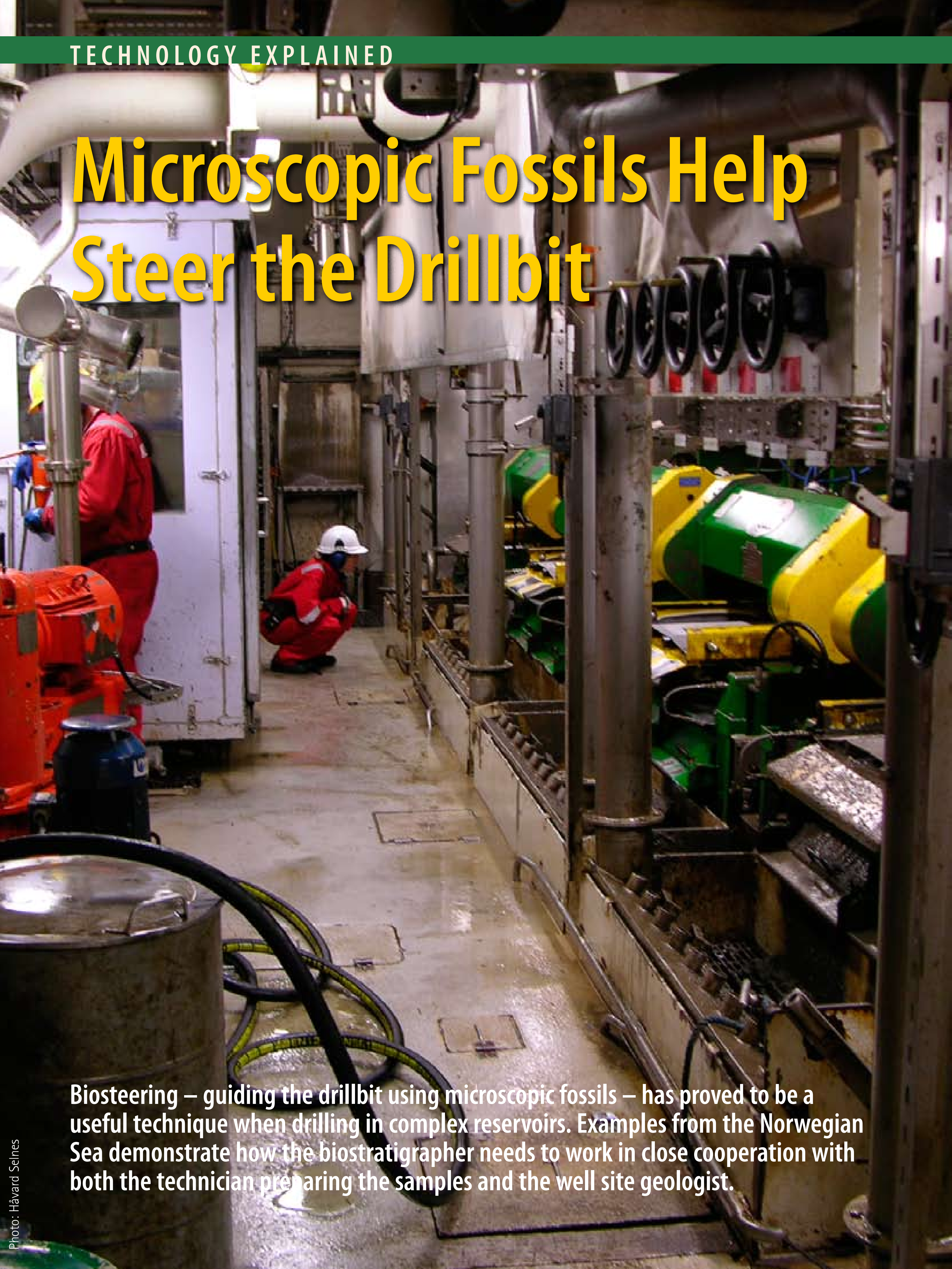
Microscopic Fossils Help Steer the Drillbit



Biosteering – guiding the drillbit using microscopic fossils – has proved to be a useful technique when drilling in complex reservoirs. Examples from the Norwegian Sea demonstrate how the biostratigrapher needs to work in close cooperation with both the technician preparing the samples and the well site geologist.

