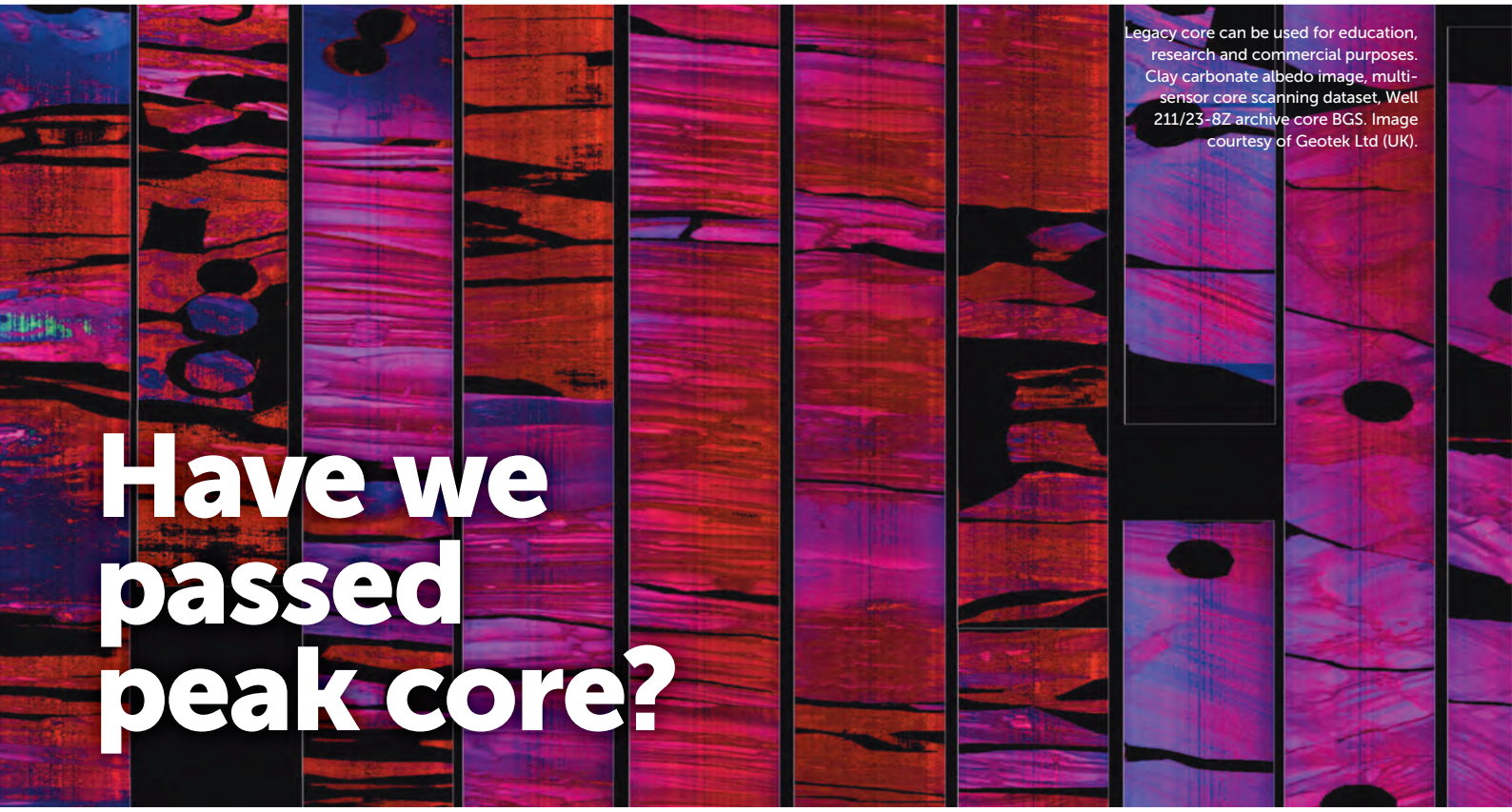

Legacy core can be used for education, research and commercial purposes. Clay carbonate albedo image, multi-sensor core scanning dataset, Well 211/23-8Z archive core BGS. Image courtesy of Geotek Ltd (UK).

Have we passed peak core?

Extracting and analysing core samples is expensive. With pressure on budgets and the changing energy landscape, Lucy Williams and colleagues ask whether core continues to provide critical value to subsurface assessments

CORE has traditionally played a key role in the characterisation of conventional and unconventional hydrocarbon reservoirs, from exploration to mature production, because it provides the only means to observe and make measurements on actual reservoir rock. However, recent oil-industry downturns have driven many to question the value of routinely taking core, given the associated costs and potential risks to well operations. In tandem, advances in other reservoir visualisation techniques, such as seismic and borehole imaging, give weight to the contention that coring now represents a much less significant means of characterising reservoirs than it once did. In May 2021, the Geological Society's Energy Group convened the virtual conference *Core Values: The Role of Core in 21st Century Reservoir Characterisation* to ask, "Does core have a future?"

