Remote Well Site Biostratigraphy and Advances in Automated Fossil Analysis*

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Abstract

Real time well site biostratigraphy monitors the stratigraphic progress of drilling wells, advising if the well is conforming to or deviating from predicted stratigraphy, including determining if Total Depth criteria have been met. It is the only offshore technology that can provide absolute age information. New technology now makes it possible to do well site biostratigraphy remotely. An automatic microscope has been developed that can scan and photograph nannofossil and palynology slides at a quality almost indistinguishable from conventional microscopy. A technician present on the well will make a slide from cuttings and place it on the microscope where software takes over and scans the slide at several focus levels, compresses the files and transfers the images to the office. A biostratigrapher in the office looks at the images and makes taxonomic identifications, just as if present at the well site. The technology has been implemented on several wells and provided adequate stratigraphic support.

Remote well site biostratigraphy creates a verifiable record, makes it possible to QC biostratigraphic calls, releases up space on the rig and improves HSE for biostratigraphers. Development in progress of automated image recognition will further speed up analysis and improve on accuracy. The software identifies possible fossil candidates and cuts them out from the background. Discarding of the background reduces file sizes. Directed shape sorting allows the analyst to quickly focus on marker species without lengthy searches. Statistical counts of abundances and size sorting of large data sets can be done in seconds.
Successfully Applied on Several Wells

After offshore testing in 2013, BHP Billiton first applied the remote technology in January 2014 on the SB103 well drilled in the Gulf of Mexico. Nannofossil slides were prepared and scanned at well site and images transferred to the office in Houston for analysis. In 2016, Shell International E & P in Houston added palynology to the remote well site biostratigraphy on their exploration well in Nova Scotia, Canada.

Hardware and Software

Version 2.5 modified microscope with automated XYZ scanning stage.

Miniaturized computer with automation controller.

Windows 7, 64bit operating system

Intel Core i7 3.2 Ghz or above

Intel Z87 or 297 based motherboard

Gigabit network

Nvidia or AT1 based graphics card

Fast CCD camera with 3M pixel resolution.

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New technology now makes it possible to do well site biostratigraphy remotely. An automatic microscope has been developed that can scan and photograph nannofossil and palynology slides at a quality almost indistinguishable from conventional microscopy.

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Scanning

Images are of excellent quality even at high levels of magnification and suitable for identifications at species level of nannofossils, (size about 3-15 um).

The system is capable of scanning the entire area of a regular microscope slide or thin section. A motor moves the stage in predetermined X and Y increments, allowing for image capture of various field of views (fov). The images of individual (camera) fov are then stitched together replicating the complete slide for viewing.

Different magnifications can be used. To capture the three dimensionality of the studied objects (in this case nannofossils), the camera takes images at different focus levels. The number of focus levels and their incremental depth change is customized to fit the purpose of the study.

The microscope is placed on an anti-vibration table and/or a magnetically levitated anti-vibration plate to counter motion of drill ship.

The equipment is packed into four large pelican cases for transfer to the rig. The microscope assembly and camera calibration takes less than 1 hour by trained personnel.

These settings have been tested in the office and on a previous pilot test to reasonably replicate BHP Billiton standard well site microscopy for nannofossils which relies on a routine analysis of a minimum of one traverse at X1000 magnification along a standard slide.

Automatic scanning of 300 camera fields of view takes about 7-10 minutes.

Biostratigraphic technician and automated microscope in action on offshore drill ship.

Promoting Efficiency

Remote Well Site Biostratigraphy
Remote Well Site Biostatigraphy and Advances in Automated Fossil Analysis

Facilitating Communications

File Transfer
In order to transfer the file efficiently, a compression algorithm is automatically applied which reduces their size from about 3.5GB to about 1.2GB without any detectable loss of resolution. Image files are moved from the rig to Houston offices on company internal networks.

Transmission of images over satellite connection normally takes less than 15 minutes with a bandwidth of 128kilobits.

Real Time Analysis in the Office
Without remote monitoring, the logistical operation in the office is to rely on written reports by the well site biostatigrapher describing the observed fossil assemblages and their stratigraphic significance. The team in the office has to rely on independently verified fossil identification and interpretations of stratigraphy.