Photo: Håvard Selnes

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The science of biostratigraphy is a well-established discipline when drilling exploration, appraisal and development wells in geologically complex areas. The knowledge obtained from analysing the microfossil content of the sediments whilst drilling is very useful. This is especially the case when it is necessary to obtain a detailed account of which layers are penetrated by the drillbit on its way down to or through the reservoir.

Biostratigraphy is also used when drilling through reservoirs with complicated stratigraphy to detect faults and unconformities and, since the introduction of horizontal wells, its importance in development drilling has increased substantially. It can help optimise the well path in multiple sandstone beds separated by shale barriers, or show the faults with throws that cannot be resolved on a seismic scale in any detail. Complex reservoirs of this kind are found in the Norwegian Sea, in fields such as Heidrun, Norne and Njord, all producing from Jurassic shallow marine deposits situated in densely faulted areas. The giant Troll field in the North Sea, on the other hand, exemplifies a typical layer cake geology in which the method has no merit.

Be prepared!

The successful use of biostratigraphy when drilling a well requires thorough biostratigraphic studies of well samples and reported data before travelling to the wellsite. It is necessary to make a detailed account of the distribution of microfossils (plants and plant remains) in each horizon that will be penetrated. This is called biozonation and means that the wellsite palaeontologist will have a good knowledge of the fossil contents of each layer before going to work. This is certainly the most important tool that the biostratigrapher can use and without it, he or she is almost helpless. When on site, day or night, the biostratigrapher uses the **biozonation** to assist getting an accurate account of which formations are being drilled through.

The rock samples (ditch cuttings) are taken from the shale shakers and carried to the on-board laboratory for cleaning and extracting fossils.

Slide with fossil plant remains under the microscope.

Numerous slides are prepared to find the right well path.

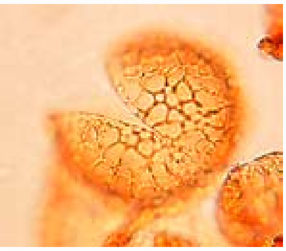


Photo: Håvard Selnes

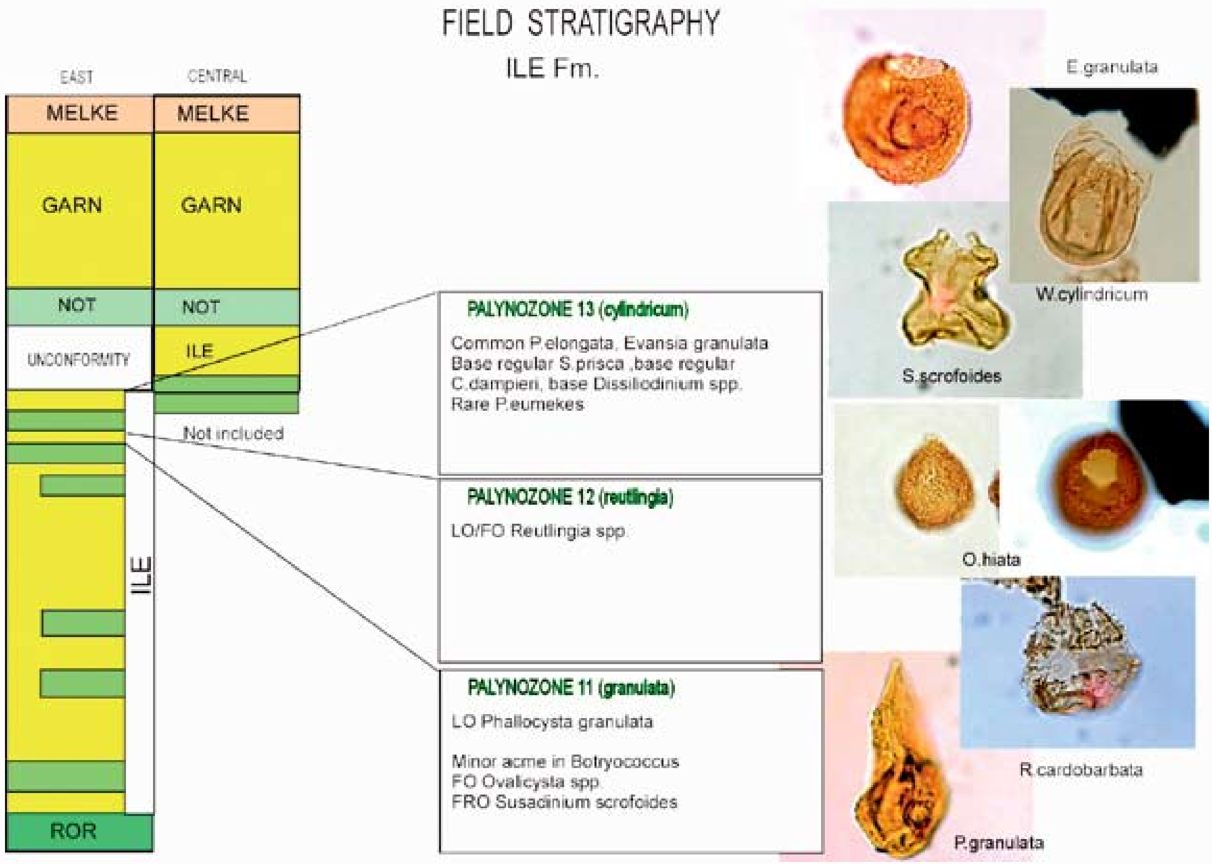
In development drilling, the biozonation is based on data from cores taken during exploratory drilling. However, there are significant lateral changes within a sedimentary basin and the biozonation for one particular field may be of limited value for another.

