Special Logging Techniques of Underground Storage and Solution Mining Wells

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ABSTRACT

Logging operations in underground storage and brine solution wells can be improved by the adoption of superior survey and detection technology. This paper describes the design and operation of the Micro-Gage Density-Interface tool in logging and detection of well problems. Special emphasis is placed in the varied functions this one detection tool can perform as well as simplicity of operation.

TOOL USES

The Micro Gage Density-Interface tool is a multi-purpose device designed for logging underground storage and solution mining wells. Consisting of a collar locator, electronic section, a radiation counter or detector and a radiation source, this tool can be used in various field applications by changing the spacing between the detector and source and by changing the strength of the source.

The most common application of the tool is in detecting the brine and LPG interface (Fig. 1). This can be done through as many as three strings of pipe. An interface survey will give the exact depth of the product as well as serving as a safety precaution when the well is either almost full or empty. The survey also will serve an inventory function when used with the sonar caliper survey.

Another important usage is as a density tool. In this capacity it can locate washouts behind the long cemented string. (Figs. 1, 2) In the case of a washout it will give the user the vertical extent, but not the diameter of the washout. In addition to detecting washouts, the density tool also can locate close borehole, ledges or shelves close to the tubing (Fig. 3) and any sand or rubble buildup around the bottom of the tubing string (Fig. 4). This feature is especially useful in areas of bedded or layered salt where debris has fallen around the base of the tubing. If conditions necessitate cutting or perforation of the tubing, the density tool helps select the best possible location for such an operation. In solution mining wells the density tool is especially effective in locating the oil bed or blanket (Fig. 5, 6).

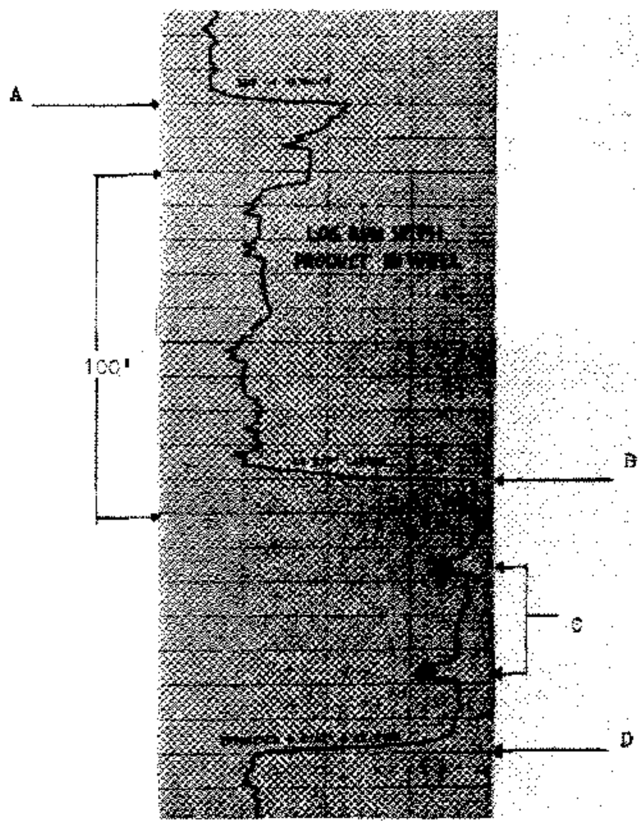

Figure 1. Log run with product in well; a. top of washout behind 13 3/8" cemented casing, LPG trapped in this area, b. bottom of 13 3/8" cemented casing, c. tubing collars, d. normal brine-LPG interface.