With remote monitoring, the stratigraphic information is interpreted directly by the company biostatigrapher and is effectively integrated with the operations team.

A permanent record is created. The normal written reports for partners can be supplemented with pictures of key specimens.

Future Improvements
To avoid large files which are slow to transfer, only part of the slide is currently scanned off-site. This comfort is impossible to achieve on the rig with contract staff changing for work setups. This comfort is impossible to achieve on the rig with contract staff changing for work setups.

Strategic information is conveyed immediately to the operations team with no reporting delays.

While Improving Health and Safety
Health and Safety
Reduces staff on the rig.
No offshore survival course needed.
No helicopter transport needed.

If the biostatigrapher becomes ill, hishecane quickly be replaced.

Health analysis outlined in a permanent data environment allows for ergonomic user work stations. The comfort is impossible to achieve on the rig with contract staff changing for each job.

Possible to reduce length of shift and avoid shift.

With normal well site biostatigraphy either two biostatistians each work a 12-hour shift offshore, or a single biostatigrapher has to monitor as best as possible. With remote monitoring, it is possible to have three biostatistians offshore at any one time, plus two normal well site monitoring staff who work in their own time zone, avoiding night shift.

Remote Well Site Monitoring is Efficient

Allows for first-hand examination of data.

Allows for monitoring of partner wells.

Allows for experienced staff to have second opinions on critical calls.

Allows for guidance and training of inexperienced staff.

Brings access to a wider pool of biostatigraphers:
- Specialists that cannot commit the time to well site.
- Allows for experienced staff to have second opinions on critical calls.
- Allows for monitoring of partner wells.
- Allows for consultation of consultants.

The software has the option of instructing the software as unstitched tiles.

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Artificial Intelligence

Applied to Fossil Imaging
High-quality imaging allows for automatic shape sorting of fossils through artificial intelligence.

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Development in progress of automated image recognition will speed up analysis and improve accuracy.

The software identifies possible fossil candidates and cuts them out from the background.

Discarding the background reduces file sizes. Directed shape sorting allows the analyst to guide focus on mantle species without excessive statistics. Statistical counts of abundances and sorting of large data sets can be done in seconds.

The Training Process

This process is not perfect as a human editor still picks out objects from the background.

When the fossils have all been placed in their boxes, the software is instructed to sort on shape and similarity.

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Advances in Automated Fossil Analysis

Providing More Objective Results

Neural Network Training

Convolutional Neural Network (CNN) is applied to training fossil recognition.

The process of training the CNN has 5 steps:

1. Boxed fossils are augmented in 15 ways to enhance the training quality.
   - Flip (horizontal)
   - Flip (vertical)
   - Flip (horizontal&vertical)
   - Rotation (90)
   - Rotation (180)
   - Rotation (270)
   - Sharpening (+1)
   - Sharpening (+2)
   - Brightness (+1)
   - Brightness (+2)
   - Zoom in (+1)
   - Crop (upper-left)
   - Crop (upper-right)
   - Crop (bottom-left)
   - Crop (bottom-right)

2. Software engineers structure augmented fossils into a format of input data, LevelDB, for training.

3. When the data is ready, they run training.

   During the training, features of each fossils are extracted for several steps, convolutional layers, and trained in neural network layers. This training step iterates 400,000 times.

4. In each iteration, the training software checks the training quality using test data.

   4. Accuracy
   5. Error Rate
   6. Iterations

Improving Speed and Accuracy in Fossil Identification

5. When the training is done, we can get accuracy rate and trained CNN engine as results.

   Final step of the process is application of trained CNN engine into the software, now with improved sorting accuracy.

   Biostratigrapher oversees and is in charge of the sorting process and can move specimens between the groups and create new groups.

Future Impact

Automated fossil identification and sorting will allow biostratigraphers to quickly gather large and statistically robust data sets. Objective identification criteria will make analyses of different sections more easy to compare and correlate.

The purpose is not to remove the biostratigrapher from the process, but to direct the specialist to identify critical specimens and to spend more time on interpretations. Biostratigraphy can then be applied more often and with more impact.