APPLICATION OF A LIGHT WEIGHT CEMENT SLURRY IN A NATURALLY FRACTURED FORMATION

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ABSTRACT

The Mesa Verde formation is highly naturally fractured and varies in depth from 5500' to 6200'. Low recoverable reserves make wells in this area marginally economical. The lower hole is air drilled and cemented back to the intermediate at 3700 feet. Historically, the production casing has been cemented with a 50/50 Poz/H blend mixed at 13.2 ppg. Bond logs were often marginal and fall back was a problem.

This paper reviews the application of a lightweight cement system with the ability to develop high compressive strength to enhance the mechanical seal. This slurry needed to have plating lost circulation material (LCM) to prevent fall back and minimize node buildup due to high fluid loss. The results of over forty jobs are summarized with operation and bond log results reviewed in detail from three typical wells.

INTRODUCTION

The Mesaverde grouping, the largest low permeability producer of gas in the San Juan Basin, was deposited along the Cretaceous Western Interior Seaway during the late Cretaceous period. The Mesaverde group includes the Cliff House, the Menefee, and the Point Lookout sandstone. It is a naturally fractured reservoir that has a total thickness of approximately 900 feet. The average depth to the top of formation is 5400 feet.[1] Typical frac gradients are 0.43 - 0.45 psi per foot. It is a very mature reservoir with initial production dating back to the late 1920's.[2]

The wells being drilled are on the outer edge of the basin. The average Estimated Ultimate Recovery (EUR) is the range of 0.5 – 1.5 Bcf. This makes the wells marginally economical. Any additional cost will further reduce the well's ability to produce commercially. Due to pressure depletion, the formation is not able to support a full column of water. A completion and a lightweight cement system have been developed to address these reservoir issues.

AREA OF INTEREST

The area of this study is confined to the northeast San Juan Basin, specifically in 31N-5W to 6W Rio Arriba County, New Mexico. The area consists of wells drilled to the Mesaverde along with wells drilled to the deeper Dakota formation.

DRILLING PRACTICES

The standard drilling practice in this area is to drill the intermediate casing with mud down to approximately 3700 feet. This is cemented to surface. The well is then air drilled to total depth (TD), the Mesaverde at approximately 6,100 feet or the Dakota at approximately 8,000 feet. A 4 ½" liner is run from 3600' to TD on wells designed as a single completion. A 5 ½" long string is used for dual completions.

Historically these wells were cemented with a 50:50:4 Poz:Class H:Gel blend mixed at a weight of 13.2 pounds per gallon (ppg). In the case of a long string, a lead and tail system was incorporated. The lead system was a 50:50:4 Poz: Class H:Gel mixed at 13.4 The tail system consisted of Class H plus additives. Bond logs were often marginal. Cement fall back often exposed the liner top or the zone of interest. This required numerous squeezes to ensure wellbore integrity prior to stimulation. These remedial treatments cost a considerable amount of time and expense relative to the overall economic life of the well.

To reduce remedial expense a cement system was needed that would meet the following criteria:

- Density & rheology low enough to keep the Equivalent Circulating Density (ECD) below 13.0 ppg across the Mesaverde formation.
- Compressive strengths above 1500 psi after 24 hours.
- Fluid loss below 100 ml.

PROPERTIES

A lightweight pozzolan based slurry utilizing a different base cement had been developed for use in the D J Basin of Northwestern Colorado. A derivation of this slurry was optimized for the San Juan Basin. This lightweight slurry is mixed at a weight of 12.5 ppg. The rheological properties tested in the lab were very similar to the 50:50:4 Class H slurry. However, in actual field operations the lightweight slurry mixed considerably smoother with less variation in density.

The real benefit to this system lies in the compressive strength, fluid loss and loss circulation properties. The old system at a temperature of 150 deg F developed a 24 and 48 hour compressive strength of 980 and 1825 psi, respectively. Fluid loss was 490 cc per 30 minutes with a thickening time of 3:47 with calcium chloride added.