Of course, one of the great problems in general logging operations is consistency of practice. Lack of a permanent depth reference datum often leads to a depth discrepancy

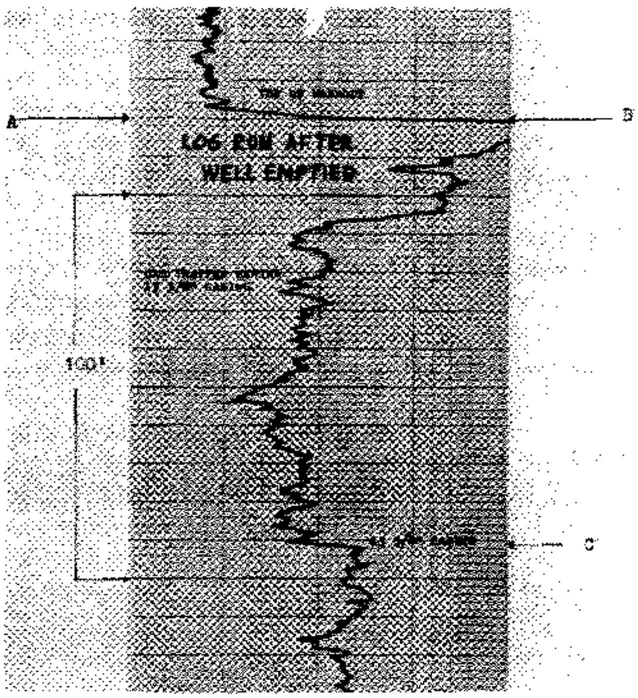

Figure 2. Log run after the same well has been emptied; a. top of washout behind 13 3/8" cemented casing, b. LPG trapped from this point to bottom of 13 3/8" casing, c. bottom of cemented casing "C."

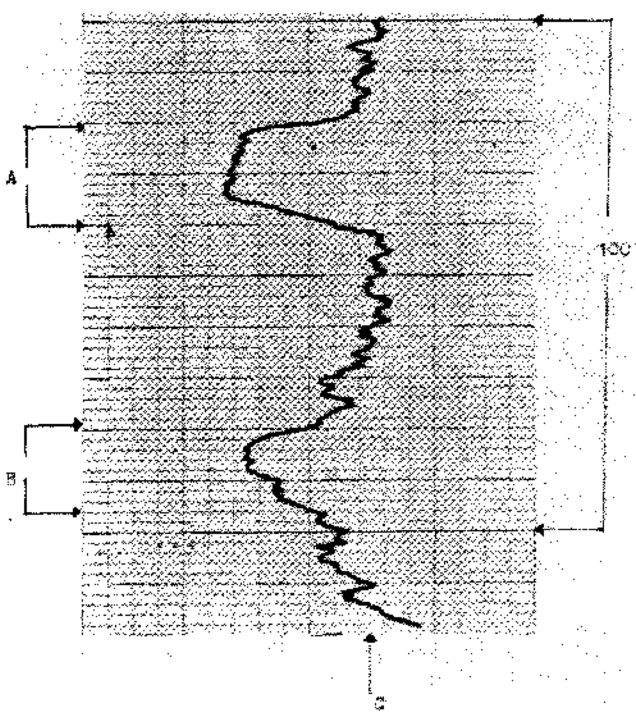

Figure 3. Log of well run close to formation. a. a change in density such as shown indicated a formation close to tool such as insoluble layers or ledges which could shear off tubing strings, b. log also indicates formation close to tubing owing to shift in left of normal base line "C," c. normal base line of log in brine.

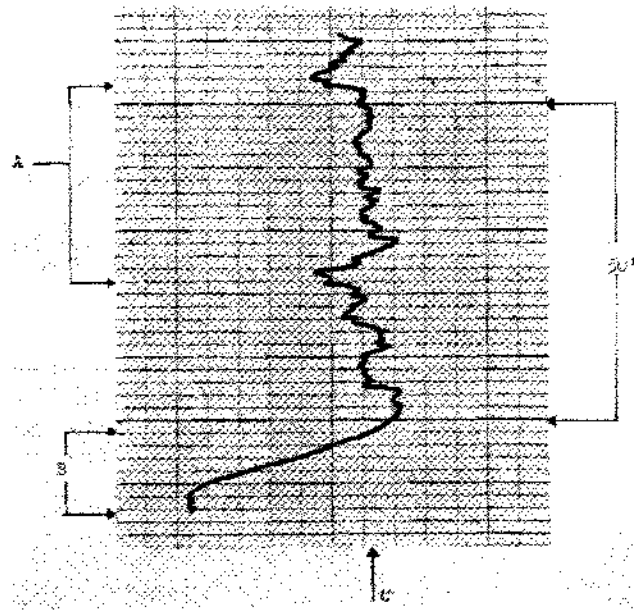

Figure 4. Log showing sand or rubble buildup at base of tubing. a. tubing collars, b. sand or rubble buildup; note shielding effect of rubble on reading which throws log far to left of normal base line "C," c. normal base line of log in brine.

