Application of Micro-resistivity Scanning Imaging Logging Data in Reservoir Thickness Division

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Abstract: Reservoir parameter interpretation is one of the main contents of reservoir description, which affects the whole process of oilfield development. According to the characteristics of micro-resistivity scanning imaging logging, which can directly reflect the changes of lithology and physical properties of reservoirs, this paper compares the thickness and interbed division of reservoirs with conventional logging data, this paper finds out the shortcomings of the conventional logging data in the interpretation of thickness and the division of interlayers, and combines the core analysis data to examine the differences in the correlation on the coring wells, and obtains good results, it has laid the foundation for the establishment of new interpretation procedure.

1. Introduction
In order to find out the distribution of fractures, in-situ stress, structural features and fault development in this area, microresistivity scanning imaging (STAR) logging was applied to the No.1 and No.2 wells. Taking these two wells as an example, this paper illustrates the application of micro-resistivity scanning imaging logging data in various reservoir thickness division and interlayer identification.

2. Principle of micro resistivity scanning imaging logging
STAR-ii microresistivity scanning imaging (STAR) logging principle is a microresistivity scanning imaging logging tool produced by atlas logging company. The tool consists of 6 plates, each with 24 button electrodes, measuring 144 curves.[1] In the process of logging, with the aid of the instrument hydraulic system, the electrode plate is close to the well wall, the electrode plate and the small electrode emit the same polarity current to the formation, and the current returns to the loop electrode in the upper part of the instrument through the loop made up of the drilling fluid column and the formation in the wellbore. The potential of the plate is constant. The current emitted from the plate focuses the current of the small electrode. The current from the small electrode is recorded by scanning measurement. When bedding, fractures, or grain size and permeability change in the formation, the current of the small electrode changes with them. After special image processing, the resistivity difference between the points near the wellbore can be transformed into black-and-white or color image, which can directly reflect the variation of formation resistivity near the wellbore. The resistivity imaging tool has a vertical resolution of about 0.2 in. And the depth of detection is comparable to the shallow side of a lateral log.
2.1 Imaging logging geological interpretation model

Imaging logging geological interpretation model is a typical image characteristics and geological characteristics of the corresponding relationship. [2] The establishment of this relation is helpful to make use of imaging logging data for quick and intuitive geological interpretation. Comparing with the results of conventional well logging interpretation, two geological models are concluded for the changes of different color levels in microresistivity scanning images, among which the models with geological significance are subdivided into three kinds and six subtypes, there are three types of models that have no geological significance.

2.1.1 A pattern of geological significance

(1) A block pattern is a single mean segment of a color level that does not change on an image and can be subdivided into two categories according to the color level change.

① Bright Color Block pattern is defined as a mean block structure with a single bright color on imaging image, indicating high formation resistivity and tight lithology. Such as dense massive carbonate rocks, compact calcareous sandstone.

② The dark color block pattern refers to a single dark color block structure on the imaging image, which indicates that the formation resistivity is low, the rocks are loose and the heterogeneity is weak. Like mudstone.

(2) The Strip pattern

It appears as regular or irregular strip structure with alternating light and dark. The Strip indicates that different resistivity appears repeatedly in the form of interbeds, which can be divided into two types according to the change of geological features. [3]

① the continuous regular light and dark belts are continuous with each other, which are thin interbeds of sand and mudstone through the wellbore, and the response characteristics of muddy limestone belts.

② the irregular bright-dark belts are called as the cross-section of the bright-dark belts, but they are not continuous in the transverse direction, only slightly discontinuous, indicating the response of the non-mean variation of rocks in the pore or thin interbedded strata through the wellbore.

(3) Linear mode

It refers to a color level background image, suddenly appeared to enhance or reduce the order of linear distribution of color level, so that the image has a variety of linear changes. It can appear in a variety of geological phenomena, in the study area there are mainly the following two distribution forms.

① The image of the Dark line-like is shown as the dark line-like, there are many kinds of shapes, including sine wave, vertical line-like, irregular curved shape and so on. It is indicated as a very thin layer of mud with regular and stable morphology.

② Combined linear layer is defined as a group of linear layers, which is the indicator of dense layers and bedding, and can be used to distinguish different types of bedding.

2.1.2 Patterns with no geological significance

(1) A white pattern is one in which there is no information on the image, or there is information but the image is blurred and has no practical significance. This phenomenon is caused by the instrument card information loss, or abnormal work of the instrument caused by the closing of the signal.

(2) The regular stripe pattern is the regular slanting or straight stripe change on the normal image, which is caused by drilling tool scratch.

(3) The irregular fringe pattern is caused by the irregular pattern change on the background of the normal image, which is caused by the vibration (regular or irregular) of the measuring instrument and is easy to be distinguished in the image.