The new system also at 150 deg F developed a 24 and 48-hour compressive strength of 1825 and 2425 psi, respectively. Fluid loss was 52 cc per 30 minutes with a thickening time of 3:12 with potassium chloride added. It also exhibited characteristics of a right angle set, which aids in the prevention of gas migration. An improved LCM was added at 4% by weight of cement (BWOC) to control fall back. These temperature conditions are typical for a Mesaverde completion.

Slurry test results for the deeper Dakota formation are similar with the exception of compressive strength, which is higher do to the elevated temperatures. As a result of the higher compressive strength of this new slurry, the tail slurry commonly utilized in Dakota completions was eliminated. This simplified the operation as well as eliminating the need for separate transports and batch mixer thus further reducing overall cost.

CASE HISTORIES

Case History #1

The first case history is a 4 ½"liner job with the 50:50 Poz:H slurry. This well was directionally drilled through the intermediate section and brought back to vertical at the bottom of the intermediate, 4280' measured depth (MD). This section was cemented to surface. The well was drilled to TD at 6800'. A spacer system consisting of 10 bbls of gel with 5 lbs bentonite per bbl followed by 10 bbls of fresh water was used to coat the annulus ahead of cement. Cement was pumped at 5 bbl/min and displaced at 7.5 bbl/min. Ten barrels of cement was reversed out from the top of the 4 ½" liner.

An acoustic bond log was run 13 days after cementing. Fig 1 shows the bond from TD to 6,630' feet. While bond is evident, the log indicates possible channeling as well as a poor bond to pipe. Fig 2 indicates that the cement fell back to approximately 6,250'. The bond from this depth to top of liner shows little or poor cement coverage.

Exceeding the fracture gradient at that depth most likely caused this cement fall back. Once the formation broke down, the formation continued to take cement until the overbalanced condition in the annulus was lost.

In order to fracture the well, two squeezes were required to isolate the Point Lookout and the Cliff House/ Menefee before these zones could be fracture stimulated. Cost of this squeeze work plus rig time was in excess of $20,000.

Case History #2

The second case history is a 5 ½" long string using utilizing the new lightweight cement system. The intermediate section was set at a depth of 3,700' and cemented to surface. The well was then drilled to TD at 8,200'. A spacer system consisting of 20 bbls of gelled water followed by 10 bbls of fresh water was used to coat the annulus ahead of the cement. The cement was pumped at rate of 5.5 bbl/min and displaced at a rate of 6 bbl/min.

An acoustic bond log was run 12 days after cementing. Figure 3 shows the bond from TD to 7,810 feet. Good bond to pipe is evident from this depth to 2,400' (Figure 4). No remedial squeezes were needed on this well thus any additional cost was avoided.

Case History #3

The third case history is a 4 ½" liner using utilizing the new lightweight cement system. The intermediate section was set at a depth of 3,811' and cemented to surface. The well was then drilled to TD at 6,235'. The liner top was set at 3,699'. A spacer system consisting of 20 bbls of gelled water followed by 10 bbls of fresh water was used to coat the annulus ahead of the cement. The cement was pumped at rate of 5.7 bbl/min and displaced at a rate of 5 bbl/min. Ten barrels of cement was reversed out from the top of the 4 ½" liner.

An acoustic bond log was run 17 days after cementing. Figure 5 shows the bond from TD to 5,950'. Good bond to pipe is evident from this depth to liner top (Figure 6). No remedial squeezes were needed on this well.

SUMMARY

From January 1999 to August 2001, a total of 53 wells were cemented with the 50:50 Poz:H blend. Remedial squeeze work was performed on 13 of those wells, a success ratio of only 75%. Assuming an average cost of $10,000 per squeeze (includes rig time and cement costs), an additional $130,000 was needed to complete these wells. Since the implementation of the lightweight slurry system in August of 2001, forty wells have been cemented. To date no squeeze work has been required. If the same cost and success ratio is applied, this amounts to direct savings of a $100,000 over the previous blend.

CONCLUSIONS

- A new lightweight cement system that has the ability to give high compressive strength, low fluid readings and good lost circulation control has been developed and successfully implemented in the San Juan Basin.
- The lightweight system is ideal for a naturally fractured environment.
- Initial cement and subsequent jobs have yielded superior bond logs and as a result zero remedial squeeze jobs have had to been performed.
- Operationally, the system has been easier to pump on location relative to the 50:50 Poz:H system. In the case of the deeper Dakota wells, it has eliminated the need for two systems.

