

Digitalisation of Palynological Samples Using High Resolution Scanners

Author: Fernando Mantilla-Duran

University of Wales Trinity Saint David

27th May 2022

Introduction to Innovation Management

Assessment B

MSc International Innovation Management

Supervisor: Alan Mumby

Contents

Synopsis.....	3
Introduction	3
The Principal Drivers for the Innovation:	4
The Key determinants in the process of committing to develop the innovation:	4
The barriers and risks faced by the company in developing this innovation:.....	5
Processes and technologies which the company used to carry this development forward:	6
The extent to which the development relied on resources external to the company and the ways in which the deployment of these resources was managed:	7
How management overview of the project was maintained:.....	7
The extent to which you feel this innovation process represents the best practice: ...	7
Critique of the innovation process and evaluation:.....	8
References.....	9

Synopsis

This manuscript discusses the use of a high-resolution microscope slide scanner as an innovative way to digitally preserve the fossil records contained in palynological slides from the Norwegian subsurface and to allow a remote analysis of this material by providing access to a digital copy of the slides through a virtual desktop infrastructure. This corresponds to the very first time an alternative way for analysing and preserving palynological samples is provided and falls primarily into the category of a breakthrough innovation following Satell's innovation matrix (Satell, 2017).

Introduction

The term *Palynology* corresponds to the study of acid-resistant, organic-walled particles usually ranging in the size from approximately 5µm to 150µm. The most common particles studied in a palynological sample are pollen, spores, acritarchs, dinoflagellate cysts and the application ranges from botanical studies to geological and archaeological research.

Specifically in geology, palynological studies are frequently used to determine the age of the sedimentary rocks, palaeoenvironments or correlation of strata; this also known as biostratigraphy. For palynological analyses, the rock material is chemically treated to extract the organic fraction and the material is then mounted in microscope slides for analysis using a transmitted light microscope.

This type of analysis is frequently used in the oil and gas sector and with applications from the early phases when the geology of an area is being understood and as much information is needed to unveil the geological history and develop a geological model, to the last phase when biostratigraphic analyses are conducted on site to monitor the stratigraphy in real time whilst the well is being drilled.

In terms of nations, Norway is one of the countries in Europe with the highest activity in the oil and gas sector and with most of its wealth derived from dividends obtained by hydrocarbon production. This means that palynological analyses are frequently performed in rocks obtained from the Norwegian subsurface. For exploration and production wells drilled in Norway, the Norwegian government entity that regulates the activities related to the oil and gas sector (Norwegian Petroleum Directorate) requires that all the palynological samples processed from the Norwegian soil and subsurface are to be sent to their facilities for storage and future consultation. As the collection of palynological slides stored keeps getting larger, a step towards digitalization of this material is necessary.

The Principal Drivers for the Innovation:

Currently, more than 1200 wells have been drilled in the Norwegian shelf (Norsk Petroleum, 2021). This figure, however, only includes exploration wells but does not account for production wells. This means that the amount of rock material obtained from the subsurface of Norway is vast. Consequently, the existing number of palynological slides processed and stored from said wells and is unequivocally huge.

For the past four decades, the National Petroleum Directorate has been storing these palynological slides on the sample repository facilities in Stavanger, Norway, and with a current count of a collection of approximately 200,000 slides (NPD, 2020). These slides are frequently requested by companies, universities or analysts to conduct further analysis or to provide training. This means that they are constantly being moved and shipped from one place to another, in other words, this repository acts as a library for palynological material that can be borrowed. These palynological slides are made of glass, meaning they can easily be damaged during transportation or manipulation. This means that when the slides are broken the fossil material preserved is lost forever. Moreover, depending on the mounting medium, palynological slides can also decay over time. Hence, the Norwegian Petroleum Directorate started a project that implements available technology used in other sectors (i.e., pathology) to migrate the fossil records contained in the palynological slides into the digital world by using a specialised high-resolution scanner.

One could then argue that the two main drivers for implementing this innovation are:

- To preserve the fossil material in a way that cannot be physically destroyed.
- Means for remote analysis of palynological slides.
- Readiness for Artificial Intelligence and Machine Learning.

The Key determinants in the process of committing to develop the innovation:

The key determinant for achieving the implementation of this innovation is the existence of a highly specialised *3D Histech Panoramic 1000* microscope slide scanner that can provide an optical resolution finer than 0.29 μm and a digital resolution of more than 20 gigapixels (NPD, 2020). Without such piece of equipment, the level of resolution would not be enough for digitally analysing a sample due to the lack of resolution for the taxonomical details of each specimen.