The biostratigrapher is part of a team of geoscientists who follow the drilling from minute to minute. This includes the wellsite geologist as well as the project geoscientists onshore. A palynologist is a biostratigrapher who specializes in microscopic plants and plant remains with a tool kit consisting of the biozonation scheme, a microscope and the software to handle the analyses. Biostratigraphic observations and interpretations are evaluated alongside other geological data obtained during logging and drilling. This enables important decisions to be made, such as whether to change the well trajectory from its planned course.

The team

When drilling through a reservoir in the

Photo: Håvard Selnes



Biozonation is a necessary tool – a reference scheme – for the palynologist when analysing the samples, as it shows which fossils that should be found within a given layer.

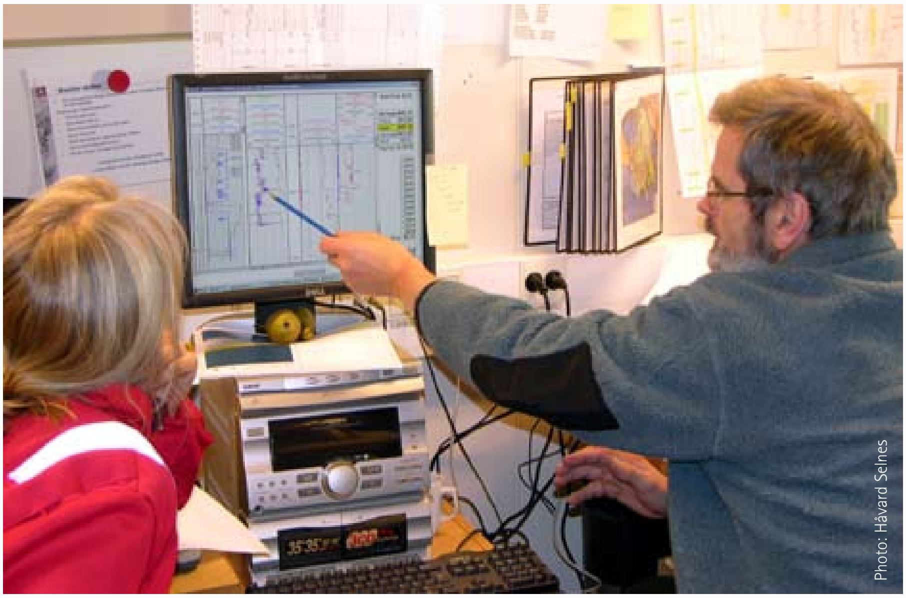
Norwegian Sea, it is common to have a biostratigraphic team consisting of at least a palynologist and a technician, although for a full 24 hours service 2 palynologists and 2 technicians are needed, with each team working 12 hour shifts. The composition of the team depends on the predicted geological challenges that they are faced with and the expected speed of drilling.