REFERENCES

1. Dutton, Shirley P., Clift, Sigrid J., Hamilton, Douglas S., Hamlin, H. Scott, Hentz, Tucker F., Howard, William E., Akhter, M. Saleem, Laubach, Stephen E.: "Major Low-Permeability Sandstone Reservoirs in the Continental United States" – Report of Investigations No. 211

2. Four Corners Geological Society: "Oil and Gas Fields of the Four Corners Area" – Volume 1 1978

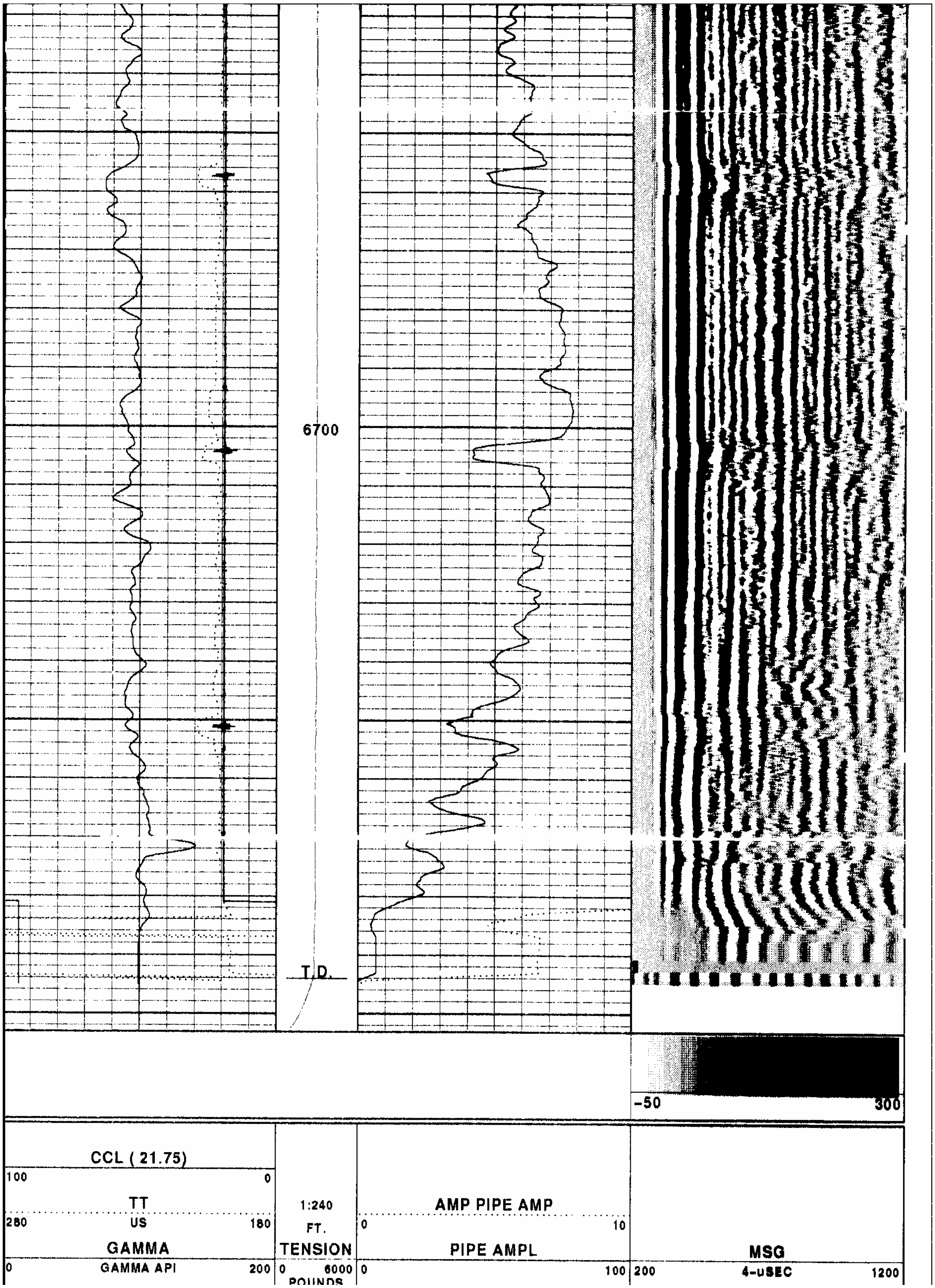

Figure 1 - Case History 1 CBL 6630' to TD

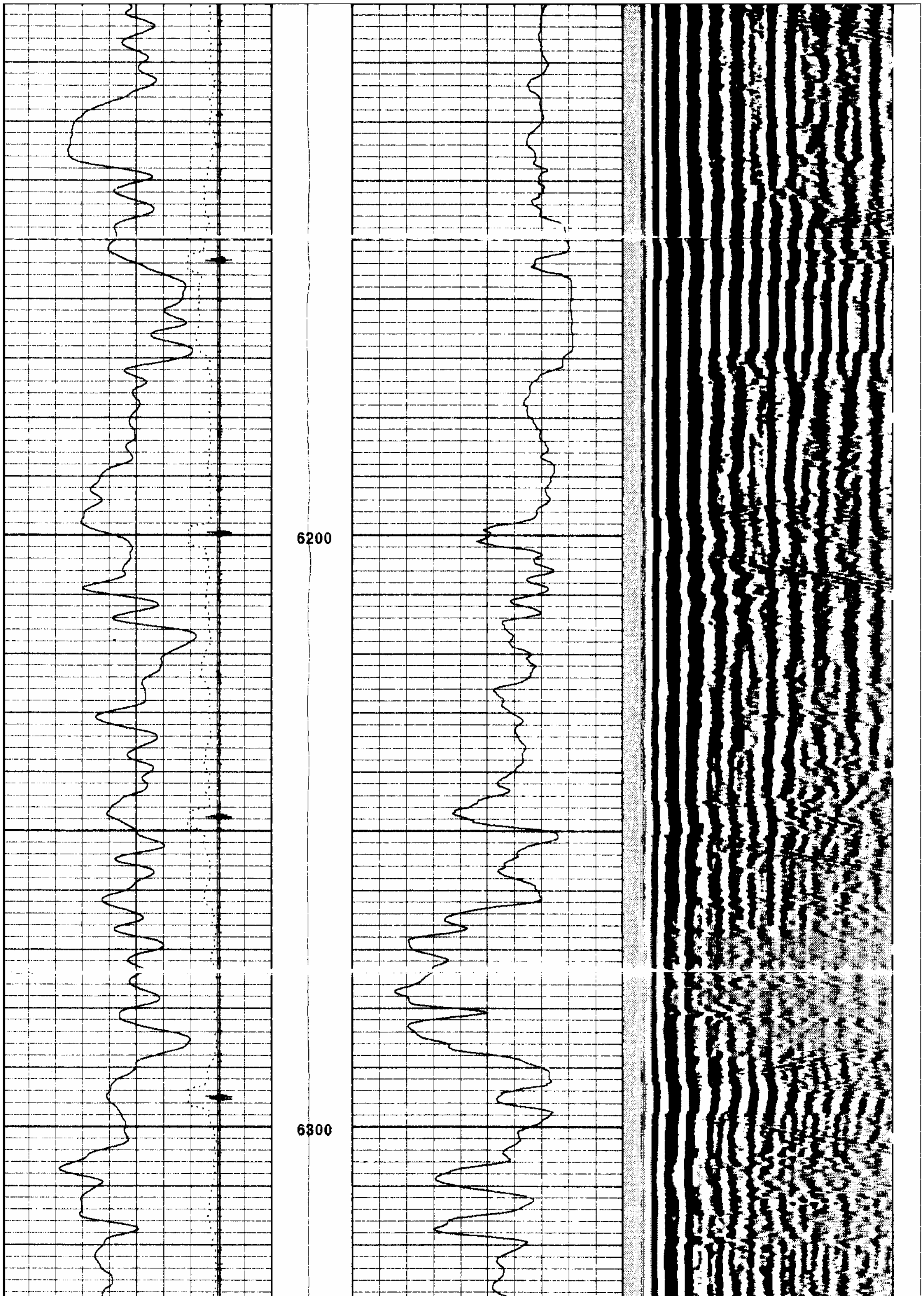