Current state of play

Whilst coring is an expensive part of well-drilling operations, a great range of measurements and observations can be made on core, either directly or indirectly using artificial intelligence (AI). These measurements and observations allow us to calibrate our subsurface static and dynamic models (as discussed in a presentation by Nordine Sabaou, BHP, USA), and to quantify and reduce uncertainty and risk (as discussed by Mike Bowman, University of Manchester, UK and Patricio Desjardins, Shell, USA), thus enabling investment decisions to be made based on a fundamental understanding of the volume of hydrocarbons in place, as well as recovery factors.

The intrinsic value of core to the sedimentological and structural characterisation of reservoirs was demonstrated in a series of presentations (for example, by Bruce Levell, University of Oxford, UK; Martin Wells, BP, UK; Haakon Fossen, University of Bergen, Norway; Steve Laubach and Julia Gale, The University of Texas at Austin, USA). Additionally, the capacity for core samples to 'ground truth' a reservoir was exemplified by a series of presentations that compared borehole image studies both with and without core. The potential for successful outcomes in cases where core samples are not available depends on our understanding of the regional

geology, prospect maturity and nature of the reservoir (Adrian Neal, Badley Ashton, UK; Emma Jude, BP, UK). For depositionally complex reservoirs, core is indispensable even with excellent borehole-image coverage (Peter Gutteridge, Cambridge Carbonates Ltd, UK).

Understandably, geoscientists must justify the value core brings to a project and a coring campaign should be designed to address specific questions or challenges. The power of core is in its multi-disciplinary and evolving use throughout the lifecycle of a hydrocarbon field (Sean Kelly, EnQuest, UK). At the point of field discovery, the future value of core can be hard to predict and quantify. However, once the field is in production and performance deviates from predictions, or when trying to maximise the economic value of a field late into its life, we often revert to the core samples to seek answers and solutions. The 'ground truth' provided by core is currently irreplaceable in clastic reservoirs and, some may argue, more so in carbonate reservoirs (Anna Matthews, BP, UK), but the true value of core emerges when it is integrated with other datasets.

Legacy core

There is a growing awareness that the decommissioning of hydrocarbon fields in the North Sea is resulting in unwanted core finding its way into landfill and the question "Does legacy core have a future?" was a key theme at the conference. National core repositories are a veritable treasure trove of information, as exemplified by talks from Jeannine Honey at the USGS Core Research Center, and Mike Howe, at the British Geological Survey National Geological Repository (NGR). These institutions are under pressure to prove their value and reduce costs, despite their resources being available for education, geoheritage, research or commercial purposes at a fraction of the cost of drilling new core. Utilisation of these repositories spares money, time, and environmental impacts.

Efforts are currently focused on harnessing the full scientific value of legacy collections, for use today and into the future in yet unrealised research and applications. The NGR is at the forefront of international endeavours to utilise digitalisation and the worldwide web to increase the impact of the collections and find solutions that turn a physical archive into an accessible digital resource for all.

The energy industry is transitioning to low-carbon solutions, placing a spotlight on the value of legacy core in assessing options to meet net-zero targets (as discussed in presentations from Richard Porter, Shell, The Netherlands; Richard Worden, University of Liverpool, UK; Samuel Krevor, Imperial College London, UK). Geothermal energy, hydrogen storage, carbon capture utilisation and storage, and subsurface waste disposal all require subsurface evaluation and share many similarities with traditional oil-and-gas prospects. Legacy core, augmented by the focused acquisition of new data to address the subtly different requirements of low-carbon technologies, provides a cost-effective solution. Given their current and future value we must ensure the on-going survival of these national assets.

Analytical revolution

Traditional methods for core analysis use only a small fraction of the data available from core and developing technologies are enhancing the value of these samples. For example, AI has an increasingly important role in core characterisation, through cost-effective, automated, high-resolution, multi-sensor scanning technologies (Magret Damasckle, British Geological Survey; Paul Linton, TerraCore, USA; James Shreeve, Geotek, UK).

The huge volumes of data created by scanning technologies require robust database and visualisation platforms, but these methods can be applied to core samples in repositories worldwide and represent a revolution in our ability to understand the subsurface, to the wider benefit of industry and society beyond hydrocarbon extraction. Cloud-based software that allows multidisciplinary teams to virtually interrogate data at a range of scales already exits (Craig Lindsay, Core Specialist Services Ltd, UK), but will no doubt improve and hopefully become the bastion of not just large oil companies, but all those involved in the subsurface characterisation of porous media.

Bright future

Core alone cannot provide all the answers. However, when integrated with AI and complementary datasets, core samples provide the only mechanism to quantitatively ground-truth models and answer many field-development questions. To realise the full value of core, we must bridge the gap between analyses carried out using thin-section, seismic, and reservoir dynamic model data, using descriptive and interpretative schemes that allow data and understanding to cascade up and down the scales of investigation.

Some argue that we have reached or passed 'peak core'. Others contend that core is not viewed by enough people – a visit to the core store is an opportunity not only for technical integration, but also team building across the geoscientific, engineering, management and commercial disciplines. In our view, the future for core looks bright. If available, we will always calibrate other datasets back to core. As challenges and needs change, and technologies evolve, the value of core is reinvented. We ask readers to consider if, as geoscientists, we are doing enough to promote the true value of core.

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A Special Publication linked to the conference is in preparation.