between logging surveys and consequent inventory errors. The best available depth reference datum is the base of the long cemented string inasmuch as this is a permanent setting. If this reference were consistently used, all surveys would be accurately oriented to the datum regardless of which logging firm were to do the work.

Locating a leak in the cemented string on a problem well is a specialized and relatively inexpensive service performed before an expensive rig is moved in to pull the pipe. This is done by rigging-up on the well head in operating condition, going through a valve and using a lubricator. The tool is spotted at a depth. Product is detected if it moved past the tool. Product is followed uphole until a leveling-off point is reached; then more product is added to determine if it returns to the same depth. If this occurs, the leak point is probably indicated. If the product did not move after the first time it was spotted, then the tool is moved down the hole to desired depth and more product is added. This is repeated until the product starts moving and then is followed until it reaches its leveling off depth which would indicate the leak.

Another problem is wells which have been washed out behind the cemented string. Washouts happen during the leaching process if the protective blanket rises past the cemented string. Some wells have been washed out as much as two hundred feet above the cemented string. After the first density-interface survey has been run on such wells, and the product found anywhere behind the cemented string, then there is always the possibility of a

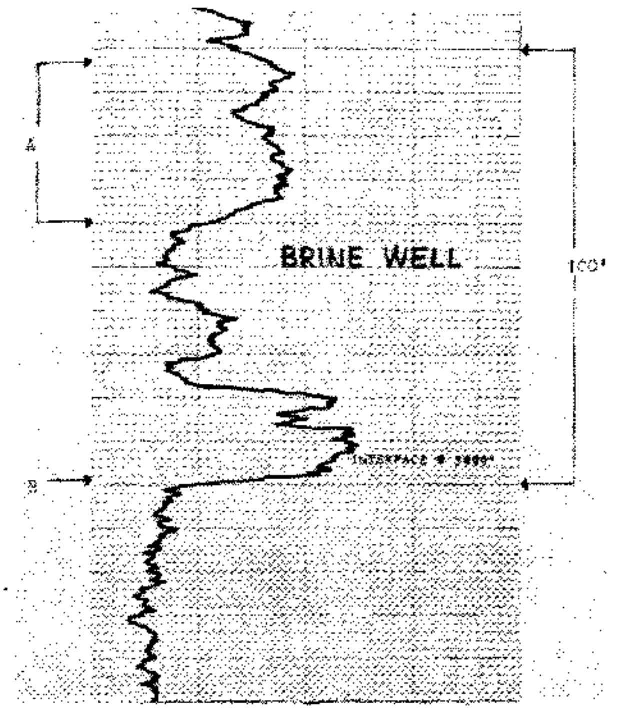

Figure 5. Log of brine well. a. brine well survey shows the diesel oil/brine interface. b. decreases in density indicate enlarged borehole as result of allowing oil pad to raise above level now shown by "B," c. diesel oil/brine interface.