In addition to this, the Institution has embarked on a journey to start implementing technology related to Industry 4.0 for long-term opportunities as well as challenges faced in the exploration of more complex areas. This therefore constitutes another key determinant; without the support from management and a clear road map to adapt and

adopt new technologies, acquisition of equipment necessary for implementing the innovation here discussed would have not been feasible.

A key factor that acted as a determinant would also be the fact that this type of technology has already been tested in the field of pathology. This potentially provided management insights of what could be achieved.

Hence, after acquiring the highly specialized scanner, the Norwegian Petroleum Directorate has taken up the task of scanning every single palynological slide that they currently hold. This therefore provides the previously inexistent option of remotely analysing a palynological sample from anywhere in the world and at any time, by simply accessing a server from a computer. As each slide has been scanned in five different focuses, the analyst can focus in and out to investigate features of the different planes of the specimens.

An additional plus of implementing this innovation is that it frees up the physical space required to store the physical slides at the sample repository.

The barriers and risks faced by the company in developing this innovation:

As time progresses, the techniques for processing palynological samples have evolved. This spans from chemical treatment to the mounting material and type of coverslips. As an example, most, if not all palynological samples in the 80's and early 90's used to use a circular coverslip. Nowadays, the standard coverslips used are either of rectangular shape (22x50 cm), or a square coverslip of 22x22 cm. This means that one of the first barriers that the Norwegian Petroleum Directorate had to overcome was the different shapes of coverslip that the scanner needed to be able to recognize and capture.

In addition to this, a more significant barrier faced when attempting to scan the slides was an uneven surface of the coverslip, or a subtle topography that would bring the image to completely out of focus when the image was been captured. There are several laboratories currently processing palynological samples that will eventually reach the scanner at the Norwegian Petroleum Directorate, and although the current techniques for processing are standard, protocols and procedures for producing samples without topography across all laboratories are inexistent. Moreover, as the samples for palynology are mainly being processed by commercial laboratories, the required quick turnaround prevents them to pay detailed attention to the topography of the slides, which is not a concern or barrier for the human analyst. The lack of control by the Norwegian Petroleum Directorate on whether the palynological slides are being processed for the standards required for scanning constitutes a significant barrier. To overcome this, personnel involved in this project have resourced to manually marking a frame on the coverslip using a regular marker to help the scanner identify the

boundaries of the sample and to aid the scanner to stay in frame and on focus for the required plane. This in addition to some manual manipulation when the topography of the slide is substantial. At the beginning of the project, this process was extremely time consuming. Nowadays, the experience has allowed personnel to learn what is exactly needed and therefore taking less time doing this process (Williams, 2021a). This, nonetheless, time and resources need to be factored in for this task until protocols for processing palynological slides specifically tailored for scanner standards are put in place across the different organisations.

Processes and technologies which the company used to carry this development forward:

The determinant of the Norwegian Petroleum Directorate to get the organisation ready for digitalisation and adopting technologies related to Industry 4.0 triggered a series of internal processes that allowed resources to be directed into the research and implementation of such technologies. Hence, for the specific innovation here being discussed, the first process was to scout for fields in science that also provide analyses at a microscopic level using the same type of microscope slides and investigate the advances made in image capturing and digitalisation. This with the aim of implementing a process of building a bridge for knowledge transfer from such fields to the field of palynology.

The field of pathology has been investigating and developing such type of technology for the past two decades (NPD, 2020). And it was at the 14th European Congress on Digital Pathology in Helsinki in 2018 that the Norwegian Petroleum Directorate obtained information and insights into the technology that was being used in pathology to aid medical diagnosis (NPD, 2020).

The piece of technology that is key for this innovation is the high-resolution scanner. Without such level of resolution, the image obtained after scanning the microscope slides would not be detailed enough to provide the required information for taxonomical identification. In addition to this, the computational power required to allow remote users to analyse the digital copy of the microscope slide constitutes another important part of the technology used that is worth mentioning. Currently, such analysis is done via Virtual Desktop Infrastructure, which allows users to access the bank of images which is currently approximately 24,000 (Williams, 2021b). This Virtual Desktop Infrastructure is coupled with an image interface that allows labelling of individual specimens and general annotations about the whole sample. In addition to this the storage required to host such vast number of images and with such high resolution needs to be big, powerful and reliable. The total size of the images as of 2020 was of 300 terabytes (NPD, 2020).

The extent to which the development relied on resources external to the company and the ways in which the deployment of these resources was managed:

It can be argued that the initial phase of the project relied on external resources from the field of pathology that provided the insights and advise on the implementation of the high-resolution microscope slide scanning. However, once the equipment was obtained and a standard procedure for microscope slide scanning was put in place, the development of the innovation did not rely too much on resources external to the company. An internal team has been fully dedicated to the development of this project and implementation of this technology and with IT support also coming from internal resources. Currently the main aspect that still relies on external resources is the servicing and support of the microscope slide scanner. As a matter of fact, a malfunction in the motor of the scanner put the whole process on hold for several months in 2020. Due to travel restrictions as a result of the global pandemic and the available technicians for repairing the equipment being based in Stockholm or Budapest, no repair was possible for several months. This delayed the scanning process by approximately 18,000 slides behind schedule (Williams, 2021b).

