Formation evaluation for drill bit analysis, selection

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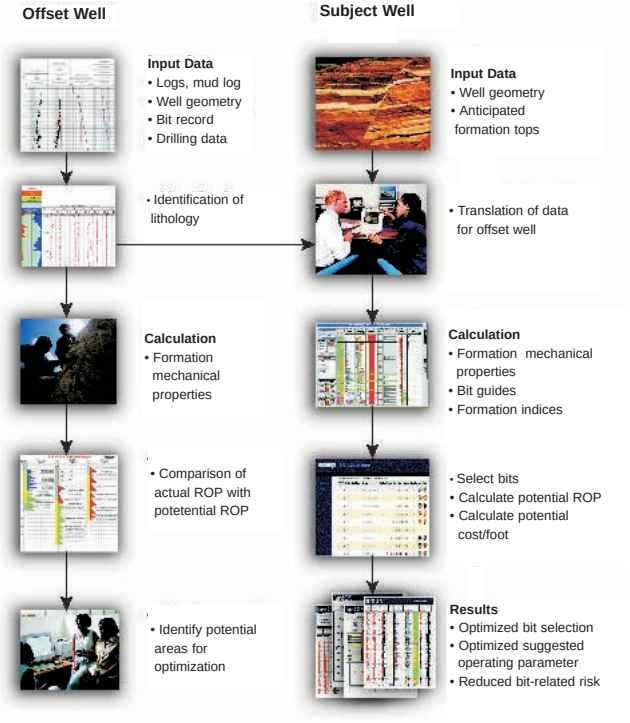
SELECTING THE OPTIMAL drill bit series, optimizing operating parameters, and identifying bit-related drilling risks are all key factors in determining consistent well construction performance at the lowest possible cost per foot.

A new type of software-based service analyzes formation evaluation and mechanical property data available from offset wells, providing operators with improved information for well planning, bit series selection and drilling execution. The software system allows operators to provide formation evaluation and drilling data from offset wells in a wide variety of formats.

The software service processes this input and provides information leading to optimum bit selection and highly refined operating and drilling practices. It does so with the aid of an intelligent selection process that chooses from a comprehensive and continually updated suite of mechanical property algorithms, proprietary formation indices, and bit selection guides.

By integrating a bit evaluation software tool into the drilling planning process, possible drilling risks are more easily identified and planned around. Combined, projected well geometry and offset well data are used to compute formation mechanical properties and pertinent formation-related indices. The data provide a predrilling snapshot of the downhole conditions to be encountered, including possible risks to be managed.



Following a software-driven bit selection process when selecting the optimum bit series for a new well allows more accurate translation of offset data to the planned well and more comprehensive cost/risk/performance analysis of the wide range of bits.

Guided by this snapshot, the software assists the user in selecting the best bit program for a given well that will both minimize potential risk and meet the desired, user-prioritized performance goals—low cost per foot, precise directional placement, high-quality borehole, and minimal measurement-while-drilling interference, among them.

HOW THE PROCESS WORKS

To ensure widespread compatibility, the software tool will accept a wide variety of input. The most basic information required to use the program includes offset gamma, compressional sonic and mud logs.

More refined evaluations require the input of offset neutron-density, porosity, shear sonic, caliper and photoelectric logs.

Digital drilling data from the offset well can also be analyzed for more detailed bit optimization.

Actual program use begins by entering known offset well parameters, including 3D trajectory, casing design, major formation tops, and bit performance. The first three of these parameters are then defined for the planned well.

Next, available offset well log data are entered. At this point the user performs log data quality control through an interactive routine. A detailed lithologic description is built using offset gamma and mud log data.

The software automatically translates offset well information to the planned well, allowing for differences in trajectories, formation depths, and formation faults. Formation mechanical properties and other indices are then computed using sophisticated algorithms.

Operating parameters and bit series selection are then made based on these results.

Also computed is a calculation called specific energy rate of penetration (SE ROP), which is based on planned operating parameters.

The calculated SE ROP from the offset well is compared with its actual ROP to determine areas of the planned well's program that may require special optimization. Different bit scenarios for the planned well are run to compare the potential cost/risk outcomes of each.

The software's use does not end with bit series and operating parameter selection. At the rigsite, while drilling, software outputs and reports can be used as a drilling map, identifying anticipated performance and risk variations. These assist the drilling team in making informed decisions about operating parameters and forward bit selections.

FORMATION EVALUATION PROCESS SPECIFICS

Once the formation related data have been input, the software provides for a detailed quality control check during which all input data are reviewed and amended, as needed. Following this stage, the software performs the following calculations:

- Synthetic shear sonic (if no shear sonic log exists)
- Sonic porosity (if no sonic porosity log exists
- Density (if no density log exists)

- Clay fraction
- Effective porosity

Next, elastic properties are computed for use in calculating compressive strength values and other indices:

- Dynamic Young's modulus
- Dynamic shear modulus
- Dynamic bulk modulus
- Poisson's ratio
- Dynamic bulk compressibilit.

Customized reports generated include offset log data, lithology description, and porosity and effective porosity values, which are often used along with lithology as a basis for regional rules on both bit selection and drilling practices.

The software contains a library of more than 30 rock types that graphically depict lithology. Identifying the depths at which lithology type variations occur is important in determining both optimum bit type and best drilling practices.

Actual unconfined compressive strength (UCS) values are calculated, using one of five field-proven and continually updated calculation methods.

The method selected depends on the specific formation parameters of a given site. UCS values are crucial in selecting the drill bit series, but are not sufficient in and of themselves. They cannot, for example, describe overburden stresses acting on the formations being drilled. Thus the need for other values, such as confined compressive strength (CCS), which is based on the overburden confinement stress.

CCS is an indicator of the increasing effective strength of a formation as depth increases. When calculating CCS values, the angle of internal friction is also calculated.

The software system takes advantage of a number of proprietary, continually updated indices and bit selection guides. These include formation abrasiveness, formation vibration potential, and formation balling potential.

The higher the abrasiveness index, the greater the bit wear rate. Local operating parameters can be modified to minimize this effect.

Vibration potential and balling potential are derived from proprietary algorithms. If the vibration potential index is greater than 100, great care needs to be taken in selecting bits, the bottom hole assembly (BHA), operating parameters, and drilling practices.

If the balling potential index is greater than 100, bit types and hydraulic parameters that minimize balling are preferred, especially when using water-based mud.

THE BIT OPTIMIZATION PROCESS

When working with mechanical property data, a system user follows the same procedures as outlined for formation evaluation, with the same emphasis on data quality control and correction. The software tool compares actual ROP with the potential ROP, based on SE.

The SE ROP is calculated based on actual operating parameters for the offset well and compressive strength values calculated by the software tool. Using proprietary values, the software tool computes a drilling strength guide and a wear potential guide to help identify the best bits for drilling the well under consideration.

The formation evaluation results are useful in determining bit optimization. By this stage in the process, users will have determined initial bit selection, operating parameters, the potential SE ROP, drilling times, and costs.

While these values cannot predict ROP with full accuracy, they do indicate potential bit performance, the energy being supplied to the bits, and the formation's compressive strength.

Potential bit selection scenarios can be varied to help the user choose the bit program series that best meets cost/risk/performance preferences.

PROCESS VALUE

The software-based service described herein allows a well-planning team to explore the likely outcomes of more drilling plans—bits and procedures selected—and the costs, risks and performance likely with each, than traditionally possible.

Examining more drilling program options based on actual offset formation and mechanical data adds a level of planning and performance certainty not previously enjoyed.