Figure 2 - Case History 1 Top of Cement After Fallback

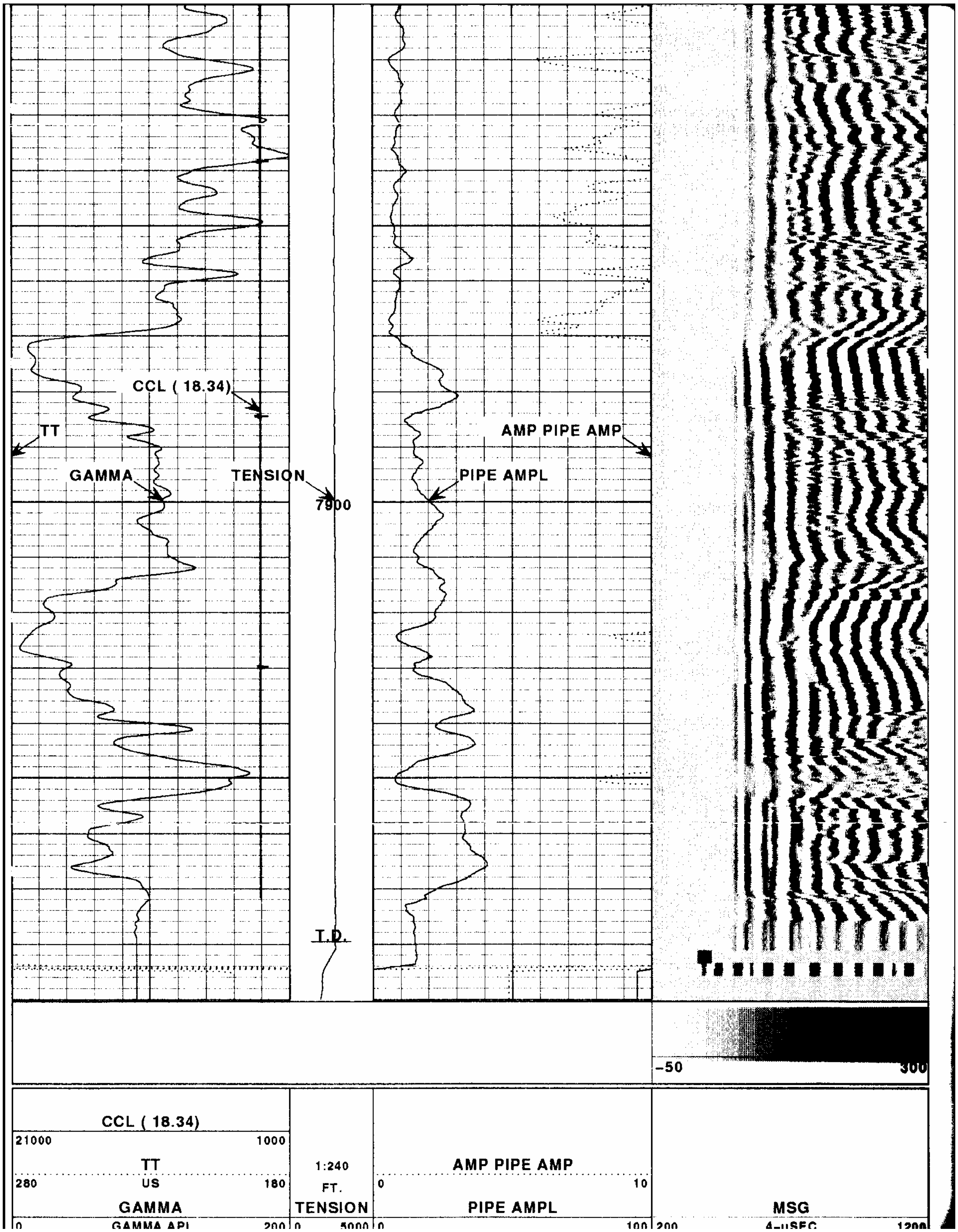

Figure 3 - Case History 2 Light Slurry CBL 6630' to TD