3. Geological application

In the conventional logging interpretation of the Development block microsphere curves and acoustic curves are used to divide the layers into high-resistance layers and low-resistance layers, and
acoustic curves are used to identify the high-resistance layers, using microelectrode curve to divide low resistance interlayer.[4]

3.1 Detailed description of the thickness of various reservoirs
Which in the development zone generally has the characteristics that the better the lithology and physical properties, the better the oil-bearing properties, compared with the oil-bearing property and the thickness division of various oil layers in 1181 rock samples from two sealed inspection wells, No.1 well and No.2 well, have been observed, the method of judging oil-bearing grade on the imaging map is summarized as follows: First look at the lithology, then look at the oil-bearing grade.
(1) Description of thick oil reservoir
The thick oil layer is characterized by No.2 well, the depth is 952.4-961.4 m, the thickness of the second type is 7.0 m, the thickness of the first type and the effective thickness are 6.4 m, which is 0.7 m less than that of the first type and the effective thickness of the core, the second thickness is less than 0.1 m, which is interpreted by imaging logging. The thickness of each type is the same as the core, and the oil-bearing description is basically consistent with the core description.
(2) Description of thin and poor reservoir No.2, depth 987.0-993.0 m, compared with core characterization thickness, log interpretation shows that the thickness of the second type is 0.1 m, and the thickness of the first type is less than 0.6 m, the effective thickness is less than 0.1 m, the types depicted by imaging images are the same as the cores, and the oil-bearing description is basically consistent with the cores. No.2 thin and poor reservoir characterization result map from the above interpretation, the accuracy of image logging division thickness is greatly affected by personal interpretation experience, the analysis of the main cause of misjudgment is in the determination of Lithology, the lithology of mud-bearing and mud-bearing prefixes is not easy to distinguish on imaging map. [5] Experience shows that if mud-bearing 6 plates can be seen and the color is lighter, mud-bearing 6 plates can be seen but the color should be dark and generally black. In the case of impure sand, the basic lithology is mostly siltstone, and the corresponding oil-bearing grade may be one of oil-immersed, oil-speckled or oil traces, such as oil-immersed mud-bearing siltstone, which should be a continuous regular strip pattern on the imaging map, the dark stripes are filled evenly by a certain color level. The oil-spotted argillaceous siltstone should be a discontinuous strip pattern on the imaging image. Generally, no dark stripes are formed on 1-2 plates. At the same time, experience shows that conventional log interpretation plays an important role in the process of reservoir characterization by imaging logging. The step of thickness characterization of various oil layers is to find the corresponding depth segment on the imaging map first, then describe lithology and oil-bearing property, the better the general lithology is, the better the oil-bearing property is, and finally determine the top and bottom boundary of various thickness.

3.2 Fine description of interbeds
(1) Conventional logging and imaging logging interpretation of interbeds contrast No.1 well, depth 1070.0-1074.0 m, as shown in figure 1 with reference to the interbed classification standard in conventional logging interpretation, further analysis of the imaging data of the well, as shown in Fig. 2, the Blue Line corresponding to the interlayer is the same as the conventional logging interpretation interlayer, and the red line corresponding to the interlayer is a newly divided interlayer on the imaging image, which is consistent with the core description.
Establishment of the Thin Inter-bedded Identification Chart.

Using data from 4 sealed coring wells, thin interbeds are well recognized in typical channel sand bodies of SA 2 and Pu 1 group. It is found that the interbeds in the channel are mainly lateral interbeds, vertical interbeds, erosion mudstones and diagenetic interbeds, which mainly act as partial shielding, and the lithology is mainly argillaceous siltstone and argillaceous silty sand, of which 77.4% are of thickness less than 10 cm. At present, the recognition rate of the interbed in conventional logging interpretation is only 30.4%, which is basically over 10 cm. [6] The interbed below 10 cm is either unclassified or lack of experience in this kind of interbed interpretation. Through establishing the identification model of thin interbed logging in coring well, combining with imaging logging and core description data, it is determined that the return rate of RMG is more than 5% and the minimum return value of RMN is less than 13 m as the criteria for determining thin interbed, the identification chart of thin interlayer in channel sand body is established. After applying this standard, the identification rate of the occluded thin interlayer in channel sand body reaches 73%, and a good result is obtained.

4. Conclusion

(1) The log of the micro-resistivity scanning can accurately depict the thickness of various reservoirs and improve the reservoir utilization ratio.
(2) In the division of interlayer, the development of the interbeds in the reservoir is described in detail by combining the imaging logging data, and the interbeds whose thickness and lithology are stable but which can not be identified or returned to the micro-potential curve are not enough, the characteristics of other curves are summarized, and then the type of interbed is identified in the process of log interpretation.

(3) The experience gained in the division of thickness and interlayer will lay a good foundation for the next qualitative identification of water flooded zone and the analysis of the formation mechanism of remaining oil.

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