127.5

Same very porous limestone as above with occasional thin interbeds of fine-grain shale, limy.

127.5-128

This begins to grade back into rock same as overlying stuff. Very fine grained. Light gray, slightly vuggy, limy.

128-129.6

Light gray-tan, very fine grained shale - mud. Fractured and faulted, most crumbled in pieces. Some gypsum. Fracture pattern very irregular. Some laminations ~128.3. Near 130 - rock becomes fine silt, crumbles into tiny balls.

129.6-132.5

Missing.

132.5-134.5

Limestone - medium gray, vuggy, porous. Laminated - broken into irregular pods and lenses, slump and flow. Thin interbeds and stringers of finer gray rock. Vugs becoming a bit larger around 134.

134.5-135.2

Change to finer grained shale/mudstone, light gray, laminations broken into pods. Flow and slumping. Thin interbed of gypsum, partially dissolved.

135.2-137

Laminated, churned up limestone, surface of core pitted and vuggy. Fine silt grains. Irregular lenses and pods of darker gray, bedding very disturbed.

4.3 Detailed Description of the Amoco #1 Hargrave (Continued)

137-140.2

Medium gray limestone. Broken along bedding planes, fine silt grains.

140.2-142

Limestone, fine laminations of brown-yellow. For the most part, very smooth and regular (two are contorted in a thin band at ~140.8). This also breaking at fairly regular intervals along bedding plane.

142-143.2

Very fine grained shale, limy, or dolomitic - most of rock is bands and large blotchy nodules of gypsum. Bands run parallel to bedding planes, are fibrous/crystalline to planes, clear blotches - light brown.

143.2-145.3

Very fine grained shale, slightly limy or dolomitic, highly laminated gray-green-brown-yellow. Laminations a bit contorted, broken into pods and lenses, some vertical stringers of red-brown rock. Same grain size, etc. Laminations becoming more yellow, less red-brown with depth.

145.3-146

Shale - medium gray, very fine grained limy-calcareous. Tend to break along bedding planes, but not fractured. Large gypsum nodules and bands (as above) near top - 145.3-145.6. Shale has laminations with minor contortions.

146-148.4

Gypsum, with scattered inclusions of tan, very fine grained limy shale near bottom.

148.4-151.5

Dark to medium gray shale, some laminations. A few small fossil

fragments near top. Fine lamination, irregular, broken into pods and lenses. Small pore-like holes scattered throughout - vuggy. Becoming darker, more churned looking and fissile at 151. Many fractures, mostly horizontal along bedding planes. Rock breaks off in small thin pieces ~.5 cm thick.

151.5-152.1

Rock changes, becomes very light tan, limy shale, no laminations. Contact with overlying dark shale irregular, slump and flow. No fractures.

152.1-153.8

Gypsum with inclusions of above tan shale.

153.8-155.3

Medium gray shale, limy, churned up, irregular pods and lenses. Becomes laminated at 154.5. Laminations are fine, irregular, broken in places.

155.3-156

Gypsum with included shale as above.

156-160

Finely laminated tan and medium to dark gray shale, moderately limy, laminations contorted, wavy, some broken. Gypsum near top. Becoming grayer with depth, no fractures. Slump and flow. Calcareous percent increases with depth, irregular pods, lenses.

160-163.6

Limestone, medium to dark gray. Vuggy in places. Dirty, fairly churned up. Stringers of gypsum to bedding (a few only). No fractures. Becomes a bit lighter gray with depth, more vuggy and porous. Many

4.3 Detailed Description of the Amoco #1 Hargrave (Continued)

tiny, irregular inclusions of gypsum.

163.6-164.5

Same rock. Laminations become a bit more regular. Still many irregular lenses, churned, dirty fine silt.

164.5-164.9

Very clean, light gray limestone. A few burrows filled with siltier material as above. Contact with above rock very irregular with below - regular.

164.9-172.8

Limestone, light gray and medium gray laminations, fairly regular and even. Thin, jagged stringers of gypsum, also some larger nodules. Some slump, flow, etc., no fractures. Very "solid."

172.8-179

Light to medium gray limestone. Very porous, scattered irregular inclusions of very fine grained shale or limestone (tan-gray). Massive, not fractured or broken. Very disturbed bedding. Scattered fossil fragments more with depth. A few occasional stylolites. Much of dark color due to little round to oval

dark structures similar to those in Barstow. Many have been dissolved, giving rock porous appearance (especially to 175.5).

179.180

Limestone, medium to light gray. Burrows (big ones) filled with medium gray material. Scattered fossil fragments. Very churned up. Grades into a more layered-looking sequence at 180.

180-183.2

Light, medium gray limestone mottled - laminated appearance, bed disturbed. Irregular pods and lenses. Slump and flow structures. Fossil fragments, darker laminations of below rock start at 183.2.

183.2-194

Limestone, light-dark gray beds - laminations, some very churned up. Much fossil material. Rock has very striped appearance. Occasional fine. Not many hairline fractures to bedding planes. Very fine grained. Massive, no fracture pattern. Slump and flow, many irregular pods and lenses. Rock for the most part is dark gray, occasional bands of lighter gray.