The technician, responsible for extracting the valuable plant fossils, is in charge of a laboratory within a pressured container that is moved to the rig when it is needed. Within it there is a water supply, sink, fumehood, hot plates, centrifuge, sieves, and a HES outfit for safe handling of potentially hazardous chemicals. The rock fragments are dissolved in strong acids, and the fossils constitute the resulting product, as they are insoluble in most acids.

The technician's skill is extremely important in order to obtain a good result. It is a difficult and tedious task to extract fossils, particularly from sandstone reservoirs that can often be very poor in fossils. The analyses and the conclusion to be drawn by the palynologist depend totally on the quality of the preparations. The value of a good technician can therefore not be overestimated.

Good planning essential

On the average, depending on how deep the actual drilling goes, it takes about an hour to circulate cuttings from the drill bit to the surface. The preparation process takes another hour, and then the palynologist needs an hour or so for the analysis. Altogether this means that it may take up to 3 hours from drilling into a certain bed or formation before the palynologist can give his or her opinion. This may sound fairly slow compared to the snap decisions



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Having analysed and interpreted the sample with reference to the biozonation, the next step for the biostratigrapher is to discuss any ambiguous results with the well site geologist (right). In this case, the discussion takes place in front of the MWD-logs (measurements while drilling), that are all recorded in real time.

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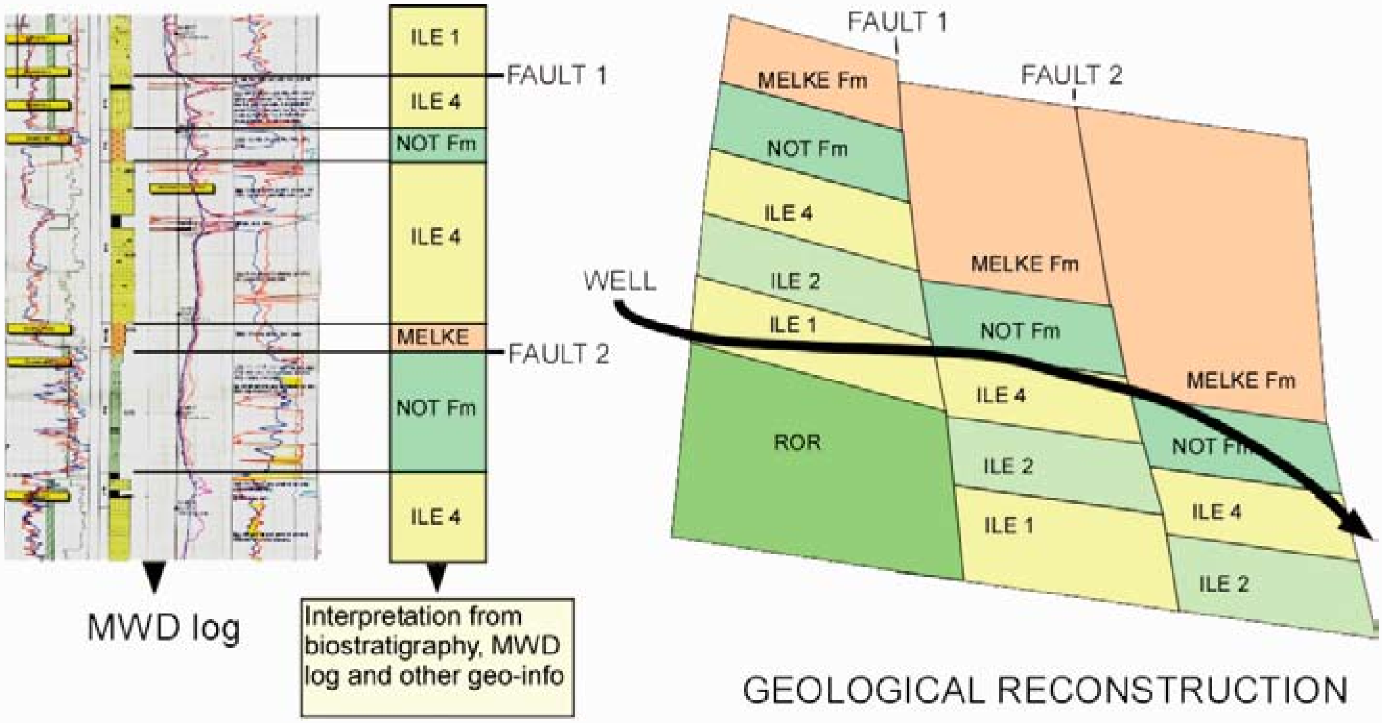

Well trajectory illustrating the need for steering the drill bit because of faults.

that can be taken on log signals, but it could make an important contribution to the right judgment being made. Compared with the long time it takes to send samples to laboratories on land, the rig-based biostratigraphy is practically *real time*.

