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Project Summary

Location of Abandoned Wells with Geophysical Methods

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Mathematical modelling of the magnetic anomaly induced by steel-cased wells indicated abandoned wells could be located with high-sensitivity aeromagnetic surveys at an altititude of 60 meters with a spacing between flight lines of 100 meters. The locations of an estimated 95-98 percent of the abandoned oil and gas wells in an Oklahoma test area were identified in an aeromagnetic survey and substantiated by record and historical photography searches. Sharp anomalies resulting from variations in the near-surface sedimentary rocks caused difficulty in interpretation of the aeromagnetic results from a pilot study in Colorado. A ground magnetometer was used to locate some of the abandoned wells to within one or two meters accuracy. Electrical geophysical methods were briefly evaluated for the location of uncased wells, but test results indicated the methods would be impractical in locating most abandoned wells.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Las Vegas, NV, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The Underground Injection Control Regulations, promulgated by the Environmental Protection Agency, established a minimum radius of review of ¼ mile for proposed injection wells. This radius can be extended if warranted by the hydrological properties of the area. The concern is that abandoned wells near the injection well could serve as conduits for the transmission of injected wastes into an underground source of drinking water.

In the United States, approximately 500,000 municipal, industrial, commercial, agricultural, and domestic wells are used to inject wastes into the ground, and approximately 5,000 new injection wells are being constructed each year. Abandoned wells located near these injection wells, particularly newer injection wells, must be located and properly completed and plugged to prevent contamination of potable water. The exact location of many abandoned are often difficult to determine because records may be imprecise, incomplete, antiquated, and difficult to locate. Record searches can be time consuming and expensive, and there is always a chance that a records search will not show an abandoned well falling within the radius of review for an injection well. Other means for locating abandoned wells are needed.

The primary emphasis in this study was on the use of aeromagnetic surveys. Records and historical aerial photographic searches were also used to locate candidate test areas and to verify the correlation of a magnetic anomaly with an abandoned well. Two ground-based methods were secondarily evaluated: electromagnetics and magnetometers. Electromagnetic methods were briefly evaluated for locating abandoned wells that had no steel casing and no magnetic anomaly. However, these methods quickly proved impractical because they were time consuming and too localized for use in large-scale studies. Further research into these methods was not pursued.

Procedures

The United States Geological Survey (USGS) determined through mathematical modelling that aircraft flight lines at 100-meter spacings and at an altitude of 60 meters above the ground should be sufficient to detect wells with some steel casing. Field measurements, together with mathematical modelling, indicated that most wells containing approximately 60 meters or more of 22-centimeter or larger diameter surface casing could be detected by a low altitude, high-resolution aeromagnetic survey. Through a records search, the University of Oklahoma's Environmental and Ground Water Institute identified 24 sections in four townships around Oklahoma City as a test area where more than 15 wells per section could be found in rural areas.

The high-resolution aeromagnetic survey was conducted with the use of a microwave navigation system that used transponders on the ground and a real-time display of the flight-line location in the aircraft. The radar altimeter and aircraft orientation sensors were used to compensate for fluctuations in the earth's magnetic field from changes in the altitude and orientation of the aircraft. Photographs of the ground were taken from the aircraft to aid in the interpretation of the magnetic data and to confirm the association of a magnetic anomaly with an abandoned well.

The Environmental Monitoring System Laboratory's Environmental Photographic Interpretation Center conducted an historical aerial photographic search of the 24 sections to evaluate another method for locating abandoned wells while providing a basis for evaluating the magnetic technique. Aerial photographs dating back to the 1930's were examined for evidence of drilling. The locations of the past drilling activities were plotted on recent photographs and maps. The aerial photographic search together with the records searches formed the basis for comparison with the abandoned wells identified in the aeromagnetic survey.

Results and Discussion

The results of the study show that the magnetic method is effective in locating abandoned wells. Depending on the total area to be surveyed, most agencies or organizations with the responsibility for finding wells will require technical assistance in designing and carrying out magnetic surveys; however, the results of this study do not indicate that further research is required before the magnetic method can be applied in the search for abandoned wells.

The aeromagnetic results in Oklahoma agreed well with those obtained by a records search and by interpretation of aerial photographs. The aeromagnetic survey located an estimated 95-98 percent of the abandoned wells. The exact figure varied from one section to the other.

Most wells in the Oklahome test areas produced easily identifiable magnetic anomalies. In a few cases the anomalies were small; but, with careful analysis, most of them were recognized. When several wells occurred in close proximity, it was difficult to determine how many there were from the aeromagnetic results. Anomalies due to other manmade features,such as pipelines and transmission line towers, were a minor problem in interpreting the aeromagnetic results.

In considering the application of the magnetic method in the search for abandoned wells, the most important questions are: (1) What size magnetic anomalies are the casings likely to produce? (2) How much magnetic interference will there be from other manmade sources and from natural sources? These questions can never be completely answered in advance, since each area will be somewhat different from those already investigated. However, the test areas in Colorado and Oklahoma are representative of conditions in many oilfields, and the results from these studies can be used in planning and conducting work in other areas. areas.

Conclusions

The results of this study indicate that it is very useful to employ three methods, records search, photo interpretation, and magnetic surveys, in locating wells. All three methods should be considered for use in new areas. However, since each method has deficiencies, there is the possibility that in particular areas one or more of the methods will not be applicable. Also, in some areas, it is probable that wells can be located by use of only one or two of the three methods.

There are a number of different circumstances in which the use of magnetic methods to locate abandoned wells should be considered. Sometimes it is necessary to physically locate buried wells which are known from records. Ground-magnetic methods are most useful for this purpose. The EPA regulations require a search for abandoned wells within a certain minimum radius of ¼ mile, of proposed new injection wells. Ground or airborne methods might be used in such a search; however, if a search is to be made around the location of several proposed injection wells in the same general area, airborne methods will become less expensive. Finally, a need may arise to search for sites for injection wells which are the prescribed distance from an abandoned well. In such a case, the economics of an aeromagnetic survey become more favorable.

Some of the advantages of the magnetic method in locating casings are:

(1) The method can be readily used to accurately locate buried casings where there has been no surface evidence of the well for many years.

(2) By use of an aircraft, large areas can be surveyed rapidly without need for access to the property.

(3) With the use of a ground magnetometer, the horizontal position of a casing can be located to within one or two meters accuracy and the results are immediately available.

Some of the disadvantages of magnetic methods and problems in their use are:

(1) Wells which do not contain near-surface casing or other pipes cannot be detected at all, and it may be impractical to locate wells containing only a small amount of casing.

(2) The magnetic method may be relatively costly compared with other methods, particularly if the areas are small and few in number.

(3) In some areas, magnetic disturbances caused by manmade objects, such as pipelines and steel buildings or anomalies due to naturally occurring magnetic minerals in near-surface rocks, interfere with the recognition of anomalies caused by casings.

(4) Most companies and public institutions having a need to search for abandoned wells will, at least initially, require technical assistance from outside their organization. The method requires a large initial capital investment

and the high-resolution aeromagnetic survey requires extensive data interpretation by professional geophysicists or earth scientists.

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The complete report, entitled "Location of Abandoned Wells with Geophysical Methods," (Order No. PB 85-122 638; Cost: $10.00, subject to change) will be available only from:

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