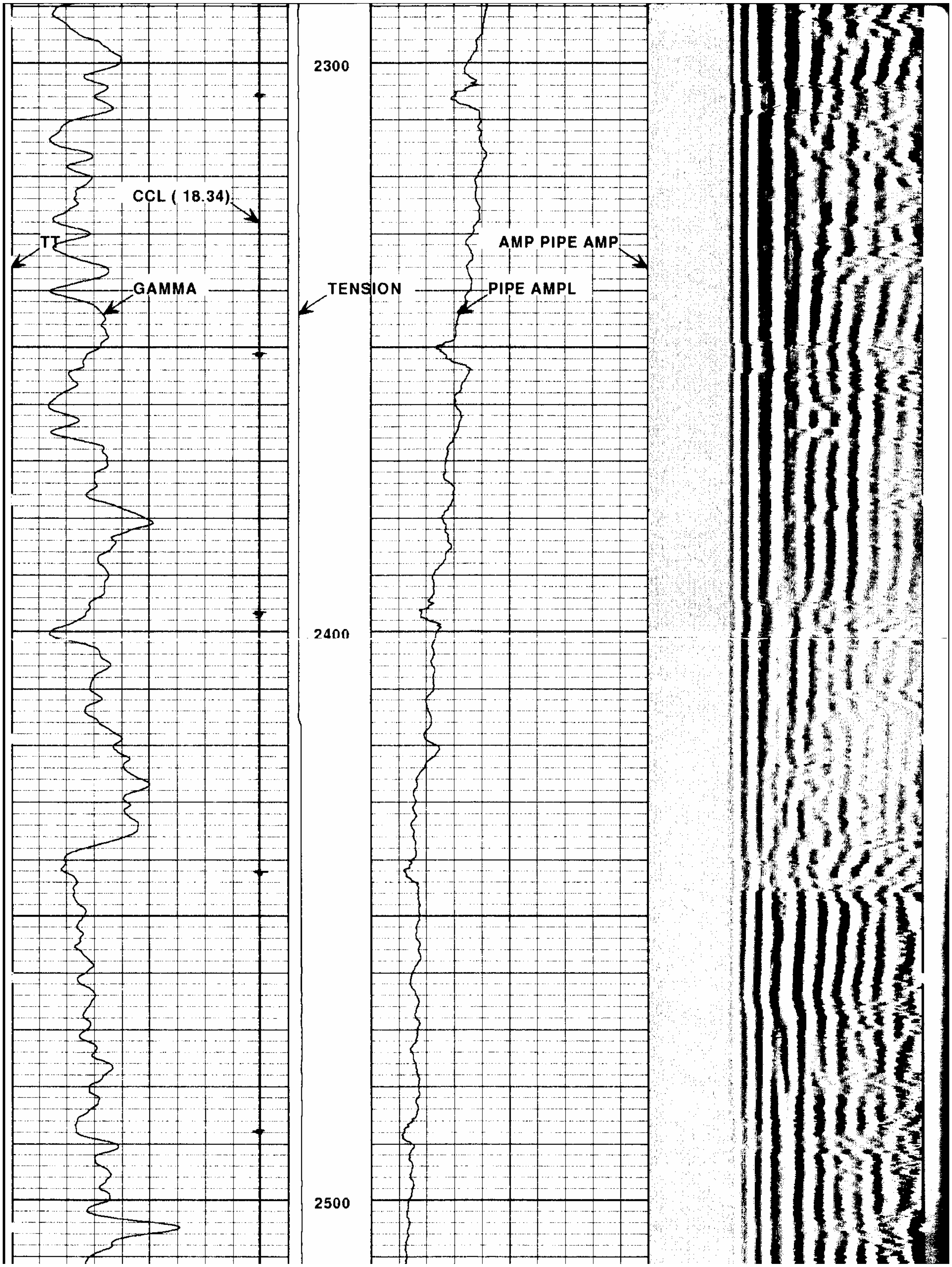

Figure 4 - Case History 2 Top of Cement at 2450 feet

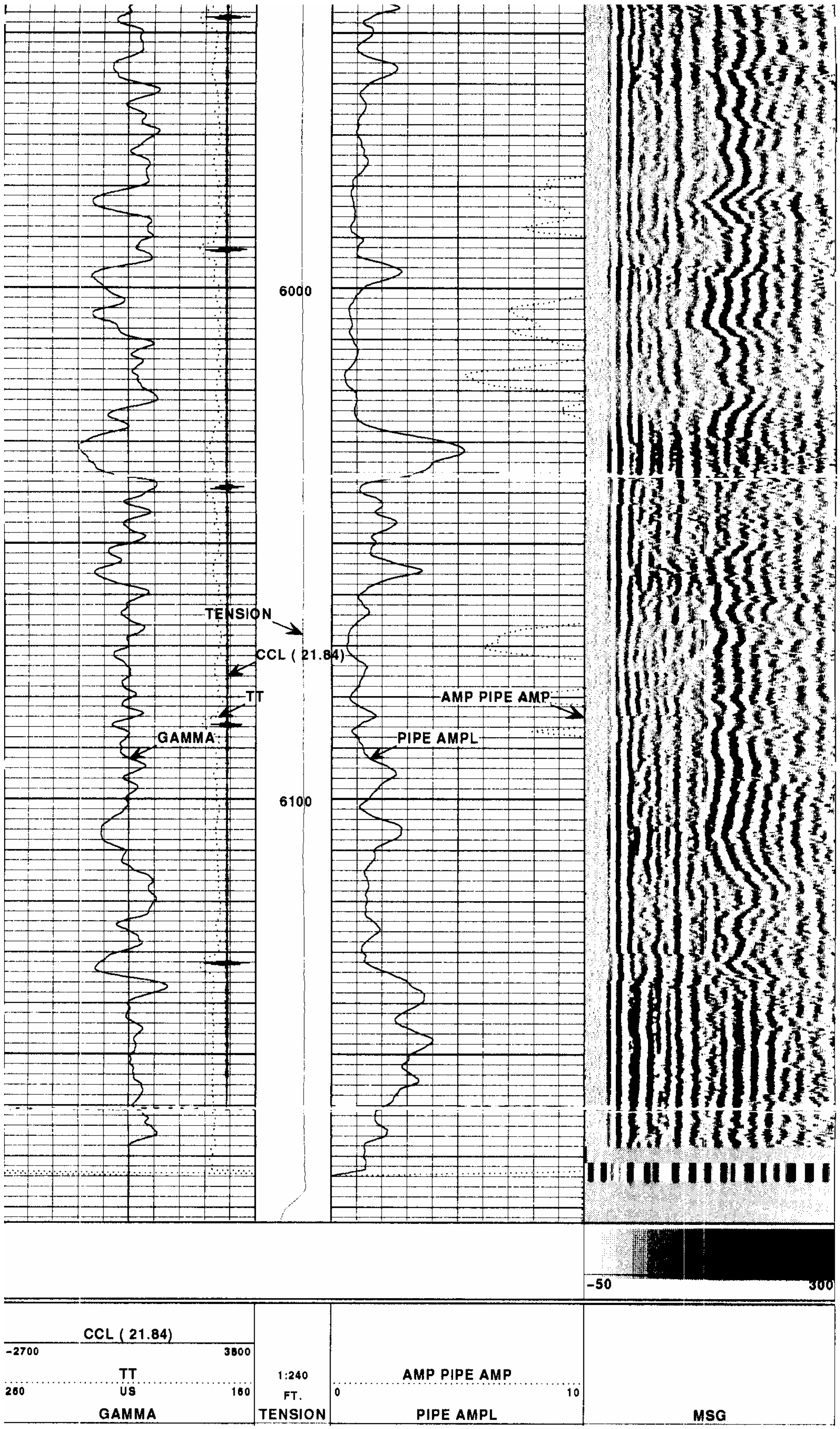

Figure 5 - Case History 3 Bond Log from TD to 5950’