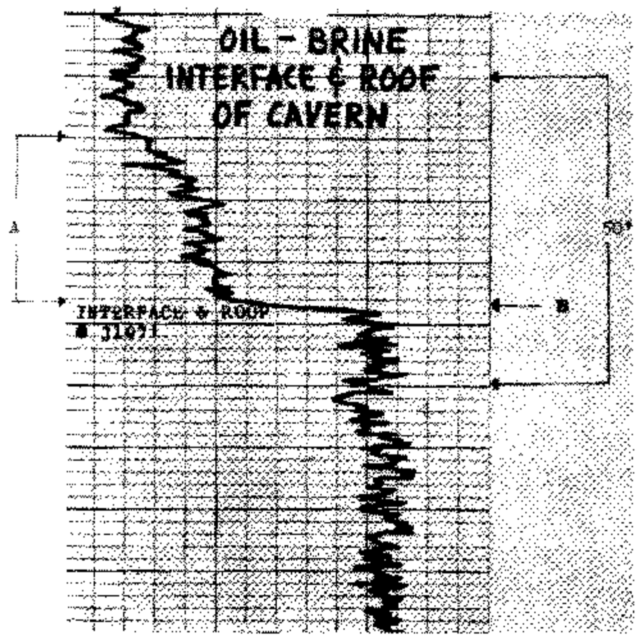

Figure 6. Log showing oil brine interface and roof of cavern in salt. a. enlarged borehole with diesel oil for leaching pad, b. increase in density indicates cavern roof with very thin layer of diesel oil protecting the roof from washing out.

leak. After the well has been emptied the first time, another density-interface survey is run to see if the product is still trapped behind the cemented string. If it is, then the well was tight and holding; if not, then there is a leak. This device also very effectively performs the function of measuring tubing settings in storage and brine wells (Fig. 7).

Actual field experience with the Micro Gage Density-Interface tool has demonstrated its effectiveness in varied testing situations. Moderate expense and simplicity of operation make it a valuable piece of equipment for the industry.

The following seven figures are taken from actual well logs obtained in the field an display decreasing density to the right side of the log. They illustrate the Micro Gage Interface-Density tool's performance in the various well conditions described above.

1. Normal interface survey showing the brine-product interface and the long cemented string with a washout behind it (Fig. 1).
2. Same well as in Fig. 1 after the well is emptied showing washout with trapped product behind cemented string. This reading done at higher sensitivity due to lack of amplification by absence of product (Fig. 2).
3. Ledges close to tubing string (Fig. 3).
4. Sand or rubble buildup at base of tubing. Note

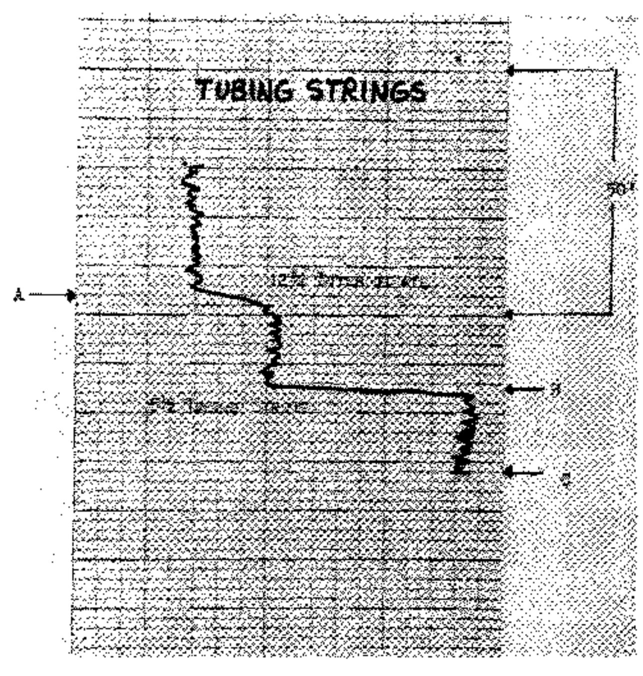

Figure 7. Log showing tubing hanging string in storage well. Increases in density indicate where bottom of pipe is located in relation to bottom of well. Also used as indicator of how much sand or rubble buildup has occurred since last survey. a. 12 3/4" intermediate string hanging 20 feet above water string, b. 5 1/2" water string hanging 16 feet off bottom of cavern "C," c. indicates total depth of cavern.

shielding effect of rubble on reading, throwing reading to the left of normal base line (Fig. 4).

5. A brine well survey showing the diesel oil-brine interface (Fig. 5).

6. Oil-brine interface and roof of cavern. Note characteristic configuration caused by thin oil pad and large, flat roofed cavern. Both the pad and roof are picked up simultaneously (Fig. 6).

7. Two hanging tubing strings. Different tubing settings are indicated by the change in density (Fig. 7).