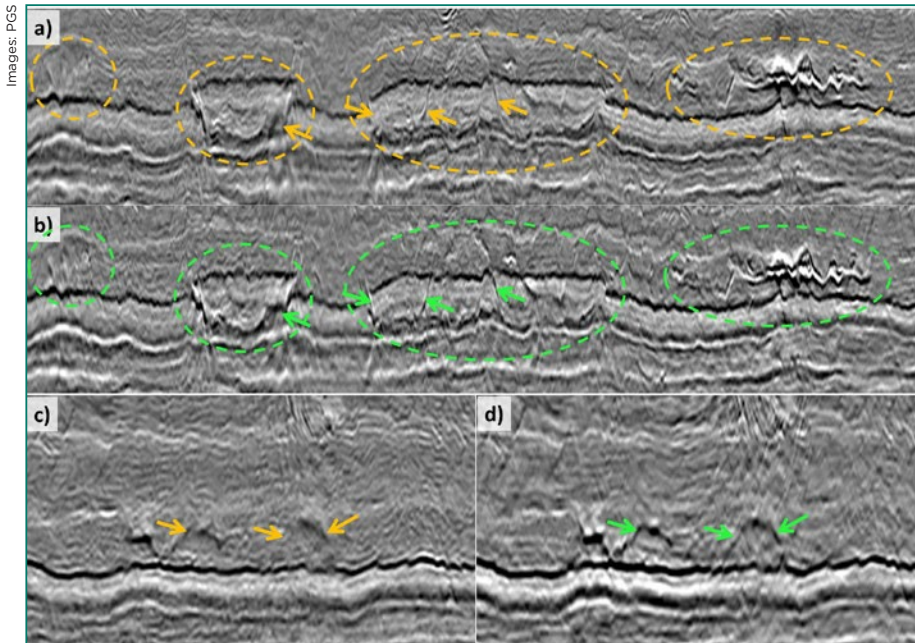# IMPROVING INJECTITE RESOLUTION

Both PGS and Aker BP conclude that clear structural improvements and better resolution of small-scale details are achieved with the introduction of LSM. These details are significant for the reservoir geologist

Images: PGS

Zoomed display of the Kirchhoff PSDM image for an arbitrary line (a) and a crossline (c) compared with LSM results (b) and (d). The arbitrary line goes through several of the injectite systems in this area while the crossline shows an injectite with weak reflectivity due the low impedance contrast compared to the background sediments. PGS and Aker BP conclude that clear structural improvements and small-scale details are achieved with the introduction of LSM.

Imaging of injectites has until recently relied on conventional imaging technologies (migration). In these there are no corrections for the wave field propagation effects and band limitations of the migration operator.

"The image will therefore suffer from a biased illumination that essentially will result in incorrect seismic amplitudes. Typically, flat reflectors will be better illuminated and imaged compared to steep dipping events and fault planes. To correct for these undesired effects of migration, the imaging should be posed as an inversion process with least-squares migrations (LSM)," Øystein Korsmo with PGS says.

At **NCS Exploration 2019** in May (Recent Advances in Exploration Technology), PGS presented a case study from the Frosk and Bøyla fields, well known for their injectite reservoirs.

"These targets are characterized by complex and steeply dipping sands and areas of weak reflectivity. The reason for the latter is low impedance

Images: PGS
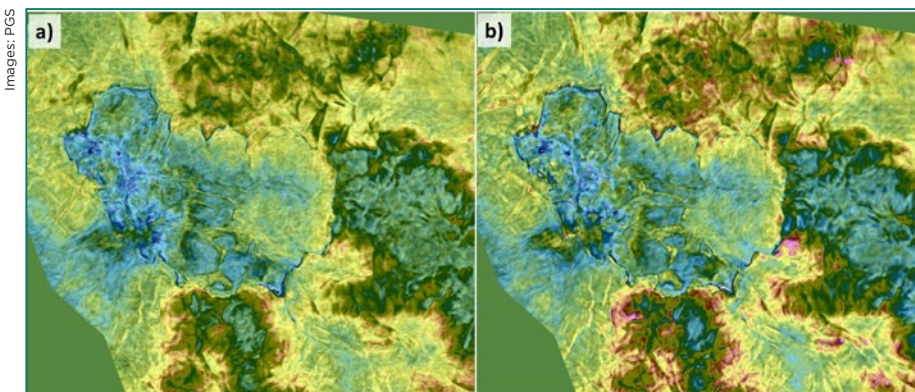
Depth slices at 2050 m depth comparing Kirchhoff PSDM (a) and LSM (b) with an overlay of the corresponding relative acoustic impedance. Mapping of the steeply dipping faults and sand systems improves significantly with LSM compared to migration. These details provide critical information required to understand the extent and complex geometry of the target structures.

contrast compared to the background sediments", Øystein Korsmo from PGS said in his talk.