The rate of drilling (ROP) depends on the rock that is being drilled through. In indurated limestone stringers the drilling rate may be only a few centimetres per hour, but in loosely consolidated sandstones, the rate may easily be as much as 60 metres per hour. Typical drilling rates are in the order of 10 to 30 metres per hour in rocks of Mesozoic age in the Norwegian Sea.

Given that the drilling rate is about 20 metres per hour, and that the palynologist's analysis is delayed by 3 hours, the analyses will typically be 60 metres behind the drill bit. With only one palynologist and one technician on board, crucial samples may be easily missed. Good planning is therefore vital. Experienced staff able to plan their work within the allowed 12 work

Håvard Selnes studying plant remains in the microscope in order to determine in which formation the drillbit is.

The technician prepares the samples for analysis. His or her skill is extremely important if the palynologist is to do a good job.

hours per day are essential to the overall performance. However, in some critical cases it is deemed necessary to have an extended team to ensure a full 24 hours coverage.

Pitfalls

The challenge for the palynologist is that the total number of fossils in the sample is often small and possibly poorly preserved, bringing a risk that the identifications will be false, with serious implications for the decisions that are to be made. For this reason, one sample is frequently not enough. It is necessary to analyse several and try to establish a trend in order to come to a confident conclusion.

In addition, when undertaking the interpretations there are further possible pitfalls that the team needs to be aware of and to take into consideration before drawing their conclusions. For example, reservoir rocks often contain fossils that belong to older formations. These have their origin in the rocks that were eroded and later redeposited when the reservoir rock was formed. With a large accumulation of redeposited fossils the biostratigrapher may easily think that the drilling has reached older beds than it has. Similarly, reservoir rocks may contain fossils that belong to younger formations, as fossil bearing rocks above the drill bit (but not above the casing sho e) may shed fragments (cavings) into the hole and contaminate the samples. It is almost impossible to avoid this happening, and in some cases it can seriously disturb the process and interpretation.

The palynologist finally compares his conclusions with the biozonation scheme developed in the research phase of the project and gives his opinion to the well-site geologist. If everything is according to the plan, drilling will continue. However, if there is strong evidence, or even indications, that the last section of the drilling is not according to expectations, both the well-site geologist and the project geologist on duty become involved and a consensus must be reached before making a decision on how to proceed.

Communicating the results to non-biostratigrapers is probably the most challenging part of the biostratigrapher's work. Decisions regarding the drilling have to be taken then and there, and the drilling managers seek unambiguous answers from the contributors. There is nothing between yes and no.

Photo: Håvard Selnes

Entering the laboratory for a clean-up.

Examples

In our first example from a (Middle) Jurassic Ile Formation reservoir in the Norwegian Sea, the biostratigrapher was quickly able to determine that the drillbit had penetrated a fault and which formations that were reached on the far side. With well logs only, this would be an almost impossible task, but using the work of the palynologist, it was possible to adjust the direction of the drillbit to get back to the best part of the reservoir.

Another example of the use of biostratigraphic data is in optimising the casing point. The reason for setting the casing in the very top of the reservoir is to seal off a potentially unstable shale formation. In principle, it is easy to detect a sandstone formation when entering it, but the trouble may be that it is not the required reservoir sand, but a local sandstone stringer or lens above, encased in the sealing shales. The logs will not tell the thickness of the sandstone before it has been drilled through, and there is a risk of setting the casing shoe too high above the main reservoir, with consequent borehole instability.

The reverse may also be the case. The drilling team wants to avoid entering the reservoir before the casing is set because of an abnormally pressured reservoir. Using biostratigraphy, it may be possible to find an optimal location for the casing shoe within the overlying cap rock.