How management overview of the project was maintained:

To make sure the end result is fit for purpose, management has appointed an experienced palynologist to lead the project. It is understood that a set number of scanned microscope slides scanned per week was established as a target for weekly basis. In addition, as the Norwegian Petroleum Directorate is a governmental institution, yearly reports are generated and published in their website. Hence, the set milestones related to the number of scanned slides per month and the overview provided by an experienced palynologist secures a continuous progress of the project.

The extent to which you feel this innovation process represents the best practice:

The innovation here discussed corresponds to an innovative way to provide means for remotely analysing a palynological sample as well as digitally archiving the information contained on each sample. Different firms and institutions outside the field of palynology have used this type of technology in the past. However, the Norwegian Petroleum Directorate is the first one that brings palynology into this digital world. In terms of best practices, this institution is one of the few places in the world with a huge collection of palynological slides and leverages from four decades worth of information. Hence, an allocated team of people working on the scanning of this

material, and with milestones in the form of number of slides per week to be scanned, will guarantee a continuous progress on this front. However, on the aspect of remotely analysing the samples, the virtual desktop infrastructure provided to perform the analysis, does not allow image capturing nor access to the raw data of the image. This hinders potential collaborations with external institutions or firms via remote access to develop training datasets for Machine Learning. As per mentioned by Williams (2021b), this is not due any restrictions to the raw data of the image, as these are for public access, but rather because of the need to remotely accessing the servers of the institution and potentially exposing themselves to hacks or other sorts of attacks. It has been suggested that in the future, a *sandbox* will be implemented to mitigate this issue. This will eventually help brining this innovation to a new phase of Machine Learning with algorithms assisting analysts in the identification of specimens and further down the line to completely automate analysis at least on stratigraphic intervals with simple and easy to recognize palynology.

Lastly, although it goes beyond the institution's realm of control, the lack of a standard processing of palynological slides that is tailored for scanning from the different laboratories involved in palynological processing, makes the scanning process sometimes a bit cumbersome and with some manual manipulation required to correct any topography in the slide. A standard procedure put together by this institution and shared with all the laboratories involved in sample processing, would improve the current practice for slide scanning. Perhaps the solution for avoiding the topography is a simple one, but since the laboratories have not been exposed to the process of slide scanning, they are completely unaware of what exactly is required. Some potential awareness sessions and workshops with all the parties involved would be beneficial.

Critique of the innovation process and evaluation:

Overall, the field of palynology has been conducting analysis in the same way (i.e. direct fossil identification with a microscope) since this discipline first came about. This innovation was therefore much needed in this field. The benefits of this innovation are immense as it removes geographical barriers to access this fossil collection. Hence, universities from all over the world for instance, can leverage on this and provide training in palynology without having to spend resources in sample processing. Students from anywhere in the world will also be able to use this material for research purposes. On the other hand, the Norwegian Petroleum Directorate needs to implement a mechanism allow access to the raw data and engage more in external collaborations to move forward on the field of Machine Learning applied to palynology. As this project started rather recently, it is expected that this will be the strategic orientation moving forward.

In terms of measuring the innovation, following Satell's innovation matrix (Satell, 2017), the innovation here discussed would be a blend between (mainly) breakthrough innovation and sustaining innovation. Breakthrough innovation as it takes a leap forward in the way palynological samples are stored and analysed compared to the previous practices. The problem, or goal of the project was well defined since the beginning, but the exact equipment and procedure to achieve the objectives was initially somewhat blurry. Currently as the process on how to scan the slides has substantially improved, the domain is well defined so it would *provisionally* position the innovation as sustaining innovation. Emphasis is made in *Provisionally* as it is expected that this innovation will leap into another breakthrough innovation once collaborations with external institutions will allow open innovations in the field of Machine Learning applied to palynology.

References

NPD (2020), '*Report Resource 2020 Exploration*' Norwegian Petroleum Directorate

Norsk Petroleum (2021), *Exploration Activity*. Available at: <https://www.norskpetroleum.no/en/exploration/exploration-activity/> (Accessed: 23rd May, 2022)

Satell. (2017). *Mapping innovation: a playbook for navigating a disruptive age*. McGraw-Hill Education.

Williams, R. (2021a) 'FORCE Meeting, Advances in Biostratigraphy' oral presentation.

Williams, R. (2021b) Email to Fernando Mantilla-Duran, May 11, 2021.