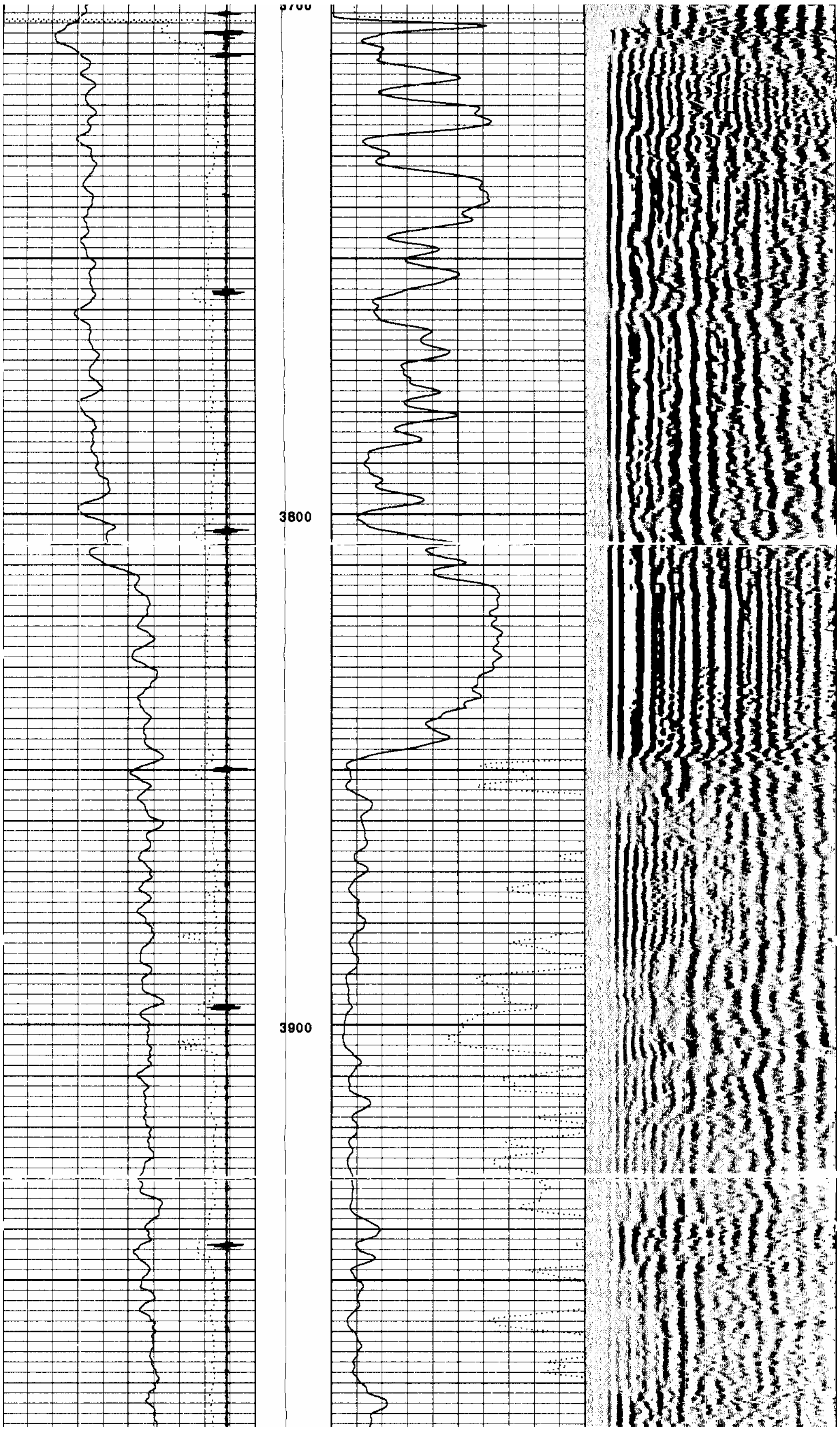

Figure 6 - Case History 3 Bond Log 3980’ to Liner Top