"The image resolution at a given depth is controlled by the migration operator, the acquisition parameters such as source signature, frequency bandwidth and acquisition geometry, the earth properties at the reflector depth and the overburden (velocity and attenuation)", he explained.

Together with co-authors from both PGS and Aker BP (operator of Frosk and Bøyla), Korsmo demonstrated how the inversion process can de-blur and focus the image through balancing the wavenumbers and correct for acquisition and illumination effects.

According to PGS and Aker BP the inverted images reveal much more detail of these complex targets compared to conventional imaging. These details are of particular interest and importance for reservoir geologists to better understand the extension and structure of these reservoirs. Other oil companies have shown interest in the technology, and LSM has been demonstrated in several other geological settings than injectite reservoirs.

The methodology was introduced some 30 years ago, but at that time computer capacity was not sufficient. In this case study PGS has utilized a visco-acoustic least-squares migration to improve and focus an already high-quality Kirchhoff PSDM image over the Frosk and Bøyla fields.

"To ensure a cost-efficient inversion through rapid convergence, we have optimized the initial reflectivity model based on existing migrations. Furthermore, our deconvolution imaging condition contributed to an accelerated convergence and the 3D Q-model optimized the image corrections across and below the Q-anomalies," Øystein Korsmo said.

The reader is left to judge for her or himself.

HALFDAN CARSTENS

NORWAY LEADS THE PACK
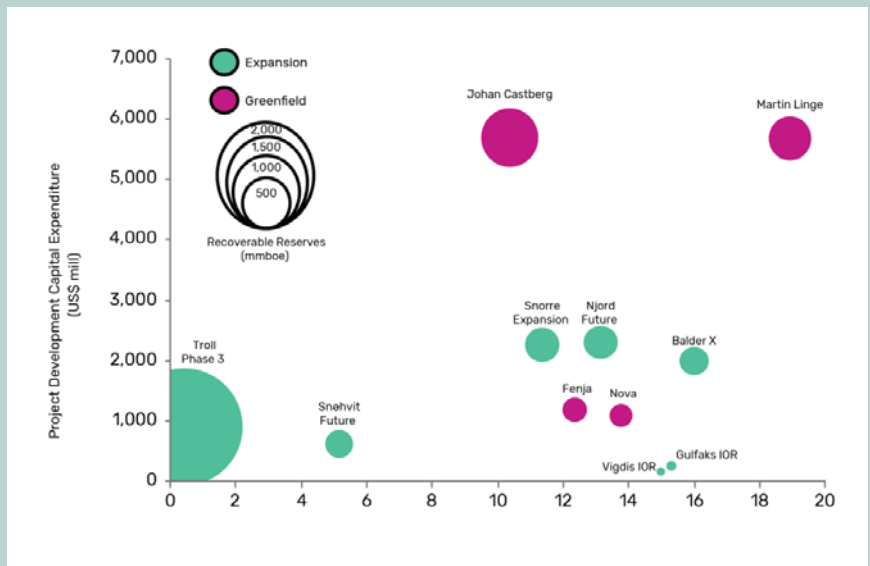
GlobalData's latest research reveals that Norway has the highest number of expansion projects under construction globally. Investments are expected to exceed USD **10 billion** in total capex.

Global Data is a fairly recent consolidation of several well-established data and analytics providers.

The average oil recovery of producing fields in Norway is currently 45%. For gas fields it is almost 70%. These recoveries have been the outcome of advancements in recovery **technology**, coupled with significant **investment and government-led initiatives**, according to GlobalData.

Since 2010, **nine** enhanced oil recovery (EOR) projects commenced operations off the Norwegian continental shelf. In comparison, only **two** were initiated in the UK during the same period.

However, less than 10% of fields currently producing in Norway are applying EOR techniques, signifying substantial upside for application across additional fields to boost remaining value and volumes on the NCS.

"Oil and gas giant Equinor has a strong track record of maximising recovery from major fields in Norway. The company has been able to achieve greater than 50% recovery factors from large fields, including Statfjord and Gullfaks, through enhanced and improved recovery mechanisms. Utilising innovative technologies, improved production efficiencies, and enhanced recovery practices have been key to Equinor's success in maximising value from Norwegian fields", says Daniel Rogers, Upstream Oil & Gas Analyst at GlobalData.

Of the identified expansion projects, **Troll Phase 3** will cost the lowest on a capital expenditure (CAPEX) per barrel of oil equivalent (boe) basis. It will target an additional **2.2 billion boe**, as well as extending field life by 17 years with a project breakeven price of below US$10 per barrel.